Protection of reinforced soil structures using geosynthetic cementitious composite mats

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Abstract. Geosynthetic Cementitious Composite Mats (GCCMs) are geosynthetics that contain cementitious material, which harden on hydration to form a thin, durable, concrete layer. This presentation considers the use of GCCM's to protect Geosynthetic Reinforced Soil structures. It focusses on the three main applications where GCCMs can be used: a) the provision of a robust facing element to prevent UV degradation, vandalism and animal damage of geosynthetic reinforced wrap faced structures, b) the provision of top of wall drainage to collect surface water and prevent saturation of the reinforced soil block and c) the provision of toe drainage to prevent saturation and erosion of foundation soils. The characteristics and properties of GCCMs relevant for each application are reviewed and compared with traditional concrete solutions to determine when they can be used to protect Reinforced Soil structures.

1 Introduction

In the past decade, GCCMs have been used in civil and geotechnical engineering to provide erosion control solutions for a number of applications. Rather than replace existing erosion control geosynthetics such as Turf Reinforcement Mats (TRM's) which improve the resistance of vegetation to erosion, GCCMs are used as an alternative to conventional concrete, such as poured, precast and sprayed solutions. They are often used when vegetation cannot grow or needs to be prevented from establishing in order to avoid long term maintenance issues. GCCMs are commonly being used in conjunction with conventional geosynthetics to provide a complete project solution, one such application is in the design of Reinforced Soil Structures (RSS). Here we will consider the properties of GCCMs that may enable them to be used as an alternative to conventional concrete in these applications.

2 GCCM Properties

ASTM D4439 'Standard Terminology for Geosynthetics' defines GCCMs as 'a factory-assembled geosynthetic composite consisting of a cementitious layer contained within a layer or layers of geosynthetic materials that becomes hardened when hydrated'. As shown in Figure 1, GCCMs typically consist of 3 layers: - A fibrous top surface that wicks water into the central layer, which is composed of a dense, 3-dimensional fibre reinforced matrix filled with a cementitious blend that has a high early strength gain. The hardened central layer acts to protect a bottom waterproof polymeric layer. The layers act to contain the cementitious blend during transport and installation, ensuring a consistent density of cement throughout

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the material and control of the water: cement ratio on hydration. Properly manufactured GCCMs cannot be over hydrated as they will fully set underwater, which greatly facilitates hydration on site by removing the need for careful water: cement ratio control. GCCM physical properties change with the addition of water and in service the GCCM becomes a thin rigid element. Once cured, GCCM's performance is evaluated by a flexural bending test, which ASTM D8058 sets out the procedure for measuring GCCM Initial Flexural Strengths (the first crack of the cementitious material) and the Final Flexural Strength (the ultimate strength of the geosynthetics). ASTM D8364 is the Standard Specification for GCCM materials, defining three classes of GCCM and setting minimum performance properties such as ASTM D8058 flexural strength, ASTM D8329 compressive strength, abrasion resistance and puncture resistance. The cured performance properties of GCCMs enable them to be suitable for use in the design of RSS drainage and facings as discussed below.

3 Crest drainage for surface water runoff

Incorrect surface water management and drainage design can be a significant contributing factor to potential RSS failure. Saturation of a reinforced soil mass (that cannot drain) will build up hydrostatic forces and increase lateral pressures, reducing the factor of safety in a reinforced soil structure design. Collecting and removing water before it enters the reinforced zone of influence can reduce the likelihood of water related failure. The GCCM can be installed immediately after RSS construction as its flexural properties enables the GCCM to practically accommodate potential settlements from the RSS. This provides a significant benefit over poured concrete, which can crack under settlement and enable water ingress into the reinforced soil mass.

Larger GCCM drainage channels can also be used to collect surface water runoff before it reaches the RSS, thereby preventing saturation of the reinforced mass and reducing the risk of increasing hydrostatic pressures. This can be a preferred solution if the catchment area upslope is large and would result in significant water runoff heading towards the RSS. These channels collect and direct the water away from the RSS. An example of a GCCM drainage channel to the back of an MSE Wall reinforced soil mass is shown in Figure 2.

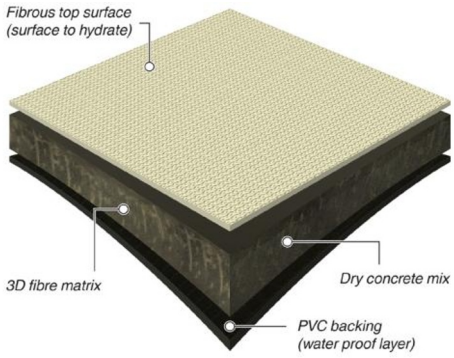

Figure 1. typical GCCM cross section

Figure 2. GCCM channel behind RSS mass

4 Toe drainage

Toe of RSS drainage design is critical in preventing erosion at the base and edges of the structure. Designers need to ensure that any flowing water (including water from weep holes) is safely directed away from the structure and cannot erode foundation soils which could

cause undermining leading to likely failure. Insufficient toe drainage design can result in saturation of foundation soils, which can compromise an RSS by causing soil softening and deterioration of the engineering properties of the foundation.

GCCM's can provide an effective toe drainage solution to these issues. The abrasion resistance of the GCCM prevents scour and erosion of drainage channels that are subject to sediment flow and ensures that watercourses in front of RSS's are not undermined (Figure 3). GCCMs can also be mechanically fixed to hard facings, so any back of wall internal drainage can discharge through the wall and onto the GCCM, preventing scour and undermining at the toe of the structure. The weed suppression benefits of GCCMs, prevent possible drainage capacity reduction through vegetation growth and silting, reducing future maintenance needs.

5 Facing to reinforced soil structures

Geosynthetic wrap faced structures may be specified for RSS construction and can reduced construction costs over hard facing systems. Vegetation typically provides sufficient protection to geosynthetic elements from UV resistance. However, establishing vegetation cover on steep slopes is not always possible and depends on a number of factors including but not limited to: final slope face angle, orientation/exposure to sunlight, quality of topsoil behind the wrap face and irrigation. Seasonal weather changes can also prevent year- round vegetation growth. Other factors that could affect geosynthetic durability include damage from wildlife or vandalism. When vegetation does not establish or if the structure is damaged, permanent repair solutions need to be considered in order to prevent further degradation of the geosynthetic structure face and its eventual propagation into the integrity of the rest of the reinforced soil structure, if left unrepaired.

GCCM's can be used as a permanent facing option to protect unvegetated or damaged reinforced soil structures, replacing conventional concrete solutions. The GCCM can be draped over the face and anchored along the perimeter edges to prevent wind and water ingress. The roll applied GCCM can be easier to handle than precast elements, minimising or eliminating the need of temporary scaffolding for construction. The GCCM flexural strength allows it to accommodate potential reasonable settlement or movement of the reinforced soil mass. GCCMs have been used to protect geosynthetic wrap slopes and walls worldwide. Examples are shown in Figures 4, 5 and 6.

Figure 3. GCCM toe drain to gabion faced wall

Figure 4. GCCM protection of wrap faced bund

Figure 5. GCCM facing to unvegetated wrap faced RSS

Figure 6. GCCM facing to EPS and reinforced soil wall

6 Conclusions

The physical and practical properties of GCCMs enable them to be incorporated in RSS design to replace conventional concrete techniques. When designing new structures, GCCMs can be specified into crest and toe drainage designs to provide low permeability, low maintenance drainage channels directing water away from reinforced soil structures and foundation soils, preventing potential structure failure. For existing reinforced soil structures that cannot vegetate or are subject to physical damage, GCCMs can be used as a protective facing to ensure the longevity of the structure. GCCMs have a distinct advantage over poured or sprayed concrete in these applications as they can accommodate acceptable post construction settlements, providing the performance of conventional concrete solutions, but with the flexibility of geosynthetics.

References

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