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FACING OPTIONS FOR GEOSYNTHETIC REINFORCED RETAINING STRUCTURES IN INFRASTRUCTURE PROJECTS

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Abstract

An economic development increases the demand for new infrastructural projects allowing people to travel and goods to be transported faster and at lower costs. Reconstruction of some outdated structures that can no longer provide sufficient carrying capacity and comfort also adds to the planning and budgeting. Retaining structures with steep or vertical slopes that must be constructed in challenging geological or environmental conditions is an essential part of almost any modern infrastructural project. One of the most cost-effective and durable solutions to construct high-end retaining walls or bridge abutments is the use of geosynthetic materials as soil reinforcement in combination with facing elements. This paper is a brief introduction into the variety of facing options for such geosynthetic reinforced retaining structures.

Keywords: retaining structures, geosynthetics, facing, infrastructure

1 Introduction

Retaining structures are usually constructed to support soil masses laterally so that the soil can be retained at different levels with various face angles (e.g., up to 90°.) Depending on the face angles, one could distinguish such retaining structures as steep slopes and retaining walls. If a retaining structure serves as a bridge abutment (i.e., a substructure at the ends of a bridge span whereon a superstructure rests or contacts), it should not only support a soil mass laterally but also carry vertical loads applied from the superstructure (Figure 1.)
According to BS 8006 [1], retaining structures with face angles within 20° of the vertical are defined as slopes. BS 8006 [1] states that "The angle of the slope will have some influence on the method of analysis to be employed, but most importantly will determine the type of facing to be employed and the method of construction to be used [...] It is usually necessary to provide some form of facing for steep slopes to enable anchorage of the reinforcement in the active zone and to provide erosion protection".
Typical application fields of the geosynthetic reinforced retaining structures are retaining walls, wing and frontal walls at bridge abutments and noise barriers in road infrastructure. Geosynthetic reinforced retaining structures create a suitable method for the application on large-scale surfaces with low maintenance intensity and intervals.
A separate design of the connection of the facing elements to the reinforced soil as well as the proof of the safety against sliding, overturning and bearings capacity of the foundation are typically required.

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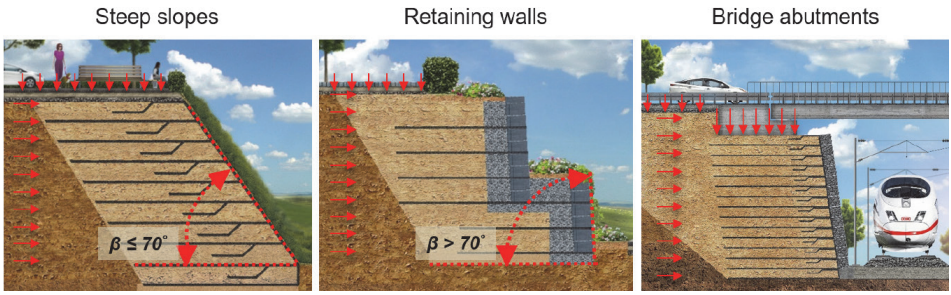

Figure 1 Main types of geosynthetic reinforced retaining structures

2 Concept of active and passive facing systems

One could divide facing systems into two major groups (i.e., passive and active facing systems) based on the influence of the facing elements on the stability and serviceability of a geosynthetic reinforced retaining structure. The efficacy and safety of each system depend on several factors, e.g., subsoil conditions, construction schedule, etc. Both systems have their pros and cons, which will be described in this chapter.

2.1 Passive facing systems

A so-called passive facing requires the fill material to be reinforced by geosynthetics and mostly serves as a protection and architectural part of a geosynthetic reinforced retaining structure. The lateral earth pressure is not transferred to the facing elements but kept by the geosynthetic reinforced soil via wrap-around. A gap between the geosynthetic reinforced soil and the facing elements is therefore created. The only horizontal forces applied to the facing come from the infill (e.g., crushed stone, sand, EPS, lava stone) of the space between the geosynthetic reinforced soil and the facing elements (Figure 2). One could also account for the horizontal forces applied to the facing due to the impact of wind, but typically such impacts can be neglected in the design.
Facing elements can be either connected to the geosynthetic reinforced soil, or they can be freestanding.

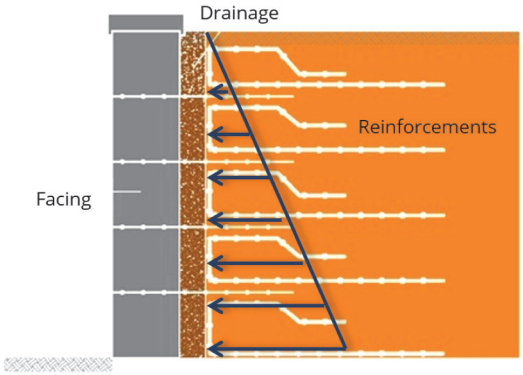

Figure 2 Passive facing system and typical distribution of lateral earth pressure on the wrap-around

2.2 Active facing systems

A so-called active facing serves not only as a protective and an architectural part of a geosynthetic reinforced soil structure but also as an element that withstands a part of the lateral earth pressure. The lateral earth pressure is transferred to the geosynthetic reinforced soil as well as to the facing elements, although reduced by the geosynthetic reinforcement. As no wrap-around of the geosynthetic reinforcement is required, there is no gap between the facing elements and the geosynthetic reinforcement. However, a drainage layer is usually applied behind the facing elements (Figure 3) to minimise the hydrostatical pore pressure acting on the facing. Facing elements are typically anchored to the earth body by the geosynthetic reinforcement.

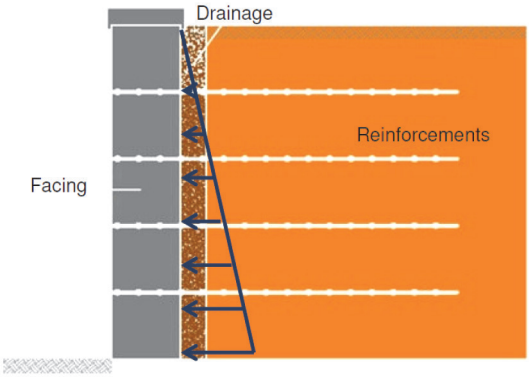

Figure 3 Active facing system and typical distribution of lateral earth pressure on the facing

2.3 Pros and cons of passive and active facing systems

Depending on the geological conditions, working schedule, availability of construction materials and economical aspects, either passive or active facing system might be more appropriate. Some of the advantages and disadvantages of both systems can be summarised and are presented in Table 1.

Table 1 Advantages and disadvantages of passive and active facing systems

Aspect	Passive facing	Active facing
Sensitivity to geological conditions	Moderate or non-sensitive	Very sensitive
Construction of facing and reinforced soil	Allows simultaneous as well as separate construction of facing and reinforced soil	Must be constructed simultaneously with the reinforced soil

In general, passive facing systems constructed with the geosynthetic wrap-around could be described as more advantageous due to greater robustness and flexibility. Geosynthetic reinforced soil structures with wrap-around are flexible in terms of overall stiffness, hence they permit the absolute and differential settlements without loss of safety. All the settlements might be compensated after the required degree of consolidation of the subsoil has been reached. Therefore, such issues as breakage, cracking or occurrence of differential settlements of the facing elements might be easily avoided even in cases of poor subsoil con-

ditions by allowing a separate construction of the geosynthetic reinforced soil and facing elements. The best performance could be expected if the geosynthetic reinforced soil with wrap-around is constructed first, the subsoil is left to consolidate (i.e., all the excess settlements occur) and then the facing elements are installed.
One should consider that the settlements might take days, months or even years to occur, depending on the intensity of the loading and the permeability of the subsoil. Such solutions as prefabricated vertical drains, stone or sand columns, etc. might be used to accelerate the consolidation of the subsoil.

3 Components of facing systems

Both passive and active facing systems can be constructed using various structural and architectural elements such as precast concrete full height or discrete plates, concrete or stone blocks, gabions, steel mesh, vegetation, and others (Figure 4)

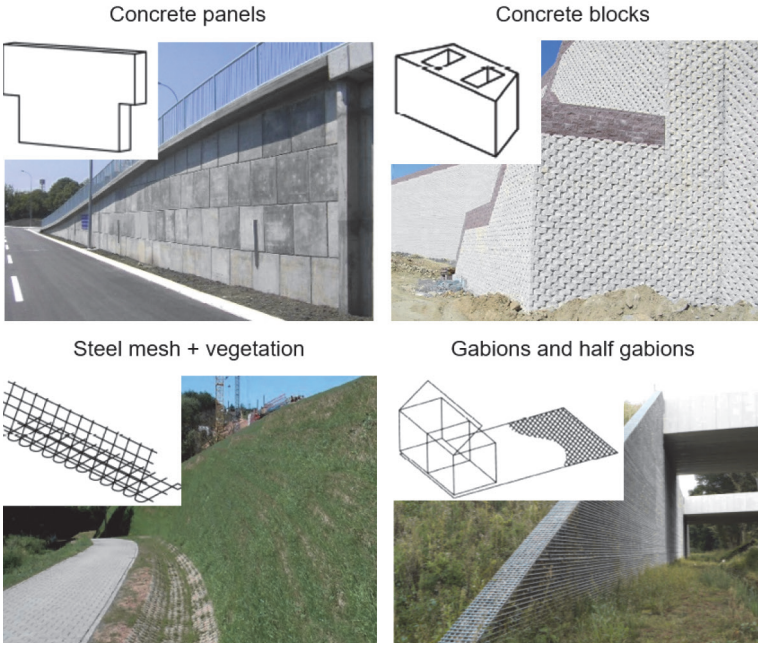

Figure 4 Some examples of facing solutions

According to DIN EN 14475 [2], all facing elements are divided into three groups:
- non-deformable (rigid),
- partially deformable,
- deformable (flexible).

Non-deformable facing elements are usually made of precast concrete (e.g., panels or blocks). Partially deformable facing elements are made of steel elements (e.g., wire mesh or gabions filled with rock material). And deformable facing elements are the padded walls with wrap-around geosynthetic reinforcement [3].
Each type of facing elements has different properties in terms of costs, stiffness, strength, architectural appearance, protection against UV-radiation, fire, vandalism, etc. Depending on the type of facing costs of materials, transportation and assembly works may vary signif-

icantly starting from the least laborious and least expensive vegetated slopes and finishing by typically more demanding and costly precast concrete blocks or panels. The choice of the facing element type can influence the total price of the structure quite significantly.
Availability of materials on the market, as well as climate conditions, should always be accounted for. The limitations of each system should also be well understood. For instance, vegetated slopes are not recommended to be steeper than 70° due to the issues of the vegetation growth on steep surfaces even in moderate climate conditions.
Similar structural elements such as prefabricated concrete panels can be used in combination with the geosynthetic reinforced retaining structures as both passive and active facings. Full height panels are usually applied as a passive facing (Figure 5), whereas discrete panels are more typical for active facing systems (Figure 6).

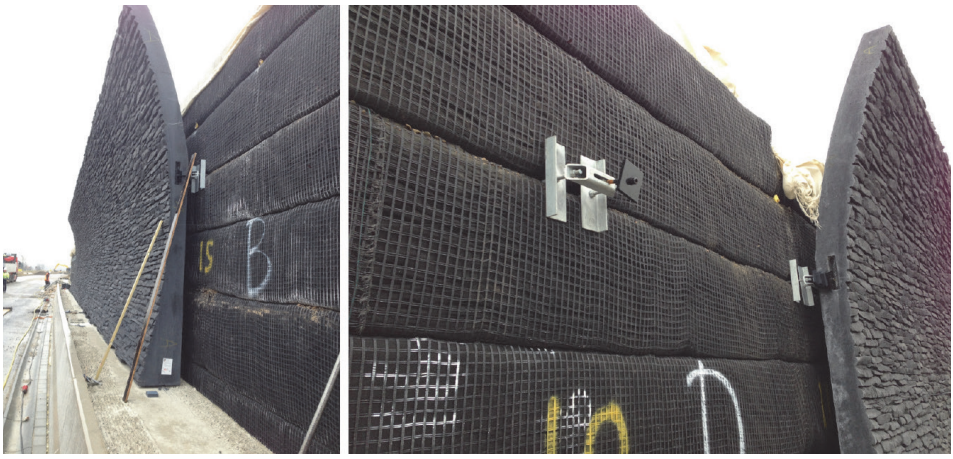

Figure 5 Full height concrete panels installed as a passive facing (Vrijenburgweg, Netherlands)

Figure 6 Discrete concrete panels installed as an active facing (Targu Mures, Romania)

Each geosynthetic reinforcement layer is connected to the discrete concrete panels during the assembly, whereas full height panels might require only one or even no connection to the geosynthetic reinforced soil. The sufficient connection strength is to be designed and tested in both cases to ensure the successful long-term performance of the geosynthetic reinforced retaining structure.

4 Conclusion

The use of geosynthetics as soil reinforcement provides cost-effective and durable solutions for infrastructural projects. A variety of facing types and systems may be utilized together with geosynthetic reinforced soil.
Depending on the role of facing in a retaining structure, one could differentiate between the so-called passive and active facing systems. Passive facings are not intended to withstand the lateral earth pressure. Active facings support the soil mass and withstand part of the lateral earth pressure together with the geosynthetic reinforcement. Each system has an application area and limitations depending on the numerous factors that should be considered at the design stage.
There are many different types of facing elements: rigid elements, such as prefabricated concrete plates or blocks, partially deformable steel mesh and gabions, or flexible geosynthetic wrap-around facings. The choice of the type of the facing elements should be based on the features of the local market, purpose and architectural requirements of a retaining structure, limitations and costs of materials and assembly works.

References

[1] BS 8006-1:2010 Code of Practice for strengthened/reinforced soils and fills, BSi London, London, UK, 2010.

[2] DIN 14475: 2006 (2006), Execution of special geotechnical works (Spiezialtief-construction) - reinforced bulk bodies, German Institute for Standardization e.V., Beuth Verlag, Berlin, Germany, April 2006.

[3] EBEGO (2010), Recommendations for the construction and calculation of earth bodies with reinforcements made of geosynthetics, German Geotechnical Society, 2nd edition, Ernst and Son, Berlin, Germany, 2010.

[4] Silber-Hasslacher, T., Sňahničan, J.: Active and passive facing systems for reinforced soil structures, 13. ročník konferencie Geosyntetika, Žilina, Slovakia, 2019.

[5] van Keßel, M.-T., van Duijnen, P.-G., van Eekeren, H., Detert, O.: Development, Mode of Operation and Installation of an Active Wall System for Geogrid-Reinforced Walls, Department of Geosynthetics, Munich, Germany, 2015.

[6] Alexiew, D., Ayasrah, I.M., Abu-Hassan, M.: Geogrid-reinforced walls with almost vertical facings: specific solutions in different environments, Proc. 6th International Conference Geosynthetics Middle East 2013 (GEOME 2013), pp. 69-78, Abu-Dhabi, UAE, October 2013.

[7] Leshchinsky, D., Kaliakin, V.N., Ling, H.I.: Alleviating connection load (designs for marginal conditions can be based on straightforward and sound geotechnical engineering), Geotechnical Fabrics Report, USA, October/November 2000.

[8] Koerner, R.M.: Geosynthetic reinforced segmental retaining walls, Drexel University/GRI, Proc. 17th PaDOT/ASCE Conf. on Geotechnical Engineering, USA, 1999.