GEO Technical Guidance Note No. 48 (TGN 48)
Detailing of Flexible Debris-resisting Barriers

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1. SCOPE

1.1 This Technical Guidance Note (TGN) stipulates the recommendations on the detailing of flexible debris-resisting barriers.

1.2 Any feedback on this TGN should be directed to the Chief Geotechnical Engineer/ Landslip Preventive Measures 2 of the Geotechnical Engineering Office (GEO).

2. TECHNICAL POLICY

2.1 The technical recommendations promulgated in this TGN were agreed by GEO Geotechnical Control Conference in 8 November 2019.

3. RELATED DOCUMENTS

3.1 GEO (2014). *Guidelines on Empirical Design of Flexible Barriers for Mitigating Natural Terrain Open Hillslope Landslide Hazards (GEO TGN 37)*. Geotechnical Engineering Office, Hong Kong, 18 p.

3.2 Kwan, J.S.H. & Cheung, R.W.M. (2012). *Suggestions on Design Approaches for Flexible Debris-resisting Barriers (Discussion Note No. DN 1/2012)*. Geotechnical Engineering Office, Hong Kong, 90 p.

3.3 Kwan, J.S.H., Koo, R.C.H. & Lam, C. (2018). *A Review on the Design of Rigid Debris-resisting Barriers (GEO Report No. 339)*. Geotechnical Engineering Office, Hong Kong, 33 p.

3.4 Sun, H.W. & Lam, T.T.M. (2006). *Use of Standardised Debris-resisting Barriers for Mitigation of Natural Terrain Landslide Hazards (GEO Report No. 182)*. Geotechnical Engineering Office, Hong Kong, 92 p.

3.5 Sze, E.H.Y. & Lam, H.W.K. (2019). *Some Suggested Detailing of Flexible Barriers Traversing a Stream Course for Drainage Purposes (GEO Report No. 344)*. Geotechnical Engineering Office, Hong Kong, 46 p.

4. BACKGROUND

4.1 Kwan & Cheung (2012) and GEO (2014) provided some suggestions on design approaches for flexible debris-resisting barriers. Sze & Lam (2019) consolidated experience gained on the detailing of flexible barriers traversing a stream course for drainage purposes.

4.2 A desk study review and site inspection of selected flexible barriers have been undertaken recently. Good practices commonly adopted in installation and detailing provisions have been identified. This TGN stipulates the recommendations on the detailing of flexible debris-resisting barriers.

5. TECHNICAL RECOMMENDATIONS

5.1 Barrier Alignment

5.1.1 The alignment of barriers should be as straight and horizontal as practicably possible to avoid load concentration and inducing adverse loading as well as to achieve high system efficiency. Sufficient structural restraints should be provided to the flexible barriers to maintain their stability and for the robustness of the barrier system against extraordinary unfavourable environmental conditions during their service life.

Particular attention should be paid to those barriers with an overall convex alignment on plan where the top longitudinal cables may have little contribution in resisting barriers against backward tilting comparing with barriers with an overall concave or straight alignment (Figure 1). In addition, if there is a local change in the direction of barrier alignment, an out-of-plane force may be induced at the top of the affected posts when the barrier is subjected to external loads (including debris impact loading). In these cases, proper design provisions should be allowed (e.g. provision of proper structural restraints to the barrier, and positioning ‘break-points’ (see also Section 5.1.3) at those posts defining changes in barrier alignment.

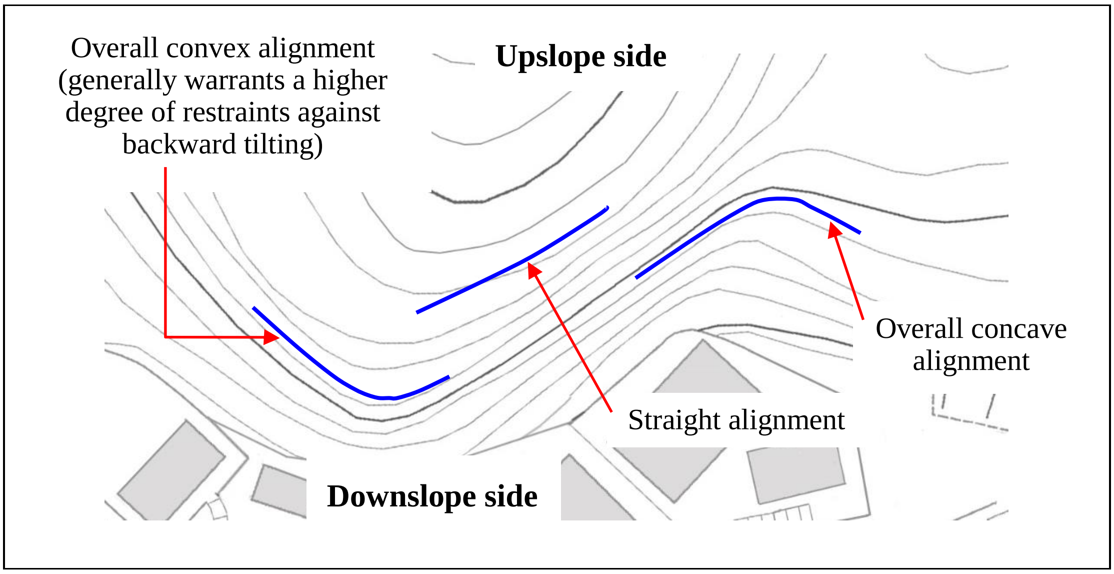
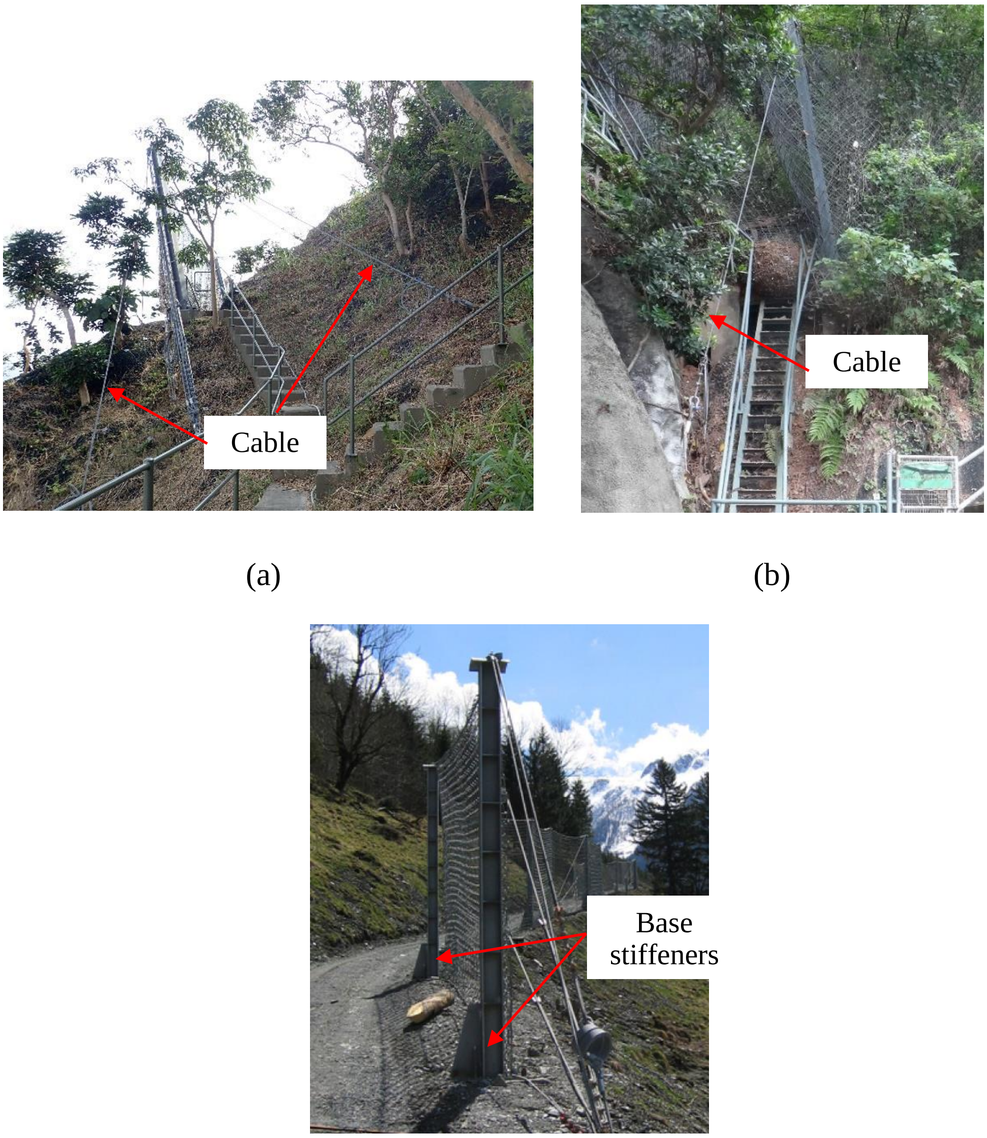


Figure 1 Flexible barriers of different types of alignment

5.1.2 Cables are commonly installed at the posts of a barrier to provide required structural restraints for barrier stability (Figures 2a & b). Other forms of restraints such as base stiffeners may also be considered to suit the site conditions (Figure 2c) and any of such restraints provided should fulfil the durability requirements of the barriers, e.g. corrosion protection. Some barrier manufacturers provide specific structural details to prevent backward tilting of individual posts primarily during installation (Figure 3), and to a certain extent, these provisions would also enhance the stability of barriers.



(c)

Figure 2 Examples of structural restraints for barrier stability

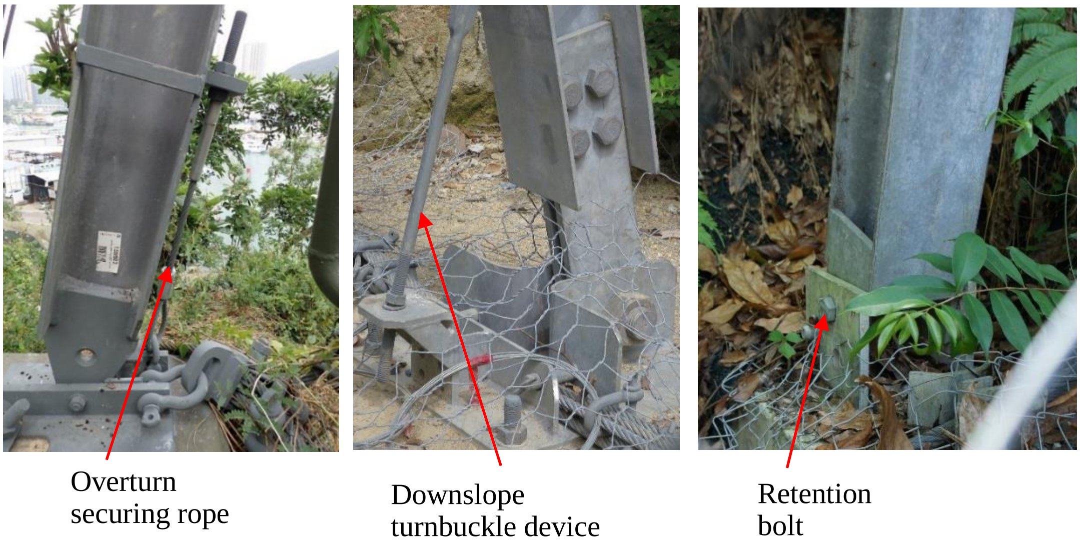


Figure 3 Specific details for prevention of backward tilting of a post

5.1.3 For lengthy barrier alignment, it is a good practice to introduce ‘break points’ (i.e. by means of segmenting the barrier into independent units) to maintain efficiency of the barrier system as well as to facilitate construction and maintenance. Different barrier manufacturers adopt different lengths for introducing a ‘break-point’ in their flexible barrier products. The ‘break points’ may be provided by the construction of separate barriers with certain overlapping on plan, which may allow optimisation in design (e.g. installing barriers of different heights/energy ratings) and intermittent upslope / downslope cross-passage points for the ease of maintenance.

5.2 Anchor Locations and Detailing

5.2.1 In general, cables would be more effective in providing structural restraints to the posts of barriers if the cables are installed at a suitably shallow angle. Anchors should be cautiously positioned in order that the cables would provide the required directional restraints to maintain the stability of barriers.

5.2.2 Detailing of anchors should be sufficiently robust to prevent local failure at the connection. For example, a loop anchor (Figure 4(a)) would be more robust than a hook-shaped anchor bar. Anchors should be located at areas less susceptible to ponding (e.g. gentle terrain below hillslope) as far as practicable. If such case is unavoidable, provision against corrosion such as the construction of an anchor head (see Figure 4(b) as an example) should be adopted.

(a)

(b)

Figure 4 Examples of anchor detailing: (a) loop anchor; and (b) anchor head provided at an area susceptible to ponding.

5.3 **Detailing of Flexible Barriers Traversing a Stream Course for Drainage Purpose**

5.3.1 In general, flexible barriers installed across a natural stream course should be designed to resist landslide debris, and passageways for stream loads should be provided as far as practicable.

5.3.2 Detailing for flexible barriers traversing a stream course for drainage purposes should be designed on a case-by-case basis with consideration given to the following factors:

(a) Flexible barriers are designed and constructed to arrest mainly the coarse particles within landslide debris. The normal stream flow should be maintained. Passage of stream loads should be allowed to avoid blockage to the stream course as far as practicable. Where appropriate, proper detailing and/or drainage measures should be adopted.

(b) Secondary mesh for flexible barriers should be used with caution. Judgement should be exercised when deciding the need and extent of secondary mesh for a flexible barrier, with due consideration mainly given to the opening size of principal net, the proximity of the downslope facilities being affected and the characteristic of stream course. In general, as a good practice, for flexible barriers including those installed on an open hillside, if a secondary mesh is considered necessary, an adequate clearance between the skirt of the secondary mesh and the ground surface should be provided to prevent trapping of fallen leaves/debris carried by surface runoff.

(c) If the opening size of principal net is small (i.e. equivalent to the opening size of a secondary mesh), the secondary mesh can be omitted.

(d) It is prudent to allow a suitably-sized basal opening for the barrier to prevent trapping stream loads and impedance of stream flow. However, such basal opening should not be excessive as it could also be a potential gap for the passage of large amount of debris in case of landslides. The size of the basal opening could be determined with due regard to the depth of the stream flow (prevailing stream flow in wet season), size of stream loads, the designed debris flow thickness, the geometry of stream course, the type and proximity of the downslope facilities being affected, the consequence of debris leaking through the basal opening, the environmental/ecological considerations (e.g. free passage of fauna in the stream course), etc. Figure 5 shows an example of basal opening. Where a flexible barrier is installed in an incised drainage line, there could be a large gap between the base of the barrier and the ground surface. In such case, site-specific measures should be considered to deal with the possibilities of debris travelling through the gap.

(e) Regular inspection and clearance of trapped stream loads on flexible barriers installed across a stream course are important. In this regard, proper maintenance access to the upslope side of the flexible barrier should be provided as far as practicable.

Figure 5 An example of basal opening

5.4 Other Considerations in Detailing

5.4.1 The structural form of flexible barriers should be properly selected with due regard to the topographical setting. With reference to overseas design practice, for an incised topography (e.g. drainage line), side-anchored flexible barriers (Figure 6), instead of rectangular post-supported flexible barriers (e.g. energy-rated rockfall-resisting barriers), are generally preferred because this type of barrier takes a trapezoidal form, and thus better fits the shape of a typical drainage line.

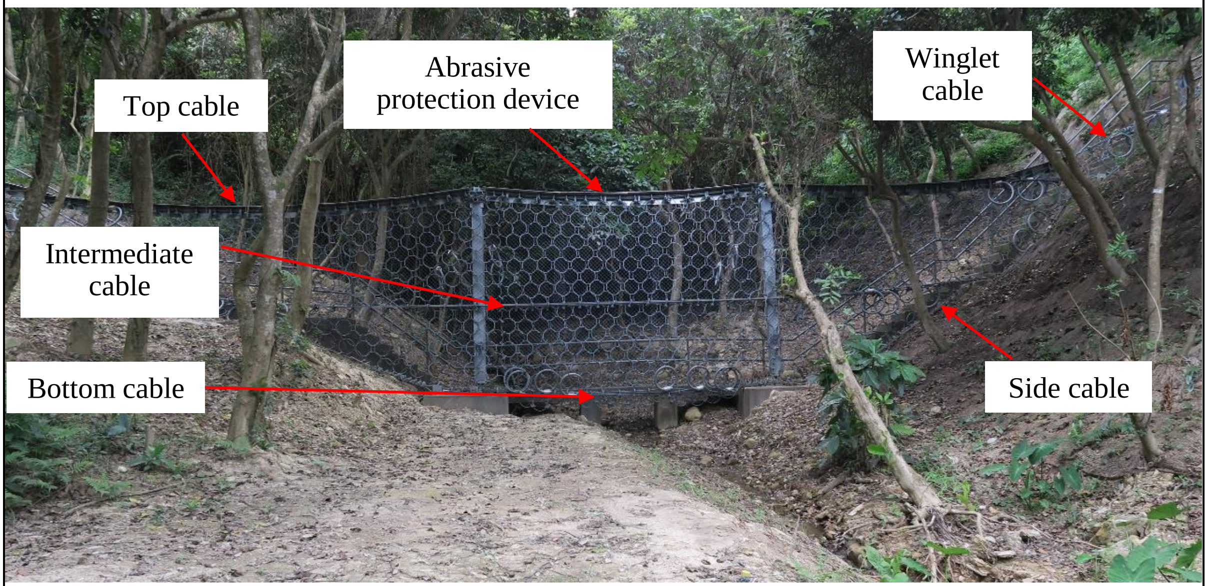


Figure 6 An example of side-anchored flexible barriers installed in Hong Kong

5.4.2 For a flexible barrier designed for debris overflow conditions, the top cables would be subject to abrasion or wearing, in particular for debris flows with presence of hard inclusions. In this regard, a proper abrasive protection device, e.g. proper steel angle (see Figure 6), to prevent such wearing of top cables should be provided.

5.4.3 The posts of a barrier, because of their high structural stiffness, may be susceptible to structural damage under boulder impacts. There were overseas cases where these posts were significantly damaged when impacted directly by sizeable boulders entrained in a debris flow. In this regard, posts should be judiciously located away from the path of the drainage line as far as practically possible, and suitable measures (e.g. baffles, debris-straining structures or in-situ boulder stabilisation) should be provided, with a view to reducing the chance of direct boulder impact on the posts. Some design considerations for baffles in resisting boulder impacts are given in Appendix C of Kwan et al. (2018).

5.4.4 Local erosion and scouring of soils around the anchor points of a flexible barrier could adversely affect the performance of a flexible barrier. Proper positioning and detailing of the anchor head should be adopted. The anchor head should be embedded in competent ground to prevent possible damage due to impact of debris flow. Where necessary, appropriate erosion control measures can be deployed to protect the ground in the vicinity of the anchoring point from erosion and scouring (see an example in Figure 6 of Sun & Lam (2006)). In addition, the winglet cable shown in Figure 6 can be located at a higher anchoring point to prevent surface erosion due to debris overflow conditions, if necessary.

5.5 The recommendations for detailing of flexible barriers presented in this TGN are not meant to be exhaustive. Designers should be cautious of any subtle detailing that could adversely affect the performance of barriers. Input from designers is required at the construction stage to initiate design changes to suit site condition and to evaluate any adverse implications of the changes made. Where necessary, specialist advice from barrier manufacturers or structural engineers should be sought.

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