GENERAL SPECIFICATION FOR CIVIL ENGINEERING WORKS

土木

Volume 1 of 2
2020 EDITION

香港特別行政區政府
The Government of the Hong Kong
Special Administrative Region

General Specification for Civil Engineering Works (GS), 2020 Edition
Volume 1 of 2

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FOREWORD

The General Specification for Civil Engineering Works lays down the quality of materials, the standards of workmanship, the testing methods and the acceptance criteria for civil engineering works undertaken for the Government of the Hong Kong Special Administrative Region. Where necessary, this General Specification should be supplemented by a particular specification.

The 2020 Edition of the General Specification comprises mainly the latest update on the review of obsolete standards with the updated text printed in green colour for easy reference. It was produced under the guidance of a Steering Committee comprising members from the main Government departments involved in civil engineering works. The Quality Management & Standards Unit of the Civil Engineering and Development Department (CEDD) was responsible for the overall co-ordination of comments received from departmental circulation, editing and production of the document. The 2020 Edition comprises 26 sections and is posted on CEDD Homepage on the Internet.

The General Specification will be updated continuously. The electronic files of the sections affected by any amendment issued will be kept up-to-date on CEDD Homepage.

December 2020

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FOR
CIVIL ENGINEERING WORKS

SECTION 1

GENERAL

SECTION 1

GENERAL

INTERPRETATION OF DOCUMENTS

Application of the General Specification for Civil Engineering Works

1.01 (1) The provisions contained in the Particular Specification and the Drawings shall prevail over the provisions contained in this General Specification for Civil Engineering Works (GS).

(2) The provisions contained in this General Specification for Civil Engineering Works shall prevail over the provisions contained in British Standards, British Standard Codes of Practice and similar standard documents stated in the Contract.

Abbreviations

1.02 (1) The following list shows the meaning of the abbreviations for the common terms used in this GS but is not intended to be exhaustive:

AASHTO	American Association of State Highway and Transportation Officials
APHA	American Public Health Association
AWWA	American Water Works Association
ANSI	American National Standards Institute
AS/NZS	Australian/New Zealand Standards
ASTM	American Society for Testing and Materials
BQ	Bills of Quantities
BS	British Standards
BS EN	European Standard adopted as British Standards
BS EN ISO	European Standards (EN) & International Organization for Standardization for (ISO)’s Standards adopted as British Standards
CBR	California Bearing Ratio
CCTV	Closed circuit television
CD	Chart Datum (0.146 m below Principal Datum)
C & D	Construction and demolition
CI	Cast iron
CIPP	Lining with cured-in-place pipes
CP	British Standard Code of Practice
CS	Construction Standard issued by Standing Committee on Concrete Technology, HKSAR
CSF	Condensed Silica Fume
CSSM	Construction Site Safety Manual
DI	Ductile iron
DDF	Disposal Delivery Form
DFT	Dry film thickness
DN	Nominal size
dn	Nominal size of tees and tapers
DRS	Daily Record Summary
EM&A	Environmental Monitoring and Audit
EPD	Environmental Protection Department
ET	Environmental Team
FGL	Finished ground level, or finished level of the permanent works
GCC	General Conditions of Contract
GEO	Geotechnical Engineering Office, Civil Engineering and

	Development Department
GI	Galvanized iron
GGBS	Ground Granulated Blastfurnace Slag
GS	General Specification for Civil Engineering Works
HDPE	High-density polyethylene
HKSAR	Hong Kong Special Administrative Region
HOKLAS	Hong Kong Laboratory Accreditation Scheme
HSFG	High strength friction grip
ISO	International Organisation for Standardization
JIS	Japanese Industrial Standards
LPG	Liquefied petroleum gas
PC	Portland cement
PD	Principal Datum
PE	Polyethylene
PFA	Pulverised-fuel ash
PFAC	Portland fly ash cement
PFC	Public Fill Committee
ppm	parts per million
PS	Particular Specification
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
QPME	Quality Powered Mechanical Equipment
QSPSC	Quality Scheme for the Production and Supply of Concrete
RAP	Reclaimed asphalt pavement
SCC	Special Conditions of Contract
SIS	Swedish Standards
SMM	Standard Method of Measurement for Civil Engineering Works
SRPC	Sulphate resisting Portland cement
TTS	Trip-ticket system
ULSD	Ultra-low-sulphur diesel
uPVC	unplasticised polyvinyl chloride
VHS	Video Home System
VOC	Volatile Organic Compound
WIS	Water Industry Specification, Water Research Centre

(2) The following list shows the meaning of the abbreviations for the units used in this GS but is not intended to be exhaustive:

°C	degrees Celsius
dB	decibels
g	gram
g/mL	gram(s) per millilitre
g/m^2	gram(s) per square metre
ha	hectare
hr	hour
Hz	hertz
J	joule
kg	kilogram
kHz	kilohertz
kJ	kilojoule
km	kilometre
km/hr	kilometre(s) per hour
kN	kiloNewton
kPa	kiloPascal
kV	kiloVolt
kW	kiloWatt

L	litre
L/min	litre(s) per minute
L/s	litre(s) per second
m	metre
m^2	square metre
m^3	cubic metre
m/s	metre(s) per second
Mg	megagram
Mg/m^3	megagram(s) per cubic metre
min	minute
mL	millilitre
mm	millimetre
mm^2	square millimetre
mm^3	cubic millimetre
mm/s	millimetre(s) per second
MPa	megaPascal
N	Newton
N/mm	Newton(s) per millimetre
N/m^2	Newton(s) per square metre
No.	number
NTU	nephelometric turbidity units
Pa.s	Pascal(s) second
r/min	revolution(s) per minute
r/s	revolution(s) per second
s	second
s	
t	tonne
μm	micrometer(micron)
%	percentage

Glossary of terms 1.03

(1) Words and expressions to which meanings are assigned in any section of the GS shall have the same meanings in other sections of the GS except when the context otherwise requires.

(2) Utilities are the installations (including cables, ducts and pipes) used to supply or provide electricity, lighting, traffic control, telecommunications, cable television, gas, water, drainage, sewerage and tramway, including all associated protection, supports, ancillary structures, fittings and equipment.

Trials and approval 1.04

(1) Reference in this GS to the approval of the Engineer shall mean approval given by the Engineer in writing. Materials, methods of construction and any other matters, which have been approved by the Engineer, shall not be changed without the approval of the Engineer to the proposed changes.

(2) Trials shall be carried out as stated in the Contract to demonstrate that proposed materials and methods of construction will produce work which complies with the specified requirements.

(3) Trials shall be carried out before the relevant permanent work starts so as to allow the Engineer a sufficient period to determine if the trial complies with the specified requirements. The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before the trial starts.

(4) Trials shall be carried out using materials and methods of construction of the types submitted to the Engineer, and at locations agreed by the Engineer.

(5) If in the opinion of the Engineer, the work that complies with the specified requirements has not been produced in the trial, particulars of proposed changes to the materials or methods of construction shall be submitted to the Engineer. Further trials shall be carried out until the work that complies with the specified requirements has been produced in the trial unless otherwise agreed by the Engineer. Works for which trials are required shall not commence, until in the opinion of the Engineer, the work that complies with the specified requirements has been produced in the trial.

(6) Unless permitted by the Engineer, the materials and methods of construction used to produce the work that complies with the specified requirements in a trial, shall not be changed unless further trials have been carried out to demonstrate that the proposed changes are satisfactory.

British Standards, European Standards adopted as British Standards, Codes of Practice and other standards

1.05 (1) Unless otherwise stated in the Contract, reference in this GS to British Standards, European Standards adopted as British Standards, British Standard Codes of Practice and similar standards shall be to that edition of the document stated in Appendix 1.1 of this Section which shall be deemed to include all amendments/corrigenda issued or published on or before the original date set for close of tender.

(2) Later editions of British Standards, European Standards adopted as British Standards, British Standard Codes of Practice and other similar standards, or standards which are considered to be equivalent, shall not apply unless approved by the Engineer. The Engineer shall not be bound to give or withhold his approval until the Contractor has provided him with a legal copy of the relevant standard for information. If approval is obtained, the Contractor shall provide two legal copies of the document for use by the Engineer.

Specifications in metric and imperial units

1.06 (1) Specifications in imperial units shall not be substituted for specifications in metric units stated in the Contract unless approved by the Engineer.

(2) Conversion of metric units to imperial units and of imperial units to metric units shall be in accordance with the Hong Kong Government Metric Reference Guidebook.

Dimensions from Drawings

1.07 Dimensions shall not be obtained by scaling from the Drawings. Dimensions that are not shown on the Drawings or calculable from dimensions shown on the Drawings shall be obtained from the Engineer.

PROGRAMME

Programme

1.08 (1) In addition to the programme to be submitted to the Engineer in accordance with Clause 16 of GCC for Civil Engineering Works, the Contractor shall submit within a further 14 days a programme showing a detailed breakdown of the work to be carried out in the first 3 months, and an outline for the remainder of the work. A programme showing the work completed to date, a detailed breakdown of the work to be carried out in the next 3 months and an updated outline for the remainder of the work shall be submitted to the Engineer not later than 4 weeks before the commencement of each subsequent 3-monthly period.

(2) Programmes submitted in accordance with Clause 1.08 (1) shall be in the form of a bar chart showing the earliest and latest start and finish dates for each activity, and the critical path.

(3) The breakdown of the work to be shown for each Section of the Works on the programme submitted in accordance with Clause 1.08 (1) shall be comprehensive. It shall include the key activities, key dates and milestones from the programme submitted under Clause 16 of GCC for Civil Engineering Works, the information required under Clause 16 of GCC for Civil Engineering Works and the effects of the matters listed in Clause 63 of GCC for Civil Engineering Works, together with the following:

(a) Work to be carried out, including testing and commissioning,

(b) Fabrication, delivery and installation of materials to be fabricated off the Site,

(c) Delivery of critical materials originating from outside the HKSARG,

(d) Activities for which the Employer or Engineer is responsible, including the issue of critical drawings and other information, provision of materials by the Employer, nomination and approval of Nominated Sub-contractors and consideration and approval of drawings and proposals, and

(e) Work to be carried out by Government departments, utility undertakings and other contractors.

(4) The Contractor shall be responsible for arranging, co-ordinating and agreeing with the utility undertakings a programme for their works. The Contractor shall make full allowance for time and provision of facilities for the utility undertakings in the preparation of his programmes.

CONTRACTOR'S SUPERINTENDENCE

Surveyor 1.09

(1) The Contractor shall employ on the Site a Surveyor for setting out the Works and for conducting slope and retaining wall record survey.

(2) The Surveyor shall possess a Diploma/ Higher Certificate in Land Surveying or a Higher Diploma in Geomatics from a Hong Kong technical institute/ polytechnic or university; or an Associate Membership of the Hong Kong Institute of Surveyors in the Land Surveying Division; or equivalent qualification appropriate to the nature of the survey work required for the Contract, plus a minimum of 2 years of relevant experience in engineering surveying.

Foreman for concrete works 1.10

If structural concrete works are included in the Contract, the Contractor shall employ on the Site a Foreman who is suitably experienced in concrete works. The Foreman shall be on the Site at all times when concreting is in progress.

Supervision of piling works 1.11

(1) If piling works are included in the Contract, the Contractor shall employ on the Site a Construction Engineer who is required to visit the site at such time and frequency as necessary and shall be present to supervise inter alia, but not limited to, the following items:

(a) 100% check on the depth of excavation and the quality of retrieved material at the founding stratum, and

(b) 100% verification on the depth of the constructed piles by proof drilling (for large-diameter bored piles) including the retrieval of concrete and rock core samples for inspection and testing.

(2) The Contractor shall also employ on the Site a Construction Supervisor who shall be full time on site to supervise the piling works.

(3) The Construction Engineer shall be a holder of a recognized degree in civil/structural/geotechnical engineering with 5 years of relevant experience. The Construction Supervisor shall either be a holder of a Higher Diploma/ Higher Certificate in civil/structural/geotechnical engineering with 3 years of relevant experience in piling works, or a holder of a Diploma/Certificate in the same subjects with 5 years of relevant experience in piling works, or an Associate Member of the Hong Kong Institution of Engineers in the civil/ structural/geotechnical discipline with 3 years of relevant experience in piling works.

Particulars of Agent and employees

1.12 (1) The proposed Agent as an employee of the Contactor shall hold a university degree acceptable to the Engineer and the HKIE academic requirements for Corporate Membership, or an equivalent qualification, in civil engineering or in a branch of civil engineering appropriate to the nature of the work included in the Contract, and shall have at least two years of relevant working experience. He must be bestowed with adequate authority to receive and carry out the directions and instructions from the Engineer and the Engineer's Representative.

(2) The following particulars of the proposed Agent, Surveyor, Construction Engineer and Construction Supervisor for piling works and foreman for concrete works shall be submitted to the Engineer:

(a) Name,

(b) Copy of Hong Kong Identity Card,

(c) Details of qualifications, including copies of certificates, and

(d) Details of previous experience.

(3) The particulars of the proposed Agent, Surveyor, Construction Engineer and Construction Supervisor for piling works shall be submitted to the Engineer for approval and the particulars of the proposed foreman for concrete works shall be submitted to the Engineer for information.

(4) The particulars of the proposed Agent, Surveyor, Construction Engineer and Construction Supervisor for piling works shall be submitted within 7 days of commencement of the Works. The particulars of the proposed Foreman for concrete works shall be submitted within 7 days of his appointment.

CONSTRUCTION SAFETY AND SAFETY OF THE PUBLIC

Construction safety and safety of the public

1.13 (1) The Contractor shall keep on the Site a set of the current Construction Site Safety Manual (CSSM) issued by the Environment. Transport and Works Bureau (ETWB) of the Government of the Hong Kong Special Administrative Region (HKSAR). Attention of the Contractor is drawn to Appendix III of Chapter 3 of the CSSM about the need to keep one set of the legislation, regulations and/or codes of practice on the Site.

(2) Safety precautions for working in sewers, drains and other confined spaces shall comply with the Factories and Industrial Undertakings (Confined Spaces) Regulations. The major provisions of these Regulations are contained in the current edition of the document “A Brief Guide to the Factories and Industrial Undertakings (Confined Spaces) Regulation” issued by the Labour Department of the Government of the HKSAR.

(3) Divers shall undergo regular medical checks and obtain certificates of fitness. Safety precautions for diving shall be in accordance with the current edition of the “Code of Practice: Safety and Health at Work for Industrial Diving” issued by the Labour Department of the Government of the HKSAR.

(4) Adequate safety equipment including, as appropriate, safety helmets, goggles, ear protectors, safety belts, safety equipment for working in sewers, drains and confined spaces, equipment for rescue from drowning, fire extinguishers, first aid equipment and other necessary safety equipment shall be available on the Site at all times.

(5) Safety equipment, scaffolds, working platforms, ladders and other means of access, and lighting, signing and guarding equipment shall be inspected and maintained regularly. Lights and signs shall be kept clean and easy to read. Equipment that are damaged, dirty, incorrectly positioned or not in working order shall be repaired or replaced immediately.

(6) Posters in both English and Chinese to draw attention to safety shall be obtained from the Labour Department and displayed at prominent locations around the Site including site offices, workshops and canteens.

(7) The Contractor shall take all reasonable precautions to ensure the safety of the public at and adjoining the Site. The Contractor shall also take all reasonable measures to prevent the public from entering those parts of the Site where work is in progress or where there exists any potential hazard to the public, and where necessary, adopt effective measures to prevent the public from getting close to the dangerous areas of the Site or being endangered by the construction activities. Posters and/or warning signs in both Chinese and English drawing the attention of the public to the potential hazards in connection with the Works shall be displayed at prominent locations around the Site.

WORK ON ROADS

Approval for temporary traffic arrangements and control

1.14 (1) In addition to any other requirements stated in the Contract, temporary traffic arrangements shall be in accordance with conditions and restrictions imposed by the Commissioner for Transport and the Commissioner of Police. In case works with temporary traffic arrangement affecting carriageway, including that with pedestrian diversion onto carriageway, the details of the temporary traffic arrangements, including necessary supporting material such as staging of works, traffic impact assessment, drawings, plans and calculations shall be prepared and submitted by the Contractor. These details shall be prepared and signed by a professional engineer who has been a corporate member of the Hong Kong Institution of Engineers in the Civil Discipline or Logistics and Transportation Discipline (or has possessed equivalent qualifications) for at least 3 years. Temporary lighting, signage, guarding and traffic control arrangements shall be in accordance with conditions and restrictions imposed by the Director of Highways. Traffic signs that are not prescribed by the Road Traffic Ordinance or its subsidiary legislation shall be in accordance with conditions and restrictions imposed by the Commissioner for Transport.

(2) The Contractor shall make all arrangements with and obtain the necessary approvals from the Commissioner for Transport, the Commissioner of Police, the Director of Highways and any other relevant authority for temporary traffic arrangements and control.

Temporary traffic arrangements and control

1.15 (1) Temporary traffic diversions and pedestrian routes shall be provided where work in roads or footways obstructs existing vehicular or pedestrian access. The relevant work shall not commence until the approved temporary traffic arrangements and control have been implemented.

(2) Temporary traffic arrangements and control for work in roads and footways shall comply with the requirements contained in the current edition of the document `Code of Practice for Lighting, Signing and Guarding of Road Works' issued by the Government of the HKSAR. A copy of the document shall be kept on the Site.

(3) Temporary traffic light signals shall be of a type approved by the Commissioner for Transport and shall comply with the requirements contained in the current editions of the documents `Type Approval Procedure for Portable Traffic Light Signals' and `Specification for Vehicle Actuated/Fixed Time Portable Traffic Signal Equipment' issued by the Government of the HKSAR.

(4) Temporary traffic signs, including posts, backing plates and faces, shall comply with the requirements for traffic signs contained in Section 12 except as stated in Clauses 1.15(5) and (6).

(5) The thickness of backing plates for temporary traffic signs that will be erected for less than 6 months may be reduced to 1.5 mm. The posts for signs may be constructed of timber or other material provided that in the opinion of the Engineer the traffic signs will be stable and safe.

(6) The Contractor shall design the arrangement of information on sign the faces for temporary traffic directional signs. The details of the background, borders and legends, including letters, numerals, characters and symbols, shall

comply with the requirements of the Commissioner for Transport.

(7) The Contractor shall inspect and regularly maintain the temporary traffic arrangements and control, both day and night. He shall keep the traffic lights, lights and signs clean and easy to read, and shall immediately repair or replace the equipment that is damaged, dirty, incorrectly positioned or not in working order.

Particulars of temporary traffic arrangements and control

1.16 The following particulars of proposed temporary traffic arrangements and control shall be submitted to the Engineer for approval at least 7 days before the traffic arrangements and control are implemented:

(a) Details of traffic diversions and pedestrian routes,

(c) Details of lighting, signage, guarding and traffic control arrangements and equipment, and

(c) Any conditions or restrictions imposed by the Commissioner for Transport, the Commissioner of Police, the Director of Highways or any other relevant authority, including copies of applications, correspondence and approvals.

Use of roads and footways

1.17 (1) Roads, footways and cycle-tracks on the Site shall be maintained in a clean and passable condition and shall not be used to store materials or park construction plant or other vehicles, other than those required for immediate use on the Works. The construction plant, materials and temporary works shall be placed with minimum interference with or disturbance to the use of any right of way by the public.

(2) Measures shall be taken to prevent excavated material, silt or debris from entering drainage systems in roads, footways and cycle-tracks. Entry of water to gullies shall not be obstructed.

(3) Surfaced roads on the Site and leading to the Site shall not be used by tracked vehicles unless protection against damage is provided.

(4) Construction plant and other vehicles leaving the Site shall be properly cleaned, loaded and covered in such a manner that excavated material, mud or debris is not deposited on roads. Measures to be adopted shall include but not be limited to those specified under Clauses 25.15 and 25.26.

Work on roads and footways

1.18 (1) Work on roads on the Site shall be carried out in sections such that the length of road occupied at any time does not exceed that stated in the Contract and the width of road occupied at any time does not exceed the width of one traffic lane unless permitted by the Engineer. Work on each section shall be completed and the road shall be reinstated and opened to traffic before work commences on the next section. Work on any section, including loading and unloading, shall be carried out in such a manner that traffic and utilities on the adjacent road and pedestrian access in the adjacent footway are adequately maintained.

(2) Before excavations are carried out on roads or footways, except in areas covered with paving blocks or tiles, the limits of the area to be reinstated shall be bounded by a continuous saw-cut groove. The groove shall be at least 6 mm wide and at least 50 mm deep. Cutting the groove and breaking out the road or footway shall be carried out in such a manner that the adjacent road or footway, including edges, is not damaged.

(3) Excavated material shall not be stored adjacent to excavations in roads or footways unless permitted by the Engineer.

(4) Any vehicular access across excavations in roads shall be provided with steel covers. The covers shall be designed to BS EN 1993-1 unless otherwise specified and shall be capable of withstanding the full load of traffic permitted to use the road. The covers shall be secured in position and shall have anti-skid coating so that the skid resistance values of the covers measured in accordance with BS EN 1436 shall be Class S1. Sufficient steel covers shall be kept on the Site adjacent to excavations in roads to permit access for vehicles across the excavations in case of emergency. When installed, the steel covers shall be set to match the road surface smoothly so as to avoid/minimize any noise nuisance by rocking under the action of traffic.

(5) Work on roads, footways and cycle-tracks shall be carefully planned to minimize the period of temporary excavation. If the Contractor is unable to proceed with the works after any excavation is carried out, he shall immediately backfill or temporarily reinstate the excavation.

(6) In respect of works covered by the excavation permits issued by Highways Department and/or Lands Department as appropriate pursuant to the Land (Miscellaneous Provisions) Ordinance Cap 28 where the Contractor is the Nominated Permittee and the Employer is the Permittee, the Contractor shall comply with all conditions imposed on him as stated in the excavation permits.

Reinstatement of roads and footways 1.19 Temporary diversions, pedestrian access and lighting, signage, guarding and traffic control equipment shall be removed immediately they are no longer required. Roads, footways and other items affected by temporary traffic arrangements and control shall be reinstated to the condition existing before the work started or to such other condition as may be agreed or instructed by the Engineer.

CARE OF THE WORKS

Protection from water 1.20 (1) Unless otherwise permitted by the Engineer, all work shall be carried out, as near as may be practicable in the circumstances, in dry conditions, except where the work is required to be carried out in or with water or other fluids.

(2) Where necessary and as far as practicable, the Works including materials for use in the Works shall be kept free of water and protected from damage due to water. Temporary drainage, pumping systems or other effective measures approved by the Engineer shall be used. Silt and debris shall be intercepted with traps before water is discharged from the Site.

(3) The discharge points of the temporary drainage and pumping systems shall be approved by the Engineer. The Contractor shall make all arrangements with and obtain the necessary approvals and inspections from the relevant authorities for discharging water to drains, watercourses or the sea. The relevant work shall not start until the approved arrangements for disposal of the water have been implemented.

(4) Measures shall be taken to prevent flotation of new and existing

structures.

Protection from weather 1.21 (1) Works shall not be carried out in weather conditions that may adversely affect the works unless protection by methods agreed by the Engineer is provided.

(2) Permanent works, including materials for permanent works, shall be protected by methods agreed by the Engineer from exposure to weather conditions that may adversely affect the work or materials.

Protection of works 1.22 Finished works shall be protected with methods agreed by the Engineer from damage that could arise from the execution of adjacent works. Works shall be carried out in such a manner that works carried out by others, including Government departments, utility undertakings and other contractors, is not damaged.

DAMAGE AND INTERFERENCE

Damage and interference 1.23 (1) Works shall be carried out in such a manner that, as far as is reasonable and practicable, there is no damage to or interference with the following, other than such damage as is required to enable the execution of the Works:

(a) Watercourses;

(b) Utilities;

(c) Structures, roads including street furniture, or other property;

(d) Public or private vehicular or pedestrian accesses; and

(e) Trees, graves or burial urns.

(2) The Contractor shall inform the Engineer as soon as practicable of any item, utility or thing which is not stated in the Contract as requiring diversion, removal or relocation but which the Contractor considers as requiring diversion, removal or relocation to enable the Works to be executed. The Contractor shall not divert, remove or relocate any such item, utility or thing without the prior approval of the Engineer.

(3) Items which are damaged or interfered with as a result of the works being carried out and items which are diverted, removed or relocated to enable the works to be carried out, shall be reinstated to the same condition as was existing before the works started or to such other condition as may be agreed or instructed by the Engineer.

Watercourses and drainage systems 1.24 (1) The Contractor shall be responsible for maintaining all river and stream courses, drains and culverts within the Site until handover of the Site to the Employer. Rivers and stream courses shall be maintained in accordance the requirements of Clause 25.09. Maintenance of drains and culverts shall include, but not be confined to, the periodic clearance of debris, weed growth and other obstructions from the drains, culverts, manholes and flap valve chambers to the satisfaction of the Engineer. The Contractor shall ensure throughout the contract period that the flow capacity is not reduced and the quality of water is not worsened by execution of the Works.

(2) The Contractor shall be responsible for any temporary training or diversion of natural streams/rivers, drainage systems, nullahs and watercourses during execution of the Works and subsequent reinstatement. The Contractor shall submit to the Engineer particulars of the diversion and reinstatement proposals at least 21 days before the diversions are implemented. The Contractor shall programme construction of the Works to take account of all the necessary temporary diversions of the existing natural streams/ rivers, nullahs, watercourses and drains. The Contractor shall illustrate in his overall programme how the Works can be phased smoothly with the various necessary diversions.

(3) All diversions shall be of adequate capacity so as not to increase the risk of flooding to any area within, upstream or downstream of the Site either from heavy rainfall or high tides. The Contractor shall ensure that adequate provision is made for dealing with flood flows. Where the design of diversion proposals relies on contingency measures to quickly remove the installed temporary works from the drainage systems in order to provide sufficient flow capacity during adverse weather conditions, any such contingency measures and associated procedures shall be demonstrated to be 'fail-safe'. The diversion shall be carefully planned to minimize disturbance caused to the natural beds of river/streams and riparian vegetation. The diversion shall be properly reinstated, including removal of any obstructions to flow, as soon as practicable after the works are completed, to the satisfaction of the Engineer.

(4) The natural bottom and existing flow in the river shall be preserved as much as possible to avoid disturbance to the river habitats. If temporary access track on riverbed is unavoidable, this shall be kept to the minimum width and length. Temporary river crossings shall be supported on stilts above the riverbed. Stockpiling of construction material, if necessary, shall be properly covered and located away from any natural stream/river. Measures shall be taken to prevent excavated material, silt or debris from being deposited or washed into existing streams and rivers, drainage systems, nullahs, watercourses, diversion channels or the sea. The measures to be adopted shall include but not be limited to those specified under Clauses 25.07, 25.08 and 25.09.

(5) Any sediment or debris that accumulates in any catchpit, manhole, sump, trap, drain, drainage channel or watercourse, whether temporary, existing or newly constructed, within the Site, shall be removed on a frequent basis, or as directed by the Engineer.

(6) Removal of existing vegetation alongside the riverbanks shall be avoided or minimized. When disturbance to vegetation is unavoidable, all disturbed areas shall be hydroseeded or planted with suitable vegetation to blend in with the natural environment upon completion of works.

Utilities 1.25

(1) The details of existing utilities are given for information only and the accuracy of the details is not guaranteed. The Contractor shall make his own enquiries and shall carefully excavate inspection pits to locate accurately the utilities indicated to him by the utility undertakings.

(2) Temporary supports and protection to utilities shall be provided by methods agreed by the Engineer. Permanent supports and protection shall be provided if instructed by the Engineer.

(3) The Contractor shall inform the Engineer and the utility undertakings without delay of the following:

(a) Damage to utilities,

(b) Leakage of utilities,

(c) Discovery of utilities not shown on the Drawings, and

(d) Diversion, removal, repositioning or re-erection of utilities, which is required to enable the execution of the Works.

(4) The Contractor shall take all steps necessary to enable the utility undertakings to proceed in accordance with the programme agreed between the Contractor and the utility undertakings under Clause 1.08(4). The Contractor shall maintain close liaison with the utility undertakings and shall inform the Engineer of any delays in works by the utility undertakings.

(5) Records of existing utilities encountered shall be kept by the Contractor on the Site with a copy provided for the Engineer. The records shall be agreed by the Engineer and shall contain the following details:

(a) Location of utility,

(b) Date on which utility was encountered,

(c) Nature and size of utility,

(d) Condition of utility, and

(e) Temporary or permanent supports provided.

(6) Further to Clause 1.25(1), the Contractor shall submit for the Engineer's agreement, at least 14 days before any excavation by mechanical plant, a proposal for investigations to ascertain the nature, location and size of existing utilities by hand-dug inspection pits. Such investigations by inspection pits shall not relieve the Contractor of any of the duties, responsibilities, obligations or liabilities imposed upon him by any of the provisions of the Contract.

(7) Unless otherwise agreed by the Engineer in writing, the Contractor shall carry out investigations to locate utilities in accordance with the proposal referred to in Clause 1.25(6). The Contractor shall make his own enquiries with the utility undertakings as and when required and should any utility installations including cover tiles be exposed, the respective utility undertakings shall be contacted to determine if all their utilities have been located. Utility installations including cover tiles shall only be removed by the utility undertakings concerned.

(8) No excavation with mechanical plant shall commence until the nature, location and size of utilities that may be affected by the excavation have been ascertained and the setting-out details have been checked by the Engineer. The nature includes the type of utilities, protective uPVC/GI ducts or conduits, concrete surround, haunching and the like. The location includes the top/bottom levels, the coordinates of the center-lines of the utilities and the like.

(9) The Contractor shall provide adequate and experienced site personnel to control the operation of heavy mechanical plant in the proximity of utilities.

(10) The Contractor shall make arrangements to avoid any heavy

mechanical plant or vehicles standing or passing over buried pipe-work in particular those at shallow depths with less than 1 metre overburden cover, especially when the road surface is removed. Unless agreed by the Engineer, the Contractor shall not stockpile any material immediately over or in the vicinity of any pipe-work.

(11) Pursuant to Clause 1.25(1), the Contractor shall carry out the Works in such a manner to avoid any damage or interference with any concrete blocks or structures attached to the utilities. The Contractor shall ensure that all cable draw-pits, valve-pits and the like are not covered up or removed as a result of his works and are accessible by utility undertakings at any time during the course of the Works for emergency repair.

(12) Further to Clause 1.25(2), where utility installations are exposed, the Contractor shall liaise with the utility undertakers about the necessary protection for the exposed utilities and provide temporary protective measures and warning signs to prevent damaging the utility installations.

Structures, roads and other property

1.26 The Contractor shall immediately inform the Engineer of any damage to structures, roads or other property not required for the execution of the Works.

Access

1.27 Alternative access shall be provided if interference with existing public or private vehicular or pedestrian access is necessary to enable the execution of the Works. The arrangements for the alternative access shall be as agreed by the Engineer. The permanent access shall be reinstated as soon as practicable after the works are complete and the alternative access shall be removed as soon as practicable after it is no longer required.

RECORDS

Records of wage rates

1.28 The average, high and low wage rates for workers of each trade employed on the Site shall be entered on monthly wage return forms provided by the Engineer, and the completed forms returned to the Engineer within 4 days of the start of the succeeding month. For the purpose of completing the returns, actual trades shall be entered as the equivalent trades stated in Table 1.1.

Records of correspondence

1.29 Copies of correspondence relevant to execution of the Works (and not of a confidential nature) received from or despatched to Government departments, utility undertakings and other contractors employed by the Employer shall be submitted to the Engineer for information as soon as possible, but in any case not later than 7 days after receipt or despatch.

Records and reports

1.30 Reports and records, which are to be submitted to the Engineer, shall be in a format agreed by the Engineer. Reports and records shall be signed by the Contractor's agent or by another representative authorised by the Contractor.

Table 1.1: Equivalent trades

Actual trade	Equivalent trade
Office attendant	Labourer (unskilled)
Watchman	Labourer (unskilled)
Working ganger	Ordinary worker in the trade in which he is employed or, if the trade is not listed, lorry driver
Survey labourer	Concretor's labourer
Turf-layer	Concretor's labourer
Bituminous material layer	Concretor's labourer
Shot-firer	Plasterer
Lorry checker	Labourer (unskilled)
Motor driver (car/van)	Truck driver
Survey leveller	Plumber
Welder	Painter
Coxswain, barge Engineer	Truck driver
Dredger crew, barge crew	Diver's linesman

LIAISON WITH OTHERS

Liaison with others 1.31 (1) The Contractor shall make all necessary arrangements with and obtain the necessary approvals from Government departments, utility undertakings and other duly constituted authorities for carrying out the Works.

(2) The Contractor shall maintain close liaison with other contractors employed by the Employer, and utility undertakings or other authorities who are carrying out works on or adjacent to the Site. The Contractor shall ensure as far as possible that the progress of the Works is not adversely affected by the activities of such other contractors.

SITE CLEANLINESS

Site cleanliness 1.32 (1) The Site shall be maintained in a clean and tidy condition. Materials, including materials required for Temporary Works, shall be stored in an orderly manner. The measures to be taken shall include but not limited to the following:

(a) Promptly remove all debris and litter on the site including those dumped into the site from outside by the public.

(b) Promptly remove debris and litter not within the site if the debris and litter are in connection with the Works or disposal of by the persons working on the site.

(c) Keep traffic cones, temporary traffic lights and signs clean, secure and in an orderly manner and refurbish, repaint and/or repair hoardings and/or steel barriers half yearly.

(d) Keep passageways clear and free of greasy dirt, waste and timber.

(2) The Contractor shall assign a designated person, with adequate knowledge, experience and authority, for the overall co-ordination, monitoring and overseeing of the performance of the site on cleanliness and control of mosquito breeding. Thereafter, the Contractor shall notify the Engineer of the name and contact telephone number of the assigned person and any subsequent change.

Prevention of mosquito breeding

1.33 (1) Measures shall be taken to prevent mosquito breeding on the Site. The measures to be taken shall include the following:

(a) Empty cans, oil drums, packings and other receptacles that may retain water shall be deposited at a central collection point and those not required for future use shall be removed from the Site regularly.

(b) Standing water shall be treated at least once every week with an oil which will prevent mosquito breeding.

(c) Construction plant and other items on the Site which may retain water shall be stored, covered or treated in such a manner that water will not be retained.

(d) Properly cover all water storage tanks, remove unnecessary stagnant water and disused containers, or use non-hazardous larvicide to prevent mosquito breeding as the last resort. The Contractor shall submit the characteristics, mixing formulation and method of application of the proposed larvicide to the Engineer for approval before its use; and

(e) Cut bamboo poles for scaffolding as near to the nodes of the poles as possible.

(2) Posters in both English and Chinese drawing attention to the dangers of permitting mosquito breeding shall be obtained from the Government of the HKSAR and displayed prominently on the Site.

Prevention of dust

1.34 Works shall be carried out in such a manner that avoidable dust is not generated. Measures to be adopted shall include but not be limited to those specified under Clause 25.15.

Control of Dogs on Construction Sites

1.34A (1) No dog shall be kept by the Contractor or his employees, his agents or sub-contractors or their employees, on the Site unless the dog is acceptable for licensing by the Agriculture, Fisheries and Conservation

Department (AFCD), and is licensed under the Rabies Ordinance (Cap. 421), implanted with a microchip and vaccinated against rabies. In addition, the keeper of the dog under the license shall either be:

(a) an employee of the Contractor who shall be of a rank not lower than deputy site agent or equivalent as agreed by the Engineer; or

(b) a security firm in its own name or an employee of the firm who shall not be of a rank lower than assistant manager level, where the security firm is engaged by the Contractor solely for the purpose of Site security.

(2) All licensed dogs kept on the Site must be neutered. The Contractor shall keep or cause the aforesaid security firm to keep on the Site a copy of the licence, together with a copy of the certificate issued by a registered veterinary surgeon confirming that the dogs kept on the Site have been neutered, for inspection by the Engineer upon request. All licensed dogs on the Site shall be identified by suitable markings on their collars as agreed by the Engineer, and shall be removed by the Contractor from the Site upon completion of the Works under the Contract.

(3) The Contractor shall alert the AFCD and facilitate access, where appropriate, to the Site for removal of any unlicensed dogs from the Site.

(4) The Contractor shall observe and undertake, or cause his employees, his agents or sub-contractors or their employees to observe and undertake, the licensing and control measures as set out in the current edition of the Code of Practice for the Keeping of dogs on Construction Sites in Hong Kong issued by AFCD for any dogs kept on the Site. The Engineer or his Representative shall have the power to order the removal of any person who fails to comply with the requirements from the Site.

MATERIALS AND EQUIPMENT

Materials and equipment provided by the Employer

1.35 (1) Materials and equipment which are to be provided by the Employer will be as stated in the Contract.

(2) Materials and equipment provided by the Employer shall be collected by the Contractor from the locations stated in Contract and delivered by the Contractor to the Site. The Contractor shall inspect the materials and equipment before taking receipt and shall immediately inform the Engineer of any shortage or damage.

(3) Materials or equipment provided by the Employer which are damaged after collection shall be repaired by the Contractor and submitted to the Engineer for approval. Materials or equipment, which are lost or which in the opinion of the Engineer are not capable of being or have not been repaired satisfactorily, shall be replaced by the Contractor.

(4) Useless crates and containers for materials or equipment provided by the Employer shall be disposed of by the Contractor as agreed by the Engineer.

(5) Equipment and materials provided by the Employer which are surplus to the requirements of the Works shall be returned with crates and containers to the locations stated in the Contract.

(6) The Contractor shall protect and maintain equipment provided by the Employer while it is on the Site and shall provide operatives, fuel and other consumables required to operate the equipment.

Materials 1.36 (1) Materials for inclusion in the permanent works shall be new or other material as stated in the Contract or approved by the Engineer.

(2) Certificates of tests by manufacturers that are submitted to the Engineer shall relate to the material delivered to the Site. Certified true copies of certificates may be submitted if the original certificates cannot be obtained from the manufacturer. A letter from the supplier stating that the certificates relate to the material delivered to the Site shall be submitted with the certificates.

(3) Samples of materials submitted to the Engineer for information or approval shall be kept on the Site and shall not be returned to the Contractor or used in the permanent works unless permitted by the Engineer.

TESTING

Not used 1.37 Not used.

Batches, samples and specimens 1.38 (1) A batch of material is a specified quantity of the material, which satisfies specified conditions such that it may be assumed that all of the material in the batch is of consistent type and quality. If one of the specified conditions is that the material is delivered to the Site at the same time, material delivered to the Site over a period not exceeding 7 days may be considered as part of the same batch if in the opinion of the Engineer there is sufficient evidence that the other specified conditions applying to the batch apply to all of the material delivered over the period.

(2) A sample is a specified amount, or a specified number of pieces or units, taken from a batch for testing, such that the result of tests on the sample can be taken as representing the quality of the batch as a whole.

(3) A specimen is a portion of a sample that is to be tested.

Samples for testing 1.39 (1) For the purpose of this Clause and Clauses 1.40, 1.42 and 1.49, “the Employer’s laboratories” shall mean:

(a) The laboratories of the Employer such as Public Works Laboratories (PWL), and

(b) The laboratories currently appointed by the Employer or PWL.

(2) Samples for laboratory tests or test locations for insitu tests shall be randomly selected by the Engineer. In addition, the Engineer shall be free to select samples or test locations at where the Works he suspects to be defective. The test locations for insitu tests so selected and, if applicable, the area/extent of Works covered by the tests, shall be traceable by means of either a referenced co-ordinates system or a location plan with defined test positions

and levels.

(3) Samples shall be representative and of sufficient size to enable all specified tests to be performed.

(4) Samples shall be taken on Site under close supervision of the Engineer or by the Employer's laboratories having no direct commercial relationship with the Contractor, its sub-contractors or material suppliers, and shall be clearly, indelibly and individually marked for identification.

(5) Once selected and taken, samples stored on Site before delivery to the place of testing shall remain in the charge of the Engineer or the Employer's laboratories, who/which shall be given adequate facilities (including sample store room) to keep samples securely under lock and key inaccessible to unauthorised persons at all times.

(a) Samples shall be protected, handled and stored in such a manner that they are not damaged nor contaminated such that the properties of the sample are not affected. The method of storage shall comply with the requirements of the relevant test methods.

(b) Where insitu concreting works are to be carried out, the Contractor shall, at the discretion of the Engineer, provide sufficient number of steel container rooms (or the like) and curing tanks for storage and curing test cubes to the satisfaction of the Engineer in accordance with Clause 1.49(4).

(6) Samples shall be collected and delivered by the Contractor under close supervision of the Engineer or by the Employer's laboratories to the specified place of testing. During transportation from Site to the specified place of testing, all samples shall be securely locked in containers or suitably modified vehicle compartments unless otherwise approved by the Engineer, with keys kept by the Engineer or the Employer's laboratories.

(7) The transfer of samples from one place/person to another shall be clearly documented and checked. The person receiving the samples shall acknowledge the receipt and confirm the identification of the samples. A record showing:

(a) When, where and by whom the samples are taken, and

(b) Persons who have handled the samples before and during delivery to the place of testing,

shall be prepared and maintained by the Engineer (with assistance of the Employer's laboratories when necessary) so that the samples delivered from Site to the specified place of testing are traceable.

(8) For those tests where supervisory attendance is essential for providing guidance on Site or for obtaining test data, details of such supervisory site staff present shall be recorded in relevant data sheets and/or sample submission forms to enhance data integrity.

(9) For the purpose of stock control to preclude the swapping of materials under test and where applicable the unauthorised use of materials before receipt of test results, the Contractor shall:

(a) Clearly identify all batches of materials arriving on the Site (the identification marks so designed shall contain information which can reveal the identity of the batch for each type of material such as the Contract number, type of material, batch number and other information as required by the Engineer);

(b) Keep stockpiles and stock items from which samples have been taken pending test results separated from other materials by means of labels denoting “Stock under Test” or similar agreed by the Engineer;

(c) Establish and maintain a record system showing identification marks, testing status of all materials (under test or approved for use or rejected or re-test or omitted for testing, etc.), key dates (e.g. date of testing) and locations of storage; and

(d) In connection with the above, submit a proposal for a stock management system on Site peculiar to the Contract to prevent unauthorised or uncontrolled use of materials for approval by the Engineer at the commencement of the Contract and subsequent supervision by the Engineer.

(10) Samples on which non-destructive tests have been carried out shall be collected from the place of testing after testing and delivered to the Site or other location instructed by the Engineer.

(11) Samples which have been tested may be incorporated in the permanent works provided that:

(a) The sample complies with the specified requirements,

(b) The sample is not damaged, and

(c) Such use as permitted under Clause 1.36(3).

(12) Additional samples shall be provided for testing if in the opinion of the Engineer:

(a) Material previously tested no longer complies with the specified requirements, or

(b) Material has been handled or stored in such a manner that it is no longer represented by previously tested samples.

Testing 1.40 (1) Unless otherwise stated in the Contract, insitu tests and laboratory tests shall be carried out by the Employer’s laboratories if the aforesaid tests can be undertaken by the Employer’s laboratories. Testing shall not be carried out in other laboratories unless permitted by the Engineer. If testing is permitted to be carried out by the laboratories engaged by the Contractor:

(a) Independent laboratories with no affiliation as a legal entity to the Contractor or its sub-contractors shall be used,

(b) Laboratories accredited by HOKLAS for the relevant tests shall be used, if available, in which case results shall be issued on HOKLAS endorsed test reports, and

(c) Particulars of the laboratory proposed by the Contractor, including a declaration made by the laboratory that it is not a holding company, a subsidiary company, an associated company or a related party of the Contractor or any of his sub-contractors under the Contract, and that there is no actual, potential or perceived conflict of interest arising between its personal/ financial interests and its duties in carrying out the testing, shall be submitted to the Engineer for approval.

(2) Permitted tests carried out by the Contractor shall be adequately supervised by the Engineer. The result recording of insitu tests shall be countersigned by the Engineer.

(3) The Contractor may carry out quality control tests using their own laboratories or commercial laboratories for their own purposes. However, these tests should not be taken as the compliance tests done through the Employer's laboratories.

(4) The Contractor shall be entitled to attend testing associated with the Works that is carried out in the Employer's laboratories, and to inspect relevant records.

(5) Unless otherwise stated in the Contract, equipment, apparatus and materials for insitu tests and laboratory tests carried out by the Contractor shall be provided by the Contractor. The equipment and apparatus shall be maintained by the Contractor and shall be calibrated before testing starts and at regular intervals agreed by the Engineer. Calibration requirements and source of calibration applicable to all laboratory equipment shall follow those recommended in the HOKLAS Supplementary Criteria No. 2 "All Test Categories - Equipment Calibration and Verification". The equipment, apparatus and materials for insitu tests shall be removed by the Contractor as soon as practicable after testing is complete.

(6) Workability tests of fresh concrete shall be carried out by skilled personnel of the Contractor.

Compliance of a batch

1.41 (1) Unless otherwise stated in the Contract, the results of tests on samples or specimens shall be considered as representing the whole of the batch from which the sample was taken.

(2) A batch shall be considered as complying with the specified requirements for the material if the results of specified tests for specified properties comply with the specified requirements for the properties.

(3) If additional tests are permitted and separate compliance criteria for the additional tests are not stated in the Contract, the Engineer shall determine if the batch complies with the specified requirements for the material on the basis of the results of all tests, including the additional tests, for every property.

Raw records of tests and test reports

1.42 (1) Raw records of insitu tests carried out by the Contractor (excluding the laboratories engaged by the Contractor) shall be submitted to the Engineer immediately after the tests, or at such other time stated in the Contract, with a copy of the whole set of records kept by the Contractor on the Site.

(2) For all insitu tests and laboratory tests, a test report shall be submitted to the Engineer in sealed envelope within 7 days, or such other time stated in the Contract, after completion of each test. The report shall contain the

following details:

(a) Material or part of the work tested,

(b) Location and area/extent of the batch from which the samples were taken or location and area/extent of the part of the work,

(c) Place of testing,

(d) Date and time of each test,

(e) Weather conditions in the case of insitu tests,

(f) Technical personnel supervising or carrying out the tests,

(g) Size and description of samples and specimens,

(h) Method of sampling,

(i) Properties tested,

(j) Method of testing,

(k) Readings and measurements taken during the tests,

(l) Test results, including any calculations and graphs, and

(m) Other details stated in the Contract.

(3) All test reports compiled by the laboratories (which refer to the Employer's laboratories and those engaged by the Contractor) shall be delivered directly to the Engineer in a sealed envelope without routing through the Contractor.

(4) For tests carried out through the Employer's laboratories, a copy of test reports will be given to the Contractor by the Engineer on request.

WORKMANSHIP AND TOLERANCES

Workmanship 1.43 Workmanship shall comply with best trade practice and with relevant standards.

Tolerances 1.44 (1) Tolerances stated in the Contract shall be measured perpendicular to the specified lines or planes unless otherwise stated in the Contract.

(2) If adjacent parts of the Works are subject to different dimensional tolerances then the most critical tolerance shall apply to all such works that relate to each other in respect of dimension, line and level.

SITE ESTABLISHMENT

Use of the Site 1.45 (1) The Site shall not be used by the Contractor for any purpose other than for executing the Works or carrying out other works associated with the Works and approved by the Engineer.

(2) Concrete batching and mixing plant erected on the Site shall not be used to provide concrete for work outside the Site.

(3) Bituminous materials batching and mixing plant erected on the Site shall not be used to provide bituminous materials for works outside the Site.

(4) Rock crushing plant shall not be erected on the Site unless stated in the Contract.

(5) The location and size of stockpiles of materials, including excavated material, within the Site shall be as agreed by the Engineer. Stockpiles shall be maintained in a stable condition.

(6) Entry to and exit from the Site shall be only gained at the locations stated in the Contract or agreed by the Engineer.

Occupancy and Rental of Private Land of Ecological Values

1.45A The Contractor shall not rent or occupy any private land falling within the designated areas listed below for any purposes arising out of or in connection with the Contract unless prior approval is obtained from the Engineer:

(a) Existing country parks designated under the Country Parks Ordinance (Cap 208);

(b) Areas designated as Coastal Protection Area, Site of Special Scientific Interest, Green Belt, Conservation Area and Other Specified Uses (River Park) on statutory plans (i.e. Outline Zoning Plans and Development Permission Area Plans) under the Town Planning Ordinance (Cap 131);

(c) Restricted areas under the Wild Animals Protection Ordinance (Cap 170); and

(d) Areas designated under the Marine Parks Ordinance (Cap 476).

Submission of particulars

1.46 (1) The following particulars shall be submitted to the Engineer for approval not more than 14 days of the commencement of the Works:

(a) Drawings showing the layout within the Site of the Engineer's and Contractor's accommodation, project signboards, access roads and major facilities required early in the Contract,

(b) Drawings showing the layout and the construction details of the Engineer's accommodation, and

(c) Drawings showing the details to be included on project signboards.

(2) Drawings showing the location of stores, storage areas, concrete and bituminous materials batching and mixing plants, rock crushing plants and other major facilities not required early in the Contract shall be submitted to the Engineer for approval as early as possible, but in any case not later than 28 days before such facilities are constructed on the Site.

Survey of the Site

1.47 A survey of the Site to establish the precise boundaries of the Site and the levels within the Site will be carried out by the Engineer after site clearance, and before other works start in each area to be surveyed. The Contractor shall carry out the survey jointly with the Engineer and agree the result as soon as practicable after completion of site clearance, before commencing other works in the area surveyed.

Fences and signs on the Site

1.48 (1) Hoardings, fences, gates and signs on the Site shall be maintained in a clean, presentable, stable and secure condition. Logos, pictures and text shall be legible and not visually obstructed at all times.

(2) Project signboards stated in the Contract shall be erected not more than 4 weeks, or such other period agreed by the Engineer, after the date for commencement of the Works. Other advertising signs shall not be erected on the Site unless permitted by the Engineer.

(3) The Engineer's permission shall be obtained before hoardings, fences, gates or signs are removed. Hoardings, fences, gates and signs that are to be left in position after completion of the Works shall be repaired and repainted as instructed by the Engineer.

(4) All components of site hoardings and signboards shall be metallic and not be made of timber. Bolts and nuts shall be used to join the panels of hoardings and signboards unless otherwise approved by the Engineer.

The Engineer's Site accommodation

1.49 (1) For new accommodation to be erected, preference shall be given to the used prefabricated units that are in good working and serviceable conditions. The accommodation to be provided on the Site for the Engineer shall be ready for occupation, including connection of all utilities, not more than 8 weeks after the date of approval by the Engineer of the proposed location, layout, construction details and measures against all foreseeable hazards such as flooding, landslides, lightning, etc.

(2) The accommodation shall be maintained in a clean, stable and secure condition and shall be cleaned at least daily. The services of a full-time attendant shall be provided for the Engineer.

(3) Equipment provided for the use of the Engineer or persons authorised by the Engineer shall be maintained in a clean and serviceable condition and all consumables shall be replenished when required. Equipment shall, wherever practicable, have Grade 1 Energy Efficiency Labels, or Energy Labels for equipment operated only under the "Recognition Type" labelling system, under the Hong Kong Energy Efficiency Labelling Scheme. They shall include features to facilitate the minimization of waste and consumables. Office equipment must be able to handle use of paper on both sides. Consumables shall be made from recycled material and shall be recyclable wherever practicable. Measuring and testing equipment shall be calibrated before it is used and at regular intervals agreed by the Engineer. Calibration requirements as well as source of calibration applicable to all laboratory equipment shall follow those recommended in the HOKLAS Supplementary Criteria No. 2 "All Test Categories - Equipment Calibration". Survey equipment shall be maintained by the service agent and shall be calibrated by an approved laboratory at regular intervals agreed by the Engineer. Equivalent replacements shall be provided for equipment that is out of service.

(4) Where insitu concreting works are to be carried out, steel container rooms and curing tanks shall be provided on the Site, at the discretion of the Engineer, according to the requirements stated in Appendix 1.2 and Appendix 1.3 respectively. In this connection, concreting works shall not commence until curing tanks and container rooms (or the like) are completed and

accepted by the Engineer or unless otherwise approved by the Engineer. Where directed by the Engineer, Employer's laboratories shall be given sole access and use of the steel container rooms and curing tanks together with all the equipment provided under the Contract.

(5) All contract preliminary items shall be provided to the office of the Engineer's Representative for central acceptance and distribution. The Engineer's Representative should inform the Contractor of the name of the officers responsible for accepting these items. The Contractor shall not provide the items directly to an individual member of the site supervisory staff. The Engineer's permission shall be obtained before accommodation or equipment is removed. Portable accommodation shall be moved at the times instructed by the Engineer. Accommodation or equipment which is to be left in position or become the property of the Employer after completion of the Works shall be repaired, repainted and serviced as instructed by the Engineer.

The Contractor's Site accommodation

1.50 The Contractor's offices, sheds, stores, mess rooms, latrines and other accommodation on the Site shall be maintained in a clean, stable and secure condition. Living accommodation shall not be provided on the Site unless stated in the Contract or approved by the Engineer.

Site utilities and access

1.51 (1) Temporary water, electricity, telephone, sewerage and drainage facilities shall be provided for the Engineer's accommodation and for the Contractor's use in carrying out the Works. The Contractor shall make all arrangements with and obtain the necessary approvals from the relevant authorities for the facilities.

(2) Access roads and parking areas shall be provided within the Site as required and shall be maintained in a clean, passable and stable condition with regular suppression of dust as required in Section 25.

Transport for the Engineer

1.52 (1) A new motor vehicle as transport for the Engineer will not always be required. However, where a used motor vehicle will suffice, it shall not be more than 2 years old when first brought to Site. The motor vehicle shall achieve emission standard of Euro IV (for 4 or 5 seater car) or Euro III (for others). Transport for the Engineer shall be provided from the date of commencement of the Works unless otherwise permitted or instructed by the Engineer.

(2) The transport shall be for the exclusive use of the Engineer in connection with supervision of Works and persons authorised by the Engineer and shall be available at all times during normal working hours and at other times when the Contractor is working or when instructed by the Engineer. The transport shall not be used by the Contractor or other persons who are not authorised by the Engineer. The contract transport for the Engineer should be properly painted or affixed by adhesive plastic labels with the contract number, Contractor name, Department name, Department logo, Department complaint hotline (or other suitable identifications) and the phrase "For Official Use Only" "只供公務用途" in good size letters for easy identification.

(3) The transport shall be maintained in a clean and serviceable condition and shall be serviced regularly. Fuel, oil and other consumables, taxes, licenses, insurances, toll charges and parking and mooring fees shall be provided by the Contractor. The engines of land transport shall be propelled by petrol, liquefied petroleum gas (LPG), electricity, hybrid of petrol-electricity, or any other non-fossil fuels as approved by the Engineer. Land

transport shall be covered by fully comprehensive insurance, which includes passenger liability and which allows the vehicle to be driven by any driver.

(4) A competent English-speaking driver shall be appointed and shall be available to drive transport when required by the Engineer.

(5) Marine transport shall be equipped and manned in accordance with the statutory requirements of the Marine Department and licensed under the Merchant Shipping (Launches and Ferry Vessels) Regulations Chapter 281. A qualified English-speaking coxswain shall be appointed and shall be available when the marine transport is required by the Engineer.

(6) Records of journeys shall be kept in logbooks provided by the Engineer. Records shall include details of the times and purpose of journeys with appropriate odometer readings and distances travelled. The person using the transport or authorising the journey shall sign against the logbook entries. Logbooks shall be presented for inspection when required by the Engineer and all completed logbooks shall be handed over to the Engineer.

(7) Equivalent transport shall be provided when transport is unavailable for any reason.

(8) The transport shall be provided until the end of the Maintenance Period or such earlier date instructed by the Engineer.

Clearance of the Site 1.53 Temporary Works that are not to remain on the Site after completion of the Works shall be removed on completion of the Works or at other times instructed by the Engineer. The Site shall be cleared and reinstated to the lines and levels and to the condition existing before the Works started except as otherwise stated in the Contract.

MEETINGS

Meetings 1.54 The Contractor's agent shall attend, and shall arrange for the representatives of Sub-contractors, Government departments, transport companies, utility undertakings and other Contractors to attend, meetings when required by the Engineer. The Contractor shall inform the Engineer in 48 hours (or such a shorter period as agreed by the Engineer) before conducting meetings with Government departments, transport companies, utility undertakings and/or other Contractors and shall give the Engineer an opportunity to attend such meetings.

PHOTOGRAPHS

Progress photographs and record photographs

1.55 (1) The Contractor shall take progress photographs at monthly intervals or at an interval agreed by the Engineer, to show the progress of the Works or state of materials and workmanship during the course of the Contract. Progress photographs, including aerial and underwater photographs, shall be taken from the same vantage points on various sections of the Works or at locations instructed by the Engineer. Information for each of the photographs, including the date, time, location and description of the subject recorded shall be provided by the Contractor.

(2) Record photographs shall be taken before commencement of the Works at adjoining properties or amenities and at locations instructed by the Engineer. Other record photographs shall be taken when instructed by the Engineer.

(3) General requirements of the photographs include:

(a) The photograph should include something to indicate the scale of the subject when this is not readily apparent.

(b) The photographs shall be colour digital with image resolution of minimum 10 megapixels.

(c) The digital photographs shall be in JPEG format and stored in a CD-ROM or DVD and shall be submitted to the Engineer within a time limit as agreed by the Engineer.

(d) If instructed by the Engineer, the Contractor shall submit one authenticated copy of selected photographs for record. The authenticated copy shall be a colour print of the selected photographs with the size up to A4 each as specified by the Engineer and with a minimum resolution of 300 dots per inch. The selected photographs shall be authenticated by the Contractor and the Engineer by signing and dating on the colour print.

(4) The Employer shall have the copyright of all progress and record photographs.

APPENDIX 1.1

STANDARDS

1.1.1 BRITISH STANDARDS

BS 144:1990	Wood preservation using coal tar creosotes
BS 373:1957 (1986)	Methods of testing small clear specimens of timber
BS 381C:1996	Specification for colours for identification, coding and special purposes
BS 416:1990	Discharge and ventilating pipes and fittings, sand-cast or spun in cast iron
BS 434:Part 2:2006	Bitumen road emulsions. Code of practice for the use of cationic bitumen emulsions on roads and other paved areas
BS 718:1991	Specification for density hydrometers
BS 743:1970	Specification for materials for damp-proof courses
BS 864:Part 2:1983	Specification for capillary and compression fittings for copper tubes
BS 882:1992	Specification for aggregates from natural sources for concrete
BS 903	Physical testing of rubber
- BS 903:Part A18:1973 (1985)	Determination of equilibrium water vapour absorption
BS 952	Glass for glazing
- BS 952:Part 1:1995	Classification
- BS 952:Part 2:1980	Terminology for work on glass
BS 1070:1993	Specification for black paint (tar-based)
BS 1052:1980 (1999)	Specification for mild steel wire for general engineering purposes
BS 1161:1977 (1984)	Specification for aluminium alloy sections for structural purposes
BS 1203:2001	Hot-setting phenolic and aminoplastic wood adhesives. Classification and test method
BS 1336:1971 (1988)	Specification for knotting
BS 1377 (as modified in accordance with Geospec 3, entitled "Model Specification for Soil Testing")	Methods of test for soils for civil engineering purposes
- BS 1377:Part 1:1990	General requirements and sample preparation

- BS 1377:Part 3:1990	Chemical and electrochemical tests
- BS 1377:Part 4:1990	Compaction-related tests
- BS 1377:Part 9:1990	In-situ tests
BS 1387:1985 (1990)	Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads
BS 1449:Part 1.1:1991	Steel plate, sheet and strip. Carbon and carbon-manganese plate, sheet and strip. General specification
BS 1473:1972	Specification for wrought aluminium and aluminium alloys for general engineering purposes - rivet, bolt and screw stock
BS 1494:Part 2:1967	Sundry fixings
BS 1722:Part 1:1986	Specification for chain link fences
BS 1722:Part 16: 2009	Fences. Specification for powder coatings used as a plastics finish to components and mesh
BS 1740:Part 1:1971 (1990)	Specification for wrought steel pipe fittings (screwed BS 21 R-series thread)

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BS 1924:Part 2:2018	Hydraulically bound and stabilized materials for civil engineering purposes. Sample preparation and testing of materials during and after treatment
BS 2015:1992	Glossary of paint and related terms
BS 2456:1990	Specification for floats (plastics) for float operated valves for cold water services
BS 2499	Hot-applied joint sealant systems for concrete pavements
- BS 2499:Part 1:1993	Specification for joint sealants
- BS 2499:Part 2:1992	Code of practice for the application and use of joint sealants
- BS 2499:Part 3:1993	Hot-applied joint sealant systems for concrete pavements. Methods of test
BS 2523:1966 (1983)	Specification for lead-based priming paints
BS 2633:1987	Specification for Class I arc welding of ferritic steel pipework for carrying fluids
BS 2648:1955	Performance requirements for electrically-heated laboratory drying ovens
BS 2782	Methods of testing plastics

- BS 2782:Part 3: Methods 320A to 320F:1976	Tensile strength, elongation and elastic modulus
- BS 2782:Part 3: Method 365A:1976 (1989)	Determination of softness number of flexible plastics materials
- BS 2782:Part 10:Method 1005:1977 (U.K. national version of European Standard EN 63:1977 with identical text)	Methods of testing plastics. Glass reinforced plastics. Determination of flexural properties. Three point method.
- BS 2782:Part 6:Method 630A:1994	Methods of testing plastics. Dimensional properties. Determination of thickness by mechanical scanning of flexible sheet
- BS 2782:Part 6:Method 631A:1993	Methods of testing plastics. Dimensional properties. Determination of gravimetric thickness and yield of flexible sheet
-BS 2846:Part 4:1976 (1985)	Techniques of estimation and tests relating to means and variances
BS 3262:Part 3:1989	Specification for application of material to road surfaces
BS 3416:1991 with AMD 7288	Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water
BS 3506:1969	Specification for unplasticized PVC pipe for industrial uses
BS 3692:1967	Specification for ISO metric precision hexagon bolts, screws and nuts. Metric units
BS 3698:1964 (1979)	Specification for calcium plumbate priming paints
BS 3900	Methods of test for paints
- BS 3900:Part G6:1989 (2000)	Assessment of resistance to fungal growth
BS 3921:1985	Specification for clay bricks
BS 3987:1974	Specification for anodic oxide coatings on wrought aluminium for external architectural applications
BS 3998:2010	Recommendations for tree work
BS 4019:1993	Rotary core drilling equipment
BS 4072:1987	Wood preservation by means of copper/chromium/ arsenic compositions
BS 4190:2014	Specification for ISO metric black hexagon bolts, screws and nuts
BS 4211:2005 + A1:2008	Specification for ladders for permanent access to chimneys, other high structures, silos and bins
BS 4254:1983	Specification for two-part polysulphide-based sealants

BS 4320:1968	Specification for metal washers for general engineering purposes. Metric series
BS 4346	Joints and fittings for use with unplasticized PVC pressure pipes
- BS 4346:Part 1:1969	Injection moulded unplasticized PVC fittings for solvent welding for use with pressure pipes, including potable water supply
BS 4449:2005	Steel for the reinforcement of concrete – Weldable reinforcing steel – Bar, coil and decoiled product - Specification
BS 4482:2005	Steel wire for the reinforcement of concrete products - Specification
BS 4483:2005	Steel fabric for the reinforcement of concrete - Specification
BS 4486:1980	Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete
BS 4514:2001	Specification for unplasticized PVC soil and ventilating pipes, fittings and accessories
BS 4515:1984	Specification for welding of steel pipelines on land and offshore
BS 4515-1:2009	Specification for welding of steel pipelines on land and offshore. Carbon and carbon manganese steel pipelines
BS 4622:1970 (1983)	Specification for grey iron pipes and fittings
BS 4652:1995 Incorporating Amd No. 1	Specification for metallic zinc-rich priming paint (organic media)
BS 4660:2000	Thermoplastics ancillary fittings of nominal sizes 110 and 160 for below ground gravity drainage and sewerage
BS 4756:1998	Specification for ready-mixed aluminium priming paints for woodwork
BS 4873:2016	Thermal spraying. Metallic and other inorganic coatings. Zinc, aluminium and their alloys
BS 4933:2010	Specification for ISO metric black cup and countersunk head bolts and screws with hexagon nuts
BS 5154:1991	Specification for copper alloy globe, globe stop and check, check and gate valves
BS 5163:1986	Specification for predominantly key-operated cast iron gate valves for waterworks purposes
BS 5163-1:2004	Valves for waterworks purposes. Predominantly key-operated cast iron gate valves. Code of Practice
BS 5163-2:2004	Valves for waterworks purposes. Stem caps for use on isolating valves and associated water control apparatus. Specification

BS 5252F:1976 (2004)	Framework for colour co-ordination for building purpose: colour matching fan
BS 5255:1989	Specification for thermoplastics waste pipe and fittings
BS 5262:1991	Code of practice for external renderings
BS 5270-1:1989	Bonding agents for use with gypsum plasters and cement. Specification for polyvinyl acetate (PVAC) emulsion bonding agents for indoor use with gypsum building plasters
BS 5284:1993	Methods of sampling and testing mastic asphalt used in building and civil engineering
BS 5385-1:2009	Wall and floor tiling. Design and installation of ceramic, natural stone and mosaic wall tiling in normal internal conditions. Code of practice
BS 5385-2:2015	Wall and floor tiling. Design and installation of external ceramic, natural stone and mosaic wall tiling in normal conditions. Code of practice
BS 5395:Part 1:2010	Code of practice for the design of straight stairs
BS 5493:1977	Code of practice for protective coating of iron and steel structures against corrosion
BS 5572:1994	Code of practice for sanitary pipework
BS 5589:1989	Code of practice for preservation of timber
BS 5606:1990	Guide to accuracy in building
BS 5756: 2007+A2:2017	Visual strength grading of temperature hardwood. Specification
BS 5835:Part 1:1980	Compactability test for graded aggregates.
BS 5896:2012	Specification for high tensile steel wire and strand for the prestressing of concrete
BS 5911:Part 1:2002+A2:2010	Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete pipes (including jacking pipes) and fittings with flexible joints
BS 5911:Part 3:2002 + A1:2014	Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete manholes and soakaways
BS 5911:Part 4:2002 + A2:2010	Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete inspection chambers
BS 5911:Part 6:2004+ A1:2010	Specification for road gullies and gully cover slabs
BS 5930:1981	Code of practice for site investigations
BS 5931:1980	Code of practice for machine laid in situ edge details for paved areas

BS 5980:1980	Specification for adhesive for use with ceramic tiles and mosaics
BS 61502006+A1:2014	Painting of buildings. Code of practice
BS 6349-1-4:2013	Maritime works. General. Code of practice for materials
BS 6362:1990	Specification for stainless steel tubes suitable for screwing in accordance with BS 21 `Pipe threads for tubes and fittings where pressure-tight joints are made on the threads'
BS 6398:1983	Specification for bitumen damp-proof courses for masonry
BS 6405:1984	Specification for non-calibrated short link steel chain (Grade 30) for general engineering purposes: class 1 and 2
BS 6510:2010	Steel-frame windows and glazed doors. Specification
BS 6515:1984	Specification for polyethylene damp-proof courses for masonry
BS 6699:1992	Specification for ground granulated blastfurnace slag for use with Portland cement
BS 6700:1987	Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their cartilages
BS 6744:2001+A2:2009	Stainless steel bars for the reinforcement of and use in concrete. Requirements and test methods
BS 6779:Part 1:1998	Highway parapets for bridges and other structures. Specification for vehicle containment parapets of metal construction
BS 6920	Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water
- BS 6920:Part 1:2014	Specification
- BS 6920:Part 2	Methods of test
- BS 6920-2.1:2014	Samples for testing
- BS 6920:Section 2.2	Odour and flavour of water
- BS 6920:Subsection 2.2.1:2000+A3:2014	General method of test
- BS 6920:Subsection 2.2.2:2000+A1:2014	Method of testing odours and flavours imparted to water by multi-layered hoses and pipes
- BS 6920:Subsection 2.2.3:2000+A2:2014	Method of testing tastes imparted to water by hoses for conveying water for food and drink preparation
- BS 6920:Section 2.3:2000+A1:2014	Appearance of water
- BS 6920:Section 2.4:2000+A1:2014	Growth of aquatic micro-organisms test

- BS 6920:Section 2.5:2000+A2:2014	The extraction of substances that may be of concern to public health
- BS 6920:Section 2.6:2000+A2:2014	The extraction of metals
- BS 6920:Part 3:2000	High temperature tests
BS 6925:1988	Specification for mastic asphalt for building and civil engineering (limestone aggregate)
BS 6949:1991	Specification for bitumen-based coatings for cold application, excluding use in contact with potable water
BS 7671:2018+A1:2020	Requirements for Electrical Installations. IET Wiring Regulations
BS 8000:1989	Workmanship on Building Sites
BS 8000-0:2014	Workmanship on construction sites. Introduction and general principles
BS 8000-7:1990	Workmanship on building sites. Code of practice for glazing
BS 8000-12:1989	Workmanship on building sites. Code of practice for decorative walkcoverings and painting
BS 8215:1991	Code of practice for design and installation of damp-proof courses in masonry construction
BS 8217:2005	Reinforced bitumen membranes for roofing. Code of practice
BS 8442:2015	Miscellaneous road traffic signs and devices. Requirements and test methods
BS 8481:2006	Design, preparation and application of internal gypsum, cement and lime plastering systems. Specification
BS 8666:2005	Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete – Specification
BS 594987:2015 + A1:2017	Asphalt for roads and other paved areas. Specification for transport, laying, compaction and product type testing protocols
PD CLC/TR 50426:2004	Assessment of inadvertent initiation of bridge wire electro-explosive devices by radio-frequency radiation. Guide

1.1.2 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS

ASTM C939 / C939M-16a	Standard Test Method of Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)

ASTM C 940-98a	Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C979 / C979M	Standard Specification for Pigments for Integrally Colored Concrete
ASTM C1028-89	Standard test method for determining the static coefficient of friction of ceramic tile and other like surfaces by the horizontal dynamometer pull-meter method
ASTM C1036-16	Standard Specification for Flat Glass
ASTM D5-13	Standard Test Method for Penetration of Bituminous Materials
ASTM D562-10	Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer
ASTM D113-07	Standard Test Method for Ductility of Bituminous Materials
ASTM D140-16	Standard Practice for Sampling Asphalt Materials
ASTM D242-14	Specification for mineral filler for bituminous paving mixtures
ASTM D546-17	Standard test method for sieve analysis of mineral filler for bituminous paving mixtures
ASTM D790-15e2	Measurement/Properties of internal lining for repair of pipelines and culverts: Flexural properties
ASTM D946-15	Specification for penetration-graded asphalt cement for use in pavement construction
ASTM D979-15	Methods for sampling bituminous paving mixtures
ASTM D562-10	Standard test method for consistency of paints measuring krebs unit (KU) viscosity using a stormer-type viscometer
ASTM D1754-14	Test method for effect of heat and air on asphaltic materials (thin-film over test)
ASTM D2000-12	Classification system for rubber products in automobile applications
ASTM D2027-13	Specification for cutback asphalt (medium-curing type)
ASTM D2041-11	Test method for theoretical maximum specific gravity and density of bituminous paving mixtures
ASTM D2042-15	Test method for solubility of asphalt materials in trichloroethylene
ASTM D2171-10	Test method for viscosity of asphalts by vacuum capillary viscometer

ASTM D2172-17	Test method for quantitative extraction of asphalt binderfrom asphalt mixtures
ASTM D2240	Standard test method for rubber property - durometer hardness
ASTM D2486-17	Standard test method for scrub resistance of wall paints
ASTM D2671-13	Standard Test Methods for Heat-Shrinkable Tubing for Electrical Use
ASTM D2726-14	Test method for bulk specific gravity and density of non-absorptive compacted bituminous mixtures using saturated surface-dry specimens
ASTM D3203-17	Test method for percent air voids in compacted asphalt mixtures
ASTM D3289-17	Test method for density of semi-solid and solid bituminous materials by nickel crucible
ASTM D3359	Standard test methods for measuring adhesion by tape test
ASTM D4329	Standard practice for fluorescent UV exposure of plastics
ASTM D6307-16	Standard test method for asphalt content of asphalt mixture by ignition method
ASTM D4956-16b	Standard Specification for Retroreflective Sheeting for Traffic Control
ASTM D5444-15	Standard Test Method for Mechanical Size Analysis of Extracted Aggregate Amd 2/2022
ASTM G53-88	Practice for operating light and water-exposure apparatus (fluorescent UV-condensation type) for exposure of non-metallic materials
ASTM G154-06	Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

1.1.3 AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) STANDARD

AASHTO Designation M252-18	Standard Specification for Corrugated Polyethylene Drainage Tubing
AASHTO Designation M320-16	Standard Specification for Performance-Graded Asphalt Binder
AASHTO Designation T48-06 (2015)	Standard Method of Test for Flash and Fire Points by Cleveland Open Cup
AASHTO Designation T240-13	Standard Method of Test for Effect of Heat and Air on a Moving Film of Asphalt Binder (Rolling Thin-Film Oven Test)

AASHTO Designation T315-12 (2016)	Standard Method of Test for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
AASHTO Designation T316-13	Standard Method of Test for Viscosity Determination of Asphalt Binder Using Rotational Viscometer

1.1.4 AMERICAN WATER WORKS ASSOCIATION (AWWA) STANDARDS/ AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

AWWA C 203-15	Coal-Tar Protective Coatings and Linings for Steel Water Pipes
ANSI/AWWA C210-15	Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings
ANSI/AWWA C213-15	Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipelines
ANSI A108-A118-A136.1:2019	American National Specifications for the Installation of Ceramic Tile
ANSI A118.6:1992	Ceramic tile grouts

1.1.5 CONSTRUCTION STANDARDS OF THE GOVERNMENT OF THE HKSAR

CS1:2010	Testing Concrete
CS2:2012	Steel Reinforcing Bars for the Reinforcement of Concrete
CS3:2013	Aggregates for Concrete

1.1.6 AMERICAN PUBLIC HEALTH ASSOCIATION (APHA) STANDARDS

APHA 4500-Cl-B, 21st Edition (2005)	Chloride, Argentometric method
APHA 4500-SO42-C, 21st Edition (2005)	Sulphate, gravimetric method with ignition of residue

1.1.7 EUROPEAN STANDARDS ADOPTED AS BRITISH STANDARDS (BS EN)

BS EN 196-1:2005	Method of testing of Cement – Part 1: Determination of strength
BS EN 196-2:2005	Method of testing of Cement – Part 2: Chemical analysis of cement
BS EN 196-3:2005+A1:2008	Method of testing of Cement – Part 3: Determination of setting times and soundness

BS EN 196-6:2010	Method of testing of Cement – Part 6: Determination of fineness
BS EN 196-7:2007	Method of testing of Cement – Part 7: Methods of taking and preparing samples of cement
BS EN 197-1:2011	Cement – Part 1: Composition, specifications and conformity criteria for common cements
BS EN 200:2008	Sanitary tapware. Single taps and combination taps for water supply systems of type 1 and type 2. General technical specification
BS EN 295-1:2013	Vitrified clay pipe systems for drains and sewers. Requirements for pipes, fittings and joints
BS EN 295-2:2013	Vitrified clay pipe systems for drains and sewers. Evaluation of conformity and sampling
BS EN 295-3:2012	Vitrified clay pipe systems for drains and sewers. Test methods
BS EN 301:2017	Adhesives, phenolic and aminoplastic, for load-bearing timber structures. Classification and performance requirements
BS EN 302:2017	Adhesives for load-bearing timber structures
BS EN 338-2016	Structural Timber – Strength Classes
BS EN 445:2007	Grout for prestressing tendons. Test methods
BS EN 450:Part 1:2012	Fly ash for concrete. Definition, specifications and conformity criteria
BS EN 459-1:2015	Building lime. Definitions, specifications and conformity criteria
BS EN 480-12:2005	Admixtures for Concrete, Mortar and Grout – Test Methods Part 12: Determination of the Alkali Content of Admixtures Amd 1/2023
BS EN 485	Aluminium and aluminium alloys. Sheet, strip and plate
BS EN 485:Part 1:2016	Aluminium and aluminium alloys. Sheet, strip and plate. Technical conditions for inspection and delivery
BS EN 485:Part 2:2016+A1:2018	Aluminium and aluminium alloys. Sheet, strip and plate. Mechanical properties
BS EN 485:Part 3:2003	Aluminium and aluminium alloys. Sheet, strip and plate. Tolerances on dimensions and form for hot-rolled products
BS EN 485:Part 4:1994	Aluminium and aluminium alloys. Sheet, strip and plate. Tolerances on shape and dimensions for cold-rolled products
BS EN 515:2017	Aluminium and aluminium alloys. Wrought products. Temper designations

BS EN 545:2006	Ductile iron pipes, fittings, accessories and their joints for water pipelines. Requirements and test methods
BS EN 573-1:2004	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Numerical designation system
BS EN 573-2:1995	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Chemical symbol based designation system
BS EN 573-3:2019	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Chemical composition and form of products
BS EN 573-5:2007	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Codification of standardized wrought products
BS EN 598:2007+A1:2009	Ductile iron pipes, fittings, accessories and their joints for sewerage applications – Requirements and test methods
BS EN 607:2004	Eaves gutters and fittings made of PVC-U. Definitions, requirements and testing
BS EN 681-1:1996	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Vulcanized rubber
BS EN 754	Aluminium and aluminium alloys. Cold drawn rod/bar and tube
BS EN 754:Part 1:2016	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Technical conditions for inspection and delivery
BS EN 754:Part 2:2016	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Mechanical properties
BS EN 754:Part 3:2008	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Round bars, tolerances on dimensions and form
BS EN 754:Part 4:2008	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Square bars, tolerances on dimensions and form
BS EN 754:Part 5:2008	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Rectangular bars, tolerances on dimensions and form
BS EN 754:Part 6:2008	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Hexagonal bars, tolerances on dimensions and form
BS EN 754:Part 7:2016	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Seamless tubes, tolerances on dimensions and form
BS EN 754:Part 8:2016	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Porthole tubes, tolerances on dimensions and form
BS EN 755	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles

BS EN 755:Part 1:2016	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Technical conditions for inspection and delivery
BS EN 755:Part 2:2016	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Mechanical properties
BS EN 755:Part 3:2008	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Round bars, tolerances on dimensions and form
BS EN 755:Part 4:2008	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Square bars, tolerances on dimensions and form
BS EN 755:Part 5:2008	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Rectangular bars, tolerances on dimensions and form
BS EN 755:Part 6:2008	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Hexagonal bars, tolerances on dimensions and form
BS EN 755:Part 7:2016	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Seamless tubes, tolerances on dimensions and form
BS EN 755:Part 8:2016	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Porthole tubes, tolerances on dimensions and form
BS EN 755:Part 9:2016	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Profiles, tolerances on dimensions and form
BS EN 816:2017	Sanitary tapware. Automatic shut-off valves PN 10
BS EN 818:Part 1:1996 + A1:2008	Short link chain for lifting purposes. Safety. General conditions of acceptance
BS EN 932-1:1997	Tests for general properites of aggregates. Methods for sampling
BS EN 932-6:1999	Tests for general properties of aggregates. Definitions of repeatability and reproducibility
BS EN 933-7:1998	Tests for geometrical properties of aggregates. Determination of shell content. Percentage of shells in coarse aggregates
BS EN 934:Part 2:2009+A1:2012	Admixtures for concrete, mortar and grout. Concrete admixtures. Definitions, requirements, conformity, marking and labeling
BS EN 934:Part 4:2009	Admixtures for concrete, mortar and grout. Admixtures for grout for prestressing tendons. Definitions, requirements, conformity, marking and labeling
BS EN 1008:2002	Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete
BS EN 1011-2:2001	Welding. Recommendations for welding of metallic materials. Arc welding of ferritic steels Amd 3/2022

BS EN 1011:Part 4:2000	Welding. Recommendations for welding of metallic materials. Arc welding of aluminium and aluminium alloys
BS EN 1015-2:1999	Methods of test for mortar for masonry. Bulk sampling of mortars and preparation of test mortars
BS EN 1074-1:2000	Valves for water supply. Fitness for purpose requirements and appropriate verification tests. General requirements
BS EN 1074-2:2000	Valves for water supply. Fitness for purpose requirements and appropriate verification tests. Isolating valves
BS EN 1090:Part 2:2018	Execution of steel structures and aluminium structures. Technical requirements for steel structures
BS EN 1090:Part 3:2019	Execution of steel structures and aluminium structures. Technical requirements for aluminium structures
BS EN 1092-1:2018	Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated Part 1: Steel flanges
BS EN 1092-2:1997	Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated Part 2. Cast iron flanges
BS EN 1097-8: 2020	Tests for mechanical and physical properties of aggregates. Determination of the polished stone value
BS EN 1171:2015	Industrial valves — Cast iron gate valves
BS EN 1286:1999	Sanitary tapware. Low pressure mechanical mixing valves. General technical specification
BS EN 1287:2017	Sanitary tapware. Low pressure thermostatic mixing valves. General technical specification
BS EN 1329-1:2014	Plastics piping systems for soil and waste discharge (low and high temperature) within the building structure. Unplasticized poly(vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system
BS EN 1337	Structural bearings
BS EN 1337:Part 1:2000	Structural bearings. General design rules
BS EN 1337:Part 2:2004	Structural bearings. Sliding elements
BS EN 1337:Part 3:2005	Structural bearings. Elastomeric bearings
BS EN 1337:Part 4:2004	Structural bearings. Rollar bearings
BS EN 1337:Part 5:2005	Structural bearings. Pot bearings
BS EN 1337:Part 6:2004	Structural bearings. Rocker bearings

BS EN 1337:Part 7:2004	Structural bearings. Spherical and cylindrical PTFE bearings
BS EN 1337:Part 8:2007	Structural bearings. Guide bearings and restraint bearings
BS EN 1337:Part 9:1998	Structural bearings. Protection
BS EN 1337:Part 10:2003	Structural bearings. Inspection and maintenance
BS EN 1337:Part 11:1998	Structural bearings. Transport, storage and installation
BS EN 1338:2003	Concrete paving blocks. Requirements and test methods
BS EN 1339:2003	Concrete paving flags. Requirements and test methods
BS EN 1342:2012	Setts of natural stone for external paving. Requirements and test methods
BS EN 1344:2013	Clay pavers. Requirements and test methods
BS EN 1346:2007	Adhesives for tiles. Determination of open time
BS EN 1348:2007	Adhesives for tiles. Determination of tensile adhesion strength for cementitious adhesives
BS EN 1367-2:2009	Tests for thermal and weathering properties of aggregates. Magnesium sulfate test
BS EN 1401-1:2009	Plastic piping systems for non-pressure underground drainage and sewerage. Unplasticized poly(vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system
BS EN 1423:2012	Road marking materials. Drop on materials. Glass beads, antiskid aggregates and mixtures of the two
BS EN 1424:1998	Road marking materials. Premix glass beads
BS EN 1427:2015	Bitumen and bituminous binders. Determination of the softening point. Ring and Ball method
BS EN 1436:2018	Road marking materials. Road marking performance for road users
BS EN 1462:2004	Brackets for eaves gutters. Requirements and testing
BS EN 1463:Part 1:2009	Road marking materials. Retroreflecting road studs. Initial performance requirements
BS EN 1463:Part 2:2000	Road marking materials. Retroreflecting road studs. Road test performance specifications
BS EN 1514-1:1997	Flanges and their joints. Dimensions of gaskets for PN-designated flanges. Non-metallic flat gaskets with or without inserts
BS EN 1561:2011	Founding. Grey cast irons

BS EN 1562:2012	Founding – Malleable cast irons
BS EN 1563:2011	Founding – Spheroidal graphite cast irons
BS EN 1774:1997	Zinc and zinc alloys. Alloys for foundry purposes. Ingot and liquid
BS EN 1871:2000	Road marking materials. Physical properties
BS EN 1916:2002	Concrete pipes and fittings, unreinforced, steel fibre and reinforced
BS EN 1917:2002	Concrete manholes and inspection chambers, unreinforced, steel fibre and reinforced
BS EN 1982:2008	Specification for Copper and copper alloys — Ingots and castings
BS EN 1992	Eurocode 2: Design of concrete structures
- BS EN 1992:Part 1-1:2004 + A1:2014	Eurocode 2: Design of concrete structures. General rules and rules for rules for buildings
- BS EN 1992: Part 2:2005	Eurocode 2: Design of concrete structures. Concrete bridges. Design and detailing rules
BS EN 1993-1-1:2005	Design of Steel Structures : General rules and rules for buildings
BS EN 1993-1-5:2006	Design of Steel Structures : Plated structural elements
BS EN 1993-1-6:2007	Design of Steel Structures : Strength and stability of shell structures
BS EN 1993-1-7:2007	Design of Steel Structures : Plate structure subject to out of plane loading
BS EN 1993-1-8:2005	Design of Steel Structures : Design of joints
BS EN 1993-1-9:2005	Design of Steel Structures : Fatigue
BS EN 1993-1-10:2005	Design of Steel Structures : Material toughness and through-thickness properties
BS EN 1993-1-11:2006	Design of Steel Structures : Design of structures with tension components
BS EN 10025	Hot rolled products of structural steels
- BS EN 10025:Part 1:2004	Hot rolled products of structural steels. General technical delivery conditions
- BS EN 10025:Part 2:2019	Hot rolled products of structural steels. Technical delivery conditions for non-alloy structural steels
- BS EN 10025:Part 3:2004	Hot rolled products of structural steels. Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels

- BS EN 10025:Part 4:2004	Hot rolled products of structural steels. Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels
- BS EN 10025:Part 5:2004	Hot rolled products of structural steels. Technical delivery conditions for structural steels with improved atmospheric corrosion resistance
- BS EN 10025:Part 6: 2004 + A1:2009	Hot rolled products of structural steels. Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition
BS EN 10029:2010	Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3 mm thick or above
BS EN 10051:2010	Continuously hot-rolled strip andplate/sheet cut from wide strip of non-alloy and alloy steels. Tolerances on dimensions and shape
BS EN 10056	Structural steel equal and unequal leg angles
- BS EN 10056:Part 1:2017	Structural steel equal and unequal leg angles. Dimensions
- BS EN 10056:Part 2:1993	Specification for structural steel equal and unequal angles. Tolerances on shape and dimensions
BS EN 10084:2008	Case hardening steels. Technical delivery conditions
BS EN 10085:2001	Nitriding steel. Technical delivery conditions
BS EN 10087:1999	Free cutting steels. Technical delivery conditions for semi-finished products, hot rolled bars and rods
BS EN 10088-1:2005	Stainless steels. List of stainless steels
BS EN 10088:Part 2:2014	Stainless steels. Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes
BS EN 10088:Part 4:2009	Stainless steels. Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes
BS EN 10095:1999	Heat resisting steels and nickel alloys
BS EN 10143:2006	Continuously hot-dip coated steel sheet and strip. Tolerances on dimensions and shape
BS EN 10149:Part 3:2013	Specification for hot-rolled flat products made of high yield strength steels for cold forming. Delivery conditions for normalized or normalized rolled steels
BS EN 10160:1999	Ultrasonic testing of steel flat products made of high yield strength steels for cold forming. Delivery conditions for normalized or normalized rolled steels

BS EN 10164:2018	Steel products with improved deformation properties perpendicular to the surface of the product. Technical delivery conditions Amd 3/2022
BS EN 10210	Hot finished structural hollow sections of non-alloy and fine grain steels
- BS EN 10210:Part 1:2006	Hot finished structural hollow sections of non-alloy and fine grain steels. Technical delivery requirements
- BS EN 10210:Part 2:2006	Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties
BS EN 10214:2000	Steel threaded pipe fittings
BS EN 10220:2002	Seamless and welded steel tubes. Dimensions and masses per unit length
BS EN 10223:Part 2:2012	Steel wire and wire products for fencing and netting. Hexagonal steel wire netting for agricultural, insulation and fencing purposes
BS EN 10224:2002	Non-alloy steel tubes and fittings for the conveyance of water and other aqueous liquids. Technical delivery conditions
BS EN 10226	Pipe threads where pressure tight joints are made on the threads
- BS EN 10226:Part 1:2004	Pipe threads where pressure tight joints are made on the threads. Taper external threads and parallel internal threads. Dimensions, tolerances and designation
- BS EN 10226:Part 2:2005	Pipe threads where pressure tight joints are made on the threads. Taper external threads and taper internal threads. Dimensions, tolerances and designation
- BS EN 10226:Part 3:2005	Pipes threads where pressure-tight joints are made on the threads. Verification by means of limit gauges
BS EN 10244-2:2009	Steel wire and wire products. Non-ferrous metallic coatings on steel wire. Zinc or zinc alloy coatings
BS EN 10250-4:2000	Open steel die forgings for general engineering purposes. Stainless steels
BS EN 10255:2004	Non-alloy steel tubes suitable for welding and threading. Technical delivery conditions
BS EN 10293:2015	Steel castings for general engineering uses
BS EN 10296-2:2005	Welded circular steel tubes for mechanical and general engineering purposes. Technical delivery conditions. Stainless steel
BS EN 10297:Part 1:2003	Seamless circular steel tubes for mechanical and general engineering purposes. Technical delivery conditions. Non-alloy and alloy steel tubes

BS EN 10298:2005	Steel tubes and fittings for onshore and offshore pipelines. Internal lining with cement mortar
BS EN 10300:2005	Steel tubes and fittings for onshore and offshore pipelines – bituminous hot applied materials for external coating
BS EN 10312:2002	Welded stainless steel tubes for the conveyance of aqueous liquids including water for human consumption. Technical delivery conditions
BS EN 10365:2017	Hot rolled steel channels, I and H sections. Dimensions and masses
BS EN 12004:2001	Adhesives for tiles. Definitions and specifications
BS EN 12004-1:2017	Adhesives for ceramic tiles. Requirements, assessment and verification of constancy of performance, classification and marking
BS EN 12004-2:2017	Adhesives for ceramic tiles. Test methods
BS EN 12020	Aluminium and aluminium alloys. Extruded precision profiles in alloys EN AW-6060 and EN AW-6063
BS EN 12020-1:2008	Aluminium and aluminium alloys. Extruded precision profiles in alloys EN AW-6060 and EN AW-6063. Technical conditions for inspection and delivery
BS EN 12020-2:2016	Aluminium and aluminium alloys. Extruded precision profiles in alloys EN AW-6060 and EN AW-6063. Tolerances on dimensions and form
BS EN 12163:2011	Copper and copper alloys — Rod for general purposes
BS EN 12167:2011	Copper and copper alloys — Profiles and bars for general purposes
BS EN 12200-1:2000	Plastics rainwater piping systems for above ground external use. Unplasticized poly (vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system
BS EN 12201-1:2011	Plastics piping systems for water supply, and for drainage and sewerage under pressure – Polyethylene (PE) – Part 1: General
BS EN 12201-2:2011+A1:2013	Plastics piping systems for water supply, and for drainage and sewerage under pressure – Polyethylene (PE) – Part 2 : Pipes
BS EN 12201-3:2011+A1:2012	Plastic piping systems for water supply, and for drainage and sewerage under pressure – Polyethylene (PE) – Part 3 : Fittings
BS EN 12288:2010	Industrial valves. Copper alloy gate valves
BS EN 12591:2009	Bitumen and bituminous binders. Specifications for paving grade bitumens
BS EN 12620:2002+A1:2008	Aggregates for concrete

BS EN 12878:2014	Pigments for the colouring of building materials based on cement and/or lime. Specifications and methods of test
BS EN 12899:Part 1:2007	Fixed, vertical road traffic signs - Part: 1 Fixed Signs
BS EN 13055-1:2002	Lightweight aggregates. Lightweight aggregates for concrete, mortar and grout
BS EN 13101:2002	Steps for underground man entry chambers. Requirements, marking, testing and evaluation of conformity
BS EN 13139:2013	Aggregates for mortar
BS EN 13263:2017	Thermoplastics piping systems for non-pressure underground drainage and sewerage. Thermoplastics fittings. Test method for impact strength
BS EN 13279-1:2008	Gypsum binders and gypsum plasters. Definitions and requirements
BS EN 13279-2:2014	Gypsum binders and gypsum plasters. Test methods
BS EN 13303:2009	Bitumen and bituminous binders. Determination of the loss in mass after heating of industrial bitumen
BS EN 13391:2004	Mechanical tests for post-tensioning systems
BS EN 13598-1:2010	Plastics piping systems for non-pressure underground drainage and sewerage – unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) Part 1: Specifications for ancillary fittings including shallow inspection chambers
BS EN 13658-1:2005	Metal lath and beads. Definitions, requirements and test methods. Internal plastering
BS EN 13658-2:2005	Metal lath and beads. Definitions, requirements and test methods. External rendering
BS EN 13707:2013	Flexible sheets for waterproofing. Reinforced bitumen sheets for roof waterproofing. Definitions and characteristics
BS EN 13808:2013	Bitumen and bituminous binders. Framework for specifying cationic bituminous emulsions
BS EN 13835:2012	Founding. Austenitic cast irons
BS EN 13914-1:2016	Design, preparation and application of external rendering and internal plastering. External rendering
BS EN 13914-2:2016	Design, preparation and application of external rendering and internal plastering. Internal plastering
BS EN 13924-1:2015	Bitumen and bituminous binders. Specification framework for special paving grade bitumen. Hard paving grade bitumens

BS EN 13986:2004+A1:2005	Wood-based panels for use in construction – Characteristics, evaluation of conformity and marking
BS EN 14188:Part 2:2004	Joint fillers and sealants. Specifications for cold applied sealants
BS EN 14399:Part 3:2015	High-strength structural bolting assemblies for preloading. System HR. Hexagon bolt and nut assemblies
BS EN 14411:2016	Ceramic tiles. Definition, classification, characteristics, assessment and verification of constancy of performance and marking
BS EN 14814:2016	Adhesives for thermoplastic piping systems for fluids under pressure – Specifications
BS EN 14901-1:2014+A1:2019	Ductile iron pipes, fittings and accessories. Requirements and test methods for organic coatings of ductile iron fittings and accessories. Epoxy coating (heavy duty)
BS EN 14901-2:2019	Ductile iron pipes, fittings and accessories. Requirements and test methods for organic coatings of ductile iron fittings and accessories. Thermoplastic acid modified polyolefin coating (TMPO)
BS EN 15091:2013	Sanitary tapware. Electronic opening and closing sanitary tapware
BS EN 15167-1:2006	Ground granulated blast furnace slag for use in concrete, mortar and grout. Definitions, specifications and conformity criteria
BS EN 15167-2:2006	Ground granulated blast furnace slag for use in concrete, mortar and grout. Conformity evaluation
BS EN 15322:2013	Bitumen and bituminous binders. Framework for specifying cut-back and fluxed bituminous binders
BS EN 16228	Drilling and foundation equipment. Safety
BS EN 16228:Part 1:2014	Drilling and foundation equipment. Safety. Common requirements
BS EN 16228:Part 2:2014	Drilling and foundation equipment. Safety. Mobile drill rigs for civil and geotechnical engineering, quarrying and mining
BS EN 16228:Part 4:2014	Drilling and foundation equipment. Safety. Foundation equipment
BS EN 16228:Part 5:2014	Drilling and foundation equipment. Safety. Diaphragm walling equipment
BS EN 16228:Part 7:2014	Drilling and foundation equipment. Safety. Interchangeable auxiliary equipment
BS EN 16737:2016	Structural timber: Visual strength grading of tropical hardwood
EN 63:1977 (same as BS 2782:Part 10:Method 1005:1977)	Glass reinforced plastics. Determination of flexural properties. Three point method.

PD 970:2005	Wrought steels for mechanical and allied engineering purposes. Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels
PD 6695-1-10	Recommendations for the design of structures to BS EN 1993-1-10 Amd 3/2022
PD/CEN/TR 15123:2005	Design, preparation and application of internal polymer plastering systems

1.1.8 EUROPEAN STANDARDS (EN) and/or INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO) STANDARDS ADOPTED AS BRITISH STANDARDS (BS EN ISO)

BS EN ISO 62:2008	Plastics - Determination of water absorption
BS EN ISO 148:Part 1:2016	Metallic materials. Charpy pendulum impact test. Test method
BS EN ISO 178:2010+A1:2013	Plastics – Determination of flexural properties
BS EN ISO 527-1:2019	Plastics. Determination of tensile properties. General principles
BS EN ISO 1183-1:2012	Plastics - Methods for determining the density of non-cellular plastics, Part 1: Immersion method, liquid pyknometer
BS EN ISO 1452 – 1:2009	Plastics piping systems for water supply and for buried and above–ground drainage and sewerage under pressure. Unplasticized poly (vinyl chloride) (PVC U). General
BS EN ISO 1452 – 2:2009	Plastics piping systems for water supply and for buried and above–ground drainage and sewerage under pressure. Unplasticized poly (vinyl chloride) (PVC U). Pipes
BS EN ISO 1452 – 3: 2010	Plastics piping systems for water supply and for buried and above–ground drainage and sewerage under pressure – Unplasticized poly (vinyl chloride) (PVC-U) Part 3: Fittings
BS EN ISO 1452 – 5:2009	Plastics piping systems for water supply and for buried and above–ground drainage and sewerage under pressure. Unplasticized poly (vinyl chloride) (PVC U). Fitness for purpose of the system

BS EN ISO 1461:2009	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
BS EN ISO 1513:2010	Paint and varnishes. Examination and preparation of test samples
BS EN ISO 1518-1:2011	Paints and varnishes. Determination of scratch resistance. Constant-loading method
BS EN ISO 1519:2011	Paints and varnishes. Bend test (cylindrical mandrel)
BS EN ISO 1524:2013	Paints, varnishes and printing inks. Determination of fineness of grind
BS EN ISO 2063:2005	Thermal spraying – Metallic and other inorganic coatings. Zinc, aluminium and their alloys
BS EN ISO 2431: 2011	Paints and varnishes. Determination of flow time by use of flow cups
BS EN ISO 2808:2007	Paints and varnishes. Determination of film thickness
BS EN ISO 2813:2014	Paints and varnishes. Determination of gloss value at 20 degrees, 60 degrees and 85 degrees
BS EN ISO 2814:2006, BS 3900-D4:2006	Paints and varnishes. Comparison of contrast ratio (hiding power) of paints of the same type and colour
BS EN ISO 3231:1998, BS 3900-F8:1993	Paints and varnishes. Determination of resistance to humid atmospheres containing sulfur dioxide
BS EN ISO 3269:2019	Fasteners. Acceptance inspection
BS EN ISO 3452:Part 1:2013	Non-destructive testing. Penetrant testing. General principles
BS EN ISO 3506-1:2020	Mechanical properties of corrosion-resistant stainless-steel fasteners. Bolts, screw and studs
BS EN ISO 3506-2:2009	Mechanical properties of corrosion-resistant stainless-steel fasteners. Nuts
BS EN ISO 4016:2011	Hexagon head bolts. Product grade C.
BS EN ISO 4034:2012	Hexagon regular nuts (stle 1). Product grade C.
BS EN ISO 4042:2018	Fasteners. Electroplated coatings
BS EN ISO 4618:2014	Paints and varnishes. Terms and definitions
BS EN ISO 4624:2016	Paints and varnishes. Pull-off test for adhesion
BS EN ISO 6892:Part 1:2019	Metallic materials. Tensile testing. Method of test at room temperature
BS EN ISO 7089:2000	Plain washers. Normal series. Product grade A
BS EN ISO 7090:2000	Plain washers, chamfered. Normal series. Product grade A

BS EN ISO 7092:2000	Plain washers. Small series. Product grade A
BS EN ISO 7093:Part 1:2000	Plain washers. Large series. Product grade A
BS EN ISO 7500-1:2018	Metallic materials. Calibration and verification of static uniaxial testing machines. Tension/compression testing machines. Calibration and verification of the force-measuring system
BS EN ISO 7599:2018	Anodizing of aluminium and its alloys. General specifications for anodic oxidation coatings on aluminium
BS EN ISO 8501	Preparation of steel substrates before application of paints and related products
- BS EN ISO 8501-1:Part 1: 2007	Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness. Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings
- BS EN ISO 8501:Part 3:2007	Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness. Preparation grades of welds, edges and other areas with surface imperfections
BS EN ISO 8502:Part 3:2017	Preparation of steel substrates before application of paints and related products -- Tests for the assessment of surface cleanliness. Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)
BS EN ISO 8502:Part 6:2006	Preparation of steel substrates before application of paints and related products -- Tests for the assessment of surface cleanliness. Extraction of soluble contaminants for analysis -- The Bresle method
BS EN ISO 8503:Part 1:2012	Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces
BS EN ISO 8503-2:1995	Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Method for the grading of surface profile of abrasive blast-cleaned steel. Comparator procedure
BS EN ISO 8503-3:1995	Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Method for the calibration of ISO surface profile comparators and for the determination of surface profile. Focusing microscope procedure
BS EN ISO 8503-4:1995	Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Method for the calibration of ISO surface profile comparators and for the determination of surface profile. Stylus instrument procedure

BS EN ISO 9117-1:2009	Paints and varnishes. Drying tests. Determination of through-dry state and through-dry time
BS EN ISO 9117-3:2010	Paints and varnishes. Drying tests. Surface-drying test using ballotini
BS EN ISO 9445-1:2010	Continuously cold-rolled stainless steel. Tolerances on dimensions and form. Narrow strip and cut lengths
BS EN ISO 9445-2:2010	Continuously cold-rolled stainless steel. Tolerances on dimensions and form. Wide strip and plate/sheet
BS EN ISO 9606:Part 1:2017	Qualification testing of welders. Fusion welding. Steels
BS EN ISO 10601:2008	Micaceous iron oxide pigments for paints. Specifications and test methods
BS EN ISO 10545:Part 2:2018	Ceramic tiles. Determination of dimensions and surface quality
BS EN ISO 10545: Part 3:2018	Ceramic tiles. Determination of water absorption, apparent porosity, apparent relative density and bulk density
BS EN ISO 10545: Part 4:2019	Ceramic tiles. Determination of modulus of rupture and breaking strength
BS EN ISO 10545: Part 6:2012	Ceramic tiles. Determination of resistance to deep abrasion for unglazed tiles
BS EN ISO 10545: Part 7:1999	Ceramic tiles. Determination of resistance to surface abrasion for glazed tiles
BS EN ISO 10545:Part 8:2014	Ceramic tiles. Determination of linear thermal expansion
BS EN ISO 10545:Part 11:1996	Ceramic tiles. Determination of crazing resistance for glazed tiles
BS EN ISO 10545:Part 13:2016	Ceramic tiles. Determination of chemical resistance
BS EN ISO 10545:Part 14:1997	Ceramic tiles. Determination of resistance to stains
BS EN ISO 10684:2004	Fasteners. Hot dip galvanized coatings
BS EN ISO 11124	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives
BS EN ISO 11124-1:1997	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. General introduction and classification
BS EN ISO 11124-2:2018	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. Chilled-iron grit
BS EN ISO 11124-3:1997	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning

	abrasives. High-carbon cast-steel shot and grit
BS EN ISO 11124-4:1997	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. Low-carbon cast-steel shot
BS EN ISO 11126	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives.
BS EN ISO 11126:Part 1:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. General introduction and classification
BS EN ISO 11126:Part 3:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Copper refinery slag
BS EN ISO 11126:Part 4:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Coal furnace slag
BS EN ISO 11126:Part 5:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Nickel refinery slag
BS EN ISO 11126:Part 6:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Iron furnace slag
BS EN ISO 11126:Part 7:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Specification for fused aluminium oxide
BS EN ISO 11126:Part 8:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Olivine sand
BS EN ISO 11126:Part 9:2004	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Staurolite
BS EN ISO 11126:Part 10:2017	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Almandite garnet
BS EN ISO 11296:Part 4:2018	Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks. Lining with cured-in-place pipes
BS EN ISO 11600:2003+A1:2011	Building construction. Jointing products. Classification and requirements for sealants
BS EN ISO 12567-1:2010	Thermal performance of windows and doors — Determination of thermal transmittance by the hot-box method. Complete windows and doors

BS EN ISO 12944	Paints and varnishes. Corrosion protection of steel structures by protective paint systems.
BS EN ISO 12944:Part 3:2017	Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Design considerations
BS EN ISO 12944:Part 5:2019	Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Protective paint systems
BS EN ISO 13918:2018	Welding. Studs and ceramic ferrules for arc stud welding
BS EN ISO 14555:2017	Welding. Arc stud welding of metallic materials
BS EN ISO 14713	Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures
BS EN ISO 14713:Part 1:2017	Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures. General principles of design and corrosion resistance
BS EN ISO 14713:Part 2:2020	Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures. Hot dip galvanizing
BS EN ISO 14713:Part 3:2017	Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures. Sherardizing
BS EN ISO 15613:2004	Specification and qualification of welding procedures for metallic materials. Qualification based on pre-production welding test
BS EN ISO 15614	Specification and qualification of welding procedures for metallic materials. Welding procedure test
BS EN ISO 15614:Part 1:2017+A1:2019	Specification and qualification of welding procedures for metallic materials. Welding procedure test. Arc and gas welding of steels and arc welding of nickel and nickel alloys
BS EN ISO 17636	Non-destructive testing of welds. Radiographic testing.
BS EN ISO 17636:Part 1:2013	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with film
BS EN ISO 17636:Part 2:2013	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with digital detectors
BS EN ISO 17637: 2016	Non-destructive testing of welds. Visual testing of fusion-welded joints
BS EN ISO 17638:2016	Non-destructive testing of welds. Magnetic particle testing
BS EN ISO 17640:2018	Non-destructive testing of welds. Ultrasonic testing. Techniques, testing levels, and assessment
BS EN ISO 22282-3	Geotechnical investigation and testing. Geohydraulic testing. Water pressure tests in rock

BS ISO 34-1:2004	Rubber, vulcanized or thermoplastic. Determination of tear strength. Trouser, angle and crescent test pieces
BS ISO 37:2011	Rubber, vulcanized or thermoplastic. Determination of tensile stress-strain properties
BS ISO 48:2010	Rubber, vulcanized or thermoplastic. Determination of hardness (hardness between 10 IRHD and 100 IRHD)
BS ISO 188:2007	Rubber, vulcanized or thermoplastic. Accelerated ageing and heat resistance tests
BS ISO 815:Part 1:2019	Rubber, vulcanized or thermoplastic. Determination of compression set. At ambient or elevated temperatures
BS ISO 974:2000	Plastics. Determination of the brittleness temperature by impact
BS ISO 1051:1999	Rivet shank diameters
BS ISO 1431:2004	Rubber, vulcanized or thermoplastic. Resistance to ozone cracking. Static and dynamic strain testing
BS ISO 1817:2005	Rubber, vulcanized. Determination of the effect of liquids
BS ISO 2285:2007	Rubber, vulcanized or thermoplastic - Determination of tension set under constant elongation, and of tension set, elongation and creep under constant tensile load
BS ISO 2781:2008	Rubber, vulcanized or thermoplastic - Determination of density
BS ISO 3310	Test sieves. Technical requirements and testing
- BS ISO 3310:Part 1:2016	Test sieves. Technical requirements and testing. Test sieves of metal wire cloth
- BS ISO 3310:Part 2:2013	Test sieves. Technical requirements and testing. Test sieves of perforated metal plate
BS ISO 4587:2003	Adhesives. Determination of tensile lap-shear strength of rigid-to-rigid bonded assemblies
BS ISO 4649:2017	Rubber, vulcanized or thermoplastic. Determination of abrasion resistance using a rotating cylindrical drum device
BS ISO 14654:1999	Epoxy-coated steel for the reinforcement of concrete
BS ISO 14656:1999	Epoxy powder and sealing material for the coating of steel for the reinforcement of concrete
BS ISO 16132:2016	Ductile iron pipes and fittings. Seal coats for cement mortar linings
BS ISO 16269:Part 6:2014	Statistical interpretation of data. Determination of statistical tolerance intervals

1.1.9 JAPANESE INDUSTRIAL STANDARDS (JIS)

JIS Z 1902:2000	Petrolatum tapes for corrosion protection
JIS A 6910 – 1988	Quality tests for multi-layer acrylic paint

1.1.10 INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO) STANDARDS

ISO 4591:1992	Plastics - Film and sheeting - Determination of average thickness of a sample, and average thickness and yield of a roll, by gravimetric techniques (gravimetric thickness)
ISO 4593:1993	Plastics - Film and sheeting - Determination of thickness by mechanical scanning
ISO 9001:2000	Quality management systems – Requirements

1.1.11 WATER INDUSTRY SPECIFICATION, WATER RESEARCH CENTRE

WIS 4-52-01:1992	Polymeric anti-corrosion (barrier) coatings
WIS 4-32-08:2016 issue 4	Specification for the fusion jointing of polyethylene pressure pipeline systems using PE80 and PE100 materials

1.1.12 NATIONAL WATER COUNCIL, UK

Manual of Sewer Condition Classification, 5th Edition, 2013	Coding system for recording of results

1.1.13 AUSTRALIAN/NEW ZEALAND STANDARDS (AS/NZS)

AS/NZS 4456.2:2003	Masonry units and segmental pavers – Methods of test. Method 2: Assessment of mean and standard deviation
AS/NZS 4456.14:2003	Masonry units and segmental pavers - Methods of test. Method 14: Determining water absorption properties

1.1.14 中華人民共和國行業標準

JTG F40-2004	公路瀝青路面施工技術規範 (Technical Specifications for Construction of Highway Asphalt Pavements)

1.1.15 CANADIAN STANDARD

CSA-A3000-2018	Cementitious Materials Compendium

1.1.16 PUBLICLY AVAILABLE SPECIFICATION

PAS 1075:2009-04	Pipes made from Polyethylene for alternative installation techniques – Dimension, Technical Requirements and Testing

1.1.17 GEO PUBLICATION

GEO Publication No. 1/2006	Foundation design and construction

1.1.18 DESIGN MANUAL PUBLISHED BY HIGHWAYS DEPARTMENT

Structures Design Manual for Highways and Railways 2013 Edition	Structures Design Manual for Highways and Railways

1.1.19 IEC SYSTEM OF CONFORMITY ASSESSMENT SCHEMES FOR ELECTROTECHNICAL EQUIPMENT AND COMPONENTS (IECEE)

IEC 61386-1:2008/AMD1:2017 CSV	Conduit systems for cable management – Part 1: General requirements
IEC 61386-21:2002	Conduit systems for cable management – Part 21: Particular requirements – Rigid conduit systems
IEC 60670-1:2015	Boxes and enclosures for electrical accessories for household and similar fixed electrical installations – Part 1: General requirements

APPENDIX 1.2

REQUIREMENTS FOR STEEL CONTAINER ROOM

General 1.2.1 As a reference, a standard steel container room of nominal size 6000 mm x 2500 mm x 2350 mm may accommodate up to a maximum of five standard curing tanks (see Appendix 1.3 – Clause 1.3.1(2)).

Equipment 1.2.2 Each steel container room shall be equipped with the following:

(a) A security door-lock.

(b) Windows with security metal grilles.

(c) Fluorescent lighting.

(d) Air-conditioner with heating and cooling facilities that is capable of keeping the room temperature at 25°C ± 5°C.

(e) Adequate number of power sockets for operating the curing tanks.

(f) Water supply.

(g) Drainage outlets for connecting to the drainage valves and overflow system of the curing tanks.

APPENDIX 1.3

REQUIREMENTS FOR CURING TANK

General 1.3.1 (1) The requirements for a curing tank shall be as stated in Appendix A of CS1.

(2) As a reference, a standard curing tank of nominal size 1650 mm x 860 mm x 510 mm has a capacity to accommodate about sixty-four number of 150 mm concrete cubes.

(3) For curing tanks of different non-standard sizes, the number of curing tanks required may be estimated on the basis of the capacity for a standard curing tank of equivalent volume at the discretion of the Engineer, who may require appropriate adjustments in the pump and heater capacities.

(4) Each curing tank shall be accessible for operation and maintenance.

(5) At least one stand-by curing tank shall be provided at all times.

Equipment 1.3.2 Each curing tank shall be constructed of corrosion-resistant material of adequate strength such as galvanized sheet steel to BS EN ISO 1461 for hot-dip galvanized coating or BS EN ISO 2063 for flame sprayed metal coating, fully welded on all seams and equipped with the following accessories:

(a) A lockable insulated lid (or cover) properly numbered.

(b) A recirculating water pump and a stand-by pump, both of a waterproof type and with capacity not less than 1000 litres per hour, earthed and fitted internally at one end of the tank drawing water through a pipe from the bottom to the diagonally opposite top of the tank at least 25 mm above the water level to stimulate efficient mixing of the water by free falling.

(c) A thermostatically controlled electric immersion heater and a stand-by heater, both with power of not less than 3 kW and connected through a temperature sensor for continual control of the water temperature at 27°C ± 3°C.

(d) A set of three removable lower racks.

(e) A drainage valve and an overflow system.

(f) A steel stand supporting the water tank.

(g) Minimum/maximum thermometers for measuring water temperature.

(h) A switch panel.

Maintenance 1.3.3 Each curing tank shall be cleaned at regular intervals and the water in each tank be changed at least once a month in accordance with CS1 or as directed by the Engineer. In order to ensure adequate circulation of water and to facilitate the removal of test cubes from the curing tank, a gap of at least 15 mm shall be provided between the test cubes and the sides of the tank.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 2

SITE CLEARANCE

SECTION 2

SITE CLEARANCE

GENERAL

General requirements 2.01 The works and materials specified in Clauses 2.02 and 2.03 shall comply with the sections stated, unless otherwise stated in this Section.

Pipes and manholes to be abandoned 2.02 The abandonment of pipes and manholes shall comply with Section 5.

Earthworks 2.03 Earthworks, including blasting, shall comply with Section 6.

SITE CLEARANCE

Demolition 2.04 (1) Areas adjacent to demolition works shall be protected from damage resulting from the demolition.

(2) Structures that are to be demolished shall be surveyed by the Contractor and the result given to the Engineer, before demolition starts.

(3) Particulars of the proposed methods of carrying out demolition works, handling and sorting of recyclable materials and disposal of construction and demolition waste shall be submitted to the Engineer for information at least 14 days before the demolition starts.

(4) The proposed methods shall enhance site safety, maximize recovery of recyclable materials and minimize generation of construction and demolition waste. The recommendations of the Code of Practice for Demolition of Buildings (Year 2004), issued by the Buildings Department, shall be followed.

Pipes and cables 2.05 The Contractor shall make all arrangements with and obtain the necessary approvals from the relevant authorities for disconnecting utilities inside and outside the Site. The ends of disconnected utilities shall be made good and sealed; the positions of the ends shall be marked with marker posts or by other methods agreed by the Engineer.

Trees 2.06 The Contractor shall comply with the requirements of preservation and protection of existing trees stipulated in Section 26 before commencing site clearance.

Reinstatement 2.07 (1) Unless otherwise permitted by the Engineer, areas affected by site clearance shall be reinstated as stated in Clause 2.07(2) to (5).

(2) Fine fill material shall be deposited and compacted in voids that are left in the ground.

(3) Holes that are left in structures and pavements shall be made good using material similar to that in the adjoining area.

(4) The ends of fences, walls, structures, utilities and other items shall be made good in such a manner that the affected parts will not corrode or deteriorate, and will remain stable.

(5) Straining posts shall be fixed at the end of strained fences that have been cut, and the fences shall be restrained.

Materials and equipment for re-use and storage

2.08 (1) Items that are to be re-used or taken to store shall be dismantled and removed by a suitable method so as to avoid damage or minimise the damage if this is unavoidable. The items shall be cleaned before re-use or taking to store.

(2) Items that are to be re-used in the Works shall be kept in storage areas provided by the Contractor. Storage areas shall be on levelled, well drained and maintained hard-standing ground to facilitate cleansing and minimize dust generation.

(3) Items that are to be taken to the Employer’s store shall be delivered by the Contractor.

(4) Materials or equipment which are to be re-used or taken to store and which are damaged due to the Contractor's negligence shall be repaired by the Contractor by a method agreed by the Engineer. Materials or equipment that are lost or, in the opinion of the Engineer, are not capable of being repaired satisfactorily shall be replaced by the Contractor. Except for items which are to be re-used or taken to store, demolished items, trees, shrubs, vegetation, boulders, debris, rubbish and other items arising from site clearance shall be disposed of by the Contractor and shall become the property of the Contractor when they are removed from the Site.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 3

LANDSCAPE SOFTWORKS AND ESTABLISHMENT WORKS

SECTION 3

LANDSCAPE SOFTWORKS AND ESTABLISHMENT WORKS

GENERAL

General requirements 3.01 The works and materials specified in Clauses 3.02 to 3.05 shall comply with the sections stated, unless otherwise stated in this Section.

Site clearance 3.02 Site clearance shall comply with Section 2. During site clearance, where appropriate and as required by the Engineer, topsoil shall be stripped and stockpiled by a method agreed by the Engineer and in an area designated or agreed by the Engineer.

Earthworks 3.03 Earthworks shall comply with Section 6.

Landscape hardworks 3.04 Landscape hardworks shall comply with Sections 4, 5, 11, 14, 16, 18, 22 and 24.

Geotechnical works 3.05 Geotechnical works shall comply with Section 7.

Weather and ground conditions 3.06 Soiling, cultivation, planting and other similar landscape softworks and establishment works operations shall not be carried out at times when weather or ground conditions may, in the opinion of the Engineer, adversely affect the permanent works.

Use of chemicals 3.07 Chemicals shall not be used for landscape softworks and establishment works unless approved by the Engineer. Chemicals shall be used, stored, mixed and applied in accordance with the manufacturer's recommendations. Containers for chemicals shall be disposed of off Site by methods agreed by the Engineer.

GLOSSARY OF TERMS

Landscape softworks 3.08 Landscape softworks are all works of a horticultural nature, and shall include the placing, cultivation and preparation of topsoil and subsoil layers, and the supply and planting of trees, shrubs and other plant material, and any work essentially associated with these.

Landscape hardworks 3.09 Landscape hardworks are the tree grills, tree guards and tree rings and any other items stated as such in the Contract.

Establishment works 3.10 Establishment works are the regular inspections, cultivation, watering, fertilizing and other operations specified to be performed during the period stated in the Contract for such inspections and operations.

MATERIALS

Seedling trees 3.11 Seedling trees shall have the following characteristics:

(a) Aged between 1 and 2 years,

(b) A single slender stem,

(c) A well developed vigorous root system,

(d) Total height above soil level of at least 150 mm but not exceeding 900 mm,

(e) Grown and supplied in a container at least 75 mm in diameter and 150 mm deep, or a tube at least 60 mm in diameter and 150 mm long, and

(f) Free of any pest, fungi and disease.

Whip trees 3.12 Whip trees shall have the following characteristics:

(a) Aged between 2 and 3 years,

(b) A single central stem well furnished with side branches according to species,

(c) A well developed vigorous root system,

(d) Total height above soil level exceeding 900 mm but not exceeding 2000 mm,

(e) Grown and supplied in a container at least 125 mm in diameter and 200 mm deep, and

(f) Free of any pest, fungi and disease.

Light standard trees 3.13 Light standard trees shall have the following characteristics:

(a) A sturdy straight stem at least 1500 mm high from the root collar to the lowest branch,

(b) Stem diameter of at least 25 mm but not exceeding 45 mm measured at a height of 1 m from the root collar,

(c) According to species, either a well balanced branching head or a well defined straight and upright leader with branches growing out from the stem with reasonable symmetry,

(d) Total height above the root collar exceeding 2000 mm but not exceeding 3000 mm,

(e) A rootball at least 300 mm in diameter and 300 mm deep,

(f) When container-grown trees are required, grown in a container at least 350 mm in diameter and 400 mm deep, and

(g) free of pests, fungi and disease.

Standard trees 3.14 Standard trees shall have the following characteristics:

(a) A sturdy straight stem at least 1800 mm high from the root collar to the lowest branch,

(b) Stem diameter exceeding 45 mm but not exceeding 75 mm measured at a height of 1 m from the root collar,

(c) According to species, either a well balanced branching head or a well defined straight and upright leader with branches growing out from the stem with reasonable symmetry, and a minimum length of 600 mm,

(d) Total height above the root collar exceeding 2750 mm but not exceeding 3500 mm,

(e) A rootball at least 450 mm in diameter and 300 mm deep,

(f) When container grown trees are required, grown in a container at least 500 mm in diameter and 500 mm deep, and

(g) Free of pests, fungi and disease.

Heavy standard trees 3.15 Heavy standard trees shall have the following characteristics:

(a) A sturdy straight stem at least 2000 mm high from the root collar to the lowest branch,

(b) Stem diameter exceeding 75 mm but not exceeding 150 mm measured at a height of 1 m from the root collar,

(c) According to species, either a well balanced branching head or a well defined straight and upright leader with branches growing out from the stem with reasonable symmetry, and a minimum length of 800 mm,

(d) Total height above the root collar exceeding 3500 mm but not exceeding 6000 mm,

(e) A rootball at least 750 mm in diameter and 400 mm deep,

(f) When container grown trees are required, grown in a container at least 750 mm in diameter and 600 mm deep and

(g) Free of pests, fungi and disease.

Semi-mature trees 3.16 Semi-mature trees shall have all the following characteristics:

(a) A sturdy straight stem at least 2200 mm high from the root collar to the lowest branch,

(b) Stem diameter exceeding 150 mm measured at a height of 1 m from the root collar,

(c) According to species, either a well balanced branching head or a well defined straight and upright leader with branches growing out from the stem with reasonable symmetry, and a minimum length of 1500 mm,

(d) Total height above the root collar exceeding 6000 mm,

(e) A rootball at least 1500 mm in diameter and 600 mm deep,

(f) A root system previously undercut a minimum of one year before lifting, to encourage compact fibrous growth, and

(g) Free of pests, fungi and disease.

Small shrubs

3.17 Small shrubs shall have the following characteristics:

(a) A minimum of three vigorous, one-year old shoots with a well balanced shape and bushy habit,

(b) A well developed, vigorous root system,

(c) Total height above soil level at least 300 mm but not exceeding 600 mm,

(d) Grown and supplied in a container at least 125 mm in diameter and 150 mm deep, and

(e) Free of pests, fungi and disease.

Large shrubs

3.18 Large shrubs shall have the following characteristics:

(a) A minimum of five vigorous, one-year old shoots, with a well balanced shape and bushy habit to produce a diameter 2/3 of the height,

(b) A well developed, vigorous root system,

(c) Total height above soil level exceeding 600 mm,

(d) Grown and supplied in a container at least 200 mm in diameter and 250 mm deep, and

(e) Free of pests, fungi and disease.

Conifers

3.19 Conifers shall have the following characteristics:

(a) A well developed, upright stem well furnished with vigorous leaf or needle bearing side shoots with good symmetry,

(b) A well developed, vigorous root system,

(c) For small conifers, total height above the root collar at least 1500 mm but not exceeding 2500 mm,

(d) For large conifers, total height exceeding 2500 mm but not exceeding 3500 mm,

(e) Grown and supplied in a container with dimensions not less than the dimensions stated in the Contract, and

(f) Free of pests, fungi and disease.

Palms 3.20 Palms shall have the following characteristics:

(a) A well developed, upright habit and vigorous fronds with good symmetry,

(b) A well developed, vigorous root system,

(c) For small palms, a minimum height from soil level to the base of the lowest frond as stated in the Contract and a rootball at least 300 mm in diameter and 300 mm deep, and

(d) For medium palms, a minimum height from soil level to the base of the lowest frond as stated in the Contract and a rootball at least 500 mm in diameter and 450 mm deep.

(e) For large palms, a minimum height from soil level to the base of the lowest frond as stated in the Contract and a rootball at least 700 mm in diameter and 600 mm deep, and

(f) Free of pests, fungi and disease.

Bamboos 3.21 Bamboos shall have the following characteristics:

(a) A well developed, vigorous root system, with a healthy rhizome capable of shooting fresh culm,

(b) For single stem species, a single shoot or trunk with total height above soil level not less than the height stated in the Contract,

(c) For multi-stemmed species, a clump of at least four stems with total height above soil level not less than the height stated in the Contract,

(d) Grown and supplied in container at least 450 mm in diameter and 450 mm deep, and

(e) Free of pests, fungi and disease.

Herbaceous plants 3.22 Herbaceous plants shall have the following characteristics:

(a) Well developed vigorous shoots in number not less than that stated in the Contract,

(b) A well developed, vigorous root system,

(c) Total height above soil level or diameter of plant for clumps not less than the height or diameter stated in the Contract,

(d) Healthy well developed bulbs, corms, rhizomes or tubers,

(e) Grown and supplied in a container at least 125 mm in diameter and 150 mm deep, and

(f) Free of pests, fungi and disease.

Ground covers 3.23 Ground cover plants shall have the following characteristics:-

(a) Well developed, vigorous shoots in number not less than that stated in the Contract,

(b) A well developed, vigorous root system,

(c) Total height above soil level at least 150 mm,

(d) Grown and supplied in a container at least 125 mm in diameter and 150 mm deep, and

(e) Free of pests, fungi and disease.

Climbers 3.24 Climbers shall have all the following characteristics:-

(a) A minimum of four vigorous, one-year old shoots at least 600 mm long unless otherwise specified,

(b) A well developed, vigorous root system,

(c) Grown and supplied in a container at least 125 mm in diameter and 150 mm deep, and

(d) Free of pests, fungi and disease.

Containerised plants 3.25 Containerised plants shall be grown in open ground and then lifted and placed in a rigid or semi-rigid container of dark colour; plants shall be left to grow in the containers for at least 3 months before being delivered to the Site. The dimensions of containers shall not be less than the relevant rootball or container dimensions stated in Clauses 3.11 to 3.24. Containerised plants shall be well watered before despatch from the nursery and shall remain in the containers until required for planting.

Grass seed 3.26 (1) All seed shall be covered by an appropriately numbered seed analysis report or certificate. The numbered reports or certificates shall always refer to the number on the seed containers. The origin of all seed and the name of the supplier shall be stated on the seed containers.

(2) The quality of grass seed shall be gauged by purity, germination percentage and freedom from weeds. The total weed seed content shall not exceed 0.5% by mass and the total content of other crop seed shall not exceed 1% by mass. The germination capacity of each constituent of the mixture over a seven-day test period shall not be less than 80%, and the purity of the mixture shall not be less than 90%.

(3) The basic minimum grass seed mix for hydroseeding shall be as follows, unless otherwise specified: -

(a) Between April and August inclusive, the minimum seed mix shall total 25 g/sq m and shall consist of: -

Cynodon dactylon	13 – 15 g/sq m
Paspalum notatum	8 – 10 g/sq m

Other species from the list below 0 – 4 g/sq m
Chloris gayana
Eragrostis curvula (2% maximum)
Eremochloa ophiuroides
Cenchrus echinatus

(b) Between September and March inclusive, the minimum seed mix shall total 30 g/sq m and shall consist of :-

Cynodon dactylon	15 g/sq m
Paspalum notatum	10 g/sq m
Lolium perenne	5 g/sq m

Turf 3.27 (1) Turf shall possess the following characteristics:-

(a) Free of sticky clay, weeds, impurities, pests, fungi and disease with grass of even density, green colour and capable of healthy growth;

(b) With a sufficiently fibrous root system to hold together during handling;

(c) Size of 500 mm x 300 mm with a minimum thickness of 50 mm and with an even thickness of grass sward and soil thickness.

(2) Turf species shall be one of the following species unless otherwise specified:

Axonopus compressus
Cynodon dactylon
Eremochloa ophiuroides
Zoysia japonica
Zoysia matrella

Sprigs 3.28 Sprigs shall consist of *Axonopus compressus*, *Cynodon dactylon*, *Paspalum paspaloides* and other stoloniferous grasses. *Axonopus compressus* shall not be used on slopes exceeding 15° to the horizontal. Sprigs shall be at least 100 mm long and shall be free of pests, fungi and disease.

Plant name 3.29 In the event that botanical name, English common name and Chinese common name are given for any plant specified, the botanical name shall always take precedence.

Soil-mix 3.30 (1) Soil-mix shall be ready and evenly mixed before delivery onto the Site.

(2) Soil-mix shall consist of friable, completely decomposed granite and soil conditioner in the proportions of 3:1 by volume. Soil-mix shall be free of grass or weed growth, sticky clay, salt, chemical contamination, and any other deleterious materials and stones exceeding 25 mm diameter in any direction, and shall possess the following properties:

(a) PH value between 5.5 and 7.0;

(b) Organic matter more than 10%;

(c) Nitrogen content more than 0.2%;

(d) Extractable phosphorous (P) content more than 45 mg/kg;

(e) Extractable potassium (K) content more than 240 mg/kg;

(f) Extractable magnesium (Mg) content more than 80 mg/kg;

(g) Soil texture content:

Sand (0.05 - 2.0 mm):	at the range of 20% - 75%;
Silt (0.002 - 0.05 mm):	at the range of 5% - 60%;
Clay (less than 0.002 mm):	at the range of 5% - 25%.

Soil conditioner 3.31 (1) Soil conditioner shall be organic material and shall be free of weed growth, impurities, foreign materials, contamination and substances injurious to plants. Soil conditioner shall have the following properties:

(a) PH value between 5.0 and 7.5,

(b) Moisture content measured in accordance with Clause 6.78(2) between 30% and 50%,

(c) Fine and freely flowing consistency,

(d) Stable composition,

(e) Not capable of raising the temperature of the treated soil more than 50∘C above the temperature of the untreated soil,

(f) Not giving off toxic nor obnoxious fumes,

(g) Organic matter content not less than 85% (dry matter), and

(h) Carbon: nitrogen ratio between 20 and 55.

Mulch 3.32 Mulch shall be a composted organic material either as stated in Clause 3.31 for soil conditioner or granulated tree bark or wood shavings, with a nominal size of 5 mm – 20 mm.

Mulch for hydroseeding 3.33 Mulch for hydroseeding shall be a proprietary type approved by the Engineer and shall be a hydroseeding mulch manufactured from cellulose or paper based materials.

Fertilizer 3.34 (1) Pre-planting fertilizer shall be 15:9:15:2 (nitrogen/phosphorus/potassium/magnesium) slow release granular fertilizer or an equivalent approved by the Engineer.

(2) Post-planting fertilizer shall be 12:12:17 (nitrogen/phosphorus/potassium) granular fertilizer or an equivalent approved by the Engineer.

(3) Hydroseeding fertilizer shall be 15:15:15 (nitrogen/phosphorus/potassium) or an equivalent approved by the Engineer.

(4) Phosphate fertilizer shall be triple superphosphate powder or an equivalent approved by the Engineer.

(5) Fertilizer shall be supplied in sealed waterproof bags.

Soil binder 3.35 Soil binder shall be a proprietary type approved by the Engineer and shall consist of a binding medium applied in aqueous suspension by spraying onto the surface of the soil to stabilise and condition the soil. The binding agent shall not be injurious to plant growth.

Stakes, ties and guys 3.36

(1) Metal stakes shall be 40 mm x 40 mm x 4 mm thick galvanized mild steel angle painted with one coat of approved primer and one coat of approved finishing coat before installation. Total length of stake shall be 1800 mm or as specified to suit the height of the plant being supported. All sharp edges of the metal stakes shall be removed to avoid damage to the plant The primer and finishing coat shall be approved by the Engineer before its application.

(2) Bamboo stakes shall be bamboo poles of minimum 50 mm in diameter. Total length of stake shall be 1500 mm or as specified to suit the height of the plant being supported.

(3) Ties shall be of dark colour and shall be one of the following which shall be capable of adjustment after fixing, and shall be fitted with flexible rubber or plastic sleeves to prevent chafing, rubbing or abrasion of the plant:

(a) 5 mm diameter rot-proof rope,

(b) 3 mm overall diameter plastic coated wire,

(c) 3 mm diameter stainless steel braided wire with 20 mm adjustable stainless steel screw clamp.

(4) Guys shall be of dark colour and shall be one of the following which shall be fitted with a flexible rubber or plastic sleeve to prevent chafing, rubbing or abrasion of the plant, and a 100 mm long stainless steel turnbuckle for adjustment:

(a) 8 mm diameter rot-proof rope,

(b) 4 mm overall diameter plastic coated wire,

(c) 4 mm to 6 mm diameter stainless steel braided wire with 20 mm adjustable stainless steel screw clamp.

(5) Guying stakes shall be 25 mm x 25 mm x 5 mm thick galvanized mild steel angle with 5 mm to 10 mm diameter hole drilled 30 mm from the top before galvanizing, painted with one coat of approved primer and one coat of approved finishing coat before installation. The primer and finishing coat shall be approved by the Engineer before its application.

(6) Clear unplasticised polyvinyl chloride (uPVC) plastic hosing 10 mm to 25 mm in diameter shall be used as guy cover and trunk protection hosing or flexible rubber pad 2 mm thick and 150 mm wide with length enough to wrap twice round the trunk shall be used as trunk protection.

Protective fabric material 3.37

Protective fabric material for hydroseeding shall be a proprietary type of degradable fabric approved by the Engineer. The fabric shall not degrade within 100 days of application or until the specified grass cover has been established.

SUBMISSIONS

Particulars of seed mixture, turf, sprigs, soil conditioner, soil-mix and water

3.38 (1) The following particulars of the proposed materials for landscape softworks and establishment works shall be submitted to the Engineer for approval:

(a) Origin of trees, shrubs, turves, sprigs and other plant materials,

(b) Details of nurseries,

(c) A certificate or a numbered seed analysis report for each seed mixture issued and covering results of tests carried out within 6 months before the date of use of the seed showing the species and variety of the seed, the date of testing and including results of tests for:

- Percentage germination of pure seed in a fixed time under standard laboratory conditions; and

- Percentage composition by weight, including details of impurities,

(d) A certificate of analysis for soil conditioner including details of the composition and results of tests for the properties stipulated for compliance in Clause 3.31(1) and the following properties,

- Organic carbon content (using loss of ignition 'Ashing' Method of testing); and

- Nitrogen content (using 'Kjeldahl' Method),

(e) A certificate of analysis for soil-mix including details of the composition and results of tests for the properties stipulated for compliance in Clause 3.30(2), and

(f) Source of water for watering.

(2) The particulars shall be submitted to the Engineer at least 14 days before the relevant work starts.

Particulars of hydroseeding

3.39 (1) The following particulars of the proposed materials and methods for hydroseeding shall be submitted to the Engineer:

(a) Species and rate of application of grass seed,

(b) Type and rate of application of fertilizer, mulch and soil binder,

(c) Type and colour of dye,

(d) Type of protective fabric material, and

(e) Details of the company employed to carry out the hydroseeding and the equipment to be used.

(2) The particulars shall be submitted to the Engineer at least 14 days before hydroseeding starts.

Samples of materials 3.40 (1) Samples of the following proposed materials shall be submitted to the Engineer for approval at the same time as particulars of the material are submitted and before confirming orders, and delivery to and use on the Site:

(a) 0.5 kg sample of each seed mixture,

(b) A sample of 5 turves (each turf 500 mm x 300 mm with a minimum thickness of 50 mm),

(c) A sample of 10 sprig individuals of each species,

(d) 0.027 m^3 sample of soil-mix,

(e) 0.027 m^3 sample of soil conditioner,

(f) 0.027 m^3 sample of each mulch,

(g) 0.5 kg sample of each fertilizer,

(h) 300 mm sample of each type of tree stake,

(i) A sample of tree tie,

(j) 300 mm sample of tree guy,

(k) A sample of tree guying stake, and

(l) A sample of tree guy cover.

(2) Samples of materials for landscape works and establishment works may be inspected by the Engineer at nurseries and other sources before the materials are delivered to the Site.

HANDLING, STORAGE AND TRANSPORT

Handling and storage of rootballed stock 3.41 Plants grown in open ground shall be well watered before lifting and shall be lifted in such a manner that the specified rootball is obtained with minimum disturbance to the roots. The rootball shall be securely wrapped immediately after lifting to prevent loss of soil and moisture using hessian, straw or other material agreed by the Engineer. The wrapping material shall not be removed until the plant is required for planting.

Handling and storage of container grown and containerised stock 3.42 Container grown and containerised stock shall be well watered before despatch from the nursery and shall remain in the containers until required for planting.

Transport of plants 3.43 Plants shall be wrapped and protected to prevent mechanical damage during lifting and transport. The trunk from soil level to the lower branches of trees in the light standard, standard, heavy standard and semi-mature categories shall be securely wrapped to prevent moisture loss using hessian, straw or other material agreed by the Engineer. All plant materials that are to be lifted and transported while in leaf shall be covered with tarpaulin during transport to reduce excessive transpiration. All materials used for protection of plants during transport shall be removed before planting or as directed or agreed by the Engineer.

Storage of plants 3.44 (1) Plants shall be protected from exposure to conditions that may affect the plant adversely.

(2) Plants shall be protected from damage and damaged plants shall not be used in the permanent work unless permitted by the Engineer. If the Engineer permits damaged plants to be used, damaged material shall be pruned as stated in Clause 3.86.

Storage of trees and shrubs 3.45 Trees and shrubs which are not immediately planted in their permanent positions shall be supported upright on level ground, regularly watered and maintained in good condition.

Handling and storage of turf and sprigs 3.46 Turf and sprigs shall not be lifted when waterlogged or very dry and shall be packed to avoid drying out. Turf and sprigs shall be stored by spreading out and shall not be stacked. Turf and sprigs shall be kept moist and in good condition and shall be delivered and laid within 36 hours after lifting.

Storage of grass seed 3.47 Grass seed shall be stored in bags off the ground in a clean, dry, well-ventilated location free of vermin. Prolonged storage shall be carried out under controlled conditions of temperature and humidity.

Storage of fertilizer 3.48 Fertilizer shall be stored off the ground in sealed waterproof bags and shall be protected from exposure to conditions that may adversely affect the fertilizer.

PRE-PLANTING WORKS

Preparatory works 3.49 Before soiling or planting for landscape softworks and establishment works starts, preparatory works shall be carried out by one or more of the treatments stated in Clauses 3.50 to 3.57, as appropriate or as stated elsewhere in the Contract.

Cleaning ground 3.50 Weeds, rubbish, litter, stones exceeding 25 mm diameter and all deleterious material shall be removed from the surface of the ground. Vegetation shall be cleared without using herbicide unless permitted by the Engineer. If permitted, the herbicide shall be a proprietary type approved by the Engineer and shall be applied in accordance with the manufacturer's recommendations.

Ripping 3.51 The ground shall be ripped by drawing a tine through the soil to a depth of 300 mm at 500 mm centres. All obstructions to cultivation or deleterious material brought to the surface shall be removed and voids left by the ripping operation shall be filled with soil of the same type as existing. Ground at a slope exceeding 15° to the horizontal shall not be ripped.

Contaminated ground 3.52 Ground that is contaminated by oil, chemicals or other substances, which in the opinion of the Engineer may affect plant growth adversely, shall be excavated to 500 mm below the contaminated depth and beyond the extent of the contamination. Voids left by excavation shall be filled with uncontaminated soil of the same type as existing.

Soiling 3.53 Soil-mix shall be spread and levelled to the depth stated in the Contract. The depth of uncompacted soil-mix shall be sufficient to allow the level of the area to comply with finished levels after natural settlement has taken place. Placing and spreading of soil mix shall not take place during periods of heavy rain, nor when the soil-mix is saturated. After soiling, the Contractor shall take all necessary preventative measures to control erosion and siltation and prevent the area from compaction.

Cultivation 3.54 (1) Cultivation is the controlled decompaction of the upper layer of soil to provide an evenly textured, friable planting medium with sufficient air penetration and water retention for favourable plant growth.

(2) Cultivation of areas stated in the Contract or instructed by the Engineer shall be carried out in accordance with the following or as stated elsewhere in the Contract:

Minimum depth of cultivation (mm)	Pre-planting fertilizer (g/m^2)	Thickness of pre-planting fertilizer and soil conditioner over the surface before cultivation (mm)
150	25	100
300	50	200
450	75	300

(3) Cultivated soil shall be hand picked to remove any stones exceeding 25 mm diameter and all other deleterious materials. All such materials shall be disposed of from the Site.

Scarifying 3.55 Scarifying shall be carried out by loosening the soil to a depth of between 10 mm and 20 mm using a pronged implement such as a rake but without turning the soil.

Protection of prepared ground 3.56 (1) Prepared ground shall be protected from compaction, erosion and siltation and shall not be used by construction plant, other vehicles or pedestrian traffic.

(2) Prepared ground that becomes compacted, eroded, silted up or damaged shall be replaced or dealt with by methods agreed by the Engineer.

Removal of material 3.57 Weeds, rubbish, litter, stones exceeding 25 mm diameter and deleterious material removed during ground preparation shall be disposed of by the Contractor by methods agreed by the Engineer.

PLANTING

General 3.58 (1) Planting for landscape softworks and establishment works shall be carried out as stated in Clauses 3.58(2) and 3.59 to 3.70.

(2) Unless otherwise permitted by the Engineer, planting shall be carried out between 1st March and 30th September except as stated in Clause 3.06. If planting is permitted at other times, particulars of changes to the materials and methods for planting shall be submitted to the Engineer for approval.

Use of excavated material 3.59 Material excavated from planting pits, which complies with the specified requirements for decomposed granite, may be used for soil-mix. Material excavated from planting pits, which does not comply with the specified requirements for decomposed granite, shall be disposed of by the Contractor and shall be replaced by material which complies with the specified requirements for decomposed granite.

Planting 3.60 (1) Rootballs of light standard trees, standard trees, heavy standard trees, semi-mature trees, conifers and palms shall be thoroughly soaked with water for several hours before planting. The soil in the container or rootball shall be moist and cohesive. Containers or rootball wrapping shall not be removed until the time of planting and the rootball shall not be disturbed by loosening or breaking.

(2) Each plant shall be placed upright in the pit and set at the same level as planted in the nursery or container.

(3) Soil-mix shall be deposited and compacted in layers around the rootball until level with the surrounding ground in such a manner that the rootball is not disturbed. Plants shall be well watered to soak the rootball and soil-mix immediately after planting.

Staking, tying and guying 3.61 (1) Stakes shall be driven into the ground after the pit has been excavated and before planting in such a manner that the rootball and aerial parts of the plant are not damaged. The stake shall be secure after driving and shall not be higher than 30% of the overall height of the plant.

(2) Guys and sleeves shall be fixed in such a manner that chafing, rubbing and abrasion of the plant is prevented and shall be secured to a well driven steel stake or other anchor. Each plant shall be fitted with three guys secured at a point not higher than 60% of the overall height of the plant. Turnbuckles shall be adjusted as necessary after planting.

(3) Bamboo stakes shall be used in locations stated in the Contract and where in the opinion of the Engineer it is impracticable to use steel stakes or guys. Bamboo stakes shall be securely tied with "scaffold tie" to form a tripod not exceeding 60% of the overall height of the plant. The plant shall be secured to the tripod as stated in Clauses 3.61(1) and (2).

Mulching 3.62 After planting and watering, mulch shall be spread to a consolidated thickness of at least 50 mm on areas of bare ground as stated in the Contract.

Notch planting of seedlings 3.63 Notch planting of seedlings shall be carried out by forming a notch making two cuts at approximately 90° using a hand held pick or spade with the apex pointing up any slope; the notch shall be sufficiently deep to accommodate the root system of the seedling. The notch shall be opened on the second cut to receive the plant and shall then be pushed firmly back into place.

Pit planting of seedlings, shrubs, whips, climbers, ground covers and herbaceous plants 3.64 (1) The size of pits for seedlings, shrubs, whips, climbers, ground covers and herbaceous plants shall be 100 mm greater than the rootball or container diameter and 50 mm deeper than the rootball or container. 50 g of pre-planting fertilizer shall be mixed into the soil-mix.

(2) Each of the whips, which require to be staked as specified or as instructed by the Engineer, shall be secured using one bamboo stake as Clause 3.36(2) with one tie as Clause 3.36(3) or using other securing method as approved by the Engineer.

(3) Unless otherwise instructed by the Engineer, the Contractor shall remove the staking or other securing measures from the Site at the end of the period for establishment works or when instructed by the Engineer.

Pit planting of light standard trees and standard trees

3.65 (1) The size of pits for light standard trees and standard trees shall be 200 mm greater than the rootball or container diameter and 100 mm deeper than the rootball or container. The bottom of the pit shall be broken up to a depth of 150 mm. 150 g of pre-planting fertilizer shall be mixed into the soil-mix.

(2) Each of the light standard trees and standard trees, which require to be staked as specified or as instructed by the Engineer, shall be secured using one of the following methods as specified or using other securing method as approved by the Engineer:

(a) Three bamboo stakes as Clause 3.36(2) with two ties as Clause 3.36(3),

(b) Two metal stakes as Clause 3.36(1) with two ties as Clause 3.36(3).

(3) Unless otherwise instructed by the Engineer, the Contractor shall remove the staking or other securing measures from the Site at the end of the period for establishment works or when instructed by the Engineer.

Pit planting of heavy standard tree and semi-mature trees

3.66 (1) The size of pits for heavy standard trees and semi-mature trees shall be 300 mm greater than the rootball or container diameter and 150 mm deeper than the rootball or container. The bottom of the pit shall be broken up to a depth of 150 mm. 250 g of pre-planting fertilizer shall be mixed into the soil-mix.

(2) Each of the heavy standard trees not exceeding 4 m overall height, which require to be staked as specified or as instructed by the Engineer, shall be secured using three metal stakes as Clause 3.36(1) with two ties as Clause 3.36(3) or using other securing method as approved by the Engineer.

(3) Each of the heavy standard trees exceeding 4 m overall height and the semi-mature trees, which require to be staked as specified or as instructed by the Engineer, shall be secured using three guys as Clause 3.36(4) with three guying stakes as Clause 3.36(5) or using other securing method as approved by the Engineer.

(4) Unless otherwise instructed by the Engineer, the Contractor shall remove the staking or guying or other securing measures from the Site at the end of the period for establishment works or when instructed by the Engineer.

Pit planting of bamboo, conifers and palms

3.67 Bamboos, conifers and palms shall be planted in accordance with the following:

(a) Height not exceeding 2000 mm	:	Clause 3.64
(b) Height exceeding 2000 mm and not exceeding 2500 mm	:	Clause 3.65
(c) Height exceeding 2500 mm	:	Clause 3.66

Pit planting on slopes 3.68 Pits excavated for planting on or adjacent to slopes shall not be left open during wet weather.

GRASSING

Hydroseeding 3.69 (1) Hydroseeding for landscape softworks and establishment works shall be carried out as stated in Clauses 3.69(2) and 3.70 to 3.75.

(2) Unless otherwise permitted by the Engineer, hydroseeding shall be carried out between 1st March and 30th September except as stated in Clause 3.06. If hydroseeding is permitted at other times, particulars of changes to the materials and methods for hydroseeding shall be submitted to the Engineer for approval.

Hydroseeding cover 3.70 Hydroseeding shall achieve a cover by grass species of at least 90% of the surface area of each 10 m^2 of the area to be hydroseeded not mote than 100 days after the area has been hydroseeded. The grass cover shall be healthy, vigorous and free of perennial and other weeds. The method of determining the cover shall be as stated in Clauses 3.94 to 3.96.

Surface conditions for hydroseeding 3.71 The surface to be hydroseeded shall be finished to a coarse open textured surface and shall not be smooth or glazed. Finishing work on slopes by machines shall be carried out across the slope. Vehicle track marks and bucket teeth marks shall not be left parallel to the line of maximum gradient of the slope.

Application of hydroseeding 3.72 (1) Hydroseeding shall be carried out using a proprietary type of hydroseeding equipment unless otherwise approved by the Engineer.

(2) Materials for hydroseeding shall be well mixed on the Site in the hydroseeding equipment immediately before spraying, ensuring that seed is not damaged.

(3) At the time of spraying, fertilizer shall be applied at a minimum rate of 60 g/m^3. Mulch shall be applied at a minimum rate of 200 g/m^2. Soil binders shall be applied at the rate recommended by the manufacturer, modified as necessary to suit conditions in Hong Kong. Dye shall be used to demonstrate that adequate cover has been achieved, unless in the opinion of the Engineer runoff or water-courses will be coloured to an unacceptable level. Where used, dye shall be applied at a maximum rate of 0.05 g/m^2.

(4) The hydroseeding mixture shall be constantly agitated during spraying to keep it homogeneous and avoid blockage to pipes. Measures shall be taken during application to ensure that material is not lost due to runoff.

(5) Walking on areas that have been hydroseeded shall be restricted to access for fixing protective material and for patching up.

Protective material 3.73 Areas that have been hydroseeded shall be covered with protective material within 2 days of hydroseeding. The material shall be spiked or stapled to the soil surface with a minimum of 150 mm overlap. On sloping ground, the material shall be laid along the greatest slope and shall be made to fully adhere to the hydroseeded surface by sprinkling with water with an approved spray. Care must be taken not to sprinkle excessive water onto the slope causing erosion of the slope. The material shall also be applied to all areas to be subsequently re-sprayed. Unless otherwise instructed by the Engineer, the

Contractor shall remove the material from the Site at 10 weeks after placement or when instructed by the Engineer.

Patching up 3.74

(1) Immediately after germination and a general greening of the hydroseeded area is apparent, areas where in the opinion of the Engineer germination has been unsuccessful shall be re-sprayed. Areas affected by repairs to washout and gullies and other erosion on slopes shall be re-sprayed.

(2) Areas that in the opinion of the Engineer are not accessible or are too small for the use of a hydroseeder may be patched up by broadcasting seed. The area shall be lightly scarified with a rake or similar implement and the seed and fertilizer shall be broadcast over the area at a rate of not less than 75 g/m^2. The seed shall be covered by lightly working into the surface or by spreading sufficient soil to just cover the seed. Broadcast seeding shall be carried out using Cynodon dactylon, Lolium perenne or Axonopus compressus.

Post-planting fertilizer 3.75

Post-planting fertilizer shall be applied between 2 months and 9 months after application of hydroseeding and, unless otherwise permitted by the Engineer, shall be applied between 1st March and 30th September.

Turfing 3.76

(1) Turf shall not be laid on slopes exceeding 15° to the horizontal.

(2) The area to be turfed shall be cultivated by applying pre-planting fertilizer at a uniform rate of 40 g/m^2 and shall then be raked and consolidated to the required level. The finished level after turfing shall be 25 mm above adjacent kerbs, paving, covers, frames and other hardware.

(3) The turves shall be laid on the prepared soil and shall be firmed into position using wooden beaters; the beaters shall be frequently scraped clean of accumulated soil or mud. A top dressing of soil-mix shall be applied and well worked into joints and spaces. Irregularities in finished levels due to variation in turf thickness or uneven consolidation of the soil shall be adjusted.

(4) Turfed areas shall be watered immediately after turf has been laid and as often as is necessary to ensure establishment. If shrinkage occurs and the joints open, soil-mix shall be worked in and well watered.

(5) Turf edges and margins shall be laid with whole turves.

Sprigging 3.77

(1) Sprigging shall not be used on slopes exceeding 45° to the horizontal.

(2) The area to be sprigged shall be scarified before sprigging and sprigs shall be evenly spread over the area at approximately 50 mm centres. The area shall be topdressed with soil-mix to just cover the sprigs and pre-planting fertilizer shall be applied at a uniform rate of 40 g/m^2.

Completion of turfing and sprigging 3.78

(1) Turfing and sprigging shall be considered to be complete when the first flush of growth achieves 90% cover. The method of determining the cover shall be as stated in Clauses 3.94 to 3.96. Turfing and sprigging shall be considered to be complete when the first flush of growth achieves 90% cover. The method of determining the cover shall be as stated in Clauses 3.94 to 3.96.

(2) Bare patches or areas that in the opinion of the Engineer fail to become established shall be returfed or resprigged to maintain 90% cover throughout the establishment period. Areas affected by repairs to washouts and gullies

and other erosion shall be returfed or resprigged.

ESTABLISHMENT WORKS

Establishment works 3.79 (1) Establishment works shall be carried out for the period stated in the Contract.

(2) Establishment works shall be carried out as stated in Clauses 3.79(3) and 3.80 to 3.93.

(3) All necessary measures shall be taken to ensure that grass, trees and other plants become established and to keep the landscape softworks neat and tidy and free of litter and rubbish.

Inspection of establishment works 3.80 An inspection of landscape softworks and establishment works shall be carried out jointly by the Contractor and the Engineer at monthly intervals to determine the establishment works which are required. The Engineer shall instruct the Contractor to carry out establishment works which in the opinion of the Engineer are necessary; the work instructed shall be completed within 14 days of the date of the Engineer's instruction.

Replacement of plants and grass 3.81 (1) Plants that in the opinion of the Engineer are dead, dying or otherwise unsatisfactory shall be replaced. Replacement planting shall be carried out in season as stated in Clause 3.58(2), unless otherwise instructed by the Engineer, using plant material of a similar size to that already established. Measures shall be taken to ensure satisfactory establishment of the replacement plants before the end of the period for establishment works.

(2) 90% cover of the grass area shall be maintained throughout the period for establishment works and the grass shall provide effective cover of 90% of the area at the end of the period for establishment works. The grass shall be healthy, vigorous and free of perennial and other weeds. Areas that in the opinion of the Engineer are unsatisfactory shall be reseeded by hydroseeding or broadcast seeding as stated in Clause 3.74(2) or returfed as stated in Clause 3.76 or sprigged as stated in Clause 3.77. Measures shall be taken to ensure satisfactory establishment of the replacement grass or turf before the end of the period for establishment works.

Security of stakes, ties and guys 3.82 The Contractor shall be responsible for the security of stakes, ties and guys throughout the establishment period. An inspection of stakes, ties and guys shall be carried out each month by the Contractor. Broken, damaged and other unsatisfactory stakes, ties and guys shall be replaced and ties that are causing chafing or abrasion of the plant shall be adjusted. Ties that are loosened shall be appropriately tightened, and guying turnbuckles shall be adjusted as necessary to ensure guys are taut.

Firming up plants 3.83 Plants that become loose as a result of wind rock or other causes shall be firmed up. The Contractor shall carry out an inspection of the plants each month and after heavy rain or wind for this purpose.

Watering 3.84 (1) Fresh water shall be used for watering landscape softworks. Water shall be applied using a rose or sprinkler of a type agreed by the Engineer and in such a manner that compaction, washout of soil or loosening of plants will not be caused; any damage caused shall be made good immediately.
(2) All planted areas shall be watered to ensure successful establishment of the plants. Plants reaching permanent wilting point shall be watered

immediately.

(3) Grass shall not be watered in the period for establishment works unless stated in the Contract.

Weeding

3.85 (1) All grassed and planted areas shall be kept free of weeds throughout the period for establishment works. Any unwanted plants including *Mikania micrantha* found within the Site is considered as weeds and shall be removed by the Contractor once it is identified or when instructed by the Engineer throughout the period for establishment works.

(2) Weeding shall be carried out by hand or by mechanical methods agreed by the Engineer in such a manner that damage to the grass and planted areas will not be caused. The Contractor shall not use chemicals or fire for weeding operation, unless otherwise instructed or approved by the Engineer. All weeds, litter and other rubbish resulting from the weeding operation shall be disposed of from the Site by the Contractor. Any ground cover plants, herbaceous plants, climbers, mulch or soil disturbed or removed during the weeding operation shall be replaced.

(3) Planted areas in bare ground shall be weeded to remove all unwanted vegetative growth including aerial parts and roots, over the complete area. Planted areas other than in bare ground shall be weeded to remove all competing and overhanging vegetative growth by cutting the growth down to not more than 50 mm above soil level.

Pruning

3.86 (1) The Contractor shall provide all necessary tools and equipment, and physical support, and shall take all necessary safety precautions to protect the people engaged in the pruning work as well as the people and property in the vicinity.

(2) All pruning work shall be carried out in accordance with good horticultural practice and the recommendations of BS 3998.

(3) Pruning and removal of branches shall be done using sharp, clean implements to give a single flat, sloping face.

(4) Ragged, rough edges of bark or wood shall be trimmed cleanly from around wounds with a sharp knife to the minimum extent that is necessary so as to hasten wound closure, and twigs less than 15 mm diameter shall be cut with sharp secateurs.

(5) Pruning shall be carried out with the cut just above and sloping away from an outward facing healthy bud, and removal of branch shall be carried out by having the final cut of the last branch segment made just outside the branch collar when it is present or at an angle being the mirror image of the branch bark ridge when there is no branch collar, so that no part of the stem is damaged or torn, and no snags or stumps are left.

(6) Large branches shall be removed in stages beginning with the removal of the main weight of the branch from perimeter of crown in towards the trunk and with the final cut of the last branch segment made in a way as described in sub-clause (5) of this Clause, without leaving a stub and damaging the bark.

(7) All cuts shall be made to avoid splintering or tearing of bark that would catch water and encourage rot, and cracks, cavities or rotten wood shall be cut back with a clean, sharp implement to remove the dead, damaged and decayed

tissue without damaging the living tissue.

(8) Topping shall not be carried out in any circumstances.

(9) Unless otherwise instructed by the Engineer, any cuts or wounds shall be left uncovered and no wound dressing shall be applied.

(10) Any material pruned from the trees shall be removed from the Site as soon as possible, and any areas affected by the pruning work shall be reinstated.

Grass cutting 3.87 (1) Grassed areas shall be cut by manual or mechanical methods agreed by the Engineer and in a manner that does not cause pulling of roots or damage to planting in or near the grassed area. All cuttings shall be raked off and disposed of within 24 hours after cutting.

(2) Category 1 grass shall be as stated in the Contract and shall be reduced by cutting to a height of 50 mm when it reaches 100 mm high.

(3) Category 2 grass shall be as stated in the Contract and shall be reduced by cutting to a height of 100 mm when it reaches 300 mm high.

(4) Category 3 grass cutting shall be cutting of areas of hydroseeding stated in the Contract to be subsequently maintained as mown grass.

Litter collection 3.88 All litter exposed by grass cutting shall be gathered up and disposed of within 24 hours. Any other litter within the grassed or planted areas shall also be removed by the Contractor once it is identified or when instructed by the Engineer throughout the period for establishment works.

Post-planting fertilizer 3.89 Post-planting fertilizer shall be applied not less than 100 days, and not more than 300 days, after grassing or planting. The fertilizer shall be applied at a rate of:

(a) 100 g/m^2 for amenity grass and shrub planting,

(b) 100 g for each light standard, standard and heavy standard tree,

(c) 50 g for each seedling and whip tree, and

(d) 40g/m^2 for grass on slopes and grass grown by hydroseeding.

Control of pests, fungi and disease 3.90 The Contractor shall take all necessary precautionary measures to protect the plants from pest, fungal and disease attack and all necessary control measures to eradicate pests, fungi and disease from the infected and/or infested plants. The Contractor shall regularly check for any pest, fungal and disease attack, particularly during known periods of activity.

(2) The Contractor shall report to the Engineer any such occurrence and shall carry out pest, fungal and disease control measures by use of pesticide, insecticide or fungicide and any other necessary chemical treatment and associated arboriculture works to the infected and / or infested areas, as approved by the Engineer. The Contractor shall comply with the following requirements in applying the pest, fungal and disease control measures:

(a) Environmentally friendly measures shall be adopted,

(b) All pesticides, insecticides, fungicides and chemicals to be used shall be proprietary products registered in Hong Kong,

(c) Safety precautions as the manufacturer's instruction shall be strictly followed in using pesticides, insecticides, fungicides and chemicals so as to avoid causing danger or harm to the public and the environment, and

(d) Plant parts pruned from diseased plants shall not be stockpiled anywhere on the Site and shall be disposed of from the Site.

Forking over 3.91 Surfaces of bare ground which in the opinion of the Engineer are subject to surface panning or compaction of the soil shall be forked over in such a manner that roots are not disturbed and plants are not loosened; plants which are disturbed or loosened shall be firmed up and well watered immediately.

Mulching 3.92 All mulch that is disturbed by replacement planting, weeding or watering shall be made good. Additional mulching over areas of forking-over and over areas disturbed by others shall be carried out if instructed by the Engineer.

Completion of work 3.93 Immediately before the end of the period for establishment works:

(a) All tree and shrub planting shall be free of weeds,

(b) All planted and grassed areas shall be free of litter,

(c) All replacement planting and patching up of grass shall be completed,

(d) All stakes and ties shall be secure, and

(e) All grassed areas shall be cut and the edges trimmed.

TESTING: GRASS COVER

Testing: grass cover 3.94 (1) Tests shall be carried out to determine the grass cover. The tests shall be carried out 100 days after grassing and at the end of the period for establishment works. The grass shall be cut to a height of 300 mm if necessary over the parts of the area to be tested.

(2) The number of tests shall be as instructed by the Engineer.

(3) Testing to determine the grass cover will be carried out by the Engineer.

(4) Tests shall be carried out at locations, which in the opinion of the Engineer are representative of the grassed area as a whole. At each test location an approximately square area of 10 m^2 shall be marked.

(5) The percentage of bare ground other than rock and other hard material in each 10 m^2 test area shall be measured.

Compliance criteria: grass cover 3.95 At least 90% of each test area shall be covered with grass.

Non-compliance: grass cover 3.96 If the result of any test for grass cover of landscape softworks and establishment works does not comply with the specified requirements for grass cover the area shall be rehydroseeded or reseeded in accordance with Clause 3.74 (1) or (2) as instructed by the Engineer, depending upon the size of the defective area.

TREE TRANSPLANTING

Transplanting of existing trees 3.97 (1) For the purpose of this Clause, palms and conifers are also considered as trees.

(2) Before commencing any work to the trees on the Site, the Contractor shall submit and obtain approval from the Engineer a detailed method statement and programme for transplanting the existing trees, outlining the method, sequencing, timing of operations, and the location and type of machinery to be used for the following operations:

(a) Protection before lifting and transplanting,

(b) Root pruning, including the rootball size, and the number of stages, the operations involved in each stage, and the period between each stage of root pruning,

(c) Crown pruning,

(d) Excavating trenches for rootball preparation,

(e) Design and construction of supporting measures,

(f) Attaching lifting gear to the trees,

(g) Protection during transit,

(h) Temporary holding nursery, if required,

(i) Lifting,

(j) Transportation to new location, including routing,

(k) Preparation of receptor site,

(l) Placement, backfilling, mulching and securing at receptor site,

(m) Backfilling and making good the donor site,

(n) Schedule of establishment works during the period for establishment works.

(3) Any tree transplanted or to be transplanted that dies or is damaged to an extent that, in the opinion of the Engineer, replacement planting is necessary, shall be replaced by the Contractor at his own expense if the necessity for such work is, in the opinion of the Engineer, due to neglect or failure on the part of the Contractor to comply with any obligation expressed or implied on the Contractor's part under the Contract. The Contractor shall provide replacement planting of new trees of the same species and of similar

size and form as the dead or damaged ones before the death or damage or provide other alternative replacement planting as agreed by the Engineer. The Contractor shall complete the replacement planting within 28 days of the Engineer's instruction or other time duration as agreed by the Engineer.

(4) Rootball box sizes shall vary depending on the tree rootball size. Allowance shall be made such that there is at least 150 mm clearance between the rootball edge to the sides and at least 300 mm to the bottom of the rootball box. This clearance shall be filled with moist peat or other materials as agreed by the Engineer. Trench size shall be at least 300 mm wide and 1000 mm deep.

(5) The Contractor shall allow the tree transplanting works in his programme of Works in such a way that the root pruning to the approved size of rootball shall commence as early as possible so as to ensure maximum fibrous root growth before the transplanting operations.

(6) The Contractor shall take all necessary precautions to ensure that no damage is done to the tree during all processes of transplanting.

(7) The application of root activator, where necessary, shall be carried out according to the manufacturer's instruction.

(8) Transplanting operations shall be timed so as to enable transplanting of the trees direct to the areas of proposed planting. No lifting and transplanting operations shall commence until either the receptor sites or the holding nursery are fully prepared as specified. Any tree lifted must be transplanted and watered on the same day.

(9) Lifting and transplanting operations shall be carried out only following a period of consistent rainfall which has thoroughly watered the trees to the satisfaction of the Engineer or following a thorough watering of the trees by the Contractor at a rate agreed by the Engineer.

(10) Trees shall be lifted carefully to avoid damage to roots and to obtain the approved size of rootball. Roots shall be cut free of ground, not pulled, using a suitable implement to give a clean cut. All roots greater than 50 mm diameter shall be treated with an approved sealant.

(11) All trees to be transplanted shall be wrapped and protected to prevent mechanical damage during lifting and transportation. They shall also be protected against excessive sunlight, wind and drought. Care shall be taken in packing to prevent over-heating with its resultant loss of foliage.

(12) Trees transplanted direct to the receptor sites are to be planted in accordance with the requirements in Clauses 3.58 to 3.68 unless otherwise proposed in the Contractor's method statement and approved by the Engineer.

(13) Trees transplanted to the holding nursery are to be containerized before planting, using containers appropriate to the approved rootball size. They shall be planted in an upright position, allowing adequate space for growth, and tied and staked securely to avoid damage to the tree stems. Immediately following planting the trees shall be watered thoroughly to ensure a thorough soaking of the roots.

(14) Trees shall be treated with establishment works immediately after transplanting works, for a period of 12 months. Such establishment works

shall include all measures necessary to establish and maintain the trees in an acceptable vigorous and healthy growing condition. The establishment works shall be carried out in accordance with the requirements in Clauses 3.79 to 3.93 unless otherwise proposed in the Contractor's method statement and approved by the Engineer.

(15) Immediately after transplanting, the base of the trees shall be well watered to thoroughly soak the rootball. The trees shall be well watered in the evening and early morning only. Watering shall be carried out daily during the dry season, generally from September to April. Watering shall be carried out as required during the wet season.

(16) At least two applications of fertilizer shall be carried out in the period for establishment works.

(17) Rootball areas shall be kept free of weeds at all time.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 4

FENCING

SECTION 4

FENCING

GENERAL

General requirements	4.01	The works and materials specified in Clauses 4.02 to 4.09 shall comply with the sections stated, unless otherwise stated in this Section.
Handrailing	4.02	Handrailing shall comply with Section 19.
Earthworks	4.03	Earthworks shall comply with Section 6.
Pedestrian guardrailing	4.04	Pedestrian guardrailing shall comply with Section 11.
Formwork and finishes to concrete	4.05	Formwork and finishes to concrete shall comply with Section 14.
Reinforcement	4.06	Reinforcement shall comply with Section 15.
Concrete	4.07	Concrete shall comply with Section 16.
Steelwork	4.08	Steelwork, including protective treatment, shall comply with Section 18.
Vehicular parapets	4.09	Vehicular parapets shall comply with Section 20.

MATERIALS

Wire 4.10

(1) Wire for fencing, including plastic coated wire, shall be galvanized mild steel complying with BS 4102. Wire for fencing, including plastic coated wire, shall be galvanized mild steel complying with BS 4102.

(2) Barbed wire shall consist of two line wires and point wire formed in accordance with BS 4102, Clause 4.1.

(3) Galvanized coating to steel wire shall comply with BS EN 10244-2:2009.

(4) Plastic coating to steel wire shall be green and shall comply with BS 4102, Section 6.

Chain link fence 4.11 Chain link fence shall comply with BS 1722:Part 1 unless otherwise stated in this Section.

Timber 4.12 Timber shall not be used unless approved by the Engineer.

Steel 4.13 Steel for fencing shall comply with the following:

Hot rolled sections :BS EN 10365

Hot rolled structural steel sections

-	Equal and unequal angles	:BS EN 10056
-	Hollow sections	:BS EN 10210
-	Weldable structural steel	:BS EN 10025

Bolts, nuts, washers and fittings 4.14 (1) Bolts, nuts and washers for fencing shall comply with the following:

ISO metric black hexagon bolts, screws and nuts	: BS 4190
ISO metric black cup and countersunk head, bolts and screws with hexagon nuts	: BS 4933
Metal washers for general engineering purposes	: BS 4320

(2) The length of bolts shall be such that the threaded portion of each bolt projects through the nut by at least one thread and by not more than four threads.

(3) Fittings, including eye bolt strainers, cleats, winding brackets, stretcher bars, extension arms, hook bolts and base plates, shall be galvanized mild steel.

(4) Bolts, nuts, washers and fittings for fixing to concrete and timber shall be galvanized. Bolts, nuts, washers and fittings for fixing to steel shall have the same protective treatment as the steel.

(5) Staples shall be D-section galvanized wire.

FABRICATION OF FENCING

Fabrication of steelwork 4.15 Steelwork for fencing shall be fabricated in accordance with BS EN 1090:Part 2.

Galvanizing to steel 4.16 (1) Steel to be galvanized shall be hot-dip galvanized in accordance with BS EN ISO 1461.

(2) Galvanizing to steel shall be applied as far as possible after welding, drilling and cutting are complete.

Welding steel 4.17 (1) Welds to steel for fencing shall be full depth fillet welds. Weld surfaces shall be clean and flush before application of the protective coating.

(2) Steel shall not be welded after galvanizing unless permitted by the Engineer and if permitted, the welded areas shall be free of scale and slag and shall be treated with an alternative galvanizing or zinc coating system approved by the Engineer.

POSTS AND GATES FOR FENCING

Concrete posts 4.18 (1) Concrete posts and struts for fencing shall be precast using Grade 30/10 concrete. The finish to the formed surfaces shall be Class F4 and the finish to the unformed surfaces shall be Class U5. The tops of posts and all arises shall be rounded or chamfered.

(2) Reinforcement for concrete posts and struts shall be Grade 250 plain round steel bars.

Gates 4.19 (1) Steel gates shall be of welded construction. The frame shall be square with the corners mitred or saddled.

(2) Chain link infilling in gates shall be of the same type and size as in the adjoining fence and shall be attached to the framework by stretcher bars.

SUBMISSIONS

Particulars of fencing 4.20 (1) The following particulars of the proposed fencing shall be submitted to the Engineer:

(a) Drawings showing the fabrication details of gates, and

(b) Details of the source, type and properties of the proposed materials.

(2) The particulars of the proposed fencing shall be submitted to the Engineer at least 14 days before the fencing is erected.

Samples of materials 4.21 The following samples of the proposed materials shall be submitted to the Engineer at the same time as particulars of the proposed fencing are submitted:

(a) Each type of wire and fitting,

(b) Chain link, and

(c) Recast concrete, steel and timber posts.

STORAGE OF MATERIALS

Storage of fencing 4.22 (1) Gates and concrete and steel posts and struts for fencing shall be stored off the ground on level supports and in a manner which will not result in damage or deformation to the materials or in contamination of the materials.

(2) Fencing shall be protected from damage and damaged fencing shall not be used in the permanent works unless permitted by the Engineer.

ERECTING FENCING

Alignment of fencing 4.23 Fencing shall be erected to a smooth alignment with no abrupt irregularities. The ground shall be trimmed or filled in such a manner that the bottom of the fence will approximately follow the level of the ground. The distance between the bottom of chain link mesh and hoardings and the ground shall not exceed 100 mm and any gap between the bottom of hoardings and the ground shall be sealed to the satisfaction of the Engineer.

Posts for fencing 4.24

(1) Straining posts for fencing shall be provided at all ends and corners, at changes in direction, at abrupt changes in level, at gate posts and at intervals not exceeding 30 m along straight lengths of fencing. Struts shall be fitted to straining posts in the direction of each wire secured to the post.

(2) Intermediate posts shall be provided at intervals not exceeding 3.5 m.

Erecting posts for fencing 4.25

(1) Posts and struts for fencing shall be set in excavations for foundations and the excavations shall be filled with Grade 30/20 concrete up to 50 mm below ground level. Posts and struts for fencing shall be set in excavations for foundations and the excavations shall be filled with Grade 30/20 concrete up to 50 mm below ground level.

(2) Struts shall be fitted into slots in concrete posts and shall be bolted to steel posts.

(3) The ground surface around posts shall be made good with the same material as in the adjoining area.

Fixing wire for fencing 4.26

(1) Line wire, chain link mesh and barbed wire for fencing shall be strained tightly between straining posts. Winding brackets shall be used for straining between steel posts and winding brackets or eye bolt strainers shall be used for straining between concrete posts. The tension in the wire on each side of straining posts shall be equal. Wire shall not be strained until at least 14 days after concrete has been placed in the foundation.

(2) Chain link mesh shall be secured at each straining post by a stretcher bar and shall be tied to the line wire by tying wire at 150 mm intervals.

(3) Each line wire and each line of barbed wire shall be secured to each intermediate post by one of the following methods as stated in Table 4.1.

(a) A hairpin staple shall be passed through a hole in the post and secured to the wire by three complete turns on each side of the post.

(b) A stirrup shall be passed through a hole in the post and the ends bent over twice.

(c) The wire shall be threaded through a hole in the post.

(e) The wire shall be stapled to the post.

(e) A hook bolt shall be passed through a hole in the post and secured with a nut and washer.

Table 4.1: Method of securing wire to intermediate posts

Type of fence	Type of wire	Type of post	Method of securing wire
Strained wire	Line wire	Concrete	(a), (b) or (c)
		Steel	(a), (b) or (c)
	Barbed wire	Concrete	(a) or (b)
		Steel	(a)
Chain link	Line wire	Concrete	(a), (b) or (d)
	Mesh wire	Steel	(a) or (c)
	Barbed wire	Concrete	(a), (b) or (d)
		Steel	(a)

Fixing gates 4.27 Gates shall be hung plumb and shall not be installed until the wire has been strained.

TOLERANCES

Tolerances: fencing 4.28 Fencing shall comply with the following requirements:

(a) The position of posts shall be within 75 mm of the specified position.

(b) The level of the top of posts shall be within 25 mm of the specified level.

(c) Posts shall be vertical to within 5 mm in the height of the post.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 5

DRAINAGE WORKS

SECTION 5

DRAINAGE WORKS

GENERAL

General requirements	5.01	The works and materials specified in Clauses 5.02 to 5.08 shall comply with the sections stated, unless otherwise stated in this Section. Hardwood is strictly prohibited for being used in falsework and shoring of trenches and pits unless approved by the Engineer.
Metalwork	5.02	Metalwork for handrailing, ladders, stairs, metal flooring, toe plates and safety chains shall comply with Section 19.
Earthworks	5.03	Earthworks shall comply with Section 6.
Formwork	5.04	Formwork and finishes to concrete shall comply with Section 14.
Concrete	5.05	Concrete shall comply with Section 16, except that recycled aggregates may be used in the concrete if specifically permitted in the relevant clauses of this Section
Materials for grout	5.06	Materials for grout shall comply with Section 16.
Water supply pipeworks	5.07	Water supply pipeworks shall comply with Section 22.
Cable duct systems	5.08	Cable duct systems for electrical and mechanical installations shall comply with Section 13.
Recycled Aggregates	5.09	Recycled aggregates, if proposed by the Contractor, shall be approved by the Engineer before they are used in drainage works.

GLOSSARY OF TERMS

Pipes	5.10	Pipes for drainage works are pipes for conveying sewage and surface water.

MATERIALS

Precast concrete pipes and fittings	5.11	(1) Precast concrete pipes and fittings shall comply with BS EN 1916 and BS 5911:Part 1. (2) Precast concrete pipes and fittings shall have flexible spigot and socket joints.
Vitrified clay pipes and fittings	5.12	(1) Vitrified clay pipes and fittings shall comply with BS EN 295. The pipes and fittings shall be glazed and shall be the normal chemical resistant type. (2) Vitrified clay pipes and fittings shall have flexible mechanical joints.

DI pipes and fittings 5.13

(1) DI pipes and fittings shall comply with BS EN 545 and BS EN 598. Pipes and fittings shall be lined internally with cement mortar and shall be coated externally with bituminous coating.

(2) Flexible joints in DI pipes and fittings shall be the push-in type and shall be capable of withstanding the required minimum angular deflection. Flexible joints shall also be capable of withstanding axial movements and shall allow a minimum withdrawal of 38 mm when there is no deflection of the joint.

(3) Flanged joints in DI pipes and fittings shall be PN 16 rating complying with BS EN 1092-1.

(4) Pipes that are to be built in to structures shall have puddle flanges welded on.

Grey iron pipes and fittings 5.14

Grey iron pipes and fittings shall comply with BS 4622.

uPVC pipes and fittings 5.15

(1) uPVC pipes and fittings shall comply with the relevant British Standard stated in Table 5.1.

(2) uPVC pipes and fittings above ground shall have solvent welded spigot and socket joints. uPVC pipes and fittings below ground shall have either solvent welded spigot and socket joints or flexible spigot and socket joints with elastomeric joint rings as stated in the Contract.

(3) Fittings for uPVC pressure pipes complying with BS 3506 shall comply with the following:

Injection moulded uPVC fittings for solvent welding	: BS 4346:Part 1
Fittings for uPVC pressure pipes	: BS EN ISO 1452-3

(4) Adhesives for uPVC pressure pipes shall comply with BS EN 14814.

(5) The Class of uPVC pressure pipes complying with BS 3506 shall depend on the pressure rating.

GI pipes and fittings 5.16

(1) GI pipes and fittings shall comply with the following:

Steel tubes and tubular suitable for screwing to BS 21 pipe threads	: BS EN 10255
Pipe threads for tubes and fittings where pressure-tight joints are made on the threads	: BS 21
Wrought steel pipe fittings (screwed BSP thread)	: BS 1740:Part 1

(2) GI pipes and fittings shall be medium class thickness and shall be galvanized in accordance with BS EN ISO 1461.

Table 5.1: uPVC pipes and fittings

Use	Nominal size (mm)	Standard
Gravity sewage pipes and fittings above ground	32 - 50	BS 5255 BS EN 1329-1
	82 - 160	BS 4514 BS EN 1329-1
Gravity surface water pipes and fittings above ground	50 - 160	BS EN 12200-1 BS EN 607 BS EN 1462
Gravity sewage and storm water pipes and fittings below ground	110 - 1000	BS EN 1401-1 (Fittings also refer to BS 4660 and BS EN 13598-1)
Pressure pipes and fittings above and below ground	10 - 600	BS 3506

PE pipes and fittings

5.16A (1) PE compounds used for manufacturing PE pipes and fittings shall conform to BS EN 12201-1 and meet the requirements of PE 100-RC as defined in Clause 3.1 of PAS 1075. PE compounds shall also be 100% virgin, pre-coloured compounds. No reprocessed, recycled or own reprocessed materials shall be used in the manufacturer of any pipes or fittings.

(2) PE pipes shall comply with BS EN 12201-2.

(3) PE fittings shall comply with BS EN 12201-3 and have a material designation of PE 100.

Bolts, nuts and washers 5.17 (1) Bolts, nuts and washers for flanged joints, detachable couplings and flange adapters shall comply with the following:

ISO metric black hexagon bolts, screws and nuts	: BS 4190
Metal washers for general engineering purposes	: BS 4320

The bolts, nuts and washers shall be hot-dip galvanised in accordance with BS EN ISO 1461 or treated with other suitable coating approved by the Engineer.

(2) Stainless steel bolts and nuts shall comply with BS EN ISO 3506-1 and BS EN ISO 3506-2, steel Grade A4 and property Class 80. Washers shall be Grade A4 to the standards stated in Clause 5.6.9.1 of BS EN 1090:Part 2.

(3) Spheroidal graphite cast iron bolts shall be Grade EN-GJS-500-7 complying with BS EN 1563.

(4) Bolts, nuts and washers shall be insulated from electrochemically dissimilar metal by non-metallic washers and sleeves.

(5) Bolts and nuts shall be compatible with the type of joint and, unless otherwise approved by the Engineer, shall be obtained from the same manufacturer as the joint.

Elastomeric joint rings 5.18 (1) Elastomeric joint rings shall be Type WC complying with BS EN 681-1. The rings shall be compatible with the type of joint and, unless otherwise approved by the Engineer, shall be obtained from the same manufacturer as the joint.

(2) Elastomeric gaskets for flanged pipes shall be the inside bolt circle type. The gaskets shall be natural rubber with a thickness of 3 mm and with other dimensions complying with BS EN 1514-1.

Detachable couplings and flange adapters 5.19 (1) Detachable couplings and flange adapters shall be of a proprietary type approved by the Engineer.

(2) Detachable couplings and flange adapters shall accommodate the angular deflection and straight draw stated in Table 5.2 for the different nominal diameters of pipes connected.

Table 5.2: Angular deflection and straight draw

Nominal diameter of pipe	Detachable coupling		Flange adapter	
	Angular deflection	**Straight draw**	**Angular deflection**	**Straight draw**
Not exceeding 450 mm	± 6°	± 10 mm	± 3°	± 5 mm
exceeding 450 mm and not exceeding 600 mm	± 5°		± 2.5°	
exceeding 600 mm and not exceeding 750 mm	± 4		± 2°	
exceeding 750 mm and not exceeding 1200 mm	± 3°		± 1.5°	
exceeding 1200 mm and not exceeding 1800 mm	± 2°		± 1°	
exceeding 1800 mm	± 1°		± 0.5°	

Anticorrosion tape 5.20 (1) Anticorrosion tape shall be a proprietary type approved by the Engineer. The tape shall be a rubber/bitumen compound with fabric reinforcement and shall be backed with PVC film. The tape shall have a high resistance to cathodic disbonding, acids and alkalis and shall have the minimum properties stated in Table 5.3.

(2) Anticorrosion tape shall be applied to valves, flanged joints, slip-on couplings and flange adapters. Type 1 shall be used for pipes smaller than 700 mm diameter and Type 2 shall be used for pipes 700 mm diameter and above.

(3) Primer and mastic filler for use with anticorrosion tape shall be compatible with the tape and shall be a type recommended by the manufacturer of the tape and approved by the Engineer.

Table 5.3: Properties of anticorrosion tape
(except where stated the values shown are minimum values)

Property	Value	
	Type 1	Type 2
Thickness of PVC backing (μm)	85	500
Tensile strength (N/mm)	8	10
Elongation (%)	≤ 26	≤ 26
Tear strength (N)	20	36
Adhesion strength (N/mm)	2	2
Holiday test voltage (kV)		
- single layer	10	10
- double layer	15	15
Impact strength (J)	3.5	8
Temperature range (°C)	5 - 60	8 - 60
Total thickness (mm)	1.6	2.0
Mass (kg/m^2)	1.8	2.4

Bituminous coatings 5.21 (1) Bituminous coatings shall comply with the following:

Bitumen-based hot-applied coating for corrosion protection of steel pipes and fittings	: BS EN 10300
Black bitumen coating solutions for cold application	: BS 3416, Type II

(2) Bituminous coatings used for repairing joints and coatings shall be compatible with the adjacent coatings.

Aggregates for granular bed and granular fill 5.22 (1) Granular bed shall be Type A material and granular fill shall be Type B material.

(2) Type A or Type B material shall consist of hard, clean, crushed slag, gravel, crushed rock, crushed concrete or crushed inert demolition material having a grading within the limits of Table 5.4. The ten per cent fines values shall be at least 50 kN. The material passing the 425 μm BS test sieve shall be non-plastic when tested in accordance with Geospec 3.

(3) Type A and Type B materials shall be obtained from a source approved by the Engineer.

(4) Aggregates for granular bed shall have the compacting fraction values stated in Clause 5.88.

Table 5.4: Range of grading of Type A and Type B materials

BS test sieve	Percentage by mass passing	
Metric	**Type A**	**Type B**
63 mm	-	100
37.5 mm	100	85 - 100
20 mm	-	0 - 20
10 mm	45 - 100	0 - 5
3.35 mm	25 - 80	-
600 µm	8 - 45	-
75 µm	0 - 10	-

Table 5.5: Joint filler for concrete bed, haunch and surround

Nominal diameter of pipe	Thickness of joint filler (mm)
less than 450 mm	18
450 mm - 1200 mm	36
exceeding 1200 mm	54

Joint filler and compressible padding 5.23 (1) Joint filler for joints in concrete bed, haunch and surround shall be a firm, compressible, single thickness, non-rotting filler. The thickness of the filler shall be as stated in Table 5.5.

(2) Compressible padding between pipes and supports shall be bitumen damp-proof sheeting complying with BS 743.

Polyethylene sheeting 5.24 Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 0.125 mm.

Precast concrete manholes 5.25 Precast concrete manhole units shall comply with BS EN 1917 & BS 5911:Part 3. Cover slabs and reducing slabs shall be reinforced as required to comply with the load test requirements stated in BS 5911:Part 3.

Chambers and gullies 5.26 (1) Precast concrete chambers shall comply with BS EN 1917 and BS 5911:Part 4. Cover slabs shall be reinforced as required to comply with the load test requirements stated in BS EN 1917 and BS 5911:Part 4. The types of cement for the manufacture of precast concrete chambers and gullies, and cover slabs shall be as stated in BS EN 1917 and BS 5911:Part 4, or a combination of PFA and PC or PFAC complying with BS EN 197-1. The PFA content shall not exceed 40% by mass of the cementitious content.

(2) Vitrified clay gullies shall comply with BS EN 295.

(3) Precast concrete gullies shall comply with BS 5911:Part 6.

Step irons 5.27 Step irons shall comply with BS EN 13101. Step irons shall be malleable cast iron complying with BS EN 1562 and shall be hot-dip galvanized in accordance with BS EN ISO 1461.

Manhole covers, gully 5.28 (1) Manhole covers, gully gratings and kerb overflow weirs made of cast

gratings and kerb overflow weirs made of cast iron

iron shall be of Grade EN-GJL-150 complying with BS EN 1561. Bolts and nuts shall comply with BS 4190.

(2) Covers, gratings and weirs shall be cleanly cast, free of air holes, sand holes, cold shuts and chill and shall be neatly dressed and fettled. Castings shall be free of voids whether due to shrinkage, gas inclusions or other causes. Bolts and nuts shall not be over-tightened.

(3) The dimensions of the different types of covers, gratings and weirs shall be as stated in the Contract. The test loads which the covers and gratings are required to withstand, and the minimum masses of covers gratings and weirs, shall be as stated in Tables 5.6, 5.7 and 5.8.

(4) Covers, gratings and weirs shall have the manufacturer's name cast integrally with the unit in a raised form and shall be protected with bituminous coating. Covers shall have a raised design on the top surface as stated in the Contract.

Gully gratings and channel gratings made of compound material

5.28A (1) Gully gratings and channel gratings made of compound material essentially shall comprise of non-metallic components with strength and properties complying with the conditions stated in this clause. Embedded steel reinforcement bars are permitted on condition that there is a minimum 10 mm cover.

(2) Gratings shall be cleanly cast and free of any holes or voids. The outer surface shall be smooth, regular and with no observable damage.

(3) Gratings shall have the manufacturer’s name cast integrally with the unit in a raised form.

(4) Gratings shall be stored off the ground on level supports in a manner which will not result in damage or deformation of the units. The units shall be protected from direct sunshine.

Table 5.6: Details of manhole covers and frames

Type of manhole cover and frame	Minimum mass (kg)	Grade	Test requirements	
			Diameter of block (mm)	Test load (t)
Double triangular manhole cover and frame	180	Medium duty	100	5
Double triangular manhole cover for sewers	130	Heavy duty	300	30
Frame	105	Heavy duty	300	30
Double triangular desilting manhole cover for sewers	290	Heavy duty	300	30
Frame	165	Heavy duty	300	30
Double seal terminal manhole cover for sewers				
- Type MA2-29/29A & B	-	Heavy duty	300	20
- Type MA2-45/45A & B	-	Heavy duty	300	20
- Type MC2-29/29A & B	-	Medium duty	100	5
- Type MC2-45/45A & B	-	Medium duty	100	5

Table 5.7: Details of gully gratings and frames

Type of gully grating and frame	Minimum mass (kg)	Grade	Test requirements	
			Diameter of block (mm)	Test load (t)
Grating for hinged gully grating Type GA2-325	28.0	Heavy duty	300	20
Frame	24.5	Heavy duty	300	20
Grating for double triangular gully grating Type GA1-450	57.5	Heavy duty	300	20
Shallow frame				
- adjacent to kerb	33.5	Heavy duty	300	20
- away from kerb	36.5	Heavy duty	300	20
Deep frame				
- adjacent to kerb	40.5	Heavy duty	300	20
- away from kerb	44.0	Heavy duty	300	20
Grating for hinged gully grating Type GA2-450	61.5	Heavy duty	300	20
Frame	37.0	Heavy duty	300	20

Table 5.8: Details of kerb overflow weirs

Type of kerb overflow weir	Minimum mass (kg)
Type 1-325	39.5
Type 3-325	31.5
Type 1-450	44.0
Type 3-450	36.5
Type 4-450	33.0

Penstocks 5.29 (1) Penstocks shall comply with the following requirements:

(a) Frames and gates shall be cast iron complying with BS EN 1561, Grade EN-GJL-250.

(b) Stems shall be stainless steel complying with BS EN 10084, BS EN 10085, BS EN 10087, BS EN 10088-1, BS EN 10095, BS EN 10250-4 and PD 970, Grade 1.4401.

(c) Operating nuts shall be gunmetal complying with BS EN 1982, Grade CC491K.

(d) Sealing faces shall be phosphor bronze complying with BS EN12163 & BS EN12167, Grade CW452K.

(e) Sealing strips at inverts of flush invert penstocks shall be elastomer complying with ASTM D 2000.

(f) Assembly and fixing nuts and bolts shall be stainless steel complying with Clause 5.17(2).

(g) Adjustable wedges shall be phosphor bronze complying with BS EN12163 & BS EN12167, Grade CW452K or stainless steel complying with BS EN 10084, BS EN 10085, BS EN 10087, BS EN 10088-1, BS EN 10095, BS EN 10250-4 and PD 970, Grade 1.4401.

(2) Penstocks shall be designed for on-seating pressure or off-seating pressure or both on-seating and off-seating pressures as stated in the Contract.

(3) Sealing faces shall be of rectangular sections and shall be fixed to the frames and gates using taperhead screws of the same material as the sealing faces.

(4) Adjustable wedges shall have sufficient contact areas with the gates to minimise wear.

(5) Frames shall include guide rails or guide faces for gates. Clearance within guides shall be as small as practicable such that the gates will not vibrate under flow conditions.

(6) Penstocks shall have rising stems unless otherwise stated in the

Contract. Rising stems shall have perspex protection tubes with open/close indicators.

Gate valves 5.30 (1) Gate valves shall comply with BS EN 1171 and with the following requirements:

(a) Bodies and wedges shall be cast iron complying with BS EN 1561, Grade EN-GJL-250 and shall have renewable gunmetal seat rings.

(b) Gunmetal for renewable seat rings shall be Grade CC491K complying with BS EN 1982.

(c) Stem nuts shall be gunmetal complying with BS EN 1982, Grade CC491K.

(d) Stems shall be aluminium bronze complying with BS EN12163 & BS EN12167, Grade CW307G.

(e) Assembly and fixing nuts and bolts shall be stainless steel complying with Clause 5.17(2).

(2) Gate valves shall be double flange-ended solid wedge type with nominal pressure designation PN 16. Flanges shall be PN 16 complying with BS EN 1092-1.

(3) Gate valves shall have outside screw rising stems unless otherwise stated in the Contract. Rising stems shall have perspex protection tubes with open/close indicators.

(4) Gate valves shall be fitted with a plate showing the operating position of the valve in the closed, quarter closed, half closed, three-quarters closed and open positions.

(5) Chains for chain operated gate valves shall be mild steel complying with BS EN 10084, BS EN 10085, BS EN 10087, BS EN 10088-1, BS EN 10095, BS EN 10250-4 and PD 970 and hot-dip galvanized in accordance with BS EN ISO 1461. The chains shall be continuous.

Flap valves 5.31 (1) Flap valves shall comply with the following requirements:

(a) Frames and flaps shall be cast iron complying with BS EN 1561, Grade EN-GJL-250.

(b) Sealing faces and hinge pins shall be gunmetal complying with BS EN 1982, Grade CC491K.

(2) The flap shall be hung with double hinges and secured with hinge pins.

(3) Flanges for flange mounting types of flap valves shall be PN 16 complying with BS EN 1092-1.

Sludge valves 5.32 (1) Sludge valves shall comply with the following requirements:

(a) Bodies and valve sections shall be cast iron complying with BS EN 1561, Grade EN-GJL-250.

(b) Sealing faces and stem nuts shall be gunmetal complying with BS EN 1982, Grade CC491K.

(c) Stems shall be aluminium bronze complying with BS EN12163 & BS EN12167, Grade CW307G.

(2) The stems of sludge valves shall operate through non-rising stem nuts housed in bridges bolted over the body sections.

(3) Outlet flanges of sludge valves shall be PN 16 complying with BS EN 1092-1.

Air valves

5.33 (1) Air valves shall be of the elongated body type and shall have a pressure rating of 3 bars unless otherwise stated in the Contract.

(2) Dual orifice air valves shall have:

(a) A small orifice valve for releasing air at working pressure, and

(b) A large orifice valve for allowing air to pass at atmospheric pressure during emptying and filling of pipework.

(3) The bodies and covers of small and large orifice valves shall be cast iron complying with BS EN 1561, Grade EN-GJL-250. The trim and float shall be stainless steel complying with BS EN 10084, BS EN 10085, BS EN 10087, BS EN 10095, BS EN 10088-1, BS EN 10250-4 and PD 970, Grade 1.4401.

(4) Small orifice valves shall have an adjustable Vitron orifice button to ensure positive sealing. Large orifice valves shall have a Buna-N seat.

(5) The valve inlet of small orifice valves shall be 75 mm diameter and the valve outlet shall be 25 mm diameter. The venting orifice shall be 5 mm diameter. The valve inlet and the valve outlet of large orifice valves shall be 75 mm diameter.

(6) Air valves shall be provided with isolating gate valves.

Fittings for penstocks and valves

5.34 (1) Handwheels and tee keys for penstocks and valves shall turn in a clockwise direction for closing. Handwheels shall have smooth rims and the direction of opening and closing shall be clearly cast on the handwheel. The opening effort required at any point on the handwheel rim shall not exceed 250 N when operated against the full unbalanced pressure.

(2) Extension stems for penstocks and valves shall be stainless steel of the same grade as the stems. Extension stems shall be connected with muff couplings.

(3) Handwheels, tee keys, headstocks, guide brackets for stems, supporting brackets, surface boxes and other fittings for penstocks and valves shall be cast iron complying with BS EN 1561.

(4) Bolts and nuts for fixing penstocks and valves to structures shall be stainless steel complying with Clause 5.17(2). Bolts shall be indented foundation bolts.

(5) Grout for filling rebates and box-outs shall be of a proprietary type

approved by the Engineer and shall contain a non-shrink admixture.

Filling abandoned pipes and manholes

5.35 (1) Foam concrete for filling abandoned pipes, culverts, manholes and voids shall be composed of PC (or PFAC), fine aggregate (from natural or recycled aggregate), water, admixtures for accelerating or retarding the setting time and foam to reduce the density and to produce a flowing self levelling material.

(2) As an alternative to foam concrete when permitted by the Engineer, a grout of PC/PFA and water may be used. Sand and admixtures may not be used in the PC/PFA grout unless approved in writing by the Engineer.

(3) The PC/PFA grout shall consist of 15 parts of PFA to 1 part of PC by mass together with the minimum amount of water necessary to achieve a consistency suitable for flowing into the pipes, culverts, manholes and voids.

SUBMISSIONS

Particulars of pipes, joints and fittings

5.36 (1) The following particulars of the proposed pipes, joints and fittings for drainage works shall be submitted to the Engineer:

(a) Manufacturers' literature, including details of:
- manufacturing process
  pressure and temperature ratings
- permissible values of straight draws and angular deflection of flexible joints
- recommendations for handling, storage, laying, jointing and repair
- drilling and tapping equipment for connections to pipes, and

(b) A certificate for each material showing the manufacturer's name, the date and place of manufacture and showing that the material complies with the requirements stated in the Contract and including results of tests required in accordance with the Contract.

(2) The particulars, including certificates, shall be submitted to the Engineer at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material delivered to the Site.

Particulars of anticorrosion tape and joint filler

5.37 (1) The following particulars of the proposed anticorrosion tape and joint filler for drainage works shall be submitted to the Engineer:

(a) Manufacturer's literature for anticorrosion tape, and

(b) Certificates for anticorrosion tape and joint filler showing the manufacturer's name, the date and place of manufacture and showing that the material complies with the requirements stated in the Contract and including results of tests in accordance with the Contract.

(2) The particulars, including certificates, shall be submitted to the Engineer at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material delivered to the Site.

Particulars of aggregates for granular bed

5.38 (1) A certificate for each type of aggregate showing the source of the aggregate and showing that the aggregate complies with the requirements stated in the Contract, and including the results of tests in accordance with the Contract, shall be submitted to the Engineer for the proposed aggregates for granular bed for drainage works.

(2) The particulars, including certificates, shall be submitted to the Engineer at least 14 days before the first delivery of the aggregate to the Site and thereafter each time the source is changed.

Particulars of manholes, chambers and gullies

5.39 (1) The following particulars of the proposed materials for manholes, chambers and gullies for drainage works shall be submitted to the Engineer:

(a) A certificate for each type of manhole and chamber unit and for each type of gully showing the manufacturer's name, the date and place of manufacture and showing that the materials comply with the requirements stated in the Contract and including results of tests required in accordance with the Contract,

(b) A certificate for step irons showing the manufacturer's name, the date and place of manufacture and showing that the step irons comply with the requirements stated in the Contract, and including results of tests required in accordance with the Contract, and

(c) A certificate for each type of manhole cover, gully grating and kerb overflow weir showing the manufacturer's name, the date and place of manufacture and showing that the materials comply with the requirements stated in the Contract and including results of tests in accordance with the Contract.

(2) The particulars, including certificates, shall be submitted to the Engineer at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material delivered to the Site.

Particulars of penstocks and valves

5.40 (1) The following particulars of the proposed penstocks and valves for drainage works shall be submitted to the Engineer:

(a) Manufacturer's literature, including details of:
- Materials
- Pressure ratings
- Recommendations for handling, storage and installation,

(b) Drawings showing details of the penstocks and valves, including lengths of stems and details of handwheels, tee keys, extension stems, headstocks, guide brackets for stems, supporting brackets, surface boxes and other fittings, and positions and sizes of rebates and box-outs.

(2) The particulars shall be submitted to the Engineer at least 28 days before the first delivery of the material to the Site.

Particulars of foam concrete and PC/PFA grout

5.41 (1) The following particulars of the foam concrete and grouting procedure for filling abandoned pipes, culverts, manholes and voids shall be submitted to the Engineer:

(a) Proportions of each constituent,

(b) Source of supply,

(c) Details of mixing,

(d) Setting time,

(e) Strength,

(f) Shrinkage expected (for PC/PFA grout),

(g) Details of mixing and grouting equipment, and

(h) Method of grouting, including details of trials.

(2) The particulars shall be submitted to the Engineer at least 7 days before grouting starts.

Particulars of tests 5.42 (1) The following particulars of the proposed procedures for tests on pipelines and penstocks for drainage works shall be submitted to the Engineer:

(a) Test equipment and method of setting up the equipment,

(b) Calibration certificates for pressure gauges,

(c) Procedure for carrying out the test, and

(d) Programme for testing.

(2) The particulars shall be submitted to the Engineer at least 14 days before the test starts.

Particulars of CCTV inspections 5.43 (1) The following particulars of the proposed procedure for CCTV inspections shall be submitted to the Engineer:

(a) Names and experience of persons carrying out or supervising the inspections,

(b) Details of equipment,

(c) Details of the format of report, and

(d) Examples of video films and photographs obtained from inspections employing the same equipment.

(2) The particulars of the procedure shall be submitted to the Engineer at least 28 days before the inspection starts.

Particulars of diversions of flow 5.44 Unless otherwise permitted by the Engineer particulars of the proposed procedures for diversions of existing flows shall be submitted to the Engineer at least 14 days before the diversion starts.

TRANSPORT, HANDLING AND STORAGE OF MATERIALS

Transport, handling and storage of pipes, joints and fittings

5.45 (1) Pipes, joints and fittings for drainage works shall be transported, handled and stored in accordance with the manufacturer's recommendations and in a manner which will not result in damage or deformation to the pipes, joints and fittings or in contamination of the pipes, joints and fittings.

(2) Pipes, joints and fittings shall be protected from damage and damaged pipes, joints and fittings shall not be used in the permanent work unless permitted by the Engineer.

(3) PE pipes, uPVC pipes, and their joints and fittings shall be protected from exposure to conditions which may affect the material.

(4) Bolts and nuts shall be packed in sealed metal containers.

(5) Elastomeric joint rings shall be packed in bags and lubricant for joints shall be stored in sealed containers marked to identify the contents. The rings and lubricant shall be protected from exposure to conditions that may affect the material.

Handling of pipes and fittings

5.46 (1) Pipes and fittings shall be handled manually or by using lifting appliances or chains, wire rope or canvas slings of a type recommended by the pipe manufacturer and agreed by the Engineer. Hooks shall not be used.

(2) Slings shall be placed around the pipes and fittings and padding shall be provided at points of contact between pipes and fittings and metal lifting appliances or slings. Pipes shall not be handled by means of metal slings passed through the pipes.

(3) Pipes and fittings shall not be subjected to rough handling, shock loading or dropping and shall not be rolled down ramps unless permitted by the Engineer. If permitted, the ramps shall be padded.

Storage of pipes

5.47 (1) Pipes shall be stored horizontally at least 75 mm above the ground on wedged timber bearers. The bottom layers and the outer pipes in each layer shall be securely wedged to prevent sideways movement.

(2) Socket and spigot pipes shall be stored with the sockets alternating and in such a manner that loads are not applied to the sockets.

(3) The height of stacks of pipes shall not exceed 2 m unless recommended by the manufacturer and permitted by the Engineer.

(4) Pipes shall not be strung out along the route of the pipeline unless permitted by the Engineer.

Storage of anticorrosion tape and joint filler

5.48 Anticorrosion tape and joint filler shall be stored in accordance with the manufacturer's recommendations in a dry, weatherproof store with a raised floor.

Handling and storage of aggregates for granular bed

5.49 Aggregates for granular bed shall not be handled or stored in a manner that will result in mixing of the different types and sizes or in contamination of the aggregates. Different types and sizes of aggregates shall be stored in separate stockpiles.

Handling and storage of units for manholes, chambers and gullies

5.50 (1) Units for manholes, chambers and gullies shall be lifted only at the lifting points recommended by the manufacturer and shall not be subjected to rough handling, shock loading or dropping.

(2) Units for manholes, chambers and gullies shall be stored off the ground on level supports and in a manner that will not result in damage to the units or in contamination or deformation of the units. The units shall be protected from damage and damaged units shall not be used in the permanent work unless permitted by the Engineer.

Storage of covers, gratings, weirs penstocks and valves

5.51 Manhole covers, gully gratings, kerb overflow weirs, penstocks and valves, including fittings, shall be stored off the ground on level supports and in a manner which will not result in damage to the units or in contamination or deformation of the units. The units shall be protected from damage and damaged units shall not be used in the permanent work unless permitted by the Engineer.

EXCAVATION

Excavation

5.52 (1) Excavation for any section of a trench for drainage works shall not commence until the nature, location and size of existing utilities which may be affected by the excavation have been ascertained and the setting out details have been approved by the Engineer.

(2) The effective trench width of trenches for drainage works shall not exceed the relevant effective trench widths stated in Table 5.9 for the different diameters of pipe. The effective trench width shall be measured as stated in the Contract.

Table 5.9: Effective trench widths

Nominal diameter of pipe (mm)	Effective trench width (mm)	Nominal diameter of pipe (mm)	Effective trench width (mm)
100	550	1125	2200
150	600	1200	2300
225	700	1350	2450
300	750	1500	2600
375	1050	1650	2800
450	1150	1800	2950
525	1200	1950	3150
600	1350	2100	3350
675	1450	2250	3400
750	1500	2400	3500
825	1600	2550	3650
900	1900	2700	3800
975	2000	2850	3950
1050	2050	3000	4150

LAYING AND BEDDING PIPES

Laying pipes 5.53 (1) The Contractor shall allow the Engineer to inspect trenches, bedding, pipes, joints, fittings and valves before pipe-laying for drainage works starts. The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before pipe-laying starts in any part of the permanent work.

(2) The permission of the Engineer shall be obtained before pipe-laying starts in any part of the permanent work.

(3) The Contractor shall inspect pipes, joints, fittings and valves, including internal and external coatings, immediately before and after pipe-laying. Valves shall be inspected to ensure that they are in working order and are capable of being fully opened and closed. Deleterious material shall be removed and damage shall be repaired immediately before and after pipe-laying.

(4) The inside of pipelines shall be kept clean and free of water, dirt, stones, debris and deleterious material. Except when pipes are being jointed, the open ends of pipelines shall be sealed with a wooden plug or stopper or by

other methods agreed by the Engineer.

(5) Measures shall be taken to prevent flotation of pipes.

(6) Pipe-laying, testing and backfilling shall follow as closely as practicable on excavation of the trench.

(7) Unless otherwise permitted by the Engineer, pipelines shall be laid in an uphill direction with sockets facing uphill.

(8) Pipes shall be laid in such a manner that water will not pond in locations with zero or shallow gradients and such that the pipes will comply with the specified tolerances.

Bedding pipes 5.54 (1) Surfaces on which pipes for drainage works will be laid shall be cleaned and objects that may damage the pipes shall be removed before pipes are laid.

(2) The bottom of trenches on which pipes will be laid directly shall be shaped to support the pipes uniformly along the length of the barrel. Holes shall be dug to prevent pipes resting on the sockets and to allow the pipes to be jointed.

CUTTING PIPES

Cutting pipes 5.55 (1) Pipes for drainage works shall be cut and the ends shall be prepared in accordance with the manufacturer's recommendations. Purpose-made equipment recommended by the manufacturer or approved by the Engineer shall be used for cutting the pipes.

(2) Cut ends of pipes shall be square or cut to the correct angle and without damage to the pipe or coating. Cut ends shall be trimmed and chamfered to suit the type of joint and in such a manner that elastomeric joint rings will not be damaged by the cut end.

(3) Pipes requiring to be cut to form closing lengths shall not be cut until adjacent pipes have been laid and jointed and the length to be cut can be accurately measured.

(4) Reinforcement in precast concrete pipes that are cut shall be cut back flush with the concrete and protected with epoxy resin or by other methods agreed by the Engineer.

(5) Pipes which terminate at the inside face of structures shall be cut such that the end of the pipe is flush with the face.

JOINTING PIPES

Jointing pipes 5.56 (1) Pipes for drainage works shall be jointed in accordance with the manufacturer's recommendations and using jointing equipment and jointing materials recommended by the manufacturer or approved by the Engineer.

(2) The Contractor shall inspect pipes, joints, fittings and valves, including internal and external coatings, immediately before and after jointing. Deleterious material shall be removed and damage shall be repaired immediately before and after jointing. Surfaces that are to be jointed and jointing materials shall be cleaned immediately before jointing. Pipes shall be cleaned out with clean water.

(3) All joints in pipelines shall be watertight.

(4) The widths of gaps at joints shall be in accordance with the manufacturer's recommendations and shall be achieved by marking the outside of the pipe, by using metal feelers or by other methods agreed by the Engineer. The position of elastomeric joint rings shall be checked by using metal feelers after jointing.

(5) Gaps at joints in pipes shall be protected after jointing, by methods agreed by the Engineer, to prevent dirt, stones or other material entering the joint.

Flanged joints 5.57 (1) Flanged joints in pipes for drainage works shall be made as stated in Clauses 5.57(2) and (3).

(2) Bolts holes in flanged joints and joints incorporating bolted components shall be correctly orientated before the bolts are tightened. The correct size of bolts and nuts shall be used. Bolt threads shall be lubricated and bolts shall be tightened using the correct size of spanner. Bolts shall be tightened in diametrically opposite pairs working around the bolt circle until all bolts are tightened to the torque recommended by the manufacturer.

(3) Bolt holes in flanged joints shall be orientated symmetrically about the vertical diameter with no bolt holes on the vertical diameter. Elastomeric joint rings shall be the correct size and shall not protrude into the bore of the pipe. The rings may be temporarily fixed to the face of the flange using a minimum amount of adhesive of a type recommended by the manufacturer. Jointing compound or paste shall not be used for this purpose.

Flexible collar joints 5.58 (1) Flexible collar joints in pipes for drainage works shall be made as stated in Clauses 5.58(2) to (4).

(2) The elastomeric joint rings shall be placed in position inside the grooves of the sleeve. The ends of the pipes shall be well smeared with lubricant over a distance of at least 100 mm from the end of the pipe.

(3) The sleeve shall be placed on the end of the laid pipe and pushed home to the location mark on the pipe. The location mark shall be at a distance of half the length of the sleeve minus 3 mm from the end of the pipe unless otherwise recommended by the manufacturer.

(4) The pipe that is to be jointed to the laid pipe shall be placed in the sleeve

and pushed home to the location mark on the pipe.

Push-in joints 5.59 Push-in joints in pipes for drainage works shall be made by smearing the elastomeric joint ring with lubricant and placing the ring in position on the spigot end of the pipe. The spigot shall be placed in the socket of the laid pipe and pushed home.

Detachable joints 5.60 (1) Detachable joints in pipes for drainage works shall be jointed as stated in Clauses 5.60(2) and (3).

(2) Both CI flanges, the elastomeric joint rings and the central collar shall be placed over the ends of the pipes before the pipes are placed to the required line and level. A gap of between 5 mm and 6 mm shall be left between the ends of the pipes.

(3) The flanges, elastomeric joint rings and central collar shall be moved into position at the ends of the pipes. The central collar shall be positioned centrally over the gap between the ends of the pipe before the bolts are tightened.

Flange adapters 5.61 Joints with flange adapters in pipes for drainage works shall be made by placing the flange adaptor on the plain end before the bolts are tightened.

Solvent welded joints 5.62 Solvent welded joints in pipes for drainage works shall be made by applying solvent cement to the pipes to be jointed and pushing the pipes home. Excess solvent shall not be applied and surplus solvent shall be removed after jointing. Solvent welded pipes jointed outside the trench shall not be placed in the trench until the solvent setting period recommended by the manufacturer has elapsed. In addition, any material or thing contaminated by the solvent shall not be left in the pipe or trench.

Screw joints 5.63 Screw joints in pipes for drainage works shall be made using a threaded coupler. The threaded surfaces of the pipes and coupler shall be cleaned and the threads shall be painted with two coats of bituminous paint. The pipe thread shall be wrapped with three turns of spun yarn or other material approved by the Engineer and the joint tightened using purpose- made tools. Coal tar compounds or white lead paint shall not be used. Locking nuts to branch connections shall be tightened. Branch connections shall not protrude inside the pipe.

Butt fusion joints 5.63A The butt fusion welding parameters for welding PE pipes to pipes and PE pipes to spigot fittings shall be recommended by the manufacturer. Site PE fusion jointing shall be made in accordance with WIS No. 4-32-08 using automatic equipment with data printout facilities.

Electrofusion joints 5.63B The electrofusion joints used in PE electrofusion fittings, including couplers, reducers, socket ends, tees, etc. shall comply with BS EN 12201-3. The electrofusion welding parameters shall be recommended by the manufacturer. Site fusion jointing shall be made in accordance with WIS No. 4-32-08 using automatic equipment with data printout facilities.

PROTECTION OF JOINTS

Protection of joints 5.64

(1) Flanged joints, detachable couplings and flange adapters on buried pipes for drainage works shall be protected as stated in Clauses 5.64(2) to (4).

(2) The joint, including bolts and nuts, shall be cleaned to remove all moisture, dust, oil, grease and deleterious material. Bolts and nuts shall be painted with two coats of bituminous point and the joint shall be coated with primer. Mastic filler shall be applied in such a manner that all depressions, corners and voids between the bolts and nuts are filled and a smooth surface is available on which to apply the anticorrosion tape.

(3) At least two layers anticorrosion tape shall be applied to all parts of the joint and to the adjacent pipe for at least 200 mm beyond each end of the joint. The tape shall be applied in accordance with the manufacturer's recommendations and shall be wrapped spirally around the joint and pipe with at least 55% overlap per spiral.

(4) The tape shall be moulded manually after application to take up the contours of the parts being protected.

REPAIRS TO COATINGS AND LININGS

Repairs to coatings and linings 5.65

Damage to coatings and linings of pipes for drainage works shall not be repaired unless permitted by the Engineer. If permitted, repairs shall be carried out using materials recommended by the manufacturer and approved by the Engineer.

THRUST AND ANCHOR BLOCKS

Thrust and anchor blocks 5.66

(1) Thrust or anchor blocks shall be used to resist forces at bends, branches and stopends in pressure pipelines for drainage works except where self anchoring joints are used. Concrete for thrust and anchor blocks shall be Grade 20. The aggregates for the Grade 20 concrete shall be natural stone, crushed rock, crushed concrete or recycled aggregates.

(2) The bearing face, and other faces stated in the Contract, of concrete anchor and thrust blocks shall be cast directly against undisturbed ground. The faces of excavations shall be trimmed to remove loose material before concreting. Excavation required for the block beyond the trench width shall be carried out after the pipe or fitting has been jointed. Excess excavation beyond the face at the block shall be filled with concrete of the same Grade as the block.

(3) Internal pressure shall not be applied to the pipeline until thrust and anchor blocks have developed the specified grade strength.

BED, HAUNCH AND SURROUND

Granular bed 5.67

(1) The granular bed to pipelines for drainage works shall be constructed as stated in Clauses 5.67(2) to (4).

(2) Aggregates for the granular bed shall be deposited in the trench in layers not exceeding 150 mm thick and for the complete width of the trench. Each layer shall be compacted using a plate vibrator or by other methods agreed by the Engineer.

(3) Holes shall be dug in the granular bed to prevent pipes resting on the sockets and to allow the pipes to be jointed. The pipes shall be laid directly on the granular bed. Temporary supports shall not be used.

(4) After the pipes have been jointed, aggregate shall be deposited in layers not exceeding 150 mm thick equally on both sides of the pipe to the specified level for the complete width of the trench. Each layer shall be compacted using a plate vibrator or by other methods agreed by the Engineer.

Concrete bed, haunch and surround 5.68

(1) The concrete bed, haunch and surround to pipelines for drainage works shall be constructed as stated in Clauses 5.68(2) to (7).

(2) Concrete for the concrete bed, haunch and surround shall be Grade 20.

(3) Polyethylene sheeting or a blinding layer shall be placed on the trench bottom before concreting.

(4) Pipes shall be supported at the required level by Grade 20 precast concrete wedges, blocks or cradles or by other methods agreed by the Engineer. One support shall be placed adjacent to each end of each pipe and the spacing between supports shall not exceed 3 m. Compressible sheeting shall be placed between the pipes and supports.

(5) Flexible joints shall be formed in the concrete bed, haunch and surround at flexible joints in pipelines. Joint filler shall be placed next to the flexible joint in the pipeline and shall extend for the complete thickness of the bed, haunch and surround.

(6) Concrete shall be placed evenly over the complete width of the bed and over the complete length of the pipe being concreted up to a level of 25 mm below the underside of the pipe. Concrete shall then be placed on one side of the pipe only and worked under the pipe until the concrete spreads under the pipe. Concrete shall then be placed equally on both sides of the pipe to the specified level.

(7) Pipes for drainage works which are 1 m or less below the surface of a carriageway shall be protected with Grade 20 concrete surround.

(8) The aggregate for Grade 20 concrete stated in (1) to (7) of this clause shall be natural stone, crushed rock, crushed concrete, or recycled aggregates if available and if proposed by the Contractor. Such Grade 20 concrete shall have the following minimum cementitious content:

Exposure condition*	Minimum cementitious content (kg/m^3)

Moderate	280
Severe	330

[* Exposure condition shall be as stated in the Contract]

Fill material surround 5.69 Fill material surround to pipelines for drainage works shall be deposited and compacted as stated in Clauses 6.43 and 6.48.

TOLERANCES

Tolerances: pipelines for drainage works 5.70 (1) Except as stated in Clause 5.70(2), pipelines for drainage works shall comply with the following requirements:

(a) The line of gravity pipelines shall be within 20 mm of the specified line.

(b) The invert level of gravity pipelines shall be within 6 mm of the specified invert level and shall be such that there is no backfall at any point.

(c) The line of pressure pipelines shall be within 50 mm of the specified line.

(d) The invert level of pressure pipelines shall be within 20 mm of the specified invert level.

(2) Termination pipes in pipelines for drainage works which are designed to connect to pipes or fittings laid by others shall comply with the following requirements:

(a) The position of the centre of the termination face of the pipe in the longitudinal direction shall be within 10 mm of the specified position.

(b) The position of the centre of the termination face of the pipe in the lateral direction shall be within 3 mm of the specified position.

(c) The gradient of the termination pipe shall be within 0.5° of the specified gradient.

(d) The invert level at the termination face of the pipe shall be within 3 mm of the specified invert level.

CONNECTIONS

Connections to structures 5.71 (1) The joints between pipes for drainage works and structures into which the pipes are built shall be watertight. Protective coatings shall be removed over the length to be built in before the pipe is built in. Pipe collars and sockets shall not be built in to structures.

(2) Two flexible joints shall be provided in pipelines (except PE pipelines) adjacent to the outside faces of structures into which pipes will be built. The

distances from the outside face of the structure to the first joint and from the first joint to the second joint shall be as stated in Table 5.10.

(3) The ends of pipes, which are built in to structures, shall be temporarily sealed with a blank flange, brickwork or timber boarding as instructed by the Engineer. The temporary seals shall be left in position until the Engineer instructs their removal.

Table 5.10: Flexible joints at structures

Diameter of pipe	**Position of first flexible joint From structure**		**Distance of second flexible joint from first flexible joint**
	Minimum	Maximum	
not exceeding 450 mm	150 mm	500 mm or diameter of pipe, whichever is less	450 mm - 800 mm
exceeding 450 mm but not exceeding 1050 mm			900 mm - 1200 mm
exceeding 1050 mm			1500 mm - 1800 mm

Connections to pipes 5.72

(1) Pipe saddles shall be connected to concrete or vitrified clay pipes by bedding the saddle on a cement mortar bed and forming a cement mortar fillet to provide at least 50 mm cover to the base of the saddle. Cement mortar shall consist of cement and sand in the proportions 1:3 by mass.

(2) uPVC pipe saddles shall be fixed to uPVC pipes by means of a purpose-made mechanical clip or solvent cement of a type recommended by the manufacturer and approved by the Engineer.

(2A) PE pipe saddles shall be fixed to PE pipes by means of electrofusion as recommended by the manufacturer and approved by the Engineer.

(3) Unless otherwise agreed by the Engineer, branch pipelines shall be connected to main pipelines using Y-junctions of the same type and strength as the stronger of the pipes being jointed. The angle of the Y-junction shall be between 30° and 45°.

(4) Pipes which are to be connected to concrete or clay pipes without a Y-junction or purpose-made pipe saddle shall be cut on a splay to form a junction such that the incoming pipe is at an angle of between 30° and 60° to the main pipe upstream of the joint. The hole that is cut in the main pipe to which a connection is to be made shall be of a suitable elliptical shape to suit the cut end of the branch pipe. The length of the branch pipe shall be such that:

(a) The cut end of the pipe rests on the outside barrel of the main pipe, and

(b) The cut pipe does not project inside the main pipe.

The joint between the cut pipe and the main pipe shall be sealed externally and, unless otherwise permitted by the Engineer, sealed internally flush with the main pipe with cement mortar. Cement mortar shall consist of cement and sand in the proportions 1:3 by mass.

(5) The positions of the pipe junctions relative to the manhole or structure immediately downstream shall be measured and recorded before backfilling.

(6) The ends of connecting pipes, which are not required for immediate use, shall be sealed with a blank flange, brickwork or other methods instructed by the Engineer and the position measured and recorded before backfilling.

MANHOLES, CHAMBERS, GULLIES AND CHANNELS

Manholes, chambers and gullies

5.73 (1) Bases, inverts and benching for precast concrete manholes shall be constructed in-situ using Grade 20 concrete, unless otherwise stated in the Contract.

(2) Precast concrete units for manholes and chambers shall be set vertically with step irons staggered and vertically aligned above each other. Joints between precast units shall be the rebated type and shall be sealed with cement mortar. Lifting holes shall be filled with cement mortar. Surplus cement mortar shall be removed and joints shall be pointed.

(3) Concrete surround to manholes, chambers and gullies shall be Grade 20 concrete. Joints in concrete surround shall be staggered by at least 150 mm from joints in the precast units. Concrete surround to gullies shall be placed up to the sides of the excavation.

(4) The frames for manhole covers and gully gratings shall be set to the same levels as the surrounding surface, allowing for falls and cambers, using brickwork and/or concrete as specified in the Contract. The number of courses of brickwork used below frames shall not exceed three and the minimum grade for concrete shall be Grade 20.

(5) Cement mortar for fixing manhole covers and gully gratings in position and bonding brickwork shall consist of cement and sand in the proportions 1:3 by mass.

(6) Excavations around manholes and chambers in carriageways shall be filled using Grade 10 concrete up to the carriageway formation level. Fill material for excavations around other manholes and chambers shall be fine fill material.

Concrete open channels

5.74 (1) The top surfaces of side-walls of concrete open channels shall be constructed to the same levels as the adjoining permanent works. Excess excavation beyond the channel walls shall be filled with Grade 10 concrete.

(2) Expansion joints in concrete channels shall comply with Section 16. Expansion joints shall be provided at intervals of 10 m maximum in all concrete channels. Joints for channels, berm slabs, aprons and walls etc. shall be on the same alignment.

MARKER BLOCKS

Marker blocks 5.75 (1) The ends of pipes that do not terminate at a manhole, chamber, gully or structure shall be marked with marker blocks. The blocks shall be 150 mm x 150 mm x 150 mm and shall be constructed using Grade 20 concrete.

(2) A wire shall be connected from a hook on the underside of the block to the plug on the end of pipes.

(3) Marker blocks shall be set flush with level of the adjacent permanent works and shall have the letters `CD' marked on the upper surface.

INSTALLATION OF PENSTOCKS AND VALVES

Installation of penstocks and valves 5.76 (1) Penstocks and valves shall be installed in accordance with the manufacturer's recommendations and in the closed position.

(2) Frames for penstocks shall be fixed in position leaving a 20 mm gap between the frame and the concrete surface. Contact between the penstock door and frame shall be checked using a feeler gauge 0.1 mm thick or other size recommended by the manufacturer.

(3) Box-outs and rebates for penstock and valve frames and gaps between frames and concrete surfaces shall be filled with cement mortar.

(4) After installation, penstocks and valves shall be cleaned and moving parts shall be lightly greased and checked for ease of operation. Penstocks and valves shall be left in a closed position.

PIPES AND MANHOLES TO BE ABANDONED

Pipes and manholes to be abandoned 5.77 (1) If the top of a pipe or culvert, or the bottom of a manhole, chamber or gully, which is to be abandoned is 1 m or less below the finished ground level (for a pipe, culvert, manhole, chamber or gully underneath or within carriageways, the corresponding depth should be increased to 1.2 m), the abandoned pipe, culvert, manhole, chamber or gully shall be removed and disposed of unless otherwise permitted by the Engineer. The void shall be filled with foam concrete, granular fill material or special fill material (or recycled aggregates proposed by the Contractor) as directed by the Engineer.

(2) If the top of a pipe or culvert, or the bottom of a manhole, chamber or gully, which is to be abandoned is more than 1 m below the finished ground level (for a pipe, culvert, manhole, chamber or gully underneath or within carriageways, the corresponding depth should be increased to 1.2 m), the abandoned pipe, culvert, manhole, chamber or gully if not demolished or removed shall be filled with foam concrete or grout as stated in Clause 5.35.

(3) Manholes, chambers and gullies that are to be abandoned shall be demolished to at least 1 m below the finished ground level (for manholes, chambers and gullies underneath or within carriageways, the corresponding

depth should be increased to at least 1.2 m) unless otherwise stated in the Contract. Abandoned pipes, culverts, manholes, chambers and gullies shall be filled with foam concrete or grout, by pumping or by gravity. The lowest point of the abandoned pipes shall be sealed with concrete, bricks or by other methods approved by the Engineer. Filling shall start from the lowest point and shall continue until all voids are completely filled.

CLEANING OF PIPELINES

Cleaning of pipelines 5.78 (1) Pipelines for drainage works shall be cleaned by pigging, by high-pressure water jetting or by other methods agreed by the Engineer. Manholes and chambers shall be cleaned and washed. Cleaning shall be carried out after:

(a) the pipeline has been tested,

(b) Temporary Works required for testing have been removed, and

(c) parts of the pipeline removed for testing have been reconnected.

(2) Unless otherwise permitted by the Engineer, pipelines shall be cleaned not more than 7 days before the pipeline is handed over.

(3) Materials excavated/cleared from pipelines shall be disposed of at dumping site(s) provided by the Contractor or the Employer. They shall be handled in an environmentally responsible manner without causing pollution or nuisance to the public as far as possible. In particular :

(a) Materials excavated/cleared shall either be placed in bags as soon as possible after excavation or, if they are temporarily stockpiled on roads/footpaths or areas close to the public, be covered and underlain by tarpaulin sheets to minimize fouling of the ground and escape of odour. The ground shall be cleansed after removal of the materials.

(b) The materials shall be dewatered before disposal in accordance with the requirements of the dumping site if necessary. During transportation of the materials, measures shall be taken to prevent leakage of foul water onto roads and public areas and escape of odour.

INSPECTION OF PIPELINES

Inspection of pipelines 5.79 Unless otherwise permitted by the Engineer, the cleanliness, bore, linearity and joints of pipelines of 450 mm diameter or less shall be checked by pulling a mandrel through the completed pipeline, or parts of the pipeline if permitted by the Engineer, after cleaning. The mandrel shall be 750 mm long and 12 mm less in diameter than the nominal diameter of the pipe.

Inspection of pipelines by CCTV 5.80 The procedure for internal inspection of pipelines by CCTV shall be as stated in Appendix 5.1.

TESTING: PIPES FOR DRAINAGE WORKS

Batch: pipes for drainage works

5.81 A batch of pipes or fittings for drainage works is any quantity of pipes or fittings of the same type and nominal diameter, manufactured by the same manufacturer, covered by the same certificates and delivered to the Site at any one time.

Samples: pipes for drainage works

5.82 Unless otherwise required by the Engineer, one sample of pipe for drainage works and each type of fitting shall be provided from each 50 pipes or fittings or part thereof in a batch.

Testing: pipes for drainage works

5.83 (1) Unless otherwise permitted by the Engineer, each sample of pipes and fittings for drainage works shall be tested in accordance with the relevant British Standards and European Standards.

(2) The method of testing shall be in accordance with the following:

Concrete pipes and fittings	: BS EN 1916 and BS 5911:Part 1
Vitrified clay pipes, fittings and joints	: BS EN 295
Ductile iron pipes and fittings	: BS EN 545 and BS EN 598
Grey iron pipes and fittings	: BS 4622
uPVC pipes for industrial purposes	: BS 3506
uPVC soil and ventilating pipes, fittings and accessories	: BS 4514 for DN/OD 82 (if adopted by industry); BS EN 1329-1 (for others)
uPVC gravity surface water pipes and fittings above ground	: BS EN 12200 - 1, BS EN 607, BS EN 1462
uPVC storm water pipes and fittings below ground	: BS 4660 & BS EN 13598-1
uPVC pipes and fittings for gravity sewage pipes above ground	: BS 5255, BS EN 1329-1
uPVC pipes and fittings for gravity sewage pipes below ground	: BS EN 1401-1
PE compounds	: BS EN 12201-1
PE pipes	: BS EN 12201-2
PE fittings	: BS EN 12201-3

Non-compliance: pipes for drainage works 5.84 (1) If the result of any test required in accordance with the relevant British Standard for pipes and fittings for drainage works does not comply with the specified requirements for the test, one additional sample shall be provided from the same batch and additional tests for the property shall be carried out.

(2) The batch shall be considered as not complying with the specified requirements for the property if the result of any additional test does not comply with the specified requirements for the property.

TESTING: AGGREGATES FOR GRANULAR BED

Batch: aggregates for granular bed 5.85 A batch of aggregates for a granular bed is any quantity of aggregates for granular bed of the same type, produced at the same time in the same place, covered by the same certificates and delivered to the Site at any one time.

Samples: aggregates for granular bed 5.86 (1) Unless otherwise permitted by the Engineer, one sample of aggregates for a granular bed shall be provided from each batch of aggregates for granular bed delivered to the Site.

(2) The size of each sample shall be 40 kg.

(3) The method of sampling shall be in accordance with CS3.

(4) The moisture content of the sample shall be representative of the moisture content of the material in the batch.

Testing: aggregates for granular bed 5.87 Each sample of aggregates for a granular bed shall be tested to determine the particle size distribution and the ten per cent fines value in accordance with CS3, and the compaction fraction value in accordance with Appendix 5.2.

Compliance criteria: compaction fraction value 5.88 The results of tests for compaction fraction value of aggregates for a granular bed shall comply with the following requirements:

(a) The compaction fraction value for a bed for pipes not exceeding 300 mm nominal diameter shall not exceed 0.3.

(b) The compaction fraction value for a bed for pipes exceeding 300 mm nominal diameter shall not exceed 0.15.

TESTING: PRECAST CONCRETE UNITS FOR MANHOLES, CHAMBERS AND GULLIES

Batch: manholes, chambers and gullies 5.89 A batch of precast concrete units for manholes, chambers or gullies is any quantity of precast concrete units for manholes, chambers or gullies of the same type and size, manufactured by the same manufacturer, covered by the same certificates and delivered to the Site at any one time.

Samples: manholes, chambers and gullies 5.90 Unless otherwise permitted by the Engineer, one sample of precast units for manholes, chambers or gullies shall be provided from each 50 precast concrete units for manholes, chambers or gullies or part thereof in a batch.

Testing: manholes, chambers and gullies 5.91 (1) Unless otherwise permitted by the Engineer, each sample of precast concrete units for manholes, chambers or gullies shall be tested in accordance with the relevant British Standard.

(2) The method of testing shall be in accordance with the following:

Precast concrete units for manholes	: BS EN 1917 & BS 5911:Part 3
Inspection chambers	: BS EN 1917 and BS 5911-4
Precast concrete gullies	: BS 5911:Part 6
Vitrified clay gullies	: EN 295

Non-compliance: manholes, chambers and gullies 5.92 (1) If the result of any test required in accordance with the relevant British Standard for precast concrete units for manholes, chambers or gullies does not comply with the specified requirements for the test, one additional sample shall be provided from the same batch and additional tests for the property shall be carried out.

(2) The batch shall be considered as not complying with the specified requirements for the property if the result of any additional test does not comply with the specified requirements for the property.

TESTING: MANHOLE COVERS, GULLY GRATINGS AND KERB OVERFLOW WEIRS MADE OF CAST IRON

Batch: covers, gratings and weirs 5.93 A batch of manhole covers, gully gratings or kerb overflow weirs is any quantity of covers, gratings or weirs of the same type, manufactured by the same manufacturer, covered by the same certificates and delivered to the Site at any one time.

Samples: covers, gratings and weirs 5.94 One sample of manhole covers, gully gratings or kerb overflow weirs shall be provided from each 20 covers, gratings or weirs or part thereof in a batch.

Testing: covers, gratings and weirs 5.95 (1) Each sample of manhole covers, gully gratings or kerb overflow weirs shall be weighed and subjected to a load test.

(2) The method of testing shall be as stated in Appendix 5.3. The test loads shall be as stated in Table 5.6 and Table 5.7.

Compliance criterion: resistance to fracture of covers and gratings 5.96 Manhole covers and gully gratings shall withstand the test load without fracturing or cracking.

Non-compliance: mass of covers, gratings and weirs 5.97 (1) If any manhole cover, gully grating or kerb overflow weir does not comply with the specified requirements for mass, every cover, grating and frame in the batch shall be weighed to determine its mass.

(2) If any cover, grating or weir does not comply with the specified requirements for mass, it shall not be used in the permanent work.

Non-compliance: resistance to fracture of covers and gratings

5.98 (1) If any manhole cover or gully grating does not comply with the specified requirements for resistance to fracture, two additional samples shall be provided from the same batch and tested to determine their resistance to fracture.

(2) The batch shall be considered as not complying with the specified requirements for resistance to fracture if the result of any additional test does not comply with the specified requirements for resistance to fracture.

TESTING: GULLY GRATINGS AND CHANNEL GRATINGS MADE OF COMPOUND MATERIAL

Batch

5.98A A batch of gratings is any quantity of gratings manufactured by the same manufacturer, covered by the same certificate and delivered to the Site at any one time.

Samples

5.98B One sample of grating shall be provided from each 20 gratings or part thereof in a batch.

Testing and compliance critieria

5.98C (1) Each sample of gully grating shall be subjected to a load test.

(2) The method of testing shall be as stated in Appendix 5.3. The minimum mass and test loads which the gratings and frames shall withstand without fracturing or cracking shall be as stated in Table 5.10A.

(3) Unless the Contractor presents evidence of compliance to the satisfaction of the Engineer, full-scale tests as listed in Clause 5.98C(4) and (5) shall be carried out with one sample from each 100 gratings or part thereof in a batch as defined in Clause 5.98A.

(4) For double triangular gratings, the permanent set under the test load stated in Table 5.10B shall not exceed the larger of 1mm or CO/500, where CO is the diameter of the largest circle that can be placed within the external boundary of the grating. For rectangular gratings, CO is equal to the length of the shorter side of the grating. The procedures of permanent set testing on a grating are as follows:

(a) Before the load is applied, take an initial reading at the geometric centre of the grating. (For double triangular gratings, initial readings shall be measured on both triangular gratings, as close as possible to their geometric centres.)

(b) The load shall be applied at a rate of 1 kN/s to 5 kN/s up to the test load as stated in Table 5.10B.

(c) Remove load from the grating.

(d) Repeat the procedures (b) to (c) four more times.

(e) Take final reading at the geometric centre of the grating and determine the value of permanent set as the absolute difference of the measured readings between the initial and the final readings at the geometric centre of the grating.

(5) The gratings and frames shall comply with the requirements in Table 5.10C as determined by the testing methods as follows:

(a) Acid Resistance Test

- The grating sample is immersed in a sulfuric acid solution (H_2SO_4) of 20% concentration for 48 hours.

(b) Heat Resistance Test

- The grating sample is placed in an oven at 80°C for 168 hours and then cooled down to room temperature for 24 hours before the load test.
- The arrangement of the load test shall follow Appendix 5.3. The diameter of the transfer block is in Table 5.10A. A compressive load is applied to the centre of the block at a rate of 1 kN/s to 3 kN/s. The grating sample is subjected to 5 cycles of loading to 30% of the test load in Table 5.10A and unloading to 0 kN. The grating is then loaded to and sustained at 45% of the test load in Table 5.10A for 5 minutes and unloaded to 0 kN. Lastly, the grating is loaded to 95% of the test load in Table 5.10A for 5 minutes and unloaded to 0 kN.

(c) Weather Resistance

- The grating sample is placed in a weather test chamber conditioned at 65±3°C and 65±5% relative humidity, under a light intensity of 550±50W/m^2, and subjected to distilled water spray cycles (each cycle of 18 minutes spray and 102 minutes no spray) for 500 hours. Afterwards, the sample is cooled down to room temperature for at least 24 hours before the load test.
- The load test shall be carried out in accordance with the second paragraph in (b) above.

Table 5.10A: Details of gully gratings and frames and channel gratings made of compound materials

Type of gully grating and frames and channel grating	Minimum mass of each grating (kg)	Test requirements	
		Diameter of block (mm)	Test load (t)
Grating for double triangular gully grating Type GA1-450	33.0	300	20
Frame			
- adjacent to kerb	12.0	300	20
- away from kerb	13.0	300	20
Channel grating not subject to vehicular load (mm)			
600 x 400 x 40	14	300	5
600 x 325 x 40	10	300	5
Channel grating subject to vehicular load (mm)			
600 x 400 x 70	26	300	20
600 x 325 x 70	21	300	20

Table 5.10B: Test load for permanent set testing on gully gratings and channel gratings made of compound material

Type of gully grating and channel grating	Test load (t)
Grating for double triangular gully grating Type GA1-450	6
Channel grating not subject to vehicular load	1.5
Channel grating subject to vehicular load	6

Table 5.10C: Properties of the gully gratings and channel gratings made of compound material

Properties	Requirements
Acid Resistance	No obvious corrosion on surface of the sample and loss in mass < 1%
Heat Resistance	No crack found after the load test
Weather Resistance	No crack found after the load test

TESTING: WATERTIGHTNESS OF PENSTOCKS

Testing: watertightness of penstocks

5.99 (1) Penstocks that are to be tested shall be tested for watertightness after installation by applying pressure using a head of water applied to one face of the penstock and no head of water on the other face. The test pressure and the face on which the pressure is to be applied shall be as stated in the Contract.

(2) The method of testing shall be as agreed by the Engineer.

(3) The test pressure shall be maintained for 24 hours.

Compliance criteria: watertightness of penstocks

5.100 The results of tests for watertightness of penstocks shall comply with the following requirements:

(a) There shall be no leaks through the penstock during the test.

(b) There shall be no leaks or damp patches visible at the joint between the penstock and the structure during the test.

Non-compliance: watertightness of penstocks

5.101 If the result of any test for watertightness of penstocks does not comply with the specified requirements, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the penstock shall be re-tested.

TESTING: GRAVITY PIPELINES FOR DRAINAGE WORKS

Testing: gravity pipelines for drainage works

5.102 (1) Gravity pipelines for drainage works shall be tested as stated in Clause 5.102(2) to (6).

(2) Gravity pipelines for sewage shall be tested by the methods stated in Table 5.11 at the following times:

(a) After the pipes have been jointed and the bedding has been placed and immediately before haunch or surround is placed or fill material is deposited, and

(b) After haunch and surround has been placed and fill material has been deposited and compacted, and

(c) Not more than 7 days before the pipeline is handed over.

(3) Gravity pipelines for surface water shall be tested by the methods stated in Table 5.11 at the following times:

(a) After the pipes have been jointed and the bedding has been placed and immediately before haunch or surround is placed or fill material is deposited, or

(b) After haunch and surround has been placed and fill material has been deposited and compacted.

(4) Water tests and air tests on pipelines shall be carried out on the complete

pipeline between manholes, chambers and structures. Pipelines shall not be tested in parts unless permitted by the Engineer or unless the specified test pressure would otherwise be exceeded. Short branch pipelines shall be tested with the main pipeline and long branch pipelines shall be tested separately.

(5) Infiltration tests shall be carried out on the complete pipeline between manholes, chambers and structures, including manholes, chambers and branches within the pipeline system.

(6) The method of testing shall be in accordance with Appendix 5.4.

Table 5.11: Testing gravity pipelines

Type of pipeline	**Diameter of pipeline**	**Time of test**	**Method of testing**
Sewage	Not exceeding 900 mm	As Clause 5.102(2)(a)	Water test or air test
		As Clause 5.102(2)(b)	Water test or air test
		As Clause 5.102(2)(c)	Infiltration test
Sewage	Exceeding 900 mm	As Clause 5.102(2)(a)	Visual inspection
		As Clause 5.102(2)(b)	Water test or air test
		As Clause 5.102(2)(c)	Infiltration test
Surface water	Not exceeding 900 mm	As Clause 5.102(3)(a) or As Clause 5.102(3)(b)	Water test or air test
Surface water	Exceeding 900 mm	As Clause 5.102(3)(a)	Visual inspection
		As Clause 5.102(3)(b)	Water test or air test

Compliance criteria: gravity pipelines for drainage works

5.103 The results of tests on gravity pipelines for drainage works shall comply with the following requirements:

(a) The leakage of water from the pipeline determined by the water test shall not exceed the permitted leakage calculated in accordance with Clause 5.4.8 of Appendix 5.4.

(b) There shall be no discernable leakage from the pipe or from any joint during the water test.

(c) The air pressure shall remain above 75 mm head of water at the end of the air test.

(d) There shall be no infiltration or damage to pipes or joints as determined by the visual inspection.

Non-compliance:

5.104 If the result of any test on gravity pipelines does not comply with the specified *gravity pipelines for drainage works*

requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the pipeline shall be re-tested.

TESTING: PRESSURE PIPELINES FOR DRAINAGE WORKS

Testing: pressure pipelines for drainage works

5.105 (1) Pressure pipelines for drainage works shall be tested as stated in Clauses 5.105(2) to (7).

(2) The pipeline shall be tested at the following times:

(a) After the pipes have been jointed and the bedding has been placed and immediately before haunch or surround is placed or fill material is deposited, and

(b) After haunch and surround has been placed and fill material has been deposited and compacted.

(3) The test stated in Clause 5.105(2)(a) shall not be carried out on parts of a pipeline unless permitted by the Engineer or unless the specified test pressure would otherwise be exceeded. The test stated in Clause 5.105(2)(b) shall be carried out on the complete pipeline.

(4) The test pressure shall be as stated in the Contract. If the test pressure is not stated in the Contract, the test pressure shall be 1.5 times the maximum working pressure in the part of the pipeline tested.

(5) Tests shall not be carried out simultaneously on more than one pipeline in the same trench.

(6) The method of testing shall be in accordance with Appendix 5.5.

(7) Testing of pressure pipelines by means of tests on individual joints shall not be carried out instead of tests stated in Clauses 5.105(2) to (6) unless permitted by the Engineer. If permitted, the method of testing and the compliance criteria shall be as approved by the Engineer.

Compliance criteria: pressure pipelines for drainage works

5.106 The results of tests on pressure pipelines for drainage works shall comply with the following requirements:

(a) The leakage of water from the pipeline determined by the pressure test shall not exceed the permitted leakage calculated in accordance with Clause 5.5.4 of Appendix 5.5.

(b) There shall be no discernable leakage of water from the pipeline or from any joint during the pressure test.

Non-compliance: pressure pipelines for drainage works

5.107 If the result of any test on pressure pipelines for drainage works does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the pipeline shall be re-tested.

REPAIR OF PIPELINES AND CULVERTS BY INTERNAL LINING

General 5.108 (1) The internal lining for repair of cracking and leakage in drainage pipelines and culverts shall be specifically developed and manufactured by a proprietary manufacturer for such purpose, and be of the following types:

(a) Lining with cured-in-place pipes (CIPP);

(b) Other types of lining approved by the Engineer.

(2) The lining shall be installed in the whole length of pipeline/culvert from manhole to manhole, installed in part of the pipeline/culvert between two manholes, or be a sleeve for repair of a short section of the pipeline/culvert as specified in the Contract.

(3) Grouting of the annular space between the lining and the wall of the existing pipe shall comply with Section 7 Part 4.

Materials 5.109 (1) Cured-in-place lining shall be a tube of fibrous materials manufactured from synthetic or mineral fibre, impregnated with a resin that is thermosetting, ambient-cured or otherwise. The tube may contain plastic coatings and/or reinforcement material. The materials shall comply with BS EN ISO 11296:Part 4 or equivalent standards.

(2) Other types of linings shall conform to internationally recognised specifications and their manufacturer's specifications.

Design of lining 5.110 The lining shall be designed by the Contractor in accordance with the procedures given in "Sewerage Rehabilitation Manual", 4^{th} Edition, Water Research Centre, 2001. The material shall be designed to resist external loading as well as stresses developed during installation and during its lifetime. Linings for repair of pipes with leakage and/or minor structural deficiencies only shall be able to resist external loading due to ground water pressure. Linings for repair of pipes in poor structural condition which cannot withstand existing design loading shall be able to resist all external loading including traffic loads, earth loads and ground water pressure. The external loadings to be designed for are either specified in the Contract or will be determined by the Engineer on a case-by-case basis.

Submissions 5.111 (1) The following particulars of the proposed lining materials and methods of carrying out the lining works shall be submitted for approval by the Engineer before commencement of works :

(a) Materials and equipment for the works, method of installation, method of sampling and design statement with supporting calculations;

(b) Reports of tests on the lining materials including type tests on short term and long term structural properties to support the design calculations;

(c) Performance tests to be carried out on the finished lining and the compliance criteria of such tests;

(d) Arrangements for dealing with lateral branch connections along the pipeline to be lined, if any;

(e) Where grouting is required, the details of grout mix, including admixtures;

(f) Where grouting is required, the method of grouting, including grouting stages, order of working, re-grouting, controlling of seepage, methods of monitoring and instrumentation.

(2) When requested by the Engineer, the Contractor shall submit a certificate showing that the manufacturer has provided adequate training to the Contractor's staff in respect of the relevant skills in proper production, handling and installation of the lining. The certified personnel shall submit a method statement to the Engineer.

Installation of lining 5.112 (1) The lining shall be installed by means of trenchless method. No excavation is permitted unless the Contractor can demonstrate that access through manholes is not adequate for installation.

(2) Before installation, the Contractor shall clean and clear the pipeline thoroughly and remove all loose material, deposits and obstructions that may affect the proper installation of the lining.

(3) After cleaning the surfaces of the pipeline and before installation of the lining, a CCTV confirmatory survey shall be carried out as required. All pertinent information such as the position, size and angle of approach of all lateral connections shall be recorded and logged. The Contractor shall submit a sample log sheet to the Engineer for approval. On completion of installation of lining and before re-commissioning the pipeline, a CCTV post-installation survey shall be carried out. The Contractor shall provide two copies of a video record of the CCTV confirmatory survey and the post-installation survey, where required to be carried out, and two copies of log sheets to the Engineer within 2 working days of completion of the lining works.

(4) The method of installation shall follow the manufacturer's recommendations, or shall be approved by the Engineer. The Contractor shall produce a smooth, corrosion-resistant and durable internal lining of adequate strength with its outer surface in close and firm contact with the pipeline interior after completing the installation.

(5) For in-situ internal sleeve lining, the sleeve shall be brought into position in the pipeline/culvert and installed by an inflatable packer, mandrel or other approved remote-controlled method.

(6) During installation, the Contractor shall, where necessary, provide temporary diversion of all existing flow from the pipe/box culvert and its lateral branch connections thus providing dry and workable conditions for the Works.

(7) The annular space between the lining and the existing pipe wall, if any, shall be filled by pressure grouting or other methods recommended by the manufacturer and approved by the Engineer. For linings designed to be close-fit against the existing pipe wall, the Contractor shall still check the ends of the lining for presence of voids between the lining and the existing pipe wall after completion of installation, and seal up such voids by an approved

sealant to the satisfaction of the Engineer.

(8) For cured-in-place linings, the finished lining shall, as far as possible, be free of visual defects including foreign inclusions, dry spots, air bubbles, pinholes and pimples. Wrinkling of more than 2% of the internal pipe diameter or the least internal dimension of the box culvert will not be accepted.

(9) After completion of installation of lining, lateral branch connections sealed up by the lining shall be re-opened using a robotic cutting device with CCTV camera, or other trenchless methods approved by the Engineer. The annular gap between the liner and the lateral shall be sealed up.

Performance tests on internal lining materials

5.113 (1) The Contractor shall carry out performance tests on the lining materials to check compliance against the standards/material properties recommended by the manufacturer and approved by the Engineer.

(2) For cured-in-place lining, the wall thickness and the short-term flexural (bending) properties on samples shall be determined as the performance control tests on the finished lining. The method of test shall be proposed by the Contractor for approval by the Engineer, and shall be selected from the following standards (one test for flexural properties and one for wall thickness) :

Test on	Standards
Flexural properties	BS EN ISO 178: 2010+A1:2013; BS 2782-10: Method 1005:1977; EN 63:1977; ASTM D790-15e
Wall thickness	BS 2782-6: Method 630A:1994; ISO 4593:1993; BS 2782-6: Method 631A:1993; ISO 4591:1992

The wall thickness shall be determined at a minimum of 5 locations. The measuring device shall be accurate to ±0.1mm. The wall thickness at all points shall be not less than the specified design thickness and may be up to 15% greater.

The 90% lower confidence limits of short term flexural modulus E_o, flexural stress at first break σ_b and flexural strain at first break ε_b shall be not less than the respective design values declared by the supplier.

If any result of the above tests on flexural properties of the samples fails to meet the acceptance criteria, the Contractor shall carry out test on samples taken from the finished lining to determine the long term flexural modulus in accordance with Annex C of BS EN ISO 11296:Part 4 for validation against the manufacturer's creep data.

If any wall thickness determined in the sample testing fails to meet the design thickness but the result of tests on flexural properties is up to the acceptance criteria, the actual wall thickness measured on finished lining shall not be less than the design thickness.

(3) For in-situ internal sleeve lining, the Contractor shall, in addition to other tests specified in this clause, also test the repaired location for leakage

by a proprietary joint tester according to the testing procedures recommended by the manufacturer and approved by the Engineer. The test results shall satisfy the compliance criteria equivalent to those stated in Clause 5.103 (for gravity pipelines) or Clause 5.106 (for pressure pipelines).

(4) For other types of lining, they shall be sampled and tested according to internationally recognised specifications and their manufacturer's specifications, and/or as specified by the Engineer as a condition of approval in accordance with sub-clause (1) of Clause 5.111.

(5) If the result of any performance test on the samples fails to meet the compliance criteria, the Engineer may instruct that the test be repeated on samples taken from the finished lining for validation against the manufacturer's data. The number of samples of the finished lining to be taken and the positions of taking samples shall be determined by the Engineer.

(6) The Contractor shall propose 3 laboratories capable of carrying out the required tests for selection and approval by the Engineer. The Engineer shall select one laboratory for testing and one laboratory as backup in case the performance of the selected laboratory is unsatisfactory. As required by the Engineer, the Contractor shall provide assistance in delievering the samples to the approved laboratory for carrying out the performance tests based on the Contractor's approved testing proposal. Test reports and the tested samples shall be sent to the Engineer directly by the approved laboratory.

(7) The maximum number of samples which may be ordered by the Engineer for each type of performance test shall be one per 50m of lined pipe/culvert.

APPENDIX 5.1

CCTV INSPECTION OF PIPELINES

Scope 5.1.1 This method covers the internal inspection of pipelines by means of closed circuit television.

Equipment 5.1.2 The following equipment is required:

(a) A CCTV colour camera with integral lighting unit. The camera shall be a type designed and constructed for the specified purpose and shall be capable of operating in 100% relative humidity. The camera shall be fitted with a rotating mirror for complete circumferential viewing. The system shall be capable of producing an accurate, clear and high quality picture of the entire periphery of the pipe on the monitor screen and recording tape. The camera and lighting unit shall be mounted on a self-propelled crawler or on skids linked to a manual or power operated winch.

(b) A monitor screen that displays the camera view during the inspection. The monitor screen shall be housed in covered accommodation with facilities for inspection by the Engineer and others.

(c) A screen writer which displays on the monitor screen details of the inspection including date, location, pipe material, diameter of pipe, direction of view and comments on the condition of the pipe.

(d) A measuring device that displays the camera location automatically on the monitor screen. The device shall be capable of measuring the location to within an accuracy of 0.1% of the length of the pipeline or ±0.3m whichever is the greater.

(e) A control unit which controls camera movement, lighting intensity, focusing and recording.

(f) A video recording system approved by the Engineer to record the inspection and information displayed on the monitor screen.

(g) A digital camera capable of producing photographs with the date.

Procedure 5.1.3 The procedure shall be as follows:

(a) The camera shall be moved through the pipeline in the direction instructed by the Engineer. The speed of the CCTV camera in the sewer or drain shall be limited to not more than 0.1m/s for sewers and drains of diameter less than or equal to 200mm, 0.15m/s for sewers and drains of diameter exceeding 200mm, or such other speed as agreed by the Engineer to enable all details to be extracted from the video recording system. If the camera cannot pass through the complete pipeline in one operation, the inspection may be carried out from both ends of the pipeline.

(b) The camera shall be stopped whenever instructed by the Engineer to allow inspection by the Engineer.

(c) The video recording system shall be operated during the complete inspection to provide a continuous record of the inspection and information on the monitor screen.

(d) Photographs of the monitor screen shall be taken whenever instructed by the Engineer.

Recording of results 5.1.4 (1) Records of the inspections shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within 14 days of completion of the inspection. The report shall contain the following details:

(a) Key map showing pipelines inspected and associated manholes, chambers and structures,

(b) Tables listing details of inspection, including date, location, pipe material, diameter of pipe, chainage, manholes, junctions and other features and the condition of pipes and joints. The condition of pipes and joints shall be illustrated by a coding systems in accordance with the “Manual of Sewer Condition Classification” 5th Edition (2013) published by the U.K. National Water Council, and

(c) A summary showing the number and type of defects in each pipeline inspected. The summary shall include photographs to illustrate degree of mortar loss, size of a crack/fracture, size of a void or any other quantifiable defect. A suitable metric scale shall be included and be clearly visible and in focus within the photograph.

(2) The following items shall be submitted at the same time as the report:

(a) Video providing a continuous record of the inspection and information. The media shall be of high quality, new and unused before recording and shall be of a digital format (DVD+/-R or CD-R) or Video Home System (VHS) format, subject to approval by the Engineer; and

(b) Photographs of the monitor screen including date and chainage. The photographs shall be 3R size and shall be mounted in photograph albums.

APPENDIX 5.2

DETERMINATION OF THE COMPACTION FRACTION VALUE OF AGGREGATES FOR GRANULAR BED

Scope 5.2.1 This method covers the determination of the compaction fraction value of aggregates for granular bed.

Apparatus 5.2.2 The following apparatus is required:

(a) A steel open-ended cylinder, 150 mm internal diameter by 250 mm high, with a wall thickness of not less than 3.5mm.

(b) A steel rammer of 40 mm diameter weighing approximately 1 kg.

(c) A steel rule calibrated to 1 mm.

Procedure 5.2.3 The procedure shall be as follows:

(a) The sample shall be placed on a clean surface and shall be divided by quartering or by using a riffle box to obtain a specimen weighing approximately 10 kg.

(b) The cylinder shall be placed on a firm level surface and shall be filled without tamping with material taken from the sample. Surplus material shall be struck off level with the top of the cylinder, and cleared from the area around the cylinder.

(c) The cylinder shall be lifted clear of the contents and placed alongside the material.

(d) Approximately one quarter of the material shall be placed in the cylinder and compacted using the rammer until no further compaction can be achieved. The procedure shall be repeated for each of the remaining three quarters of the material. The top surface shall be compacted as level as practicable.

(e) The distance (d) from the top of the cylinder to the top surface of the material shall be measured to the nearest 1 mm.

Calculation 5.2.4 The compaction fraction value of the material shall be calculated from the equation:

Compaction fraction value = d/h

Where:

- d is the distance from the top of the cylinder to the top surface of the material (mm),
- h is the height of the cylinder (mm).

Reporting of results 5.2.5 The following shall be reported:

(a) Identification of sample.

(b) The compaction fraction value to the nearest 0.01.

(c) Source and type of material.

(d) Date of test.

(e) That the test method used was in accordance with this Specification.

APPENDIX 5.3

DETERMINATION OF THE RESISTANCE TO FRACTURE OF MANHOLE COVERS AND GULLY GRATINGS

Scope 5.3.1 This method covers the determination of the resistance to fracture of manhole covers and gully gratings by means of a load test.

Equipment 5.3.2 The following equipment is required:

(a) The manufacturer's recommended frame for the manhole cover or gully grating or a fabricated test frame of a type agreed by the Engineer which will simulate the normal conditions of use of the cover or grating.

(b) A circular hardwood bearing block faced with hard rubber or other resilient material. The diameter of the block shall be as stated in Table 5.6 or Table 5.7 for the relevant cover or grating. The block shall be sufficiently rigid to ensure that the load is equally distributed over the whole area of the block.

(c) Test loads.

(d) Equipment for measuring the loads applied, readable and accurate to 0.05 t or 2% of the specified test load, whichever is greater.

Procedure 5.3.3 The procedure shall be as follows:

(a) The full bearing area of the frame shall be rigidly supported.

(b) The cover or grating shall be placed in the frame. The bearing block shall be placed centrally on the cover or grating.

(c) The specified test load as stated in Table 5.6 and 5.7 shall be applied without shock.

(d) The specified test load shall be maintained for at least 30 seconds and removed.

Reporting of results 5.3.4 The following shall be reported:

(a) Identification of sample.

(b) The load applied, to the nearest 0.05 t or 2% of the specified test load, whichever is greater.

(c) Details of any fracture or cracks.

(d) That the test method used was in accordance with this Specification.

APPENDIX 5.4

TESTS ON GRAVITY PIPELINES FOR DRAINAGE WORKS

Scope 5.4.1 This method covers water tests, air tests, visual inspections and infiltration tests on gravity pipelines for drainage works.

Equipment 5.4.2 The following equipment is required:

(a) Expanding disc stoppers, air bags or other methods of sealing pipes agreed by the Engineer.

(b) Struts and wedges.

(c) Force pump for water test.

(d) Standpipe for water test.

(e) Measuring vessel for water test, readable and accurate to 0.01 litre.

(f) U-tube for air test.

(g) Trolleys to obtain access inside pipelines for visual inspections. Mechanical fans shall be provided to ensure that an adequate air supply is available. Engine-driven fans shall be fitted with a flexible exhaust or other methods of keeping exhaust fumes clear of the fresh air intake.

Procedure: before tests and inspections 5.4.3 The procedure before tests and inspections shall be as follows:

(a) Debris and water shall be removed from the pipeline.

(b) Openings to the pipeline shall be sealed using expanding disc stoppers, air bags or other methods agreed by the Engineer and the seals secured against movement.

Procedure: water test 5.4.4 The procedure for the water test shall be as follows:

(a) The pipeline shall be filled with water and shall be kept filled for two hours before testing starts to allow absorption to take place.

(b) A test pressure of 1.2 m head of water above the soffit of the pipe at the high end shall be applied at the standpipe and maintained for 30 minutes. The test pressure applied shall not exceed 6 m (for PE pipeline, it shall not exceed 5 m) head of water at the invert of the low end of the pipe.

(c) The head of water at the standpipe shall be topped up at 5-minute intervals during the test, and shall be filled to the specified head at the end of the test period. The amount of water added to the standpipe shall be measured using the measuring vessel.

(d) The leakage of water from the pipeline shall be measured as the amount of water added to maintain the specified head of water.

Procedure: air test 5.4.5 The procedure for the air test shall be as follows:

(a) Air shall be pumped into the pipeline until a test pressure of slightly more than 100 mm of water is registered on a U-tube manometer connected to the pipeline. Five minutes shall be allowed for stabilisation of the air temperature, and the air pressure shall then be adjusted to 100 mm of water.

(b) The pressure shall be read from the U-tube at the end of a five-minute period without further pumping.

Procedure: visual inspection 5.4.6 The inside of the pipeline shall be inspected visually, and infiltration or damage to pipes or joints shall be recorded.

Procedure: infiltration test 5.4.7 The procedure for the infiltration test shall be in accordance with the following:

After backfilling has been completed and the ground water level has stabilized, the sewer should be checked for infiltration. All live inlets should be sealed and the line inspected from the manholes. Any flow from the pipeline coming into the manholes or within the manholes themselves should be investigated to establish its source. In small pipes the point of infiltration may be located visually with light and mirror or with an inflated rubber plug. When conditions justify it a video camera can be used.

The sewer may normally be acceptable if the infiltration does not exceed 1 litre per hour per metre diameter per metre of pipe run, although this will depend on the judgment of the Engineer and the extent of exfiltration shown by the water test.

Calculation 5.4.8 The permitted leakage of water from the pipeline during the water test shall be calculated from the equation:

Permitted leakage = d x l x (t/60) litre

where:

- d is the internal diameter of the pipe (m),
- l is the length of pipeline tested (m),
- t is the test period (min).

Reporting of results 5.4.9 The following shall be reported:

(a) The nominal internal diameter of the pipe.

(b) The location and length of pipeline tested to the nearest 0.3 m.

(c) The test pressure applied during the water test to the nearest 0.01 m, and during the air test to the nearest 1 mm head of water.

(d) The test period to the nearest 1 min.

(e) The leakage and permitted leakage for the water test to the nearest 0.1 litre.

(f) The amount of infiltration for the infiltration test to the nearest 0.1 litre.

(g) Details of any discernable leakage of water from the pipe or from any joint during the water test.

(h) That the test method used was in accordance with this Specification.

APPENDIX 5.5

TESTS ON PRESSURE PIPELINES FOR DRAINAGE WORKS

Scope 5.5.1 This method covers the determination of the leakage of water from pressure pipelines for drainage works by means of a pressure test.

Equipment 5.5.2 The following equipment is required:

(a) Blank flanges or caps.

(b) Struts and wedges.

(c) Temporary concrete blocks or other anchors.

(d) Force pump.

(e) Pressure gauge, readable and accurate to 0.01 m head of water. The gauge shall be either a conventional circular type of at least 300 mm diameter or shall be a digital indicator type.

(f) Measuring vessel, readable and accurate to 0.01 litre.

Procedure 5.5.3 The procedure shall be as follows:

(a) Pipes and valves shall be cleaned and the operation of valves shall be checked. Air valves shall be isolated.

(b) Blank flanges or caps shall be fixed to the ends of the pipeline, or part of the pipeline, to be tested. Tests shall not be made against closed valves unless permitted by the Engineer.

(c) The blank flanges and caps and closed valves against which tests are made shall be secured with struts and wedges against temporary concrete blocks or other anchors. The blocks shall be completed and shall have hardened sufficiently before testing starts. Thrust and anchor blocks, pipe straps and other devices required to prevent movement of pipes and fittings shall be completed before testing starts.

(d) The pipeline shall be filled with water and all air shall be removed. Measures shall be taken during filling to provide free outlets for air and to prevent water hammer.

(e) The pressure in the pipeline shall be increased to working pressure and the pipeline shall remain filled at this pressure for 2 hours to allow absorption to take place and to achieve conditions that are as stable as practicable.

(f) The pressure in the pipeline shall be increased slowly by pumping water into the pipeline using a force pump until the specified test pressure is reached at the lowest part of the pipeline being tested.

(g) The pressure in the pipeline shall be maintained at the specified test pressure, using the force pump if necessary, for a period of at least 1 hour.

(h) At the end of the 1 hour period the pressure shall be increased, if necessary, to the specified test pressure and pumps and water supply points shall be disconnected.

(i) The pipeline shall be left in this condition for a test period of 1 hour. No water shall be allowed to enter the pipeline during the test period.

(j) At the end of the test period the pressure in the pipeline shall be recorded.

(k) The pumps and water supply points shall be reconnected and the pressure shall be increased to the specified test pressure.

(l) Water shall be drawn off from the pipeline until the pressure in the pipeline is the same as at the end of the test period. The leakage of water from the pipeline shall be measured as the amount of water drawn off.

Calculation 5.5.4 (1) The average test pressure (P) shall be calculated as the average of the specified test pressure and the pressure at the end of the test period.

(2) The permitted leakage of water from the pipeline during the pressure test shall be calculated from the equation:

Permitted leakage = d x l x (t/12) x P litre

where:

- d is the nominal internal diameter of the pipe (m),
- l is the length of pipeline tested (km),
- t is the test period (hr),
- P is the average test pressure (m).

Reporting of results 5.5.5 The following shall be reported:

(a) The nominal internal diameter of the pipe.

(b) The location and length of pipeline tested to the nearest 0.3 m.

(c) The test period to the nearest one minute.

(d) The specified test pressure to the nearest 0.01 m head of water.

(e) The pressure at the end of the test period to the nearest 0.01 m head of water.

(f) The average test pressure to the nearest 0.01 m head of water.

(g) The leakage and permitted leakage to the nearest 0.1 litre.

(h) Details of any discernable leakage of water from the pipeline during the test.

(i) That the test method used was in accordance with this Specification.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 6

EARTHWORKS

SECTION 6

EARTHWORKS

GENERAL

Reclamation 6.01 Reclamation shall comply with Section 21 except as stated in this Section.

Trip-ticket System 6.02 The disposal of construction and demolition materials generated from the Contract shall comply with the Trip-ticket System promulgated by the Environment, Transport and Works Bureau.

GLOSSARY OF TERMS

Areas of fill 6.03 Areas of fill are areas within the Site, including areas in embankments, platforms and slopes and in excavations for structures, pits and trenches, in which fill material is deposited and compacted as part of the permanent work.

Earthworks final surface 6.04 Earthworks final surface is the surface to which the work included in Section 6 is finished.

Inert construction and demolition material 6.05 Inert construction and demolition material shall mean rock, rubble, earth, soil, concrete, asphalt, brick, tile and masonry generated from construction and demolition works.

Earthworks material 6.06 Earthworks material may consist of soil, rock, or inert construction and demolition material on or below the Site at the commencement of the Contract, or which is imported to the Site to carry out the Works.

Formation 6.07 Formation is that part of the earthworks final surface on which a pavement, structure or utility, is constructed, or on which the blinding or bedding for a pavement, structure or utility is placed.

Intermediate areas of fill 6.08 Intermediate areas of fill are areas of fill which are stated in the Contract as such, and in which fill material is deposited and compacted directly into shallow water or onto naturally occurring soft ground.

MATERIALS

Fill material 6.09 (1) Fill material shall consist of naturally occurring or processed material, or inert construction and demolition material, which at the time of deposition is capable of being compacted in accordance with the specified requirements to form stable areas of fill.

(2) Fill material shall not contain any of the following:

(a) Material susceptible to volume change, including marine mud, soil with a liquid limit exceeding 65% or a plasticity index exceeding 35%, swelling clays and collapsible soils,

(b) Peat, vegetation, timber, organic, soluble or perishable material,

(c) Dangerous or toxic material or material susceptible to combustion, and

(d) Metal, rubber, plastic or synthetic material.

(3) The different types of fill material shall have the particle size distributions within the ranges stated in Table 6.1.

(4) Special fill material shall consist of material which has a liquid limit not exceeding 45%, a plasticity index not exceeding 20% and a coefficient of uniformity exceeding 50.

(5) Granular fill material shall consist of clean, hard and durable material including recycled aggregates, rock and concrete.

(6) Rock fill material shall consist of pieces of concrete or hard and durable rock of which the maximum size shall not be greater than three times the minimum dimension of individual pieces and in the opinion of the Engineer not more than 30% by mass is discoloured or shows evidence of decomposition.

(7) Recycled rock fill material (Grade 200) shall be recycled rock or inert construction and demolition material which is hard and durable, and free from cracks, veins, and other evidence of decomposition.

(8) For works which use grade 200 rock fill material as specified in the contract, priority shall be given to using grade 200 recycled rock fill material unless the material is found inappropriate by the Engineer.

(9) The soluble sulphate content of fill material placed within 500 mm of concrete, cement bound material or cementitious material shall not exceed 1.9 grams of sulphate, expressed as SO_3, per litre.

(10) The total sulphate content, expressed as SO_3, of fill material placed within 500 mm of metalwork shall not exceed 0.5% by mass.

(11) Well-graded material shall consist of material that has a coefficient of uniformity exceeding 10.

(12) Uniform-graded material shall consist of material that has a coefficient of uniformity of 10 or less.

Table 6.1: Particle size distributions of fill material

Type of fill material	Percentage by mass passing					
	Size		BS test sieve			
	400 mm	200 mm	75 mm	20 mm	600 μm	63 μm
Fine fill material	-	-	100	-	-	-
General fill material	-	100	75-100	-	-	-
Special fill material	-	-	100	-	-	0-45
Granular fill material	-	-	100	-	0-5	-
Rock fill material/ Recycled rock fill material (Grade 200)	-	100	20-75	0-50	-	-
Rock fill material (Grade 400)	100	20-75	10-30	0-25	-	-

SUBMISSIONS

Particulars of earthworks

6.10 (1) The following particulars of the proposed materials and methods of construction for earthworks shall be submitted to the Engineer:

(a) Details of construction plant and haulage vehicles,

(b) Methods of excavation and of deposition and compaction of fill material,

(c) Use of different types of excavated material and sources of imported fill material,

(d) Arrangements for stockpiling, sorting and separating excavated material, earthworks material and fill material, and for reusing and disposing of such materials,

(e) Methods of controlling the moisture content of fill material,

(f) Methods of controlling surface water and groundwater and of protecting earthworks and earthworks material from damage due to water and from weather conditions which may affect the earthworks or earthworks material,

(g) Methods of monitoring groundwater levels, and

(h) Methods of monitoring the ground and structures for movements.

(2) The particulars shall be submitted to the Engineer at least 14 days before the relevant work starts.

Particulars of blasting

6.11 (1) The following particulars of the proposed blasting procedures shall be submitted to the Engineer:

(a) Any conditions or restrictions imposed by the Commissioner of Mines, including copies of applications, licences, permits and correspondence,

(b) Names, qualifications and experience of the persons responsible for the design and supervision of blasting operations,

(c) Location, diameter, inclination and depth of holes to be charged with explosive,

(d) Type and total mass of explosive to be used and its mass and distribution in each hole,

(e) Dimensions of stemming and decking,

(f) Initiation sequence, delay periods and mass of explosive per delay,

(g) Burden and bench height,

(h) Ratio of diameter of explosive to diameter of hole,

(i) Arrangements for and methods of instrumentation and monitoring the effects of blasting,

(j) Details of velocity seismographs, including manufacturer's literature,

(k) Method of controlled blasting,

(l) Details of blasting trials, and

(m) Protective measures.

(2) The particulars, other than particulars relating to blasting trials, shall be submitted to the Engineer at least 48 hours before the relevant blasting starts. Particulars relating to blasting trials shall be submitted to the Engineer at least 14 days before the blasting trials are carried out.

GENERAL EARTHWORKS REQUIREMENTS

Ownership of earthworks material 6.12 (1) Earthworks material within the Site at the commencement of the Contract shall remain the property of the Employer except as stated in Clause 6.12(2).

(2) Earthworks material that needs to be disposed of by the Contractor shall become the property of the Contractor when it is removed from the Site and shall be disposed of in tips provided by the Contractor, unless otherwise stated in the Contract.

Temporary Works for earthworks

6.13 (1) The design of Temporary Works associated with earthworks, including temporary slopes, stockpiles and drainage, shall be such that the risk of failure is not more than that which would be adopted if the Temporary Works were to be permanent. Allowance may be made in the design of the Temporary Works for the shorter design life and for the risk to persons and property and the surface water and groundwater conditions that are likely to occur during construction.

(2) The Contractor shall provide details to the Engineer to demonstrate that the design of Temporary Works has been considered and incorporated measures, which minimise excavation of materials.

Handling and storage of earthworks material

6.14 (1) Earthworks material shall not be handled or stored in a manner which will result in segregation, deterioration, erosion or instability of the material.

(2) Different types of earthworks material shall be kept separate from each other. Earthworks material that is suitable for use as fill material shall be maintained in a suitable condition and shall not be contaminated.

(3) Material handling and storage areas shall be levelled and well drained. Stockpiles of material shall be sprayed with water or a dust suppression chemical to minimize dust generation.

Protection from water and weather

6.15 (1) Earthworks after site clearance, excavation or filling and earthworks material after excavation shall be kept free of water and shall be protected from damage due to water and from exposure to weather conditions which may affect the earthworks or earthworks material. The measures to be taken shall include the following:

(a) As stated in Clauses 1.19 and 1.20.

(b) Surfaces shall be maintained in a stable condition and shall be formed to falls to shed water and to prevent ponding.

(c) The area of exposed surfaces shall be kept to a minimum.

(2) Excavations for structures, pits and trenches shall not be carried out on or adjacent to slopes unless measures are taken to drain the excavation and to prevent water from the excavation entering the slope.

Earthworks material allowed to become unsuitable or to deteriorate

6.16 (1) Earthworks material which has been used, or is required for use, in the permanent work and which is allowed to become unsuitable such that in the opinion of the Engineer it no longer complies with the specified requirements for that type of material shall be replaced or dealt with by methods agreed by the Engineer.

(2) Earthworks material which is not stated in the Contract to be excavated and which the Contractor causes or allows to deteriorate such that in the opinion of the Engineer the permanent work will be affected shall be replaced or dealt with by methods agreed by the Engineer.

(3) Material provided to replace earthworks material, which has been allowed to become unsuitable, or which the Contractor causes or allows to deteriorate, shall be an equivalent material approved by the Engineer. The replacement material shall have the same volume after compaction as the material replaced.

(4) The material that is to be replaced shall be disposed of by the Contractor.

Additional excavation and stabilisation 6.17 (1) Earthworks material which is not stated in the Contract to be excavated but which in the opinion of the Engineer has inadequate strength, durability or stability shall be dealt with by additional excavation or filling as stated in Clause 6.17(2) or by stabilisation as stated in Clause 6.17(3) or by other methods instructed by the Engineer.

(2) Additional excavation shall be carried out and the resulting voids shall be dealt with as follows:

(a) General fill material, fine fill material or special fill material shall be deposited and compacted below areas of fill and below formations other than in rock.

(b) Grade 10 concrete shall be placed and compacted below formations in rock.

(c) Granular fill material shall be deposited below standing water.

(3) Stabilisation shall be carried out using rock fill material (Grade 400) deposited directly into the original unstable material and compacted to form a stable foundation on which to construct the subsequent work.

Removal of earthworks material 6.18 Earthworks material that is required for use in the permanent work as fill material shall not be removed from the Site unless permitted by the Engineer. The Contractor shall notify the Engineer before any earthworks material is removed from the Site.

EXCAVATION

Disposal of excavated material 6.19 (1) The Contractor shall take measures to sort and separate excavated material on site for use in the permanent works as required in the environmental protection measures unless otherwise stated in the Contract. Excavated material, which in the opinion of the Engineer cannot be selected, processed or mixed in a practical manner to make it suitable for use in the permanent works, as fill material shall be disposed of by the Contractor unless otherwise stated in the Contract.

(2) Excavated material that is surplus to the requirements of the permanent work shall be disposed of by the Contractor unless otherwise stated in the Contract. The Contractor shall, unless otherwise stated in the Contract, take all practical measures to sort and separate the surplus material according to its nature before disposal as required in the environmental protection measures and dispose of the material off-site using the Trip-ticket System.

Use of excavated material 6.20 (1) Excavated material required for use in the permanent work which is capable of being selected, processed and mixed to make it suitable for use as fill material shall not be used for any other purposes unless permitted by the Engineer.

(2) Excavated material that is required for use in the permanent work as fill material and which the Engineer permits to be removed from the Site or used for other purposes shall be replaced by an equivalent material approved by the

Engineer. The replacement material shall have the same volume after compaction as the material replaced.

Obstructions in excavations	6.21	(1) The Contractor shall inform the Engineer without delay of the nature and location of any unforeseen obstruction encountered during excavation. (2) Boulders that intersect the earthworks final surface or formation shall be dealt with as excavation proceeds by methods agreed by the Engineer. Boulders shall not be left protruding unless permitted by the Engineer.
Excavation	6.22	(1) Temporary supports or other methods shall be used to maintain excavations in a stable condition and to prevent settlement of structures or utilities due to excavation or dewatering. (2) Construction plant or other vehicles shall not be operated or parked adjacent to excavations and earthworks material or other materials shall not be placed adjacent to excavations unless this has been allowed for in the design of the Temporary Works for the support of the excavation.
Excavations adjacent to structures and utilities	6.23	(1) Excavations shall be carried out by hand adjacent to utilities that are known, proven or suspected to exist. (2) Unless otherwise permitted by the Engineer excavations next to structures shall be carried out by hand.
Excavations for structures, pits and trenches	6.24	(1) Excavations for structures, pits and trenches shall be the minimum size necessary to construct the permanent work. The sides of excavations shall be vertical unless otherwise permitted by the Engineer. (2) The length of trench excavation left open at any one time shall not exceed that agreed by the Engineer. (3) Unless permitted by the Engineer, trenches for utilities in fill areas shall not be excavated until the fill material has been deposited and compacted up to the earthworks final surface or formation or up to 1 m above the top of the utility, whichever is lower.

NOT USED

Not used	6.25	Not used
Not used	6.26	Not used
Not used	6.27	Not used
Not used	6.28	Not used
Not used	6.29	Not used

BLASTING

Statutory requirements for blasting

6.30 Blasting operations, including the supply, transport and storage of explosives, on site manufacture of explosives, and the use of explosives including preparing, placing and firing a charge, handling misfires, and destroying or disposing surplus/unused explosives, as well as related preventive, protective, monitoring and contingency measures, shall be in accordance with the conditions and restrictions imposed by the Commissioner of Mines. The Contractor shall make all arrangements with and obtain all licences and permits from the Commissioner of Mines in connection with blasting operations.

Recording vibrations and air-overpressures due to blasting

6.31 (1) Measurements of vibrations and air-overpressures shall be taken at locations as stated in the conditions of the blasting permit/licence and at any other locations stated in the Contract or instructed by the Engineer at all times when blasting is carried out. Arrangements for installing instruments and taking measurements both inside and outside the Site shall be made by the Contractor. Records of vibration/air-overpressure measurements, in a format to be agreed by the Engineer, shall be kept by the Contractor on the site and a copy of the records shall be provided to the Engineer.

(2) Blasting monitoring equipment shall have adequate sensitivity and a measurement range commensurate with that required for monitoring affected sensitive receivers. The number, type and specification of all blasting monitoring equipment shall be agreed with the Engineer prior to commencing blasting.

(3) Vibrations due to blasting shall be measured in terms of particle velocity and vibrational amplitude for all of the three amplitude orthogonal axes. Unless stipulated otherwise as the controlling criterion for a structure being monitored and/or instructed by the Engineer, the peak particle velocity and the peak vibrational amplitude shall be taken as the maximum values recorded for any one of the three orthogonal axes during the blast vibration history. The peak particle acceleration shall also be calculated and reported.

(4) Unless otherwise stated in the Contract or agreed by the Engineer, instrumentation used for monitoring vibrations shall record the full time history of the blast event in terms of peak particle velocity and vibration amplitude over a frequency of 2-250 Hz in three mutually perpendicular directions.

(5) Unless otherwise stated in the Contract or agreed by the Engineer, the instrumentation used to monitor air-overpressure shall record the absolute maximum pressure level in dBL and shall be able to reproduce the signal for the full duration of the blast event. The frequency range of the measurement equipment must also cover the frequency from at least 2 Hz to 250 Hz.

(6) The accuracy of seismographs for vibration monitoring and the equipment for air-overpressure monitoring shall be checked at regular intervals, as per the manufacturer’s recommendations, and agreed by the Engineer, and a copy of relevant calibration certificates issued by the manufacturer or an authorized calibration laboratory shall be submitted to the Engineer.

Preparatory work for

6.32 Before each blast is carried out, all vegetation, overburden and soft or loose

surface blasting

material shall be removed to expose the rock that is to be blasted, in order to assess the suitability of the proposed blast design and related safety measures.

Notification of blasting

6.33 The Contractor shall notify the Engineer by not later than noon of the previous day of his intention to bring any explosives to the Site or to carry out any blasting.

Storage of explosives

6.34 Explosives and detonators shall not be stored on the Site unless in a temporary site magazine (Mode A store) approved by the Commissioner of Mines. All explosives and detonators left over after charging in a blast must be disposed of, in accordance with a disposal method approved by the Commissioner of Mines.

Restrictions on blasting times

6.35 Unless permitted by the Commissioner of Mines and the Engineer, blasting shall not be carried out at the following times:

(a) On General Holidays,

(b) Before 8:30 a.m. or after 5:30 p.m. on any day,

(c) When a Hong Kong Observatory thunderstorm warning is in force, and

(d) When strong wind signal or storm signal No. 3 or higher is hoisted.

Blasting

6.36 (1) Unless otherwise permitted by the Commissioner of Mines, sufficient protective measures shall be available on site, prior to the issue of a Blasting Permit and subject to the satisfaction of the Commissioner of Mines, to prevent the projection of flying fragments of materials (flyrock) resulting from blasting.

(2) Unless permitted by the Commissioner of Mines, surface charges shall not be used.

(3) Unless otherwise permitted by the Commissioner of Mines, dry, angular crushed rock of 10 mm diameter shall be used for stemming and decking between charges in a blast hole

(4) Unless permitted by the Commissioner of Mines, electric detonators shall not be used within 60 m of overhead power lines. The use of electric detonators in the vicinity of static or mobile radio transmitters shall comply with PD CLC/TR 50426.

(5) Unless otherwise permitted by the Commissioner of Mines, delay blasting with millisecond delays shall be used for all blasting, except as stated in Clause 6.37(6).

(6) Unless permitted by the Director of Water Supplies or his delegate and the Engineer, blasting shall not be carried out within a distance of:

(a) 50 m on plan from any water retaining structure of Water Supplies Department;

(b) 6 m on plan from water mains or other water supply structures or installations;

(c) 60 m on plan from the centre line of any waterworks tunnel; and

(d) 100 m on plan from the centre line of any submarine pipeline.

(7) Unless permitted by the Engineer, the vibrations at structures, installations, slopes and land due to blasting measured in terms of peak particle velocity and/or peak vibrational amplitude shall not exceed the values stipulated in the Contract and those submitted to the Commissioner of Mines in support of the application for a Blasting Permit. If additional or different requirements are identified during the course of the Contract, the Contractor shall seek agreement from the relevant owners of the structures, installations, slopes and land, regulatory authorities, maintenance authorities and/or the Engineer on such requirements and adhere to the agreed requirements.

(8) Unless more stringent values are stipulated in the Contract or identified during the course of the Contract, or other appropriate values are permitted by the Engineer, the vibrations at structures and installations as referred to in sub-clause (7) of this Clause shall not exceed the values stated in Table 6.2.

(9) Unless permitted by the Engineer, the air-overpressure level measured shall not exceed the values stipulated in the Contract and those submitted to the Commissioner of Mines in support of the application for a Blasting Permit. If additional and different requirements are identified during the course of the Contract, the Contractor shall seek agreement from the regulatory authorities, maintenance authorities and/or the Engineer on such requirements and adhere to the agreed requirements.

Table 6.2: Restrictions on peak particle velocity and vibrational amplitude

Type of structure or Installation	**Peak particle velocity (mm/s)**	**Peak vibrational amplitude (mm)**
Water retaining structures Water tunnels	13	0.1
Water mains Other structures and pipes	25	0.2

Controlled blasting 6.37 (1) Earthworks final surfaces which are to be formed by blasting and which slope at a gradient exceeding 2 vertical to 1 horizontal and exceed 3 m in height shall be formed by pre-splitting. Other methods of controlled blasting shall not be used unless permitted by the Engineer.

(2) Pre-splitting and other methods of controlled blasting shall be carried out in such a manner that the rock mass is cleanly split on the required plane to within the specified tolerances and such that rock outside the earthworks final surface is not shattered or loosened.

(3) Faces formed by pre-splitting or other methods of controlled blasting shall not exceed 15 m in height in any one blasting operation unless permitted by the Engineer.

(4) If an earthworks final surface is to be formed by pre-splitting or other methods of controlled blasting:

(a) Other blast holes shall be located at a sufficient distance from the earthworks final surface to avoid damaging the surface, and

(b) The row of blast holes nearest to that surface shall be parallel to the row of pre-splitting holes.

(5) Holes for pre-splitting shall not be drilled into the sub-grade below berm levels. Rock that remains in position on berms after blasting shall be removed by methods other than blasting.

(6) Unless otherwise stated in the Contract, the Contractor shall propose and agree with the Engineer all particulars of pre-splitting, including but not limited to the length of explosives loaded in the blast holes, the detonating sequence and delays, the blast hole diameter and spacing, the hole inclination relative to the final surface.

DEPOSITION OF FILL MATERIAL

Types of fill material 6.38 Unless otherwise stated in the Contract, areas of fill shall be formed of general fill material.

Sources of fill material 6.39 Except in public filling area as stated in Clause 6.58, fill material shall be obtained from excavation within the Site. If there is insufficient fill material of the required types within the Site, imported fill material shall be provided by the Contractor from sources outside the Site.

Surface preparation for fill material 6.40 Except as stated in Clause 6.56, surfaces on which fill material is to be deposited shall be prepared after site clearance in accordance with the following requirements:

(a) Topsoil, grass, and other organic matter shall be removed.

(b) Soft spots, boulders and other materials, which in the opinion of the Engineer are unsuitable or unstable, shall be removed.

(c) Watercourses shall be diverted as stated in the Contract.

(d) Benches shall be cut and sub-soil drainage systems installed as stated in the Contract.

(e) Voids shall be dealt with as stated in the Contract or instructed by the Engineer.

(f) Surfaces other than rock shall be scarified to a depth of 200 mm and compacted to the same standard as the fill material that is to be deposited.

Commencement of deposition of fill material 6.41 The permission of the Engineer shall be obtained before deposition of fill material starts in any area of fill.

Haulage of fill material 6.42 Haulage of fill material to an area of fill shall proceed only when the compaction plant operating at the area to be filled is sufficient to achieve the specified requirements for relative compaction of the fill material.

Deposition of fill 6.43 (1) Fill material obtained from excavations within the Site shall be

material

deposited in its final location as soon as practicable after it has been excavated.

(2) Fill material shall be deposited in layers of a thickness appropriate to the compaction method to be used. In deposition of fill material, the Contractor shall ensure that a good bond is achieved between layers of fill, and unless otherwise directed by the Engineer, no material shall be placed on previously compacted layers unless the surface has been scarified or otherwise broken up and, if necessary, watered.

(3) Unless otherwise permitted by the Engineer, layers of fill material shall be horizontal, except for any gradient required for drainage, and the thickness of each layer shall be uniform over the area to be filled. The fill material shall be brought up from the bottom in uniform horizontal layers, with the top of each layer graded to enable surface water to drain readily.

(4) Except in excavations for structures, pits and trenches, if the difference in level between adjacent areas to be filled exceeds 1 m, the edge of the higher area shall be benched before fill material is placed against it.

(5) Execution of the Works shall be controlled in such a manner that any compaction of the fill material resulting from the passage of construction plant or haulage vehicles is uniform.

(6) Except as stated in Clause 6.56, fill material shall not be deposited by end-tipping, by pushing loose material down slope faces or by other methods which may result in segregation or inadequate compaction of the fill material.

Overfilling 6.44

In areas of fill formed of material other than rock fill material, earthworks final surfaces sloping at a gradient exceeding 1 vertical to 3 horizontal shall be formed by overfilling and cutting back after compaction. Over-filling shall extend beyond the earthworks final surface by a horizontal distance of 0.5 m or three times the thickness of the compacted layer, whichever is greater.

Deposition of fill material adjacent to structures and utilities 6.45

(1) Except as stated in Clause 6.45(4), fill material deposited within 0.5m of a structure or utility shall be fine fill material unless otherwise stated in the Contract. In addition, the material may contain up to 5% by weight of fresh, slightly decomposed or moderately decomposed rock fragments of up to 200 mm provided that these do not cause any damage to structures, nor do they interfere with the compaction requirements.

(2) Fill material shall not be deposited adjacent to or above structures or utilities until the construction of the structure or utility is sufficiently advanced to accept the imposed forces without disturbance or damage.

(3) Fill material shall be deposited evenly on all sides of structures and utilities and in such a manner that the structure or utility is not disturbed or damaged.

(4) Unless otherwise stated in the Contract, fill material around water, sewage and drainage pipes which are laid as part of the permanent work shall be special fill material. They shall be deposited in layers not exceeding 100 mm thick to a level of 300 mm above the top of the pipe. The fill material shall be deposited in such a manner that the layer on one side of the pipe is not more than 100 mm higher than the layer on the other side.

Deposition of rock fill material 6.46

(1) The final compacted thickness of each layer of rock fill material shall exceed 1.5 times and shall not exceed twice the nominal Grade size of the rock fill material.

(2) The surface voids of each layer of rock fill material shall be filled with fragments of rock before the next layer is deposited. The final surface of rock fill material shall also be blinded with fine fill material.

Deposition of fill material in excavations for structures, pits and trenches 6.47

If sheet piling, timbering or other temporary supports to excavations for structures, pits and trenches are not to be left in place, the sheet piling, timbering or supports shall be removed as deposition of fill material proceeds. The supports shall be removed in such a manner that the stability of the adjacent ground is maintained and the compacted fill material is not disturbed.

COMPACTION OF FILL MATERIAL

Compaction of fill material 6.48

(1) Fill material in areas of fill shall be compacted in layers to a stable condition as soon as practicable after deposition and in a manner appropriate to the location and to the material to be compacted.

(2) The permission of the Engineer shall be obtained before the next layer is deposited on each layer of compacted fill material.

(3) Except as stated in Clauses 6.50(2), 6.52(1), 6.54(2), 6.57 and 6.66, fill material shall be compacted to obtain a relative compaction of at least 95% throughout unless otherwise stated in the Contract.

Moisture content of fill material 6.49

Fill material other than rock fill material and material as stated in Clause 6.52(1) shall be at optimum moisture content during compaction. The tolerance on the optimum moisture content percentage shall be ±3%, provided that the fill material is still capable of being compacted in accordance with the specified requirements to form stable areas of fill. All necessary measures shall be taken to achieve and maintain the specified moisture content.

Compaction of fill material adjacent to structures and utilities 6.50

(1) Fill material shall be compacted in such a manner that structures or utilities are not disturbed or damaged.

(2) Fill material around water, sewage and drainage pipes, which are constructed as part of the permanent work, shall be compacted by hand-rammers or manually operated power equipment. Fill material within 300 mm above the top of sewage and drainage pipes shall be compacted to obtain a relative compaction of at least 85% throughout.

Compaction of rock fill material 6.51

(1) Every layer of rock fill material shall be compacted by at least eight passes of a vibrating roller or by other equivalent compaction method approved by the Engineer. The final surface of rock fill material shall be compacted by at least two additional passes of a vibrating roller or by other equivalent compaction method approved by the Engineer.

(2) Vibratory rollers used for the compaction of rock fill material shall have a static load per 100 mm width of roll of at least 2 kN for layers with a compacted thickness not exceeding 500 mm and at least 4 kN for layers with a compacted thickness exceeding 500 mm.

Compaction of general 6.52

(1) For general fill material of which less than 90% passes a 20 mm BS test

fill material with a large portion of coarse material

sieve, it is difficult to determine of the moisture content and maximum dry density according to Clauses 6.75(2), 6.75(3), 6.78(2), 6.81(5) and 6.81(6). This type of material shall be compacted to the requirements of Clauses 6.52(2), 6.52(3) and 6.52(4).

(2) Each horizontal layer of general fill material shall be spread and levelled with a thickness not less than 1.5 times of the maximum size of the general fill material and not exceeding the maximum depth of compacted layer in accordance with Table 6.2A. If there is a presence of over-sized coarse material in the general fill, the over-sized coarse material shall be removed or broken down to sizes acceptable to the Engineer. Each layer shall be systematically compacted by a vibratory roller with the stipulated minimum number of passes corresponding to the minimum static load per 100 mm width of the roller.

(3) The number of passes of the roller shall only be counted when the roller is travelled on the material to be compacted at a speed of not more than 2 km per hour with full vibration. Plant other than a vibratory roller carrying out material spreading or providing some preliminary compaction, to assist the use of heavier plant, shall be disregarded in counting the number of passes.

(4) Variation from the method or the use of plant different from that specified in Clause 6.52(2) will be permitted only if the Contractor demonstrates at site trials that equivalent compaction is achieved by the alternative method or plant. The procedure to be adopted for these site trials shall be agreed with and approved by the Engineer.

(5) Without prejudice to the provision of the Conditions of Contract and in order that the Engineer may take proper provision for the supervision of compaction in the permanent work, the Contractor shall, not less than 24 hours before he proposes to carry out compaction processes, apply in writing to the Engineer for permission to do so.

(6) When materials of widely divergent grading are used in embankments and fill areas, they shall be spread and compacted in separate clearly defined areas.

(7) If more than one class of material is being used in such a way that in the opinion of the Engineer, it is not practicable to define the areas in which each class occurs, compaction plant shall be operated as if only the material that requires the greatest compaction effort is being compacted.

Table 6.2A: Compaction requirement for general fill material with a large portion of coarse material

Force per 100 mm width	**Well-graded material**		**Uniform-graded material**	
(kN)	**Maximum depth of compacted layer (mm)**	**Minimum no. of passes**	**Maximum depth of compacted layer (mm)**	**Minimum no. of passes**
0.25 – 0.45			150	16
0.46 – 0.70			150	12
0.71 – 1.25	125	12	150	10
1.26 – 1.75	150	8	200	10
1.76 – 2.30	150	4	225	10
2.31 – 2.80	175	4	250	10
2.81 – 3.50	200	4	275	8
3.51 – 4.20	225	4	300	8
4.21 – 4.90	250	4	300	8

COMPLETION OF EARTHWORK SURFACES

Completion of earthwork final surfaces

6.53 (1) Earthwork final surfaces shall be completed to a stable condition as soon as practicable after excavation or after deposition and compaction of fill material has been completed. The subsequent permanent work or surface protection shall be carried out as soon as practicable after the earthworks final surface has been completed.

(2) Earthworks final surfaces shall be completed to smooth alignments without abrupt irregularities unless otherwise stated in the Contract.

Completion of formations

6.54 (1) Formations above structures or utilities shall be completed after construction of the structure or utility.

(2) Except in excavations in rock and in areas of fill formed of rock fill material or fill material as stated in Clause 6.52(1), formations shall be compacted to obtain a relative compaction of at least 98% to a depth of 200 mm below the formation.

(3) Unless otherwise permitted by the Engineer, proof rolling shall be carried out on formations. The formation shall be rolled in the presence of the Engineer by at least two passes of a non-vibrating rubber tyred roller. The roller shall have a static load per 100 mm width of roll of at least 4 kN and shall travel at a speed not exceeding 2 km/h. Any defect in the formation which is revealed during proof rolling by deformation of the formation which in the opinion of the Engineer is excessive shall be made good as instructed by the Engineer.

(4) After all other formation work and testing have been completed and damage caused by testing reinstated, formations for pavements shall be rolled with one pass of a smooth steel-wheeled non-vibrating roller. The roller shall have a load per 100 mm width of roll of at least 2 kN.

(5) Unless otherwise permitted by the Engineer, formation surfaces that

will not be immediately covered by the subsequent permanent works shall be protected by methods agreed by the Engineer.

Protection of earthwork final surfaces and formations 6.55 (1) Earthwork final surfaces and formations shall be maintained in a stable condition and shall be protected from damage due to water or other causes and from exposure to conditions which may adversely affect the surface.

(2) Formation shall not be used by construction plant or vehicles other than those which, in the opinion of the Engineer, are essential to construct the subsequent work.

INTERMEDIATE AREAS OF FILL

Deposition of fill material in intermediate areas of fill 6.56 Fill material may be deposited in intermediate areas of fill by end-tipping or by pushing into position until, in the opinion of the Engineer, it is sufficient to form a stable foundation on which to construct the subsequent work.

Compaction of fill material in intermediate areas of fill 6.57 Fill material in intermediate areas of fill up to the level stated in Clause 6.56 shall be compacted to a degree, which in the opinion of the Engineer is practicable. Except as stated in Clause 6.52(1), fill material above the level stated in Clause 6.56 shall be compacted to obtain a relative compaction of at least:

(a) 90% throughout,

(b) 95% within 1.5 m of earthworks final surfaces and formations, and

(c) 98% within 200 mm of formations.

EARTHWORKS IN PUBLIC FILLING AREA

Public filling area 6.58 Public filling area shall mean any area or portion of earthworks/reclamation works to receive inert construction and demolition material, and other materials disposed of by the public as stated in the Contract.

Public fill 6.59 Public fill shall mean inert construction and demolition material that is disposed of at a public filling area.

Combined reception and exit offices 6.60 (1) Combined reception and exit offices for the operation of a public filling area shall be provided at the location shown on the Drawings.

(2) The Contractor shall design and provide the combined reception and exit office in accordance with the schematic layout shown on the Drawings. The combined reception and exit office shall comply with the following requirements:

(a) Each shall consist of two floors and shall be constructed on a 1300mm high raised hollow platform. The upper floor is an inspection cabin, which shall be designed to withstand at least 5kPa live load and equipped with staircases and guard railings.

(b) Windows of sliding type with locks and security bars shall be provided at the sides to enable a clear view of the approaching traffic. All windows shall be provided with venetian blinds.

(c) Collision barriers, collision bollards, separation barriers, red/green light type automatic signaling system and drop-bars shall be provided as shown on the Drawings.

(d) An overhead water-spraying system shall be installed at each of the reception hallways. It shall consist of groups of nozzles and shall be supported firmly with posts standing on the ground. Each overhead water-spraying system shall be capable of emitting 100 litres of water in 30 seconds.

(e) The roof and all walls shall be fully lined, well insulated, waterproof and painted.

(f) All doors shall have secure and efficient locks.

(g) A surveillance system shall be installed in each combined reception and exit office at locations agreed by the Engineer. The surveillance system shall consist of closed circuit digital colour video camera, closed circuit video duplex multiplexer and the accessories with schedule as stated in the Contract. The surveillance system shall be operated in accordance with Clause 6.60(3).

(h) Weighbridge system shall be installed at each combined reception and exit office at locations as agreed with the Engineer to measure and record the weight of each and every dump truck using the public filling area. The weighbridge system shall be calibrated by a suitable method and at frequency as agreed with the Engineer.

(3) The surveillance system shall be operated as follows: -

(a) The camera of the surveillance system shall allow continuous recording and close surveillance of activities within the public filling area during the operation hours.

(b) Images captured by the cameras shall be continuously recorded by DVD recorders. Each recorded DVD shall be kept for at least 6 months. The Contractor shall insert and replace the DVD for the surveillance system so as to ensure the continuous recording of the operation activities.

(c) The position and angle of each camera of the surveillance system shall be as instructed by the Engineer. The Contractor shall be responsible for any relocation and/or adjustment required.

(4) Detailed proposals for the combined reception and exit offices shall be submitted by the Contractor to the Engineer for approval within 14 days of the date for commencement of the Works. The proposal shall include locations, layouts, associated facilities and construction details.

(5) Within 28 days of the date of approval by the Engineer, the Contractor shall complete the construction of the combined reception and exit offices that shall be ready for occupation and operation.

(6) The combined reception and exit offices shall be maintained in a clean, stable and secure condition daily.

(7) Equipment provided for the use of the Engineer shall be maintained in a clean and serviceable condition and all consumables shall be replenished as instructed by the Engineer.

(8) The permission of the Engineer shall be obtained before the combined reception and exit office or equipment is removed. The combined reception and exit office or equipment which are to be left in position or become the property of the Employer after completion of the Works shall be repaired, repainted and serviced as instructed by the Engineer.

Reception areas, queuing areas and access roads

6.61 (1) Reception areas, queuing areas and access roads shall be provided in accordance with the Drawings.

(2) The Contractor shall operate and maintain reception areas, queuing areas and access roads complying with the following requirements:

(a) The riding surfaces shall be kept in good condition without excessive bumps and depressions,

(b) The surfaces shall be kept in wet condition so as to minimize dust generation,

(c) The surfaces shall be kept free of grease, debris and the like, and

(d) Measures shall be taken to prevent ponding and flooding.

Management of dump truck movements

6.62 (1) The Contractor shall manage entry to and exit from the public filling area to:

(a) Maintain orderly traffic conditions at the reception areas, queuing areas and access roads,

(b) Ensure all dump trucks are inspected and weighed at the combined reception and exit offices before and after deposition. In the event that the materials carried by a dump truck are inspected as not acceptable, the Contractor shall direct the dump truck to leave the Site as instructed by the Engineer, and

(c) Direct dump trucks to the designated deposition point for deposition.

(2) The maximum speed of dump trucks within the public filling area shall be restricted to 10km per hour.

Upon instruction by the Engineer, the Contractor shall within three hours tow away any broken down dump truck from an operation area to a safe area within the Site as agreed with the Engineer so as not to disrupt the operation of the public filling area.

(3) The Contractor shall supply and erect temporary traffic signs, including speed limit signs, for directing dump trucks and traffic diversion within the public filling area.

Temporary haul roads and drains 6.63

(1) The Contractor shall provide and maintain temporary haul roads and drains to suit the programme of deposition and shall remove all temporary drainage systems after the Works. Lighting facilities shall be provided along the temporary haul roads and at each deposition point to ensure safe operation.

(2) The Contractor shall design the temporary haul roads and drains to ensure good riding condition and safety. All temporary haul roads shall be paved with granular material. The Contractor shall submit the details of the proposed temporary haul roads and drains to the Engineer for agreement 14 days before implementation or commencement of associated work whichever is earlier.

(3) The Contractor shall grade, regulate and compact all temporary haul roads as instructed by the Engineer to prevent undulation.

Handling and storage of wet soil 6.64

(1) Public fill may consist of wet soil. Wet soil may be any naturally occurring or processed material, which at the time of deposition is unable to be compacted in accordance with the specified requirements to form a stable area of fill.

(2) The Contractor shall plan the Works by allowing stockpiling space as agreed with the Engineer for handling wet soil. The Contractor shall process the wet soil received including mixing it with pubic fill to make it suitable for compaction and use in the Works. The processed material shall be handled and stored in accordance with Clause 6.14. The proposed method of processing and mixing shall be agreed with the Engineer at least 7 days before any processing and mixing starts.

Deposition of public fill 6.65

Clauses 6.43(2), 6.43(3), 6.43(4), 6.43(5), 6.43(6), 6.44, and 6.56 shall apply to deposition of public fill.

Compaction of public fill 6.66

(1) In addition to Clauses 6.48(1), 6.48(2) and 6.50(1), public fill shall be compacted to the requirements of Clauses 6.66(2), 6.66(3) and 6.66(4). The Contractor shall submit the proposed method of compaction including the proposed compaction plant, thickness of compacted layer and minimum number of passes to the Engineer for approval at least 7 days before any compaction starts.

(2) Each horizontal layer of public fill shall be spread and levelled with a thickness not exceeding the maximum depth of a compacted layer in accordance with Table 6.2B. Each layer shall be systematically compacted by the compaction plant with the minimum number of passes approved by the Engineer.

(3) Definitions and requirements associated with Table 6.2B are as follows:

(a) Where combinations of different types or categories of plant are used, the compaction requirements shall be:

- The depth of layer shall be that for the type of plant requiring the least depth of layer; and

- The number of passes shall be that for the type of plant requiring the greatest number of passes.

(b) The number of passes of the roller shall only be counted when the roller is travelled on the materials to be compacted at a speed of not more than 2 km per hour with full vibration where appropriate.

(c) The plant other than the approved compaction plant by the Engineer as stated in Clause 6.66(1) to carry out material spreading or to provide some preliminary compaction only to assist the use of heavier plant shall be disregarded in counting the number of passes.

(d) The force per 100 mm width is the total weight on the roll divided by the total roll width. Where a smooth-wheeled roller has more than one axle the machine will be assessed on the basis of the axle giving the highest value of force per 100 mm width.

(e) Wheel load is the total weight of the roller divided by the number of wheels.

(f) Vibratory rollers are machines having means of applying mechanical vibration to one or more rolls.

- The requirements for vibratory rollers are based on the use of the lowest gear on a self-propelled machine and a towing speed of 1800 - 2400 m/hour for a towed machine. If higher gears or speed are used, an increased number of passes shall be provided in proportion to the increase in speed of travel.

- Vibratory rollers operating without their vibration mechanism in use will be classified as smooth-wheeled rollers.

- Vibratory rollers shall only be operated with their vibration mechanism operating at the frequency of vibration recommended by the manufacturers. All such rollers shall be equipped with a device automatically indicating the frequency at which the mechanism is operating.

(g) Vibrating-plate compactors are machines having a base-plate to which a source of vibration consisting of one or two eccentrically weighted shafts is attached.

- The static pressure under the plate of a vibrating-plate compactor is calculated by dividing the total weight of the machine in working order by the area in contact with compacted material.

- Vibrating-plate compactors shall be operated at the frequency of vibration recommended by the manufacturer. They shall normally be operated at travelling speeds of less than 900 m/hour but, if higher speeds are necessary, the number of passes shall be increased in proportion to the increase in speed of travel.

(h) Vibro-tampers are machines in which an engine-driven reciprocating mechanism acts on a spring system, through which oscillations are set up in a base-plate.

(i) Power rammers are machines that are actuated by explosions in an internal combustion cylinder, each explosion being controlled manually by the operator.

(4) Variation from the methods or the use of plant different from that specified in Clause 6.66(2) will be permitted only if the Contractor demonstrates by site trials that equivalent compaction effect is achieved by the alternative method or plant. The procedure to be adopted for these site trials shall be agreed with and approved by the Engineer.

(5) Without prejudice to the provision of the Conditions of Contract and in order for the Engineer to make proper provision for the supervision of compaction in the permanent work, the Contractor shall, not less than 24 hours before he proposes to carry out compaction processes, apply in writing to the Engineer for permission to do so.

Table 6.2B: Compaction requirement

Type of compaction plant	Category	Maximum depth of compacted layer (mm)	Minimum no. of passes
Smooth-wheel roller	Force per 100 mm width		
	2.1 – 2.6 kN	125	10
	2.61 – 5.2 kN	125	8
	More than 5.2 kN	150	8
Grid-roller	Force per 100 mm width		
	5.3 – 7.8 kN	125	12
	More than 7.8 kN	150	12
Pneumatic-tyre roller	Wheel load		
	2 - 2.5 tonnes	125	12
	2.6 - 4 tonnes	125	10
	4 - 6 tonnes	125	10
	6 - 8 tonnes	150	8
	8 - 12 tonnes	150	8
	More than 12 tonnes	175	6
Vibratory roller	Force per 100 mm width		
	0.71 – 1.25 kN	100	12
	1.26 – 1.75 kN	125	8
	1.76 – 2.3 kN	150	4
	2.31 – 2.8 kN	175	4
	2.81 – 3.5 kN	200	4
	3.51 – 4.2 kN	225	4
	4.21 – 4.9 kN	250	4
Vibratory-plate compactor	Static pressure under base plate (kN/m^2)		
	13.8 - 17.2	100	6
	17.3 - 20.7	150	6
	More than 20.7	200	6
Vibro-tamper	Mass (kg)		
	50 – 65	100	3
	66 – 75	125	3
	More than 75	150	3
Power rammer	Mass (Kg)		
	100	150	6
	More than 500	275	12

Use of fill material adjacent to structures and utilities in public filling area

6.67 Fill material shall be used adjacent to structures and utilities in public filling areas as stated in the Contract. Fill material shall comply with Clause 6.09. The use of fill material shall comply with Clauses 6.45, 6.47 and 6.50.

TOLERANCES

Tolerances: earthworks final surfaces and formations

6.68 (1) Earthworks final surfaces and formations shall be within the tolerances of the specified lines and levels stated in Table 6.3. The tolerances for formations do not apply to pipes or preformed structures that require to be supported over their complete length or area.

(2) In excavation, a positive tolerance refers to insufficient excavation and a negative tolerance refers to excess excavation. In areas of fill, a positive tolerance refers to excess fill material and a negative tolerance refers to insufficient fill material.

Table 6.3: Tolerances for earthworks final surfaces and formations

Type of surface	**Method of forming surface**	**Tolerance (mm)**	
		+	-
Formations for structures and utilities	Excavation except in rock	0	25
	Excavation in rock	0	150
	Deposition and compaction of fill material	0	25
Formations for pavements, including carriageways, footways, cycletracks, paved areas, aircraft pavements and railway trackbeds.	Excavation except in rock	0	50
	Excavation in rock	0	150
	Deposition and compaction of fill material	0	50
Earthworks final surfaces other than formations, with a gradient not exceeding 1 vertical to 10 horizontal	Excavation except in rock	0	100
	Excavation in rock	0	200
	Deposition and compaction of fill material	0	100
Other earthworks final Surfaces	Excavation except in rock	100	100
	Excavation in rock	100	200
	Deposition and compaction of fill material	100	100

TESTING: FILL MATERIAL - GENERAL REQUIREMENTS

Batch: fill material 6.69 A batch of fill material is any quantity of fill material of the same type and which in the opinion of the Engineer has similar properties throughout. For the purpose of testing for moisture content and relative compaction a batch shall, in addition to the above, be fill material which is deposited in a single layer in any area of fill presented by the Contractor for testing on one occasion.

Samples: fill material 6.70 (1) Each sample of fill material shall consist of at least four increments taken from different parts of the batch. The increments shall be combined and thoroughly mixed and shall then be divided by quartering or by using a riffle box to obtain specimens of an appropriate size to carry out the individual tests.

(2) The size of samples of fill material other than rock fill material shall be in accordance with Geospec 3, Clauses 2.5.1, 4.2 and Table 2.1. Each sample of rock fill material of Grade size not exceeding 200 shall have a mass of at least 250 kg and each sample of rock fill material of Grade size exceeding 200 shall have a mass of at least 1000 kg.

TESTING: FILL MATERIAL - PARTICLE SIZE DISTRIBUTION, LIQUID LIMIT, PLASTICITY INDEX, COEFFICIENT OF UNIFORMITY AND SULPHATE CONTENT

Samples: particle size distribution, liquid limit, plasticity index, coefficient of uniformity, sulphate content 6.71 Samples of fill material to be tested for particle size distribution, liquid limit, plasticity index, coefficient of uniformity and sulphate content shall be delivered at least 14 days, or such shorter period agreed by the Engineer, before deposition of the fill material starts. The number of samples to be provided from each batch shall be as stated in Table 6.4.

Table 6.4: Number of samples to be tested for particle size distribution, liquid limit, plasticity index, coefficient of uniformity, sulphate content, optimum moisture content and maximum dry density

Description	**Size of batch**	**No. of samples per batch**
Special fill material	0 - 3,000 m^3	3
	Exceeding 3,000 m^3	1 for each 1,000 m^3 or part thereof
Fill material other than special fill material	0 - 15,000 m^3	3
	Exceeding 15,000 m^3	1 for each 5,000 m^3 or part thereof

Testing: particle size distribution, liquid limit, plasticity index, coefficient of uniformity, sulphate content

6.72 (1) Each sample of fill material taken as stated in Clause 6.71 shall be tested to determine the particle size distribution. In the case of special fill material, testing shall include calculation of the coefficient of uniformity as stated in Clause 6.72(4). Unless otherwise agreed by the Engineer, each sample of fill material other than rock fill material shall be tested to determine the liquid limit and the plasticity index of that portion of the fill material passing a 425μm BS test sieve. Each sample of fill material, which will be deposited within 500 mm of concrete, cement, bound material, cementitious material or metalwork shall be tested to determine the soluble sulphate content.

(2) The method of testing shall be in accordance with the following:

Particle size distribution	: Clause 6.72(3)
Liquid limit	: Test Method 6.1 of Geospec 3
Plasticity index	: Test Method 6.1 of Geospec 3
Soluble sulphate content	: Test Method 9.3 of Geospec 3
Total sulphate content	: Test Method 9.3 of Geospec 3

(3) The particle size distribution of fill material passing a 75 mm BS test sieve shall be determined in accordance with Geospec 3, Test Method 8.1 or 8.2, whichever as instructed by the Engineer. The size of particles of fill material, which do not pass a 75 mm BS test sieve, shall be taken as the largest dimension measured in any plane.

(4) The coefficient of uniformity (Cu) shall be calculated from the equation:

$$Cu = D_{60}/D_{10}$$

where:

- D_{60} and D_{10} are the equivalent sieve sizes in millimetres, interpolated from the particle size distribution curve, through which 60% and 10% of the fill material would pass respectively.

Non-compliance: particle size distribution, liquid limit, plasticity index, coefficient of uniformity, sulphate content

6.73 (1) If the result of any test for soluble sulphate content of fill material does not comply with the specified requirements for soluble sulphate content, each sample shall be tested to determine the total sulphate content.

(2) If the result of any test for particle size distribution, liquid limit, plasticity index, coefficient of uniformity or total sulphate content of fill material does not comply with the specified requirements for the property, additional samples shall be provided from the same batch and additional tests for the property shall be carried out. The number of additional samples shall be as stated in Table 6.4.

TESTING: FILL MATERIAL - OPTIMUM MOISTURE CONTENT AND MAXIMUM DRY DENSITY

Samples: optimum moisture content, maximum dry density

6.74 (1) Samples of fill material to be tested for optimum moisture content and maximum dry density shall be delivered at least 72 hours, or such shorter period agreed by the Engineer, before deposition of the fill material starts. The number of samples to be provided from each batch shall be as stated in Table 6.4.

(2) The Contractor shall inform the Engineer of the exact location in which the fill material from which each sample is taken is to be deposited.

(3) Samples to be tested for optimum moisture content and maximum dry density shall also be taken after the fill material has been deposited in its final position, at intervals of not more than 28 days. Samples to be tested for optimum moisture content and maximum dry density shall also be taken after the fill material has been deposited in its final position, at intervals of not more than 28 days.

(4) Samples shall not be provided from:

(a) Fill material including rock fill material which contains an insufficient proportion of particles passing a 20 mm BS test sieve to permit determination of the moisture content and maximum dry density, and

(b) Fill material that is to be deposited as stated in Clause 6.56.

Testing: optimum moisture content, maximum dry density

6.75 (1) Each sample of fill material taken as stated in Clause 6.74 shall be tested to determine the optimum moisture content and the maximum dry density.

(2) The method of testing shall be in accordance with Geospec 3, Test Method 10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7 or 10.8, whichever is instructed by the Engineer.

(3) If agreed by the Engineer, the Hilf method stated in Appendix 6.3 may be used instead of the methods stipulated in Clause 6.75(2) to determine the optimum moisture content and maximum dry density.

(4) If in the opinion of the Engineer there is any undue discrepancy between the results of tests for optimum moisture content of fill material using methods stipulated in Clause 6.75(2) and the results of tests using the Hilf method, the results of tests using methods stipulated in Clause 6.75(2) shall prevail.

Consistency: optimum moisture content, maximum dry density

6.76 If the result of any test for optimum moisture content or maximum dry density of fill material indicates that the batch contains material which in the opinion of the Engineer, differs to such an extent that subsequent tests for relative compaction may be affected, the batch shall be divided into smaller batches. Each of the smaller batches shall comprise material with similar properties throughout. Additional samples shall be provided from each of the smaller batches and additional tests for optimum moisture content and maximum dry density shall be carried out. The number of additional samples shall be as stated in Table 6.4.

TESTING: FILL MATERIAL - MOISTURE CONTENT

Samples: moisture content

6.77 (1) Samples of fill material to be tested for moisture content shall be taken during deposition and compaction of fill material and shall be delivered not more than 1 hour after the fill material has been deposited in its final position.

(2) The number of samples to be provided from each batch shall be as stated in Table 6.5. Samples shall not be provided if, in accordance with Clause 6.74(4)(a) or (b), the optimum moisture content has not been determined.

Testing: moisture content

6.78 (1) Each sample of fill material taken as stated in Clause 6.77 shall be tested to determine the moisture content.

(2) The method of testing shall be in accordance with one of the following methods:

(a) Method 1 : Geospec 3, Test Method 5.1 or 5.2, whichever is instructed by the Engineer

(b) Method 2 : Microwave oven drying method as stated in Appendix 6.2.

(c) Method 3 : Infrared oven drying method as stated in Appendix 6.5

Method 1 shall be used unless otherwise agreed by the Engineer.

Compliance criteria: moisture content

6.79 If in the opinion of the Engineer there is any undue discrepancy between the results of tests for moisture content of fill material using Method 1 and the results of tests using Method 2 or 3 in Clause 6.78, the results of tests using Method 1 shall prevail.

Non-compliance: moisture content

6.80 If the result of any test for moisture content of fill material differs from the optimum moisture content by more than the specified amount and if instructed by the Engineer, the moisture content of the whole of the batch of fill material shall be adjusted. Additional samples shall be provided from the same batch and additional tests for moisture content shall be carried out. The number of additional samples shall be as stated in Table 6.5.

Table 6.5: Number of samples to be tested for moisture content and number of tests for relative compaction

Description	Size of area of fill in batch	No. of samples/No. of tests per batch = (a) + (b)	
		(a)	(b)
Areas of fill in excavations for structures, pits and trenches and on formations	0 - 100 m^2	3	-
	exceeding 100 - 500 m^2	1	2 for each 100 m^2 or part thereof
	exceeding 500 m^2	6	1 for each 100 m^2 or part thereof
Other areas of fill	0 - 1 ha	-	4 for each 1000 m^2 or part thereof
	exceeding 1 - 10 ha	10	3 for each 1000 m^2 or part thereof
	exceeding 10 ha	110	2 for each 1000 m^2 or part thereof

TESTING: FILL MATERIAL - RELATIVE COMPACTION

Testing: relative compaction

6.81 (1) Unless otherwise agreed by the Engineer, each batch of fill material shall be tested to determine the relative compaction. Tests shall be carried out after the fill material has been deposited and compacted in its final position. The number of tests on each batch shall be as stated in Table 6.5. Tests shall not be carried out on:

(a) Fill material including rock fill material which contains an insufficient proportion of particles passing a 20 mm BS test sieve to permit determination of the relative compaction, and

(b) Fill material that has been deposited as stated in Clause 6.56.

(2) Tests shall be carried out at positions, which in the opinion of the Engineer are representative of the batch of compacted fill material as a whole.

(3) Testing will be carried out by the Engineer.

(4) The relative compaction of fill material shall be determined in accordance with one of the following methods:

(a) Method 1: Geospec 3, Test Method 11.4

RC = IDD/MDD x 100%

where:

- IDD is the in-situ dry density determined as stated in Clause 6.81(5)

- MDD is the maximum dry density determined as stated in Clause 6.75(2)

(b) Method 2: The relative compaction (RC) shall be calculated from the equation:

RC = IBD/MCBD x 100%

where:

- IBD is the in-situ bulk density determined as stated in Clause 6.81(5)

- MCBD is the maximum converted bulk density determined by the Hilf method as stated in Appendix 6.3

Method 1 shall be used unless otherwise permitted by the Engineer.

(5) The in-situ bulk density and the in-situ dry density of fill material shall be determined in accordance with one of the following methods:

(a) Method 1 : Geospec 3, Test Method 11.1 or 11.2

(b) Method 2: Nuclear densometer method as stated in Geospec 3, Test Method 11.3

Method 1 shall be used unless otherwise permitted by the Engineer.

(6) The maximum converted bulk density of fill material of which more than 5% is retained on a BS 20 mm test sieve, shall be adjusted as stated in Appendix 6.4.

Compliance criterion: relative compaction

6.82 If in the opinion of the Engineer there is any undue discrepancy between the results of tests for relative compaction of fill material using Method 1 and the results of tests using Method 2 in Clause 6.81, the results of tests using Method 1 shall prevail.

Non-compliance: relative compaction

6.83 If the result of any test for relative compaction of fill material does not comply with the specified requirements for relative compaction, additional tests for relative compaction shall be carried out on the same batch. The number of additional tests shall be as stated in Table 6.5.

APPENDIX 6.1

TEST METHODS FOR FILL MATERIAL

General 6.1.1 The definitions, terms, abbreviations symbols, and grouping of materials stated in BS 1377:Part 1 shall apply except as stated in Clauses 6.1.2 and 6.1.3.

Terms and symbols 6.1.2 Terms used in the GS, and in BS 1377:Part 1 are identified in the GS by the abbreviations and symbols stated in Table 6.1.1.

Table 6.1.1: Abbreviations and Symbols

Abbreviation/ Symbol	**Term**
BD	Bulk density
CBD	Converted bulk density
DD	Dry density
IBD	In-situ bulk density
IDD	In-situ dry density
MDD	Maximum dry density
MCBD	Maximum converted bulk density
RC	Relative compaction
W	Moisture content
w_i	In-situ moisture content
w_o	Optimum moisture content

Grouping of material 6.1.3 (1) Fine-grained material is material of which at least 90% passes a 2 mm BS test sieve.

(2) Medium-grained material is material of which at least 90% passes a 20 mm BS test sieve and more than 10% is retained on a 2 mm BS test sieve.

APPENDIX 6.2

DETERMINATION OF THE MOISTURE CONTENT OF FINE GRAINED AND MEDIUM GRAINED MATERIAL BY THE MICROWAVE OVEN DRYING METHOD

Scope

6.2.1 This method covers the determination of the moisture content of fine- grained and medium-grained material as a percentage of the mass of the dry material.

Apparatus

6.2.2 The following apparatus is required:

(a) A microwave oven with a timer and an adjustable power setting.

(b) An airtight container of microwave safe and non-reflective material.

(c) A balance readable and accurate to 0.01g.

(d) A desiccator containing anhydrous silica gel.

Procedure

6.2.3 The procedure shall be as follows:

(a) The container shall be cleaned, dried and weighed to the nearest 0.01g (m_1).

(b) A specimen shall be crumbled and placed loosely in the container and the lid shall be replaced. Each specimen of fine-grained material shall be at least 30 g and each specimen of medium-grained material shall be at least 300 g. Specimens of medium-grained material may be tested in several parts each less than 300 g and the results aggregated.

(c) The container and contents shall be weighed to the nearest 0.01g (m_2).

(d) The lid of the specimen container shall be removed and the container with its lid and contents shall be placed in the microwave oven and dried. The specimen shall be considered to be dry when, after an initial drying period, successive weighings at intervals of 1 minute produce results that are the same to the nearest 0.01g. Alternatively, the oven may be set to an appropriate time and power setting to dry the specimen as determined by calibration of the oven on soil of a similar type.

(e) After drying, the container and contents shall be removed from the microwave oven and placed in the desiccator to cool.

(f) The lid shall be replaced and the container and contents shall be weighed to the nearest 0.01g (m_3).

Calculation 6.2.4 The moisture content of the material (w) shall be calculated as a percentage of the dry mass of the material from the equation:

$$w = (m_2 - m_3)/(m_3 - m_1) \times 100\%$$

where:

- m_1 is the mass of the container (g)
- m_2 is the mass of the container and contents before drying (g)
- m_3 is the mass of the container and contents after drying (g)

Reporting of results 6.2.5 The following shall be reported:

(a) Source and identification of the soil.

(b) The moisture content of the material to the nearest 0.1%.

(c) That the test method used was in accordance with this Specification.

APPENDIX 6.3

DETERMINATION OF THE MAXIMUM CONVERTED BULK DENSITY BY THE HILF METHOD

Scope 6.3.1 This method covers the determination of the maximum converted bulk density and the difference between the optimum moisture content and the in-situ moisture content of a material by relating the converted bulk density and the moisture added.

Apparatus 6.3.2 The following apparatus is required:

(a) Apparatus in accordance with Geospec 3, Test Methods 10.1, 10.2, 10.5 or 10.6 Amd 1/2024, whichever as instructed by the Engineer.

(b) Apparatus for determination of the moisture content in accordance with either Geospec 3, Test Method 5.1 or 5.2 or Appendix 6.2 or Appendix 6.5, whichever as instructed by the Engineer.

(c) Apparatus to extract specimens from the mould.

(d) Apparatus, such as a warm air blower, for rapid drying of the material.

Procedure 6.3.3 The procedure shall be as follows:

(a) A sample of material shall be taken immediately after completing the in-situ bulk density test at the same location as the test. The sample shall be obtained by digging to the same depth as that of the in-situ bulk density test, keeping the sides of the excavation vertical and the bottom flat and level. The size of the sample shall be sufficient to yield a minimum of 13 Amd 1/2024 kg after screening over a 20 mm BS test sieve. For material which is susceptible to crushing, following minimum mass of material shall be collected:

i. Minimum 15 kg for material with percentage by mass of the sample retained on 20mm BS test sieve less than 5%;

ii. Minimum 20 kg for material with percentage by mass of the sample retained on 20mm BS test sieve between 5% and 20%;

iii. Minimum 40 kg for material with percentage by mass of the sample retained on 20mm BS test sieve exceeding 20%.

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(b) The sample shall be weighed to the nearest 0.01 g.

(c) The sample shall be screened over a 20 mm BS test sieve, ensuring that moisture loss is kept to a minimum and that any free moisture appearing in the containers is worked back into the sample.

(d) The amount retained on the sieve shall be weighed to the nearest

0.01 g and expressed as a percentage of the mass of the sample. If the percentage exceeds 5%, an adjustment for coarse material shall be made in accordance with Appendix 6.4. If the percentage does not exceed 5%, no adjustment is required.

(e) The material to be tested shall be thoroughly mixed and divided by quartering or by using a riffle box to obtain a minimum of five Amd 1/2024 specimens of at least 2500 g each, ensuring that moisture loss is kept to a minimum. Alternatively, if it has previously been ascertained that the material is not susceptible to crushing, a single specimen of at least 2500 g may be used for repeat testing.

(f) Each specimen shall be weighed to the nearest 0.01 g and the result shall be taken as the mass of the specimen at the in-situ moisture content.

(g) Each specimen and any remaining material shall be placed in separate moisture-tight containers and the containers sealed.

(h) The converted bulk density of at least three specimens shall be plotted against the amount of water added or removed as a percentage of the mass of the specimen at the in-situ moisture content (z) on a graph where the ordinate shows the converted bulk density and the abscissa shows the amount of water added/removed as a percentage of the mass of the specimen (see Civil Engineering and Development Department Standard Drawing No. C2006/1) Amd 1/2024 in accordance with the procedure stated in Clause 6.3.3(i) to (o).

(i) The first point on the graph shall be obtained as follows:

- A specimen shall be compacted at its in-situ moisture content in accordance with Geospec 3, Test Method 10.1, Clause 10.1.5, Amd 1/2024 Test Method 10.2, Clause 10.2.5, Test Method 10.5 Amd 1/2024, Clause 10.5.5 or Test method 10.6 Clause 10.6.5, Amd 1/2024 whichever is instructed by the Engineer.

- A diametrical slice of approximately 400 g to 500 g shall be cut from the specimen along its entire length. The in-situ moisture content of the slice (w) Amd 1/2024 shall be determined in accordance with either Geospec 3, Test Method 5.1 or 5.2 or Appendix 6.2 or Appendix 6.5, whichever as instructed by the Engineer.

- The bulk density (BD_1) shall be calculated as stated in Clause 6.3.4(1) and plotted on the 0% ordinate of the graph as the converted bulk density (CBD_1).

(j) The second point on the graph shall be obtained as follows:

- A second specimen shall be examined and, if the in-situ moisture content obviously exceeds the optimum moisture content, the procedure stated in Clause 6.3.3(k) shall be followed.

- The moisture content of the specimen shall be increased by adding an amount of water equal to approximately Amd 1/2024

2% of the mass of the specimen. The specimen shall be thoroughly mixed and compacted in accordance with the method stipulated in Clause 6.3.3(i).

- The bulk density (BD_2) shall be calculated as stated in Clause 6.3.4(1), adjusted to converted bulk density (CBD_2) as stated in Clause 6.3.4(2) and plotted on the +2% ordinate of the graph.

(k) If the in-situ moisture content of the second specimen obviously exceeds the optimum moisture content, the specimen shall be dried until the amount of water removed is approximately 2% of the mass of the specimen and cooled. The specimen shall be thoroughly mixed and compacted in accordance with the method stipulated in Clause 6.3.3(i). The amount of water removed shall be determined. The bulk density (BD_2) shall be calculated as stated in Clause 6.3.4(1), adjusted to converted bulk density (CBD_2) as stated in Clause 6.3.4(2) and plotted on the negative ordinate of the graph at a point which corresponds to the amount of water removed.

(l) The third point on the graph shall be obtained as follows:

- If the plotted value of CBD_2 is equal to or greater than the plotted-value of CBD_1, the moisture content of a third specimen shall be increased by adding an amount of water equal to approximately Amd 1/2024 4% of the mass of the specimen. Alternatively, if the procedure stated in Clause 6.3.3(k) has been followed, the specimen shall be dried until the amount of water removed is approximately 4% of the mass of the specimen after cooling.

- If the plotted value of CBD_2 is less than the plotted value of CBD_1, the third specimen shall be dried until the amount of water removed is approximately 2% of the mass of the specimen after cooling. Alternatively, if the procedure stated in Clause 6.3.3(k) has been followed, the moisture content shall be increased by adding an amount of water equal to approximately Amd 1/2024 2% of the mass of the specimen.

- The specimen shall be thoroughly mixed and compacted in accordance with the method stipulated in Clause 6.3.3(i). The amount of water removed shall be determined.

- The bulk density (BD_3) shall be calculated as stated in Clause 6.3.4(1), adjusted to converted bulk density (CBD_3) as stated in Clause 6.3.4(2) and plotted on the graph at a point which corresponds to the amount of water added or removed.

(m) If the centre point of the three points plotted is lower than one of the other two points, or is higher than one point and equal to the other, an additional point or points shall be obtained by proceeding in 2% increments or decrements as appropriate.

(n) If it is apparent that the moisture condition of the material is such that a total of five points will not result in the determination of the optimum moisture content, increments and decrements of 3% moisture content may be adopted for the entire procedure.

(o) A smooth approximately parabolic curve shall be drawn to the plotted points. The peak value of the curve, as the maximum converted bulk density (MCBD), Amd 1/2024 shall be determined as the maximum converted bulk density (MCBD).

(p) Calculate the Amd 1/2024 amount of water added or removed as a percentage of the mass of the specimen at the in-situ moisture content corresponding to the maximum converted bulk density shall be determined (z_m).

(q) The moisture content adjustment value (z_c) shall be determined according to Civil Engineering and Development Department Standard Drawing No. C2006/2. Amd 1/2024

Calculation

6.3.4 (1) The bulk density (BD) shall be calculated from the equation:

$$BD = (m_2 - m_1)/V \quad Mg/m^3$$

where:

- m_1 is the mass of the mould and base (g)
- m_2 is the mass of the mould, base and wet material (g)
- V is the volume of the mould (mL)

(2) The converted bulk density (CBD) shall be calculated from the equation:

$$CBD = BD/(1+z/100) \quad Mg/m^3$$

where:

- z is the amount of water added or removed as a percentage of the mass of the specimen at the in-situ moisture content
- z is negative for values below the in-situ moisture content

(3) The difference between the optimum moisture content (w_o) and the in-situ moisture content (w_i) of the material shall be calculated from the equation:

$$w_o - w_i = z_m + z_c \quad \%$$

where:

- z_m is the amount of water added or removed as a percentage of the mass of the specimen at the in-situ moisture content corresponding to the maximum converted bulk density (%)
- z_c is the moisture content adjustment value (%) Amd 1/2024

(4) Amd 1/2024 The maximum dry density (MDD) shall be calculated from the equation:

$$MDD = MCBD/(1 + w_i/100) \quad Mg/m^3$$

where:

- w_i is the in-situ moisture content of the material (%) Amd 1/2024

- MCBD is the maximum converted bulk density of the material (Mg/m^3)

(5) Amd 1/2024 The relative compaction (RC), if required, shall be calculated from the equation:

$$RC = IBD/MCBD \times 100\%$$

where:

- IBD is the in-situ bulk density of the material determined in accordance with Geospec 3, Test Method 11.1 or 11.2 as appropriate to the grain size of the material

Reporting of results 6.3.5 The following shall be reported:

(a) Source and identification of the soil.

(b) The graph showing the plotted points and the parabolic curve passing through them.

(c) The maximum converted bulk density to the nearest 0.01 Mg/m^3.

(d) The optimum moisture content to the nearest 0.1%.

(e) The maximum dry density to the nearest 0.01 Mg/m^3.

(f) The relative compaction to the nearest 0.1%, if determined.

(g) The difference between optimum moisture content and the in-situ moisture content to the nearest 0.1%, if determined. Amd 1/2024

(h) Amd 1/2024 The percentage retained on the 20 mm BS test sieve and the percentage retained on the 37.5 mm BS test sieve to the nearest 1%, if applicable.

(i) Amd 1/2024 Whether the test was carried out using individual specimens or repeat testing of a single specimen.

(j) Amd 1/2024 Whether a manual or an automatic compaction rammer was used.

(k) Amd 1/2024 That the test method used was in accordance with this Specification.

APPENDIX 6.4

ADJUSTMENT OF THE MAXIMUM CONVERTED BULK DENSITY FOR THE DETERMINATION OF THE RELATIVE COMPACTION

Scope 6.4.1 This method covers the adjustment of the maximum converted bulk density determined in accordance with Appendix 6.3 for the determination of the relative compaction of a material containing more than 5% of the mass of the material at the in-situ moisture content retained on a 20 mm BS test sieve.

Apparatus 6.4.2 The following apparatus is required:

(a) Apparatus in accordance with Appendix 6.3.

(b) A 20 mm and a 37.5 mm BS test sieve.

(c) A mould with collar as used for determination of the California Bearing Ratio (CBR mould).

(d) An extrusion device as used for determination of the California Bearing Ratio.

Procedure 6.4.3 The procedure shall be as follows:

(a) If the amount of material retained on the 20 mm BS test sieve exceeds 5% and does not exceed 20%, the material passing the sieve shall be compacted in accordance with Appendix 6.3. The maximum converted bulk density ($MCBD_{20}$) shall be determined and adjusted as stated in Clause 6.4.4.

(b) If the amount of material retained on the 20 mm BS test sieve exceeds 20%, the retained material shall be screened over the 37.5 mm BS test sieve. The procedure stated in either Clause 6.4.3(c) or Clause 6.4.3(d) as appropriate shall be followed.

(c) If the amount of material retained on the 37.5 mm BS test sieve does not exceed 5%, the procedure stated in Clause 6.4.3(e) shall be followed.

(d) If the amount of material retained on the 37.5 mm BS test sieve exceeds 5% and does not exceed 20%, the retained material shall be replaced with an equal mass of material which is of a similar nature and which is retained on a 20 mm BS test sieve but passes a 37.5 mm BS test sieve. The procedure stated in Clause 6.4.3(e) shall be followed.

(e) The procedure stated in Appendix 6.3 shall be followed except that the material shall be compacted into the CBR mould and each layer shall be subjected to 62 blows of the rammer. The material to be tested shall be thoroughly mixed and divided by quartering or by using a riffle box to obtain a minimum of five specimens of at least 6,000g each, ensuring that moisture loss is kept to minimum. Alternatively, if it has previously been ascertained that the material is not susceptible to crushing, a single specimen of at least 6,000g may be used for repeat testing. Amd 1/2024

Calculation 6.4.4 The maximum converted bulk density (MCBD) shall be calculated from the equation:

$$MCBD = MCBD_{20}\left[1 + \frac{m}{1+\frac{z}{100}}\left(1 - \frac{MCBD_{20}}{G_s}\right)\right] Mg/m^3$$

where:

- $MCBD_{20}$ is the maximum converted bulk density of the material passing the 20 mm BS test sieve (Mg/m^3)

- z is the amount of water added as a percentage of the mass of the specimen at the in-situ moisture content corresponding to the maximum converted bulk density (%)

- m is the weight of particles retained on the 20mm BS test sieve expressed as a fraction of the fill wet weight

- Gs is the specific gravity of the particles retained on the 20mm BS test sieve Amd 1/2024

Reporting of results 6.4.5 The following shall be reported:

(a) The source and identification of the soil.

(b) The results in accordance with Appendix 6.3.

(c) The mass of the original material not passing the 20 mm and 37.5 mm BS test sieve as a percentage of the mass of the material at the in-situ moisture content to the nearest 0.1%.

(d) The type of mould used.

(e) The number of blows per layer.

(f) Whether the specific gravity was measured or assumed and, if measured, the method used.

(g) That the test method used was in accordance with this Specification, and the results have been adjusted in accordance with this Appendix.

APPENDIX 6.5

DETERMINATION OF THE MOISTURE CONTENT OF SOIL BY THE INFRARED OVEN DRYING METHOD AT 105 ± 5 °C

Scope 6.5.1 This method covers the determination of the moisture content of Amd 1/2024 by infrared oven drying with convection heating Amd 1/2024 at 105 ± 5 °C. The method is not suitable for soil containing gypsm, calcareous material or organic matters.

Amd 1/2024

Apparatus 6.5.2 The following apparatus is required:

(a) An infrared oven with convection heating and with Amd 1/2024 a suitable power control device and ventilation, capable of maintaining oven Amd 1/2024 temperature at 105 ± 5 °C and meeting Amd 1/2024 the performance requirements: - Amd 1/2024 Amd 1/2024

(i) the difference of mass of the test specimens(1) taken in 3 hours and 3½ hours after drying in the infrared oven shall be less than 0.1% of the original wet mass of the test specimens; Amd 1/2024

(ii) the temperature of test specimens not exceeding 110°C; and Amd 1/2024

(iii) the difference between the moisture content values of the test specimens by infrared oven drying and further convection oven drying at 105 ± 5 °C for 24 hours shall be less than 0.4%.

Note: (1) Test specimens used for verifying the performance of the infrared oven should have a minimum moisture content of optimum moisture content plus 3%. Amd 1/2024

(b) Suitable corrosion-resistant Amd 1/2024 containers with lids.

(c) A balance, readable to 0.01g and accurate to 0.05g for fine-grained soils Amd 1/2024.

(d) A balance, readable to 0.1g and accurate to 0.3g for medium-grained soils. Amd 1/2024

(e) A balance, readable to 1g and accurate to 3g for coarse-grained soils. Amd 1/2024

Procedure 6.5.3 The procedure shall be as follows:

(a) The container and its lid shall be cleaned, dried and weighed to the nearest 0.01g, 0.1g or 1g for fine-grained, medium-grained or coarse-grained soils respectively Amd 1/2024 (m_1).

(b) A test specimen shall be crumbled and placed loosely in the container. The mass of soil required for the preparation of a test specimen shall follow Clause 5.1.4 of Test Method 5.1 of Geospec 3. Amd 1/2024

(c) The container and contents together with its lid on shall be weighed to the nearest 0.01g, 0.1g or 1g for fine-grained, medium-grained or coarse-grained soils respectively Amd 1/2024 (m_2).

(d) The lid of the container shall be removed and the container with its contents shall be placed in the infrared oven and dried.

(e) After an initial drying period of 3 hours, the lid shall be replaced and the container and contents shall be weighed to the nearest 0.01g, 0.1g or 1g for fine-grained, medium-grained or coarse-grained soils respectively. Amd 1/2024

(f) The lid of the container shall be removed and the container with its contents shall be placed back in the infrared oven for successive drying of half an hour.

(g) The lid shall be replaced and the container and contents shall be weighed to the nearest 0.01g, 0.1g or 1g for fine-grained, medium-grained or coarse-grained soils respectively. Amd 1/2024

(h) The test specimen shall be considered to be dry when the difference between the mass readings taken 3 hours and 3½ hours after drying is less than 0.1% of the original wet mass of the test specimen. In case the drying criterion is not satisfied, the test specimen shall be Amd 1/2024 returned to the infrared Amd 1/2024 oven for successive drying until the drying criterion is satisfied Amd 1/2024. In this case, the test specimen shall be successively weighed at half-hourly intervals and the specimen shall be considered to be dry when the difference between two consecutive mass readings is less than 0.1 % of the original wet mass.

(i) The final mass of the container, its lid and contents shall be weighed to the nearest 0.01 g, 0.1g or 1g for fine-grained, medium-grained or coarse-grained soils respectively Amd 1/2024 (m_3) when the test specimen is dried.

Calculation 6.5.4 The moisture content of the test specimen (w) shall be calculated as a percentage of the dry soil mass to the nearest 0.1% from the equation:

$$w = [(m_2-m_3)/(m_3-m_1)] \times 100\%$$

where:

- m_1 is the mass of container (in g) Amd 1/2024;
- m_2 is the mass of container Amd 1/2024 and wet soil (in g) Amd 1/2024; and
- m_3 is the mass of container Amd 1/2024 and dry soil (in g) Amd 1/2024.

Reporting of results 6.5.5 The following shall be included in the test report:

(a) Source and identification of the test specimen.

(b) The moisture content of the test specimen to two significant figures for values up to 10% or to the nearest whole number for values above 10%. Amd 1/2024

(c) The duration of all drying activities to the nearest half hour.

(d) A statement stating that the test method used was in accordance with this Specification.

Amd 1/2024

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 7

GEOTECHNICAL WORKS

SECTION 7

GEOTECHNICAL WORKS

PART 1: GENERAL REQUIREMENTS

GENERAL

General requirements 7.01 The works and materials specified in Clauses 7.02 to 7.05 shall comply with the sections stated, unless otherwise stated in this Section.

Site clearance 7.02 Site clearance shall comply with Section 2.

Drainage works 7.03 Drainage works shall comply with Section 5.

Earthworks 7.04 Earthworks shall comply with Section 6.

Concrete 7.05 Concrete shall comply with Section 16.

Prestressed ground anchors 7.06 Prestressed ground anchors shall comply with the requirements stated in the Contract.

Reinforced fill structures 7.07 Reinforced fill structures shall comply with the requirements stated in the Contract.

TRIALS

Trials for geotechnical works 7.08 Details of trials to be carried out for geotechnical works shall be as stated in the Contract.

PART 2: GROUND INVESTIGATION

GLOSSARY OF TERMS

(The meanings hereby respectively assigned to the following words and expressions shall only be applicable to Clauses 7.29 to 7.83.)

Block Sample	7.09	A Block Sample is an undisturbed sample recovered by in-situ hand trimming of a block of material from the surrounding soil.
Bulk Sample	7.10	A Bulk Sample is a sample of at least 10 kg mass, which is representative of the grading of the material at the point of sampling.
Inspection Pit	7.11	An Inspection Pit is a pit for locating and identifying underground utilities and structures.
Jar Sample	7.12	A Jar Sample is a disturbed sample of at least 0.7 kg mass contained in a transparent airtight jar, which has a screw cap with an airtight sealing ring.
Sample	7.13	A Sample is any quantity of material obtained from the ground for the purposes of inspection, logging or testing.
Slope Surface Stripping	7.14	Slope Surface Stripping is the removal of surface protection and vegetation from existing slopes to expose underlying soil or rock for inspection.
Trial Pit	7.15	A Trial Pit is a pit for inspecting and logging the ground and in which to carry out in-situ testing and sampling.
Trial Trench	7.16	A Trial trench is any excavation with dimensions larger than a trial pit on plan.
U76/U100 Sample	7.17	A U76/U100 Sample is an undisturbed sample recovered by advancing a thin-walled tube of approximately 76 mm/100 mm diameter with a cutting edge into the soil.
Undisturbed Soil Sample	7.18	An Undisturbed Soil Sample is a sample complying with Class 1 or Class 2 of BS 5930.
Ground Investigation	7.19	Ground Investigation is the works carried out on site to investigate the subsurface conditions.
Ground Investigation Site	7.20	A Ground Investigation Site is the area required to be investigated as indicated on the drawings issued from time to time by the Engineer,
Investigation Station	7.21	An Investigation Station is the area within 2m from the specified point or area.
Common Ground	7.22	Common Ground is material of clay, silt, sand, gravel, cobbles and all other types of material other than rock or boulders.
Rock	7.23	Rock is naturally occurring material of Grades I to III as classified in Table 4 of Geoguide 3 "Guide to Rock and Soil Descriptions".
Boulders	7.24	Boulders are rock fragments greater than 200 mm in size.
Cobbles	7.25	Cobbles are rock fragments 60 mm to 200 mm in size.
Gravel/ Sand	7.26	Gravel is soil particles 2 mm to 60 mm in size. Sand is soil particles 0.06 mm to 2 mm in size. Sand shall be natural sand or crushed natural stone.

Hard Strata 7.27 Hard Strata are natural or man-made materials which cannot be penetrated except by the use of rotary drilling or powered breaking tools.

AGS Digital Format 7.28 AGS Digital Format is a data format that complies with the Third Edition of the Association of Geotechnical and Geoenvironmental Specialists (AGS) publication "Electronic Transfer of Geotechnical and Geoenvironmental Data".

SUBMISSIONS

Particulars of ground investigation 7.29 (1) The following particulars of proposed materials and methods for ground investigation shall be submitted to the Engineer:

(a) Details of drilling and in-situ testing equipment,

(b) Details of sampling equipment, and

(c) Details of filter materials and fill materials for drilling and testing,

(2) The particulars shall be submitted to the Engineer for approval at least 7 days before the relevant work starts.

INSPECTION PITS, TRIAL PITS AND SLOPE SURFACE STRIPPING

Inspection pits 7.30 (1) Inspection pits shall not be less than 0.25 m^2 in plan and not less than 1.5 m deep, unless otherwise instructed by the Engineer.

(2) Small disturbed samples shall be taken every 0.5 m in all Common Ground layers encountered in the inspection pit for logging purposes, commencing at ground level or below any concrete or road surfacing layers.

Trial pits and trial trenches 7.31 (1) Trial pits shall have nominal plan dimensions of 1.5 m x 1.5 m to their full depth of excavation, unless otherwise instructed by the Engineer or due to restricted space at the pit location or where prevented by the presence of hard strata. Where trial pits are excavated on sloping ground the base of each pit shall be horizontal and any instructed termination depth shall be taken as the depth of excavation at the mid-point of the base to original ground level.

(2) Any trial pit or trial trench left open overnight, shall be provided with both a strong wooden cover securely battened down and appropriate fencing to prevent persons and animals from falling into the excavation.

(3) Before commencing any excavation, three dynamic probing tests shall be performed in a triangular pattern not more than 800 mm apart around the centre of each proposed trial pit, unless otherwise instructed by the Engineer. In trial trenches, one dynamic probing test shall be carried out for each 1.0 m^2 of plan area of the excavation, equally spaced, unless otherwise instructed by the Engineer. All probes shall be terminated at the initial instructed depth of the trial pit or trial trench. On sloping ground, each individual dynamic probing test shall be terminated at the instructed base of the trial pit or trial

trench. A second attempt shall be made for each test if refusal is met before the instructed termination depth, at a distance of not less than 150 mm from the original position. Dynamic probing tests shall be carried out in accordance with Clause 7.69.

(4) The preliminary results of the dynamic probing tests carried out prior to excavation shall be submitted to the Engineer, with the relevant daily site records for each trial pit or trial trench excavated. They shall be included in the Final Field Work Report and provided in AGS digital format.

(5) Trial pits and trial trenches shall be excavated vertically by manual methods to the termination requirements or depths instructed by the Engineer. Benching and shoring shall be carried out as necessary and as agreed by the Engineer. Hardwood shall not be used for shoring purposes. Powered tools shall only be used with the agreement of the Engineer.

(6) Steel ladders or products having equivalent functions or performance as agreed by the Engineer shall be provided as necessary.

(7) If instructed by the Engineer, the excavated material shall be removed from the site and the same or similar material shall be imported for subsequent backfilling. Otherwise, material excavated from trial pits and trial trenches shall be safely stockpiled and protected from the weather. For excavations on sloping ground, the material shall be protected in such a manner that it does not fall or wash downhill or in any way enter surface water drainage systems. All necessary measures shall be taken to prevent the ingress of surface water into the excavations.

(8) No logging or photography of each trial pit or trial trench shall be carried out until the termination of each excavation has been approved by the Engineer.

Pumping from trial pits and trial trenches 7.32

Trial pit and trial trench excavations shall be kept free from water. The base of each excavation shall be clearly visible during logging and taking photographs.

Backfilling of inspection pits, trial pits or trial trenches 7.33

(1) Inspection pits shall be plugged at the bottom with concrete or similar material, and backfilled on completion of the drillhole. Trial pits and trial trenches shall be backfilled within 2 working days of the date of issue of an instruction from the Engineer. The backfill material shall not contain material exceeding 200mm in size, refuse, metal, rubber or synthetic material, peat, vegetation, perishable material or toxic material or material susceptible to combustion or to volume change. The ground surface shall be restored to its condition prior to the excavation, i.e. any pitching, paving, chunam, concrete or turf shall be replaced.

(2) The backfill material shall be compacted mechanically in successive layers of not more than 150 mm thick.

(3) As backfilling of each trial pit or trial trench proceeds, timber, sheeting and other excavation supports shall be progressively removed, but the removal of such supports shall not endanger the stability of the Works.

(4) Notwithstanding sub-clause (1) above and Clause 6.09, for a trial pit or trial trench carried out under an Excavation Permit, the excavation works including backfilling and reinstatement shall comply with the Conditions of the Excavation Permit. Satisfactory compaction of backfill shall be

demonstrated by testing for relative compaction instead of by dynamic probing. Relative compaction testing shall be carried out for every metre depth of backfill in each trial pit and trial trench, at locations instructed by the Engineer. The more stringent requirement shall prevail in case of any ambiguities or discrepancies between this General Specification and the Conditions of an Excavation Permit.

(5) On completion of backfilling and prior to any reinstatement of the ground surface at the location of any trial pit or trial trench, a further set of dynamic probing tests shall be carried out unless otherwise instructed by the Engineer. Three such tests shall be carried out in a triangular pattern not more than 0.80 m apart around the centre of each trial pit. In trial trenches, one such test shall be carried out for each 1 m^2 of plan area of the excavation, equally spaced. Each test shall be terminated at the level of the excavated base of the respective trial pit or trial trench. A second attempt shall be made for each test if refusal is met before the required depth, at a distance of not less than 150 mm from the first test. All dynamic probing tests shall be carried out in accordance with Clause 7.69. The average dynamic probing test value of the post-backfilled set of probes, at any level within the excavation depth of the pit or trench excavation, shall be not less than 80% of the average value of the pre-excavation set of probes at the same level, and no less than 10 blows/100 mm. Notwithstanding this requirement, any subsequent depression of the ground surface occurring due to settlement shall be filled in and compacted. The results of the dynamic probing tests shall be submitted to the Engineer with the relevant daily site records for each trial pit or trial trench excavated.

Slope surface protection stripping

7.34 (1) Surface protection, including that containing reinforcement shall be stripped and disposed of, from slopes to expose underlying Common Ground or rock. The width of stripping shall be 500 mm, unless otherwise instructed by the Engineer, with the axis of the strip parallel to the dip of the slope. The underlying Common Ground shall be excavated to a minimum depth of 100 mm and up to 300 mm as instructed by the Engineer. All excavation shall be terminated if boulders, rock or hard strata are encountered, unless otherwise instructed by the Engineer. The stripping shall start at the top of the slope or where instructed by the Engineer and shall proceed downwards.

(2) If instructed by the Engineer, the stripping shall be limited to specified intervals (windows) along the instructed length. A record for the full instructed length of the stripping shall be provided to the Engineer.

Access

7.35 Access shall be provided for inspection by the Engineer.

Protection of stripped surface

7.36 Stripped areas shall be covered up at the end of each working day and during rainstorms to prevent the ingress of water into the slope and to minimise the channelling of rainwater run-off.

Reinstatement of stripped surface

7.37 Stripped areas shall be reinstated in form, colour and conditions similar to the original. The permission of the Engineer shall be obtained before reinstatement starts.

Disturbed samples from trial pits, trial trenches or slope stripping

7.38 (1) Small disturbed samples shall be taken in all trial pits and trial trenches at the top of each Common Ground layer encountered and then at intervals of 0.5 m in any layer thicker than 0.5 m. Small disturbed samples shall be taken in Common Ground every 0.5 m along each stripping, commencing at the base. The disturbed samples shall be representative of the composition of the Common Ground exposed. Samples of material predominantly coarser grained than sand, or if instructed by the Engineer, shall be placed in large polythene bags. Other material shall be placed in airtight plastic containers, of minimum 100 mm diameter, with a screw top. Sufficient material shall be taken to fill the bag or container, which shall be sealed immediately after recovery. Each sample shall be labelled as specified in Clause 7.55, including the face number from which the sample was taken.

(2) Large disturbed samples of at least 25 kg shall be taken in trial pits, trial trenches or from slope stripping, if instructed by the Engineer. All large disturbed samples shall be placed in heavy-duty polythene bags immediately after they are taken, and securely fastened. Before taking samples from slope stripping, a minimum of 100 mm of material, or other thickness, as instructed by the Engineer, shall be removed first.

Records of inspection pits

7.39 Details of each inspection pit shall be included in the relevant daily site record and drillhole record. A photograph taken vertically downwards into each inspection pit shall be submitted together with the daily site record for the relevant drillhole. A board showing the contract number and drillhole number, and the depth indicator used shall be clearly visible in the photograph.

Records of trial pits and trial trenches

7.40 (1) The format of daily site records shall be similar to figure 7 of "Geoguide 2" and to the approval of the Engineer. The following additional shall be included:

(a) Contractor's name, Contract number and Ground Investigation title,

(b) weather conditions,

(c) depths and details of all sampling and field testing including total blow count for driven samples and sample recovery, and

(d) any other relevant information e.g. comments on stability, maximum and average trial pit and trial trench depths and plan dimensions, water inflow, powered tools used.

(2) Preliminary and final records shall show the following information:

(a) for trial pits, the co-ordinates of the centre of the pit, for trial trenches, coordinates of both ends of the longer axis,

(b) for trial pits located on level or sloping ground, the reduced level at the centre of the pit; for trial trenches, the reduced levels of both ends of the longer axis,

(c) water levels with full details of fluctuation and seepage. If no groundwater is encountered then this shall be stated,

(d) a hand drawn (preliminary) and computer-generated (final) representation of the features and material types encountered in each face and the base of the trial pit or trial trench. Fill shall be shown as its constituent materials in the face sketch and its legend pattern in the legend column,

(e) stability conditions during excavation,

(f) the size and orientation of any services encountered,

(g) a sketch showing the dimensions of any sub-surface structures, including foundations exposed in the excavations, and

(h) a remarks section which shall include groundwater and wall stability observations, average and maximum depths, use of shoring and details of any obstruction encountered. If the required number of dynamic probing tests was not carried out, the excavation was terminated earlier than specified, or the plan area of the excavation was reduced, these facts shall be noted with reasons.

Photographs of trial pits or trial trenches

7.41 (1) Within 2 working days of the date of approval of any trial pit or trial trench it shall be photographed using a reference board with maximum dimensions of 300 mm (width) by 450 mm (length). Each face and the base shall be photographed.

(2) Each photograph shall cover a length of the excavated face of between 1.5 m and 2.0 m in both vertical and horizontal directions. Where more than one photograph is required to cover the full excavated depth or length of a face, the overlap between adjacent photographs shall be between 10% and 20%.

(3) Each photograph shall identify the face of the excavation and shall contain a natural scale. In the case of trial trenches, it shall also identify the location of the photograph by the metrage along the face of the excavation.

(4) One colour print of minimum size 85 mm x 125 mm of each trial pit or trial trench photograph shall be supplied with the preliminary records. Each copy of the Final Field Work Report shall contain colour photocopies of A4 mounted prints of minimum size 125 mm x 175 mm. Within 3 weeks of the award of the Contract, the name(s) of the suppliers and samples of the colour photocopies shall be submitted for the Engineer’s approval. The quality of the colour photocopies shall be maintained as approved throughout the Contract.

Slope stripping records

7.42 Preliminary and final slope stripping records shall be either a hard copy or soft copy as determined by the Engineer. A hard-copy record shall be printed double sided on recycled paper. A soft copy record shall be in read-only format. Each record shall include descriptions of strata (including decomposed rock) encountered and levels and co-ordinates of the top and bottom of strips, berms, benches and changes in type of slope surfacing. The survey results shall include all points on each strip where there is a change in gradient. Any other salient features shall be noted e.g. dip and dip direction of joints. The direction and bearing of the slope and the results of any in situ testing carried out shall be shown on the record. The record shall include a dimensioned sketch of the strip cross-section.

DRILLING FOR GROUND INVESTIGATION

Drilling rigs for ground investigation 7.43 Drilling rigs shall meet the following requirements:

(a) drilling rigs shall be of the hydraulic feed type having the capacity to drill in the sizes and to the termination requirements or depths instructed,

(b) drilling rigs shall be capable of providing stable drill-string rotation at speeds in the range 50-1250 rpm and have a minimum ram stroke length of 400 mm if applicable. The rigs shall be fitted with a tachometer, a hydraulic feed pressure gauge of an appropriate scale and a pressure gauge for reading water flushing pressure. The hydraulic feed pressure readings shall be readily converted to loads transferred to the bit in pounds or kilograms according to the manufacturer's specification. In order to provide a means of measuring penetration and estimating the rate of advance, a rigid rod, clearly graduated in 10 mm increments, shall be permanently attached to, and parallel with, the hydraulic feed rams, and

(c) if the flushing medium is water, the pump shall be equipped with a gearbox and shall be capable of delivering up to 2 L/s. It shall incorporate a surge bottle to reduce fluctuations in water pressure and the suction hose shall be fitted with a suitable filter. It shall have a by-pass system allowing full control of water flow at all pump delivery rates.

Drilling equipment for ground investigation 7.44 (1) The core barrels, drill rods and drill bits of drilling equipment for ground investigation shall be of a type appropriate to the purpose of the drilling and sampling. Drill bits shall be diamond, tungsten carbide or combination tipped core bits, of a type appropriate to the purpose of the drilling and sampling and suitable for the percentage core recovery and diameters required by the Contract. Triple tube core barrels shall be provided with bits suitable for air-foam flush. The type and make of core barrels shall be approved by the Engineer.

(2) The size of casings shall be appropriate to the drilling, coring, sampling, testing and other installation requirements.

(3) Only standard nominal lengths of casing and drill rods shall be used. The mixing of standard nominal imperial and metric lengths shall not be permitted.

(4) Casings and drill rods shall be straight, in good condition, clean at the time of drilling and free from scale, dirt and other loose material.

(5) All accessories and spare parts shall be as supplied or recommended by the same manufacturer unless otherwise approved by the Engineer. They shall be compatible with the equipment in use and with each other. Sufficient spares for core barrels, core bits, core lifters and other accessories shall be available for use on site without causing any delay to drilling operations. The condition of the core bit in use shall be carefully monitored and if any damage occurs, such as breaking of teeth, it shall be replaced immediately.

(6) Core barrels shall always be maintained in proper working order and particular attention shall be paid to the condition of the extrusion piston. The rubber O-rings shall be maintained in good condition so that no water escapes past the piston during extrusion of the cores.

(7) Sediment catcher tubes attached to the top of the core barrels shall be used if instructed by the Engineer. The tube shall have the same external diameter as the core barrel, and be approximately 0.75 m long.

(8) Core barrels and drill rods shall be stored on steel frame trestles.

Drilling for ground investigation

7.45 (1) Drillholes for ground investigation shall be sunk by rotary methods. The methods and equipment used shall be such that:

(a) The soil encountered and the levels at which changes in ground conditions occur can be accurately identified,

(b) The specified sampling requirements can be achieved,

(c) In-situ tests can be carried out and field installations can be incorporated at any depth in the drillhole, and

(d) Consistency of measurement and minimal disturbance of the ground is achieved.

(2) No nominally vertical hole shall deviate from the vertical direction by more than 0.5° unless otherwise agreed by the Engineer. For inclined drillholes, neither the inclination nor the bearing shall differ from the instructed values by more than ±2° throughout the length of the hole.

(3) The type and state of the core bit, feed rates and management of the drill string shall be such that the specified minimum acceptable core recovery in any single core run can be obtained where the condition of the ground permits.

(4) In Grade III rock or better, 3 m core runs may be used. For Grade IV or V, maximum core run lengths shall be limited to 1.5 m. If the percentage core recovery in a core run is less than that specified in Clause 7.64 the following run shall be reduced by 50%, to a minimum length of 0.5 m. Notwithstanding this requirement, with the approval of the Engineer, the core barrel shall be withdrawn and core removed more frequently as necessary to secure the maximum possible core recovery.

(5) Common Ground around the bottom of a drillhole shall not be unduly disturbed by water entering or leaving the hole, or by stress relief. The water level in a drillhole shall be kept at least 1 m to 2 m above the ambient groundwater level at all times, unless otherwise instructed by the Engineer. Rapid a withdrawal of rods and sampling equipment, causing rapid fluctuation in the water level inside the casing, shall be avoided.

(6) Casings shall be advanced concurrently with the removal of material in such a manner that loss of ground is avoided. Larger casings shall be set concentric with drillholes that are being reamed.

(7) Drilling lubricants other than clean water shall not be used, unless otherwise instructed by the Engineer.

Categories of core drilling

7.46 Three categories of core drilling shall be available:

(a) Category "A" - Water/Air-foam flush with triple tube core barrels using split inner tube (4C-MLC, HMLC or NMLC).

(b) Category "B" - Water/Air-foam flush with double tube core barrels (T2-101, TNW or products having equivalent functions or performance approved), and

(c) Category "C" - Water/Air-foam flush with single tube core barrels.

Rotary open hole drilling

7.47 A hole up to 170 mm in diameter, to a maximum depth of 40 m in Common Ground or Rock, Hard Strata without the recovery of core or samples, shall be advanced, if instructed, by means of a tricone roller bit, drag bit or other non-coring bit with water as the flushing medium.

Air-Foam Drilling

7.48 An appropriate air-compressor and all necessary ancillary equipment shall be provided to carry out drilling with air-foam flush to the Engineer's satisfaction. The foam return shall be the consistency of thick shaving cream and the hole shall be kept full of foam at all times. The foam shall either be fully biodegradable or water soluble and arrangements shall be made for the collection and removal or dispersal of the foam returns, if required. The proposed foam additive and mixes shall be to the approval of the Engineer. A typical arrangement of air-foam mixing and flushing system is shown in Figure 12, Geoguide 2.

Disposal of flush returns

7.49 The flushing medium for drilling shall be passed through a sedimentation basin to remove drilling cuttings/arisings and shall either be reused or, where permitted, be discharged to surface drains or natural stream courses. Measures shall be taken to prevent the flushing medium seeping through the ground. Re-circulation pits or re-circulation tanks shall be provided at the drillhole locations if the flush returns cannot be discharged safely or if instructed by the Engineer.

Backfilling of drillholes and rotary open holes

7.50 (1) All drillholes and rotary open holes in which no instrumentation will be installed shall be backfilled with cement bentonite grout within one working day of the completion of the hole. The grout shall be a pumpable mix of cement and bentonite in the proportion of 4:1 by dry weight, or an alternative mix agreed by the Engineer. The water content of the grout shall be limited to that necessary for proper mixing and placement. In no case shall the water cement ratio exceed 3. The resulting grout shall be free of lumps and foreign material. A method statement shall be submitted for the Engineer's approval. A demonstration of the proposed equipment, material, mixing, handling and placement procedures including appropriate quality controls and checks to be adopted shall be given.

(2) For each drillhole backfilled with grout, the viscosity of the grout measured by Marsh Funnel and specific gravity of the grout measured by Mud Balance or any instrument of sufficient accuracy to permit measurement within $\pm$0.01 g/cc shall be recorded. A labelled jar sample of grout from each hole shall be kept.

(3) Unless otherwise instructed by the Engineer, the grout shall be fed into the bottom of the hole using a suitable pump and a tremie pipe, the end of which shall always be maintained below the grout/water interface. Casing shall be removed in stages during grouting to ensure that the entire hole is

backfilled. Grout level shall be checked at least 24 hours after initial grouting, and any significant drop in grout level shall be topped up with additional grout, or backfilled with material agreed by the Engineer. Any subsequent depression shall be levelled and compacted.

(4) Only if instructed by the Engineer shall granular material, cement mortar or other materials be used to backfill the holes. Under no circumstances shall cement-bentonite balls (i.e. mixed paste) be used to backfill the hole.

(5) A complete record of backfilling operations including the quantity of grout placed, the drop in grout level after 24 hours, the viscosity and specific gravity of the grout and any other relevant information shall be included in the Daily Site Record and shall be submitted to the Engineer within 3 days of completion of backfilling.

(6) For backfilling involving an Excavation Permit, the work shall comply with the requirements set out in the Conditions of the Excavation Permit. If there are any discrepancies between this clause and the Conditions of the Excavation Permit, the more stringent requirement shall prevail.

Sampling from drillholes

7.51 (1) Jar samples from drillholes shall be taken from the cutting shoe of each undisturbed sample, from any anomalous material, from each standard penetration test and at other locations as instructed by the Engineer.

(2) All loose material and material disturbed by drilling or in-situ tests shall be removed from the sides and bottom of the drillhole before each undisturbed sample is taken.

Records of drillholes

7.52 (1) Records of drillholes for ground investigation shall be kept on the Site. Drillhole logs shall be comprehensive and shall be in a form similar to that shown in Figure 44 of `Geoguide 2: Guide to Site Investigation', Hong Kong Government, 1987. Soil and rock descriptions shall comply with those stated in the insert titled `Checklist for Soil Descriptions' and `Checklist for Rock Descriptions' in `Geoguide 3: Guide to Rock and Soil Descriptions', Hong Kong Government, 1988 or with any other system agreed by the Engineer.

(2) Drillhole logs shall be drawn to a constant vertical scale of 1:50 unless otherwise agreed by the Engineer and shall contain the following details:

(a) Information shown and in the format in Figure 44 and paragraphs 40.2.6 (2), (4) and (5) of `Geoguide 2: Guide to Site Investigation', Hong Kong Government, 1987,

(b) Reduced levels of observation well bases, piezometer tips, and sand filter layers,

(c) Details of utilities identified in the inspection pit excavated at the drillhole location.

SAMPLING FOR GROUND INVESTIGATION

Supply of sampling equipment and containers

7.53 All the sampling equipment and containers shall conform to the requirements of Geoguide 2 and this General Specification. Specifications and examples of the proposed equipment and containers to use shall be submitted to the Engineer for approval prior to the commencement of the Contract.

(a) For general purpose open tube samples and thin-walled samples, the sample tube and cutting shoe shall be free of rust, pitting, burring or any other defect. The use of oil inside the sampler shall be limited to the minimum practical. Each sample tube shall have a unique reference number and the word `TOP' engraved on its exterior at one end. The sample tube shall be driven with the end marked `TOP' uppermost. The dimensions, construction and condition of each sample tube; cutting shoe and adaptor head shall be approved by the Engineer prior to sampling. The adaptor head shall be fitted with a ball valve to permit the exit of air or water during driving and to assist in retaining the sample during withdrawal, and it shall have an allowance for over-driving. In soil of low cohesion such as silt and silty fine sand the sampler shall be equipped with a basket core retainer to enhance core recovery.

(b) U100, U76 and U40 thin-walled samplers shall be approved 102 mm (for U100), 78 mm (for U76) and 42 mm (for U40) diameter open drive sample tubes made from thin-walled seamless cadmium plated or stainless steel. They shall be not less than 450 mm (for U100), 350 mm (for U76) and 200 mm (for U40) in length fitted with a cutting shoe tapered at an angle not exceeding 20°. The area ratio of the sampler as defined in Figure 13 of `Geoguide 2: Guide to Site Investigation', Hong Kong Government, 1987 shall not exceed 30%.

(c) Piston samplers shall be a thin-walled fixed piston sampler to the approval of the Engineer. The piston sampler shall be capable of operating to a depth of at least 20 m below ground level with no lateral movement during the actual sampling operation. The design and maintenance of the sampler shall be such that a partial vacuum is formed over the retained sample in the tube. The minimum recovered sample length shall be 900 mm. The thin-walled tube shall have an external diameter of 75 mm or 100 mm as instructed by the Engineer. The area ratio of the sampler as defined in Figure 13 of `Geoguide 2: Guide to Site Investigation', Hong Kong Government, 1987 shall not exceed 10%.

General sampling requirements

7.54 (1) Both disturbed and undisturbed samples shall be taken from an Investigation Station at the depths and intervals instructed by the Engineer. All samples shall be transported and delivered in core boxes or in any other containers as specified.

(2) Small disturbed samples shall be taken in drillholes from the cutting shoe of each undisturbed sample, from any anomalous material, from each standard penetration test and at other locations as instructed by the Engineer.

(3) In all drillholes, small disturbed samples of Common Ground shall be

taken on entering each new stratum (including decomposed rock) and every 1.0 m in between other small disturbed samples from cutting shoes or core bits. They shall be taken with a driven sample tube or other method approved by the Engineer. The disturbed sample shall be representative of the composition of the Common Ground.

Numbering and labelling of samples

7.55 (1) A reference number shall be assigned to each Common Ground sample (both disturbed and undisturbed) and groundwater samples taken, commencing with samples obtained from the inspection pit, if excavated. The number shall be unique for that Investigation Station and shall be in order of depth below ground level. The number shall also be shown on the records adjacent to the sample symbol.

(2) All sample containers and tube samples shall be clearly marked both on the side and the top of the sample with a permanent marker pen with the following information:

(a) Works Order number, if any,

(b) Reference number of the Investigation Station,

(c) Reference number of the sample,

(d) Date of sampling, and

(e) Depth of the top of the sample below existing ground level.

(3) Each core box shall be identified by the following information, which shall be clearly marked on the top, both ends and beneath the core box lid using waterproof ink or paint:

(a) Contract number,

(b) Works Order number, if any,

(c) Ground Investigation title,

(d) Investigation Station number,

(e) Depths of material contained, and

(f) Core box number.

(4) The depths at which each core run started and finished shall be recorded at the ends of each core run by permanent marker pen on the edge of the box or on wooden blocks which fit between the dividing slats. If a core run is contained in two sequential core boxes, the abbreviation "cont'd" shall be used on the adjacent edges of the core boxes.

Sealing of common ground tube samples

7.56 (1) Once a sample tube has been detached or removed from the sampling equipment, the visible ends of the sample shall be cleared of any disturbed material, and the edges trimmed at 45°. After cleaning the sides of the tube above the recovered sample, the ends shall be coated with three successive thin films of just molten microcrystalline wax. A metal foil disc shall then be added and followed by more molten wax to give a total thickness of not less than 20 mm. Any space remaining in the ends of the sample tube shall be solidly filled with damp sawdust or other material approved by the

Engineer and the ends of the sample tube shall be covered with tight fitting rubber caps.

(2) The tubes containing samples shall be handled with care to avoid any possible disturbance, stored in a cool and dry location and protected against the sun or inclement weather whilst on site.

(3) The material from the cutting shoe/core bit shall be immediately placed in a plastic container of minimum diameter 100 mm, with a screw top. They shall be arranged securely in the corebox in their proper sequence.

Core boxes

7.57 Core boxes shall be 1.05 m in length, 0.45 m in width and of sound robust construction, able to withstand the weight of the cores and stacking of the boxes. The lid shall be fitted with metal hinges, hasp and staple and a locking device. Rope strands shall be attached to each end of the core box for lifting. Boxes shall be provided with rigid separating slats.

Delivery and storage of samples

7.58 (1) All samples, including cores, obtained from Ground Investigations shall be delivered to the storage facilities location specified by the Engineer, within 3 working days of the date of completion of the field work, unless otherwise instructed by the Engineer.

(2) Samples shall be stored in a cool and dry location and protected against the sun or inclement weather. Block samples shall be stored in their correct orientation. All samples recovered from vertical/sub-vertical or horizontal/sub-horizontal drillholes shall be stored and transported in their correct orientation, and in purpose-built racks which shall hold the samples securely. Core boxes shall be stacked by Investigation Station and box order.

(3) Samples shall be delivered to the laboratory specified by the Engineer within 3 working days of receipt of an instruction. Any discrepancies between the laboratory testing schedule attached to the instruction and the samples, such as incorrect sample depths or reference numbers, shall be raised with the Engineer prior to delivery. A signed delivery docket shall be obtained to record the delivery and all the samples shall be checked off with a representative from the laboratory.

(4) On completion of the laboratory testing, the Engineer may require the samples to be removed from the laboratory. These samples, together with any samples kept at designated storage facilities shall be delivered or disposed of as directed by the Engineer. A list of the samples delivered, agreed by the person receiving the samples where possible, shall be sent to the Engineer.

Undisturbed tube sampling of common ground in drillholes

7.59 Before an attempt to take an undisturbed sample from a drillhole is made, all loose material and material disturbed by drilling or field testing shall be removed from the hole. On recommencement of work at the start of each shift during the progress of a drillhole, a minimum of 0.3 m of material shall be removed before the next undisturbed sample is taken, unless otherwise instructed by the Engineer.

Retractable triple tube core sampling

7.60 (1) Undisturbed samples of Common Ground shall be taken in drillholes using a triple tube retractable core barrel (Geoguide 2) fitted with either a detachable rigid clear ABS plastic or rigid opaque PVC or Polyethylene (PE) liner.

(2) The dimensions of the core barrel and liner shall be as follows:

Item			Dimension (mm)
Core Barrel	Outer Tube	OD	98.5 ± 2.0
	Inner Tube	ID	78.0 ± 1.0
		OD	85.0 – 89.0
	Cutting Shoe	ID	72.5 ± 1.0
	(Leading Edge)	OD	77.2 ± 1.0
	Drill Bit	OD	101.1 ± 2.0
Liner	ID		74.0 ± 1.0
	OD		77.0 ± 1.0
	Ovality		± 0.5
	Bow		3 per metre
	Length		1000 ± 5
	Wall Thickness		1.5 minimum

(3) Face-discharge bits made of steel and set with tungsten carbide inserts in a saw tooth profile shall be used. The drill bit shall have groove cuts on the external sidewall to facilitate return of flushing fluid.

(4) The cutting shoe shall have an area ratio of 10 to 15%. The ID of the leading edge of the cutting shoe shall be smaller than the ID of the liner tube with an inside clearance between 1.5 and 3.5%. Three lengths of cutting shoes, referred to as "long", "medium" and "short" with decreasing lengths of protrusion beyond the drill bit when mounted, shall be available. The "long" shoe with a protrusion of not more than 50 mm shall be used generally for looser or softer soils, and the "medium" or "short" shoes for denser or stiffer soils.

(5) The liner shall fit tightly inside the inner tube, in both radial and longitudinal directions. The liners shall be obtained from a manufacturer approved by the Engineer. Within 3 weeks of award of the Contract, the name(s) of the suppliers, material specification and examples of the liners proposed, shall be submitted to the Engineer for approval. If approved, the quality of the liners shall be maintained for the duration of the Contract.

(6) The barrel, drill bit and cutting shoe shall be free from significant defects and in good working condition. A sediment tube may be attached to the top of the barrel to trap the cuttings falling out of suspension from the flushing medium. A core retainer of suitable design may be used only when it is necessary to reduce the risk of sample loss.

(7) Prior to lowering the barrel down the drillhole, it shall be checked to ensure that the inner barrel rotates freely, the retractor spring works and that the check valve at the top of the inner barrel is functioning properly.

(8) The bottom of the drillhole shall be cleaned out properly prior to sampling to the specified sampling commencement depth within a tolerance of ±25 mm, unless otherwise agreed by the Engineer.

(9) In order to alleviate disturbance to the soil being sampled, the applied flushing pressure shall be kept to a minimum. An optimum combination of the applied bit pressure and rotation speed shall be used to achieve a steady penetration but this shall not be so slow as to cause unnecessary disturbance

by the flushing medium.

(10) Successful sampling shall mean a minimum recovery of 80% of the sampled length when water flush is being used, and 90% of the sampled length when air-foam flush is being used. If sampling is not successful, the hole shall immediately be cleared of material disturbed by the sampling process and another attempt shall be made from the level of the base of the failed attempt.

(11) If continuous retractable triple tube core sampling has been instructed and the second attempt also proves unsuccessful the Engineer shall be informed immediately, or as early as possible on the next working day, and a proposal made for improving sample recovery for the Engineer's approval.

(12) If interval sampling has been instructed and the second attempt also proves unsuccessful, a Standard Penetration Test with a liner sample shall be performed and the sampling sequence instructed shall be continued. If two consecutive sequences of failed undisturbed sampling occur in any one drillhole the Engineer shall be informed immediately, or as soon as possible the next working day. The sampling sequence shall be continued unless otherwise instructed.

Piston sampling

7.61 (1) Undisturbed samples of Common Ground shall be taken in drillholes using a thin-walled stationary piston sampler. The sampling tube shall be 1000 mm long, formed from stainless steel with an integral cutting edge and shall have an internal diameter of 75 mm or 100 mm (±1 mm) as directed by the Engineer. The area ratio of the tube shall not exceed 10% and the cutting edge taper angle shall not exceed 15°. No inside clearance shall be permitted. The sampling operation shall ensure the sampling tube is pushed into the soil vertically at a steady rate with no lateral deflection. The design and performance of the sampler shall be such that a vacuum is formed over the retained sample in the tube.

(2) The minimum recovery shall be 90% of the sampled length. If the length of sample recovered is less than that specified, the hole shall immediately be cleared of material disturbed by the sampling process and another attempt shall be made from the level of the base of the failed attempt. If this second sampling attempt also fails to recover the minimum specified, the sampling sequence instructed shall be continued but the Engineer shall be informed immediately, or as early as possible the next working day.

(3) Purpose-built sample boxes shall be provided for transporting and storing all piston samples in a vertical position. Each box shall be used to transport two piston samples. These boxes shall be robust, water-tight, and shall be fitted with hinged top and rope-strand lifting handles. The inside of the box shall be provided with styrofoam padding which holds the samples tightly in place.

U100 and U76 sampling

7.62 (1) General

(a) Samples of Common Ground shall be taken in drillholes, trial pits and trial trenches using 101 mm (±1 mm) [for U100] or 77 mm (±1 mm) [for U76] internal diameter open sample tubes. The tubes shall be thin walled seamless stainless steel or galvanised mild steel not less than 450 mm in length fitted with a cutting shoe tapered at an angle not exceeding 20°. The area ratio of the sample tube cutting shoes shall not exceed 30% and inside clearance between the shoe and each tube shall not exceed 2% unless a core retainer is used, in which case the inside clearance shall not exceed 4%. Each sample tube shall have the word "TOP" marked on its exterior at the end driven uppermost. The minimum recovery shall be 80% of the sampled length.

(b) The adaptor head at the top of the sample tubes shall be fitted with a ball valve to permit the exit of air or water during driving and to assist in retaining the sample during withdrawal. The use of oil inside the sample tubes shall not be permitted and care shall be taken to ensure that the sample is not compressed by over-driving.

(c) All recovered samples shall be stored and transported vertically, in their correct orientation, in purpose-built racks which shall hold the tubes securely.

(2) In Drillholes

(a) The sampler shall be driven by means of either a jarring link (i.e. drilling rods delivering the impact at the adaptor head of the sampler), a sliding hammer arrangement to the approval of the Engineer or a single ram stroke. No vertical pull-up action shall be applied to the sampling tube during the lift-up of any hammering operation. The total depth driven or pushed and, where relevant, the number of blows used shall be recorded in the daily site records. Where driven samples are instructed in Common Ground of low cohesion, such as silts and silty fine sands, a core retainer of suitable design shall be provided to improve sample recovery. In cohesive Common Ground, the initial attempt to obtain a sample shall be made without the use of a core retainer.

(b) Before withdrawal from the drillhole, the sampler shall be rotated through two complete revolutions to shear the Common Ground horizontally at the bottom of the cutting shoe. If necessary, this operation shall be delayed to allow the development of sufficient adhesion inside the tube. The sampler shall then be withdrawn smoothly so as to cause minimal disturbance to the sample.

(c) If an initial attempt to take a U100 or U76 sample in a drillhole recovers a length of sample less than specified, the hole shall immediately be cleared of material disturbed by the sampling process and another attempt shall be made from the level of the base of the failed attempt, using a core retainer. Should the second attempt also prove unsuccessful, a Standard Penetration Test with a liner sample shall be performed, and the sampling sequence as instructed shall be continued. If two consecutive sequences of failed sampling occur in any one drillhole, the Engineer shall be informed immediately, or as soon as possible the next working day.

(3) In Trial Pits and Trial Trenches

(a) Prior to sampling in trial pits or trial trenches, all disturbed material shall be cleared in order to expose Common Ground in its natural condition. The samples shall be taken using a sliding hammer arrangement with care being taken to ensure that no lateral movement takes place during driving with the use of guide frame as necessary. The proposed method of driving shall be to the approval of the Engineer. The sample tubes shall then be removed by excavating around them.

(b) If a driven sample in a trial pit or trial trench recovers less than that specified a second attempt shall be made beside the first, but not closer than one tube diameter to the first attempt. If this second attempt fails then a third and final attempt shall be made at a distance of at least one tube diameter from any previous attempt. If the third attempt fails the Engineer shall be informed immediately, or as soon as possible the next working day.

Block samples 7.63 (1) Block samples of Common Ground shall be taken either from the sides or bottom of trial pits or trial trenches or from slope stripping. Samples shall be not less than 230 mm cube.

(2) The top and four sides of the sample, but not the base, shall be excavated, trimmed, wrapped in aluminium foil and waxed. A wooden box, with two opposite sides removed, shall then be placed over the prepared sample such that a minimum annulus of 25 mm exists between the inside of the box and the sample. The top and side annuli shall then be filled using polyurethane by means of two reagents. After hardening of the polyurethane, the top of the box shall be attached and the sample carefully broken away at its base at a depth of no less than 50 mm below the base of the sample. The sample shall then be carefully inverted and the "base" trimmed, wrapped in aluminium foil and waxed before the basal annulus is filled with polyurethane. After hardening, the base of the wooden box shall be attached. The top and bottom of the sample shall be clearly marked on the box, as shall the direction of magnetic north relative to the in situ sample.

Recovery of cores 7.64 Total core recovery is defined as the length of core recovered expressed as a percentage of the length of the core run carried out. The total core recoveries given below are the minimum which shall normally be accepted for the categories of drilling defined in Clause 7.46:

Minimum Acceptable Total Core Recovery for Category of Drilling (%)

	"A"	**"A"**	**"B"**	**"C"**
Ground Conditions	(Air-foam flush)	(Water flush)	(Water/ Air-foam flush)	(Water/ Air-foam flush)
Rock of Decomposition Grade I To III or Concrete or Boulder	98	98	95	90
Common Ground	80	N/A	N/A	N/A

Extrusion and handling of cores 7.65 (1) All cores shall be removed from double tube core barrels using a hydraulic extruder, unless otherwise instructed by the Engineer. Under no circumstances shall air pressure be used for the extrusion of cores. The extruder shall apply a continuous pressure to one end of the core whilst the barrel is in a horizontal position. Only gentle hammering with a wooden mallet on the side of the core barrel to free wedged pieces shall be permitted.

(2) Cores from single and double tube core barrels shall be carefully extruded onto split plastic piping of similar diameter to the core such that the core fits tightly into the pipe and is not free to rotate. If instructed by the Engineer, or if the recovered core is heavily jointed or fragmented and is likely to be disturbed during transportation, it shall also be wrapped in self-clinging transparent film, or similar approved by the Engineer.

(3) Cores from split inner tube triple tube core barrels shall be wrapped in self-clinging transparent film and then aluminium foil and carefully transferred into split plastic piping of the same internal diameter as the split inner tubes.

(4) As core is extruded it shall be arranged in core boxes in a proper sequence starting with the shallowest core on the left side nearest the hinge and then working along the slat and subsequently outwards towards the hasp (i.e. from left to right with the box lid on the far side of the box as the core is placed). Slats shall be positioned and secured such that the core is restrained from movement.

(5) Fractured core shall be packed securely. At no time should any core be loose in the box. Core losses in individual core runs shall be shown by wooden blocks or polystyrene of square cross section to fill the core box, of a length equal to the core lost.

(6) Until the boxes containing the cores are transported from the site they shall be neatly stored at the drillhole locations in such a manner that inspection of the cores can easily be made. The boxes shall be stored under cover and protected from the weather. All core boxes shall be carefully transported to avoid damage and disturbance to the contents.

Photographs of core boxes

7.66 (1) Within 3 working days of the date of completion of the drillhole, the samples and/or cores contained within each core box shall be photographed. The core shall be evenly lit with no shadows, the core box and reference board in each photograph shall fill the frame, and the focal plane of the camera and the plane of the core box shall be parallel.

(2) The photograph shall contain a reference board of minimum dimensions 350 mm (height) by 1000 mm (length). The reference board shall contain:

(a) the Ground Investigation title,

(b) the core box number,

(c) the depth below ground level at the start and finish of all material in the core box, and

(d) a reference scale over the entire board length marked in 100mm units.

(3) All cores, except those susceptible to deterioration on contact with water, shall be thoroughly moistened before being photographed. Where coreboxes contain disturbed samples, the lids shall be removed from the containers so that the contents are visible in the photograph. The first disturbed sample in any photographed core box shall be identified by its

unique sample number and depth so that subsequent disturbed samples in that box can also be identified.

(4) One full set of colour prints of minimum size 85 mm x 125 mm shall be supplied with the preliminary records. Colour photocopies of A4 mounted prints of minimum size 200 mm x 250 mm shall be supplied in each copy of the Final Field Work Report. Within 3 weeks of award of the Contract, the name(s) of the proposed supplier of the colour photocopies and samples shall be supplied for the Engineer's approval. If approved, the quality of the colour photocopies shall be maintained for the duration of the Contract.

Groundwater samples 7.67 Groundwater samples shall be taken from drillholes, trial pits or trial trenches, if instructed by the Engineer. Where water has been used for drilling, a volume of water at least equivalent to that of the drillhole volume shall be bailed out before sampling. Each sample taken shall not be less than 2 litres and shall be placed in a sterilized airtight bottle of sufficient capacity. Bottles shall be flushed out twice with the water to be sampled before use.

IN-SITU TESTING

Standard penetration tests 7.68 (1) The apparatus and procedure for standard penetration tests shall comply with BS 1377:1990 (Part 9, Test 3.3), amended by this Clause as necessary. The drive hammer shall be a type incorporating an automatic trip mechanism to ensure free fall. The steel anvil of the drive assembly shall have a diameter of 145 ± 5 mm. The guide rod arrangement that permits the hammer to drop with minimal resistance shall have an outer diameter of at least 3 mm smaller than the diameter of the central hole of the hammer.

(2) A cone ended adaptor with a 30° half angle shall be available to replace the open-ended driving shoe for use in gravelly Common Ground, or if instructed by the Engineer.

(3) If a liner sample is required in conjunction with the test, the split barrel sampler shall have an enlarged internal diameter to accommodate a thin stainless steel or aluminium liner of 35 mm internal diameter which shall fit tightly inside. The internal diameter of the liner may be up to 0.2 mm larger but in no case be smaller than that of the drive shoe. The liner shall have a smooth internal surface and may comprise two separate sections of equal length. The enlarged split barrel shall not be used without a liner in place. After the sampler has been withdrawn from the drillhole, the liner and the retained soil shall be treated in the same manner as an undisturbed sample.

(4) Standard penetration tests shall be carried out below the level of the casing. The base of the drillhole shall be fully cleaned before the test starts. Jar samples shall be taken from the split-barrel shoe after each test.

(5) The number of blows of the drive hammer required to achieve each 75 mm of shoe penetration until a total penetration of 450 mm has been achieved shall be recorded. The N-value shall be recorded as the sum of the number of blows of the drive hammer required to achieve the last 300 mm of shoe penetration.

(6) If the full penetration of the seating drive is not achieved after 50 blows of the drive hammer, the number of blows and the penetration achieved (in

millimetres) shall be recorded and the test continued with the test drive from that point.

(7) If the full penetration of the test drive is not achieved after 100 blows of the drive hammer, the number of blows and the penetration achieved (in millimetres) shall be recorded and the test terminated unless otherwise directed by the Engineer.

(8) The water level in the drillhole at the time of test shall be recorded and reported. When testing below the groundwater table particular care shall be taken to maintain the water level in the drillhole at or above the ambient groundwater level.

(9) If instructed by the Engineer, the Standard Penetration Test split spoon sampler shall be provided with a liner. After withdrawing the sampler from the hole, the liner containing the Common Ground sample shall be sealed in accordance with Clause 7.56.

(10) If liner samples have not been instructed, the sample recovered from the split spoon shall be immediately placed in a plastic container of minimum diameter of 100 mm, with a screw top. It shall then be arranged securely in the core box with the core, in proper sequence.

(11) Test results shall be submitted with daily site records and with both preliminary and final drillhole records. Test results shall be reported as shown in the table below:

Seating Drive	Test Drive	Summary	Remarks
17,25	25,27,22,23	N=97	Full penetration
17,25	38,62/50 mm	100/125 mm	Test terminated in increment 4
17,25	35,27,38/30 mm	100/180 mm	Test terminated in increment 5
27,23/35 mm	25,27,22,23	N=97	Test drive commenced after completion of 50 blows in the seating drive
50/20 mm	35,27,38/30 mm	100/180 mm	Test drive commenced after completion of 50 blows in the seating drive: test terminated in increment 3

Dynamic probe tests 7.69 (1) Dynamic probe test equipment shall be generally as shown in Geoguide 2, Figure 36 and amplified below:

(a) The mass of the hammer shall be 10.0 kg ±0.1 kg. The ratio of the length to the diameter of the hammer shall be between 1 and 2. The hammer shall be provided with an axial hole with a diameter which is 2-3 mm larger than the diameter of the guide rod,

(b) the anvil shall be rigidly fixed to the extension rods. The mass of the anvil shall be between 1.5 kg and 1.8 kg and the diameter between 60 mm and 70 mm. The combined mass of the anvil, guide rod and upper anvil shall not exceed 5.0 kg,

(c) the hammer shall fall freely and not be connected to any object which may influence the acceleration or deceleration of the hammer. The hammer shall be stationary in its upper position prior to release. The fall shall be 300 mm ±5 mm,

(d) the diameter of the rods shall be between 11 mm and 13 mm and the length 1000mm ±10 mm. The rods shall be straight and shall be connected so as to bear against each other over their full area by means of external couplers of maximum diameter 20 mm,

(e) the diameter of the point shall be 25 mm ±0.2 mm. The cylindrical portion of the point shall have a length of 25 mm ±1 mm. The point shall have a conical tip with an apex angle of 45° ±2°.

(2) The probing shall be carried out by the method described in Appendix 7.1

(3) If refusal is met at a depth of less than 3 m, then a second test shall be carried out at a distance of between 0.3 m and 0.6 m from the first test.

(4) All probe holes shall be sealed on completion with cement grout consisting of cement and water in the proportions 0.4:1 by mass, for at least the top 600 mm.

(5) For dynamic probing tests that are not related to trial pit or trial trench excavations, preliminary results shall be submitted within 6 working days of the date of completion of all dynamic probing testing instructed or as directed by the Engineer.

Vane shear tests 7.70 (1) Vane shear tests shall be carried out as specified in BS 1377:1990 (Part 9, Test No. 4.4), amended by this Clause.

(2) Vanes capable of measuring shear strengths up to approximately 75 kPa shall be available. The area ratio of each vane blade shall be less than 12%. The torque measuring instrument shall be calibrated by a method approved by the Engineer and a copy of the most recent certified calibration chart shall be submitted with each set of vane test results and be included in the Final Field Work Report.

(3) The vane shall be advanced to the test depth and the torque applicator assembly shall be carefully connected. After a pause of 5 minutes, the vane shall be rotated at a constant rate of between 0.1 and 0.2 degrees/second. Readings shall be taken at intervals of each 5° rotation. The maximum torque required to rotate the vane shall be recorded. The vane shall then be rotated rapidly through 12 revolutions without taking any readings. After a further pause of 5 minutes, the test procedure shall then be repeated in order to obtain the remoulded (disturbed) undrained shear strength.

(4) Preliminary results shall be submitted in a format agreed by the Engineer with the corresponding Investigation Station preliminary records. Final results of undrained shear strength, corrected using the torque head

calibration curve, shall be submitted with the Final Field Work Report in a format agreed by the Engineer. For tests on Common Ground, the residual value of undrained shear strength shall be reported.

In situ density tests 7.71 (1) In situ density tests shall be carried out in accordance with Geospec 3, Test 11.1 or 11.2.

(2) Preliminary results shall be submitted using a HOKLAS approved worksheet along with the Preliminary Records of the trial pit or trial trench in which the test was performed. The Final Field Work Report shall contain the results presented on a HOKLAS endorsed test report.

Falling or rising head permeability test 7.72 (1) If instructed by the Engineer, a falling or rising head permeability tests shall be performed in a drillhole. The drillhole shall be flushed prior to carrying out the test. The installation shown in Geoguide 2, Figure 27, shall be used unless otherwise instructed by the Engineer. The graded filter material and sand shall be to the approval of the Engineer and shall be placed in the hole by tremie pipe. The groundwater level shall be allowed to equalise in the completed installation for at least one hour before the test commences.

(2) The method of flushing of the bottom of the hole for field permeability tests shall be as follows:

(a) Clean water shall be introduced to the cased hole through a 38 mm diameter pipe fed from a storage tank. The feed pipe shall contain a perforated section 480 mm in length consisting of 20 rings of holes at 25 mm centres, each containing 4 holes of 6 mm diameter. The end of the perforated section of pipe shall be capped. The complete perforated section shall be positioned such that it is just below the existing ground water level in the borehole.

(b) The flushing water shall be withdrawn from the casing through a 38 mm diameter pipe positioned with its open end between 150 mm and 200 mm above the base of the borehole. The discharge shall be by means of a pump of sufficient capacity to extract the flushing water from the base of the borehole. Control of the flow of clean water and discharge water shall be by means of valves positioned on the inflow pipe and the discharge pipe.

(3) For a falling head permeability test the water level in the piezometer shall be raised by adding clean water by a minimum of 3 m, or the maximum practical. The water level shall then be allowed to equalise with the groundwater level. Water levels in the piezometer shall be measured by means of a suitable dip meter at the following elapsed times in minutes from the start of the test:

0, 0.25, 0.5, 0.75, 1, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30, 45, 60, 90, 120, 150, 180.

The test shall be terminated at 180 minutes, or earlier if:

(a) the water level has returned to its initial level, or

(b) a head ratio (the ratio of water head at any time during the test to the initial head at the commencement of test) of 0.3 is achieved, or

(c) instructed by the Engineer.

(4) For a rising head permeability test, the water level in the piezometer shall be lowered by pumping by a minimum of 3 m, or the maximum practical. The water level shall then be allowed to equalise with the groundwater level. Water levels in the piezometer shall be measured following the same procedure as for a falling head test.

(5) Both types of permeability test shall be repeated once to demonstrate that consistent results have been obtained. If the results differ by more than 20% then the test shall be repeated again.

(6) Preliminary results of a falling and rising head permeability test shall be submitted on a record sheet to the approval of the Engineer, together with the corresponding Investigation Station preliminary record.

Response test

7.73 (1) A response test shall be performed in any piezometer or standpipe within 3 working days of the completion of the installation, in order to prove its successful operation. The test shall be carried out as for a falling head permeability test except that it shall be terminated after 60 minutes or when the water level has returned to its initial level, whichever is sooner.

(2) Preliminary results shall be submitted on a record sheet, to the approval of the Engineer, with the corresponding Investigation Station preliminary record.

Constant head permeability test

7.74 (1) For a constant head permeability test in a drillhole, the procedure for flushing the hole, setting up the installation and allowing the ambient groundwater level to equalise, shall be the same as for a falling or rising head permeability test.

(2) Clean water shall be fed into the piezometer at a constant rate until a constant water level is established or until the water level is 0.3 m below the top of the piezometer tube. The constant rate of inflow to maintain a constant head shall be recorded. A flow meter capable of measuring flows down to 0.1 litre shall be used.

(3) Cumulative inflow readings shall be recorded, once the constant head has been achieved, in the following sequence:

(a) 4 readings at 15 second intervals,

(b) 9 readings at 1 minute intervals,

(c) 4 readings at 5 minute intervals, and

(d) readings at 10-minute intervals until the inflow values do not differ by more than 10% in any 10 minute interval.

(4) Preliminary results shall be submitted on a record sheet, to the approval of the Engineer, with the corresponding Investigation Station preliminary record.

Packer (water absorption) test

7.75 (1) If instructed by the Engineer single or double packer tests shall be carried out in vertical or inclined drillholes in TNW and T2-101 size. Testing shall follow the method described in Geoguide 2. The general arrangement of the tests shall be as shown in Geoguide 2, Figure 31.

(2) At the commencement of the Contract, and at other times if instructed by the Engineer, calibration of the equipment for friction head loss shall be carried out by connecting the pressure gauges, flow meter and supply pipe headworks, three or four different lengths of drill rod and the packer with its tailpipe to the water supply. Water shall be pumped through the system and flow rates recorded for several values of back pressure. A graphical relationship of flow against pressure loss for the number of drill rods used shall be established and submitted to the Engineer. It shall be included in the Final Field Work Report if packer tests are carried out.

(3) A single packer test shall be carried out by expanding a hydraulic or pneumatic packer in the drillhole (not in the casing) to create a seal at the top of the test section. All rods and couplings must be watertight and the threads of drilling rods supplying the water to the test section shall be wrapped with thread sealing tape. The length of test section required shall be instructed by the Engineer. The drillhole below the packer shall be filled with water and kept full at the specified water pressure for 15 minutes immediately before the test commences. The flow meter used shall be capable of measuring flow quantities to the nearest 0.1 litre. The water levels in the drillhole above the packer shall be monitored at regular intervals during the test, by means of a suitable dip meter, to check whether leakage is occurring around the packer.

(4) The acceptance of water by the test section shall then be measured and recorded at successive pressures as instructed by the Engineer, the maximum of which will not exceed 75% of the effective overburden pressure at the mid-depth of the test section. A calibrated pressure gauge capable of measuring the required pressure to the following accuracies shall be used:

(a) 0 - 100 kPa Maximum Value (accurate to ± 5 kPa),

(b) 0 - 200 kPa Maximum Value (accurate to ± 10 kPa),

(c) 0 - 500 kPa Maximum Value (accurate to ± 20 kPa), and

(d) 0 - 1000 kPa Maximum Value (accurate to ± 20 kPa).

(5) At each pressure, the flow of water into the drillhole shall be measured over three periods, each of 5 minutes duration. If the first two readings do not differ by more than 10%, the third reading is not required. A complete test shall comprise measurement of the flow through the full cycle of pressures and any calibration tests required by the Engineer.

(6) Packer tests using single or double packers may also be required after the drillhole has been completed. The double packer test shall be performed as for a single packer test, except that the water pressure shall be applied to a specified length of drillhole isolated between two packers.

(7) Preliminary results shall be submitted on record sheets with the corresponding Investigation Station preliminary records. The record sheet used shall be to the approval of the Engineer.

Impression packer tests 7.76

(1) If instructed by the Engineer, a drillhole impression packer survey shall be performed in a vertical or inclined drillhole in TNW or T2-101 size, in accordance with Geoguide 2, using equipment and methods to the approval of the Engineer. The equipment shall be capable of surveying a minimum

1.5 m length of drillhole for each test.

(2) The survey shall be carried out by inserting the impression packer device into the drillhole to the depths instructed by the Engineer, expanding the packers and obtaining an impression of the drillhole wall on the thermoplastic film surrounding the packers. The survey shall be referenced to a known direction by means of a downhole compass. Sufficient time shall be allowed for the compass to set following the expansion of the packer. Great care shall be taken when placing the thermoplastic film onto the packers and when transferring the north point from the compass to the film.

(3) If an impression packer survey is instructed over a continuous length of drillhole longer than the length of the impression packer itself, successive impression packer test sections shall overlap by a minimum of 250 mm to ensure continuity of information and cross-checking of the north direction between successive test sections.

Inclination and bearing measurements

7.77 (1) If instructed by the Engineer, the inclination and bearing of a drillhole shall be measured using a single-shot or multi-shot photographic survey tool or similar instrument approved by the Engineer.

(2) The results of each test shall be reported on the daily site records and the average inclination and bearing over the length of the drillhole shall be stated on both the preliminary and final drillhole records. The original film data shall be submitted with the daily site records.

REPORTS FOR GROUND INVESTIGATION

General

7.78 Unless otherwise stated, records and reports may be either a hard copy or soft copy, as instructed by the Engineer. A hard-copy shall be printed double sided on recycled paper. A soft copy shall be in read-only format. The records and reports shall be in a format to the approval of the Engineer.

Site log book

7.79 For each Investigation Station, a Site Log Book shall be maintained in a format to the approval of the Engineer. All visitors to an Investigation Station shall sign the Site Log Book on each visit. The Site Log Book shall also be used to record all verbal requests at that particular Investigation Station and shall be countersigned by the authorized personnel making the request before the work is carried out. The Site Log Book shall be copied to the Engineer within 3 working days of the date of completion of the field work for each Investigation Station.

Daily site records

7.80 During the progress of any field work, one copy of all daily site records relevant to a particular Investigation Station shall be submitted to the Engineer within 3 working days, with additional copies (up to a maximum of 3) if instructed.

Preliminary records

7.81 (1) One copy of Investigation Station preliminary records and additional copies (up to a maximum of 3), as instructed, shall be submitted to the Engineer. Preliminary drillhole records shall be submitted within 6 working days of the date of completion of the Investigation Station excluding backfilling and reinstatement. Preliminary records of trial pit, trial trench, or slope stripping shall be submitted within 6 working days of the date of completion of coring, excavation and field testing for the Investigation Station to which they refer.

(2) Preliminary records of all field testing shall be submitted within the times specified in the Contract and on the forms specified. Preliminary records shall show all the information required for the final records except the co-ordinates and levels of the Investigation Station, which shall be submitted within 6 working days of the completion of the last Investigation Station.

Submission of Final Field Work Report

7.82 (1) Unless otherwise instructed by the Engineer, four copies of the Final Field Work Report, dated and certified as checked and complete, shall be submitted for approval.

(2) The Final Field Work Report shall be typed and contain all the information obtained from the investigation. Each Final Field Work Report shall contain:

(a) a factual description, prepared by the Geotechnical Engineer, of the nature and methods of the particular Ground Investigation carried out

(b) if drillholes have been sunk, a summary table of the depths and thicknesses of all strata (including decomposed rock and rock) encountered at each drillhole location and the reduced level of each stratum boundary,

(c) a copy of the location plan amended as necessary to show the exact position of each completed Investigation Station,

(d) a table of the as-drilled co-ordinates,

(e) Investigation Station final records together with data in AGS digital format to the approval of the Engineer,

(f) colour photocopies of any photographs taken,

(g) a Contract Data Summary sheet in a format to the approval of the Engineer, on the second page of each copy

(3) One copy of the Final Field Work Report shall be marked "Master Copy" and shall contain negatives and one set of colour prints of any photographs taken.

Submission of digital image of Final Field Work Report

7.83 (1) Unless otherwise instructed by the Engineer, five copies of a digital image of the Final Field Work Report shall be delivered to the Engineer. Each digital image shall be stored in a single file on a CD-ROM and placed in a plastic protective pocket. Four copies shall be attached to the hard copy of the Final Field Work Report at the time of delivery. The fifth copy shall be provided separately at the same time.

(2) Unless otherwise agreed by the Engineer, the digital image of the Final Field Work Report shall be in Acrobat format.

(3) The first page of the digital image shall be a scanned image of the first of page of the Report signed by the person certifying it as complete and checked. The digital image shall contain the complete contents of the report, including all drawings.

(4) The resolution of all colour images shall not be less than 150 dots per inch (dpi) with colour depth of 24-bit true colour. The resolution of black and white images shall not be less than 200 dpi.

(5) Each compact disc submitted shall be securely and clearly labelled.

PART 3: SLOPE TREATMENT WORKS

MATERIALS

Cement mortar 7.84 (1) Cement mortar for in-filling joints in rock faces, for bedding rock for masonry infilling and for surfacing slopes shall consist of Portland Cement (PC) and sand in the proportions 1:3 by mass.

(2) PC shall comply with BS EN 197-1.

(3) Sand shall be natural sand or crushed natural stone complying with BS 1200.

Rock for masonry infilling 7.85 Rock for masonry infilling shall not exceed 300 mm in size and shall be obtained from a source approved by the Engineer.

Soil-cement 7.86 (1) Soil-cement shall consist of PC, sand and inorganic soil in the proportions 1:3:12 by mass unless otherwise stated. The mix proportion of soil-cement is 1:3:40 by mass when it is applied to the top layer (maximum 300 mm thick) or other areas as directed or agreed by the Engineer.

(2) PC shall comply with BS EN 197-1.

(3) Sand shall be natural sand or crushed natural stone complying with BS 1200.

(4) Inorganic soil shall be free of organic matter and shall contain not more than 30% of soil particles passing a 63 μm BS test sieve.

Aggregates for sprayed concrete 7.87 The nominal maximum aggregate size of aggregates for sprayed concrete shall not exceed 10 mm.

Reinforcement for sprayed concrete 7.88 Unless otherwise approved by the Engineer fabric reinforcement including A393 and A252 for sprayed concrete shall comply with GS Section 15 except that the 50 mm x 50 mm x 2.7 mm (wire diameter) hot-dip galvanized steel welded mesh shall have tensile strength not less than 275N/mm^2.

Protective mesh and fixings 7.89 (1) Protective mesh for slopes shall be PVC coated galvanized steel wire woven into a double twist hexagonal mesh. Each hexagon shall be 80 mm x 60 mm. The steel wire shall be at least 2.2 mm diameter and the PVC coating shall be at least 0.4 mm thick. PVC coating on steel wire shall comply with BS 1722-16 or equivalent. The colour of PVC coating is to be approved by the Engineer. Wire for protective mesh shall comply with BS 1052. Galvanized coating on wires shall comply with BS EN 10244-2. The tolerance on the opening of mesh shall comply with BS EN 10223-2.

(2) Tying wire for protective mesh shall be 2.2 mm diameter PVC coated galvanized soft annealed steel wire.

(3) Bolts for fastening protective mesh to rock or structure shall be galvanized mild steel hooks as stated in the Contract.

(4) Stainless steel anchor bolts and accessories for fastening protective mesh to soil nail heads shall be as stated in the Contract.

(5) Hooks, fixing pins, steel plates and washers for fixing the protective mesh

to slope face shall be as shown on the Drawings and shall be galvanized to BS EN ISO 1461.

(6) Galvanizing shall comply with BS EN ISO 1461.

Rock bolts 7.90 (1) Rock bolts shall be a proprietary type approved by the Engineer. Rock bolts shall comply with CS2 and shall be mild steel or high yield deformed steel as stated in the Contract. Rock bolts shall be galvanized to BS EN ISO 1461. Rock bolts shall have non-corrodible centralizers capable of ensuring an even annulus of grout as approved by the Engineer.

(2) The rated working load of rock bolts shall not exceed 50% of the ultimate tensile strength. A reduction of 4 mm in the diameter of the bolt shall be taken into account for corrosion when calculating the ultimate tensile strength.

(3) Nuts for rock bolts shall be of grade 4 steel and comply with BS 4190. Connectors shall comply with Section 15 of this GS. Bearing plates shall be of grade S275 steel plate and comply with BS EN 10025:Part 1 and BS EN 10025:Part 3. Holes in steel plates for rock bolt heads shall be drilled perpendicular to the face of the steel plate and the centre of the hole shall be at a position of within 2 mm from the centroid of the plate. The clearance between the steel bar and the hole of the steel plate shall not be more than 2 mm. All nuts, connectors and bearing plates shall be galvanized to BS EN ISO 1461. Rock bolts shall have non-corrodible centralizers capable of ensuring an even annulus of grout as approved by the Engineer. Grease shall comply with Table 1 of Geospec 1.

Grout for rock bolts 7.91 Grout for rock bolts shall be as stated in Clauses 7.174 and 7.182 except that the water cement ratio shall not exceed 0.45.

Rock dowels 7.92 Rock dowels shall comply with CS2 and shall be galvanized to BS EN ISO 1461. Rock dowels shall have non-corrodible centralizers capable of ensuring an even annulus of grout around the steel bar as approved by the Engineer.

Grout for rock dowels 7.93 Grout for rock dowels shall be as stated in Clauses 7.160 and 7.168 except that the water cement ratio shall not exceed 0.45.

Soil nails 7.94 (1) Soil nail bars shall be of high yield deformed bars. Dimensions, mass per metre and permissible deviation of soil nail bars shall refer to CS2 Cl. 1.4. Chemical composition of soil nail bars shall refer to CS2 Cl. 1.5 and mechanical properties shall refer to CS2 Cl. 1.6. Definition of relevant terms such as stockist, manufacturer, etc. in the clauses in relation to soil nails shall be referred to CS2 Cl. 1.2. Nuts shall be of Grade 4 steel and comply with BS 4190. Connectors shall comply with this Section. Bearing plates shall be of Grade S275 steel plate and comply with BS EN 10025:Part 1 and BS EN 10025:Part 3. Permanent casings shall comply with BS 4019-3. Holes in steel plates for soil nail heads shall be drilled perpendicularly to the face of the steel plate and the centre of the hole shall be at a position of within 2 mm from the centroid of the plate. The clearance between the steel bar and the hole of the steel plate shall not be more than 2 mm. All steel components for soil nails shall be galvanized to BS EN ISO 1461. Materials for repair to hot dip galvanized coating shall comply with BS EN ISO 1461.

(2) Soil nails shall have non-corrodible centralizers capable of ensuring an even annulus of grout around the soil nail bars. The nominal diameter of the centralizers shall not differ from the specified diameter of the drillhole by more than 10 mm. Wires and ties for fixing and anchoring packers,

centralizers and grout pipes etc. shall be made of non-corrodible materials. The spacing of the centralizers and the suitability of the method of fixing the centralizers, grout pipes and corrugated sheathing where required shall be determined by carrying out trials on site until no damage, deformation and displacement of the centralizers, grout pipes and corrugated sheathing are observed on completion of assembling all components, during inserting and withdrawing the soil nails. Once approval is given, no change to the type, method and arrangement of fixing of the centralizers, grout pipe and corrugated sheathing shall be made without the prior approval of the Engineer.

(3) Connectors for soil nail bars shall be of a proprietary type approved by the Engineer. Connectors shall be a cold swaged or threaded type. The connectors shall be capable of developing the full tensile strength of the parent bar and shall comprise high tensile steel studs and seamless steel tubes fitted with protective plastic caps. For soil nails using threaded type connectors but without galvanized coating on either the threads inside the connectors or the threads at the ends of soil nail bars, heat-shrinkable sleeve of a proprietary type as approved by the Engineer shall be used as an alternative to galvanization as a corrosion protection measure to the connections. Any rust on the threads of soil nail bars and connectors shall be thoroughly cleaned before being connected together.

(4) Unless otherwise specified by the manufacturer and approved by the Engineer, the heat-shrinkable sleeve for soil nail bars connectors shall be made of a layer of radiation cross-linked polyethylene and a layer of anti-corrosion mastic sealant material. The properties of polyethylene and mastic sealant materials shall comply with the following requirements:

Property	Test Method	Unit	Acceptance
Properties of polyethylene			
Tensile strength at 23°C (Cross head speed: 50mm/min)	BS EN ISO 527-1	MPa	≥ 17
Ultimate elongation at 23°C (Cross head speed: 50mm/min)	BS EN ISO 527-1	%	≥ 350
Impact brittleness	BS ISO 974	°C	≤ -40
Water absorption at 23°C, 24 hrs	BS EN ISO 62	% increase in weight	≤ 0.1
Properties of mastic sealant material			
Corrosion effect	ASTM D2671 (Procedure A)		No corrosion
Peel strength to steel at 23°C (Cross head speed : 100mm/min)	DIN 30672	N/cm	≥ 4
Shear strength at 23°C (Cross head speed : 50mm/min)	BS ISO 4587	N/cm^2	≥ 10
Softening point	ASTM E28	°C	≥ 70

Soil nails with double-corrosion protection

7.95 (1) Materials for soil nails with double-corrosion protection shall comply with Clause 7.94 unless otherwise specified in the following sub-clauses.

(2) Corrugated sheathing for the double corrosion protection shall be a proprietary type approved by the Engineer and shall be made of high density thermoplastic materials which shall be homogeneous, thermally stable, chemically inert and resistant to chemical, bacterial and fungal attack. The wall thickness of the sheathing shall be at least 1.0 mm. Plastic sheathing and all associated components shall comply with the requirements as stipulated in Table 2 of the Model Specification for Prestressed Ground Anchors (GEOSPEC 1).

(3) Finished internal and external surfaces of the sheathing shall be smooth, clean and free of flaws, pin-holes, bubbles, cracks and other defects. Sheathing and all associated components shall be used in accordance with the manufacturer's instructions.

(4) Sheathing and other plastic protective components shall:

(a) Not contain any substances that will promote corrosion;

(b) be covered to prevent exposure to ultra-violet light from direct or indirect sunlight;

(c) be resistant to slip; and

(d) be capable of withstanding the applied handling stresses, the hydrostatic and grouting pressures.

(5) Centralizers shall be provided on the soil nail bars and the sheathing at suitable intervals to meet the following requirements:

(a) The soil nail bars shall be positioned in the sheathing so that a minimum grout cover to the bar of 10 mm is maintained; and

(b) There shall be minimum clearance of 15 mm between the sheathing and the sides of the drillholes or casing.

(6) Corrugated sheathing shall be embedded at least 50 mm into soil nail head.

Grout for soil nails

7.96 Grout for soil nails shall be as stated in Clauses 7.174 and 7.182 except that the water cement ratio shall not exceed 0.45 and PFA shall not be used unless agreed by the Engineer.

Non-biodegradable mats for erosion control

7.97 (1) Non-biodegradable mats for erosion control shall be woven and ultraviolet stabilized mats. The mats shall have the material properties stated in the Contract.

(2) The mats must be produced by proprietary manufacturers and specifically designed for the erosion control of sloping ground.

(3) The colour of the mats shall be black or dark green or other colour as directed or approved by the Engineer.

Biodegradable mats for erosion control 7.98 (1) Biodegradable mats for erosion control shall be woven coir mesh mats or woven jute mats. The mats shall have the material properties stated in the Contract.

(2) The mats must be produced by proprietary manufacturers and specifically designed for the erosion control of sloping ground.

Wire mesh for erosion control 7.99 Wire mesh for erosion control shall comply with Clause 7.89(1). Unless otherwise specified in the Drawings, the wire mesh shall be fixed onto the slope surface by means of anchor bolts and/or fixing pins. The fixing pins, steel plates and washers for fixing the wire mesh to slope face shall comply with Clause 7.89. Galvanized coating on wires shall comply with BS EN 10244-2. The anchor bolts, nuts and washers for fixing the wire mesh to soil nail heads shall be stainless steel complying with Section 5. Details of the anchor bolts and fixing pins shall be submitted to the Engineer for approval. Anchor bolts and accessories shall have the following properties:

(a) The minimum size of the anchor bolts shall be M8.

(b) The components of the anchor bolts shall include:

(i) Hexagonal bolt or threaded rod with hexagonal nut.

(ii) Washer with minimum diameter of 20 mm.

(c) The length and diameter of the drillholes and the minimum size and embedment depth of the anchor bolts shall be as stated in the Contract or otherwise approved by the Engineer.

(d) The mean ultimate tensile resistance and mean ultimate shear resistance of the anchor bolts shall be 31 kN and 47 kN respectively in non-crack concrete with concrete strength at 30 N/mm^2.

SUBMISSIONS

Particulars of access 7.100 Particulars of the proposed means of access for slope treatment works, including access structures and reinstatement, shall be submitted to the Engineer for approval at least 14 days before the slope treatment works start.

Particulars of sprayed concrete 7.101 (1) The following particulars of the proposed materials and methods of construction shall be submitted to the Engineer:

(a) Type and performance of mixing and spraying plant,

(b) Details of water sprays and associated pumps for surface spraying,

(c) Method of curing,

(d) Details of trial panels and test panels,

(e) Methods of measuring surface temperature and moisture content of the soil,

(f) Methods of achieving the specified thickness of sprayed concrete and the specified cover to reinforcement and methods of measuring the thickness and cover after spraying

(g) Method of fixing reinforcement,

(h) Details of materials and mix design,

(i) Details of dry mix process and/or wet mix process for applying sprayed concrete,

(j) Name and details of the experience of the shotcretors,

(k) Details of working platform,

(l) Method of forming expansion joints, and

(m) Sequence of spraying on sloping surfaces.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before sprayed concrete is used.

Particulars of rock bolts 7.102 (1) The following particulars of the materials and methods of construction for rock bolts shall be submitted to the Engineer:

(a) Details of rock bolts, nuts, washers, bearing plates, connectors, sleeves, grease and centralizers,

(b) Methods of tensioning and grouting,

(c) Proposed working loads,

(d) Previous performance records, and

(e) Details of equipment for testing rock bolts, including test and calibration certificates

(f) Details of working platform and drilling equipment, including method of drilling and size of drillholes,

(g) Details of equipment for Packer tests in drillholes including test and calibration certificates,

(h) Grout mix details and grouting equipment.

(2) The particulars shall be submitted to the Engineer for approval at least 28 days before pull-out trials start. All equipment for testing rock bolts shall be tested and calibrated by approved laboratories within 6 months prior to the date of carrying out the tests.

Samples of materials 7.103 A sample of a complete rock bolt shall be submitted to the Engineer for approval of the source and type of rock bolt at the same time as particulars of rock bolts are submitted.

Soil nails 7.104 (1) The following particulars of materials and methods of construction for soil nails shall be submitted to the Engineer:

(a) For soil nail bars, a certificate from the quality assured stockist and a copy of the manufacturer's certificate/document of the original steel bars in accordance with CS2 Cl. 4.1,

(b) Details of the proposed materials and methods of installation for soil nail bars connectors, including the manufacturer's literature,

(c) Details of and assembled component samples comprising of soil nail bars, coupling sleeves, nuts, washers, plates, connectors, centralizers, grout pipes, corrugated sheathing, packers for isolating the bond length and plugs capable of sealing the drillholes and withstanding the pressure head maintained on the grout during grouting,

(d) Details of galvanizer, including name and location of the coating factory, to be employed for galvanizing the steel components and method of making good any damaged galvanized coating. Original certificate from the manufacturer showing the date and place of application of the coating and showing that the galvanized coatings comply with the requirements stated in the Contract and including results of tests carried out by methods as recommended in BS EN ISO 1461 for thickness of coating. A document prepared by the manufacturing factory for the galvanized soil nail bars with threads and couplers, certifying each batch of steel with certificates from quality assured stockist, mill and hot dip galvanizer are properly stored, handled, processed and supplied to a purchaser,

(e) Details of heat-shrinkable sleeve for protecting the connections between soil nail bars if galvanized coating to either the threads inside connectors or at the ends of soil nail bars is not applied, together with details of the heat application equipment for shrinking the sleeves,

(f) Method of repairing damaged heat shrinkable sleeves during heat application or other installation process of soil nails,

(g) Details of corrosion protection for the threaded portion of the steel bar at soil nail head,

(h) Details of working platform,

(i) Details of temporary support to drillholes,

(j) Details of permanent casing,

(k) Method of storing materials,

(l) Method of drilling and details of drilling equipment,

(m) Method of assembling soil nail bars,

(n) Method of installing soil nail bars into drillholes,

(o) Method of grouting and details of grouting equipment,

(p) Details of equipment for measuring the volume of grout injected into each drillhole together with the accuracy and method of calibrating the equipment,

(q) Details of equipment for testing soil nails, including test and calibration certificates,

(r) Details of testing assembly including details of datum for deformation measurement and bearing pad, and

(s) Method of constructing soil nail heads.

(2) The particulars shall be submitted to the Engineer for approval at least 28 days before pull out tests commence except for the particulars stated in Clause 7.104(1)(a), (b) and (d). For the particulars stated in Clause 7.104(1)(a), it shall be submitted to the Engineer for information for each batch of soil nail bars delivered to the Site and at least 14 days before insertion of the soil nail bars starts. For the particulars stated in Clause 7.104(1)(b), it shall be submitted to the Engineer at least 28 days before assembling of the connectors starts. For Clause 7.104(1)(d), the details of galvanizer and the method of making good any damaged galvanization coating shall be submitted to the Engineer at least 14 days before the first delivery of galvanized soil nail bars to the Site. Certificates together with the particulars of the original steel bars and the document from the manufacturing factory shall be submitted for each batch of galvanized soil nail bars delivered to the Site and at least 14 days before insertion of the soil nail bars starts.

Mats for erosion control

7.105 The following particulars of materials and methods of construction for mats for erosion control shall be submitted to the Engineer for approval at least 14 days prior to installation:

(a) Details and samples of materials,

(b) Manufacturer's literature including recommended sequence of mats installation and hydroseeding,

(c) Method of drilling holes, lapping, fixing and anchor,

(d) Method of placing and tamping of soft soil into the mats, if required,

(e) Details of equipment, and

(f) A certificate from the manufacturer on the compliance of the materials, as and where appropriate.

Wire mesh for erosion control

7.106 The following particulars of materials of wire mesh, anchor bolts and method of construction shall be submitted to the Engineer for approval at least 14 days prior to installation:

(a) Details and samples of wire mesh and anchor bolts,

(b) Method of drilling holes for the bolts and details of drilling equipment, and

(c) Certificates from the manufacturer showing that the wire mesh and anchor bolts comply with requirements as stated in the Contract.

PRELIMINARY WORKS

Access to slopes

7.107 (1) Means of access consisting of scaffolding constructed of sound bamboo, metal or other materials agreed by the Engineer shall be installed to enable the Engineer to examine slope treatment works. The scaffolding shall allow access to within 0.8 m of the slope face. Hand and foot holds for climbing shall be provided by bamboo or metal members at centres not exceeding 0.5 m vertically and 0.8 m horizontally.

(2) A system of safety ropes shall be installed on the scaffolding. Safety ropes shall be 12 mm diameter and shall have a breaking force of at least 18 kN. The system of safety ropes shall consist of:

(a) Vertical ropes at not more than 3 m centres horizontally securely anchored to the crest of the slope, and

(b) Horizontal ropes at not more than 3 m centres vertically.

The system of safety ropes shall be constructed in such a manner that the ropes are tied at not more than 3 m spacings in both directions to form a net.

(3) The scaffolding shall be provided for the purpose of carrying out inspection to the slope by the Engineer and shall not be used for carrying out site operations without the permission of the Engineer.

(4) Where rock slope works are included in the Contract, sufficient time shall be allowed in the programme for the Engineer to inspect the rock slope, check the stability, design slope treatment works and determine the extent of the works required, taking into account of any specified time stated in the Contract that the Engineer may require for the inspection and design of slope treatment works.

Protection fences and barriers

7.108 (1) Protection fences and barriers for slope treatment works shall be constructed as stated in the Contract before slope treatment work starts.

(2) Damage to protection fences and barriers shall be repaired immediately. The permission of the Engineer shall be obtained before protection fences and barriers are dismantled.

Preparation for slope treatment works

7.109 (1) Vegetation shall be cleared and existing impermeable surfaces and topsoil shall be removed from existing soil slopes before slope treatment works start.

(2) Surface of slopes shall be trimmed and scarified before slope treatment works start. On completion of trimming and scarifying, any loose materials shall be removed from the surface of slopes by means of water jet coupled to compressed air for rock slopes or other hard surfaces and air jet for soil slopes unless otherwise directed by the Engineer.

(3) Rock faces and joints, and the surface and joints of retaining walls shall be cleaned of moss, vegetation and loose material, immediately before slope treatment works start, and surplus water shall be removed by an air jet. Water flowing from or across the rock face shall be diverted by relief drains or by other methods agreed by the Engineer before the application of impermeable surfaces.

(4) Any slope surface that has been stripped for inspection by the Engineer without any further slope work shall be reinstated to its original condition.

ROCK SLOPE TREATMENT WORKS

Scaling and trimming of rock slopes

7.110 Rock scaling shall only be carried out on areas as directed by the Engineer. Rock scaling shall include the removal of all loose blocks of any size using hand tools, or boulders not exceeding 0.2 m^3 in volume using powered mechanical equipment. Scaling and trimming of rock slopes shall be carried out in such a manner that soil and rock is removed from the slope face without affecting the stability and integrity of the slope. Measures shall be taken to prevent uncontrolled falls of debris arising from scaling and trimming works. Scaling and trimming of rock slopes shall be carried out using hand-held tools. All material removed or excavated by scaling and trimming and loose fragments of soil and rock shall be removed from the slope. Rock faces shall be cleaned using a water jet coupled to compressed air after scaling and trimming is complete.

Rock splitting

7.111 Rock splitting shall be carried out using percussive hammers, drills, hydraulic splitters, chemical expanding agents, hand-tools or other methods agreed by the Engineer.

Removal of boulders

7.112 Boulders that are to be removed from slopes shall be broken down by means of line drilling, expansive grouts, rock breakers or other methods agreed by the Engineer. For the purpose of this Clause, a boulder to be removed on rock slopes shall qualify as “boulder” only if it exceeds 0.2 m^3 in volume before excavation and it cannot be removed without the use of powered mechanical equipment.

Sealing and infilling of rock joints

7.113 Joints in rock faces shall be sealed with Grade 20/20 concrete, cement mortar or masonry as stated in the Contract. Rock for masonry infilling shall be bedded in cement mortar. Relief drains instructed by the Engineer shall be installed before rock joints are sealed or infilled.

Concrete buttresses

7.114 (1) Concrete for buttresses shall be Grade 20/20 unless otherwise stated in the Contract.

(2) Drainage which is required behind buttresses shall consist of relief drains connected to 50 mm diameter uPVC outlet pipes laid at a gradient of at least 1 in 50. The uPVC pipes shall be securely fixed to the formwork before concreting starts.

SOIL-CEMENT FILL

Mixing soil-cement

7.115 Soil-cement shall be thoroughly mixed in a concrete mixer. Small quantities of soil-cement shall not be hand mixed unless permitted by the Engineer. The method of mixing soil-cement shall be agreed by the Engineer.

Deposition and compaction of soil-cement fill

7.116 (1) Soil-cement fill shall be deposited in its final position and compacted no more than 30 minutes after the cement has been added to the mix.

(2) Soil-cement fill shall be compacted to specification as stated in Section

6 to obtain a relative compaction of at least 95% throughout. Soil-cement fill shall be at optimum moisture content during compaction. The tolerance on the optimum moisture content percentage shall be ±3.

SPRAYED CONCRETE

Trial panel 7.117 A trial panel at least 50 mm thick and at least 3 m × 3 m shall be constructed for sprayed concrete on the surface to be treated. The average percentage rebound shall be estimated for each trial panel and shall be used in the calculations of the cement content of the applied concrete. Where required by the Engineer, trial panels shall be constructed for different types of spraying equipment or different shotcretors. Test panels to establish the suitability of sprayed concrete mix, spraying equipment and shotcretors shall be made and tested as stated in Clauses 7.149 to 7.153.

Preparation of slope surfaces 7.118 (1) Weak material along joints or seams in slope surfaces to which sprayed concrete will be applied shall be removed to a depth equal to the width of the weak zone.

(2) If the soil surface temperature exceeds 25°C or the moisture content is less than 10%, the surface to be sprayed shall be watered using sprays unless otherwise instructed by the Engineer. Hoses without sprays shall not be used. Spraying of water onto the slope surface shall be carried out not more than 1 hour before spraying of concrete starts.

(3) Before sprayed concrete is applied, all tree trunks, railings, channels, utilities, pipes, structures, street furniture or other facilities adjacent to or within the sprayed concrete area shall be protected with approved means from being contaminated by sprayed concrete or rebound particles. All contaminated surfaces shall be cleaned and made good to the satisfaction of the Engineer.

Fixing reinforcement 7.119 Fabric reinforcement for sprayed concrete shall be fixed securely to the slope by steel nails or rawl bolts and shall be laid without sharp bends or creases. The cover to the reinforcement shall be at least 20 mm and laps between adjacent sheets shall be at least 150 mm. The fabric reinforcement shall be placed centrally in the sprayed concrete and be supported clear of the ground and away from all surface irregularities with adequate number of cover blocks

Weepholes and joints in sprayed concrete 7.120 (1) 50 mm diameter weepholes shall be constructed:

(a) On soil surfaces at 1.5 m staggered centres in each direction, and

(b) On rock faces, on rock joints and at locations/spacings as directed by the Engineer.

(2) All weepholes shall extend through the full thickness of the sprayed concrete and shall be laid with an outward inclination of 1 in 10.

(3) On soil slopes, expansion joints shall be constructed in sprayed concrete in line with the expansion joints of the adjacent channels, berm slabs and concrete structures etc. or at 15m intervals maximum in case there is no channels, berm slabs or concrete structures.

(4) Construction joints in sprayed concrete shall comply with the

requirements specified in Section 16.

Equipment for spraying concrete

7.121 (1) Sprayed concrete shall be applied using the dry process in which water and admixtures shall be added at the nozzle. Alternatively, sprayed concrete shall be applied using the wet process in which wet ready-mixed concrete shall be supplied to the nozzle.

(2) Equipment for the dry-mix process shall be capable of projecting a mixture of cement, fine and coarse aggregate and water at high velocity on to the surface of the slope to produce a dense homogenous cover. The equipment shall be fitted with weight-batching facilities.

(3) Equipment for the wet-mix process shall be capable of projecting a mixture of wet ready-mixed concrete at high velocity on to the surface of the slope to produce a dense homogenous cover.

(4) Only skilled operators experienced in the use of sprayed concrete and approved by the Engineer shall be employed as shotcretors.

Spraying concrete

7.122 (1) The surface temperature and moisture content of the soil shall be measured, and the results submitted to the Engineer, immediately before sprayed concrete is applied.

(2) For the dry-mix process, the aggregate and sand for sprayed concrete shall be kept dry before mixing. Sand shall be natural sand or crushed natural stone. The water shall be added at the nozzle at the instant of application. The air and water supply, the rate of application and all other factors affecting the quality of the work shall be adjusted to produce dense concrete with no sloughing. For the wet-mix process, the ready-mixed concrete shall comply with Section 16 of GS unless otherwise approved by the Engineer. For both the dry-mix process and the wet-mix process, rebound material shall not be reused and shall be removed within 8 hours of spraying.

(3) Sprayed concrete shall be applied in layers not exceeding 50 mm thick to the total thickness stated in the Contract. The maximum panel dimension shall not exceed 15 m^2.

(4) Sprayed concrete shall be applied perpendicularly to the surface to be sprayed and the nozzle shall not be positioned farther than 1.5 metres from the surface during spraying.

(5) Colour pigment approved by the Engineer shall be mixed thoroughly with the sprayed concrete mix. A layer of 25 mm thick of the coloured sprayed concrete shall be applied to form the total thickness of sprayed concrete stated in the Contract.

(6) Details of the colour pigments (e.g. specification and colour samples etc.) and the method statement shall be submitted for the Engineer's approval prior to application. The pigment shall comply with ASTM C979/C979M and shall have the characterization of light fast, lime proof, weather resistance and durable like concrete. Colour to be employed shall be directed by the Engineer.

Curing sprayed concrete

7.123 Sprayed concrete shall be cured for at least 4 days after application by either Method 1, Method 2 or Method 3 as stated in Section 16.

Inspection of sprayed

7.124 Completed areas of sprayed concrete shall be sounded using a wooden mallet.

concrete Cores of 75 mm diameter shall be taken from the completed sprayed concrete area at the rate of 1 no. per every 150 m^2 of sprayed surface or part thereof at locations determined by the Engineer, for checking the quality and thickness of the sprayed concrete as well as cover to reinforcement. Whenever any defect is found, further investigation shall be carried out to locate the extent of the defect. Areas which in the opinion of the Engineer are substandard or hollow shall be removed and re-sprayed. Core holes shall be reinstated with cement mortar of colour matching the adjacent surfaces.

Records of sprayed concrete 7.125 Records of sprayed concrete operations shall be kept by the Contractor on the Site and shall be submitted daily to the Engineer. The records shall contain details of the quantities of all materials used at each location. The records could be either a hard copy or soft copy as agreed by the Engineer. The hard-copy report shall use recycled papers. The soft copy shall be in read-only format and the hard copy shall be double side printed as agreed by the Engineer.

PROTECTIVE MESH FOR SLOPES

Fixing protective mesh for slopes 7.126 Unless otherwise stated in the Contract, protective mesh for slope shall be orientated, laced and suspended down and fixed onto the slope face with dowels or steel hooks at intervals not exceeding 3 m. The diameter of the drillholes for dowels or steel hooks shall be at least 20 mm larger than the diameter of the dowels or steel hooks. The method of drilling and cleaning of drillholes shall be as stated in Clause 7.128(1) and (2). The last column or row of dowels or steel hooks fixing the edges and base of the protective mesh shall be positioned not more than 300 mm from the respective edges/base of the mesh. Laps in mesh sheets in vertical direction shall be avoided as far as possible, however where necessary, the laps shall be at least 300 mm minimum wide and the lapping sheets shall be laced with 2.2mm nominal diameter galvanized and PVC-coated binding wire at the centre of the lap in the same way as adjacent vertical sheets.

ROCK BOLTS

Trials for rock bolts 7.127 The design bond length of rock bolts with bonded anchorages shall be determined for each rock type by a pull-out trial. The proof load of a pull-out trial shall be twice the working load. Pull-out trials shall be carried out on two bolts for each combination of rock bolt and rock type. Unless otherwise permitted by the Engineer the bolts used in trials shall be discarded and shall not form part of the permanent works, and the hole shall be sealed by grouting.

Drilling, preparing and testing rock bolt holes 7.128 (1) Holes for rock bolts shall be drilled at the locations instructed by the Engineer. The diameter of the hole shall be at least 20 mm larger than the diameter of the rock bolt or the outer diameter of the connectors, if used, whichever is larger. The method of drilling shall be rotary or rotary percussive with water flush or air flush accompanied by the operation of an effective dust extraction and filtering device. Holes shall be drilled to provide 50 mm cover to the end of bolts for which cement grout is used to form the bond length.

(2) Holes for rock bolt shall be flushed with clean water before rock bolt installation starts until the return water runs clear. Standing water shall be blown out from the hole using compressed air after flushing.

(3) Holes for rock bolts shall be tested by the Packer test as stated in Clauses 7.148, 7.149 and 7.150 and the results of the tests shall be submitted to the Engineer for approval, before installation of rock bolts starts.

Fixing rock bolts 7.129 (1) The permission of the Engineer shall be obtained before installation of rock bolts starts.

(2) Rock bolts shall be installed in accordance with the manufacturer's recommendations.

(3) Rock bolts shall be fully grouted after stressing. Heat-shrinkable plastic sleeves of an approved type shall be provided to the free length of rock bolts.

(4) Installation of rock bolts, including grouting of the free length and installation of head protection, shall be completed as soon as practicable and not more than 14 days after completion of the drillhole.

(5) Rock bolts with a grouted anchorage shall not be stressed until the grout crushing strength has attained a value of 21 MPa when tested in accordance with Clauses 7.194, 7.195 and 7.196.

Grouting rock bolts 7.130 (1) Grouting for rock bolts shall be in accordance with Section 7, Part 4, except as stated in the followings:-

(a) Grout shall be introduced at the lower end of drillholes with downward inclinations and shall displace all air and water through the top of the drillhole.

(b) Packers and return ducts which maintain a head on the grout until the grout has set shall be used for drillholes with upward inclinations or with inadequate downward inclinations. The packers and ducts shall be such that separate grouting of the anchorage zone and free-length zone of the drillhole can be carried out. The head to be maintained on the grout shall be as approved by the Engineer.

Proving rock bolts 7.131 Each installed rock bolt shall be proved as stated in Clauses 7.157 to 7.159. Rock bolts shall be locked off at 1.1 times the working load after proving. The complete bolt head assembly shall be encased by a concrete block after locking off.

Records of rock bolts 7.132 Records of installation of rock bolts shall be kept by the Contractor on the Site and a copy shall be submitted to the Engineer not more than 7 days after each installation operation. The records could be either a hard copy or soft copy to be determined by the Engineer. The hard-copy report shall use recycled papers. The soft copy shall be in read-only format and the hard copy shall be double side printed as agreed by the Engineer. Records shall contain the following:

(a) Rock bolt identification number,

(b) Drilling details, including:
- Date and time drilling started and finished
- Machine and operator identification
- Location, level, inclination, bearing, length and diameter of

drillhole
- Rate of penetration at 0.5 m intervals,

(c) Water tightness of drillhole, including:
- Date and time water test started and finished
- Details of any pre-grouting and redrilling
- Length of test zone
- Water pressure applied
- Duration of test
- Measured water absorption rate,

(d) Details of steel bolts, including:
- Type and diameter
- Bond length
- Overall length
- Number and type of centralising spacers
- Stressing record and lock-off load, and

(e) Details of grouting, including:
- Date and time grouting started and finished
- Details of any packers used and length of grouted zones
- Head maintained on grout during setting
- Volume of grout accepted
- Identification marks of grout cubes.

ROCK DOWELS

Drilling and preparation of rock dowel holes

7.133 The drilling and preparation of holes for rock dowels shall be as stated in Clause 7.128(1) and (2).

Grouting rock dowels

7.134 (1) Grouting for rock dowels shall be in accordance with Section 7, Part 4, except as stated in Clause 7.134 (2).

(2) Rock dowels shall be grouted over the complete length of the drillhole in which the dowel is installed. Centralisers as stated in the Contract shall be fitted to rock dowels before grouting to ensure an even annulus of grout. No jacking or hammering of the dowels shall be carried out during the whole process of insertion of dowels into drillholes. Grout shall be introduced at the lower end of drillholes with downward inclinations and shall displace all air and water through the top of the drillhole.

Records of rock dowels

7.135 Records of installation of rock dowels shall be kept by the Contractor and a copy shall be submitted to the Engineer not more than 7 days after each installation operation. The records could be either a hard copy or soft copy, as agreed by the Engineer. The hard-copy report shall use recycled papers. The soft copy shall be in read-only format and the hard copy shall be double side printed as agreed by the Engineer. The records shall contain details of the location, length, inclination and level of each rock dowel installed.

SOIL NAILS

Handling of soil nail

7.136 (1) Soil nail bars shall not be subject to rough handling, shock loading or

bars

dropping from a height.

(2) Nylon, rope or padded slings shall be used for lifting galvanized soil nail bars. Bundles shall be lifted with a strong back or with multiple supports to prevent abrasion.

Storage of soil nail bars

7.137 (1) Soil nail bars shall be stored off a levelled, well drained and maintained hard-standing ground on level supports and in a manner, which will not result in damage or deformation to the soil nail bars, or in contamination of the soil nail bars. Measures to protect the soil nail bars from wetting and rusting caused by weather shall be proposed for Engineer's approval. Soil nail bars shall be stored horizontally.

(2) Different types and sizes of soil nail bars shall be stored separately.

(3) Soil nail bars shall not be stored on or adjacent to concrete surfaces that form part of the permanent works.

(4) Galvanized soil nail bars shall be stored on wooden or padded cribbing.

Cutting soil nail bars

7.138 Soil nail bars shall be cut in accordance with BS 8666 to the specified shapes and dimensions.

Surface condition of soil nail bars

7.139 (1) Soil nail bars shall be clean at the time of assembling and shall be free of loose mill scale, loose rust or any substance that, in the opinion of the Engineer, is likely to reduce the bond or affect the bars or grout chemically. The soil nail bars shall be maintained in this condition until insertion of soil nail bars.

(2) If the surface condition of the soil nail bars deteriorates such that it does not comply with the requirements stated in Clause 7.139(1), the soil nail bars shall be cleaned or dealt with by other methods agreed by the Engineer.

Repairs to galvanized coating
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7.140 (1) If the coating to galvanized soil nail bars is damaged,

(a) At any point by an amount exceeding 25mm^2 in area or 50mm in length, or

(b) At more than three points in a 1m length by amounts each even not exceeding 25mm^2 in area or 50mm in length,

that part of the soil nail bars shall not be used in the permanent works. If the coating to galvanized soil nail bars is damaged at more than six points in the cut length of a bar by amounts each even not exceeding 25mm^2 in area or 50mm in length, that length of bar shall not be used in the permanent works.

(2) Except as stated in Clause 7.140(1), all damaged areas and cut ends of galvanized soil nail bars shall be repaired by materials to be approved by the Engineer. Sufficient material shall be applied to provide a coating of at least the same thickness as the galvanized coating. The Contractor shall refer to Section 6.3 and Annex C of BS EN ISO 1461 for advice on repair of damaged areas.

(3) Repairs to galvanized coatings shall be carried out within 8 hours of cutting or identifying damage. Traces of rust shall be removed from the surface of the soil nail bars before the repair is carried out.

Tolerances: soil nail bars

7.141 Tolerances on cutting soil nail bars shall comply with BS 8666 Table 5.

Drilling for soil nails

7.142 (1) Drilling for soil nails shall comply with Clauses 7.178 (4) and (5) and the following sub-clauses of this Clause. The set up of drilling plant and ancillary equipment shall be in such a manner that water, dust, fumes and noise generated during of drilling operation shall be sufficiently diverted, controlled, suppressed and muffled.

(2) Drilling for soil nails shall be carried out using rotary or percussive type drills with air as the flushing medium unless otherwise agreed by the Engineer. Temporary support shall be provided to drillholes to prevent the collapse of drillholes until after the completion of grouting, including but not limited to the use of temporary casing. Drillholes shall be cleared of all debris and standing water immediately before installation of soil nails. All necessary equipment and assistance shall be provided to the Engineer to check the inclination, diameter, bearing, cleanliness and length of all drillholes.

(3) Where instructed by the Engineer, drilling records including reference numbers of soil nails, date and time of drilling, penetration rate, description of strata of materials penetrated and any special observations during drilling such as underground voids encountered, collapse of hole, groundwater encountered, appropriate depth to ground water and depth of zone of no air return etc. shall be submitted to the Engineer not more than 2 working days after completion of drilling in a format agreed by the Engineer.

(4) Where required in the Contract or ordered by the Engineer, permanent steel casing of appropriate internal diameter and of 6.3 mm minimum thick shall be installed and left in place with soil nails. Unless otherwise specified by the Engineer, the bottom 2 m length of drillhole shall be left unsupported by permanent casing.

(5) The dimensions of soil nail heads and the orientation of soil nails shall be constructed in accordance with the Drawings or instructions given by the Engineer.

(6) The permitted deviation of drillholes shall be $\pm 2^{o}$ to the specified vertical and horizontal alignments. The diameter of drillholes shall be the minimum diameter as specified. The grout cover to the lower end of soil nail bars shall be at least 50 mm.

(7) No drilling shall be carried out within 10 metres radius of any freshly grouted soil nails, including soil nails for pull out tests, grouted less than 12 hours previously

Installation and grouting for soil nails

7.143 (1) Soil nail bars and connectors from each batch shall not be installed until testing of the batch has been completed. Soil nails shall be installed and grouted as soon as possible after drilling. In any case, each drillhole shall not be left unsupported for more than 3 days. All drillholes shall be checked for cleanliness prior to installation of soil nails. Connectors for soil nail bars shall be fixed in accordance with manufacturer's recommendation and using equipment recommended by the manufacturer. Soil nail bars shall not be welded unless approved by the Engineer. For soil nail bars with threaded type connectors, each length of the soil nail bars shall be tightened by means of an appropriately sized wrench. During the whole process of installation, no jacking or hammering of the soil nail bars shall be carried out. Grouting for soil nails shall comply with Clauses 7.168 to 7.174, 7.176, 7.177, 7.180, 7.181(1) to 7.181(6), 7.182, 7.184, 7.186(1), 7.187 to 7.192 and the following sub-clauses of this Clause.

(2) The gross volume of the drillholes, discounting the volume of all cast in components of each of the soil nails to be grouted shall be calculated and recorded on the request forms for inspection of soil nail installation.

(3) The grout pipe shall terminate at a point within 150 mm above the lower end of the soil nail bars and no side cut hole shall be made on the grout pipe except that the cut is made within 150 mm above the lower end. Grout pipe shall be fixed onto the soil nail bars or corrugated sheathing (in case of double corrosion protection soil nails) by non-corrodible ties at spacings of not more than 2 m. Grout pipes shall not be removed from drillholes after insertion and the part protruding from drillholes after grouting shall be trimmed down to the base of soil nail head.

(4) Where heat-shrinkable sleeve is used, the heat-shrinkable sleeve shall be heat-shrunk by means of an apparatus approved by the Engineer, and it shall be used in accordance with the manufacturer's instructions. The sleeve shall have sufficient length and shall be positioned such that a minimum 100 mm length of soil nail bars beyond the connector is protected by the sleeve after completion of heat-shrinking. No lapping of the sleeve shall be allowed. The sleeve thickness shall not be less than 1.0 mm after heat-shrinking. Finished surface of the sleeve shall be smooth, free of trapped air pockets, flaws, holes, cracks, burn marks and other defects. Any defects or damages found on the sleeve shall be made good to the satisfaction of the Engineer.

(5) Soil nails shall be grouted on the day when the soil nail bars are inserted into drillholes. Soil nails which are not grouted after insertion and are left in drillhole overnight shall be withdrawn from the drillhole and the drillhole shall be checked for cleanliness and obstructions prior to re-insertion.

(6) After insertion of soil nail bars into the drillhole, the top end of the drillhole shall be sealed with an appropriate plug capable of withstanding a grout pressure head, which is maintained during the first hour after completion of grouting as described in sub-clause (8) of this Clause. An outlet pipe extending above the slope surface shall be installed through the plug to allow discharge of air, water and grout from the upper end of the drillhole during grouting. The arrangement of outlet pipe and sealing plug shall be submitted for the agreement of the Engineer and a site trial shall be carried to demonstrate that the set up performs satisfactorily.

(7) Soil nails shall be grouted over their entire length of soil nail bars in one single operation. Grout shall be injected into drillhole through the grout pipe to the lower end of drillhole such that air and water are displaced from the drillhole as grouting proceeds. When the consistency of the grout flowing out of the outlet pipe is the same as the injecting grout, the grouting operation shall stop and the inlet grout pipe sealed. A pressure head of at least 300mm of grout measured from the top of drillhole shall be maintained in the outlet pipe during the first hour after completion of grout. Any settlement of the grout level inside the outlet pipe observed shall be replenished with fresh grout immediately.

(8) The set up of grouting plant and ancillary equipment shall be in such a manner that water, spillage of grout, dust, fumes and noise generated during the grouting operation shall be sufficiently diverted, controlled, suppressed and muffled.

(9) The volume of grout used for grouting each drillhole and the volume used for refilling each drillhole after grout settlement shall be recorded. A copy of the records shall be submitted to the Engineer not more than 3 days after each grouting operation. The records shall include all details as required in Clause 7.186(1)(a) to 7.186(1)(f) and the following:

(a) volume of grout spilled from the drillhole,

(b) volume of grout added to the outlet pipe after grout settlement.

(10) Any excessive grout loss shall be reported to the Engineer immediately. If a drillhole cannot be fully filled with grout after injecting a volume of grout equal to 10 times the calculated gross volume of the drillhole, discounting the volume of all cast-in components, the grouting operation shall immediately cease for that drillhole unless otherwise agreed by the Engineer. The grouted length of the drillhole shall be reported to the Engineer and proposals for completing the grouting for that drillhole shall be submitted to the Engineer for approval as soon as possible.

(11) Unless otherwise agreed by the Engineer, for soil nails with double corrosion protection the annular space between the wall of drillhole and corrugated sheathing shall be grouted first in a continuous operation. The annular space between corrugated sheathing and soil nail bars shall be grouted immediately afterwards in a continuous operation.

Pull-out tests for soil nails

7.144 Soil nails for pull-out tests shall be installed and tested prior to the installation of permanent soil nails. The number of pull-out tests shall be as shown on the Drawings or as instructed by the Engineer. Soil nails subjected to pull-out tests shall not form part of the permanent works. The details of the testing arrangement including the set-up and support for the testing apparatus shall be submitted for the Engineer's approval. The apparatus for measuring loads and deformations shall have an accuracy of 5 kN and 0.05 mm respectively. The apparatus for measuring deformation shall be capable of measuring a displacement of up to 50 mm. The apparatus shall be tested and calibrated by approved laboratories not more than 6 months prior to the date of carrying out the tests. Test and calibration certificates shall be submitted to the Engineer at least one week before the test. Drilling records of holes selected for pull-out tests shall be provided to the Engineer within 24 hours of drilling. The following procedure shall be adopted: -

(a) The loading apparatus shall be set up in such a way that no loading, other than the pull-out load, acts on the soil nail bars at the nail head. The reaction of the pull-out load from the loading apparatus shall act on a sufficiently sized rigid bearing plate placed against a temporary cut face at normal to the alignment of the soil nail bars to ensure adequate load spreading and to avoid eccentric loading. Monitoring instruments shall be carefully positioned and independently supported to record the extension of the soil nail bar and any movement of the steel bearing plate.

(b) The soil nail shall be grouted over the length as specified in the Drawings or as directed by the Engineer. The length to be grouted shall be isolated by means of a packer that can prevent grout from leaking through to the free-length section during grouting and that can ensure that the proposed bonded section is effectively grouted to the required length as shown in the Drawings. The entire free length of the soil nail bars shall be properly debonded or capped to ensure that the test load can be directly transferred to the bonded zone in case of grout leak through the packer. The pull-out test shall not be carried out until the grout has reached a cube strength of 21 MPa.

(c) The maximum test load shall be either 90% of the yield load of the soil nail bars of the test nail (T_p) or the ultimate soil/grout bond load (T_{ult}).

(d) The test nail shall be loaded in stages: from the initial load (T_a) via two intermediate test loads (T_{DL1} and T_{DL2}) to the maximum test load. T_{DL1} and T_{DL2} are the loads that result in the bonded zone tested to the design working bond strength and 2 times the working bond strength respectively. T_a shall not be greater than T_{DL1} or 5% of T_p. All loadings including T_a, T_{DL1}, T_{DL2} and T_p shall be specified in the Drawings or as directed by the Engineer.

(e) During the first two loading cycles, the intermediate loads, T_{DL1} and T_{DL2}, shall be maintained for 60 minutes for deformation measurement. After the measurement has been completed, the load shall be reduced to T_a and the residual deformation shall be recorded. In the last cycle, the test load shall be increased gradually from T_a straight to maximum test load and then maintained for deformation measurement. The measurement at each of the cycles shall be taken at time intervals of 1, 3, 6, 10, 20, 30, 40, 50 and 60 minutes. The test nail is considered to be able to sustain the test load if the difference of nail movements at 6 and 60 minutes does not exceed 2mm or 0.1 % of the grouted length of the test nail. In this case, the test shall proceed to the next loading cycle or be terminated if the test nail is subject to T_P.

(f) If the nail fails to sustain the test load T_{DL1}, T_{DL2} or T_p, the test shall be terminated and the nail movement against residual load with time shall be recorded. The measurements shall be taken at time intervals of 1, 3, 6, 10 and every 10 minutes thereafter over a period for at least two hours. Where required the measurements shall be continued and at intervals as directed by the Engineer.

(g) Throughout the test, the soil nail movement versus the applied load shall be measured, plotted on a graph and recorded along with all other relevant information. All the results shall be submitted to the Engineer within 3 days of completion of the test.

(h) Where required, the whole soil nail shall be pulled out from the drillhole for the Engineer's inspection. Where the soil nail bars remains in-situ after the pull-out test, the bar shall be cut-off flush with the finished ground and the remaining part of the drillhole grouted.

Soil-nail head 7.145 (1) Soil-nail heads shall be constructed in accordance with the details as specified in the Contract. A method statement for the construction of soil nail heads shall be submitted for the Engineer's agreement.

(2) The threads at the top end of soil nail bars shall be thoroughly cleaned, properly treated with galvanized coating or protected with approved zinc-rich

paint prior to construction of soil nail heads.

(3) Steel reinforcement for soil nail heads shall be of Grade 500B steel and comply with CS2 requirements. Concrete for soil nail heads shall be Grade 30/20 concrete or 30 MPa sprayed concrete and comply with GS Section 16 requirements.

(4) Concreting of soil-nail heads shall be carried out in a manner which ensures that the placed concrete is adequately compacted. Unless agreed otherwise by the Engineer, concreting of soil-nail heads using sprayed concrete shall be applied in two stages, allowing the bearing plate to be positioned firmly against the first stage concrete. The method statement as referred to in sub-clause (1) of this Clause shall include proposal for the construction sequence of 2-stage sprayed concrete soil nail heads. Trial runs shall also be conducted to demonstrate to the Engineer that the proposed method statement will produce satisfactory results and the rebound of sprayed concrete material is minimal.

(5) Any temporary excavation for constructing soil nail heads, including overbreaks shall be backfilled with Grade 30/20 concrete, 30 MPa sprayed concrete or other material as agreed by the Engineer.

(6) Where instructed by the Engineer, a maximum of 3 concreted soil-nail heads shall be uncovered from the batch of soil nail heads constructed on any one day at any site for examination of the quality of soil-nail heads. If defective workmanship is identified in any one of the uncovered soil-nail heads, the whole batch of soil nail heads constructed on the same day at that site shall be deemed to be defective. All the remaining soil nail heads constructed on the same day at that site shall be broken up for the Engineer's examination. The soil-nail heads shall be re-constructed and re-examined to the satisfaction of the Engineer.

MATS FOR SLOPE EROSION CONTROL

Preparation of surfaces 7.146 Areas to be applied with mats shall be cleared of all rubbish, debris and loose soils. All local irregular spots and areas shall be either trimmed or filled with compacted fill material or compacted soil cement to provide smooth surfaces unless otherwise specified by the Engineer. The finished slope surfaces shall be inspected by the Engineer prior to installation of mats.

Laying and fixing of mats for erosion control 7.147 Mats for erosion control shall be laid and fixed onto sloping ground in accordance with the manufacturers recommended procedures and in compliance with the following requirements:

(a) the mats except biodegradable types shall be anchored along the slope crest and each berm level with at least 200 mm length embedded into the ground or underneath the concrete berm slabs. The mats shall also be embedded at least 200 mm into any adjacent structures to be constructed. The mats shall be rolled out from top down the slope surfaces. Sufficient hot-dip galvanized anchorage pins at a maximum spacing of 1 m centre to centre shall be provided to ensure the mats are in complete and total contact with the ground at every place. In areas of irregularities due to exposed rocks or existing structures, additional anchorage pins shall be provided to prevent any gap or void forming underneath the mats. Lapping between mats shall be at least 150 mm and shall be formed with the upslope mat over the downslope mat. No lapping shall be formed within 1 m of any intersection of two slope surfaces which have a sharp difference in slope gradient or strike direction,

(b) the biodegradable erosion control mats shall be anchored along the crest of slope and each berm with at least 2 rows of bamboo sticks or wooden pegs at a maximum horizontal spacing of 550mm on 300mm length mat lapping. The mats shall be rolled out from top down the slope surfaces. Sufficient bamboo sticks or wooden pegs at a maximum spacing of 1 m centre to centre shall be provided to ensure the mats are in complete and total contact with the ground at every place,

(c) In areas of irregularities due to exposed rocks or existing structures, additional anchorage pins shall be provided to prevent any gap or void forming underneath the mats. Lapping between mats shall be at least 150 mm and shall be formed with the upslope mat over the downslope mat. No lapping shall be formed within 1 m of any intersection of two slope surfaces which have a sharp difference in slope gradient or strike direction,

(d) where recommended by the manufacturer of the mats for erosion control, on completion of laying and anchoring of the mats, soft soil shall be placed and tamped into the mats and all voids within the mats shall be completely filled to form an integral composite structure,

(e) the sequence of hydroseeding and laying of mats shall be in accordance with the manufacturer's recommended sequence. The protective materials for hydroseeding shall be laid on top of the erosion control mat, if specified.

TESTING: OPTIMUM MOISTURE CONTENT AND MAXIMUM DRY DENSITY OF SOIL-CEMENT FILL

Testing: Optimum moisture content and maximum dry density of soil-cement fill

7.148 The maximum dry density and optimum moisture content of soil-cement fill shall be as stated in Section 6 except that the method of testing shall be the Vibrating Hammer Test Method in accordance with BS 1924:Part 2.

TESTING: CONCRETE CORES FROM SPRAYED CONCRETE

Testing: test panels for sprayed concrete

7.149 (1) The strength of sprayed concrete shall be determined from concrete cores cut from a test panel constructed at the same time as sprayed concrete is applied.

(2) One test panel shall be constructed for each application in a day or as directed by the Engineer.

(3) The test panel shall be 250 mm thick and shall be at least 1 m x 1 m. The panel shall be constructed by spraying concrete into the mould at the same time as the concrete to be tested is applied. The test panel shall be cured by the same method as the sprayed concrete.

Samples: concrete cores from sprayed concrete

7.150 (1) Three concrete cores shall be provided from each test panel. Cores shall not be taken within 125 mm from the edges of the panel.

(2) Concrete cores shall be 100 mm diameter and shall be the full depth of the test panel.

(3) The method of taking concrete cores shall be in accordance with CS1.

Testing: concrete cores from sprayed concrete

7.151 (1) Each concrete core shall be tested to determine the compressive strength and density.

(2) The method of preparing and testing the cores to determine the compressive strength shall be in accordance with CS1. The method of testing the cores to determine the density shall be in accordance with CS1. Three concrete cores shall be tested at 28 days.

Compliance criteria: concrete cores from sprayed concrete

7.152 The results of tests for compressive strength of concrete cores shall be interpreted in accordance with CS1. Adjustments to the measured strength in respect of the age of the core when tested shall not be made unless permitted by the Engineer. The minimum compressive strength of concrete cores, converted to the estimated in-situ cube strength in accordance with CS1, shall be the specified grade strength at 28 days.

Non-compliance: concrete cores from sprayed concrete

7.153 If the result of any test for compressive strength or density of concrete cores from sprayed concrete does not comply with the specified requirements for the property, particulars of proposed changes to the materials, mix design, methods of production or methods of construction shall be submitted to the Engineer. Further trial mixes shall be made and further trial panels shall be constructed unless otherwise permitted by the Engineer.

TESTING: PACKER TESTS ON DRILLHOLES FOR ROCK BOLTS

Testing: Packer test

7.154 (1) The water loss from drillholes for rock bolts shall be determined by the Packer test. The number of drillholes to be tested shall be instructed by the Engineer.

(2) The Packer test shall be carried out on the bond length of the drillhole at a test pressure of 100 kPa. The method of testing shall be as stated in Clause 7.197.

Compliance criteria: Packer test 7.155 The water loss determined by the Packer test in the grouted hole shall not exceed 5 Lugeons when measured over a 10 minute period.

Non-compliance: Packer test 7.156 If the result of any Packer test on drillholes for rock bolts does not comply with the specified requirements for the test, the drillhole shall be grouted, re-drilled and retested. Grouting, re-drilling and retesting shall be continued until the result of the Packer test complies with the specified requirements for the test.

TESTING: ROCK BOLTS

Testing: rock bolts 7.157 Each installed rock bolt shall be tested to determine the loss in stress by applying a test load of 1.5 times the working load for 5 minutes.

Compliance criteria: rock bolts 7.158 The loss in stress in installed rock bolts shall not exceed 5% of the test load in 5 minutes.

Non-compliance: rock bolts 7.159 (1) If the result of any test for loss in stress of installed rock bolts does not comply with the specified requirements for the test, an additional test for loss of stress shall be carried out on the rock bolt.

(2) If the result of any additional test for loss of stress of installed rock bolts does not comply with the specified requirements for the test, the rock bolt shall be replaced.

TESTING: SOIL NAIL BARS AND CONNECTORS

Batch: soil nail bars and connectors 7.160 (1) For the purpose of testing, soil nail bars delivered to the Site is to be subdivided into batches in accordance with CS2 Cl.1.2.1.

(2) A batch of connectors is any quantity of connectors of the same type, size and grade, manufactured by the same mill, covered by the same mill and testing certificates and delivered to the Site at any one time. In addition, for a batch of galvanized soil nail bars, the coating shall have been applied at the same coating factory and shall be covered by the same original test certificates with original signatures and official authorization chop.

Sample: soil nail bars and connectors 7.161 (1) Samples of soil nail bars and connectors shall be provided from each batch of the materials delivered to the Site and at least 14 days before insertion of the soil nail starts. The number of samples to be provided from each batch shall be as stated in Table 7.1.

Table 7.1: Rate of sampling of soil nail bars and connectors

Description	Size of batch	No. of samples per batch
Soil nail bars	All size	1

Connectors	less than 100 no.	1
	100 – 500 no.	2
	Exceeding 500 no.	3

(2) The number of specimens in each sample shall be as follows:

Category	Number of specimens
Soil nail bars	In accordance with CS2 Table 10 for Class 2 steel
Thickness of galvanized coating for soil nail bars/connectors	In accordance with Table 1 of BS EN ISO 1461
Connectors for tension joint	3

(3) Each specimen of bar shall be at least 1m long. Each specimen of connectors shall consist of one connector joined to two lengths of bar each at least 500mm long. The bars shall be of the same type, size and grade as the bars to which the connector will be fixed in the permanent work.

(4) Each specimen of soil nail bars shall be taken from different bars in the batch. The ends of specimen shall be cut square before delivery to the laboratory.

Testing: soil nail bars and connectors 7.162

(1) Each sample of soil nail bars shall be tested in accordance with CS2 Cl. 5.1.1 except no test for bond property shall be carried out.

(2) Each specimen as required in Clause 7.161(2) of galvanized soil nail bars/connectors shall be tested to determine the thickness of coating in accordance with BS EN ISO 1461 for compliance.

(3) Each sample of connectors shall be tested to determine the tensile properties in accordance with Clause 7.164.

(4) The number of tests on each sample shall be as stated in Table 7.2.

Table 7.2: Number of tests on each sample of soil nail bars

Description	Type and number of tests				
	Tensile properties	Bend performance	Mass per metre	Chemical composition (product analysis)	Thickness and uniformity
Soil nail bars	In accordance with CS2 Cl. 5.1.1 for Class 2 Steel				-
Galvanized coating	-	-	-	-	In accordance with Table 2 of BS EN ISO 1461
Connectors	3	-	-	-	-

Compliance criteria: soil nail bars 7.163

If the results of the tests performed on the test specimens meet the requirements specified in CS2 Cl. 5.1.2, the batch shall be deemed to comply with the requirements.

Compliance criteria: connectors

7.164 The results of tensile properties tests on specimens of connectors shall comply with the following requirements:

(a) The tensile strength shall exceed 287.5 MPa for grade 250, 540 MPa for grade 500B and 575 MPa for grade 500C soil nail bars.

(b) When a test is made of a representative gauge length assembly comprising soil nail bars of the size, grade and profile to be used and a connector of the precise type to be used, the permanent elongation after loading to 0.6 times of the specified characteristic strength and unloading shall not exceed 0.1mm. The gauge length shall span over the connector.

Non-compliance: soil nail bars

7.165 If the result of any test fails, the acceptance of retests shall be considered in accordance with CS2 Cl. 5.1.4.

Non-compliance: galvanized coating

7.166 (1) If the result of any test for thickness of galvanized coating to soil nail bars or connectors does not comply with the specified requirements for the property, additional samples shall be provided from the same batch and additional tests for the property shall be carried out. The number of additional samples shall be as stated in Table 7.1.

(2) The number of specimens in each additional sample shall be as follows:

(i)	Galvanized soil nail bars	4
(ii)	Galvanized connectors	4

(3) The number of tests on each additional sample shall be four.

(4) The batch shall be considered as not complying with the specified requirements for the property if the result of any additional test does not comply with the specified requirements for the property.

Non-compliance: connectors

7.167 (1) If the result of any test for tensile properties of connectors does not comply with the specified requirements as stated in Clause 7.164, additional samples shall be provided from the same batch and additional tests as stated in Clause 7.164 shall be carried out. The number of additional samples shall be as stated in Table 7.1.

(2) The number of specimens in each additional sample shall be six.

(3) The number of tests on each additional sample shall be six.

(4) The batch shall be considered as not complying with the specified requirements for tensile properties if the result of any additional test does not comply with the specified requirements as stated in Clause 7.164.

PART 4: GROUTING FOR GEOTECHNICAL WORKS

GLOSSARY OF TERMS

Ground 7.168 Ground, for the purpose of grouting for geotechnical works, is fill material, soil and rock and the interfaces between fill material, soil and rock and any structures.

Grout 7.169 Grout, for the purpose of grouting for geotechnical works, is cement grout, cement-sand grout, cement-bentonite grout and proprietary grout approved by the Engineer. Sand shall be natural sand or crushed natural stone.

Grouting 7.170 Grouting, for the purpose of grouting for geotechnical works, is the mixing and injection of grout through predrilled or preformed holes.

Grouting stage 7.171 Grouting stage, for the purpose of grouting for geotechnical works, is the discrete length of drillhole into which grout is to be injected in a continuous operation.

Lugeon 7.172 Lugeon is a water loss of 1 litre per minute per metre length of hole tested at an effective pressure of 1 MPa.

MATERIALS

Materials for grout 7.173 Materials for grout shall comply with Section 16 except as stated in this Section.

Grout for geotechnical works 7.174 (1) Cement grout for geotechnical works consists of PC, PFA, sand and water. Admixtures shall not be used unless permitted by the Engineer. The use of PFA in cement grout shall follow the same requirements of PFA in concrete as specified in Section 16.

(2) Sand for grout shall be clean dry sand complying with BS 1200 and shall have a particle size distribution such that 100% passes a 2 mm BS test sieve and not more than 30% passes a 0.2 mm BS test sieve.

(3) Water for grout shall be clean fresh water having a temperature not exceeding 30°C or less than 5°C.

(4) Cement grout shall have a minimum crushing strength of 30 MPa at 28 days.

(5) The amount of bleeding of grout shall not exceed 0.5% by volume 3 hours after mixing or 1.0% maximum when measured at $23\pm1.7^{\circ}C$ in a covered glass or metal cylinder of 100 mm internal diameter and with a grout depth of approximately 100mm. In addition, the water shall be reabsorbed by the grout within 24 hours.

(6) The flow cone efflux time of grout shall not be less than 15 seconds.

Standpipes 7.175 Unless otherwise approved by the Engineer standpipes for grouting shall be standard black metal pipe complying with BS 1387. With the permission of the Engineer, non-metallic grout pipe may be used for grouting rock dowels, rock bolts and soil nails. Where metal standpipes are used for grouting rock dowels, rock bolts and soil nails, they shall be extracted from drillholes as grouting proceeds.

Particulars of grouting for geotechnical works 7.176 (1) The following particulars of the proposed materials and methods of construction for grouting for geotechnical works shall be submitted to the Engineer:

(a) Details of drilling, grouting and testing equipment,

(b) Details of grout mix, including admixtures,

(c) Methods of storing, mixing and injecting grout,

(d) Methods of drilling, cleaning, capping and sealing grout holes,

(e) Methods of grouting, including grouting stages, order of working and regrouting methods,

(f) Methods of controlling surface water, groundwater, grout leakage and ground movement, including methods of containing overflowing grout, grout spill, monitoring and instrumentation, and

(g) Safety and hazard risk control measures, including bursting of high pressure grout pipes.

(2) The particulars shall be submitted to the Engineer for approval at least 28 days before grouting starts.

Trials for grouting 7.177 Unless otherwise permitted by the Engineer a grouting trial shall be carried out. The extent and depth of holes for grouting trials and the tests to be carried out shall be as stated in the Contract.

DRILLING FOR GROUTING FOR GEOTECHNICAL WORKS

Drilling for grouting for geotechnical works 7.178 (1) Holes in rock for grouting for geotechnical works shall be drilled using rotary or percussion type drills. The tolerance for the holes shall be as stated in Clause 7.45(1) and (2) except that for drillholes of soil nails shall be as stated in Clause 7.142(6). Grease and other lubricants shall not be used in the flushing medium or on the rods, except around the threads at the ends of the rods. Drilling methods that result in drill cuttings causing blockages such that grouting cannot be performed satisfactorily shall not be used.

(2) The set-up of drilling plant and ancillary equipment shall be in such a manner that water, dust, fumes and noise generated in the course of drilling and grouting operation shall be sufficiently diverted, controlled, suppressed and muffled. The flushing medium for drilling shall be clean water or air as agreed by the Engineer.

(3) The minimum size of hole for grouting in rock shall be 40 mm.

(4) Holes in soil for grouting for geotechnical works shall be drilled by a method which is suitable to the ground conditions and which is approved by the Engineer.

(5) The location of all underground obstructions and utilities shall be determined by the Contractor before drilling starts and the drilling pattern shall take account of the location of obstructions and utilities.

(6) Casings required to prevent the collapse of grout holes shall be as stated in Clause 7.44. Casings shall be removed immediately before or simultaneously with the grouting or sleeve grouting operation in such a manner that the grout hole will not collapse and the injection of grout will not be hindered.

(7) Grout holes shall be flushed clean with water or compressed air introduced at the bottom of the hole after drilling is complete. The holes shall be protected with capping pipes or standpipes to prevent subsequent collapse or clogging after flushing.

(8) Grout holes that have been drilled more than one day before grouting of the hole starts shall be reflushed with water or compressed air immediately before grouting is commenced and excess flushing water shall be removed by air jet. Holes drilled in soft ground or in ground other than rock and in which sleeve grouts are proposed as part of the grouting operation shall be sleeve grouted as soon as practicable after drilling.

Standpipes and capping pipes 7.179

(1) Unless otherwise permitted by the Engineer, grout holes shall be capped after drilling and before grouting. Capping shall be by a suitably sealed grout connection, standpipe, packer or other methods agreed by the Engineer. The cap shall seal the hole to prevent contamination or clogging of the hole until grouting operations start.

(2) Standpipes, if stated in the Contract, shall be installed in holes after drilling. The pipe shall be sealed into the hole using cement grout consisting of PC and water in the proportions 1:1 by volume.

GROUTING FOR GEOTECHNICAL WORKS

Monitoring of grouting operations 7.180

(1) Instrumentation shall be installed to monitor heave, bulging, settlement, lateral movement, deformation or fracturing of the ground or structures due to grouting operations. Records of monitoring shall be kept by the Contractor on the Site and a copy provided for the Engineer. Arrangements for installing instruments and taking measurements inside and outside the Site shall be made by the Contractor.

(2) The accuracy of the instruments shall be checked before grouting starts and at regular intervals agreed by the Engineer.

Grouting equipment 7.181

(1) Grouting equipment for geotechnical works shall be a type, quantity and size suitable for the grouting required. The equipment shall be kept clean and in good working order.

(2) Standby grouting equipment shall be available at all times and shall be

capable of being brought into operation immediately in the event of breakdowns during grouting operations.

(3) Grout mixers shall be high-speed colloidal mixers having a rotor speed of at least 1000 r/min and capable of producing a colloidal grout mix. Mixers shall be fitted with a water volume-measuring device for batching purposes.

(4) Holding tanks shall be fitted with an agitator to provide continuous agitation of the grout at 100 r/min. The tank shall be fitted with a dipstick to allow continuous measurement of the volume of grout in the tank. A 2.36mm removable screen shall be provided between the tank and the pump or grout lines.

(5) Grout pumps shall be a positive displacement type. Pumps shall be fitted with bypass valves to allow a standby pump to be brought into operation.

(6) Working pressure gauges shall be accurate to within 3% and shall be calibrated against a test gauge before grouting starts and at weekly intervals. A test gauge with accompanying calibration certificates shall be kept on the Site for the purpose of calibrating working gauges. Working gauges shall be numbered and a record shall be kept of gauge number, shifts worked, calibration dates and repairs undertaken. Records shall be kept on the Site and shall be available for inspection by the Engineer at all times.

(7) Packers shall be such that they seal holes in rock at the specified level and shall be capable of withstanding the maximum grout or water pressure to be used at that level without leakage. Packers may be of the mechanical or inflatable rubber type. A sufficient number of packers of a size to suit the holes shall be available on the Site.

Mixing grout 7.182

(1) Grout for geotechnical works shall be mixed by volume or batched by mass as agreed by the Engineer. The mix proportions may be adjusted if approved by the Engineer depending on the results of the trial grouting, water tests in the hole or the results of previously grouted holes.

(2) Grout shall be mixed by adding approximately two-thirds of the cement to the water adding any admixture and adding the remaining one-third of cement. Other mixing procedures shall not be used unless permitted by the Engineer.

(3) The time for which grout shall be mixed in high speed mixers shall be suitable for the type of mixer used. Grout shall be continuously agitated in a holding tank after mixing and shall be screened before being circulated in the grout lines. Mixed grout shall be continuously circulated in such a manner that grout which is not taken in a hole can be returned to the holding tank.

(4) Grout to which a retarding agent has not been added, and which is not used within 30 minutes of mixing, shall not be used for grouting.

Pressure grouting 7.183

(1) Holes in rock shall be grouted in grouting stages not exceeding 3 m. Grouting may be carried out in either an upstage or a downstage sequence.

(2) Ground other than rock shall be grouted in such a manner that grout can be injected at various points along the grout hole in a multi-stage operation. The grouting method shall employ perforated pipes with rubber sleeve valves unless otherwise permitted by the Engineer.

(3) Grouting pressures shall initially be 100 kPa per 4-metre depth of hole and shall not exceed the overburden pressure unless permitted by the Engineer.

(4) Holes shall be grouted in a continuous operation at the grouting stages and pressures stated in the Contract. Unless otherwise permitted by the Engineer grouting shall be carried out by injecting the grout under pressure into each grouting stage of the hole until the grouting stage refuses to take further grout.

(5) If in the opinion of the Engineer grouting of any hole or grouting stage has not been completed due to excessive grout takes, low pressures, excessive leakage or other causes, the hole shall be redrilled or flushed out with water and re-injected with grout.

Loss or leakage of grout

7.184 (1) If during the grouting of any hole, grout is found to flow from adjacent grout holes in quantities, which in the opinion of the Engineer are sufficient to interfere seriously with the grouting operation or to cause appreciable loss of grout, the holes shall be temporarily capped. If in the opinion of the Engineer capping is not essential, ungrouted holes shall be left open to allow air and water to escape.

(2) If during the grouting of any hole grout is found to flow from joints in the geological formation at the Site or any other location, the leaks shall be plugged or caulked in a manner agreed by the Engineer.

(3) If during the grouting of any hole the grout-take increases suddenly by a significant amount, the Engineer shall be informed immediately.

Making good holes

7.185 (1) Grout holes through concrete shall be made good using concrete agreed by the Engineer. The concrete shall be firmly compacted and shall be finished to match the adjacent surface.

(2) Uncapped holes in rock shall be topped up after grouting using cement grout consisting of PC and water in the proportions 1:1 by volume, or 1:3 cement sand mortar.

Records of grouting for geotechnical works

7.186 (1) Records of grouting for geotechnical works shall be kept by the Contractor on the Site and shall be available for inspection by the Engineer at all times. Records shall include the following details:

(a) Hole location and reference number,

(b) Depth of hole,

(c) Type of grout and grout mix proportions,

(d) Volume of grout injected,

(e) Grouting pressures, and

(f) Times and details of any interruptions, leakages and equipment malfunctions.

(2) A record of grouting for each hole shall be submitted to the Engineer within 24 hours of completion of grouting of the hole. The record shall contain the following details:

(a) Hole location and reference number,

(b) Grouting stage numbers and lengths,

(c) Collar level and hole inclination,

(d) Details of grout injections including the information stated in Clause 7.186(1), and

(e) Details of the grouting procedure, including any stoppages, leaks to other holes, surface leaks and ground movement.

(3) A record of the testing for each hole, including test results, shall be submitted to the Engineer within 24 hours of completion of testing of a hole. Records of Packer tests shall contain the following details:

(a) Hole location and reference number,

(b) Depth of packer in the hole,

(c) Date and time of test,

(d) Type of gauge or meter and identifying reference number,

(e) Test readings for each 5 minute period,

(f) Calculated test results in Lugeons, and

(g) Details of any equipment malfunctions, sudden water losses or blockages, surface leakage or other variations in test procedure.

(4) A report of grouting for each part of the Works as stated in the Contract, including record drawings and logs of holes, shall be submitted to the Engineer within one week of completion and testing of grouting for that part of the Works. The form of records, logs and record drawings shall be as agreed by the Engineer.

TESTING: GROUT - GENERAL REQUIREMENTS

Batch: grout for geotechnical works 7.187 A batch of grout for geotechnical works is any quantity of grout used for grouting geotechnical works in one continuous operation in one day.

TESTING: GROUT - BLEEDING

Samples: bleeding of grout 7.188 (1) One sample of grout shall be provided from each batch of grout for geotechnical works to determine the amount of bleeding of the grout.

(2) Samples shall be provided not more than 30 minutes after the grout has been mixed and shall be protected from moisture content changes before the tests for amount of bleeding are carried out.

Testing: bleeding of grout 7.189 (1) Each sample of grout taken as stated in Clause 7.188 shall be divided into three specimens. Each specimen shall be tested to determine the amount of bleeding.

(2) Grout for geotechnical works shall be tested for bleeding in accordance with ASTM C940. Bleeding tests shall be completed immediately prior to each application in a day or as directed by the Engineer.

Non-compliance: bleeding of grout 7.190 If the result of any test for amount of bleeding of grout for geotechnical works does not comply with the specified requirements for amount of bleeding, particulars of proposed changes to the materials, grout mix or methods of production shall be submitted to the Engineer. Further grouting trials shall be carried out unless otherwise permitted by the Engineer.

TESTING: GROUT - FLOW CONE EFFLUX TIME

Samples: flow cone efflux time of grout 7.191 One sample of grout shall be provided from each batch of grout for geotechnical works to determine the flow cone efflux time of the grout.

Testing: flow cone efflux time of grout 7.192 Each sample of grout taken as stated in Clause 7.191 shall be tested to determine the flow cone efflux time. The method of testing shall be in accordance with ASTM C939 / C939M-16a.

Non-compliance: flow cone efflux time of grout 7.193 If the result of any test for flow cone efflux time of grout does not comply with the specified requirements for flow cone efflux time, particulars of proposed changes to the materials, grout mix or methods of production shall be submitted to the Engineer. Further grouting trials shall be carried out unless otherwise permitted by the Engineer.

TESTING: GROUT - CRUSHING STRENGTH

Samples: crushing strength of grout 7.194 (1) One sample of grout shall be provided from each batch of grout for geotechnical works to determine the crushing strength of the grout.

(2) Samples shall be provided not more than one hour after the grout has been mixed and shall be protected from moisture content changes before test cubes are made.

Testing: crushing strength of grout 7.195 (1) Nine 100 mm test cubes shall be made from each sample of grout taken as stated in Clause 7.194. Three test cubes shall be tested to determine the crushing strength at 3 days, three test cubes shall be tested to determine the crushing strength at 7 days and three test cubes shall be tested to determine the crushing strength at 28 days. For permanent soil nails and rock dowels, the test cubes for determining the crushing strength at 3 days and 7 days can be omitted.

(2) The method of making, curing and testing the test cubes shall be to specification as stated in Section 16.

Non-compliance: crushing strength of grout 7.196 If the result of any test for crushing strength of grout for geotechnical works does not comply with the specified requirements for grout, particulars of proposed changes to the materials, grout mix or method of production shall be submitted to the Engineer. Further trial mixes shall be made and further grouting trials shall be carried out unless otherwise permitted by the Engineer.

TESTING: PACKER TESTS ON DRILLHOLES FOR GROUTING AND GROUTED DRILLHOLES

Testing: Packer tests

7.197 (1) The water loss from drillholes for grouting and from grouted and regrouted drillholes shall be determined by the Packer test.

(2) The number of drillholes for grouting to be tested to determine the water loss shall be as instructed by the Engineer.

(3) Every grouted drillhole and every regrouted drillhole shall be tested to determine the water loss.

(4) Packer tests shall be carried out in accordance with BS EN ISO 22282-3 and Clause 7.197 (5) to (8)

(5) Tests shall be carried out using clean water, in grouting stages not exceeding 3 m in length. The rate of flow of water in the test shall be determined to an accuracy of 10% for flows exceeding 1 L/min.

(6) The test pressure shall be equal to the overburden pressure and shall not exceed the specified maximum grouting pressure for the grouting stage being tested.

(7) The test shall be carried out between a packer and the base of the hole for grouting stages at the base of a hole and shall be carried out between two packers in other cases.

(8) The test shall be carried out by pumping water at the specified pressure into the grouting stage being tested and measuring with a volume meter the water loss over three consecutive 10 minute periods. The result shall be calculated in Lugeons for each 10 minute period.

Compliance criteria: Packer tests

7.198 The water loss determined by the Packer test in the grouted hole shall not exceed 5 Lugeons when measured over a 10-minute period.

Non-compliance: Packer test on drillholes for grouting

7.199 If the result of any Packer test on drillholes for grouting does not comply with the specified requirements for the test, the drillhole shall be grouted, re-drilled and retested. Grouting, re-drilling and retesting shall continue until the result of the Packer test complies with the specified requirements for the test.

Non-compliance: Packer test on grouted and regrouted drillholes

7.200 If the result of any Packer test on grouted drillholes or regrouted drillholes does not comply with the specified requirements for the test, the grout shall be removed and the drillhole shall be regrouted and retested. Removal of grout, regrouting and retesting shall continue until the result of the Packer test complies with the specified requirements for the test.

PART 5: GROUNDWATER DRAINAGE AND CONTROL

GLOSSARY OF TERMS

Caisson drain 7.201 Caisson drain is an excavated vertical shaft, with or without raking drains, to provide drainage by intercepting and lowering the groundwater level in the vicinity.

Geotextile filter 7.202 Geotextile filter is a permeable sheet of synthetic material used like a granular filter for filtration and in-plane drainage.

Filter pipe 7.203 Filter pipe is a perforated or non-perforated pipe used for draining groundwater.

Granular filter 7.204 Granular filter is a graded sand or gravel placed against a soil to prevent the migration of fine particles out of the soil caused by water flow, and graded such that free discharge of water flowing into the filter is allowed. Sand shall be natural sand or crushed natural stone.

Prefabricated band drain 7.205 Prefabricated band drain is a synthetic drain which, when installed in a soil strata, acts as a drainage medium for dissipation of pore water pressure.

Raking drain 7.206 Raking drain is a drillhole, with or without perforated filter pipes and geotextile filter sheath, installed generally at an upward inclination for groundwater lowering by gravity flow.

Relief drain 7.207 Relief drain is a synthetic drain installed on slope surfaces or in excavations to divert water seepage before applying sprayed concrete, masonry dentition or other construction.

Trench drain 7.208 Trench drain is a trench wholly or partly filled with granular material or clean crushed rock, with or without filter pipes and geotextile filter.

MATERIALS

Granular filter material 7.209 (1) Granular filter material for granular filter, trench drains and caisson drains shall consist of durable, inert, natural material free of clay, organic material and other impurities.

(2) Granular filter material shall have the particle size distribution stated in the Contract.

Geotextile filter 7.210 Geotextile filter shall be a proprietary type approved by the Engineer and shall have the properties stated in the Contract.

Filter pipes 7.211 (1) Filter pipes shall comply with the following:

Precast concrete pipes	:	BS 5911:Part 1 and BS EN 1916
Vitrified clay pipes	:	BS EN 295
DI pipes	:	BS EN 545

Steel pipes	:	BS EN 10224
Perforated concrete pipes	:	BS 5911:Part 1 and BS EN 1916
uPVC pipes	:	BS EN 1401-1 (Fittings also refer to BS 4660 and BS EN 13598-1) or BS 3506
Corrugated polyethylene tubing	:	AASHTO M252-18

(2) Class O UPVC pipes shall not be used.

(3) The perforations in perforated pipes shall be cleanly cut and shall be uniformly spaced along the length and circumference of the pipe.

(4) UPVC plastic pipes shall be jointed by couplers.

Raking drains 7.212 (1) Type O raking drains shall be unlined raking drains. Drain holes shall be at least 40 mm diameter.

(2) Type 1 raking drains shall be single pipe raking drains consisting of a single perforated pipe with a non-perforated invert.

(3) Type 2 raking drains shall be single pipe raking drains consisting of a single perforated pipe with a non-perforated invert and enclosed within a geotextile filter sheath.

(4) Type 3 raking drains shall be double pipe raking drains consisting of an outer permanent pipe and an inner removable pipe enclosed within a geotextile filter sheath. The outer and inner pipes shall be perforated pipes with a non-perforated invert.

(5) Pipes for raking drains shall be perforated pipes with non-perforated invert as approved by the Engineer. The portion of openings in the perforated pipe shall cover between approximately two-thirds 50% and 70% of the circumference of the pipe. The percentage of opening areas to overall surface area of the pipe shall not be less than 14% for 40 mm diameter pipe, nor less than 8% for 65 mm or above diameter pipe. The pipe material shall have the following physical properties or having equivalent functions:

(a) Material: non-metallic

(b) Minimum tensile strength: <u>21,300 kN/m^2</u>

(c) Minimum compressive strength: <u>22,000 kN/m^2</u>

(d) Minimum flexural strength: <u>6,800 kN/m^2</u>

(6) Couplers for filter pipes shall also have non-perforated invert and shall be of similar strength and durability of the pipe materials. The lapped length of coupler and each end of the filter pipes shall be at least 100 mm. The elongation at the pipe connection shall be less than 5 mm under a 45 kg pulling force.

(7) Geotextile filter sheaths for raking drains shall be formed of non-woven

geotextile filter robust enough to prevent tearing and shall have the following physical properties or materials having equivalent functions or performance as approved by the Engineer:

(a) Material: non-metallic

(b) Minimum tensile strength: 17 kN/m

(c) Apparent opening size: 140 µm

(d) Coefficient of permeability under 2 kN/m^2: 5×10^{-3} m/s

(e) Flow rate at 100 mm head under 2 kN/m^2: 195 L/m^{2}s

(8) Tying wires for jointing pipes and stitching filter sheath shall be non-metallic wires of minimum breaking load 400 N or equivalent as approved by the Engineer.

Relief drains 7.213 Relief drains shall be drain mats with multi-layer porous fabric wrapped in filter fabric and covered with an impermeable fabric or products having equivalent functions or performance as approved by the Engineer. PVC flanges for connecting relief drains to outlet pipes shall be directed by the Engineer.

Fill material for trench drains 7.214 (1) Fill material to be used with geotextile filter in trench drains shall be clean crushed rock. Type A and Type B fill material shall have the particle size distributions stated in Table 7.3.

(2) Fill material passing a 425µm BS test sieve shall be non-plastic.

(3) The D15 particle size of Type A fill material for use with perforated pipes shall be at least 15% larger than twice the maximum dimension of the perforations, where D15 is the equivalent sieve size in millimetres, interpolated from the particle size distribution curve, through which 15% of the fill material would pass.

Table 7.3: Particle size distribution of fill material for trench drains

Type of fill material	**Percentage by mass passing BS test sieve**						
	63 mm	37.5 mm	20 mm	10 mm	3.35mm	600 µm	63 µm
Type A	-	100	-	45-100	25-80	8-25	0-5
Type B	100	85-100	0-20	0-5	-	-	-

Caisson liners 7.215 Caisson liners shall be concrete tapered rings at least 100 mm thick and not exceeding 1 m deep. The liners shall be constructed with well-compacted concrete of Grade 20/20 or greater.

Prefabricated band drains 7.216 (1) Prefabricated band drains shall consist of a core and a filter. The drains may be manufactured as a single unit or the filter may be wrapped around the core, and overlapped and sealed to contain the core. The drains shall be made from chemically treated paper, polyethylene, polyester, polyolefine or other synthetic material or combination of such materials.

(2) Prefabricated band drains shall be provided with an outer casing or mandrel of rhomboidal or rectangular cross section for use during installation. The drains shall also be provided with an anchor to ensure embedment of the drain during extraction of the mandrel.

(3) The strength of the materials in prefabricated band drains shall be such that the drains will withstand all forces resulting from handling and installation.

(4) The filter jacket for prefabricated band drains shall be a type which:

(a) Has been previously proved effective under similar soil and pressure conditions,

(b) Is in all cases able to prevent excessive migration of soil particles into the core, and

(c) Has a permeability not less than that of the surrounding soil.

(5) Prefabricated band drains shall be able to conform to soil deformation without buckling or crimping of the core.

SUBMISSIONS

Particulars of granular filters 7.217 (1) The following particulars of the proposed materials and methods of construction for granular filters shall be submitted to the Engineer:

(a) Whether granular filter material is to be supplied ready mixed or is to be mixed on the Site,

(b) Source of supply, including name of supplier of ready mixed material,

(c) Quantity of each constituent if the material is to be mixed on the Site,

(d) Construction Plant and methods of mixing for material mixed on the Site,

(e) Method of storage and location of storage areas on the Site,

(f) Methods of deposition and compaction of material, and

(g) Results of three tests for particle size distribution of the fill material against which the granular filter is to be placed.

(h) Details of filter design including calculations and grading envelopes.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before deposition of granular filter material starts.

Particulars of geotextile 7.218 (1) The following particulars of the proposed materials and methods of

filter

construction for geotextile filter shall be submitted to the Engineer:

(a) Manufacturer’s name and source of supply,

(b) Details of geotextile filter including manufacturer's literature,

(c) A certificate for the geotextile filter showing the manufacturer's name, the date and place of manufacture and showing that the geotextile filter complies with the requirements stated in the Contract, and including results of tests stated in the Contract,

(d) Calculations showing that the geotextile filter complies with the filtration characteristics stated in the Contract,

(e) Details of previous uses of the geotextile filter.

(f) Details of quantities to be supplied in each delivery,

(g) Method of storage,

(h) Methods of cutting and jointing geotextile filter,

(i) Method of repairing small batches, and

(j) Methods of laying and holding in position.

(2) The particulars, including certificates, shall be submitted to the Engineer for approval at least 28 days before the first delivery of the geotextile filter to the Site. Certificates shall be submitted for each batch of geotextile filter delivered to the Site.

Particulars of trench drains

7.219 (1) The following particulars of the proposed materials and methods of construction for trench drains shall be submitted to the Engineer:

(a) Method of excavation of trench and installation of geotextile filter,

(b) Details of granular fill material as stated in Clause 7.214, and

(c) Details of geotextile filter as stated in Clause 7.218.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before installation of trench drains starts.

Particulars of raking drains

7.220 (1) The following particulars of the proposed materials and methods of construction for raking drains shall be submitted to the Engineer:

(a) Method of connecting adjacent sections of pipes,

(b) Proportions of sealant mix, and

(c) Details of geotextile filter sheath.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before installation of raking drains starts.

Particulars of relief

7.221 (1) The following particulars of the proposed materials and methods of

drains construction for relief drains shall be submitted to the Engineer:

(a) Details of relief drains and outlets, and

(b) Method of fixing relief drains to the slope face.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before fixing of relief drains starts.

Particulars of caisson drains

7.222 (1) The following particulars of the proposed materials and methods of construction for caisson drains shall be submitted to the Engineer:

(a) Methods of excavation and installation and removal of caisson liners,

(b) Method of compaction of fill material,

(c) Details of granular filter material as stated in Clause 7.217, and

(d) Details of geotextile filter as stated in Clause 7.218.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before construction of caisson drains starts.

Particulars of prefabricated band drains

7.223 (1) The following particulars of the proposed materials and methods of construction for prefabricated band drains shall be submitted to the Engineer:

(a) Details of type of drain, including manufacturer's literature,

(b) A certificate showing the manufacturer's name, the date and place of manufacture and showing that the drains comply with the requirements stated in the Contract,

(c) Details of previous installations by the Contractor using similar drains,

d) Method of installation, and

(e) Details of installation mandrel, drain anchor, method of penetration and method of recording depth of installation.

(2) The particulars shall be submitted to the Engineer for approval at least 28 days before installation of prefabricated band drains starts.

Particulars of filter pipes

7.224 (1) The following particulars of the proposed materials and methods of construction for filter pipes shall be submitted to the Engineer:

(a) Details of type of pipes, including manufacturer's literature,

(b) A certificate showing the manufacturer's name, the date and place of manufacture and showing that the pipes comply with the requirements stated in the Contract,

(c) Details of previous installations by the Contractor using similar pipes, and

(d) Method of installation.

(2) The particulars shall be submitted to the Engineer for approval at least 28 days before installation of the filter pipes starts.

Particulars of groundwater control, drawdown and monitoring 7.225 (1) The following particulars of the proposed materials and methods of construction for groundwater control, drawdown and monitoring shall be submitted to the Engineer:

(a) Construction Plant and materials for dewatering,

(b) Timing and sequence of dewatering operations,

(c) Details of silt traps,

(d) Methods of monitoring flow rates and volumes of silt, including monitoring intervals, and

(e) Methods and locations for discharging groundwater.

(2) The particulars shall be submitted to the Engineer for information at least 14 days before the relevant work starts.

Samples of materials 7.226 Samples of the following proposed materials shall be submitted to the Engineer for approval of the source and type of each material at the same time as particulars of the material are submitted:

(a) Granular filter material,

(b) Geotextile filter and two pieces of geotextile filter joined in accordance with the manufacturer's recommendations for each type of joint, and

(c) Relief drains.

HANDLING, DELIVERY AND STORAGE OF MATERIALS

Handling and storage of granular filter material 7.227 (1) Granular filter material shall not be handled or stored in a manner which will result in mixing of the different types and sizes or in segregation, contamination, deterioration or erosion of the material.

(2) Stockpiles of granular filter material shall be placed on well-drained, prepared areas and shall be separated by dividing walls of sufficient height to keep the different materials separate.

Delivery and storage of geotextile filter 7.228 (1) Geotextile filter shall be delivered in secure wrappings to ensure that the geotextile filter is dry and protected from damage, contamination and exposure to conditions that may adversely affect it.

(2) Geotextile filter shall be stored on a level surface and shall be kept in a secure and dry condition, which will not result in damage to the fabric or in contamination of the fabric.

Storage of filter pipes 7.229 Coils of plastic tubing for filter pipes shall be stored flat.

Delivery and storage of prefabricated band drains 7.230 (1) Prefabricated band drains shall be supplied in rolls, securely packed in lightproof wrappings.

(2) Prefabricated band drains shall be stored in a clean, dry environment.

GRANULAR FILTERS

Mixing granular filter material 7.231 Granular filter material shall be thoroughly mixed by the method approved by the Engineer. Material that has been stockpiled shall be remixed before deposition.

Deposition and compaction of granular filter material 7.232 (1) Granular filter material shall be deposited and compacted as stated in Section 6.

(2) Granular filter material shall be deposited in a manner which will not result in segregation or contamination of the material.

(3) Granular filter material shall be deposited in such a manner that a continuous free draining zone is formed. The surface of each layer shall be cleaned and scarified before the next layer is deposited unless otherwise permitted by the Engineer.

GEOTEXTILE FILTER

Damage to geotextile filter 7.233 (1) The total period for which geotextile filter is exposed to daylight or other sources of ultra-violet radiation during handling, delivery, storage and installation shall not exceed 7 days.

(2) Geotextile filter that has been damaged or exposed to daylight or other sources of ultra-violet radiation for longer than the period stated in Clause 7.233(1) shall not be used in the permanent work unless permitted by the Engineer.

(3) Repairs to geotextile filter that has been torn or damaged during installation shall be carried out using a patch of the same material extending at least 300 mm beyond the edge of the damaged area. Repairs shall not be carried out on geotextile filter that has been damaged during storage or storage before installation.

Laying geotextile filter 7.234 (1) Geotextile filter shall be installed in such a manner that the individual yarns, webs or layers of the fabric retain their intended orientation and relative positions with respect to each another.

(2) Geotextile filter shall be installed, cut and jointed in accordance with the manufacturer's recommendations.

(3) Laps in sheets of fabric reinforcement that are not stated in the Contract to be jointed shall be at least 300 mm.

Protection of geotextile filter 7.235 Construction plant and other vehicles shall not operate on installed geotextile filter unless in the opinion of the Engineer it is adequately protected by a cover of fill material or other means agreed by the Engineer.

Records of geotextile filter

7.236 Records of installation of geotextile filter shall be kept by the Contractor on the Site and a copy shall be submitted to the Engineer each day. Records shall contain the following details:

(a) Identification of structures and sections of work where geotextile filter is installed,

(b) Type of geotextile filter, including identification of batch,

(c) Date of first exposure of geotextile filter to ultra-violet radiation before installation,

(d) Type of joint, amount of overlap, method of holding in place and any repairs to geotextile filter carried out during installation,

(e) Date of installation of geotextile filter, and

(f) Date of final covering of geotextile filter.

RAKING DRAINS

Installation of raking drains

7.237 (1) The length of raking drains assembled before installation shall not exceed 12.5 m. Connections between adjacent pipes shall be secured in such a manner that the cumulative longitudinal extension of a 12.5 m assembled length of pipe does not exceed 5 mm when pulled by hand.

(2) Pipes for Type 2 and Type 3 raking drains are to be wrapped in geotextile filter sheath in the following manner prior to installation in order to ensure that the overlap and stitching shall be at the non-perforated invert of the pipe. The pipe shall be placed onto and along the centre of a strip of geotextile filter with the non-perforated invert at the top. The strip of geotextile filter shall be of sufficient width to allow an overlap of at least 50 mm, and shall be drawn around the pipe and stitched together tightly with non-metallic wires. The stitching shall be tied off onto the pipe and the fabric at every 300 mm to prevent dislocation during installation. The filter sheath shall be marked to ensure that the non-perforated invert is correctly positioned during installation.

(3) During delivery and installation of raking drains, care must be taken to ensure that the pipe and geotextile filter sheath are not damaged. The method of installing the raking drains shall be submitted to the Engineer for approval prior to installation.

(4) Before installation of drain pipes, the drillholes shall be checked for cleanliness. Whenever any obstruction is encountered inside a drillhole during pipe insertion, the pipe shall be withdrawn and the obstruction shall be cleared before re-insertion. No jacking or hammering of pipes shall be carried out during the whole process of pipe insertion.

Drilling for raking drains

7.238 (1) Drilling lubricants other than clean air or fresh water shall not be used for drilling holes for raking drains. Casings shall be used to prevent collapse of the hole and to permit unobstructed insertion of the pipes and geotextile filter sheath.

(2) The drillhole entry point shall be positioned within a tolerance of ±75

mm. Deviation in alignment shall not exceed 1 in 20. Deviation from straight shall not exceed 20 mm in any 3 m length of drillhole. A positive gradient shall be maintained throughout the complete length of the hole. The inclination of holes shall be measured by a method agreed by the Engineer.

(3) Drilling and sampling for undisturbed soil samples and rock cores instructed by the Engineer to be recovered from drillholes shall be as stated in Clauses 7.43 to 7.67.

(4) Drillholes shall be temporarily plugged or otherwise protected to prevent entry of deleterious material after drilling.

Records of drillholes for raking drains

7.239 Records of drillholes for raking drains shall be kept by the Contractor on the Site and a drillhole log for each drillhole shall be submitted to the Engineer before installation of the raking drain starts. The borehole log shall contain the following details:

(a) Drain reference number,

(b) Location, inclination, bearings, diameter and length of hole,

(c) Details of drilling progress,

(d) Details of water seepage related to drilling progress, and

(e) Details of samples taken.

TRENCH DRAINS

Excavation for trench drains

7.240 The width of trench drains shall be at least 450 mm. The width of trench drains with filter pipes not exceeding 150 mm diameter shall be at least four times the nominal diameter of the pipe. The width of trench drains for pipes exceeding 150 mm diameter shall be at least the same as the external diameter of the pipe plus 450 mm.

Geotextile filter surround for trench drains

7.241 Geotextile filter surround for trench drains shall be installed as stated in Clause 7.234.

Bed for trench drains

7.242 (1) Concrete bed for filter pipes in trench drains shall be at least 75 mm thick and shall be Grade 20/20 concrete.

(2) Granular bed for filter pipes for trench drains shall have a thickness at least the same as the diameter of the pipe or 150 mm, whichever is greater.

Deposition and compaction of fill material for trench drains

7.243 (1) The material for granular bed for trench drains shall be deposited in the trench in layers not exceeding 150 mm thick and for the complete width of the trench. Each layer shall be compacted with six passes of a plate vibrator or by other methods agreed by the Engineer.

(2) Fill material around filter pipes in trench drains shall be deposited and compacted as stated in Section 6. The permission of the Engineer shall be obtained before fill material is deposited around filter pipes.

RELIEF DRAINS

Trials for relief drains 7.244 A trial length of relief drains of at least 2 m shall be constructed.

Fixing relief drains 7.245 Relief drains shall be fixed in position before surface protection or remedial measures are applied. Fixing shall be carried out in a manner that will not affect the serviceability of the relief drains or outlets. Water collected in relief drains shall be discharged to outlets agreed by the Engineer.

CAISSON DRAINS

Construction of caisson drains 7.246 (1) Excavation for caisson drains shall be carried out by manual methods in stages not exceeding 1.0 m depth unless otherwise permitted by the Engineer. Dewatering shall be carried out for excavation below the groundwater level so that work may be carried out, as near as may be practicable in the circumstances, in dry conditions. Dewatering shall be carried out as stated in Clauses 7.250 and 7.251.

(2) Unless otherwise permitted by the Engineer, the caisson drain shaft shall be supported at all times during construction using concrete liners. Voids between liners and excavated faces shall be filled with no fines concrete. Caisson liners for each 1.0 m stage shall be installed on the same day as that stage is excavated.

(3) Softened and loose material shall be removed from the base of the caisson drain immediately before granular filter material is deposited in the caisson drain.

(4) Part or all of the concrete liner adjacent to the granular filter layer shall be removed before granular filter material or fill material is deposited. Debris from the concrete liner shall be removed from the caisson drain.

(5) Granular filter material shall be deposited in layers not exceeding 500 mm and shall be compacted by methods approved by the Engineer.

Discharge of water from caisson drains 7.247 Water collected in caisson drains shall be discharged to the outlets stated in the Contract.

Records of caisson drains 7.248 (1) Records of caisson drains shall be kept by the Contractor on the Site and a copy shall be submitted to the Engineer not more than 14 days after completion of construction of caisson drains. The records shall contain the following details:

(a) Record of work carried out each day, and

(b) Drawings showing the exact locations of caisson drains and the final depths relative to PD.

(2) Detailed face logs of caisson drains shall be kept by the Contractor on the Site and shall be available for inspection by the Engineer at all times. The logs shall contain the following information and the format shall be as shown in Figure 10 of `Geoguide 2: Guide to Site Investigation', Hong Kong Government 1987.

(a) Details of depths and rate of groundwater seepage,

(b) Details of water levels, including dates and details of fluctuation,

(c) Four colour prints and one negative each of photographs or composite photographs taken during excavation. Each excavation stage shall be photographed using a reference board with maximum dimensions of 300 mm (width) by 450 mm (length). The photographs shall cover all the excavated face before the placing of caisson liners. Where more than one photograph is required to cover the full excavated depth or length of a face, the overlap between adjacent photographs shall be between 10% and 20%. Each photograph shall identify the face of the excavation and shall contain a natural scale and a colour comparison chart placed alongside the excavated face. The minimum size of colour prints shall be 125 mm by 175 mm.

PREFABRICATED BAND DRAINS

Installation of prefabricated band drains

7.249 (1) The installed location of prefabricated band drains shall be within 300 mm of the specified location in plan on the ground surface and the drain shall be within 2% of the installed length to the vertical.

(2) Each prefabricated band drain shall be installed in one continuous length without joints.

(3) The depth of penetration of prefabricated band drains shall be as stated in the Contract and modified as instructed by the Engineer during installation based on the resistance of the soil to penetration. The Engineer shall be notified immediately of any sudden change in the penetration resistance to the mandrel.

GROUNDWATER CONTROL AND DRAWDOWN

Drawdown of groundwater table

7.250 The groundwater table shall not be drawn down to more than 2 m below the earthworks final surface to specification in Section 6 for excavation.

Dewatering

7.251 (1) Dewatering shall be carried out in such a manner that no loss of fines from the ground occurs.

(2) Silt traps shall be provided and shall be regularly maintained. All dewatering pumps shall discharge into silt traps.

(3) Pumped groundwater shall not be discharged onto roads, footpaths, kerb channels or adjacent land. All arrangements shall be made with and the necessary approvals shall be obtained from the relevant authorities for discharging water to drainage systems, watercourses or the sea. Dewatering shall not start until the approved arrangements for disposal of the water have been implemented. Water entering the Site shall not be discharged into the same silt traps as are used for dewatering.

(4) The total capacity of pumps available on the Site for dewatering shall

be at least equal to twice the rate of flow measured through the silt traps at any time when the groundwater table is maintained at maximum drawdown.

(5) Half of the total pump capacity shall be equipped with a secondary motive power source in addition to the primary motive power. The secondary motive power source shall commence operation automatically in the event of failure of the primary motive power source or an effective alarm system shall be set up which will warn of failure of the primary motive power source. The maximum allowable delay between failure of the primary motive power source and full operation of the secondary motive power source shall not exceed 15 minutes.

(6) A full-time attendant shall be available on the Site at all times to execute the changeover if manual operation of equipment is required to bring the secondary motive power into operation.

(7) The operation of the changeover of motive power equipment shall be demonstrated before the relevant work starts unless otherwise permitted by the Engineer.

Groundwater recharge

7.252 (1) If groundwater recharge is to be carried out to maintain the specified groundwater levels at any location, the groundwater recharge system shall have the means to regulate and measure the rate of recharge and to provide an adequate continuous supply of water for recharge. Only clean water shall be used.

(2) The capacity of pumps and the power sources which are to be used for groundwater recharge shall be as stated in Clause 7.251(4) except that the rate of flow shall refer to the maximum rate of groundwater recharge required.

(3) The groundwater table at any location shall not be raised above the background groundwater table measured before the relevant work starts.

Monitoring of groundwater control and drawdown

7.253 (1) Monitoring of groundwater levels shall be carried out at locations stated in the Contract or instructed by the Engineer at all times when groundwater control and drawdown is carried out. Arrangements for installing instruments and taking measurements both inside and outside the Site shall be made by the Contractor.

(2) The survey marks for monitoring shall be located in position and level to the Hong Kong standard survey grid and to PD to within 10 mm in every direction.

(3) Monitoring stations and monitoring shall be as stated in Clauses 7.262 to 7.279.

(4) Groundwater levels shall be measured to an accuracy of 20 mm. Settlements shall be measured to an accuracy of 3 mm.

(5) The Engineer shall be notified immediately if any incremental settlement reading exceeds 5 mm or if the accumulated settlement exceeds the maximum allowable settlement stated in the Contract.

Records of settlement, groundwater control and drawdown

7.254 Records of monitoring of settlement, groundwater control and drawdown shall be kept by the Contractor on the Site and a copy shall be submitted to the Engineer within 24 hours of taking readings.

TESTING: GRANULAR FILTER MATERIAL

Batch: granular filter material 7.255 A batch of granular filter material is any quantity of granular filter material of the same type and grading delivered to the Site at any one time.

Samples: granular filter material 7.256 (1) One sample of granular filter material shall be provided from each 500 m^3 or part thereof of the material delivered to the Site.

(2) Unless otherwise permitted by the Engineer, one sample of granular material shall be provided from each 500m^3 or part thereof of granular filter material that has been deposited and compacted.

(3) The size of each sample taken as stated in Clause 7.256(1) shall be 10 kg. The method of sampling shall be in accordance with CS3.

(4) Samples, taken as stated in Clause 7.256(2), shall consist of material excavated from the compacted layer to form a flat bottomed, steep sided hole of approximately 0.13 m^2 to the complete depth of the compacted layer. A template shall be used to fix the edges of the hole if necessary. The sides and bottom of the hole shall be at least 50 mm from other types of fill material.

Testing: granular filter material 7.257 (1) Each sample of granular filter material shall be tested to determine the particle size distribution.

(2) The method of testing shall be in accordance with the wet sieving method stated in Geospec 3, Test Method 8.2

Non-compliance: granular filter material 7.258 (1) If the result of any test for particle size distribution on a sample of granular filter material taken as stated in Clause 7.256(1) does not comply with the specified requirements for particle size distribution, additional samples shall be provided from the same batch and additional tests for particle size distribution shall be carried out.

(2) The batch shall be considered as not complying with the specified requirements for particle size distribution if the result of any additional test for particle size distribution does not comply with the specified requirements for particle size distribution.

(3) If the result of any test for particle size distribution on a sample of granular filter material taken as stated in Clause 7.256(2) does not comply with the specified requirements for particle size distribution, additional samples shall be provided from the same batch and additional tests for particle size distribution shall be carried out.

(4) The batch shall be considered as not complying with the specified requirements for particle size distribution if the result of any additional test for particle size distribution does not comply with the specified requirements for particle size distribution.

TESTING: FILL MATERIAL FOR TRENCH DRAINS

Batch: fill material for trench drains 7.259 A batch of fill material for trench drains is any quantity of fill material for trench drains of the same type delivered to the Site at any one time.

Samples: fill material for trench drains 7.260 (1) Unless otherwise permitted by the Engineer, one sample of fill material for trench drains shall be provided from each batch of fill material for trench drains delivered to the Site.

(2) The size of each sample and the method of sampling shall be in accordance with Clause 7.256(3).

Testing: fill material for trench drains 7.261 (1) Each sample of fill material for trench drains shall be tested to determine the particle size distribution. Fill material passing a 425 μm BS test sieve shall also be tested to determine the plasticity index.

(2) The method of testing to determine the particle size distribution shall be in accordance with Geospec 3, Test Method 8.2. The method of testing to determine the plasticity index shall be in accordance with Geospec 3, Test Method 6.1.

PART 6: GEOTECHNICAL INSTRUMENTATION

GLOSSARY OF TERMS

Datum station 7.262 Datum station is a mark for which horizontal or vertical values, or both, have been fixed, and which is used as a datum for monitoring or control surveys.

Geotechnical instrumentation 7.263 Geotechnical instrumentation is the installation and monitoring of instruments in the ground or structures to provide information on soil and rock parameters, and to monitor specific variations in the condition of the ground or structures for the purposes of geotechnical design, construction control and performance monitoring.

Monitoring mark 7.264 Monitoring mark is a mark, fixed or installed, on a structure to be monitored.

Reference point 7.265 Reference point is a mark placed close to another important survey mark to aid recovery or replacement.

Survey station 7.266 Survey station is a mark on a stone, concrete, metal or wooden block, pipe, peg or other item defining a surveyed position.

SUBMISSIONS

Particulars of geotechnical instrumentation 7.267 (1) The following particulars of the proposed geotechnical instrumentation shall be submitted to the Engineer:

(a) Details of instruments and any alternative instruments proposed by the Contractor,

(b) Manufacturer's specifications,

(c) Test and calibration certificates,

(d) Method of installation,

(e) Method of acceptance testing,

(f) Details of ancillary measuring equipment,

(g) Schedule for installing instrumentation in relation to other work,

(h) Documents showing that the instruments are capable of measuring within the ranges and accuracies stated in the Contract,

(i) Name and experience of persons responsible for installation, testing and monitoring of instruments,

(j) Details of standpipe piezometer tips, including manufacturer's specification, and

(k) Details of the form of records.

(2) The particulars shall be submitted to the Engineer for approval at least 28 days before installation of instrumentation starts.

GENERAL GEOTECHNICAL INSTRUMENTATION REQUIREMENTS

Instruments for geotechnical instrumentation

7.268 (1) Instruments for geotechnical instrumentation and their accessories shall be provided complete with all appropriate tubing, connections, monitoring equipment, read-out units and any other tools necessary for the installation calibration, setting to work and maintenance of the instruments.

(2) Instruments shall be manufactured by companies with proven experience and only instruments which are well proven and have been in successful use shall be used, unless otherwise agreed by the Engineer.

(3) Installed instruments shall become the property of the Employer. Detachable tubing, connections, monitoring equipment and read-out units shall become the property of the Contractor upon the expiry of the Maintenance Period.

(4) Instruments shall be handled, stored, installed and used in accordance with the manufacturer's recommendations and in such a manner that the performance of the instruments will not be impaired.

(5) Instruments shall be protected from damage and measures shall be taken to ensure that the instruments suffer the minimum practicable amount of disturbance.

(6) Instruments shall be calibrated by a laboratory approved by the Engineer. Instruments shall be calibrated at intervals recommended by the manufacturer and at other intervals instructed by the Engineer. Calibration certificates shall be provided to the Engineer within 24 hours of calibration.

(7) Installation, testing and monitoring of the instruments shall be carried out under the supervision of a suitably qualified technician. Particulars of the technician, including qualifications and experience, shall be submitted to the Engineer at least 7 days before commencement of work relating to geotechnical instrumentation.

Location and arrangement of instruments

7.269 (1) The locations and arrangement of instruments for geotechnical instrumentation shall be as stated in the Contract or as agreed with the Engineer before installation.

(2) The positions and alignments of instruments shall be recorded after installation and surveys shall be carried out at times and frequencies agreed by the Engineer to detect any displacement of the instruments.

(3) At least two reference points shall be established for each survey station or monitoring mark.

(4) The survey station that has the least chance of being disturbed shall be selected as datum station. The datum station shall be stainless steel and shall be protected from damage. At least three reference points shall be established for each datum station.

(5) The survey network shall be related to the territorial control points provided by the Engineer.

Installation of instruments

7.270 (1) The Engineer shall be informed 24 hours, or such shorter period agreed by the Engineer, before the installation of each instrument for geotechnical instrumentation starts.

(2) Instruments shall be installed, fixed and protected in a manner which will ensure that the instruments will function satisfactorily. Tests shall be carried out after installation to demonstrate that the instruments have been correctly installed and are functioning correctly. Instruments that are not correctly installed or are not functioning correctly shall be reinstalled or replaced as instructed by the Engineer.

(3) All installed instruments, tubes and wires shall be clearly marked with a unique and conspicuous identification number.

Tubes and cables for instruments

7.271 (1) Tubes and cables attached to instruments for geotechnical instrumentation for remote reading shall be impervious to air and water, and shall have sufficient strength and stiffness to withstand the internal and external pressures. Tubes and cables shall be protected from mechanical damage and from the harmful effects of direct sunlight, heat and ultra violet radiation at all times.

(2) Tubes and cables shall be free of defects and shall be marked with identification colours and numbers at 5 m intervals. The tubes and cables shall be wound onto reels in such a manner that kinks are not formed and strain is not induced. Open ends of tubes and cables shall be blocked with stop ends at all times.

(3) Tubes and cables shall be buried at least 0.5 m below ground level.

(4) Tubes and cables shall be laid with sufficient slack, loops and bends to allow for settlement and other ground movements. The routing of tubes and cables shall be as agreed by the Engineer and shall be in straight lines unless otherwise permitted by the Engineer. The radius of bends shall be at least 300 mm. Each tube or cable shall be laid from the measuring instrument to the terminal duct in one continuous length without joints.

Maintenance of instruments

7.272 (1) Instruments for geotechnical instrumentation shall be maintained in good working order until the expiry of Maintenance Period. Instruments, survey marks and stations shall be protected by suitable barricades, notices, signs, marker-buoys or by other methods agreed by the Engineer. Construction shall be carried out in a manner that will avoid damage to the instruments.

(2) The Engineer shall be informed immediately of any instruments found damaged or instruments found not to be in working order. Replacements shall be installed for read-out units that are faulty or under repair.

Records of geotechnical instrumentation

7.273 (1) Records of activities relating to installation of geotechnical instrumentation shall be kept by the Contractor on the Site and a copy shall be submitted to the Engineer within 24 hours of installation of the instrument is complete.

(2) A drawing showing the locations and identification of installed instruments shall be prepared by the Contractor and submitted to the Engineer

within 24 hours of installation of the instrument is complete.

(3) A drawing showing the locations and details of survey stations, monitoring marks and reference points shall be prepared by the Contractor and submitted to the Engineer not more than 3 days after the survey network has been established.

MONITORING AND RECORDING

Recording readings 7.274 (1) Instrument readings and processed data for geotechnical instrumentation shall be recorded by the Contractor on agreed record sheets, and shall be submitted to the Engineer within 24 hours of recording. The form of record sheets shall be as agreed by the Engineer. Unless otherwise agreed by the Engineer, readings shall be taken in the presence of the Engineer.

(2) Initial readings shall be taken immediately after the instruments have been installed and after the effects of installation have subsided. The initial readings shall be submitted to the Engineer and shall form the basis of comparison of subsequent readings. The instruments and the initial readings shall be replaced if the initial readings are not repeatable.

(3) The frequencies for reading instruments shall be as agreed with the Engineer. The Engineer shall be informed immediately of sudden or significant changes in the readings.

(4) All installed instruments shall be left in correctly functioning condition after final readings have been taken or at the end of the Maintenance Period. Keys for locks shall be tagged to identify the instrument number and shall be handed over to the Engineer.

SETTLEMENT PLATES

Installation of settlement plates 7.275 (1) Settlement plates for geotechnical instrumentation shall be securely founded on level ground free of obstructions and shall be immediately surveyed for level and position and plotted on a plan.

(2) Settlement plates shall be protected from damage and shall be kept in position by a 600 mm thick layer of granular fill material or bags of sand which shall be placed by manual methods and shall extend 600 mm beyond the edges of the plate. The initial survey of levels and positions shall be taken immediately after the fill material or bags of sand have been placed.

(3) The metal rod fixed to the centre of the plate shall be in an upright position, and protected by a tubular sleeve. The sleeve and the metal rod shall be extended as fill material is placed such that at any time the sleeve and rod are at least 500 mm above the level of the surrounding fill material or high water mark, and the metal rod is within 2% of the embedded length to the vertical.

(4) The level of the top of the metal rod shall be recorded immediately before and immediately after each extension piece is added. Marker-buoys shall be fixed to the tops of tubular sleeves installed in water, unless otherwise permitted by the Engineer.

TILTMETER SYSTEM

Installation of tiltmeter system 7.276 (1) Tilt-plates for geotechnical instrumentation shall be orientated to correspond with the specified direction of measurement and fixed in place on the rock or structure. The installed direction shall be recorded to an accuracy of ±3°.

(2) A protective cap or cover shall be fitted to protect the tilt-plates from damage.

(3) Tilt-plates and the tiltmeter shall be cleaned and inspected for damage before readings are taken. The tiltmeter shall be accurately located on the tilt-plate and a reading taken. The tiltmeter shall then be removed and the contact surface recleaned. The procedure shall be repeated until consistent readings are obtained. The tiltmeter shall then be rotated through 180° and the procedures repeated.

(4) The accuracy of the tiltmeter and its readout system shall be checked both before and after the readings taken each day. Instrument errors shall be investigated and immediately corrected. A record of calibrations and adjustments shall be submitted to the Engineer together with the monitoring data.

TELLTALES

Installation of telltales 7.277 Unless otherwise approved by the Engineer telltales for geotechnical instrumentation shall be as shown in Figure 10.5 of `The Geotechnical Manual for Slopes', Hong Kong Government, 1984. Telltales shall be rigidly fixed across cracks to enable any movement across the cracks to be determined. Telltales shall be labelled and marked with the date of installation.

STANDPIPE PIEZOMETERS

Standpipe piezometers 7.278 Standpipe piezometer tips for geotechnical instrumentation shall be porous ceramic or plastic material at least 200 mm long and with a bore of at least 19 mm. The permeability shall be at least 10^{-4} m/s. The piezometer tip shall be connected to rigid PVC standpipes with a bore of at least 19 mm and with a wall thickness of at least 3 mm. The standpipes shall be jointed together and to the porous tips in such a manner that the joints remain leak-proof under the anticipated head of water.

Installation of standpipe piezometers 7.279 (1) Standpipe piezometers for geotechnical instrumentation shall be installed in drillholes at the depths instructed by the Engineer.

(2) The sand filter surrounding the piezometer tip shall be between 1000 mm and 1500 mm long and shall consist of sand between the sizes of 200 μm and 1210 μm. Measurements shall be made to determine the actual location of the sand filter column.

(3) A seal shall be formed above the sand filter by placing 500 mm of bentonite pellets of between 10 mm and 15 mm in size. The pellets shall be placed in the hole and tamped with a suitably shaped tamper to form a homogeneous plug to the hole.

(4) If the depth of the completed hole is greater than the depth at which the piezometer tip and sand filter are to be placed, the bottom of the drillhole shall be grouted with grout consisting of cement and bentonite in the proportions 1:1 by mass together with sufficient water to achieve the required workability. The drillhole above the plug shall be grouted with the same type of material.

(5) The water level in the piezometer shall be measured after the standpipe piezometer has been installed and the standpipe shall be topped up with clean water. The rate of drop of water level or pressure head shall be recorded at times of 0, 1/4, 1/2, 1, 2, 4, 8, 15, 30 minutes or until the water has returned to its initial level.

(6) The water level shall be measured by an electrical type water level probe agreed by the Engineer. The water shall be salted if necessary for response to the probe.

Measurements of the depth of piezometer tip and sand filter and the readings taken as stated in Clause 7.279(6) shall be submitted to the Engineer for approval within 24 hours of completion of installation of the piezometer standpipe.

PART 7: SLOPE AND RETAINING WALL RECORD SURVEY

GENERAL

Scope

7.280 A survey of all slopes and retaining walls formed, modified or partially modified under the Contract shall be conducted and completed upon their completion or at any other time as appropriate during the construction period. Such survey shall be completed upon the substantial completion of the Works as certified by the Engineer.

SUBMISSIONS

Particulars of slope and retaining wall record survey

7.281 (1) The following particulars of the slope and retaining wall record survey shall be submitted to the Engineer:

(a) All necessary details of the subject slopes and retaining walls as required by the Engineer, including details of the extent of new fill body of a fill slope as appropriate, recorded on a plan of 1:1000 scale showing the locations with graphical boundaries appropriately highlighted and referenced to the HK1980 Grid, and

(b) A soft copy of the plan as stated in Clause 7.281(1)(a) prepared in a format as specified in the Contract.

(2) The particulars shall be submitted to the Engineer not more than 28 days, or such other time stated in the Contract, after completion of the slope and retaining wall record survey as agreed by the Engineer.

PART 8: PAINTING TO CONCRETE / SPRAYED CONCRETE SURFACES

MATERIALS

Paint for concrete/ sprayed concrete surfaces

7.282 Paint for concrete/sprayed concrete surfaces shall be water-based paint for external use. The components of paint shall not be toxic or hazardous to health.

SUBMISSION

Particulars of paint

7.283 Details of paint products (e.g. specification and colour samples etc.) and method statement shall be submitted for the Engineer's approval prior to painting. The colour of paint shall be "Antique" to BS 5252F colour code 10B25 or other colour as directed by the Engineer.

PAINTING TO CONCRETE / SPRAYED CONCRETE SURFACES

Painting to concrete/ sprayed concrete surfaces

7.284 (1) The surface of concrete/sprayed concrete shall be prepared prior to applying the paint. The surface to be painted shall be clean, free of contaminants such as oils, grease, release agents, mortar splashes etc. All debris and loose materials shall be removed from the surface. Painting shall not be carried out in direct strong sunlight, hot windy conditions or in an environment with excessive dust.

(2) Paint shall be stored in accordance with Section 24 and shall be mixed in accordance with the manufacturer's instruction prior to application. Two coats of paint shall be applied to the surface. Each coat of paint shall be applied using an airless spray at 12 m^2/litre or equivalent to obtain a uniform finish or as recommended by the manufacturer. Sufficient time gap shall be allowed between the applications of first and second coating as recommended by the manufacturer. Each coating shall be protected from rain for the first 24 hours after application.

APPENDIX 7.1

DYNAMIC PROBE TEST

Scope 7.1.1 This method covers the determination of the penetration resistance of soil using the dynamic probe.

Apparatus 7.1.2 The following apparatus is required:

(a) Dynamic Probe as shown in Figure 36 of `Geoguide 2. The anvils shall be rigidly fixed to the guide rod; the lower anvil shall also be rigidly fixed to the extension rods. The mass of the lower anvil shall be 1.5 kg to 1.8 kg. The combined mass of the anvils and guide rod shall not exceed 5.0 kg.

(b) Extension rods with a length of 1000 mm ±10 mm. The rods shall be attached to bear against each other by means of external couplers.

Procedure 7.1.3 The procedure shall be as follows:

(a) The lower end of the probe shall be rested against the ground at the test location, with the first extension rod and guide rod in a vertical position.

(b) The hammer shall be raised to bear against the upper anvil, and shall be allowed to fall freely. It shall not be connected to objects which may influence its acceleration and deceleration, and shall be stationary when released in the upper position. The fall shall be 300 mm ± 5 mm.

(c) The hammer shall be used to drive the probe into the ground, with a rate of driving between 20 and 60 blows per minute.

(d) Additional extension rods shall be added as necessary. The rods shall be rotated clockwise one full turn each time a rod is added to ensure that screw joints are tight.

(e) The blow count for every 100 mm of penetration shall be recorded, or at refusal the penetration distance for 50 blows of the hammer. Interruptions exceeding 5 minutes shall be recorded.

(f) If any obstruction to the probe is encountered which cannot be penetrated over 100 mm by 100 blows of the driving hammer, then that probe shall be considered to have reached refusal and the test shall be terminated.

Reporting of results 7.1.4 The following shall be reported:

(a) Blow count for every 100 mm penetration or at refusal the penetration distance for 50 blows of the hammer.

(b) Interruptions exceeding 5 minutes.

(c) Dynamic probe record (Figure 37 of Geoguide 2).

(d) That the test was carried out in accordance with this Specification.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 8

PILING WORKS

SECTION 8

PILING WORKS

GENERAL

General requirements 8.01 The works and materials specified in Clauses 8.02 to 8.09 shall comply with the Sections stated, unless otherwise stated in this Section. In accordance with Clauses 1.11 and 1.12 of Section 1, the Contractor shall employ on the Site in connection with execution of the piling works a Construction Engineer and a Construction Supervisor who shall be full time on site to supervise the piling works.

Earthworks 8.02 Earthworks shall comply with Section 6.

Reinforcement 8.03 Steel reinforcement shall comply with Section 15.

Concrete 8.04 Concrete shall comply with Section 16.

Materials for grout 8.05 Materials for grout for piling works shall comply with Section 16.

Grouting 8.06 Grouting for piling works shall comply with Section 17.

Prestressing 8.07 Prestressing shall comply with Section 17.

Steelwork 8.08 Steelwork shall comply with Section 18.

Marine works 8.09 Marine works shall comply with Section 21.

Code of practice for piling works 8.10 Piling works shall comply with the GEO Publication No. 1/2006, except as stated in this Section.

Safety of piling works 8.11 Reference shall be made to the following documents regarding matters relating to the safety of piling works:

Drilling and Foundation Equipment - Safety : BS EN 16228

Section 7 of `Guidance Notes on Hand-Dug Caissons' Hong Kong Institution of Engineers,1981

GLOSSARY OF TERMS

Hand-dug caisson 8.12 A hand-dug caisson is a pile shaft which is excavated manually and which is unlined, or lined with a ring wall following each incremental advance of the excavation, or partly unlined and partly lined.

Barrette and Diaphragm Walls 8.13 (1) A barrette is a pile that is excavated using grabs and chisels through a thixotropic suspension of bentonite or other agent which supports the sides of the shaft as excavation proceeds, and which is concreted in one continuous operation.

(2) A diaphragm wall is a continuous wall consisting of a series of abutting reinforced concrete panels constructed in a trench temporarily supported by a

thixotropic suspension of bentonite or other agent. It may be used as a temporary wall for supporting deep excavation, or used as the permanent wall for a basement structure, and may be used as a foundation system for supporting vertical loads.

Large-diameter bored piles and socketted steel H-piles 8.14 (1) A large-diameter bored pile is a bored pile, the diameter of which is larger than 750 mm and determined by the Contract Drawings and/or proposed by the Contractor to the Engineer's approval.

(2) Socketted steel H-piles are piles formed by inserting steel H-piles in pre-bored holes sunk into Grade III or better rock, and subsequently filling the holes with cement grout.

Minipile 8.15 A minipile is a pile with a diameter of less than 250 mm in which the load-bearing element consists of a steel tube or one or more steel reinforcement bars.

Founding rock 8.16 "Founding rock" includes "founding rock or stratum" if the pile does not reach rock level, and "concrete/rock interface" shall be construed accordingly.

MATERIALS

Steel piles 8.17 (1) Steel bearing piles and steel sheet piles shall comply with BS EN 1090:Part 2.

(2) Steel sheet piles shall be of a proprietary section approved by the Engineer.

Pile shoes 8.18 (1) Cast iron pile shoes for precast concrete piles shall be manufactured from chill hardened iron as used for making grey iron castings complying with BS EN 1561, Grade EN-GJL-150. The chilled iron point of the shoe shall be free of major blow-holes and other surface defects.

(2) Steel pile shoes for precast concrete piles shall be manufactured from steel complying with BS EN 10025:Part 2, Grade S275JR.

(3) Cast steel pile shoes for precast concrete piles shall be manufactured from steel complying with BS EN 10293, Grade GE.

(4) Straps and fastenings for cast pile shoes for precast concrete piles shall be manufactured from steel complying with BS EN 10025:Part 2, Grade S275JR and shall be cast into the point of the shoe to form an integral part of the shoe.

(5) Pile shoes for driven cast-in-place piles shall be manufactured from durable materials approved by the Engineer and capable of withstanding driving stresses without damage. The shoes shall be designed to provide a watertight joint with permanent casings.

(6) Cast steel pile shoes for steel bearing piles shall be manufactured from steel complying with BS EN 10293, Grade GE.

(7) Welded fabricated pile shoes for steel bearing piles shall be manufactured from steel complying with BS EN 10025:Part 2, Grade S275JR.

Epoxy paint 8.19 Epoxy based paint for epoxy coatings to steel piles shall be a proprietary type approved by the Engineer.

Bituminous coating material 8.20 Bituminous coating material for steel piles shall be hot-applied filled or unfilled bituminous material complying with BS EN 10300.

Grout for piling works 8.21 (1) Grout for piling works shall consist of Portand cement (PC) and water. Sand, PFA and admixtures may be used with the approval of the Engineer.

(2) The minimum cementitious content of grout shall be 600 kg/m^3, unless otherwise permitted by the Engineer.

(3) Grout used to fill core holes shall have a minimum crushing strength of not less than the specified grade strength of the concrete surrounding the core hole.

(4) Grout used in minipiles shall have a minimum crushing strength of 30 MPa at 28 days.

(5) The amount of bleeding of grout shall not exceed 2% in the first 3 hours and shall not exceed 4% in total. The water shall be reabsorbed by the grout during the 24 hours after mixing.

(6) Free expansion of grout shall not exceed 10% at the ambient temperature.

(7) The chloride ion content of admixtures for concrete containing embedded metal or for concrete made with SRPC shall not exceed 2% by mass of the admixture or 0.03% by mass of the cementitious content, whichever is less.

(8) The maximum total chloride content of grout, expressed as a percentage relationship between the chloride ion and the cementitious content by mass in the grout, shall not exceed 0.1%.

Reinforcement connectors 8.22 Reinforcement connectors for minipiles shall be capable of transmitting the total pile load in tension or compression as appropriate.

SURFACE TREATMENT OF STEEL PILES

Surface treatment of steel piles 8.23 (1) Surface preparation and application of protective coatings other than bituminous coatings to steel piles shall be carried out in a fully enclosed well-ventilated workshop.

(2) The method of application of protective coatings to steel piles, the ambient temperature and humidity at the time of application and the time interval between the application of successive coats shall be in accordance with the manufacturer's recommendations. The complete coating shall be applied in and around clutches.

Surface preparation of steel piles 8.24 The surfaces of steel piles to which protective coatings will be applied shall be prepared by blast cleaning to medium profile grade in accordance with BS EN ISO 8503:Part 1 or Sa 2½ in accordance with BS EN ISO 8501:Part 1.

Epoxy coatings to steel piles 8.25 (1) Epoxy coatings to steel piles shall consist of three coats of epoxy- based paint, each coat having a minimum dry film thickness of 75 μm. The first coat shall be applied within two hours of blast cleaning.

(2) The finished surface of epoxy coatings shall be smooth with a dense and uniform texture and shall be free of sharp protuberances and pinholes. The thickness and continuity of completed epoxy coatings shall be measured using a magnetic thickness gauge or by other methods agreed by the Engineer.

(3) Damaged areas of epoxy coatings shall be repaired by cleaning the damaged areas to bare metal, feathering back the adjacent areas with coarse grade sandpaper and re-applying the coating.

Bituminous coatings to steel piles

8.26 (1) Bituminous coating material, or primer if the bituminous coating consists of a built-up system, to steel piles shall be applied within two hours of blast cleaning. The thickness of bituminous coatings shall be at least 300 μm.

(2) Damaged areas of bituminous coatings shall be over-coated with the same bituminous coating material to restore the specified thickness.

Surface treatment of extended steel piles

8.27 The splice areas of steel piles, which are extended in-situ, shall be prepared by blast cleaning and the protective coating shall be applied to the area. Steel piles for marine works shall be spliced and the surface treatment applied to the splice areas before the piles are driven unless otherwise permitted by the Engineer.

Removal of protective coatings to steel piles

8.28 Protective coatings shall be removed from the heads of steel piles which will be encased in concrete by blast cleaning, flame cleaning or by other methods agreed by the Engineer. The coatings shall be removed to a level of 75 mm above the underside of the concrete into which the pile will be encased.

SUBMISSIONS

Particulars of piling works

8.29 (1) The following particulars of the proposed materials and methods of construction for piling works shall be submitted to the Engineer:

(a) Details of construction plant,

(b) Methods and sequence of installation of piles, including methods of avoiding damage to adjacent piles, structures and utilities and measures to be taken to deal with hard material and obstructions,

(c) Calculations of driving stresses,

(d) Methods of jointing and lengthening piles,

(e) Methods of controlling groundwater, or groundwater treatment,

(f) Anticipated ground vibration, ground movement and groundwater drawdown and methods of instrumentation and monitoring,

(g) Methods and sequence of excavation, including methods of supporting excavations and of cleaning the excavation,

(h) Methods of concreting,

(i) Details of protective coatings to steel piles, including manufacturers' literature,

(j) Details of preliminary piles, and

(k) Methods of testing, including details of the specialist firm for non-destructive testing of welds and the programme for integrity testing.

(2) The particulars shall be submitted to the Engineer at least 21 days before the relevant preliminary piles are constructed. If preliminary piles are not required, the particulars shall be submitted to the Engineer at least 21 days before the relevant piling works start.

Particulars of construction using bentonite slurry

8.30 (1) The following particulars of the proposed materials and methods of construction using a slurry containing bentonite or other agent shall be submitted to the Engineer:

(a) A certificate for bentonite showing the type, the manufacturer's name, the date and place of manufacture and including details of the apparent viscosity range in Pa.s and the gel strength range in N/m^2 for solids in water,

(b) Characteristics of the bentonite slurry in a freshly mixed condition and in the excavation immediately before concreting,

(c) Methods of quality control, sampling, testing, mixing, storing, recirculating, removing silt and sand, preventing spillages and disposal from the Site,

(d) Head of bentonite slurry, including stability calculations,

(e) Details of guide walls,

(f) Methods of placing concrete by tremie, and

(g) Sequence of construction.

(2) The particulars shall be submitted to the Engineer at least 21 days before the relevant excavation starts.

Particulars of hand-dug caissons

8.31 Particulars of the proposed materials and methods of construction for hand-dug caissons, including details of linings, shall be submitted to the Engineer at least 21 days before the relevant excavation starts.

Particulars of minipiles

8.32 (1) The following particulars of the proposed materials and methods of construction for minipiles shall be submitted to the Engineer:

(a) Details of reinforcement or pipe section, including spacers and couplings,

(b) Details of grout mix as stated in Clause 17.13, and

(c) Sequence and timing of grouting, including details of secondary pressure grouting.

(2) The particulars shall be submitted to the Engineer at least 7 days before trial mixes for grout are made.

HANDLING AND STORAGE OF MATERIALS

Handling and storage of piles

8.33 (1) The identification number, grade of steel and length of pile shall be marked on steel piles. The identification number, date of casting and length of pile shall be marked on precast concrete piles.

(2) Piles shall be stored horizontally off the ground on level supports and in a manner, which will not result in damage or deformation to the piles, or in contamination of the piles. Coated piles shall be handled and stored in a manner, which will not result in damage to the coatings. Bituminous- coated piles shall not be stacked.

(3) Different types and sizes of piles shall be stored separately.

Handling and storage of bentonite

8.34 Bentonite shall be handled and stored in a manner, which will not result in spillages on the Site.

GENERAL PILING WORKS REQUIREMENTS

Commencement of piling works

8.35 Piling works, including groundwater control and ground treatment for piling works, shall not commence until the relevant proposed materials and methods of construction, including construction and testing of preliminary piles, have been approved.

Prevention of damage due to piling works

8.36 (1) The position of existing utilities shall be determined and underground utilities adjacent to the piles shall be exposed or otherwise accurately located before piling works start.

(2) All necessary measures shall be taken to minimise the settlement of the ground and adjacent structures and utilities and to prevent the formation of cavities in the ground resulting from piling works. All necessary measures shall be taken to minimise the settlement of the ground and adjacent structures and utilities and to prevent the formation of cavities in the ground resulting from piling works.

(3) The vibrations due to piling works at structures, utilities and previously installed piles measured in terms of peak particle velocity shall not exceed 25 mm/s.

(4) The vibrations due to piling works at structures, utilities and previously installed piles measured in terms of vibration amplitude shall not exceed 0.2 mm.

Monitoring of noise, vibration, ground movement and groundwater level

8.37 (1) Measurements of noise level, vibration, ground movement and groundwater level shall be taken at locations and time intervals stated in the Contract or instructed by the Engineer when piling works are being carried out. Records of the measurements shall be kept and a copy of the records supplied to the Engineer. Arrangements for installing instruments and taking measurements both inside and outside the Site shall be made by the Contractor.

(2) Measurements of noise level and vibration shall be made with instruments of a type agreed by the Engineer.

(3) Sufficient numbers of piezometers and survey points shall be installed to allow the changing groundwater levels and the effects on structures, utilities and previously installed piles to be measured. Measurements shall be taken at regular intervals when groundwater control is carried out and until such time as the groundwater has resumed its natural regime.

(4) The Contractor shall inform the Engineer immediately of any unanticipated change in measurements.

(5) If the specified limits, or limits agreed by the Engineer, on vibration, groundwater movement or groundwater level are exceeded, the work causing the limits to be exceeded shall be stopped and particulars of proposed changes to the methods of construction shall be submitted to the Engineer for approval.

Ground investigation for piling works

8.38 (1) Before piling works start, boreholes of minimum NX size shall be sunk and piezometers shall be installed at locations stated in the Contract or instructed by the Engineer to determine the soil characteristics and the groundwater regime and to determine the founding level of non-displacement cast-in-situ piles.

(2) Soil samples and rock samples stated in the Contract or instructed by the Engineer shall be taken from pile excavations for visual inspection and testing. The method of sampling and testing shall be as stated in Section 7.

Ground investigation for piles founded on rock

8.39 All ground investigation for piles founded on rock, including pre-drilling and proof-drilling as well as any core-drilling on the constructed piles, shall be carried out by an independent Specialist Contractor for Public Works registered under the Work Category of "Ground Investigation Field Work", who is required to make a declaration that it is not a holding company, a subsidiary company, an associated company or a related party of the Contractor or any of his sub-contractors responsible for the piles for which the ground investigation is carried out, and that it has no financial interests in the piling works to be tested.

Pre-drilling for piles founded on rock

8.40 (1) For piles founded on rock, sufficient pre-drilling should be carried out before the installation works, such that the quality of the founding rock can be identified and the appropriate founding levels can be determined. The pre-drilling should be sunk to at least 5m below the tentative founding rock levels of the piles.

(2) Pre-drilling should be carried out for each of the large-diameter bored piles, barrettes and the like. For minipiles, socketted steel H-piles and similar small diameter-bored piles, founding on rock, the number of pre-drill boreholes required should be such that the pile tip of every such pile should be within 5 metres from a pre-drill hole, or at a larger distance from it as decided by the Engineer.

(3) For a load-bearing diaphragm wall, predrill holes shall be sunk at 4 m centres along the diaphragm wall to establish founding level or one predrill hole per panel, whichever spacing is larger, but not greater than 10 m in any circumstance. For non-load bearing diaphragm wall, at least one predrill hole shall be sunk per 10m in spacing.

Founding levels

8.41 (1) The Contractor shall allow the Engineer to inspect the material at the proposed founding level and shall inform the Engineer immediately the founding level is reached.

(2) If instructed by the Engineer the founding level shall be proved by drilling to a depth of 4.5 m or three times the pile diameter, whichever is greater, below the founding level and obtaining samples of NX size.

PRELIMINARY PILES

Preliminary piles 8.42 (1) Preliminary piles shall be constructed using the materials and methods of construction proposed for the working piles and which have been submitted to the Engineer. The location and details of preliminary piles shall be as instructed by the Engineer.

(2) Unless otherwise permitted by the Engineer the relevant piling works shall not commence until the construction, testing and records of the preliminary piles stated in the contract or instructed by the Engineer have been approved.

(3) Preliminary piles shall be left in position, cut off, incorporated in the permanent work or withdrawn and disposed of as stated in the Contract. Preliminary piles intended to be incorporated in the permanent work and which do not comply with the specified requirements shall be removed and disposed of or dealt with as instructed by the Engineer.

DRIVEN PILES

Supports for driven piles 8.43 (1) Driven piles shall be supported and restrained by means of leaders, trestles, temporary supports or other guide arrangements in such a manner that:

(a) The piles are maintained in position and alignment,

(b) The piles are not loosened in the ground, and

(c) Damage resulting from oscillation, vibration or movement of free-standing piles does not occur.

The supports and restraints shall be maintained at all times during driving and until the piles are incorporated into the structure.

(2) Unless otherwise permitted by the Engineer, driven piles for marine works shall be driven from fixed stagings. The stagings shall be rigid and strong enough to ensure that the piling works can be carried out efficiently and accurately.

Use of diesel hammer 8.44 The use of diesel hammer for percussive piling is prohibited.

Followers 8.45 Followers or long dollies shall not be used unless permitted by the Engineer. If permitted, the set shall be revised by the Contractor and agreed by the Engineer, to allow for the reduction in effectiveness of the hammer blows.

Marking of piles 8.46 Piles, including temporary and permanent casings, shall be marked at 1 m intervals before pitching.

Driving piles 8.47

(1) Unless otherwise permitted by the Engineer each pile, other than sheet piles, shall be driven without interruption until the required depth or set has been achieved. If a minimum depth of penetration is stated in the Contract, the Contractor shall submit to the Engineer his proposals for achieving this requirement and it shall be his responsibility to ensure that the minimum penetration and set are achieved without causing damage to the pile.

(2) The sequence and method of driving piles shall be such as to minimise the detrimental effects of heave and lateral displacement of the ground and to cause the least possible displacement to previously installed piles. Piles, including casings, shall not be driven within a centre to centre distance of 3 m or five times the diameter of the pile or casing, whichever is less, from an unfilled excavation or from an uncased concrete pile which has been cast for less than 48 hours.

(3) The Contractor shall inform the Engineer without delay of any sudden change in driving characteristics.

Driving concrete piles 8.48

(1) Concrete piles shall not be driven until the concrete has attained the specified grade strength.

(2) The driving stresses in precast reinforced concrete piles and prestressed concrete piles shall not exceed one half of the specified grade strength of the concrete. Calculations of the driving stresses shall be submitted to the Engineer.

Displaced piles 8.49

Piles that have been displaced as a result of driving adjacent piles shall be corrected. Particulars of the method of correction and measures to be taken to avoid displacement in subsequent driving shall be submitted to the Engineer for approval.

Re-drive checks 8.50

No re-drive checks shall be carried out within 24 hours of completion of first driving.

Lengthening driven piles 8.51

The strength of piles at joints shall not be less than the strength at any normal section of the pile. Lengthened piles shall not be driven until the joint has developed the designed strength. Pile joints shall be tested as stated in the Contract or as instructed by the Engineer.

Measurement of set of driven piles 8.52

(1) Set shall be measured for each driven pile at times agreed by the Engineer and in the presence of the Engineer. The final set shall be measured as either:

(a) Penetration per 10 blows, or

(b) The number of blows required to produce 25 mm penetration.

(2) If driving is interrupted for more than 30 minutes, except as otherwise agreed by the Engineer, set shall not be measured after driving restarts until at least 20 blows of the same driving energy as at final set have been struck.

(3) When final set is measured:

(a) The exposed part of the pile shall be in good condition without damage or distortion,

(b) The dolly and packing shall be in sound condition,

(c) The hammer blow shall be in line with the axis of the pile and the impact surfaces shall be flat and at right angles to the axes of the pile and hammer, and

(d) The hammer shall be in good condition and operating correctly.

(4) The temporary compression of each driven pile shall be measured.

(5) The Contractor shall inform the Engineer at least 1 hour before final set and temporary compression are to be measured.

CAST-IN-SITU CONCRETE PILES

Excavation for cast-in-situ piles

8.53 (1) Except as stated in Clause 8.54, excavation for cast-in-situ concrete piles shall be carried out by mechanical methods. Blasting and compressed air shall not be used unless permitted by the Engineer. Large-diameter bored piles shall be formed by boring, chiseling or grabbing and filled with concrete. Piles with enlarged bases shall not be used unless specified otherwise. Where so permitted, the enlarged base shall only be formed by under-reaming with a reverse circulation drill. The relevant technique shall have been approved by the Engineer.

(2) The stability of excavations for cast-in-situ concrete piles shall be maintained where necessary by:

(a) Temporary casings,

(b) Permanent casings, or

(c) A thixotropic slurry containing bentonite or other agent.

(3) The bottom of casings shall be kept sufficiently deep to prevent the flow of soil into the casing.

HAND-DUG CAISSONS

Excavation for hand-dug caissons

8.54 (1) The Contractor shall adopt a method of construction that will only cause minimum settlement or disturbance of any kind to adjacent structures, pavements, public or private services. The Contractor shall establish an approved monitoring system and take regular readings and prepare and submit reports to the Engineer in the format and quantity as requested. The Contractor shall modify the method of construction if the effects of ground movement are detected in any such structures, pavements and services.

(2) The minimum clear working space inside a caisson (i.e. excluding the lining) shall not be less than 1.8m diameter. Caissons with an enlarged base shall not be used unless otherwise specified.

(3) Excavation for hand-dug caissons shall be carried out using manual methods or power tools. Blasting shall not be used unless permitted by the Engineer. If blasting is permitted:

(a) The position of blast holes and the size of charges shall be such that shattering of rock beyond the caisson is minimised,

(b) The rock face shall not be shattered within the toe-in or bell-out zone at the bottom of the caisson, and

(c) The caisson opening shall be covered to prevent the projection of fragments of material.

(4) The stability of excavations for hand-dug caissons shall be maintained where necessary by linings.

(5) In-situ concrete tapered rings used as permanent liners shall be at least 100 mm thick and shall not exceed 1 m deep. The rings shall be constructed with well-compacted concrete of Grade 20/20 or greater.

(6) Shaft linings shall be placed as soon as practicable and not more than 24 hours after each increment of excavation is complete.

(7) Voids between the lining and face of the excavation shall be filled with concrete of the same grade as the lining or with other materials agreed by the Engineer.

(8) Any unstable layers of subsoil encountered shall be stabilized by grouting or similar methods. No further excavation will be permitted until the stabilization works are completed.

Sealing and scaling of hand-dug caissons

8.55 Leakage of groundwater through liners or into unlined shafts of hand-dug caissons shall be stopped by a method agreed by the Engineer.

Loose rock on the faces of unlined shafts shall be scaled off and removed before concreting.

BARRETTES

Excavation for barrettes

8.56 (1) Excavation for barrettes shall be carried out by mechanical methods. Blasting shall not be used unless permitted by the Engineer.

(2) The stability of excavations for barrettes shall be maintained by a thixotropic slurry containing bentonite or other agent.

(3) The height of guide walls for barrettes shall be such that the head of slurry is sufficient to ensure the stability of excavations and that excessive movements of the adjacent ground will not occur. The position, alignment and level of guide walls shall be checked at regular intervals agreed by the Engineer.

(4) Diaphragm wall panels and barrettes shall not be excavated within a distance of 6m or equivalent to 3 times the smallest dimension of the panel or pile section (max. 8.4 m), from other deep foundation works which have been cast within 12 hrs and/or which contain workable or partially set concrete, unless they are separated by other deep concrete foundations completed for over 14 days or when their concrete has achieved 70% of the design strength, whichever is earlier.

MINIPILES

Excavation for minipiles

8.57 (1) The stability of excavations for minipiles shall be maintained where necessary by temporary casings or by other methods approved by the Engineer.

(2) Temporary casings shall be used if excavation is carried out by wash boring methods or when water or air is used as a flushing medium.

(3) The pressure of the water or air that is used as a flushing medium shall be regulated frequently to ensure that it does not induce significant disturbance to the surrounding geological strata, or cause hydraulic fracture of the ground.

(4) Unless otherwise specified in the Contract or instructed by the Engineer, mini-piles are to be socketed into Grade III rock or better with minimum total core recovery of not less than 90%. Minimum length of rock socket for the piles is shown on the Drawings or determined on Site by the Engineer.

Grouting trials for minipiles

8.58 Grouting trials shall be carried out to demonstrate accurate control of water/cement ratio, consistency of mixing, satisfactory workability and achievement of strength requirements. The trial shall be carried out on one minipile which is representative of those which will be used in the permanent work and at a location agreed by the Engineer.

CONSTRUCTION USING BENTONITE SLURRY

Excavation using bentonite slurry

8.59 (1) Excavations for piles using bentonite slurry shall be filled with the slurry from the time that excavation commences until concreting is complete. The slurry shall be maintained at a level of at least 1 m above the level of the external groundwater and such that the slurry pressure exceeds the pressure exerted by the soil and ground water.

(2) Subject to the Engineer's approval and the availability of the necessary equipment, the Contractor may use polymer slurry as an alternative to bentonite slurry. The handling and disposal of polymer slurry shall follow the supplier's recommendation and be subject to the Engineer's agreement.

(3) If there is a loss of bentonite slurry from the excavation, which is sufficient to result in a lack of stability, and if instructed by the Engineer, the excavation shall be immediately filled with material agreed by the Engineer. The cause of the loss of slurry shall be investigated and excavation shall not recommence until remedial measures have been approved by the Engineer.

Mixing of bentonite slurry 8.60 (1) Bentonite shall be thoroughly mixed with water in a colloidal mixer. The water shall be taken from the public supply of potable water and shall be at a temperature of at least 5°C. The temperature of the bentonite slurry shall be at least 5°C when supplied to the excavation.

(2) If the groundwater is excessively saline or chemically contaminated, the bentonite shall be prehydrated or the bentonite slurry shall be modified such that the slurry is suitable for the support of the excavation.

Protection of bentonite slurry material 8.61 All solid additives shall be stored in a separate waterproof store with a raised floor or in a waterproof silo, which shall not allow the material to become contaminated.

Disposal of bentonite slurry 8.62 Bentonite slurry that will not be reused shall be disposed of from the Site directly or mixed with sufficient decomposed rock or similar material before disposal to approved Public Fills as soon as practicable, in accordance with the requirements under the Construction Waste Disposal Charging Scheme and other relevant documents issued by the Civil Engineering and Development Department or Environmental Protection Department.

FIXING REINFORCEMENT FOR PILES

Fixing reinforcement for piles 8.63 Prefabricated reinforcement cages for piles shall be marked and fitted with spacers to ensure that the cage is correctly orientated and positioned within the pile. The reinforcement cage shall be lowered into position only in the daytime after the Engineer's Representative has verified both the length of the reinforcement cage and the depth of the hole and after the base has been cleaned.

Temporary protection on pile head 8.64 Reinforcement protruding above a concreted pile shaft shall be protected against corrosion with cement paste that shall be removed before subsequent construction works commence. If the protection period is longer than a few weeks, weak concrete should be used instead of cement paste.

PLACING CONCRETE IN PILES

Cleaning and drying excavations for piles

8.65 (1) The bases of excavations for piles shall be cleaned by air-lifting or by other methods agreed by the Engineer before concrete is placed. If excavation is carried out under water, cleaning shall continue until the water is clear and free of particles of soil. Measures shall be taken to prevent the accumulation of silt and other material at the base of the excavation. During the process of base-cleaning, the Contractor shall maintain a sufficient positive water head inside the borehole in order to prevent ingress of water from the outside.

(2) If the rate of ingress of water does not exceed 0.3 L/s, the base of excavations for piles shall be dried immediately before concrete is placed.

Placing concrete in piles

8.66 (1) Each pile shall be concreted as soon as practicable after the permission of the Engineer has been obtained. If a tremie pipe is used, it must be watertight and of sufficient strength. Before concreting commences, the Contractor shall submit a method statement of placing tremie concrete to the Engineer for approval. This statement should at least contain the proposals of the immersed depth of the tremie pipe below the upper surface of rising concrete, procedure of safely raising the tremie pipe as concreting proceeds, means of carrying out accurate measurement of the level of the rising concrete surface, etc. This method statement should also include a contingency plan of necessary measures that shall be taken to cater for any incident that the tremie pipe might become blocked or removed from the concrete.

(2) The concrete placed by tremie shall have a minimum designed slump value of 175 mm. The Contractor shall maintain efficient and effective communication with the concrete suppliers for ensuring sufficient workability and continuous supply of concrete throughout the process of concrete placing.

(3) If excavations for piles are supported by bentonite slurry or if the rate of ingress of water exceeds 0.3 L/s, the following shall be complied with:

(a) Concrete shall be placed by tremie unless otherwise permitted by the Engineer,

(b) The minimum cementitious content of the concrete shall be 375 kg/m^3,

(c) The level of the top of the concrete in piles shall be at least 750 mm above the specified cut-off level,

(d) If the top of the guide wall for barrettes is at the specified cut-off level, concrete shall continue to be placed until the top of the pile is free of contamination, and

(e) After the concrete has hardened, excess concrete shall be removed to the specified cut-off level.

(4) Operations that in the opinion of the Engineer are likely to disturb or affect the concrete or placing of the concrete shall not be carried out unless agreed by the Engineer.

Removal of temporary

8.67 (1) A sufficient quantity of concrete shall be maintained within temporary

casings to piles

casings that are being withdrawn to ensure that the pressure from external water or soil is exceeded and that the pile is not reduced in section or contaminated.

(2) Temporary casings which are in contact with concrete and which are not withdrawn before the initial set of the concrete has taken place shall be left in place.

Empty bores above piles

8.68 Empty bores and shafts which remain above the pile after concrete has been placed shall be temporarily protected or filled with material agreed by the Engineer as soon as practicable.

INSPECTION OF PILING WORKS

Inspection of excavations for piles

8.69 The Contractor shall allow the Engineer's Representative (ER) to inspect excavations for piles before placing concrete in the pile and at other times required by the Engineer. The ER shall decide on the most suitable method to be used for inspecting excavations (and the bases) and dipping the depth of the drilled hole personally and the Contractor shall provide all the necessary facilities and equipment to enable the ER to carry out the inspection/dipping in a safe manner. After the base of excavation has been cleaned as required by the Engineer, the Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before placing concrete in piles.

Inspection of installed piles

8.70 (1) If instructed by the Engineer, installed piles shall be exposed for inspection or testing. Excavations for exposing piles shall be of a depth agreed by the Engineer, and the face of the excavation shall be at least 750 mm from the face of the pile. The excavation shall be maintained in a stable condition and kept free of water.

(2) The surface of the pile shall be washed clean of all silt, mud or other adhering materials to permit inspection.

(3) After inspection, excavations for exposing piles shall be filled using special fill material that shall be compacted to obtain a relative compaction of at least 95% above the groundwater table.

TOLERANCES

Tolerances: steel bearing piles

8.71 Dimensional tolerances of steel bearing pile sections shall comply with the relevant standards stated in Table 2 of BS EN 1090:Part 2. Fabrication tolerances for steel bearing piles and related steelwork shall comply with BS EN 1090:Part 2.

Tolerances: precast concrete piles

8.72 The manufacturing tolerances for precast concrete piles shall comply with the following requirements:

(a) The external cross-sectional dimensions shall be within 0 mm and +6 mm of the specified dimensions.

(b) The wall thickness of hollow spun concrete piles shall be within 0 mm and +25 mm of the specified thickness.

(c) There shall be no irregularity exceeding 6 mm in a 3 m length along the face of the pile measured using a 3 m straight edge.

(d) There shall be no irregularity exceeding 25 mm in a 3 m length along the internal face of hollow spun concrete piles measured using a 3 m straight edge.

(e) The centroid of any cross-section of the pile shall not be more than 12 mm from the straight line connecting the centroids of the end faces of the pile. For the purpose of determining the centroid, the centroid of any cross-section of a hollow pile shall be determined by assuming that the pile has a solid section.

Tolerances: hand-dug caissons 8.73 The centre of each section of the shaft shall lie within 50 mm of the centreline of the whole shaft.

Tolerances: pile installations 8.74 (1) Piles, including hand-dug caissons and mini-piles, shall be installed to within the tolerances stated in Table 8.1.

(2) Piles that do not comply with the specified tolerances shall not be forcibly corrected.

Table 8.1: Tolerances of installed piles

Description	**Tolerance**	
	Land piles	**Marine piles**
Deviation from specified position in plan, measured at cut-off level	75 mm 15 mm for minipiles	150 mm
Deviation from vertical	1 in 75 1 in 100 for minipiles	1 in 25
Deviation of raking piles from specified batter	1 in 25	
Deviation from specified cut-off level	25 mm	
The diameter of cast in-situ piles shall be at least 97% of the specified diameter.		

RECORDS OF PILING WORKS

Records of piles delivered/constructed in situ 8.75 Records of prefabricated piles shall be kept by the Contractor on the Site and submitted to the Engineer at the time the piles are delivered to the Site. The records shall include test certificates, analyses and mill sheets for steel piles and proprietary piles. Records of cast-in-situ piles shall be signed by the Engineer after he has carried out the inspection/verification personally.

Records of pile driving 8.76 Records of pile driving shall be kept by the Contractor on the Site and submitted to the Engineer within 24 hours after the driving or installation of each pile has been completed. The records shall be kept on standard forms as shown in Appendices 8.2 to 8.5 and shall be available for inspection by the Engineer.

Records of bentonite slurry 8.77 Records of tests on bentonite slurry shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer at times agreed by the Engineer. The records shall be kept on standard forms as shown in Appendix 8.6 and shall be available for inspection by the Engineer.

Records of load tests on piles 8.78 Records of load tests on piles shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within 48 hours after the test has been completed. The records shall be kept on standard forms as shown in Appendix 8.7 and shall be available to the Engineer for inspection. The records shall include graphs showing load and settlement versus time, plotted in the format agreed by the Engineer.

Records of integrity tests on piles 8.79 Records of integrity tests on piles shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer not more than 3 days after the test has been completed. The records shall be available to the Engineer for inspection. The report shall contain the following details:

(a) Details stated in Clause 1.42,

(b) Pile reference numbers,

(c) Measured pile length,

(d) Defects such as cracks, fractures or discontinuities, and

(e) Pile stiffness.

Record drawings 8.80 Record drawings of installed piles shall be prepared by the Contractor and two copies shall be submitted to the Engineer within 14 days of completing the piles, including cutting and trimming, in each pile group or building block. The drawings shall include the as-constructed co-ordinates of the centre of each pile at cut-off level, the final depth and cut-off level of each pile and other information required by the Engineer.

Record of piling works 8.81 Within 14 days of completing the piles in each pile group or building block for minipiles, socketted steel H-piles and small-diameter bored piles, the Contractor shall submit to the Engineer a piling record plan showing the following:

(a) The top levels of the rock sockets;

(b) The bottom levels of the rock sockets;

(c) The lengths of the rock sockets; and

(d) The contours of the rock-head inferred from drill hole logs.

TESTING: LOAD TESTS ON PILES

Testing: load tests on 8.82 (1) The number of piles to be tested by load testing shall be as stated in

piles

the Contract, or as instructed by the Engineer.

(2) The piles shall be tested to determine the settlement of the pile under load. Testing shall be carried out in accordance with a procedure agreed by the Engineer. The method of testing shall be as stated in Appendix 8.1.

(3) Piles shall not be tested until the concrete or grout has attained sufficient strength to withstand the tests. The tests shall be carried out within 28 days of the Engineer's instruction to carry out the test unless otherwise agreed by the Engineer.

Compliance criteria: load tests on piles

8.83 Unless otherwise stated in the Contract, on completion of testing in accordance with Clause 8.82 the results of load tests on piles shall comply with the following requirements:

(a) The settlement at any load shall be less than twice the settlement at 90% of that load (Brinch Hansen's criteria),

(b) Under working load the gross pile head settlement shall not exceed 20 mm for buildings and 10 mm for other structures, and

(c) The preliminary pile shall have a factor of safety of at least 2.

Non-compliance: load tests on piles

8.84 If the result of any load test on piles does not comply with the specified requirements for settlement, the Contractor shall submit remedial proposals to the Engineer for approval.

Proof drilling

8.85 (1) Proof drilling shall be carried out on every large-diameter bored pile to check the condition at the concrete/rock interface. A base coring tube of at least 150 mm diameter shall be left at about 1000 mm above the founding level of the pile. The core-drilling shall be carried out to 1000 mm below the concrete/rock interface.

(2) Proof drilling shall be carried out to verify the adequacy of the socketted length of minipiles and socketted steel H-piles at locations as instructed by the Engineer. The number of proof drilling shall be at least 2 or 1% of the number of piles rounded up to the next higher whole number, whichever is the greater. The depths of the proof drill holes shall be at least 5 metres below the founding levels of the adjoining piles.

TESTING: CONCRETE CORES FROM PILES

Samples: concrete cores from piles

8.86 (1) The frequency of coring shall be 10% for barrettes and 5% for diaphragm wall panels, with minimum of 2 numbers or as instructed by the Engineer. The positions from which the cores are taken shall be as instructed by the Engineer.

(2) Concrete cores shall be 100 mm diameter.

(3) The method of taking concrete cores shall be in accordance with CS1.

(4) Holes formed by taking concrete cores from piles shall be reinstated using an approved concrete mix or an approved grout mix.

(5) Prestressed precast concrete piles from which concrete cores have

been taken shall be abandoned.

Testing: concrete cores from piles 8.87

(1) Each concrete core from a pile shall be inspected for evidence of segregation of the constituents and for the presence of voids. Specimens selected from each core shall be tested to determine the compressive strength. Each concrete core from a pile shall be inspected for evidence of segregation of the constituents and for the presence of voids. Specimens selected from each core shall be tested to determine the compressive strength.

(2) The method of preparing, inspecting and testing concrete cores shall be as stated in Clause 16.64(2).

Compliance criteria: concrete cores from piles 8.88

The compliance criteria for concrete cores from piles shall be as stated in Clause 16.65.

Non-compliance: concrete cores from piles 8.89

(1) If the result of any test on a concrete core from a pile does not comply with Clause 16.65 additional cores shall be taken from the same pile and additional tests shall be carried out.

(2) Additional concrete cores shall be 100 mm diameter for concrete of 20 mm nominal maximum aggregate size and 150 mm diameter for concrete of 40 mm nominal maximum aggregate size. The number of additional cores shall be as instructed by the Engineer.

(3) If the result of any additional test does not comply with the compliance criteria for concrete cores the Contractor shall submit remedial proposals to the Engineer for approval. The number of additional piles and additional tests shall be as instructed by the Engineer.

TESTING: NON-DESTRUCTIVE TESTS ON WELDS IN PILES

Testing: non-destructive tests on welds in piles 8.90

(1) The number and type of non-destructive tests on welds in piles shall be as stated in the Contract or instructed by the Engineer.

(2) Radiographic tests shall comply with BS EN ISO 17636 and ultrasonic tests shall comply with BS EN ISO 17640.

Non-compliance: non-destructive tests on welds in piles 8.91

If the result of any test on a weld in a pile does not comply with the specified requirements, the complete weld shall be cut out, the joint shall be re-welded and the weld shall be tested.

TESTING: INTEGRITY TESTS

Testing: integrity testing on piles and non-destructive integrity testing 8.92

(1) The number and type of integrity tests to be carried out on piles shall be as stated in the Contract.

(2) Integrity testing shall be carried out in sufficient time before the relevant piling works start to permit the tests to be carried out.

(3) The results of integrity tests shall be used to enable the Engineer to

select piles for further testing.

(4) Non-destructive integrity tests, if required, shall be carried out by an independent Testing Firm as agreed by the Engineer. The Contractor shall provide attendance and other preparatory works as required. The Contractor shall provide the Testing Firm with a copy of the ground investigation report, a Site plan showing bore hole locations and pile layout and a list of the piles to be tested with the date of concreting, total length, length of casing (if any), diameter and volume of concrete used plus any other relevant information required for the testing of the pile.

Non-compliance: integrity tests on piles

8.93 If the result of any integrity test on a pile does not comply with the specified requirements, additional tests shall be carried out. The number of additional tests shall be as instructed by the Engineer.

Sonic tests on bored cast-in-situ piles

8.94 (1) Before concreting, the Contractor shall install 4 nos. (which may be reduced to 3 nos. if the pile shaft is too congested to accommodate 4 nos.) watertight steel tubes of thickness not less than 2.5 mm and internal diameter not less than 42 mm and without internal projections over the full depth of each of the bored cast-in-situ piles.

(2) Sonic tests shall be carried out for all bored cast-in-situ piles unless otherwise agreed by the Engineer. An independent specialist-testing consultant appointed by the Contractor and approved by the Engineer shall conduct the tests to verify the homogeneity and integrity of the hardened concrete. The Contractor shall submit the proposed procedures for sonic tests to the Engineer for approval at least 14 days before concreting.

(3) The equipment for sonic testing shall consist of a signal transmitter probe and a signal receiver probe, which may be lowered into the tubes installed in the piles either in tandem or singly. The results of the sonic testing shall be displaced on a recording oscilloscope at the top of the pile.

(4) The signal emitted by the transducer shall be in the spectrum of 100Hz to 60kHz and of variable emission pulse rate between 1 and 20 cycles per second to suit the testing requirements.

(5) The recording oscilloscope shall be of the storage type with signal modulation representation of the received signal on a horizontal tracing: bright spots correspond to peaks and signal blanks to troughs.

(6) For one-tube installation, a single log shall be taken with probes set 1m apart in the same tube. For two or more tubes, measurements shall be taken between adjacent tubes plus one diagonal where applicable.

(7) The Contractor shall ensure that the probe matches the tube diameter to minimize concrete-tube-probe signal alternation or misleading results will arise.

(8) Results shall be in the form of time delay versus pile depth. The results shall be recorded on the oscilloscope screen and photographed. The testing consultant shall submit the test reports and photographic traces directly to the Engineer within 48 hours of making the tests. The submitted materials shall become the property of the Employer.

(9) Voids formed by the steel tubes shall be pressure-grouted in accordance with the Contract at such times as agreed with the Engineer.

(10) 3 sonic pipes are required if each diaphragm wall or barrette of dimension is less than 3 m long and a minimum of 6 sonic pipes is required if each diaphragm wall or barrette of dimension of more than or around 5.6 m. Sonic logging test shall be carried out for all barrettes and loading panels of diaphragm wall. The frequency of testing shall be minimum 10% for non-loading panels.

TESTING: BENTONITE SLURRY

Samples: bentonite slurry 8.95

(1) Samples of bentonite slurry shall be provided for testing at a frequency agreed by the Engineer. Samples for testing to determine the density of the slurry shall be provided each day. A sample of bentonite slurry taken from the base of the excavation shall be tested to determine the density of the slurry before placing of concrete.

(2) The method of sampling and the sampling apparatus shall be as agreed by the Engineer.

Testing: bentonite slurry 8.96

(1) Each sample of bentonite slurry shall be tested to determine the properties as stated in Tables 8.2A, 8.2B, 8.2C and 8.2D.

(2) The method of testing shall be as stated in Table 8.2.

(3) The measuring device for testing density shall be readable and accurate to ± 0.005 g/mL.

(4) Samples to be tested for viscosity using the Fann viscometer shall be screened before testing using a 300 μm BS test sieve.

Compliance criteria: bentonite slurry 8.97

(1) The results of tests on bentonite slurry shall be as stated in Table 8.2.

(2) Tests to determine the shear strength and pH value shall be discontinued if the results of tests indicate that a consistent working pattern has been established, taking account of the mixing process, blending of freshly mixed and previously used slurry and processes used to remove impurities from previously used slurry. If there is a subsequent change in the established working pattern, the tests to determine shear strength and pH value shall be reintroduced unless otherwise permitted by the Engineer.

Non-compliance: bentonite slurry 8.98

If the results of tests for density, viscosity, filter cake, sand content or fluid loss do not comply with the specified requirements, or if the results of tests for shear strength or pH value do not indicate a consistent working pattern, the bentonite slurry shall be deemed unsuitable for the work and concrete shall not be placed in the slurry. The slurry shall be replaced or its composition adjusted before concrete is placed.

Table 8.2(A) Fresh Bentonite

Property	Test Results	Method of Testing
Density	＞1.015 g/mL	Mud density balance
Fluid loss	≤25 mL	Refer to API Recommended Practice: RP13B-1
Viscosity	≤35 s	Marsh cone method
pH value	8.5-10.5	pH indicator paper strips or electrical pH meter
Filter cake	≤1 mm	Refer to API Recommended Practice: RP13B-1

Table 8.2(B) Bentonite during excavation

Property	Test Results	Method of Testing
Density	1.08-1.15 g/mL	Mud density balance
Fluid loss	＜45 mL	Refer to API Recommended Practice: RP13B-1
pH value	8-11	pH indicator paper strips or electrical pH meter
Filter cake	≤5 mm	Refer to API Recommended Practice: RP13B-1

Table 8.2(C)Bentonite prior to concreting

Property	Test Results	Method of Testing
Density	≤1.15 g/mL	Mud density balance
Fluid loss	≤40 mL	Refer to API Recommended Practice: RP13B-1
Viscosity	≤40 s	Marsh cone method
pH value	8-11	pH indicator paper strips or electrical pH meter
Filter cake	≤5 mm	Refer to API Recommended Practice: RP13B-1
Sand content	≤3%	Refer to API Recommended Practice: RP13B-1

Table 8.2(D) Bentonite prior to re-use

Property	Test Results	Method of Testing
Density	≤1.3 g/mL	Mud density balance
Fluid loss	≤50 mL	Refer to API Recommended Practice: RP13B-1
Viscosity	≤50 s	Marsh cone method
pH value	7.5-11.5	pH indicator paper strips or electrical pH meter
Filter cake	≤ 5 mm	Refer to API Recommended Practice: RP13B-1

(Note1: API = The American Petroleum Institute)

APPENDIX 8.1

DETERMINATION OF THE SETTLEMENT OF PILES BY LOAD TEST

Scope 8.1.1 This method covers the determination of the settlement of piles by means of a load test.

Equipment 8.1.2 The following equipment is required:

(a) Kentledge, anchor piles or other anchorages supported or installed at suitable locations to provide adequate reactions against jacking.

(b) A load-measuring device which shall consist of a load column, pressure cell, or other appropriate system, calibrated before and after each series of tests, or whenever adjustments are made to the device, or at time intervals recommended by the manufacturer of the equipment.

(c) Four deflectometers accurate to 0.025 mm.

(d) Precision levelling equipment accurate to 0.25 mm.

(e) A reference frame for supporting deflectometers and providing a datum for deflectometer measurements.

(f) Working platforms.

(g) Screens and protection from exposure to conditions which may affect the test.

(h) Hydraulic loading equipment.

Procedure: before testing 8.1.3 The procedure before testing shall be as follows:

(a) The kentledge, anchor piles or other anchorages shall be installed. The centre of each anchor pile shall be at least 2 m or three times the pile diameter, whichever is greater, from the centre of the pile to be tested and from the centre of any adjacent pile.

(b) If required, the pile to be tested shall be extended from cut-off level to ground level. The strength of piles at joints shall not be less than any normal section of the pile.

(c) A temporary square pile cap designed by the Contractor shall be constructed.

(d) Working platforms, screens and protection shall be installed.

(e) The reference frame shall be set up on supports which are at least 2 m or three times the pile diameter, whichever is greater, from the test pile and anchor pile. The four deflectometers shall be mounted on the reference frame to measure the deflection of the four corners of the temporary pile cap.

Procedure: load test 8.1.4 The procedure for the load test shall be as follows:

(a) Preliminary piles shall be tested to not less than twice the working load of the pile or other loads stated in the Contract. Working piles shall be tested to not less than 1.8 times working load. Reductions for group or boundary effects shall not be made in determining the test loads.

(b) Test loads shall be applied and removed in three stages as stated in Table 8.1.1.

(c) Unless otherwise permitted by the Engineer, the test loads shall be applied in increments, and removed in decrements, of 25% of the working load. Increments of load shall not be applied until the rate of settlement of the pile is less than 0.1 mm in 20 minutes.

(d) The full test loads for Stage I shall be applied in increments and shall then be maintained for at least 24 hours after the rate of settlement has reduced to less than 0.1 mm per hour. The test loads shall be removed in decrements and the recovery of the pile determined before loading is resumed.

(e) The procedure stated in Clause 8.1.4(d) shall be repeated for Stage II loading.

(f) The procedure stated in Clause 8.1.4(d) shall be repeated for Stage III loading unless the Engineer instructs the loading to be maintained for a longer period.

(g) The settlement of the pile shall be measured at hourly intervals or other intervals agreed by the Engineer. The settlement of the pile under each increment and decrement of loading shall be measured. The exact times at which increments are applied and decrements are removed shall be recorded. Settlements shall be measured and times shall be recorded in the presence of the Engineer.

(h) The level of the reference beam shall be checked at regular intervals agreed by the Engineer during the test.

Table 8.1.1: Test loading stages

Stage	**Test load**
I	25% of max. test load
II	50% of max. test load
III	100% of max. test load

Procedure: after testing 8.1.5 After testing, equipment shall be removed, temporary pile caps shall be demolished and pile extensions shall be removed to cut-off level. Unless otherwise permitted by the Engineer, anchor piles shall be withdrawn.

Reporting of results 8.1.6 The following shall be reported:

(a) The loads applied to the nearest 0.05 t.

(b) The settlement of the pile to the nearest 0.05 mm at hourly intervals and under each increment and decrement of loading.

(c) The exact times at which increments were applied and decrements removed.

(d) The levels of the reference beam, to the nearest 0.05 mm.

APPENDIX 8.2

PILE DRIVING RECORD

(Precast concrete, prefabricated steel and driven cast-in-place piles)

Contract No. ______________________________ Title ____________________________________

Contract No. ____

Pile data

Reference No. _____________________________ Location _________________________________

Type ______________________ Size _______________________ Rake ______________________

For precast concrete and steel piles; Preformed length ________________________________

For precast concrete piles; Date of casting ____

Drive system data

Hammer: type ________ mass ________ kg drop (at set) ___________ mm rated energy ________ kJ

Helmet, dolly & anvil: type ___________________________ mass _________________________ kg

Packing: type _______________ Condition _______________ thickness ____________________ mm

Levels

Commencing ground/sea bed* level (PD/CD)* ____

Depth of overburden/height of working platform above sea bed level ______________________

Reference working level/platform level* ____

Date & Time	Drop (m)	Depth penetrated (m)	No. of blows +	Cumulative No. of blows	Length of individual segments, location of splices and tests carried out	Remarks (State details of obstruction, delays, interruptions and location of concrete samples)++

\+ per 0.25 m for top 3.0 m of pile
++ for cast in place piles

(*delete as appropriate)

PILE DRIVING RECORD

(Precast concrete, prefabricated steel and driven cast-in-place piles)

Temporary compression record (on graph paper graduated in millimetres to be pasted in space below)

Final penetration depth ______________________mm

Temporary compression ______________________mm

Final set ______________________mm/last 10 blows

or ______________________blows/25 mm

Deviation from plumb or rake 1 in _______________

Top of pile level ______________________

Cut off level

Pile head level ______________________

Final toe level ______________________

Deviation at cut-off level x-x _________mm

y-y _________mm

For driven cast-in place piles:

Length of temporary casing _____________m

Length of permanent casing ______________m

Length of cage reinf. ____________________m

Concrete grade __________________

Date of concreting ______________________________________

Theoretical volume of concrete required ________________________________m^3

Actual volume of concrete placed ______________________________m^3

Reported by ___________________________
Contractor's Representative

Verified by _____________________________________
*IOW / Engineer / Architect

Date __________________________________

Date ____

(*delete as appropriate)

APPENDIX 8.3

PILE DRIVING RECORD

(Bored cast-in-place piles)

Contract No. ________________________ Title ____________________________

Contractor ____

Pile data

Reference No. ________________________ Location ________________________

Type __________ Diameter _______ mm Design Length ___________ mm Rake 1 in _______

Bore hole record

Commencing ground/sea bed* level (P.D./C.D.)* ______________________________

Depth of overburden/height of working platform above sea bed level ____________________ m

Casing/drilling fluid* type ________________________

Reference working level/platform level* ________________________

Date & Time	Depth penetrated	Details of strata penetrated/ground water level	Details of soil testing, proving of bedrock and under-ream	Remarks (State details of obstruction, delays interruptions, and location of concrete samples)

Deviation from plumb or rake 1 in __________ Deviation at cut-off level x-x ______________

y-y ______________

Length of temporary casing ______________ m Length of permanent casing ______________ m

(*delete as appropriate)

PILE DRIVING RECORD

(Bored cast-in-place piles)

Bore hole condition before concreting

Bottom Visible/invisible* Measured depth of bore ________________________ m

Depth of water/drilling fluid* ________________________ m

Damage and debris observations ________________________

Concrete record

Concreting in dry/by tremie* Water inflow rate ____________ litres/second

Concrete grade ____________ Slump ____________

Actual concreted level ____________ Cut off level ____________

Overall $\frac{Lt}{La}$ = ____________ %

Length of cage reinforcement ____________ m

Date & Time	Delivery note No./ Truck load No.	Quantity (m^3)	Theoretical length filled Lt (m)	Actual Length Placed La (m)	$\frac{Lt}{La}$ %	Cumulative length placed (m)	Remarks (Interruptions in placing, cause of excessive $\pm\frac{Lt}{La}$ %, Location of concrete samples, Ref. No. of cubes taken, etc.)

Reported by ____________________
Contractor's Representative

Verified by ____________________
*IOW / Engineer / Architect

Date ____________________

Date ____________________

Note: The Engineer shall be informed of any deviation greater than ±10% from the expected (theoretical) level of concrete placed.

(*delete as appropriate)

APPENDIX 8.4

PILE RECORD

(Piles cast in-hand-dug Caissons)

Contract No. ______________________ Title ______________________

Contractor ____

Pile data

Reference No. ______________________ Location ______________________

Caisson Type ______________ Diameter __________ mm Design Length __________ mm

Excavation Data

Commencing ground level (PD) ______________ Depth of overburden ______________ m

Date	Depth reached (m)	Details of Strata penetrated/surrounding ground water level	Details of soil testing, proving of bedrock, and under-ream	Remarks (State details of obstructions, interruptions and delays)

Deviation from plumb 1 in ______________ Deviation at cut-off level x-x ____________ mm

y-y ____________ mm

Bedrock level* ______________________ Water level* ______________________

Base level of shaft ______________________ Diameter of bell-out* ______________ mm

Length of toe-in* ______________ mm Depth of bell-out ______________ mm

* If none write ‘N/A’

PILE DRIVING RECORD

(Piles cast in hand-dug caissons)

Concrete record

Concreting in dry/by tremie* Water inflow rate ________________ litres/second

Concrete grade ______________________ Slump ______________________

Actual concreted level ______________________ Cut off level ______________________

Overall $\frac{Lt}{La}$ = ______________________ %

Length of cage reinforcement ________________ m

Date & Time	Delivery note No./ Truck load No.	Quantity (m^3)	Theoretical length filled Lt (m)	Actual Length Placed La (m)	$\frac{Lt}{La}$ %	Cumulative length placed (m)	Remarks (Interruptions in placing, cause of excessive $\pm\frac{Lt}{La}$ %, Location of concrete samples, Ref. No. of cubes taken, etc.)

Reported by ______________________
Contractor's Representative

Verified by ______________________
*IOW / Engineer / Architect

Date ______________________

Date ______________________

Note: The Engineer shall be informed of any deviation greater than ±10% from the expected (theoretical) level of concrete placed.

(*delete as appropriate)

APPENDIX 8.5

PILE RECORDS

(Barrettes)

Contract No. ____________________ Title ____

Contractor ____

Pile data

Reference No. ______________________________ Location ____

Size of barrette ________________________________ Shape ____

Design Length ___________________________________ m

Excavation Data

Commencing ground level (PD) ____________________ Depth of overburden ______________________ m

Guide wall levels: top ____________________________ bottom ___________________________________

Date	Depth reached (m)	Details of Strata penetrated/surrounding ground water level	Details of soil testing, proving of bedrock, and under-ream	Remarks (State details of obstructions, interruptions and delays)

Deviation from plumb 1 in ____________________ Deviation at cut-off level x-x _________________ mm

y-y _________________ mm

Base level of excavation ________________________

Depth of base from top of guide wall ______________________________ m

PILE RECORD

(Barrettes)

Concrete record

Concrete grade ______________________ Slump ______________________

Actual concreted level ______________________ Cut off level ______________________

Overall $\frac{Lt}{La}$ = ______________________ %

Length of cage reinforcement ______________ m

Date & Time	Delivery note No./ Truck load No.	Quantity (m^3)	Theoretical length filled Lt (m)	Actual Length Placed La (m)	$\frac{Lt}{La}$ %	Cumulative length placed (m)	Remarks (Interruptions in placing, cause of excessive $\pm\frac{Lt}{La}$ %, Location of concrete samples, Ref. No. of cubes taken, etc.)

Reported by ______________________ Verified by ______________________

Contractor's Representative *IOW / Engineer / Architect

Date ______________________ Date ______________________

Note: The Engineer shall be informed of any deviation greater than ±10% from the expected (theoretical) level of concrete placed.

(*delete as appropriate)

APPENDIX 8.6

BENTONITE SLURRY RECORD

Contract No. ____________________ Title ____

Contractor ____

Sample data

Ref. No. of pile ____________________________ Location ______________________________

Source of test sample:
(a) freshly mixed slurry*
(b) as supplied to excavation*
(c) from bottom of excavation before placing concrete

Date & time of sampling ____

	Test Method and Apparatus Used	Test Result
Density (g/mL)		
Viscosity (seconds)		
pH		
Sand Content (%)		
Fluid Loss (mL)		
Temperature (°C)		
Filter Cake (mm)		

Remarks:- ____

____

____

____

____

Reported by ____________________________ Verified by ____________________________
Contractor's Representative *IOW / Engineer / Architect

Date ____________________________ Date ____________________________

(*delete as appropriate)

APPENDIX 8.7

PILE LOAD TEST RECORD

(Test result)

Contract No. ______________________ Title ______________________

Contractor ____

Pile data

Reference No. ______________________ Location ______________________

Type ______________________ Size ______________________

Pile dia/diagonal width (D) ______________________ Cross pile length (Lp) ______________________

Sectional area (A) ______________________ Young's modulus (E) ______________________

Testing data

Design working load (P) ____

Test load (Q) = 2 (P) ______________________

Pressure gauge No. __________ Calibration Certificate ref. __________ Date __________

Dial gauge number	1	2	3	4
Serial number				
Calibration certificate ref.				
Date of calibration				

Level of fixed point on load reaction system: before testing ______________________

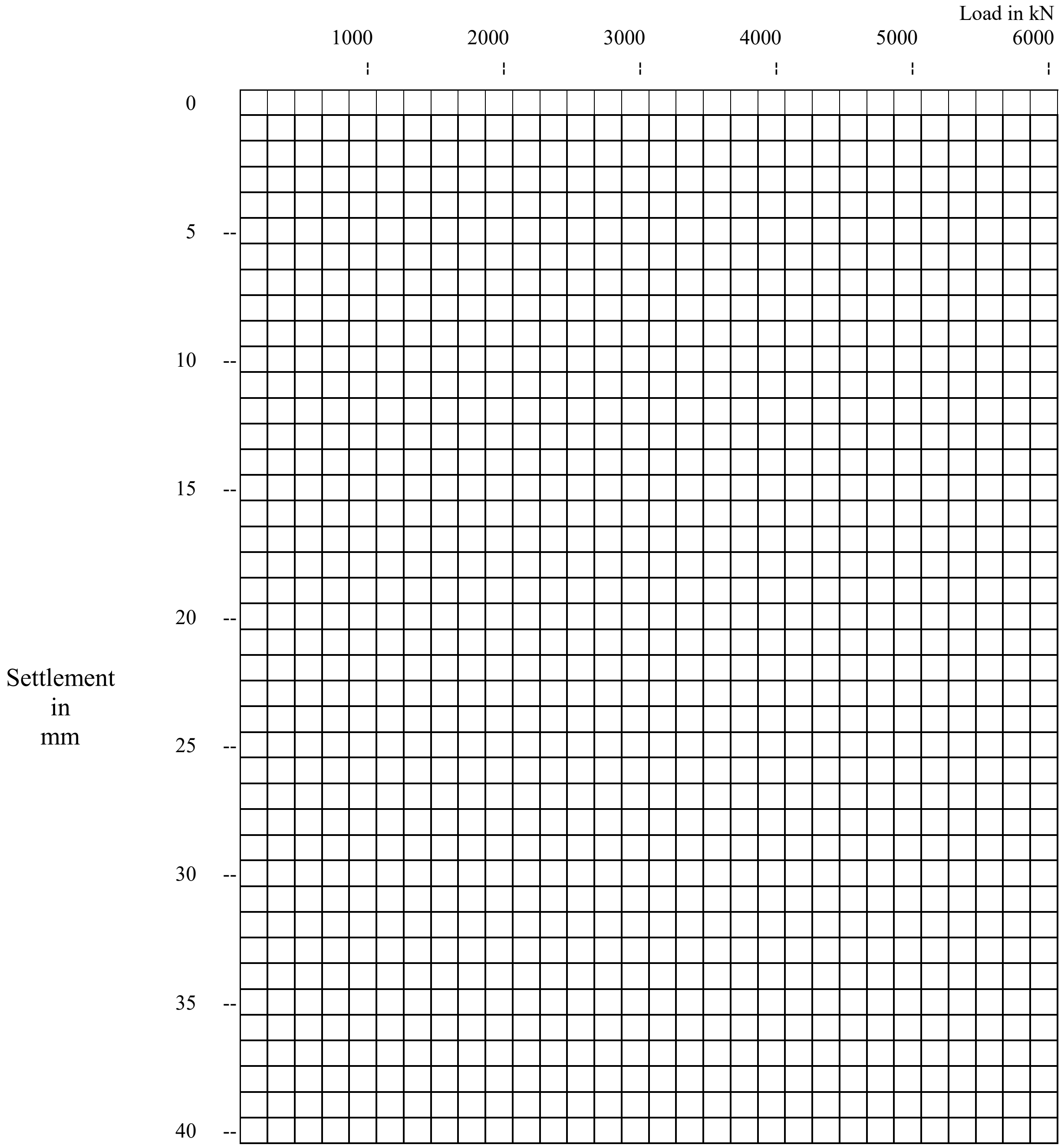
after testing ______________________

ground settlement = ______________________

Date & Time	Load (kN)	Pressure Gauge Reading	Dial Gauge Readings					Cumulative Settlement (mm)	Remarks
			Dial 1	Dial 2	Dial 3	Dial 4	Average		

PILE LOAD TEST RECORD

(Testing result)



Maximum settlement at working load: (Allowable = 20 mm for buildings and 10 mm for all other structures.)

Actual = ____________________________

Settlement at maximum test load (S_1): (Allowable = S_1 less than twice settlement at 90% of maximum test load ($2S_2$).)

Actual S_1 = ____________________________ $2S_2$ = ____________________________

Reported by ____________________________
Contractor's Representative

Verified by ____________________________
*IOW / Engineer / Architect

Date ____________________________

Date ____________________________

(*delete as appropriate)

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 9

CARRIAGEWAYS: SUB-BASE MATERIAL AND

BITUMINOUS MATERIALS

SECTION 9

CARRIAGEWAYS: SUB-BASE MATERIAL AND BITUMINOUS MATERIALS

GLOSSARY OF TERMS

Nominal maximum aggregate size 9.01 Nominal maximum aggregate size is the smallest BS sieve size for which the upper limit of the percentage of the aggregate by mass passing is 100%.

MATERIALS

Sub-base material using virgin material 9.02 Sub-base material shall be crushed rock and shall have the properties stated in Table 9.1. Sub-base material passing the 425 μm BS test sieve, when tested in accordance with Clause 9.46(4) shall be non-plastic.

Recycled sub-base material in lieu of virgin material 9.03 (1) Recycled sub-base material shall be crushed rock, crushed concrete or clean crushed inert demolition material and may contain up to 12.5 % by mass of natural sand which passes the 5mm BS test sieve. The material shall lie within the grading limits of Table 9.1, and not be gap graded.

(2) The material shall have a ten per cent fines value of 50 KN or more when tested in accordance with Clause 9.47(3).

(3) The material passing the 425μm BS test sieve shall be non-plastic when tested in accordance with Clause 9.47(4).

(4) The aggregate shall be considered suitable if it has a soundness value greater than 65%.

(5) The material shall have a water-soluble sulphate content of less than 1.9g of sulphate (expressed as SO_3) per litre, if used within 500mm of cement-bound material, concrete pavements, concrete structures or concrete products.

(6) The material shall have a minimum laboratory California Bearing Ratio (CBR) value of 30% or such other higher value as specified by the Engineer.

(7) The material shall not contain quantities of contaminants in excess of the percentages given in Table 9.2 unless otherwise approved by the Engineer.

(8) Notwithstanding the above sub-clauses, the Contractor may propose for the Engineer's approval the use of virgin aggregates in lieu of recycled aggregates in the sub-base material when there is a shortage of supply of recycled aggregates.

Table 9.1: Properties of sub-base material

Properties	BS test sieve	Percentage by mass passing
Particle size distribution	75 mm 37.5 mm 20 mm 10 mm 5 mm 600 µm 75 µm	100 85 - 100 60 - 85 40 - 70 25 - 45 8 - 22 0 - 10
Ten per cent fines value		> 50 kN

Table 9.2: Allowable contamination of recycled sub-base material

Sub-base type	Type of contamination			
	Maximum sulphate content by mass	Maximum metals content by mass	Maximum foreign material content e.g. glass, soft material, etc. by mass	Maximum organic material content by mass
Recycled sub-base	1%	1%	1%	0.5%

Aggregates for bituminous materials

9.04 (1) Coarse aggregate for bituminous materials shall be crushed rock all retained on a 5 mm BS test sieve and shall have the properties stated in Table 9.3.

(2) Fine aggregate for bituminous materials shall be crushed rock all passing 5 mm BS test sieve. The water absorption of fine aggregate shall not exceed 2.0%.

(3) For the purpose of mix design, the combined grading of aggregates for bituminous materials shall be such that the particle size distribution lies within the limits stated in Table 9.4 for the relevant bituminous material.

Table 9.3: Properties of coarse aggregate for bituminous materials

Properties	Nominal maximum aggregate size (mm)			
	37.5	**28**	**20**	**10**
Flakiness index	≤ 25.0%	≤ 26.0%	≤ 27.0%	≤ 30.0%
Ten per cent fines value	> 100 kN			
Water absorption	≤ 2.0%			

Table 9.4: Design limits for particle size distribution and bitumen content for bituminous materials

Properties		Type of bituminous material					
		Roadbase (recipe mix)	**Base course**		**Wearing course**		**Polymer modified friction course**
Nominal maximum Aggregate size (mm)		37.5	37.5	28	20	10	10
Particle size distribution	BS test sieve	Percentage by mass passing					
	50 mm	100	100	-	-	-	-
	37.5 mm	90 - 100	91 - 100	100	-	-	-
	28 mm	70 - 94	70 - 94	91 - 100	100	-	-
	20 mm	62 - 84	62 - 84	85 - 95	91 - 100	-	-
	14 mm	-	55 - 76	72 - 87	78 - 90	100	100
	10 mm	49 - 67	49 - 67	55 - 75	68 - 84	87 - 100	85 - 100
	5 mm	37 - 55	37 - 55	35 - 53	54 - 72	62 - 80	20 - 40
	2.36 mm	27 - 43	27 - 43	25 - 40	42 - 58	42 - 58	5 - 15
	1.18 mm	-	20 - 35	15 - 30	34 - 48	34 - 48	-
	600 μm	13 - 28	13 - 28	12 - 24	24 - 38	24 - 38	-
	300 μm	7 - 21	7 - 21	8 - 18	16 - 28	16 - 28	-
	150 μm	-	4 - 14	5 - 12	8 - 18	8 - 18	-
	75 μm	2 - 8	2 - 8	3 - 6	4 - 8	4 - 8	2 - 6
Bitumen content as percentage of total mass including binder	min.	3.0	4.0	4.5	5.0	6.0	5.5
	max.	4.0	4.5	5.0	5.5	7.0	7.0

Filler for bituminous materials 9.05

(1) Filler for bituminous materials shall be crushed rock filler, PC, PFAC, PFA or hydrated lime. Filler shall be free-flowing and dry before addition to the bituminous mixture.

(2) Filler for polymer modified friction course material shall contain hydrated lime. The amount of hydrated lime, expressed as a percentage by mass of the total aggregates, shall be at least 1.5%.

(3) PC and PFAC shall comply with BS EN 197:Part 1.

(4) PFA shall comply with BS EN 450:Part 1 except that the criterion for maximum water requirement shall not apply.

(5) Crushed rock filler and hydrated lime shall comply with ASTM D 242.

Bitumen 9.06 (1) Bitumen for bituminous materials other than polymer modified friction course material shall comply with ASTM D 946, Grade 60-70 and shall have a softening point exceeding 44°C and less than 55°C. The wax content of the bitumen shall comply with requirements for Grade A specified in JTG F40-2004. Unless otherwise permitted by the Engineer, blending or mixing of bitumen shall be carried out at a refinery approved by the Engineer.

(2) Bitumen for polymer modified friction course material shall be polymer modified bitumen that shall be a pre-blended type bitumen with Styrene-Butadiene-Styrene (SBS) polymer manufactured by the wet mix method unless otherwise approved by the Engineer. Dry mix method for mixing the bitumen and polymer in the batching plant shall not be allowed. The polymer modified bitumen shall have a performance grade not lower than PG 76 of the Performance Graded Asphalt Binder Specification specified by the AASHTO Designation M320.

Bituminous emulsion 9.07 Bituminous emulsion shall be cationic bituminous emulsion complying with BS EN 13808, Class C40B4.

Bituminous priming material 9.08 Bituminous priming material shall be medium curing-grade cutback bitumen complying with ASTM D 2027, Table 1, Class MC-30.

DESIGN OF SUB-BASE MATERIAL AND BITUMINOUS MATERIALS

Design procedure for sub-base material and bituminous materials 9.09 (1) Sub-base material and bituminous roadbase materials shall be recipe mixes. Laboratory design mixes other than those for sub-base material and bituminous roadbase materials shall be made and tested as part of the design procedure at a laboratory approved by the Engineer.

(2) Unless otherwise permitted by the Engineer, mix designs and associated tests shall be carried out by the Contractor in the presence of the Engineer. The Contractor shall notify the Engineer at least 7 days, or such shorter period agreed by the Engineer, before carrying out the mix designs.

(3) The Amd 1/2021 Contractor shall Amd 1/2021 use bituminous roadbase material incorporating reclaimed asphalt pavement (RAP) in Amd 1/2021 carriageway works. The specific requirements are as follows: -

(a) Roadbase incorporating RAP shall be designed, manufactured, laid and tested in accordance with the requirements for roadbase using non-recycled materials or otherwise specified by the Engineer. Failure in designing and manufacturing a mix satisfying such requirements shall not be accepted as a valid reason for not incorporating RAP in bituminous roadbase material. Amd 1/2021

(b) The RAP shall comply with the following:

(i) RAP shall be obtained from milling or excavation of existing bituminous pavements, and return loads from site and offcuts from bituminous layer joint preparation. Return loads can include bituminous materials rejected from site. RAP shall be crushed and screened as necessary such that the maximum particle size is not greater than the nominal maximum aggregate size of the type of Amd 1/2021 bituminous Amd 1/2021 materials being produced and a reasonably well-graded and consistent mixture can be produced.

(ii) RAP shall be free of foreign materials such as unbound granular sub-base, broken concrete, or other contaminants.

(iii) RAP shall be stored in separate stockpiles before use. RAP that has been stockpiled for some time shall be reprocessed, where necessary, to ensure that it is in a free-flowing state at the time of use.

(iv) The Amd 1/2021 amount of RAP allowable in the bituminous roadbase material shall be in the range of 10% to Amd 1/2021 15% by mass of the total mix. Separate mix designs shall be required for roadbase materials incorporating RAP.

(c) Notwithstanding the above clauses, the Contractor may propose for the Engineer's approval for using bituminous roadbase material without RAP when there is a shortage of supply of RAP in the market.

(4) The Contractor shall appoint a Production Manager employed by the supplier as approved by the Engineer, certifying that the specified amount of RAP is added to the bituminous material according to the mix design. All certified documents shall be submitted bi-weekly to the Engineer for verification and record. The Production Manager shall be personally responsible to certify that RAP is added for the production of the recycled bituminous materials. He shall be an experienced person with at least seven years of experience in bituminous material production or having a recognized professional qualification such as MHKIE or equivalent. The bituminous materials incorporating RAP supplied by the supplier shall not be used if the Contractor fails to appoint the Production Manager.

(5) The Contractor shall work out and submit to the Engineer for approval a method statement to ensure that the RAP generated from existing pavements are delivered, stored and used with no contamination and minimum wastage in order to produce the bituminous materials incorporated with RAP as specified. The Contractor shall at all times facilitate the inspection by the Engineer on the production of recycled bituminous materials, storage and sorting facilities for RAP. Amd 1/2021

Design of bituminous materials 9.10 (1) Bituminous materials shall consist of coarse and fine aggregates complying with Clause 9.04, filler complying with Clause 9.05 and bitumen complying with Clause 9.06. The different types of bituminous materials shall have particle size distributions and bitumen contents within the limits stated in Table 9.4.

(2) The Contractor shall use bituminous wearing course and base course materials incorporating reclaimed asphalt pavement (RAP) for carriageway works. The RAP and production of bituminous materials incorporating RAP shall comply with Clauses 9.09 (4) and (5). The specific requirements are as follows:-

(a) Wearing course and base course materials incorporating RAP shall be designed, manufactured, laid and tested in accordance with the requirements for these materials using non-recycled materials or otherwise specified by the Engineer. Failure in designing and manufacturing a mix satisfying such requirements shall not be accepted as a valid reason for not incorporating RAP in bituminous wearing course and base course materials.

(b) The RAP shall comply with the following:

(i) RAP shall be obtained from milling or excavation of existing bituminous pavements, and return loads from site and offcuts from bituminous layer joint preparation. Return load can include bituminous materials rejected from site. RAP shall be crushed and screened as necessary such that the maximum particle size is not greater than the nominal maximum aggregate size of the type of bituminous materials being produced and a reasonably well-graded and consistent mixture can be produced.

(ii) RAP shall be free of foreign materials such as unbound granular sub-base, broken concrete, or other contaminants.

(iii) RAP shall be stored in separate stockpiles before use. RAP that has been stockpiled for some time shall be reprocessed, where necessary, to ensure that it is in a free-flowing state at the time of use.

(iv) The amount of RAP allowable in the bituminous wearing course or base course materials shall be in the range of 20% to 30% by mass of the total mix. Separate mix designs shall be required for these materials incorporating RAP.

(c) Notwithstanding the above clauses, the Contractor may propose for the Engineer's approval for using bituminous wearing course or base course materials without RAP when there is a shortage of supply of RAP in the market. Amd 1/2021

(3) The properties of the different types of bituminous materials shall be as stated in Table 9.5.

(4) Bituminous materials of all aggregate sizes, other than bituminous roadbase material, shall be designed in accordance with the Marshall Method of Mix Design stated in The Asphalt Institute Handbook 'MS-2 Mix Design Methods for Asphalt Concrete and other Hot-mix Types, Sixth Edition (1997)' with modifications only if agreed by the Engineer. The Amd 1/2021 compaction standard shall be 75 blows per side. Amd 1/2021 For design of polymer modified friction course materials Amd 1/2021, the compaction standard shall be 50 blows per side unless otherwise agreed by the Engineer. The mixing and compaction temperatures for the mixes shall follow the recommendations of the manufacturer of the polymer modified bitumen.

(5) For polymer modified friction course material, binder drainage tests in accordance with BS 594987, Annex K shall be carried out on the proposed aggregate/modified binder combination to determine the maximum target binder content (T_{max}) of the mix. The proposed mix will be acceptable if the maximum target binder content (T_{max}) is equal to or greater than the proposed binder content.

Table 9.5: Properties of designed bituminous materials

Properties	Type of bituminous material				
	Base course		Wearing course		Polymer modified friction course
	Nominal maximum aggregate size (mm)				
	37.5	**28**	**20**	**10**	**10**
Minimum Marshall stability (kN)	10.0		10.0		-
Maximum flow value (mm)	4.0		4.0		-
Minimum voids in mineral aggregate as a percentage of total bulk volume	12.5	13.0	14.0	16.0	-
Air voids in mix as a percentage of total bulk volume	3.0 - 5.0		3.0 - 5.0		min. 20.0

SUBMISSIONS

Particulars of aggregate, filler, bitumen, bituminous emulsion and bituminous priming material for bituminous materials

9.11 (1) The following particulars of the proposed aggregate, filler, bitumen, bituminous emulsion and bituminous priming material for bituminous materials shall be submitted to the Engineer for approval:

(a) A certificate from the manufacturer for each type of aggregates showing the manufacturer’s name and place of manufacture and showing the aggregate complies with the requirements stated in the Contract,

(b) A certificate from the manufacturer for each type of filler showing the manufacturer's name, the date and place of manufacture and showing that the filler complies with the requirements stated in the Contract and including results of tests for particle size distribution,

(c) A certificate from the manufacturer for bitumen other than polymer modified bitumen showing the manufacturer's name, the date and place of manufacture and showing that the bitumen complies with the requirements stated in the Contract, including a temperature-viscosity relationship for the bitumen, and including results of tests for:

- Relative density
- Softening point
- Penetration
- Ductility
- Retained penetration after thin film oven test
- Solubility
- Viscosity

- Loss on heating
- Wax

(d) A certificate from the manufacturer for polymer modified bitumen showing the manufacturer's name, the date and place of manufacture and showing that the polymer modified bitumen complies with the requirements in Clause 9.06(2),

(e) A certificate from the manufacturer for bituminous emulsion showing the manufacturer's name, the date and place of manufacture and showing the bituminous emulsion complies with the requirements stated in the Contract, and

(f) A certificate from the manufacturer for bituminous priming material showing the manufacturer's name, the date and place of manufacture and showing the bituminous priming material complies with the requirements stated in the Contract.

(2) The particulars, including certificates, shall be submitted to the Engineer at the time stated in Clause 9.12(3).

(3) Further certificates showing that the materials comply with the specification shall be submitted at intervals agreed by the Engineer.

Particulars of mixes for sub-base material and bituminous materials 9.12

(1) The following particulars of sub-base material and bituminous roadbase materials shall be submitted to the Engineer for approval:

(a) Source and type of aggregates,

(b) Grading details in tabular and graphical form, and

(c) Details of each mixing plant proposed.

(2) The following particulars of bituminous materials shall also be submitted to the Engineer for approval:

For bituminous materials other than polymer modified friction course material:

(a) Certified copies of work sheets for mix designs, which shall include the relative density of the mixed aggregates,

(b) Source of bitumen, and

(c) If requested by the Engineer, past test records of the same mix produced in the same plant.

For polymer modified friction course material:

(a) Polymer modified binder content % by weight of total mass,

(b) Source and type of aggregates,

(c) Certified copies of work sheets for mix designs, which shall include the relative density of the mix aggregates,

(d) Mixing temperature during production,

(e) Grading details in tabular and graphical form,

(f) Source of polymer modified bitumen,

(g) Details of each mixing plant proposed, and

(h) If requested by the Engineer, past test records of the same mix produced in the same plant.

(3) The particulars shall be submitted to the Engineer at least 21 days before:

(a) Trial areas are constructed, or

(b) The mix is placed in the permanent work if trial areas are not required.

Particulars of virgin sub-base material and recycled sub-base material

9.13 (1) The following particulars of recycled sub-base material if used in lieu of virgin material shall be submitted to the Engineer for approval:

Details of the recycling plant, and test results for:

- Soundness value
- CBR value
- Content of contaminant in percentage by mass
- Water-soluble sulphate content
- Organic material content

(2) The following particulars of virgin sub-base material and recycled sub-base material if used in lieu of virgin material shall be submitted to the Engineer for approval:

(a) Details of the test results for:
- Ten per cent fines value
- Grading details in tabular and graphical form, and

(b) A certificate from the manufacturer for each type of aggregates showing the manufacturer's name and place of manufacture and showing the aggregate complies with the requirements stated in the Contract.

Particulars of supplier of sub-base material and bituminous materials

9.14 The name of the supplier and the location of each plant from which the Contractor proposes to obtain sub-base material and bituminous materials shall be submitted to the Engineer for approval at the time stated in Clause 9.12(3).

Particulars of methods of laying and compacting sub-bases and bituminous materials

9.15 (1) The following particulars of the proposed methods of laying and compacting sub-bases and bituminous materials shall be submitted to the Engineer for approval:

(a) Details of construction plant, and

(b) Programme and rate of working.

(2) The particulars shall be submitted to the Engineer at the time stated in Clause 9.12(3).

Samples of sub-base material, aggregate, filler and bitumen 9.16 One sample of each type of sub-base material and one sample of each type of aggregate, filler and bitumen for bituminous material shall be submitted to the Engineer at the same time as particulars are submitted.

TRIALS

Trial areas 9.17 (1) Trial areas of each type and layer of bituminous materials shall be constructed to demonstrate that the proposed materials, mixes, methods of production and methods of construction are capable of producing a carriageway that complies with the specified requirements. Unless otherwise stated in the Contract, the trial areas shall be constructed as part of the permanent carriageway at locations agreed by the Engineer. The width of each trial area shall be at least one lane of carriageway, and the length shall be at least 60 m.

(2) Trial areas shall be constructed using the materials, mixes, methods of production and methods of construction submitted to the Engineer. Materials shall be delivered in not less than two loads.

(3) The Contractor shall inform the Engineer 48 hours, or such shorter period agreed by the Engineer, before constructing trial areas.

(4) The permission of the Engineer shall be obtained before each layer of material is placed in the trial area.

(5) The Engineer shall be given sufficient time to determine whether the specified requirements have been produced in the trial area before further material of the same type is placed in the permanent carriageway.

(6) Trial areas shall be protected from damage and shall be left in position unless the Engineer instructs their removal. Trial areas which form part of the permanent carriageway and which comply with the specified requirements shall not be removed.

Table 9.6: Sampling and testing bituminous materials

Type of material	Properties	Methods of sampling	Methods of testing
Bituminous base course and wearing course material	Particle size distribution	Clause 9.55	Clause 9.56
	Bitumen content	Clause 9.55	Clause 9.56
	Rice's specific gravity	Clause 9.55	Clause 9.56
	Void content	Clause 9.62	Clause 9.63
Polymer modified friction course material	Particle size distribution	Clause 9.59	Clause 9.60
	Bitumen content	Clause 9.59	Clause 9.60
	Texture depth and permeability	-	Clause 9.66

Samples: trial areas 9.18

(1) One sample of bituminous materials, excluding bituminous roadbase materials, shall be provided from each mix used in trial areas. The method of sampling shall be as stated in Table 9.6.

(2) Ten cores shall be cut from each layer of base course and wearing course in trial areas. The method of taking cores shall be as stated in Clause 9.62.

Testing: trial areas 9.19

(1) Each sample of bituminous material taken as stated in Clause 9.18, shall be tested to determine the properties stated in Table 9.6. The method of testing shall be as stated in Table 9.6.

(2) If the layer is to form part of the permanent work, each layer of bituminous material in trial areas, excluding bituminous roadbase material, shall be tested as stated in Clause 9.40 to determine the level of the surface.

(3) The layer which is to be the final layer of the carriageway in each trial area shall be tested as stated in Clauses 9.42 and 9.43 to determine the surface regularity, if the layer is to form part of the permanent work.

(4) The layer of polymer modified friction course in each trial area shall be tested as stated in Clauses 9.66 to 9.68 to determine the texture depth and permeability.

(5) Cores shall be tested as stated in Clauses 9.62 to 9.65 to determine the compacted layer thickness and air void content.

Compliance criteria: trial areas 9.20

The properties of the materials, the levels of the surface, compaction, surface regularity, texture depth and permeability of bituminous materials laid in the trial areas shall comply with the specified requirements for the permanent carriageway.

Non-compliance: trial areas 9.21

(1) If the result of any test on trial areas does not comply with the specified requirements for trial areas, particulars of proposed changes to the materials, mixes, methods of production or methods of construction shall be submitted to the Engineer. Further trial areas shall be constructed until the result of every test on trial areas complies with the specified requirements for the trial areas.

(2) Unless otherwise permitted by the Engineer, trial areas or parts of trial areas, which do not comply with the specified requirements for the trial area, shall be removed.

Approved mix for bituminous materials other than bituminous roadbase material 9.22

(1) A mix for bituminous materials other than bituminous roadbase material that complies with the specified requirements for designed mixes and for trial areas shall become an approved mix.

(2) The approved gradation envelope for bituminous materials other than bituminous roadbase material shall be the gradation envelope found by applying the tolerances stated in Table 9.7 to the particle size distribution of the approved mix.

(3) The approved bitumen content range for bituminous materials other than bituminous roadbase material shall be the bitumen content range formed by applying a tolerance of ±0.5% to the bitumen content of the approved mix.

Table 9.7: Tolerances for particle size distribution from approved mix

BS test sieve	Tolerance of particle size distribution in percentage by mass of total mix passing BS test sieve				
	Nominal maximum aggregate size (mm)				
	37.5	**28**	**20**	**10 (for mix other than polymer modified friction course material)**	**10 (for polymer modified friction course material)**
50 mm	0	-	-	-	-
37.5 mm	± 4	0	-	-	-
28 mm	± 7	± 4	0	-	-
20 mm	± 7	± 7	± 4	-	-
14 mm	± 7	± 7	± 7	0	0
10 mm	± 7	± 7	± 7	± 4	± 4
5 mm	± 7	± 7	± 7	± 7	± 7
2.36 mm	± 7	± 7	± 7	± 7	± 7
1.18 mm	± 7	± 7	± 7	± 7	-
600 μm	± 5	± 5	± 5	± 5	-
300 μm	± 5	± 5	± 5	± 5	-
150 μm	± 3	± 3	± 3	± 3	-
75 μm	± 2	± 2	± 2	± 2	± 2

Commencement of placing bituminous materials

9.23 Bituminous material shall not be placed in the permanent works until the Engineer has approved the mix.

Changes in materials and methods of construction

9.24 Unless permitted by the Engineer, the materials and methods of production used in producing the approved mixes and the methods of construction used in trial areas shall not be changed.

HANDLING, STORAGE AND TRANSPORT OF MATERIALS

Handling and storage of sub-base material and bituminous materials

9.25 (1) Cement and PFA shall be stored as stated in Clause 16.33.

(2) Material handling and storage areas shall be levelled and well drained. Sub-base material and bituminous materials shall not be handled or stored in a manner which will result in mixing of the different types and sizes or in segregation or contamination of the materials. Measures to protect the materials from the effects of weather shall be submitted to the Engineer for approval.

(3) Unless otherwise permitted by the Engineer, bituminous materials shall not be stored in heated surge bins for more than 12 hours or in transport vehicles for more than 3 hours.

Transport of sub-base material and bituminous materials

9.26 (1) Sub-base material and bituminous materials shall be protected by covers while being transported and before laying. Covers for bituminous materials shall be heavy canvas or a similar insulating material. The covers shall completely cover the material and shall be securely fixed to minimize loss of heat and to protect the materials from contamination by dust or other deleterious material.

(2) Sub-base material and bituminous materials shall be transported in clean vehicles with smooth trays and sides.

(3) The trays of vehicles transporting bituminous materials may be lubricated with soap solution or light oil sprayed on the trays.

MIXING OF SUB-BASE MATERIAL AND BITUMINOUS MATERIALS

Mixing of sub-base material and bituminous materials

9.27 Mixing of sub-base material and mixing of bituminous materials shall be carried out before delivery to the Site at mixing plants approved by the Engineer. The plants shall be designed and operated to produce uniform mixes that comply with the specified requirements.

Mixing plant for bituminous materials

9.28 (1) The mixing plant for bituminous materials shall have at least four separate cold-feed bins for preliminary cold batching of the coarse and fine aggregates, and a rotary drum dryer, which will continuously agitate the aggregates during the heating and drying processes. After passing through the dryer, the aggregates shall be screened into at least four hot storage bins before mixing.

(2) Bitumen heating and storage tanks shall be fitted with circulating pumps to ensure an even temperature throughout the tanks.

(3) The mixing plant shall be provided with sampling devices to enable samples of hot aggregates, filler and bitumen to be taken before mixing.

(4) Insulated surge bins, if fitted to the mixing plant, shall be designed and operated to prevent segregation occurring in the mix. Heating devices fitted to surge bins shall be capable of maintaining the temperature of the mix to within the specified limits.

(5) Measuring and weighing equipment shall be maintained in a clean, serviceable condition. The equipment shall be set to zero daily and calibrated before mixes for the permanent work are produced, and at regular intervals not exceeding 6 months.

(6) Alternative methods of mixing bituminous materials may be used with the approval of the Engineer.

Mixing bituminous materials

9.29 (1) Aggregates and filler for bituminous materials shall be measured to an accuracy of ± 3.0% by mass. The aggregate moisture content after drying shall not exceed 0.4% by mass.

(2) Mixing of bituminous materials shall continue after the addition of all constituents for such period as is necessary to ensure that the aggregates and filler are uniformly coated with bitumen.

(3) Bituminous materials other than polymer modified friction course material shall comply with the temperature requirements as stated in Table 9.8 during and after mixing.

(4) The polymer modified friction course material shall comply with the temperature requirements as recommended by the supplier of the polymer modified bitumen during and after mixing.

(5) The particulars of temperature requirements for the polymer modified friction course material shall be submitted to the Engineer at the time stated in Clause 9.12(3).

(6) If instructed by the Engineer, the Contractor shall measure in the presence of the Engineer's Representative the following temperatures:

(a) Temperature after mixing,

(b) Temperature at laying, and

(c) Temperature at start of compaction.

Table 9.8: Temperature requirements for bituminous materials

Type of bituminous material		Roadbase, base course and wearing course
Aggregate temperature at mixing (ºC)	Min. Max.	130 175
Binder temperature at mixing (ºC)	Min. Max.	135 165
Bituminous mixture temperature after mixing (ºC)	Min. Max.	130 165
Bituminous mixture temperature at laying (ºC)	Min. Max.	- -
Bituminous mixture temperature at start of compaction (ºC)	Min.	-

PRELIMINARY WORK

Installation of utilities 9.30

(1) Pipes, cables, manholes, chambers, gullies and other utilities below carriageways shall be completed and fill material shall be deposited and compacted in trenches before the carriageway is constructed. Openings to manholes, chambers and gullies shall be protected with temporary covers or by other methods agreed by the Engineer.

(2) Covers, frames and other hardware which will prevent continuous laying of bituminous materials for roadbase and base course shall not be fixed in position until such work is complete.

(3) After the penultimate layer of bituminous material has been laid and compacted, the layers of asphalt shall be cut out, temporary covers shall be removed and the permanent covers, frames and other hardware shall be installed.

(4) Finishing around covers, frames and other hardware shall be carried out using bituminous material of the same type as that in the adjacent surface unless otherwise permitted by the Engineer. The material shall be compacted in layers not exceeding 50 mm thick using hand rammers or mechanical equipment up to the underside of the wearing course if the top surfacing is wearing course, or up to the underside of the polymer modified friction course if the top surfacing is polymer modified friction course.

LAYING AND COMPACTION OF SUB-BASE MATERIAL

Laying and compaction of sub-base material using virgin material

9.31 (1) Sub-base material shall be laid and compacted in a manner that will not result in segregation of the material and at a moisture content that allows the compaction stated in Clause 9.31(6) to be achieved. The moisture content shall not be less than 2%.

(2) Sub-base material shall be laid in layers in such a manner that the compacted thickness of each layer will not exceed 225 mm. If the specified final compacted thickness of the sub-base exceeds 225 mm, the material shall be laid in two or more layers. The minimum thickness of each layer shall be 100 mm and, if the layers are of unequal thickness, the lowest layer shall be the thickest.

(3) Each layer of sub-base material shall be evenly spread immediately after placing in position and shall be compacted immediately after spreading.

(4) The minimum compaction plant to be used for compaction of sub-base material shall be of the type as stated in Clause 9.36(1).

(5) The permission of the Engineer shall be obtained before the next layer is placed on each layer of compacted sub-base material.

(6) Sub-base material shall be compacted to obtain a relative compaction of at least 95% maximum dry density throughout.

(7) The surface of each layer of sub-base shall be maintained in a compacted condition until the next layer of sub-base material or roadbase material is laid. The surface shall not be disturbed by construction plant or other vehicles, and shall be free of ridges, cracks, loose material, pot-holes, ruts or other defects.

Laying and compaction of recycled sub-base material in lieu of virgin material

9.32 (1) Recycled sub-base material shall be laid and compacted in a manner which will not result in segregation of the material and at a moisture content which allows the compaction stated in Clause 9.32(7) to be achieved. The moisture content shall not be less than 2%.

(2) The recycled sub-base shall consist of an upper layer of virgin sub-base material overlying a layer of recycled sub-base material. The ratio of the thickness of the recycled sub-base layer to that of the virgin sub-base layer shall be approximately 6 to 4. During laying and compaction, the thickness of each of these two layers shall take into account the layer thickness requirements given in sub-clause (3) below.

(3) Recycled sub-base material shall be laid in layers in such a manner that the compacted thickness of each layer will not exceed 225 mm. If the specified final compacted thickness of the sub-base exceeds 225 mm, the material shall be laid in two or more layers. The minimum thickness of each layer shall be 100 mm and, if the layers are of unequal thickness, the lowest layer shall be the thickest.

(4) Each layer of recycled sub-base material shall be evenly spread immediately after placing in position and shall be compacted immediately after spreading.

(5) The minimum compaction plant to be used for compaction of recycled sub-base material shall be as stated in Clause 9.36(1).

(6) The permission of the Engineer shall be obtained before the next layer is placed on each layer of compacted recycled sub-base material.

(7) Recycled sub-base material shall be compacted to obtain a relative compaction of at least 95% maximum dry density throughout.

(8) The surface of each layer of recycled sub-base shall be maintained in a compacted condition until the next layer of sub-base material or roadbase material is laid. The surface shall not be disturbed by construction plant or other vehicles, and shall be free of ridges, cracks, loose material, pot-holes, ruts or other defects.

LAYING AND COMPACTION OF BITUMINOUS MATERIALS

Laying and compaction of bituminous materials 9.33

(1) Bituminous materials shall not be laid during periods of wet weather or when ponding water is present on the underlying surface unless in the opinion of the Engineer the works will not be adversely affected.

(2) Bituminous wearing course material shall not be laid when the ambient air temperature is below 8°C and polymer modified friction course material shall not be laid when the ambient air temperature is below 10°C. Temperatures shall be measured in the shade near to the surface on which laying is to be carried out.

(3) Surfaces on which bituminous materials are laid shall be clean and free of mud, grit and other deleterious material.

(4) If instructed by the Engineer, a tack coat of bituminous emulsion shall be applied to surfaces on or against which bituminous materials will be laid. The tack coat shall be evenly applied at a rate of between 0.4 L/m^2 and 0.6 L/m^2 using a spray machine. Other application procedures shall comply with BS 434:Part 2. Bituminous materials shall not be laid until the tack coat

has cured. Construction plant and other vehicles necessary shall only run on the tack coat as necessary to lay the bituminous materials.

(5) If approved by the Engineer, surfaces of existing carriageways may be regulated before the overlying bituminous material is laid. Bituminous regulating course material shall be a material approved by the Engineer complying with the requirements for the 10 mm nominal maximum aggregate size wearing course material as specified in Table 9.4. Regulating course material shall be laid by paving machines unless laying by manual methods is instructed by the Engineer.

(6) Bituminous materials other than polymer modified friction course material shall comply with the temperature requirements as stated in Table 9.8 during laying and compaction.

(7) Without prejudice to Clause 9.33(2) above, polymer modified friction course material shall comply with the temperature requirements as recommended by the manufacturer of the polymer modified bitumen during laying and compaction.

Laying bituminous materials by paving machine

9.34 (1) Unless otherwise permitted by the Engineer, bituminous materials shall be placed and spread using a self-propelled paving machine with a screw auger and attached screed capable of spreading and laying the material to the full width required. The paving machine shall be capable of giving initial compaction to the material and finishing it to a level suitable for subsequent compaction.

(2) Paving machines may be fitted with cut-off shoes or extensions to limit or extend the width of the screed. Screed extensions shall not be used unless the screw auger is extended in accordance with the manufacturer's recommendations. The surface texture produced by paving machines shall be free of segregation and pushing or dragging marks.

(3) Bituminous materials laid by paving machines shall be placed directly from the vehicles transporting the material into the hopper of the paving machine. Delivery of materials to the paving machine and laying of the materials shall be at a uniform rate appropriate to the capacity of the paving machine and compaction plant.

(4) If any delay in laying operations occurs, the paving machine shall be removed, the uncompacted cold material shall be removed and a transverse joint shall be formed as stated in Clause 9.37.

(5) Paving machines working in echelon shall be as close as practicable. The machines shall be not more than 30 m apart unless a longitudinal joint is formed as stated in Clause 9.37.

(6) Manual placing of materials on freshly laid surfaces shall only be used for the purpose of locally correcting levels as paving operations proceed, before compaction by rolling is commenced.

Laying bituminous materials by manual methods

9.35 Bituminous materials shall be laid by manual methods only if in the opinion of the Engineer the use of a paving machine is impracticable. If approved by the Engineer, bituminous materials may be laid by manual methods:

(a) In courses of irregular shape and varying thickness,

(b) In confined locations,

(c) Adjacent to expansion joints, covers, frames and other hardware, and

(d) In reinstatements to trenches.

Compaction of bituminous materials and sub-base material

9.36 (1) The minimum compaction plant to be used to compact bituminous roadbase, base course, regulating course, wearing course and sub-base material shall be:

(a) A smooth three-wheeled steel-wheeled roller with a mass of between 6 t and 12 t, or a vibratory tandem steel-wheeled roller with an effective mass of between 6 t and 12 t, and

A smooth pneumatic-tyre roller with a mass of between 12 t and 25 t, and with not less than seven overlapping wheels which have tyres that are capable of having pressures varying between 300 MPa and 800 MPa, and

Suitable mechanical rammers and hand-tools, or

(b) Other types of rollers, vibrating plates and rammers approved by the Engineer, or other similar plant approved by the Engineer, necessary to produce the required degree of compaction.

(2) Bituminous roadbase, base course, regulating course and wearing course materials shall be initially rolled using a steel-wheeled roller operated in a longitudinal direction along the carriageway with the driving wheels nearest the paving machine.

(3) All roller marks shall be removed from the surface of bituminous roadbase, base course and wearing course materials using either a smooth-wheeled dead-weight roller or a smooth-wheeled vibratory roller in non-vibrating mode.

(4) To ensure continuity of voids in polymer modified friction course, pneumatic-tyre roller shall not be used for compacting polymer modified friction course.

(5) Rollers shall not be parked on newly laid or compacted bituminous materials.

(6) Bituminous materials immediately adjacent to kerbs, covers, frames and other hardware where rollers cannot operate effectively shall be compacted using hand-operated mechanical compaction plant.

Joints in bituminous materials

9.37 (1) The screed of the paving machine shall overlap previously laid strips of bituminous material by at least 50 mm and shall be sufficiently high that compaction will produce a smooth dense flush joint. Bituminous materials overlapping the previously laid strip shall be pushed back to the edge of the previously laid strip and the excess material shall be removed.

(2) Longitudinal joints in polymer modified friction course or wearing course shall be formed coincident with the specified position of the lane-markings unless otherwise permitted by the Engineer.

(3) A prepared joint shall be formed between hot bituminous material and cold material or existing bituminous material which is at a temperature below the minimum specified laying temperature.

(4) The distance between prepared longitudinal joints in different layers shall be at least 150 mm and the distance between prepared transverse joints in different layers shall be at least 500 mm.

(5) Prepared joints in base course and wearing course shall be formed by cutting back the face of the cold material or existing bituminous material for a minimum distance of twice the depth of the layer or 100 mm, whichever is greater. A vertical face shall be cut for the full depth of the layer. All loosened materials shall be removed and the face shall be coated with bituminous emulsion. The bituminous emulsion shall not be applied beyond the edges of the joint. The hot bituminous materials shall be laid and compacted against the coated face with a joint formed as stated in this clause.

(6) Unless otherwise permitted by the Engineer polymer modified friction course joints shall not be coated with bituminous emulsion.

PROTECTION OF SURFACES OF SUB-BASE MATERIAL AND BITUMINOUS MATERIALS

Protection of surfaces of sub-base material and bituminous materials

9.38 (1) The surface of each layer of sub-base material and bituminous materials shall be kept clean and free of deleterious material. If instructed by the Engineer, bituminous priming coat shall be applied to the final surface of the sub-base layer at a rate of between 0.9 L/m^2 and 1.1 L/m^2.

(2) Layers of carriageways under construction shall not be used by construction plant or vehicles other than those which in the opinion of the Engineer are essential to construct the work.

(3) Unless otherwise permitted by the Engineer, bituminous courses shall not be used by construction plant or other vehicles until 6 hours after the material has been laid and compacted.

TOLERANCES

Tolerances: alignment of carriageway

9.39 The line of the edges of carriageways shall be within 25 mm of the specified line, except at the edges of structures where it shall be within 6 mm.

Tolerances: level of carriageway

9.40 (1) The levels of the surface of each layer of sub-base, roadbase, base course, wearing course and polymer modified friction course shall be determined on a grid at 10 m centres in the longitudinal direction and at 2 m centres in the transverse direction.

(2) The level of the surface of each layer of sub-base, roadbase, base course, wearing course and polymer modified friction course shall be within the tolerances stated in Table 9.9.

(3) The difference in level of the surface of wearing course and polymer modified friction course across joints shall not exceed 3 mm.

(4) The combination of permitted tolerances in levels shall not result in a reduction in the thickness of the pavement, excluding the sub-base, of more than 15 mm from the specified thickness nor a reduction in the thickness of the bituminous wearing course or polymer modified friction course of more than 5 mm from the specified thickness.

Table 9.9: Tolerances in level

Type of surface	Permitted tolerance in level (mm)	
Sub-base	+ 10	- 20
Roadbase course	+ 8	- 15
Base course	± 6	
Wearing course		
Polymer modified friction course		

Tolerances: covers, frames and other hardware

9.41 The level of covers, frames and other hardware shall be not lower than, and shall not be more than 5 mm higher than the surface of the carriageway. The level of gully gratings shall not be higher than, and shall not be more than 5 mm lower than, the surface of the carriageway.

TESTING: SURFACE REGULARITY

Testing: surface regularity

9.42 The surface regularity of the final layer of the pavement shall be determined as stated in Clause 10.55.

Compliance criteria: surface regularity

9.43 The results of tests for surface regularity shall comply with Clause 10.56.

TESTING: SUB-BASE MATERIAL

Batch: sub-base material

9.44 A batch of sub-base material is a quantity not exceeding 250 m^3 of sub-base material of the same type and same mix produced at the same mixing plant, and delivered to the Site at any one time.

Samples: sub-base material

9.45 (1) Unless otherwise permitted by the Engineer, one sample of each type of sub-base material shall be provided from each batch of sub-base material delivered to the Site.

(2) The size of each sample shall be at least 50 kg. The method of sampling shall be in accordance with CS3.

Testing: sub-base material using virgin

9.46 (1) Each sample of sub-base material shall be tested to determine the particle size distribution, ten per cent fines value, maximum dry density,

material

optimum moisture content and plasticity index of the portion passing a 425μm BS test sieve.

(2) The method of testing for particle size distribution shall be in accordance with CS3.

(3) The method of testing for ten per cent fines value shall be in accordance with CS3 under a soaked condition.

(4) The method of testing for plasticity index shall be in accordance with Geospec 3, Test Method 6.1, except that sample preparation shall be by wet sieving the material over a 425 μm BS test sieve.

(5) The method for testing for maximum dry density and optimum moisture content shall be in accordance with Geospec 3, Test Method 10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7 or 10.8, and Appendix 6.4 of this Specification, whichever as instructed by the Engineer.

Testing: Recycled sub-base material in lieu of virgin material

9.47 (1) Each sample of recycled sub-base material shall be tested to determine the particle size distribution, ten per cent fines value, maximum dry density, optimum moisture content, plasticity index of the portion passing a 425μm BS test sieve, CBR value, soundness value, water-soluble sulphate content and percentage of contaminants as defined in Table 9.2.

(2) The method of testing for particle size distribution shall be in accordance with CS3.

(3) The method of testing for ten per cent fines value shall be in accordance with CS3 under a soaked condition.

(4) The method of testing for plasticity index shall be in accordance with Geospec 3, Test Method 6.1, except that sample preparation shall be by wet sieving the material over a 425 μm BS test sieve.

(5) The method for testing for maximum dry density and optimum moisture content shall be in accordance with Geospec 3, Test Method 10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7 or 10.8, and Appendix 6.4 of this Specification, whichever as instructed by the Engineer.

(6) Soundness value shall be determined in accordance with CS3.

(7) Water-soluble sulphate content shall be determined in accordance with BS 1377:Part 3.

(8) The maximum organic material content shall be determined in accordance with BS 1377:Part 3.

(9) The maximum metals and foreign material content shall be determined in accordance with the following procedure:

By means of the sampling procedure detailed in BS EN 932:Part 6, a sample shall be obtained of the aggregate containing at least 500 particles. The particles shall then be sorted manually into the following separate fractions:

(i) Concrete and dense or normal weight aggregates.

(ii) Brick, mortar, lightweight block and lightweight aggregate.

(iii) Asphalt, bitumen, tar and mixtures of these materials with aggregate.

(iv) Wood.

(v) Glass.

(vi) Metal.

(vii) Other foreign material such as clay lumps and plastics

Because of the adherence of dust, it may be necessary to wash or break some particles to make a positive identification. The resulting fractions shall be weighed and expressed as a percentage of the total weight of material.

Notes:

(a) Lightweight block material - This should be noted as a separate category if more than 1% by volume (approx. 5 pieces in 500).

(b) Ultra-lightweight material (e.g. insulation) - This should be noted if more than 1% by volume (5 pieces in 500).

(10) CBR value shall be determined in accordance with BS 1377:Part 4 with surcharge discs. The material shall be tested at the density and moisture content likely to develop in equilibrium pavement conditions, which shall be taken as being the density relating to a uniform air voids content of 5% and the optimum moisture content determined in compliance with BS 5835:Part 1:1980.

TESTING: RELATIVE COMPACTION OF SUB-BASE

Testing: relative compaction of sub-base

9.48 (1) Each area of sub-base which contains sub-base material of the same type and same mix produced at the same mixing plant and which is laid and compacted in a single layer in one day shall be tested to determine the relative compaction. Tests shall be carried out after the sub-base material has been laid and compacted in the final position.

(2) Two tests shall be carried out on each area of 1000 m^2 or part thereof laid and compacted each day.

(3) Tests shall be carried out at positions, which in the opinion of the Engineer are representative of the area of compacted sub-base as a whole.

(4) The method of testing for relative compaction shall be as stated in Clause 6.81(4).

Compliance criteria: relative compaction of sub-base

9.49 The results of tests for relative compaction of sub-base shall comply with the requirements stated in Clause 9.31(6).

Non-compliance:

9.50 If the result of any test for relative compaction of sub-base does not comply

relative compaction of sub-base

with the specified requirements for relative compaction of sub-base, the area shall be re-compacted and two additional tests for relative compaction of sub-base shall be carried out on the area.

TESTING: AGGREGATES, FILLER AND BITUMEN FOR BITUMINOUS MATERIALS

Batch: aggregates, filler and bitumen for bituminous materials

9.51 A batch of aggregates, filler or bitumen for bituminous materials is any quantity of aggregates, filler or bitumen for bituminous materials of the same type, manufactured or produced in the same place and covered by the same certificates delivered to the Site at any one time.

Samples: aggregates, filler and bitumen for bituminous materials

9.52 (1) One sample of each type of aggregate, filler and bitumen for bituminous materials shall be provided from each batch.

(2) The size of each sample and the method of sampling shall be as stated in Table 9.10.

Table 9.10: Size of samples and method of sampling for aggregates, filler and bitumen

Material	Minimum size of sample	Method of sampling
Aggregate	CS3	CS3
Filler	5 kg	ASTM D 242
Bitumen	2 litres	ASTM D 140

Testing: aggregates, filler and bitumen for bituminous materials

9.53 Each sample of aggregate, filler and bitumen for bituminous materials shall be tested to determine the properties stated in Table 9.11. The method of testing shall be as stated in Table 9.11.

Table 9.11: Testing aggregates, filler and bitumen for bituminous materials

Material	Property	Method of testing
Coarse aggregate	Relative density Water absorption	CS3
	Ten per cent fines value	CS3
	Particle size distribution	CS3
	Flakiness index	CS3
Fine aggregate	Relative density Water absorption	CS3
	Particle size distribution	Geospec 3, Test Method 8.2
Filler	Relative density	BS EN 196:Part 6
	Particle size distribution	ASTM D 546 with modification(1)
Bitumen for bituminous materials other than polymer modified friction course material	Relative density	ASTM D 3289
	Softening point	BS EN 1427
	Penetration	ASTM D 5
	Ductility	ASTM D 113
	Retained penetration after thin film oven test	ASTM D 1754
	Solubility	ASTM D 2042
	Viscosity	ASTM D 2171
	Loss on heating	BS EN 13303
Bitumen for polymer modified friction course material	Viscosity	AASHTO Designation T316
	Dynamic Shear	AASHTO Designation T315
	Dynamic Shear after Rolling Thin-Film Oven	AASHTO Designation T315 and AASHTO Designation T240
	Flash Point	AASHTO Designation T48

Note: (1) For particle size distribution tests in accordance with ASTM D 546, the modification is that BS sieves are used instead of ASTM sieves.

TESTING: BITUMINOUS MATERIALS OTHER THAN POLYMER MODIFIED FRICTION COURSE MATERIAL

Batch: bituminous materials other than polymer modified friction course material

9.54 A batch of bituminous materials other than polymer modified friction course material is a quantity not exceeding the limits stated in Table 9.12 of bituminous materials of the same type and same mix produced at the same mixing plant in one day.

Table 9.12: Maximum size of batch for bituminous materials other than polymer modified friction course material

Material	Maximum batch size
Wearing course	100t
Base course	150t
Road base	200t

Samples: bituminous materials other than polymer modified friction course material

9.55 (1) One sample of bituminous materials other than polymer modified friction course material shall be provided from each batch unless otherwise required by the Engineer.

(2) The size of each sample shall be as stated in Table 9.13.

(3) Samples shall be taken at the mixing plant or at the location where the bituminous material will be laid as instructed by the Engineer. Samples taken at the mixing plant shall be taken from the delivery vehicle immediately after loading from the plant or from the surge bin. Samples taken at the location where the bituminous materials will be laid shall be taken from the delivery vehicle.

(4) Unless otherwise agreed by the Engineer the method of sampling shall be in accordance with ASTM D 979.

Table 9.13: Size of samples for bituminous materials other than polymer modified friction course material

Material	Minimum size of sample (in kg)
Wearing course (10mm nominal maximum aggregate size)	10
Wearing course (20mm nominal maximum aggregate size)	16
Base course	24
Roadbase	24

Testing: bituminous materials other than polymer modified friction course material

9.56 (1) Each sample of bituminous materials taken as stated in Clause 9.55(1) shall be tested to determine the particle size distribution, bitumen content and Rice's specific gravity.

(2) The method of testing shall be in accordance with the following:

Particle size distribution	:	ASTM D 5444 with modifications Amd 2/2022
Bitumen content	:	ASTM D 6307 or ASTM D 2172, Method A
Rice's specific gravity	:	ASTM D 2041, Weighing-in-water method
Bulk specific gravity	:	ASTM D 2726

(3) For particle size distribution tests in accordance with ASTM D 5444 Amd 2/2022, the modifications are:

(a) Sieves to BS ISO 3310:Part 1 and BS ISO 3310:Part 2 instead of sieves to ASTM E 11 shall be used.

(b) The washed aggregate shall be dried at a temperature of 110 ± 5ºC. Amd 2/2022

Compliance criteria: bituminous materials other than polymer modified friction course material

9.57 (1) The results of tests on bituminous materials other than bituminous roadbase and polymer modified friction course materials shall comply with the following requirements:

(a) The particle size distribution shall be such that not more than two points on the particle size distribution curve are outside the approved gradation envelopes determined as stated in Clause 9.22(2). Notwithstanding the above distribution, the percentage passing the 75 µm BS test sieve shall not exceed the approved design value by more than 3%.

(b) The bitumen content shall be within the approved bitumen content range determined as stated in Clause 9.22(3).

(2) The results of tests on bituminous roadbase material shall comply with the following requirements:

(a) The particle size distribution shall be such that not more than two points on the particle size distribution curve are outside the design limit as stated in Table 9.4. Notwithstanding the above distribution, the percentage passing the 75 µm BS test sieve shall not exceed 8 % as specified in Table 9.4.

(b) The bitumen content shall be within the allowable bitumen content range as specified in Table 9.4.

TESTING: POLYMER MODIFIED FRICTION COURSE MATERIAL

Batch: polymer modified friction course material

9.58 A batch of polymer modified friction course material is a quantity not exceeding 100 t of polymer modified friction course material of the same mix produced at the same mixing plant in one day.

Samples: polymer modified friction course material

9.59 (1) One sample of polymer modified friction course material shall be provided from each batch of polymer modified friction course material.

(2) The size of each sample shall be at least 15 kg.

(3) Samples shall be taken from roadway prior to compaction at locations where the polymer modified friction course material will be laid or from other locations as instructed by the Engineer prior to compaction.

(4) Unless otherwise agreed by the Engineer the method of sampling shall be in accordance with ASTM D 979.

Testing: polymer modified friction course material

9.60 (1) Each sample of polymer modified friction course material shall be tested to determine the particle size distribution and bitumen content.

(2) The method of testing shall be in accordance with the following:

Particle size distribution	:	Appendix 9.2
Bitumen content	:	Appendix 9.2

(3) For particle size distribution tests in accordance with ASTM D 5444 Amd 2/2022, the modifications are:

(a) Sieves to BS ISO 3310:Part 1 and BS ISO 3310:Part 2 instead of sieves to ASTM E 11 shall be used.

(b) The washed aggregate shall be dried at a temperature of 110 ± 5ºC. Amd 2/2022

Compliance criteria: polymer modified friction course material

9.61 The results of tests on polymer modified friction course material shall comply with the following requirements:

(a) The particle size distribution shall be such that not more than one point on the particle size distribution curve is outside the approved gradation envelopes determined as stated in Clause 9.22(2). Notwithstanding the above distribution, the percentage passing the 75µm BS test sieve shall not exceed the approved design value by more than 3%.

(b) The bitumen content shall be within the approved bitumen content range as determined in Clause 9.22(3).

TESTING: BITUMINOUS MATERIAL CORES

Samples: bituminous material cores 9.62

(1) Each area of roadbase, base course and wearing course which contains bituminous material of the same type and same mix produced at the same mixing plant and which is laid and compacted in a single layer in one day shall be tested to determine the compacted layer thickness.

(2) Unless otherwise approved by the Engineer each area of bituminous material to be tested shall be divided into approximately equal sub-areas as stated in Table 9.14. One core shall be taken at random from each sub-area.

(3) Cores shall not be taken from within 300 mm of covers, frames and other hardware, or construction joints in the bituminous material.

(4) Cores shall be taken by a mechanically operated coring machine.

(5) Cores shall be 150 mm diameter for bituminous material with a designed layer thickness of 40 mm or greater and shall be 100 mm diameter for bituminous material with a designed layer thickness of less than 40 mm.

(6) Cores shall be taken as soon as practicable but not later than 48 hours after completion of the paving operation.

(7) If agreed by the Engineer, the sampling rate for roadbase may be applied to wearing course and base course.

(8) Holes formed by taking cores shall be filled with compatible bituminous material as soon as practicable after the core has been taken.

Table 9.14: Rate of sampling for bituminous material cores

Area of bituminous material laid and compacted in one day	**No. of sub-areas/cores**	
	Roadbase	**Wearing course and Base course**
< 5 000 m^2	4	10
5 000 - 10 000 m^2	10	15
> 10 000 m^2	20	20

Testing: bituminous material cores 9.63

(1) Each bituminous material core shall be measured to determine the compacted layer thickness of the bituminous material and tested to determine the air void content.

(2) The method of testing for air void content shall be in accordance with ASTM D 3203.

Compliance criteria: bituminous material 9.64

The results of tests on bituminous material cores shall comply with the following requirements:

cores

(a) The average air void content of the cores taken from an area of bituminous base course or wearing course material shall be not less than 3.0% and not greater than 6.0%.

(b) The air void content of each core taken from an area of bituminous base course or wearing course material shall be not less than 2.5% and not greater than 7.5%.

(c) The air void content of each core taken from an area of bituminous roadbase material shall be not less than 3.0% and not greater than 9.0%.

(d) The compacted layer thickness as measured from each core shall comply with the thickness requirements stated in Clause 9.40(4) and shall be compatible with the level tolerances stated in Table 9.9.

Non-compliance: bituminous material cores

9.65 (1) If the result of any test for air void content of cores does not comply with the specified requirements for air void content, the following procedure shall apply:

(a) Four additional cores shall be taken from each sub-area for which the original core did not comply with the specified requirements for air void content. The cores shall be taken at locations evenly spaced throughout the sub-area such that in the opinion of the Engineer they are representative of the sub-area as a whole.

(b) Each additional core shall be tested to determine the air void content and the test results of the additional cores from the same sub-area shall be averaged.

(c) The average air void content of the sub-area thus obtained shall replace the original air void content of the respective sub-area. The new average air void content of the area of bituminous material tested shall then be calculated for compliance checking.

(2) If the air void content of any of the four additional cores determined as stated in Clause 9.63(2) is less than 2.5% or greater than 7.5% for bituminous base course material and bituminous wearing course material, or less than 3.0% or greater than 9.0% for bituminous roadbase material, the sub-area from which the cores were taken shall be considered as not complying with the specified requirements.

(3) The area of bituminous material tested shall be considered as not complying with the specified requirements for average air void content if the average air void content of the cores taken from the area does not comply with the specified requirements for average air void content.

(4) If the result of any test for compacted layer thickness of cores is not compatible with the requirements of Table 9.9 or Clause 9.40(4), four additional cores shall be taken from the same sub-area and the average compacted layer thickness determined. The cores shall be taken at locations evenly spaced throughout the sub-area such that in the opinion of the Engineer they are representative of the sub-area as a whole.

(5) If the average compacted layer thickness determined as stated in Clause 9.65(4) is not in accordance with the permitted compacted layer thickness

stated in Clause 9.64(d), the sub-area from which the cores were taken shall be considered as not complying with the specified requirements.

TESTING: TEXTURE DEPTH AND PERMEABILITY

Testing: texture depth and permeability

9.66 (1) Unless otherwise agreed by the Engineer each area of polymer modified friction course to be tested shall be divided into approximately equal sub-areas as stated in Table 9.15. Tests for texture depth and permeability shall be carried out on each sub-area at positions, which in the opinion of the Engineer are representative of the sub-area of polymer modified friction course as a whole. No measurement shall be taken within 300 mm of the longitudinal edge of the carriageway.

(2) If agreed by the Engineer the number of tests for texture depth and permeability may be reduced to the minimum stated in Table 9.15.

(3) Tests shall be carried out before the area of polymer modified friction course is used by construction plant or other vehicles.

(4) Testing to determine the texture depth will be carried out by the Engineer. The method of testing shall be by the sand patch test in accordance with Appendix 10.1.

(5) Testing to determine the permeability will be carried out by the Engineer. The method of testing shall be in accordance with Appendix 9.1.

Compliance criteria: texture depth

9.67 The results of tests for texture depth on an area of polymer modified friction course shall comply with the following requirements:

(a) The average texture depth shall not be less than 1.5 mm.

(b) Not more than one of the tests for texture depth shall give a result of less than 1.2 mm.

Compliance criteria: permeability

9.68 The time for 150 mL of water to drain into the polymer modified friction course in the permeability test stated in Clause 9.66(5) shall not exceed 30 seconds.

Table 9.15: Rate of testing for texture depth and permeability

Area of bituminous material laid and compacted in one day	No. of sub-areas/tests	
	Normal	Minimum
< 5 000 m^2	10	4
5 000 - 10 000 m^2	15	10
> 10 000 m^2	20	20

APPENDIX 9.1

DETERMINATION OF THE PERMEABILITY OF POLYMER MODIFIED FRICTION COURSE MATERIAL

Scope 9.1.1 This method covers the determination of the permeability of polymer modified friction course material by measuring the time taken for 150 mL of water to drain into the material.

Apparatus 9.1.2 The following apparatus is required:

(a) A non-porous ring with an internal diameter of 150 mm ± 2 mm, and a minimum height of 20 mm.

(b) Suitable sealant for sealing one end of the ring onto the friction course surface.

(c) A measuring cylinder for measuring 150 mL of water to an accuracy of 1 mL.

(d) Two containers, each suitable for containing and pouring 150 mL of water.

(e) A stopwatch.

Procedure 9.1.3 The procedure shall be as follows:

(a) Carefully inspect the specified test location and record any unusual features.

(b) Place one end of the ring on the friction course at the location to be tested, and seal the interface with sealant to prevent any leakage of water.

(c) Prepare two volumes of water of 150 mL each using the measuring cylinder and the two containers.

(d) Pour one 150 mL measure of water into the ring quickly and steadily without spillage.

(e) As soon as all of the water has drained into the friction course, pour the second 150 mL of water into the ring quickly and steadily without spillage, and at the same time start the stopwatch.

(f) Record the time taken for the second 150 mL of water to drain into the friction course surface.

Reporting of results 9.1.4 The following shall be reported:

(a) The test location.

(b) The time taken for the second 150 mL of water to drain into the friction course surface, to the nearest one second.

(c) That the test was carried out in accordance with this Specification.

APPENDIX 9.2

DETERMINATION OF BINDER CONTENT AND PARTICLE SIZE DISTRIBUTION OF POLYMER MODIFIED FRICTION COURSE MATERIAL

Scope 9.2.1 This method covers the determination of the polymer modified binder content (i.e. the total binder and polymer content) and particle size distribution of polymer modified friction course material by making use of a combination of two tests in accordance with ASTM D 2172, Method A and ASTM D 6307, ASTM D 5444 with modifications. Amd 2/2022

Calibration procedure 9.2.2 Testing on laboratory mix to determine the calibration factor shall be required. The procedure shall be as follows:

(a) For a particular mix, prepare a laboratory mix of known particle size distribution and bitumen content (A).

(b) Test the trial samples of the laboratory mix in accordance with ASTM D 2172, Method A (Centrifugal Method) to determine the polymer modified binder content (B) of the trial samples.

(c) Test the residual of the trial samples that have been tested by ASTM D 2172, Method A in accordance with ASTM D 6307 (Ignition Method) to determine the polymer modified binder content (C) of the residual.

(d) Calculate the calibration factor for that particular mix (Z) by the following formula:

Calibration Factor (for a particular mix), Z = C - (A - B)

(e) Repeat the above steps from (a) to (d) for two additional calibration samples.

(f) Calculate the average calibration factor (Z) by averaging the three values obtained in step (d) above.

Testing 9.2.3 The procedure for testing polymer modified friction course material shall be as follows:

(a) Test the samples in accordance with ASTM D 2172, Method A (Centrifugal Method) to obtain the polymer modified binder content (X) of the test samples.

(b) Keep the residual (Residual 1) of the test samples that have been tested in sub-clause (a) above.

(c) With the average value of the calibration factor (Z) entered into the NCAT Tester for correction purpose, test Residual 1 obtained from sub-clause (b) above in accordance with ASTM D 6307 (Ignition Method) to obtain the residual polymer modified binder content (Y) of Residual 1.

(d) Keep the residual (Residual 2) of Residual 1 that has been tested in sub-clause (c) above.

(e) Determine the particle size distribution of Residual 2 in accordance with ASTM D 5444 with modifications. Amd 2/2022

Calculation 9.2.4 (1) The polymer modified binder content of the test samples shall be calculated as follows:

Polymer modified binder content = X + Y

(2) The particle size distribution of the test samples shall be the particle size distribution of Residual 2.

Reporting of results 9.2.5 The following shall be reported:

(a) Polymer modified binder content (X).

(b) Polymer modified binder content (Y).

(c) Polymer modified binder content (total binder and polymer content).

(d) Particle size distribution.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 10

CONCRETE CARRIAGEWAYS

SECTION 10

CONCRETE CARRIAGEWAYS

GENERAL

General requirements 10.01 (1) The works and materials specified in Clauses 10.02 to 10.06 shall comply with the sections stated, unless otherwise stated in this Section.

(2) All adhesives and sealants shall contain not more than 0.01% and 0.5% by wet weight of formaldehyde and total aromatic compounds (including benzene, toluene, xylenes, ethylbenzene, etc.) respectively.

Formwork and finishes 10.02 Formwork and finishes to concrete for concrete carriageways shall comply with Section 14.

Reinforcement 10.03 Steel reinforcement for concrete carriageways shall comply with Section 15.

Concrete 10.04 Concrete for concrete carriageways shall comply with Section 16. In addition, the abrasion resistance in Los Angeles value for coarse aggregates in concrete shall not exceed 30% loss in accordance with CS3.

Curing compound 10.05 Curing compound for concrete carriageways shall comply with Section 16.

Earthworks 10.06 Earthworks for concrete carriageways shall comply with Section 6.

MATERIALS

Reinforcement 10.07 Dowel bars, tie bars, cradles and tie bars for cradles shall be Grade 250 plain round steel bars complying with Section 15. Dowel bars and tie bars shall be straight. Both ends of dowel bars and one end of tie bars shall be sawn square with all burrs removed.

Cement mortar for cradles 10.08 Cement mortar for supporting cradles shall consist of 1 part of cement to 3 parts of fine aggregate together with the minimum amount of water necessary to achieve a consistency suitable for the required work. Fine aggregates shall be sand or crushed rock to BS EN 13139 and shall be less than or equal to 4mm.

Fine aggregate 10.09 Fine aggregate for concrete shall be clean, hard and durable crushed rock in accordance with Section 16.

Polyethylene sheeting 10.10 Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 0.125 mm.

Joint filler 10.11 Joint filler shall be of a proprietary type approved by the Engineer and shall be a firm, compressible, single thickness, non-rotting filler.

Joint sealant 10.12 (1) Joint sealant shall be of a grade suited to the climatic conditions of Hong Kong and shall perform effectively over a temperature range of 0°C to 60ºC.

(2) Joint sealant shall be a cold poured two-part polymer-based sealant complying with BS EN 14188:Part 2, Class A.

(3) Primers and caulking material for use with joint sealant shall be of a proprietary type recommended by the joint sealant manufacturer and approved by the Engineer.

Bond breaker tape 10.13 Bond breaker tape shall be of a proprietary type recommended by the joint sealant manufacturer and approved by the Engineer. The tape shall be a polyethylene film with adhesive applied on one side and shall be the full width of the groove.

Groove forming strip 10.14 (1) Groove forming strip shall be of a proprietary type approved by the Engineer. The strip shall be a firm compressible strip of either ethylene vinyl acetate foam with a density of at least 90 kg/m^3 or synthetic rubber. The strip shall be 25 mm deep and 5 mm thick and shall be sufficiently rigid to remain in position during concreting without deforming or stretching.

(2) Adhesive for groove forming strip shall be of a proprietary type recommended by the groove forming strip manufacturer and approved by the Engineer.

Sleeves for dowel bars and tie bars 10.15 Sleeves for dowel bars and tie bars shall be uPVC and shall have a nominal wall thickness not exceeding 1.5 mm. The sleeves shall fit tightly to the bars.

Epoxy resin grout 10.16 Epoxy resin grout shall be of a proprietary type approved by the Engineer.

CONCRETE

Concrete mix 10.17 Concrete for concrete carriageways shall comply with the following requirements:

(a) Concrete shall be Grade 40/20 and shall be a designed mix.

(b) The concrete mix shall contain either PFAC or a minimum of 265 kg of PC plus a minimum of 85 kg of PFA per m^3 of compacted concrete.

(c) The percentage by mass of fine aggregate to total aggregate shall be at least 30%.

(d) The workability in terms of designed slump value shall not exceed 75 mm.

Cementitious content of concrete 10.18 The minimum cementitious content of concrete for concrete carriageways shall be 350 kg/m^3.

SUBMISSIONS

Particulars of materials for joints 10.19 (1) The following particulars of the proposed materials for joints in concrete carriageways shall be submitted to the Engineer:

(a) Manufacturer's literature and a certificate for joint filler showing the manufacturer's name, the date and place of manufacture and showing that the joint filler complies with the requirements stated in the Contract and including results of tests for:
- Disintegration and shrinkage
- Recovery value and reduction in mass
- Extrusion,

(b) Manufacturer's literature for joint sealant, including details of the method and time required for mixing the different components, and a certificate showing the manufacturer's name, the date and place of manufacture and showing that the sealant complies with the requirements stated in the Contract and including results of tests for:
- Application life
- Tack-free time
- Resistance to flow
- Recovery
- Adhesion and cohesion in tension and compression
- Resistance to heat ageing,

(c) Manufacturer's literature and a certificate for groove-forming strip showing the manufacturer's name, the date and place of manufacture and showing that the groove forming strip complies with the requirements stated in the Contract and including results of tests for density, and

(d) Particulars of primers and caulking material for joint sealant, adhesive for groove forming strip, bond breaker tape and sleeves for dowel bars and tie bars.

(2) The particulars, including certificates, shall be submitted to the Engineer at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material delivered to the Site.

Particulars of methods of construction 10.20 Particulars of proposed methods of construction for concrete carriageways shall be submitted to the Engineer at least 7 days before the trial length is constructed.

Samples of materials 10.21 Samples of the following proposed materials shall be submitted to the Engineer at the same time as particulars of the material are submitted:

(a) Polyethylene sheeting,

(b) Joint filler,

(c) Bond-breaker tape,

(d) Groove-forming strip, and

(e) Sleeves for dowel bars, including compressible filler, and for tie bars.

TRIALS

Compliance criteria: trial-mix concrete

10.22 The results of the tests on trial-mix concrete for concrete carriageways shall comply with the following requirements:

- Each of the six slump values shall not exceed 85 mm, and the average of the six slump values shall not exceed 80 mm.

Trial length

10.23 (1) A trial length of concrete carriageway shall be constructed to demonstrate that the proposed materials, mix design, methods of production and methods of construction will produce a concrete carriageway which complies with the specified requirements.

(2) The trial length shall be constructed using the materials, mix design, methods of production and methods of construction submitted to the Engineer.

(3) If it is not stated in the Contract that the trial length is to be constructed in a location separate from the permanent carriageway, the trial length shall be the first 30 m of the permanent carriageway, or such other length agreed by the Engineer. The trial length shall be constructed over a width of two bays and shall include at least one expansion joint, one contraction joint and the longitudinal joint between the bays.

(4) The Contractor shall inform the Engineer at least 48 hours, or within a shorter period agreed by the Engineer, before constructing the trial length.

(5) The trial length shall be completed in sufficient time before the permanent carriageway is constructed to allow the Engineer a period of at least 7 days to determine if the specified requirements have been complied with in the trial length.

(6) The trial length shall be protected from damage and shall be left in position unless the Engineer instructs its removal. A trial length which forms part of the permanent carriageway and which complies with the specified requirements shall not be removed.

Testing: trial length

10.24 (1) The trial length shall be tested to determine the accuracy of the alignment and level, the surface regularity and the texture depth. The method of testing the surface regularity shall be as stated in Clause 10.55. The method of testing the texture depth shall be as stated in Clause 10.57.

(2) Concrete cores shall be cut from the trial length to determine the thickness of the slab, the positions of the reinforcement and joint components, the amount of segregation of the constituents and the presence of voids. The method of taking, preparing, inspecting and testing concrete cores shall be as stated in Clauses 10.62 and 10.63.

Compliance criteria: trial length

10.25 The results of tests on trial lengths shall comply with the following requirements:

(a) The alignment, levels and thickness of the carriageway shall comply with Clauses 10.53 and 10.54.

(b) The surface regularity shall comply with Clause 10.56.

(c) The texture depth shall comply with Clause 10.58.

(d) The positions of the reinforcement and joint components shall comply with Clauses 10.49, 10.50, 10.51 and 10.53.

(e) The amount of segregation of the constituents and the presence of voids shall comply with Clause 10.64.

Non-compliance: trial length

10.26 (1) If the result of any test on the trial length does not comply with the specified requirements for the trial length, particulars of proposed changes to the materials, mix design, methods of production or methods of construction shall be submitted to the Engineer. Further trial lengths shall be constructed until the result of every test on the trial length complies with the specified requirements for the trial length. Further trial mixes shall be made unless in the opinion of the Engineer non-compliance of the trial length was not due to the concrete mix.

(2) Unless otherwise permitted by the Engineer, trial lengths, or parts of trial lengths, which do not comply with the specified requirements for the trial length shall be removed.

Commencement of concreting

10.27 (1) Concrete shall not be placed in the permanent carriageway other than in a trial length until the result of every test on the trial length complies with the specified requirements for the trial length.

(2) Concrete may be placed in the permanent carriageway before the results of tests for compressive strength of the trial mix are available provided that the result of every other test on the trial mix and trial length complies with the specified requirements for trial mix concrete and for the trial length.

Changes in materials and methods of construction

10.28 Unless permitted by the Engineer, the materials, mix design, methods of production and methods of construction used to produce a trial length which complies with the specified requirements shall not be changed.

STORAGE OF MATERIALS

Storage of materials for joints and polyethylene sheeting

10.29 (1) Joint sealant, primer for joint sealant and adhesive for groove forming strip shall be stored in sealed containers marked to identify the contents and protected from exposure to conditions that may adversely affect the material. The materials shall be stored in accordance with the manufacturers' recommendations and shall not be used after the recommended shelf life has been exceeded.

(2) Polyethylene sheeting, joint filler, bond breaker tape, groove forming strip and sleeves for dowel bars and tie bars shall be stored in accordance with the manufacturers' recommendations in a dry, weatherproof store with a raised floor. Joint filler shall be stored in sealed plastic bags and shall not be exposed to moisture or air.

PRELIMINARY WORK

Installation of utilities 10.30 (1) Pipes, cables, manholes, chambers, gullies and other utilities below concrete carriageways shall be completed and fill material shall be deposited and compacted in trenches before the carriageway is constructed. Openings to manholes, chambers and gullies shall be protected by temporary covers or by other methods agreed by the Engineer.

(2) Box-outs shall be formed in concrete carriageways for covers, frames and other hardware. The covers, frames and other hardware shall be fixed in position after the main slab has been concreted and before the infill slab is concreted.

Preparation of formation and sub-base 10.31 Construction of concrete carriageways shall start as soon as practicable after the formation or sub-base has been completed. The formation shall be protected as stated in Clause 6.52 and the sub-base shall be protected as stated in Clause 9.35 until construction of the carriageway starts.

Laying polyethylene sheeting 10.32 Polyethylene sheeting below concrete carriageways shall be laid flat without creases. Laps shall be at least 300 mm and there shall be no gaps at the edges of bays.

FORMWORK

Formwork 10.33 (1) Unless otherwise approved by the Engineer, formwork for concrete carriageways shall be steel. The finish to concrete surfaces for transverse and longitudinal joints shall be Class F3. The finish to concrete surfaces for other edges of the carriageway shall be Class F2.

(2) Concrete shall not be placed against excavated surfaces or against kerbs unless permitted by the Engineer.

(3) Formwork shall not be loosened or removed until at least 7 hours after concreting has been completed.

FORMING JOINTS

Forming joints 10.34 (1) Materials for joints in concrete carriageways shall be used in accordance with the manufacturers' recommendations or as otherwise stated in the Contract.

(2) Dowel bars, tie bars and their sleeves shall be securely fixed in position through holes in the formwork before concreting. The bars shall be parallel to the top surface of the slab and to each other. Bars at transverse joints shall be parallel to the adjacent longitudinal joint or to the longitudinal axis of the carriageway if there is no longitudinal joint or to other lines instructed by the Engineer.

(3) Joint filler shall be cut to size before fixing and shall be securely fixed in position to the existing concrete surface before concreting. There shall be

no gaps between the joint filler and the formation. Holes in joint filler for dowel bars shall be cut to form a sliding fit to the sleeved bar.

(4) Joints shall be formed perpendicular to the top surface of the slab.

Transverse joints

10.35 (1) Unless otherwise permitted by the Engineer, transverse joints in concrete carriageways shall be straight and perpendicular to the longitudinal axis of the carriageway.

(2) Transverse expansion joints and transverse contraction joints shall be formed only at the specified positions. The joints shall be continued across longitudinal joints and shall be in line and of the same type on both sides of the longitudinal joint. The joints shall be continued through kerbs, edgings and quadrants and their foundation and backing. The joint dimensions and materials shall be the same as the transverse joints with the omission of dowel bars. The location of additional contraction joints in accordance with Clause 11.54(3) shall be as instructed by the Engineer.

(3) The joint filler and groove for joint sealant at transverse expansion joints shall provide complete separation of adjacent slabs.

Longitudinal joints

10.36 Longitudinal joints in concrete carriageways shall be formed only at the specified positions.

Isolation joints

10.37 Isolation joints shall be formed in concrete carriageways at manholes and chambers.

Forming grooves

10.38 (1) Grooves in concrete carriageways for joint sealant shall be straight, shall have parallel sides and shall be perpendicular to the top surface of the slab. The bottom of the groove shall be flat and shall be parallel to the top surface of the slab.

(2) Grooves at transverse expansion joints and at isolation joints at manholes and chambers shall be formed by sawing the groove to the specified width and depth not less than 7 days after concreting. The grooves shall be located over the joint filler such that the upper surface of the joint filler is entirely contained in the groove.

(3) Grooves at transverse contraction joints shall be formed using one of the following methods:

Method 1: An initial groove shall be sawn as soon as practicable after concreting without causing spalling of the edges. The width of the initial groove shall be less than the specified width of the final groove and the depth of the initial groove shall be between 1/4 and 1/3 of the thickness of the slab. The final groove shall be sawn to the specified width and depth not less than 7 days after concreting. The center-lines of the initial and final grooves shall coincide.

Method 2: The final groove shall be sawn to the specified width and depth as soon as practicable after concreting without causing spalling of the edges.

(4) Grooves at transverse construction joints shall be formed by fixing groove-forming strip with adhesive to the concrete already placed before

concreting the adjacent slab.

Protection of grooves 10.39 Before permanent sealing, grooves in concrete carriageways for joint sealant shall be protected from contamination by a temporary sealing strip or by other methods agreed by the Engineer.

Sealing joints 10.40 (1) The permanent sealing of joints in concrete carriageways shall be carried out at least 7 days after concreting unless otherwise permitted by the Engineer.

(2) Immediately before permanent sealing, groove forming strips, temporary seals, dirt and loose material shall be removed from the groove and the sides of the groove shall be cleaned and roughened by water jetting, sand blasting or by other methods agreed by the Engineer.

(3) Caulking material shall be firmly packed in the bottom of the groove if the joint sealant is not required to extend to the bottom of the groove.

(4) Bond breaker tape shall be fixed continuously and evenly along the bottom of the groove for the full width and length of the groove.

(5) Primer for the joint sealant shall be applied to the sides of the groove in accordance with the manufacturer's recommendations.

(6) Joint sealant shall be applied between the minimum and maximum drying times of the primer recommended by the manufacturer. The components of the sealant shall be thoroughly mixed in accordance with the manufacturer's recommendations using a power operated paddle mixer for sufficient time to produce a homogeneous mass without entrapped air. The sealant shall be dispensed into the groove as soon as practicable after mixing and within the time recommended by the manufacturer.

(7) The groove shall be clean and dry at the time of applying the primer and joint sealant.

(8) Excess joint sealant shall be removed by using a purpose made finishing tool such that the finished surface of the sealant is between 4 mm and 6 mm below the surface of the slab.

PLACING AND COMPACTING CONCRETE

Placing and compacting concrete 10.41 (1) Concrete shall be placed continuously between the joints in concrete carriageways unless otherwise permitted by the Engineer.

(2) Concrete in unreinforced slabs shall be placed and compacted to the full thickness of the slab in one operation.

(3) Unless otherwise permitted by the Engineer, concrete in reinforced slabs shall be placed and compacted to the specified level of the fabric reinforcement. The fabric reinforcement shall be placed in position and concrete shall be placed and compacted to the remaining thickness of the slab. The time between compaction of the first layer and placing of the remaining layer shall not exceed 30 minutes unless in the opinion of the Engineer the concrete already placed is sufficiently workable and the permission of the Engineer has been obtained. If permission is not obtained, a construction joint

shall be formed as stated in Clause 16.45. Concrete shall not be placed against the concrete already placed for at least 24 hours unless permitted by the Engineer.

(4) Concrete in infill slabs at covers, frames and other hardware shall be placed and compacted after the covers, frames and hardware have been fixed in position and shall not be placed at the same time as the concrete in the main slab.

CONSTRUCTION JOINTS

Construction joints 10.42 (1) Construction joints shall be formed in concrete carriageways only where approved by the Engineer or in cases of emergency if concreting is interrupted by adverse weather, plant breakdown or similar circumstances. Construction joints shall not be formed within 2.5 m of an existing or planned expansion or contraction joint.

(2) Transverse construction joints shall be formed by either:

(a) Using formwork and cast-in tie bars, or
(b) Breaking back from an unformed edge and fixing the tie bars and sleeves with epoxy resin grout in drilled holes.

SURFACE FINISH

Surface regulation 10.43 (1) Unless combined double beam compactor-levellers are being used, then after compaction, the concrete in concrete carriageways shall be struck off to slightly above the levels of the formwork and the surface shall be regulated by a regulating machine or a vibrating beam.

(2) Regulating machines shall be purpose made and shall span the full width of the slab either transversely or obliquely. The machine shall be equipped with at least two oscillating-type transverse screeds and shall be supported on a carriage.

(3) Vibrating beams shall have a steel or aluminium surface and shall be mounted on a separate carriage. The beam shall be driven by a motor to provide a vibration frequency of at least 3500 cycles per minute.

(4) After regulation by the regulating machine or vibrating beam, the surface of the carriageway shall be regulated by at least two passes of a scraping straight edge with a blade length of at least 1.8 m. Scraping straight edges that operate in conjunction with regulating machines shall pass across the surface at right angles to the longitudinal axis of the carriageway. If the surface is torn by the straight edge, the surface shall be regulated again by the regulating machine or vibrating beam and by the scraping straight-edge.

(5) Wooden floats may be used to tamp and regulate small areas of the carriageway as agreed by the Engineer. Steel floats or trowels shall not be used.

Surface texturing 10.44 (1) After the surface of the concrete carriageway has been regulated and before the curing compound is applied, the surface, other than the surface of channels and edges of slabs that do not require to be textured, shall be textured by brushing with a wire broom.

(2) The wire broom shall be at least 450 mm wide and shall have two rows of tufts. The rows shall be 20 mm apart and the tufts in each row shall be at 10 mm centres and in line with the centre of the gaps between the tufts in the other row. The tufts shall contain an average of 14 wires, each of 32 gauge and initially 100 mm long. The broom shall be replaced if any tuft wears down to a length of 90 mm.

(3) The surface texture shall be produced by brushing evenly across the slab in one direction at right angles to the longitudinal axis of the carriageway. Brushing shall be carried out after the moisture film has disappeared from the concrete surface and before the initial set is complete.

CURING CONCRETE

Curing concrete 10.45 The surface and edges of concrete carriageways shall be protected by one of the methods stated in Clause 16.46 except that covering with hessian, sacking, canvas or other absorbent material as stated in Method 2 shall not be used. If Method 1 is used, the curing compound shall be applied to the surface immediately after the surface has been textured and shall be applied to the edges immediately after the formwork has been removed.

PROTECTION OF CONCRETE CARRIAGEWAY

Protection of concrete carriageway 10.46 (1) Immediately after the curing system has been applied, the concrete carriageway shall be fenced off from pedestrian traffic and covered with protective sheeting for at least 24 hours. The sheeting shall be lapped and securely held in position in such a manner that the surface of the carriageway will not be damaged.

(2) Loads from materials not forming part of the permanent work or from construction plant or other vehicles shall not be applied to the concrete carriageway until at least 7 days after concreting has been completed and until all grooves at joints have been temporarily or permanently sealed or protected.

TOLERANCES

Tolerances: sub-base 10.47 The level of the sub-base below concrete carriageways shall not be more than 10 mm higher, and shall not be more than 20 mm lower, than the specified level.

Tolerances: formwork 10.48 (1) The line of formwork for concrete carriageways shall be within 10 mm of the specified line of the concrete carriageway.

(2) The level of the top of the formwork shall be within 3 mm of the specified level of the concrete carriageway.

(3) Abrupt irregularities in the line of the formwork and in the level of the top of formwork shall not exceed 3 mm.

Tolerances: reinforcement 10.49 The cover to fabric reinforcement in concrete carriageways shall be within 10 mm of the specified cover.

Tolerances: dowel bars and tie bars 10.50 (1) Dowel bars at joints in concrete carriageways shall be within 20 mm of the mid-depth of the slab.

(2) Dowel bars shall be parallel to within 3 mm in half the length of the bar to:

(a) The longitudinal joint, or the longitudinal axis of the concrete carriageway if there is no longitudinal joint,

(b) The top surface of the slab, and

(c) Adjacent dowel bars.

Tolerances: grooves 10.51 Unless otherwise recommended by the manufacturer of the joint sealant the depth of grooves for joint sealant in concrete carriageways shall be within 3 mm of the specified depth.

Tolerances: covers, frames and other hardware 10.52 The level of covers, frames and other hardware shall not be higher than, and shall not be more than 3 mm lower than, the surface of the adjacent carriageway.

Tolerances: alignment of concrete carriageway 10.53 (1) The best-fit straight line of straight joints and of straight edges of concrete carriageways shall be within 25 mm of the specified line. The line of straight joints and of straight edges of concrete carriageways shall be within 10 mm of the best-fit straight line.

(2) The best fit curved line of curved joints and of curved edges of concrete carriageways shall be as agreed by the Engineer and shall be within 25 mm of the specified line. The line of curved joints and of curved edges of concrete carriageways shall be within 10 mm of the best-fit curved line.

(3) Joints in concrete carriageways shall be continuous across intersections of joints to within 5 mm of the best fit straight lines or best fit curved lines of each joint.

Tolerances: level of concrete carriageway 10.54 (1) The levels of the surface of concrete carriageways shall be determined 200 mm from the edges of each bay at 10 m centres in the longitudinal direction and at 2 m centres in the transverse direction.

(2) The level of the surface of concrete carriageways shall be within 6 mm of the specified level. In low lying and flat areas the Contractor shall pay special attention to level control to ensure that falls on the surface of the carriageway are in the specified direction.

(3) The difference in level of the surface of concrete carriageways across joints shall not exceed 3 mm.

(4) The thickness of concrete carriageway slabs shall not be less than the specified thickness minus 10 mm.

TESTING: SURFACE REGULARITY

Testing: surface regularity

10.55 (1) The surface regularity of concrete carriageways shall be determined by measuring the number of irregularities in the surface. An irregularity means that the gap between the surface of the carriageway, and a 3 m straight-edge placed on the surface of the carriageway, exceeds the specified amount. Irregularities shall be measured in millimetres perpendicular to the straight edge.

(2) The longitudinal surface regularity of carriageways with a total length of 75 m or more may be measured using a rolling straight-edge of the type designed by the UK Transport and Road Research Laboratory. The longitudinal surface regularity of carriageways with a total length of less than 75 m and the transverse surface regularity of carriageways shall be measured using a 3 m straight edge.

(3) The longitudinal surface regularity shall be measured along lines parallel to the longitudinal axis of the carriageway and approximately 1 m from the nearside edge of each carriageway lane. The transverse surface regularity shall be measured along lines at right angles to the longitudinal axis of the carriageway at 10 m intervals along the length of the carriageway.

(4) Testing to determine the surface regularity will be carried out by the Engineer.

Compliance criteria: surface regularity

10.56 The results of tests for surface regularity of carriageways shall comply with the following requirements:

(a) The size and number of irregularities in the longitudinal direction shall not exceed the size and permitted number of irregularities stated in Table 10.1.

(b) There shall be no irregularity exceeding 4 mm in a 3 m length in the transverse direction for Category A roads and there shall be no irregularity exceeding 7 mm in a 3 m length in the transverse direction for Category B roads.

Table 10.1: Permitted irregularities in the longitudinal direction

Total length of carriageway	**Size of irregularity**	**Permitted number of irregularities (Category A road)**	**Permitted number of irregularities (Category B road)**
< 75 m	> 4 mm	(9 x total length)/75	(18 x total length)/75
	> 7 mm	1	2
75 m - 300 m	> 4 mm	9 in any 75 m length	18 in any 75 m length
	> 7 mm	1 in any 75 m length	2 in any 75 m length
> 300 m	> 4 mm	20 in any 300 m length	40 in any 300 m length
		9 in any 75 m length	18 in any 75 m length
	> 7 mm	2 in any 300 m length	4 in any 300 m length
		1 in any 75 m length	2 in any 75 m length

Category A roads are roads with a legal speed limit greater than 70 kilometre per hour. All other roads are Category B roads.

Irregularities greater than 7 mm shall also be counted as greater than 4 mm.

No irregularity greater than 10 mm shall be permitted.

TESTING: TEXTURE DEPTH

Testing: texture depth 10.57 (1) The texture depth of concrete carriageways shall be determined by the sand patch test. Tests shall be carried out at least 2 days after the surface texturing has been carried out and before the area is used by construction plant or other vehicles.

(2) Each carriageway lane shall be divided into sections of equal length not exceeding 150 m. Tests shall be carried out at ten locations on each Section at approximately equal spacings as instructed by the Engineer. No measurement shall be taken within 300 mm of the longitudinal edges of the sections.

(3) Testing to determine the texture depth will be carried out by the Engineer. The method of testing shall be in accordance with Appendix 10.1.

Compliance criteria: texture depth 10.58 The results of tests for texture depth for each Section of concrete carriageway lane shall comply with the following requirements:

(a) The average texture depth shall not be less than 0.70 mm, and

(b) Not more than one out of the ten measured texture depths shall be less than 0.6 mm.

TESTING: CONCRETE

Testing: workability and compressive strength of concrete

10.59 Testing to determine the workability and compressive strength of concrete in concrete carriageways shall be as stated in Clauses 16.52 to 16.62 except as stated in Clauses 10.60 and 10.61.

Compliance criteria: workability of concrete

10.60 The average slump value of the two specimens taken from one sample of concrete shall not exceed the approved slump value by more than 10 mm.

Samples: compressive strength of concrete

10.61 One sample of concrete shall be provided from each 25 m^3 or 25 batches of concrete or from the amount of concrete produced each day, whichever is less.

TESTING: CONCRETE CORES FROM TRIAL LENGTHS

Samples: concrete cores from trial lengths

10.62 (1) Two concrete cores shall be provided from each bay, and one core shall be provided from each joint, of concrete carriageway in the trial length. The positions from which the cores are taken shall be as instructed by the Engineer.

(2) Concrete cores shall be 150 mm diameter unless otherwise permitted by the Engineer and shall be the full depth of the slab. Cores shall be taken as soon as the concrete has hardened sufficiently for the core to be taken.

(3) The method of taking concrete cores shall be in accordance with CS1.

(4) Holes formed by taking concrete cores from trial lengths that form part of the permanent carriageway shall be reinstated using the approved concrete mix. Joints shall be repaired as instructed by the Engineer.

Testing: concrete cores from trial lengths

10.63 (1) Each concrete core from trial lengths in concrete carriageways shall be inspected to determine the thickness of the slab and the positions of the reinforcement and joint components. Each core shall be inspected for evidence of segregation of the constituents and for the presence of voids.

(2) The method of preparing and inspecting concrete cores shall be in accordance with CS1.

Compliance criteria: concrete cores from trial lengths

10.64 The concrete core shall be considered as non-compliant if it exhibits honeycombing which means interconnected voids arising from, for example, inadequate compaction or lack of mortar.

TESTING: MATERIALS FOR JOINTS

Batch: joint filler, joint sealant

10.65 A batch of joint filler or joint sealant shall comply with Clause 16.89.

Samples: joint filler, joint sealant

10.66 Samples of joint filler or joint sealant shall comply with Clause 16.90.

Testing: joint filler, joint sealant

10.67 Testing of joint filler and joint sealant for joints in concrete carriageways shall be as stated in Clauses 16.91 and 16.92 except as stated in Clause 10.68.

Testing: joint sealant 10.68 Upon request by the Engineer, each sample of joint sealant shall be tested in accordance with BS EN 14188:Part 2. Otherwise, manufacturer's literature and certificates for the tests in accordance with BS EN 14188:Part 2 shall be provided.

APPENDIX 10.1

DETERMINATION OF THE TEXTURE DEPTH OF CARRIAGEWAYS

Scope 10.1.1 This method covers the determination of the texture depth of carriageways by the sand patch test.

Materials 10.1.2 The following material is required:

Dry natural sand, with a rounded particle shape, which has been washed and then screened such that it meets the grading stated in Table 10.1.1.

Table 10.1.1: Grading of sand

BS test sieve	**Percentage by mass passing**
600 µm	100
300 µm	95 - 100
150 µm	0 - 6

Apparatus 10.1.3 The following apparatus is required:

(a) A soft brush.

(b) A robust measuring cylinder having an internal diameter of 20 ± 2 mm and a flat top surface such that its internal volume is 25 ± 0.1 mL.

(c) A flat wooden disc of 65± 2 mm diameter with a 1.5 mm minimum thickness hard rubber disc attached to one face and a handle fixed to the other face.

(d) A steel rule calibrated to 1 mm.

(e) A suitable windshield.

(f) A funnel with an outlet tube at least 100 mm long with a bore of between 4 mm and 6 mm, and capable of accepting a volume of at least 200 mL.

(g) A steel straight edge for screeding off the measuring cylinder.

(h) A steel-wire brush.

Procedure 10.1.4 The procedure shall be as follows:

(a) The test location shall be at least 300 mm square. It shall be vigorously brushed ten times in two directions at right angles using the steel wire brush, and then dried and swept clean with the soft brush.

(b) Sand shall be poured into the measuring cylinder to fill it to overflowing, and any excess sand shall be screeded off using the straight edge. All sand on the outside of the cylinder shall be removed, taking care not to drop any sand onto the test location. Alternatively, this step in the procedure may be carried out in a laboratory, and the sand transferred to a suitable container ready for pouring.

(c) The measured volume of sand shall be poured onto the centre of the test location through the funnel to form a heap. The windshield shall be used to protect the test location if required.

(d) The sand shall be spread outwards with a circular motion over the test location, using the rubber-faced disc with its face parallel to the surface of the carriageway. This shall be continued until the patch of sand is approximately circular and will spread outwards no more.

(e) The size of the circular patch of sand shall be measured to the nearest 1 mm along three diameters, which are aligned at approximately 120 degrees to each other.

(f) If the difference between the maximum and minimum of the three measurements exceeds 20% of the average of the three measurements, then all the measurements shall be discarded and the test repeated at an adjacent location.

(g) The test shall be repeated for all the ten test locations for each Section of carriageway lane.

Calculation 10.1.5 (1) The texture depth (T) for each test shall be calculated from the equation:

$$T = 31000 / D^2 \text{ mm}$$

where:

- D is the average of the three diameter measurements of the sand patch calculated to the nearest 1 mm.

(2) The average texture depth for the ten tests shall be calculated.

Reporting of results 10.1.6 The following shall be reported:

(a) The test location.

(b) The average diameter of the sand patch for each test to the nearest 1 mm.

(c) The texture depth for each test to the nearest 0.1 mm.

(d) The average texture depth to the nearest 0.1 mm.

(e) That the test was carried out in accordance with this Specification.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 11

MISCELLANEOUS ROADWORKS

SECTION 11

MISCELLANEOUS ROADWORKS

PART 1: GENERAL REQUIREMENTS

GENERAL

General requirements 11.01 The works and materials specified in Clauses 11.02 to 11.08 shall comply with the sections stated, unless otherwise stated in this Section.

Earthworks 11.02 Earthworks shall comply with Section 6.

Sub-base material and bituminous materials 11.03 Sub-base material and bituminous materials shall comply with Section 9.

Joints in concrete 11.04 Joints in concrete shall comply with Section 10.

Formwork 11.05 Formwork and finishes to concrete shall comply with Section 14.

Reinforcement 11.06 Steel reinforcement shall comply with Section 15.

Concrete 11.07 Concrete shall comply with Section 16.

Steelwork 11.08 Steelwork shall comply with Section 18.

MATERIALS

Cement mortar 11.09 Cement mortar shall consist of one part of cement to three parts of fine aggregate by volume together with the minimum amount of water necessary to achieve a consistency suitable for the required work. Fine aggregates shall be sand or crushed rock to BS EN 13139 and shall be less than or equal to 4mm.

Polyethylene sheeting 11.10 Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 0.125 mm.

PART 2: CONCRETE PROFILE BARRIERS

MATERIALS

Concrete mix 11.11 Concrete for concrete profile barriers shall be Grade 30/20.

SUBMISSIONS

Particulars of concrete profile barriers 11.12 (1) The following particulars of the proposed methods of construction for concrete profile barriers shall be submitted to the Engineer:

(a) Particulars of formwork as stated in Clause 14.21 for in-situ construction using fixed forms,

(b) Details of slip-form machine for in-situ construction between sliding forms, and

(c) Methods of manufacture, handling, transport, storage and fixing in position of precast units.

(2) The particulars shall be submitted to the Engineer for information at least 14 days before construction of concrete profile barriers starts.

TRIALS

Trial length 11.13 (1) A trial length of concrete profile barrier shall be constructed to demonstrate that the proposed materials, mix design, methods of production and methods of construction will produce a concrete profile barrier which complies with the specified requirements. If it is not stated in the Contract that the trial length is to be constructed in a location separate from the permanent concrete profile barrier, the trial length shall be the first 25 m of the permanent barrier.

(2) The trial length shall be constructed in sufficient time before the permanent barrier is constructed to allow the Engineer a period of at least 7 days to determine if the specified requirements have been produced in the trial length.

(3) The Contractor shall inform the Engineer at least 24 hours, or such shorter period agreed by the Engineer, before constructing the trial length.

(4) The trial length shall be constructed using the materials, mix design, methods of production and methods of construction submitted to the Engineer.

(5) The trial length shall be used as a means of comparison against which the Engineer shall determine the compliance or otherwise of the permanent concrete profile barrier. The trial length shall be protected from damage and shall be left in position unless the Engineer instructs its removal. A trial length which forms part of the permanent barrier and which complies with the specified requirements shall not be removed.

Testing: trial length 11.14 (1) The trial length shall be tested to determine the accuracy of the alignment and level and the finish of the concrete surface.

(2) Concrete cores shall be cut from the trial length to determine the amount of segregation of the constituents and the presence of voids. The method of taking, preparing, inspecting and testing concrete cores shall be as stated in Clause 11.26.

Compliance criteria: trial length 11.15 The results of tests on trial lengths shall comply with the following requirements:

(a) The alignment and levels of the barrier shall comply with Clause 11.25.

(b) The finish of concrete surfaces shall comply with Clause 14.44.

(c) The amount of segregation of the constituents and the presence of voids shall comply with Clause 10.64 for concrete carriageways.

Non-compliance: trial length 11.16 (1) If the result of any test on the trial length does not comply with the specified requirements for the trial length, particulars of proposed changes to the materials, mix design, methods of production or methods of construction shall be submitted to the Engineer. Further trial lengths shall be constructed until the result of every test on the trial length complies with the specified requirements for the trial length. Further trial mixes shall be made unless in the opinion of the Engineer non-compliance of the trial length was not due to the concrete mix.

(2) Unless otherwise permitted by the Engineer, trial lengths, or parts of trial lengths, which do not comply with the specified requirements for the trial length shall be removed.

Commencement of concreting 11.17 (1) Except as stated in Clause 11.17(2) concrete shall not be placed in the permanent barriers until the result of every test on the trial length complies with the specified requirements for the trial length.

(2) Concrete may be placed in the permanent barriers before the results of tests for compressive strength of the trial mix are available provided that the result of every other test on the trial mix and trial length complies with the specified requirements for trial mix concrete and for the trial length.

Changes in materials and methods of construction 11.18 Unless permitted by the Engineer, the materials mix design, methods of production and methods of construction used to produce a trial length that complies with the specified requirements shall not be changed. Further trial lengths shall be constructed to demonstrate any proposed changes unless otherwise permitted by the Engineer.

FORMWORK AND FINISHES TO CONCRETE

Formwork 11.19 (1) Formwork for concrete profile barriers shall be steel unless otherwise permitted by the Engineer.

(2) Formwork shall not be loosened or removed until at least 7 hours after concreting has been completed.

Finishes to concrete 11.20 (1) The finish to unformed concrete surfaces of concrete profile barriers shall be Class U5.

(2) The finish to concrete surfaces for transverse joints shall be Class F3 and the finish to exposed concrete surfaces shall be Class F5.

JOINTS IN CONCRETE PROFILE BARRIERS

Joints in concrete profile barriers 11.21 (1) Joints shall be formed in concrete profile barriers at locations which coincide with expansion or construction joints in the adjoining structure or carriageway or at intervals not exceeding 12 m, whichever is less.

(2) Joints in concrete profile barriers shall comply with Section 16.

CONSTRUCTION OF CONCRETE PROFILE BARRIERS

Construction by slip-form machine 11.22 Construction of concrete profile barriers by slip-form machine between sliding forms shall be carried out in accordance with BS 5931. Slip-form machines shall comply with BS 5931, Appendix A.

Construction using precast units 11.23 Precast concrete profile barriers shall be laid on a cement mortar regulating layer of between 10 mm and 40 mm thick.

PROTECTION OF CONCRETE PROFILE BARRIERS

Protection of concrete profile barriers 11.24 Immediately after the formwork has been removed or the curing compound has been applied, concrete profile barriers shall be protected by polyethylene sheeting for at least 24 hours from exposure to conditions that may affect the concrete. The sheeting shall be lapped and securely held in position in such a manner that the surface of the concrete will not be damaged.

TOLERANCES

Tolerances: concrete profile barriers 11.25 Concrete profile barriers shall comply with the following requirements:

(a) The horizontal dimensions of cross-sections shall be within 5 mm of the specified dimensions.

(b) The vertical dimensions of cross-sections shall be within 10 mm of the specified dimensions.

(c) The horizontal alignment along the centreline shall be within 10 mm of the specified centreline.

(d) The level of the formation shall be within 10 mm of the specified level.

(e) The level of the top of the barriers shall be within 10 mm of the specified level.

(f) The barriers shall form a smooth alignment.

TESTING: CONCRETE CORES FROM TRIAL LENGTHS

Testing: concrete cores from trial lengths 11.26 (1) Two concrete cores shall be provided from each trial length of concrete profile barriers. The positions from which the cores are taken shall be as instructed by the Engineer.

(2) Samples, testing and compliance criteria for concrete cores from trial lengths shall be as stated in Clauses 10.62 (2) to (4), 10.63 and 10.64 for concrete carriageways.

PART 3: PEDESTRIAN GUARD-RAILING

GENERAL

Design of pedestrian guard-railing

11.27 Pedestrian guard-railing which is proposed by the Contractor as an alternative to that stated in the Contract or which is erected as Temporary Works shall be designed according to the design loads as given in Table 1.

Table 1: Design Loads for pedestrian guard-railing

Minimum design loads					
Rails	End and 90° corner posts		Other posts		Infilling
	Transverse load	Longitudinal load	Transverse load	Longitudinal load	
N/m	N	N	N	N	N
1400	1400	1400	2800	1400	1000

MATERIALS

Steel

11.28 Steel for pedestrian guard-railing shall comply with the following:

Hot finished seamless tubes	: BS EN 10297:Part 1
Steel tubes and tubular suitable for screwing to BS EN 10226 pipe threads	: BS EN 10255
Hot rolled sections	: BS EN 10365
Hot rolled structural steel sections - equal and unequal angles	: BS EN 10056
Weldable structural steels	: BS EN 10025

Stainless steel

11.29 Stainless steel for pedestrian guard-railing shall be Grade 1.4401 and shall comply with the following:

Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes	: BS EN 10088:Part 2
Stainless steel tubes suitable for threading in accordance with BS EN 10226	: BS 6362

Aluminium

11.30 (1) Aluminium for pedestrian guard-railing shall be H 30 TF and shall comply with the following:

Wrought aluminium and aluminium alloys for general engineering purposes

- plate, sheet and strip	: BS 1470

- drawn tube	: BS 1471
- bars, extruded round tubes and sections	: BS 1474

(2) Aluminium shall be anodised to Grade AA 25 in accordance with BS 1615.

Bolts, nuts, screws, washers and rivets 11.31 (1) Bolts, nuts, screws, washers and rivets for pedestrian guard-railing shall comply with the following:

ISO metric black hexagon bolts, screws and nuts	: BS 4190
ISO metric black cup and countersunk head bolts and screws with hexagon nuts	: BS 4933
Metal washers for general engineering purposes	: BS 4320
Rivets for general engineering Purposes	: BS ISO 1051
Wrought aluminium and aluminium alloys for general engineering purposes - rivet, bolt and screw stock	: BS 1473

(2) The length of bolts shall be such that the threaded portion of each bolt projects through the nut by at least one thread and by not more than four threads.

(3) Rag, indented and expansion bolts and resin bonded bolts shall be of proprietary types approved by the Engineer and shall be capable of withstanding the design loading.

(4) Galvanized bolts, nuts, screws, washers and rivets shall be used with galvanized pedestrian guard-railing. Aluminium materials shall be insulated from ferrous materials by a non-conductive insulator at least 2 mm thick of a type approved by the Engineer.

Mesh infill 11.32 Mesh infill for pedestrian guard-railing shall comply with BS 4483. The mesh infill shall be free of surface defects, surface irregularities and mesh misalignment.

FABRICATION OF PEDESTRIAN GUARD-RAILING

Galvanizing to steel 11.33 (1) Steel components forming pedestrian guard-railing shall be hot-dip galvanized in accordance with BS EN ISO 1461.

(2) Galvanizing to steel shall be applied after welding, drilling and cutting are complete.

Welding steel 11.34 (1) Welding for fabrication of pedestrian guard-railing shall be fillet welds. Welded surfaces shall be clean and flush before application of the protective coating.

(2) Steel shall not be welded after galvanizing unless permitted by the Engineer. If permitted, the welded areas shall be free of scale and slag and shall be treated with an alternative zinc-coating system approved by the Engineer.

SUBMISSIONS

Particulars of pedestrian guard-railing

11.35 (1) The following particulars of the proposed pedestrian guard-railing shall be submitted to the Engineer:

(a) A certificate from the manufacturer showing the manufacturer's name, the date and place of manufacture and showing that the materials comply with the requirements stated in the Contract, and

(b) Details of alternative designs proposed by the Contractor, including drawings, showing the proposals and that the pedestrian guard-railing has been designed in accordance with Clause 11.27.

(2) The particulars shall be submitted to the Engineer at least 28 days before fabrication of the pedestrian guard-railing starts.

Samples of materials

11.36 Samples of the following proposed materials shall be submitted to the Engineer for approval of the source and type of each material at the same time as particulars of the pedestrian guard-railing are submitted:

(a) Each type of pedestrian guard-railing,

(b) Mesh infill, and

(c) Each type of bolt, nut, and washer.

STORAGE OF MATERIALS

Storage of pedestrian guard-railing

11.37 Pedestrian guard-railing shall be stored off a levelled, well drained and maintained hard-standing ground on level supports and in a manner which will not result in damage or deformation to the guard-railing or in contamination of the guard-railing. Pedestrian guard-railing shall be protected from damage and damaged guard-railing shall not be used in the permanent work unless permitted by the Engineer. Measures to protect the materials from the effects of weather shall be submitted to the Engineer for approval.

INSTALLATION OF PEDESTRIAN GUARD-RAILING

Installation of

11.38 (1) Pedestrian guard-railing shall be installed to a smooth alignment to

pedestrian guard-railing

within 10 mm of the specified position and height.

(2) Pedestrian guard-railing which is to be installed to a radius of less than 45 m shall be curved in the workshop and shall not be made up of a series of straight lengths.

(3) Pedestrian guard-railing shall be fixed to concrete using rag, indented, expansion or resin bonded bolts and shall be bolted to metalwork. Bolts for fixing to concrete shall be fitted into pockets filled with cement mortar or resin grout.

PART 4: UNTENSIONED BEAM BARRIERS

MATERIALS

Beams 11.39 (1) Beams for untensioned beam barriers shall be formed from steel plates complying with BS 1449:Part 1.1, type BHR, and BS EN 10149:Part 3, Grade S315NC.

(2) The beams shall be capable of withstanding a tensile force of at least 300 kN and shall not deflect by more than 40 mm when loaded centrally with a point load of 1 t over a simply supported span of 3 m.

(3) Beams shall comply with the following requirements:

(a) The base metal thickness shall be within 0.2 mm of the specified thickness.

(b) The strip width shall be within + 2.5 mm and - 0 mm of the specified width.

(c) The camber of the strip length shall be within 8 mm of the specified camber.

(d) The beam shall be straight to within 1.5 mm in a 1.5 m length.

(e) Angles at bends shall be within 2° of the specified angle.

(4) Bolt slots in beams for connection to posts shall be prepared in the workshop by cold saw-cutting. The spacing of the slots shall be such that posts will be spaced at either 4 m or 2 m.

(5) Beams shall be hot-dip galvanized to BS EN ISO 1461.

Welds for end beam sections shall be full-penetration butt welds.

Posts 11.40 (1) Posts for untensioned beam barriers shall be formed from Grade 275JR steel complying with BS EN 10025:Part 2.

(2) Posts shall be hot-dip galvanized in accordance with BS EN ISO 1461.

(3) Posts fabricated from hollow sections shall be sealed by welding mild steel sealing plates over the open ends. The plates shall be at least 3 mm thick.

(4) Posts shall be within the tolerances stated in BS EN 10365.

Cleats and struts 11.41 (1) Cleats and struts for untensioned beam barriers shall be fabricated from angle sections complying with BS EN 10056 and shall be weldable structural steel complying with BS EN 10025:Part 2, Grade 275JR.

(2) Cleats and struts shall be hot-dip galvanized in accordance with BS EN ISO 1461.

(3) The dimensional tolerances of steel angles for cleats and struts shall comply with BS EN 10056.

Bolts and nuts 11.42 (1) Bolts for untensioned beam barriers shall be M 16 size and strength Grade 4.6 complying with BS 4190. Bolts for beam splicing, bolts for connecting beams to posts and bolts for connecting beams to cleats shall be round or button-headed with oval shoulders. Other bolts shall be ISO metric black hexagon type.

(2) Nuts for untensioned beam barriers shall be strength Grade 4 or 5 complying with BS 4190.

(3) Bolts and nuts shall be hot-dip galvanized in accordance with BS EN ISO 1461.

(4) Nuts shall be tapped 0.4 mm oversize to accommodate the galvanized coating.

(5) The length of bolts shall be such that the threaded portion of each bolt projects through the nut by at least one thread and by not more than four threads.

(6) Rag, indented and expansion bolts and resin bonded bolts shall be of a proprietary type approved by the Engineer and shall be capable of withstanding the design loading.

Washers 11.43 (1) Washers for untensioned beam barriers shall be black mild steel and shall comply with BS 4320, Form E, F or G. Washers shall be manufactured from steel complying with BS 1449:Part 1.1 and BS EN 10149:Part 3, Grade S315NC.

(2) Plain washers shall be 2 mm thick and shall be of dimensions suitable for use with M 16 bolts and nuts.

(3) Plain washers shall be hot-dip galvanized in accordance with BS EN ISO 1461.

(4) Shaped washers shall have a thickness of at least 5 mm and shall be cast iron complying with BS EN 13835. The washers shall be shaped to fit the curvature of circular hollow sections used as posts.

SUBMISSIONS

Particulars of untensioned beam barriers 11.44 (1) The following particulars of the proposed materials and methods of construction for untensioned beam barriers shall be submitted to the Engineer:

(a) A certificate from the manufacturer for beams in the format stated in BS EN 10025 showing the manufacturer's name, the date and place of manufacture and showing that the beams comply with the requirements stated in the Contract and including carbon equivalent values, and

(b) Details of method of installation.

(2) The particulars, including certificates, shall be submitted to the Engineer for approval of the source and type of materials at least 14 days before installation of the beams starts. Certificates shall be submitted for each batch of beams delivered to the Site.

Samples of materials 11.45 Samples of the following proposed materials shall be submitted to the Engineer for approval of the source and type of each material at the same time as particulars of the material are submitted:

(a) Beams,

(b) Posts, cleats and struts, and

(c) Bolts, nuts and washers.

STORAGE OF MATERIALS

Storage of beams and posts 11.46 Beams and posts for untensioned beam barriers shall be stored off a levelled, well drained and maintained hard-standing ground on level supports and in a manner that will not result in damage or deformation to the beams and posts or in contamination of the beams and posts. Beams and posts shall be protected from damage and damaged beams and posts shall not be used in the permanent work unless permitted by the Engineer. Measures to protect the materials from the effects of weather shall be submitted to the Engineer for approval.

CONSTRUCTION OF UNTENSIONED BEAM BARRIERS

Installation of untensioned beam barriers 11.47 (1) Untensioned beam barriers shall be ready for assembly when delivered to Site. Beams and posts shall be free of blisters, flux, uncoated spots and other defects.

(2) Untensioned beam barriers shall be installed to a smooth alignment to within 10 mm of the specified position and height. Transition sections shall provide a smooth and uniform transition.

(3) Beams which are to be installed to a radius of less than 45 m shall be curved in the workshop.

(4) Untensioned beam barriers shall be fixed to concrete using rag, indented, expansion or resin bonded bolts and shall be bolted to metalwork. Bolts for fixing to concrete shall be fitted into pockets filled with cement mortar or resin grout.

Compacted earth footings 11.48 (1) Sub-base material shall be deposited and compacted in the bottom 250 mm of pits for foundations of untensioned beam barriers with compacted earth footings. Fine fill material shall be deposited and compacted to the remainder of the pit. The sub-base material and fill material shall be compacted to obtain a relative compaction of at least 95% throughout.

(2) Posts for untensioned beam barriers shall be securely fixed in position during deposition and compaction of fill material.

Concrete footings 11.49 (1) Concrete for concrete footings shall be Grade 20/20.

(2) The top surface of concrete footings shall be finished level with the adjoining ground. The finish to the concrete surface shall be Class U5.

(3) Posts shall be surrounded with polyethylene sheeting before concrete is placed and shall be securely fixed in position during concreting.

Anchor blocks 11.50 (1) Concrete for anchor blocks shall be Grade 20/20.

(2) The finish to concrete surfaces of anchor blocks shall be Class F5 for formed finishes and Class U5 for unformed finishes.

PART 5: KERBS, EDGINGS AND QUADRANTS

MATERIALS

Concrete kerbs, edgings and quadrants

11.51 (1) Concrete for kerbs, edgings and quadrants shall be Grade 30/20. Concrete for foundations and backings to kerbs, edgings and quadrants shall be Grade 20/20.

(2) Precast concrete kerbs, edgings and quadrants shall comply with BS EN 1339 except that the requirement for testing of weathering resistance, abrasion resistance, slip/skid resistance shall not be applied. The nominal length of kerbs shall be 1 m and the nominal length of edgings shall be 750 mm.

Granite kerbs, edgings and quadrants

11.52 (1) Granite kerbs, edgings and quadrants shall be worked straight or circular. Corners shall be square and the top front and back edges shall be parallel. The length of granite kerbs and edgings shall be at least 600 mm.

(2) The ends of the kerbs, edgings and quadrants shall be chisel-dressed square to form a close butt-joint with adjacent kerbs. Kerbs shall be chisel-dressed to a depth of at least 140 mm on the front face, at least 75 mm on the back face and for the full width of the top face.

CONSTRUCTION OF KERBS, EDGINGS AND QUADRANTS

Construction of precast concrete and granite kerbs, edgings and quadrants

11.53 (1) Precast concrete and granite kerbs, edgings and quadrants shall be laid and bedded on a regulating layer of cement mortar. The thickness of the layer shall be at least 10 mm and shall not exceed 40 mm.

(2) Except as stated in this clause, joints between each kerb, edging and quadrant shall not exceed 10 mm in width and shall be filled and flush pointed with cement mortar. Joints in kerbs, edgings and quadrants at expansion joints on bridge decks shall be as stated in the Contract. Transverse expansion and contraction joints in kerbs, edgings and quadrants laid on or adjacent to concrete carriageways shall be in accordance with Clause 10.35(2).

(3) Radius kerbs shall be used for curves less than 10 m external radius.

Construction of in-situ kerbs, edgings and quadrants

11.54 (1) In-situ concrete kerbs, edgings and quadrants shall be constructed in accordance with BS 5931 and shall be laid by an automatic extrusion machine of a type approved by the Engineer.

(2) In-situ concrete kerbs, quadrants and edgings shall have regular sides, edges, arrises and chamfers. The finish to the concrete surface shall be Class U5. Kerbs, edges and quadrants shall not be finished or dressed with cement mortar.

(3) Contraction joints shall be formed at intervals not greater than approximately 4 m. Transverse expansion and contraction joints in kerbs, edgings and quadrants which are laid on or adjacent to concrete carriageways shall be in accordance with Clause 10.35(2). Joints shall be flush pointed with cement mortar.

TOLERANCES

Tolerances: kerbs, edgings and quadrants

11.55 (1) The line of kerbs, edgings and quadrants shall be within 3 mm of the specified line.

(2) The level of the top of kerbs, edgings and quadrants shall be within 3 mm of the specified level.

PART 6: FOOTWAYS, CYCLETRACKS AND PAVED AREAS

MATERIALS

Concrete for footways, cycletracks and paved areas

11.56 Concrete for footways, cycletracks and paved areas shall be Grade 30/20.

CONSTRUCTION OF FOOTWAYS, CYCLETRACKS AND PAVED AREAS

In-situ concrete footways, cycletracks and paved areas

11.57 In-situ concrete for footways, cycle tracks and paved areas shall be laid in areas not exceeding 20 m^2. The finish to the concrete surface shall be Class U4.

Flexible surfacing to footways, cycletracks and paved areas

11.58 (1) Bituminous materials for footways, cycletracks and paved areas shall be laid and compacted with steel-wheeled and pneumatic-tyred rollers. Compaction shall start before the temperature of the newly laid material falls below 100^0C and shall continue until all roller marks have been removed. For locations where rollers cannot operate effectively, the bituminous material can be compacted by hand-operated mechanical compaction plant approved by the Engineer.

(2) Cores shall be taken in accordance with Clause 9.62 for the checking of air void content and compacted layer thickness of the bituminous material for works with area of not less than 200m^2. For works with area smaller than 200m^2 but greater than 50m^2, at least 2 cores shall be taken from each layer of bituminous material laid. For works with area less than 50m^2, no coring is required unless otherwise instructed by the Engineer.

(3) The cores taken in accordance with Clause 11.58(2) shall be tested to determine the air void content. The average air void content of the cores shall be not less than 3% nor greater than 9%. If the test result does not comply with the specified requirement, 2 additional cores shall be taken at locations agreed by the Engineer and the average air void content determined from these 2 cores shall replace the original value for compliance checking. Notwithstanding this, no cores shall have an air void content of less than 2.5% nor greater than 10%.

(4) Each core taken from the final surfacing layer shall also be measured to determine the compacted layer thickness that shall not deviate by more than 5mm from the specified thickness. If the measured thickness does not comply with the requirement, 2 additional cores shall be taken at locations agreed by the Engineer and the average thickness determined from these 2 cores shall replace the original measured value for compliance checking.

(5) If no bulk sample is taken for determination of the Rice's specific gravity, the corresponding value obtained from the mix design shall be used in determining the air void content of the core unless other value is suggested by the Contractor and agreed by the Engineer.

(6) If either the air void content or the compacted thickness of the core is outside the specified limits, the sub-area from which the cores were taken shall

be considered as not complying with the requirements specified in this clause.

PROTECTION OF FOOTWAYS, CYCLETRACKS AND PAVED AREAS

Protection of footways, cycletracks and paved areas

11.59 Footways, cycletracks and paved areas shall not be used by construction plant or vehicles other than those, which in the opinion of the Engineer are essential to construct the subsequent work.

PART 7: PRECAST CONCRETE UNITS FOR PAVING

GLOSSARY OF TERMS

Unit 11.60 (1) Unit is a term used to describe a precast concrete paving slab, block or sett unless otherwise specified by the Engineer.

(2) Depending on their quality, units are classified as either Grade A or Grade B as follows:

- Grade A units shall comply with all the clauses of this PS.
- Grade B units shall comply with all the clauses of this PS except those stipulated for Grade A units only.

MATERIALS

Units 11.61 (1) The dimensions of units shall be within 3 mm of the specified dimensions unless otherwise stated. Chamfers shall not exceed 5 mm in width and depth or shall be round unless otherwise approved by the Engineer.

(2) Units may incorporate integral spacer nibs to aid the laying but these spacer nibs shall not be included in the size of the units.

(3) Units shall come in wide ranges of colours to facilitate pavement design by the Engineer. The colours of units shall be consistent over the area to be paved, stable and fade resistant under any outdoor climate situations.

(4) Units shall not exhibit defects such as cracking or flaking.

(5) Units shall be free of any surface sealant unless otherwise directed by the Engineer.

Precast concrete paving slabs 11.62 (1) Paving slabs shall be square or rectangular of metric size 200 mm x 300 mm or 300 mm x 300 mm unless otherwise specified by the Engineer.

(2) Paving slabs shall be 60 mm thick for footpaths. Paving slabs of other thickness may be used if approved by the Engineer.

Precast concrete paving blocks 11.63 (1) Paving blocks shall be as shown in relevant Highways Department Standard Drawings, unless otherwise specified by the Engineer. 200 x 200 x 60 mm paving units shall be considered as paving blocks.

(2) Paving blocks shall be 60 mm thick for footpaths and 80 mm thick for carriageways and vehicular accesses. Paving blocks of other thickness may be used if approved by the Engineer.

Precast concrete paving setts 11.64 (1) Paving setts shall be square of metric size 100 mm x 100 mm unless otherwise specified by the Engineer.

(2) Paving setts shall be 60 mm thick for footpaths and 80 mm thick for carriageways and vehicular accesses. Paving setts of other thickness may be used if approved by the Engineer.

Concrete 11.65 (1) Concrete for units in footways and cycle tracks shall be Grade 30. Concrete for units in carriageways or areas to which vehicles will have access shall be Grade 45.

The nominal maximum aggregate size for concrete in precast units shall be 10 mm.

Additional requirements for Grade A units 11.66 (1) Grade A units shall have an abrasion resistance of not more than 23 mm to BS EN 1338.

(2) Colour Pigments for Grade A units shall comply with BS EN 12878. They shall be UV-stable and shall be iron oxides, chrome oxide, titanium oxide or cobalt aluminium oxide unless otherwise approved by the Engineer.

Sand 11.67 (1) Sand for bedding units shall have the particle size distribution stated in Table 11.1. The sand shall have a moisture content exceeding 4% and not exceeding 8% at the time of laying.

(2) Sand for filling joints between precast units shall have the particle size distribution stated in Table 11.2. The sand shall have a moisture content of less than 0.5% at the time of filling joints.

Table 11.1: Particle size distribution of sand for bedding units

BS test sieve size	Percentage by mass passing
10 mm	100
5 mm	85 - 100
2.36 mm	65 - 100
1.18 mm	40 - 98
600 μm	25 - 72
300 μm	10 - 35
150 μm	0 - 15
75 μm	0 - 10

Table 11.2: Particle size distribution of sand for filling joints between units

BS test sieve size	Percentage by mass passing
2.36 mm	100
1.18 mm	90 - 100
600 μm	60 - 90
300 μm	30 - 60
150 μm	15 - 30
75 μm	5 - 10

SUBMISSIONS

Particulars of paving units 11.68 (1) The Contractor shall submit the following particulars of the proposed materials and methods of construction for the paving units to the Engineer:

(a) Name and address of manufacturer,

(b) A certificate from the manufacturer showing the source and the particle size distribution of the aggregates,

(c) A certificate from the manufacturer showing the manufacturer's name, the date and place of manufacture, and results of tests for:

- compressive strength of concrete cubes at 28 day,

- bending strength of paving slabs to BS EN 1339; and

- compressive strength of paving blocks and setts to Appendix 11.1.

(d) Drawings showing the layout of the units within the paved area.

(2) The particulars as required under Clause 11.68 (1) shall be submitted to the Engineer for approval of the source, type and layout of the units at least 14 days before laying of units starts.

Particulars of units - additional requirements for Grade A units 11.69 (1) The following particulars of the proposed materials for Grade A units shall be submitted to the Engineer:

(a) A certificate from the manufacturer showing the results of tests for:

- Dimensional deviations of paving slabs to BS EN 1339;

- Dimensional deviations of paving blocks and setts to BS EN 1338;

- Slip/skid resistance value of paving slabs to BS EN 1344;

- Slip/skid resistance value of paving blocks to BS EN 1344, or unpolished slip/skid resistance value of paving blocks to BS EN 1338;

- Slip/skid resistance value of paving setts to BS EN 1342;

- 24-hour cold water absorption value of paving slabs, blocks and setts to AS/NZS 4456.14; and

- Abrasion resistance of paving slabs, blocks and setts to BS EN 1338.

Samples of materials 11.70 Samples of each type of units shall be submitted to the Engineer for approval of the source and type of each unit at the same time as particulars of the units are submitted.

Samples of materials - 11.71 (1) Samples of each type of Grade A units showing the actual size, colour,

additional requirements for Grade A units

variation in colour, finish/texture as specified, and general characteristics of the appearance shall be submitted to the Engineer for approval at the time as particulars of the units are submitted.

(2) Samples submitted to the Engineer shall be subject to a visual inspection by the Engineer and shall comply with the following requirements:

(a) When examined in accordance with BS EN 1338, there shall not be significant visible differences in colour and texture between any samples;

(b) When examined in accordance with BS EN 1338, the samples shall not exhibit defects such as cracking, flaking or dislodging of aggregates;

(c) Fine materials shall not be easily dislodged from the surfaces of any samples during gentle manual handling; and

(d) The edges of all samples shall be sharp and straight without any defect.

HANDLING AND STORAGE OF MATERIALS

Handling and storage of units

11.72 Units shall be handled and stored on pallets to avoid damage to corners and chamfer edges. Pallets shall be stored on a levelled, well drained and maintained hard-standing ground and in a manner which will not result in damage or contamination to the units. The units shall be protected from damage and damaged units shall not be used unless permitted by the Engineer.

Storage of sand

11.73 Sand for filling joints between units shall be stored off ground in waterproof bags and shall be kept under cover on a levelled, well drained and maintained hard-standing ground on level supports until use.

LAYING UNITS

Laying units

11.74 (1) Units shall not be laid until the layout of the units within the paved area has been approved by the Engineer.

(2) Kerbs and edgings shall be completed before the units are laid. The compressive strength of the concrete used for in-situ concrete kerbs and edgings shall be at least 20 MPa before units are laid.

(3) Measures shall be taken to prevent water draining across or through the area during laying, bedding and compaction of the units.

(4) Laying of units shall start as soon as practicable after the formation has been completed. The formation shall be protected as stated in Clause 6.55 until laying starts.

(5) Paving blocks for carriageways and paved areas to which vehicles will have access shall be laid in a herringbone pattern unless otherwise stated in the Contract.

(6) Units shall be cut to size where required using mechanical cutting devices. The cut edge shall be true to line and free of chips and cracks.

The units shall be laid to any design or pattern specified by the Engineer. The design or pattern may involve a single colour or a combination of different colours.

Laying sand 11.75 (1) A layer of sand shall be laid and shall be screeded and tamped to a uniform depth over the complete width of the area to be paved. The quantity and thickness of sand shall be appropriate to the methods of preparation of the sand layer, and shall be sufficient to give the required nominal thickness of the sand layer after compaction of the sand and units.

(2) The sand layer shall not be disturbed by additional compaction, footmarks or other damage after the layer has been screeded and tamped to the required level and before the units are laid.

Bedding paving slabs 11.76 (1) Paving slabs shall be laid on the prepared sand layer immediately after screeding and tamping in such a manner that the sand is not disturbed.

(2) Paving slabs shall be adjusted to form uniform joints between 2 mm and 3 mm wide and shall be bedded into the final position using a wooden mallet or a plate vibrator fitted with a rubber base-pad.

(3) Paving slabs shall not be bedded within 1 m of an unrestrained edge of the screeded sand layer.

(4) Final levelling of the paving slabs shall be carried out as soon as practicable after bedding and before changes in the moisture content of the prepared sand layer occur.

(5) Damaged paving slabs shall be immediately removed and replaced.

Bedding paving blocks and setts 11.77 (1) Paving blocks and setts shall be laid on the prepared sand layer immediately after screeding and tamping in such a manner that the sand is not disturbed. Paving blocks and setts shall be individually laid on the prepared sand layer by manual methods or in clusters by mechanical methods.

(2) Paving blocks and setts shall be laid in such a manner that the blocks and setts are not in direct contact with each other and that uniform joints of between 2 mm and 3 mm wide are formed. Paving blocks and setts shall be bedded flush by at least two passes of a heavy-duty plate compactor fitted with a rubber base-pad.

(3) Final levelling of the paving blocks and setts shall be carried out as soon as practicable after bedding and before changes in the moisture content of the prepared sand layer occur.

(4) Paving blocks and setts shall not be bedded within 1 m of an unrestrained edge of the screeded sand layer.

(5) Damaged paving blocks and setts shall be immediately removed and replaced.

Filling joints and compaction of units 11.78 (1) After the units have been bedded, sand for filling joints shall be spread over the surface of the units and brushed into the joints in such a manner that all joints are completely filled.

(2) Joints shall be filled as soon as practicable after bedding and on the day the units are laid and bedded.

(3) After all joints are completely filled with sand, units shall be fully compacted by using a plate compactor fitted with a rubber base-pad. Additional sand shall be added to refill the joints as required and compacted into the joints by using the plate compactor with two or more passes.

(4) Carriageways and paved areas with regular heavy traffic shall be compacted by at least ten evenly-spaced passes of a pneumatic tyred roller having a gross weight of between 10 t and 12 t, or by a plate compactor which shall have the following capacity:
Minimum plate area of 0.25 m^2;
Minimum effective force per unit area of plate of 75 kN/ m2;
Frequency of 65 –100 Hz; and
Minimum mass of 200 kg.

Other suitable compacting equipment to the approval of the Engineer can be used. Sand shall be added as required and brushed and compacted into the joints.

(5) Units shall not be compacted closer than 1 m behind the laying edge of the units other than on completion of the paved area against a kerb or edging.

(6) Excess sand shall be removed after completion of compaction.

(7) Damaged units shall be immediately removed and replaced.

Mortar and concrete seal 11.79 Pigmented mortar or concrete shall be placed to full depth of the units to fill up the gaps between units and adjacent kerbs, edgings, quadrants, covers, frames and other hardware. The work shall only be carried out upon the approval by the Engineer. Unless otherwise instructed by the Engineer, colour of pigmented mortar or concrete shall match the colour of the adjacent units.

REINSTATEMENT OF UNITS

Reinstatement of units 11.80 (1) If excavation is to be carried out in areas paved with units, the units shall be extracted by manual methods for a distance of at least 300 mm beyond the limit of the excavation.

(2) Unbroken units shall be thoroughly cleaned to remove all sand and deleterious material. The units shall be stacked on pallets for re-use.

(3) Units to be re-used shall be re-laid in accordance with Clauses 11.74 to 11.79.

TOLERANCES

Levels 11.81 The level of paved areas constructed using units shall be within 3 mm of the specified level. The difference in level of adjacent units shall not exceed 2 mm.

TESTING

Batching 11.82 (1) A batch of units shall be any quantity of paving slabs, blocks, or setts of the same type, size, and finish, of the same concrete grade, manufactured in the same place, covered by the same certificates and delivered to the Site at any one time. Paving slabs, blocks, or setts of different colours can be grouped together to form their respective batches provided that they are manufactured with the same type of materials and production methods.

(2) Sampling shall be carried out at random. The sample shall comprise units that are distributed throughout the batch.

Testing requirements for units 11.83 (1) Paving slabs shall be tested for bending strength as stated in Clause 11.84.

(2) Paving blocks shall be tested for compressive strength as stated in Clause 11.85.

(3) Paving setts need not be tested for bending strength, compressive strength or slip/skid resistance unless otherwise required by the Engineer.

Bending strength test of paving slabs 11.84 (1) One sample of units in a batch shall be provided from every 1000 m^2 of units or part thereof. A batch with units for area(s) less than 1000 m^2 may be added to the untested previous or following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 8.

(2) Each sample of paving slabs shall be tested to determine the bending strength to BS EN 1339.

(3) The mean bending strength of a sample of paving slabs shall not be less than 4.0 MPa with bending strength of individual paving slabs not less than 3.2 MPa.

Compressive strength test of paving blocks 11.85 (1) One sample of units in a batch shall be provided from every 1000 m^2 of units or part thereof. A batch with units for area(s) less than 1000 m^2 may be added to the untested previous or following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 8. For paving blocks of size 200x200x60mm, specimens of size 200x100x60mm shall be cut from these blocks in accordance with Clause 11.74 (6) to form samples.

(2) Each sample of paving blocks shall be tested to determine the characteristic compressive strength at 28 days.

(3) The method of testing shall be as stated in Appendix 11.1.

(4) The characteristic compressive strength of a sample of paving blocks shall be:

(a) 30 MPa for paving blocks in footways and cycle tracks, and

(b) 45 MPa for paving blocks in carriageways and paved areas to which vehicles will have access.

Additional testing for Grade A units: dimensional deviation of paving slabs, blocks and setts

11.86 (1) One sample of units in a batch shall be provided from every 1000 m^2 of units or part thereof. A batch with units for area(s) less than 1000 m^2 may be added to the untested previous or following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 8. The sample can be used for other tests.

(2) The overall dimensions and thickness of each sample of paving slabs shall be measured in accordance with BS EN 1339.

(3) The overall dimensions and thickness of each sample of paving blocks and setts shall be measured in accordance with BS EN 1338.

(4) The tolerances for the dimensions of each individual units shall be within ±2 mm for length and width, and ±3 mm for thickness.

Additional testing for Grade A units: slip/ skid resistance of paving slabs and blocks

11.87 (1) One sample of units in a batch shall be provided from every 1000 m^2 of units or part thereof. A batch with units for area(s) less than 1000 m^2 may be added to the untested previous or following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 5. The sample can be used for other tests.

(2) Each sample of paving slabs shall be tested to determine the slip/ skid resistance to BS EN 1344.

(3) Each sample of paving blocks shall be tested to determine the slip/skid resistance to BS EN 1344.

(4) The mean slip/skid resistance of a sample shall not be less than 45 Skid Resistance Value for units in footways and cycle tracks.

(5) Notwithstanding sub-clause (4) above, if considered appropriate by the Engineer for application on steep roads, pavements with steep pedestrian crossings or exceptional high cross fall, or other difficult site conditions, the required slip/skid resistance of the units in footways and cycle tracks may be increased up to 60 Skid Resistance Value.

Additional testing for Grade A units: water absorption value of paving slabs and blocks

11.88 (1) One sample of units in a batch shall be provided from every 1000 m^2 of units or part thereof. A batch with units for area(s) less than 1000 m^2 may be added to the untested previous or following batch (es) as the case may be for testing purposes. The number of specimens in each sample shall be 10. The sample can be used for other tests.

(2) Each sample of paving slabs and blocks shall be tested to determine the 24-hour cold water absorption value to AS/NZS 4456.14.

(3) The sample shall have a characteristic water absorption value not more than 6% by 24-hour cold immersion method to AS/NZS 4456.14.

(4) The characteristic water absorption value (Wc) shall be calculated from the following equation:

$$Wc = Wm + 1.65\ Xs\ \%$$

where:

- Wm is the average water absorption rate of the sample
- Xs is the unbiased standard deviation as stated in AS/NZS 4456.2.

APPENDIX 11.1

DETERMINATION OF CHARACTERISTIC COMPRESSIVE STRENGTH OF PAVING BLOCKS

Scope

11.1.1 This method covers the determination of the characteristic compressive strength at 28 days of paving blocks by means of a load test.

Apparatus

11.1.2 The following apparatus is required:

(a) A compression test machine complying with CS1. Bearing faces of the platens on the test machine shall be at least as large as the paving blocks and shall have a flatness tolerance of 0.05 mm.

(b) If a test machine with platens smaller than the paving blocks is used, auxiliary plates of adequate size shall be placed centrally between the platens and the paving block to be tested. The flatness tolerance of the bearing faces of the auxiliary platens measured in accordance with CS1 shall not be more than 0.05 mm and the thickness of the plates shall be at least 25 mm.

(c) Two pieces of packing, each with a thickness of between 5 mm and 6 mm and dimensions exceeding the paving block by between 15 mm and 25 mm. The packing shall be plywood, chipboard or medium density hardboard.

Procedure

11.1.3 The procedure shall be as follows:

(a) The paving block shall be capped on the running surface and underside with a suitable capping material in accordance with Clause 15.5.2 of CS1 and immersed in water for at least 24 hours before compression.

(b) The paving block shall be placed symmetrically on the lower platen of the test machine, between the two pieces of packing with the running surface facing upwards.

(c) Load shall be applied without shock and shall be steadily increased at a constant rate within a stress range of between 150 kPa/s and 700 kPa/s.

(d) The load at which the paving block fractures shall be recorded as the breaking load.

(e) The test shall be repeated for the other seven paving blocks.

Calculation

11.1.4 (1) The compressive strength (C) of each paving block shall be calculated from the equation:

$$C = \frac{W}{A} \times \frac{2.5}{1.5 + \frac{L}{H}} \quad \text{MPa}$$

where:

- W is the breaking load (N)

- A is the nominal gross plan area based on the manufacturing dimensions of the paving blocks or the area of the tested portion if the block size is reduced for testing (mm^2)

- L is the lesser of the two plan dimensions (mm)

- H is the thickness of the block (mm)

(2) The unbiased standard deviation (s) shall be calculated from the following equation:

$$s = \sqrt{\frac{\sum C^2 - n(Cm)^2}{n-1}} \quad \text{MPa}$$

- where:

- n is the number of paving blocks

- ΣC^2 is the sum of the square of the compressive strengths of the n number of paving blocks (MPa)

- Cm is the average of the compressive strengths of the n number of paving blocks

(3) The characteristic strength (Cc) of the batch shall be calculated from the following equation:

Cc = Cm - 1.65s MPa

where:

- Cm is the average of the compressive strengths of the n number of paving blocks as stated in Clause 11.1.4(2)

- s is the unbiased standard deviation as stated in Clause 11.1.4(2)

Reporting of results 11.1.5 The following shall be reported:

(a) Source, name of manufacturer and type of paving blocks.

(b) Identification marks of paving blocks.

(c) Date of manufacture of paving blocks.

(d) Nominal gross plan area of each block to the nearest 100 mm^2.

(e) Nominal height of each block to the nearest mm.

(f) Breaking load of each block to the nearest kN.

(g) Compressive strength of each block to the nearest MPa.

(h) Average of the n number of compressive strengths to the nearest

MPa.

(i) Unbiased standard deviation to the nearest MPa.

(j) Characteristic compressive strength to the nearest MPa.

(k) That the test method used was in accordance with this Specification.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 12

TRAFFIC SIGNS, ROAD MARKINGS AND ROAD STUDS

SECTION 12

TRAFFIC SIGNS, ROAD MARKINGS AND ROAD STUDS

PART 1: TRAFFIC SIGNS

GENERAL

General requirements 12.01 The works and materials specified in Clauses 12.02 to 12.03 shall comply with the sections stated, unless otherwise stated in this Section.

Temporary traffic arrangements and control 12.02 Temporary traffic arrangements and control shall comply with Section 1.

Steelwork 12.03 Steelwork shall comply with Section 18.

Traffic signs 12.04 (1) Traffic signs shall comply with the Road Traffic Ordinance, Cap 374 and its subsidiary legislation. Traffic signs for road tunnels shall comply with the Road Tunnels (Government) Ordinance, Cap 368 and its subsidiary legislation.

(2) The design of traffic signs, including letters, characters, numbers, symbols and borders, shall be in accordance with conditions and restrictions imposed by the Commissioner for Transport.

(3) Traffic signs shall comply with BS EN 12899:Part 1 except that the requirements for marking signs shall not apply.

(4) Traffic signs shall be externally illuminated, internally illuminated, retroreflective, non-retroreflective or a combination of these types as stated in the Contract.

MATERIALS

Steel 12.05 Steel for traffic signs shall comply with the following:

Hot finished seamless tubes	:	BS EN 10297:Part 1
Hot rolled sections	:	BS EN 10365
Hot rolled structural steel sections - equal and unequal angles	:	BS EN 10056
Weldable structural steels	:	BS EN 10025

Stainless steel 12.06 Stainless steel for traffic signs shall be Grade 1.4401 and shall comply with the following:

Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes	: BS EN 10088:Part 2
Stainless steel tubes suitable for threading in accordance with BS EN 10226	: BS 6362

Aluminium alloy

12.07 (1) Aluminium alloy for traffic signs shall be EN AW-6082 in the T6, T651 or T62 tempers and shall comply with the following table:

Wrought aluminium and aluminium alloys for general engineering purpose	Standards
- Plate, sheet and strip	BS EN 485:Part 1, BS EN 485:Part 2, BS EN 485 Part 3 and BS EN 485:Part 4
- Drawn tube	BS EN 754:Part 1, BS EN 754:Part 2, BS EN 754:Part 3, BS EN 754:Part 4, BS EN 754:Part 5, BS EN 754:Part 6, BS EN 754:Part 7 and BS EN 754:Part 8
- Bars, extruded round tubes and sections	BS EN 755:Part 1, BS EN 755:Part 2, BS EN 755:Part 3, BS EN 755:Part 4, BS EN 755:Part 5, BS EN 755:Part 6, BS EN 755:Part 7, BS EN 755:Part 8 and BS EN 755:Part 9

(2) Aluminium alloy shall be anodized to Grade AA 25 in accordance with BS EN ISO 7599.

(3) Aluminium alloy sheet shall be free of twisting, warping and buckling and the surfaces shall be free of blemishes and other defects.

Bolts, nuts, screws, washers and rivets

12.08 (1) Bolts, nuts, screws, washers and rivets for traffic signs shall comply with the following:

ISO metric black hexagon bolts, screws and nuts	: BS 4190
ISO metric black cup and countersunk head bolts and screws with hexagon nuts	: BS 4933
Metal washers for general engineering purposes	: BS 4320
Rivets for general engineering purposes	: BS ISO 1051
Wrought aluminium and aluminium alloys for general engineering purposes - rivet, bolt and screw stock	: BS 1473

Mechanical properties of corrosion-resistant stainless-steel fasteners. Bolts, screws and studs	: BS EN ISO 3506:Part 1
Mechanical properties of corrosion-resistant stainless steel fasteners. Nuts	: BS EN ISO 3506:Part 2

(2) The length of bolts shall be such that after assembly the threaded portion of each bolt projects through the nut by at least one thread and by not more than four threads.

(3) Rag, indented andexpansion bolts and resin bonded bolts shall be of a proprietary type approved by the Engineer and shall be capable of withstanding the design working load.

(4) Galvanised bolts, nuts, screws, washers and rivets shall be used with traffic signs secured to galvanised pedestrian guard-railing. Aluminium materials shall be insulated from ferrous materials by a non-conductive insulator at least 2 mm thick of a type approved by the Engineer.

Materials for faces of traffic signs

12.09 (1) Prismatic retroreflective sheeting shall be Type IX material complying with ASTM D4956-16b. The use of Class RA2 glass bead retroreflective sheeting complying with BS EN 12899:Part 1, Table 4 shall be subject to the approval of the Engineer.

(2) Non-retroreflective sheeting shall comply with BS EN 12899:Part 1.

(3) Plastic sheeting shall be of a proprietary type approved by the Engineer.

(4) All materials and finishes shall be mutually compatible.

FABRICATION OF TRAFFIC SIGNS

Posts for traffic signs

12.10 (1) Posts for beacons at zebra crossings shall be painted with alternate black and white stripes. Other posts shall be painted grey in accordance with BS 5252F, Code 18B19 or shall be galvanized in accordance with BS EN ISO 1461.

(2) Galvanized areas affected by cutting and drilling shall be treated using a method approved by the Engineer.

(3) Posts other than posts supporting an external luminaire shall not protrude above the top of signs. The length of posts supporting external luminaries protruding above the top of signs shall be as short as practicable.

Backing plates for traffic signs

12.11 (1) Backing plates for traffic signs shall be fabricated from 3 mm aluminium sheet. Backing plates for traffic signs not exceeding 1200 mm high x 2400 mm wide shall be fabricated from a single sheet. If more than one sheet is used, the number of sheets shall be kept to a minimum. The separate sheets shall be rectangular and shall be approximately the same size.

(2) Holes in backing plates shall be drilled before the plate is painted and before retroreflective or non-retroreflective sheeting is applied.

Spill screens for traffic signs 12.12 (1) Top and bottom light spill screens shall be fabricated from the same material as the backing plate. The spill screens shall extend for the complete width of the backing plate and the corners shall be cut to the same radius as the corners of the backing plate.

(2) Spill screens shall be considered as part of the backing plate and stiffeners and mountings shall be designed to accommodate the combined size.

Faces for traffic signs 12.13 (1) Faces for traffic signs shall be formed using retroreflective or non-retroreflective plastic sheeting. Unless otherwise permitted by the Engineer, a single piece of sheeting shall be used. If more than one sheet is used, the number of sheets shall be kept to a minimum. Sheeting shall be fixed in accordance with the manufacturer's recommendations.

(2) Materials for faces of traffic signs, including the background, letters, characters, numerals, symbols and borders, shall be matched for colour in accordance with the sheeting manufacturer's recommendations at the time of fabrication to provide a uniform appearance by day and by night.

(3) Letters, characters, numerals, symbols and borders shall be clear cut and sharp-edged and shall have no cracks.

(4) Sheeting material, including letters, characters, numerals, symbols and borders shall be fully fixed using adhesive. There shall be no air bubbles, creases, cracks or other blemishes.

(5) The back of traffic sign shall be marked with the manufacturer’s name and manufacturing date in month/year as shown in the following manner:

- Manufacturer’s name
- Month/year

The marking shall either be printed on non-retroreflective self-adhesive material in accordance with BS EN 12899:Part 1 or stamped by a punch without damaging the front face of traffic sign or other method approved by the Engineer. The letter size shall not be smaller than 12 mm (h) x 8 mm (w).

(6) For each colour of externally illuminated and transilluminated signs, the uniformity of luminance, determined by the ratio of the lowest to the highest level measured at any part of the sign, shall be as shown in the following and in accordance with BS EN 12899:Part 1, Table 21.

Illuminated face area	Uniformity of luminance
$\leq 1.5\ m^2$	U2
$> 1.5\ m^2$	U1

Lacquer coatings 12.14 Lacquer coatings to faces for traffic signs shall be uniform and continuous and shall be applied at the time of manufacture of the face.

Painting to faces for traffic signs 12.15 (1) Faces of traffic signs to which a painted or stoved finish is to be applied shall be thoroughly cleaned and pre-treated before painting and stoving.

(2) Pre-treatment shall be by anodising or by using an etching primer or by a process approved by the Engineer.

(3) At least one undercoat and at least one finishing coat of paint shall be

applied and stoved to a thickness of between 0.0315 mm and 0.0375 mm of enamel over a minimum thickness of 0.025 mm of primer. If light colours are to be applied over dark colours, at least two coats of the light colour shall be applied. The final surface shall have a uniform thickness and an egg-shell flat finish and shall be smooth and free of defects.

(4) The colour of the finished coating shall be uniform. The colours, including white, shall comply with the chromaticity and luminance factors of BS EN 12899:Part 1, Tables 16 and 1 and, for comparative purposes, shall comply with the following gloss paint colours in accordance with BS 381C:

- Red : No. 537 – signal red,
- Orange : No. 557 – light orange
- Yellow : No. 355 – lemon yellow,
- Blue : No. 109 – middle blue
- Green : No. 225 – light brunswick green

(5) Parts of faces coloured black shall be non-retroreflective and shall have a luminance factor not exceeding 0.03 as specified in accordance with BS EN 12899:Part 1.

(6) The Volatile Organic Compound (VOC) content of all paint applied on surfaces of traffic signs shall comply with the VOC limits stipulated in the Air Pollution Control (Volatile Organic Compounds) Regulation.

SUBMISSIONS

Particulars of traffic signs

12.16 (1) The following particulars of the proposed traffic signs shall be submitted to the Engineer:

(a) Name of manufacturer, and

(b) Details of materials and finishes to be used in the manufacture of the signs.

(2) The particulars shall be submitted to the Engineer at least 14 days before fabrication of traffic signs starts.

STORAGE OF MATERIALS

Storage of traffic signs

12.17 (1) Traffic signs shall be stored in a dry, weatherproof store. Traffic signs that are stored together shall be separated by slip-sheets.

(2) Traffic signs shall be stored in a manner that will not result in damage or deformation to the signs.

CONSTRUCTION AND ASSEMBLY OF TRAFFIC SIGNS

Construction and assembly of traffic signs

12.18 (1) Fittings for traffic signs shall be non-corrodible material approved by the Engineer.

(2) Joints for framework and stiffeners that are not an integral part of the backing plate shall be welded or joined using brackets, nuts, bolts and washers.

(3) Materials for rivets and other fixings for joining backing plates to framework and stiffeners shall be compatible with the materials to be joined. The spacing of rivets and other fixings shall be uniform. The spacing shall not exceed 150 mm around the outside edge of sheets and shall not exceed 300 mm on cross braces.

(4) An additional washer of neoprene, nylon or other material approved by the Engineer shall be used to protect the faces of traffic signs from metal nuts, bolts, washers and screws.

(5) Backing plates shall be connected to posts by a method approved by the Engineer. Banding systems shall be stainless steel. Drilling of holes in ferrous components shall be completed before finishes are applied.

(6) A lacquer coating shall be applied to the edges of holes drilled in plates with plastic sheeting immediately before rivets and bolts are inserted. The surfaces of rivets and bolts on the faces of traffic signs shall be covered with a material coloured to match the part of the face with which it is in contact.

(7) Fixings for traffic signs erected on road lighting columns shall be compatible with the column cross-section. Columns shall not be drilled.

(8) When backing plates are stiffened with additional reinforcing members, these members shall be fixed to the backing plates in compliance with Class P2 in Table 13 of BS EN 12899:Part 1.

(9) Protection to sign edges shall be Class E1 in compliance with BS EN 12899:Part 1, Table 14.

Covering of traffic signs

12.19 (1) Traffic signs which are to be blanked out shall be covered by the following methods:

(a) Plate signs shall be covered using a 1.5 mm thick sheet that is compatible with the material in the sign.

(b) Plate signs that are to be blanked out for a period not exceeding one year may alternatively be covered using a self-adhesive plastic film.

(c) Other signs shall be covered using a loose cover sheet of material approved by the Engineer.

(2) Cover sheets shall be fixed using 5 mm diameter stainless steel bolts, washers and nuts or non-ferrous rivets at spacings not exceeding 600 mm. Bolts shall pass through 5 mm x 12 mm diameter plastic distance pieces between the face of the sign and the cover plate. Holes that remain on the finished face of the sign shall be filled using blocked rivets. The face of the rivets shall be coloured by a method approved by the Engineer.

(3) Self-adhesive plastic film shall be compatible with the material in the face of the sign and shall be fixed and removed in accordance with the manufacturer's recommendations.

(4) Loose covers shall be securely fastened to the back of the sign. Tape or other adhesive material shall not be applied to the faces of signs.

(5) Coverings to traffic signs shall be sufficiently opaque to prevent reflection from the covered sign and shall not be removed until the Engineer so instructs.

(6) Unless otherwise permitted by the Engineer, the faces of traffic signs which have been erected and which do not relate either wholly or in part to the traffic situation which applies at that time shall be blanked out as stated in this Clause.

TESTING: TRAFFIC SIGNS

Testing 12.20 (1) The number of traffic signs to be tested shall be as stated in the Contract or as instructed by the Engineer.

(2) The number and type of tests to be carried out on the traffic signs shall be as stated in the Contract as instructed by the Engineer.

(3) Testing shall be carried out in such a manner that the traffic sign will not be damaged.

(4) Testing shall be carried out by the Contractor at a laboratory approved by the Engineer.

Compliance criteria 12.21 The compliance criteria for testing traffic signs shall be in accordance with BS 8442.

PART 2: ROAD MARKINGS

GLOSSARY OF TERMS

Road Markings 12.22 Road markings are white or yellow continuous or intermittent lines, letters, characters, figures, arrows or symbols marked on the carriageway to guide road users and pedestrians.

MATERIALS

Hot-applied thermoplastic material 12.23 (1) Hot-applied thermoplastic material shall comply with BS EN 1871. In particular,

(a) The luminance factor when tested in accordance with Annex E of BS EN 1871 shall be Class LF4 for white material and Class LF2 for yellow material.

(b) The softening point when tested in accordance with Annex F of BS EN 1871 shall be Class SP2.

(2) Solid glass beads shall be included in the supplied mixture of hot applied thermoplastic material.

(3) Thermoplastic material shall be of a solvent-free marking substance supplied in block, granular or powder forms, which can be heated to a molten state and then applied with an appropriate hand or mechanical applicator, and form a cohesive film by cooling.

(4) Thermoplastic material shall belong to either of the following types:

- Type ‘A’-Standard hot applied thermoplastic material.

- Type ‘B’-Alkyd resin hot applied thermoplastic material.

Cold-applied preformed material 12.24 (1) Cold-applied preformed material for road markings shall be of a proprietary type approved by the Engineer

(2) Solid glass beads shall be applied to cold-applied preformed material at the place of manufacture.

Cold plastic road marking 12.25 Cold plastics road marking material shall comply with BS EN 1871. In particular, when applied at the manufacturer’s stated thickness and tested in accordance with Annex A of BS EN 1871, the luminance factor shall be Class LF4 for white material and Class LF2 for yellow material.

Paint for road markings 12.26 Road-marking paint material, including water-based road-marking paint, shall comply with BS EN 1871. In particular,

(a) The luminance factor when tested in accordance with annex A of BS EN 1871 shall be Class LF6 for white material and Class LF2 for yellow material.

(b) The difference in luminance factor after UV ageing shall be Class

UV1.

(c) The difference in luminance factor after bleed resistance test shall be Class BR1.

Solid glass beads 12.27 (1) Drop-on glass beads shall comply with BS EN 1423. In particular, the refractive index of the glass beads shall conform to Class A when determined in accordance with Annex A of BS EN 1423.

(2) Premix glass beads shall comply with BS EN 1424. In particular, the refractive index of the glass beads shall conform to Class A when determined in accordance with Annex A of BS EN 1423.

Functional life of the material 12.28 The functional life of the road-marking material as defined in BS EN 1436 shall be not less than 1 year after laying is carried out.

SUBMISSIONS

Test certificate and routine testing 12.29 (1) When required by the Engineer, the Contractor shall submit the test certificate prepared and signed by a local or overseas independent laboratory to the Engineer before commencing the Works in order to certify that the samples taken from the materials to be used in the Contract comply with BS EN 1871.

(2) The Contractor shall supply all samples of materials for testing. He shall render such assistance as may from time to time be required by the Engineer in taking and packing them in bags, which are to be provided by the Contractor, and dispatching them to Public Works Central Laboratory for testing.

DELIVERY AND STORAGE OF MATERIALS

Delivery and storage of thermoplastic material 12.30 Each container for keeping thermoplastic road marking material shall be clearly and indelibly marked with the following information:

(a) The name, trade mark or other means of identification of the manufacturer;

(b) Batch number;

(c) Date of manufacture;

(d) The number and date of the Standard, i.e. BS EN 1871;

(e) Whether reflectorized;

(f) Color (white, yellow, or black);

(g) Chemical description and type of resin;

(h) Maximum application temperature and maximum safe heating temperature;

(i) Relative density;

(j) If applicable, the class of its contents

(k) If applicable, a warning about the use of lead pigment.

Storage of road marking paint material 12.31 Road-marking paint material shall be discarded after expiry of the shelf life.

Storage of preformed material 12.32 Cold-applied preformed material shall be stored in accordance with the manufacturer's recommendations.

LAYING ROAD MARKINGS

Preparation of surfaces 12.33 (1) Road markings shall not be laid over loose detritus, mud or similar extraneous matter. Oil and grease shall be removed from the surface of carriageways on which road markings will be laid.

(2) Curing compound shall be removed from the surface of new concrete carriageways on which road markings will be laid, by wire brushing or by other methods agreed by the Engineer.

(3) Existing road markings that are to be replaced by a different type of material shall be removed by high pressure water jetting, shot blasting, rotary grinding or by other methods agreed by the Engineer. The existing markings shall not be masked using black paint or similar methods.

(4) Existing road markings that are to be renewed using a similar type of material shall be roughened by a method agreed by the Engineer until the thickness of the existing material is reduced by approximately 50%.

(5) A tack coat shall be applied to the surface of concrete carriageways before hot thermoplastic material is laid. The tack coat shall be compatible with the road marking material and shall be applied in accordance with the manufacturer's recommendations.

(6) Rotary grinding machines shall not be used to remove or roughen existing road markings within 100 mm of longitudinal or transverse joints on concrete carriageways.

Laying hot-applied thermoplastic material 12.34 (1) Hot-applied thermoplastic material shall be prepared and laid in accordance with BS 3262:Part 3, Clauses 4 and 5. The material shall not be laid when the surface of the carriageway is wet, or the air ambient temperature in the shade is less than 10°C.

(2) Hot-applied thermoplastic material shall be laid by machine or by screeding methods. The machine or apparatus shall be capable of producing a marking to a uniform thickness and width. The marking shall have clean edges and shall be free of streaks and blisters.

(3) The thickness of road markings, not including surface applied solid glass beads, shall comply with the following:

(a) Screed markings : 4 mm

(b) Sprayed lines other than yellow edge lines : ≥ 1.5 mm

(c) Sprayed yellow edge lines : ≥ 0.8 mm

The thickness shall be measured in accordance with BS 3262:Part 3, Appendix B.

Laying cold-applied preformed material

12.35 (1) Cold-applied preformed material shall be laid in accordance with the manufacturer's recommendations. The material shall not be laid when the surface of the carriageway is wet.

(2) The thickness of road markings shall be at least 1.5 mm

Use of road-marking paint

12.36 (1) Road-marking paint may only be used on roads or areas where the use of other road marking materials, such as thermoplastic, will affect the functional performance of the road markings and the use shall be subject to written approval of the Engineer.

(2) Road-marking paint shall be applied in accordance with the manufacturer's recommendations.

(3) Road-marking paint shall not be used for temporary road markings and shall not be used to temporarily cover up existing road markings.

Road marking performance for road users

12.37 Performance of the road marking during its functional life shall comply with BS EN 1436. In particular,

(a) The minimum luminance coefficient under diffuse illumination measured in accordance with Annex A of BS EN 1436 shall be Class Q2 and Q3 on asphaltic surface and concrete surface respectively for white markings, and shall be Class Q1 for yellow markings.

(b) The minimum coefficient of retroreflected luminance for dry road markings measured in accordance with Annex B of BS EN 1436 shall be Class R2 and R1 for permanent white and yellow markings respectively, and shall be Class R3 for temporary markings.

(c) The minimum luminance factor for dry road markings measured in accordance with Annex C of BS EN 1436 shall be Class B3 for white markings and B2 for yellow markings.

Temporary road markings

12.38 (1) Cold-applied preformed material shall be used for temporary road markings. Where existing road markings have to be masked temporarily to facilitate roadwork, the proprietary black tape approved by the Engineer shall be used.

(2) Temporary road markings shall be disposed of by the Contractor after removal. All traces of tape shall be removed from the surface of the carriageway and existing permanent road markings shall be made good such that in the opinion of the Engineer it is safe to allow traffic to use the road.

Skid resistance level 12.39 The minimum skid resistance of the road marking measured in accordance with Annex D of BS EN 1436 shall be Class S1.

TOLERANCES

Tolerances 12.40 The lengths, thicknesses and widths of road markings shall comply with the following requirements:

(a) The thickness of screed markings shall be within 1 mm of the specified thickness.

(b) The length and width of screed markings and sprayed lines shall be within +10%, -5% of the specified dimension.

REMOVING ROAD MARKINGS

Shot-Blasting Machine 12.41 Where existing road marking is directed by the Engineer to be removed by steel shot-blasting, the removal of road marking materials shall be carried out by a shot-blasting machine approved by the Engineer. The machine shall be self-propelled, and shall have a minimum cleaning path of 350 mm.

PART 3: ROAD STUDS

MATERIALS

Road studs 12.42

(1) Road studs shall comply with the Road Traffic Ordinance, Cap 374 and its subsidiary legislation.

(2) Except for thermoplastic road studs, road studs shall be of a proprietary type approved by the Engineer.

(3) Reflecting road studs shall comply with BS EN 1463:Part 1 and BS EN 1463:Part 2.

(4) Permanent reflecting road studs to be used as lane line markers on dual carriageway trunk roads and primary distributor roads shall be of a type to which traffic cylinders of a type approved by the Engineer can be attached. The method of attachment shall be such that the traffic cylinder can be easily detached from the road stud.

(5) Thermoplastic road studs of white colour shall be applied for indicating the limits of a zebra crossing or a light signal crossing, unless otherwise agreed or instructed by the Engineer.

(6) Temporary reflecting road studs to be used as markers for temporary traffic routes shall be fluorescent yellow.

Bitumen grout 12.43

(1) Bitumen grout for road studs shall consist of bitumen and filler. The bitumen content shall be 25% to 30% of the total mass.

(2) Bitumen shall be tropical grade filled bitumen, oxidised Grade R 85/25.

(3) Filler shall be hydrated lime. The percentage by mass of hydrated lime passing a 75 μm BS test sieve shall be at least 85%.

(4) The properties of bitumen grout for road studs shall comply with the following requirements:

(a) The penetration at 25°C shall be 12±4.

(b) The softening point shall be 105°C ± 5°C.

(c) The specific gravity shall not exceed 1.80.

INSTALLATION OF ROAD STUDS

Installation of road studs 12.44

(1) Road studs shall be installed in accordance with the manufacturer's recommendations.

(2) Depressible road studs shall be installed using bitumen grout.

(3) Road studs shall not be installed on concrete carriageways until the concrete has reached the specified grade strength.

(4) Surfaces to which bonded road studs are to be fixed shall be clean and all dust, grease and other deleterious material shall be removed immediately before the studs are installed.

Laying of thermoplastic road studs

12.45 (1) Road surfaces shall be prepared in accordance with Clause 12.33 prior to laying of thermoplastic road studs. The hot-applied thermoplastic material for thermoplastic road studs shall be prepared and laid in accordance with Clauses 12.34(1) and (2).

(2) The thermoplastic road studs for indicating the limits of a pedestrian crossing shall be square in plan, the sides of a square stud shall not be less than 95 mm nor more than 110 mm in length.

(3) The thickness of thermoplastic road studs, not including surface applied solid glass beads, shall not be less than 2 mm nor more than 5 mm. The thickness shall be measured in accordance with BS 3262:Part 3, Appendix B.

Test certificate

12.46 When required by the Engineer, the Contractor shall submit the test certificate prepared and signed by a local or overseas independent laboratory to the Engineer before commencing the Works in order to certify that the reflecting road studs to be used in the Contract comply with BS EN 1463:Part 1 and BS EN 1463:Part 2.