GOING DEEP INTO GROUND REALITY

Tackling slope failures with geosynthetic reinforced soil structures

Remember all the hard work you put to raise a sand castle as a child? You do all that scooping and shaping but, the next moment, a mighty wave would wash away your exquisite castle. It was indeed agonising. Every child on the beach would dream: What if I could build a sand castle that is strong enough to brave the waves and stay intact forever!

Well, it is not the child who wonders thus, but every geotechnical engineer. For the tribe of geotechnical engineers, every construction is a challenge as every site is a unique proposition. There are always problems such as slope failures or landslips awaiting them. On most such occasions, the engineer must turn to innovation, of course, factoring in affordability, engineering challenge and effectiveness.

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Slope failures due to rainwater infiltration are a serious concern, and cause severe damage to infrastructure and distress to public every year. The penetration of rainwater into the soil results in loss of strength and leads to instantaneous debris flow and slope failures.

The August 2018 deluge paved way for the worst series of landslides in Kerala in nearly a century. The state witnessed heavy rain followed by severe landslides. One sixth of the total population of Kerala was directly affected by the floods and related incidents like landslides. Heavy rain caused severe landslides in the hilly districts of Idukki, Wayanad and Kannur, and left these places completely isolated and closed to traffic.

The primary cause of failures in reinforced soil walls is attributed to the absence of properly

Photographs of landslides at different places in Kerala during August 2018 designed drainage system within the reinforced soil structures. If the excess pore pressure generated due to rainfall is not dissipated properly, it leads to instability.

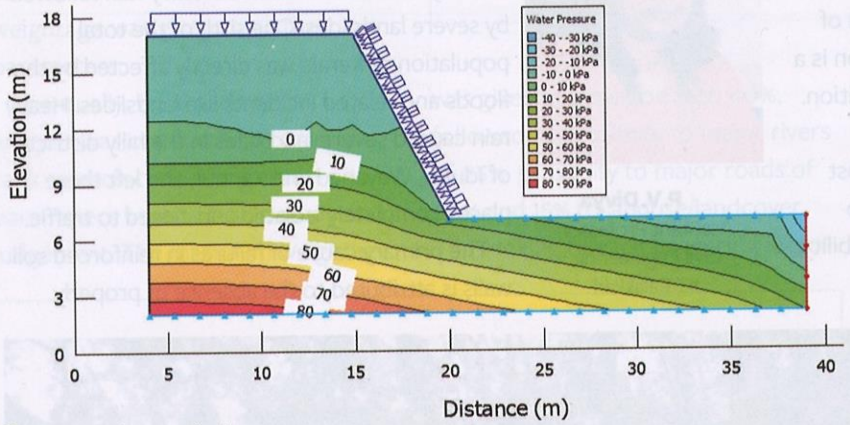
Hybrid geosynthetics and stability

Geosynthetics are widely used in the field for reinforced earth applications. The most efficient way to prevent rainfall-triggered landslides and damage would be the use of hybrid geosynthetics or geocomposites. These are assembled materials developed by integrating the reinforcement action of geogrids with the drainage function of non-woven geotextiles. These materials can be used to improve the slope stability by performing dual functions of reinforcement and drainage. The effect of inclusion of hybrid-geosynthetic layers within a slope subjected to rainfall was investigated numerically. Figure 2 highlights the possible inclusion of hybrid geosynthetics to enhance the performance and stability aspects of a slope under various rainfall intensities. It shows the distribution of pore pressure in kN/m2 for 48 hrs of rainfall at 50 mm/day for unreinforced and hybrid geosynthetic reinforced slope after 24 hours.

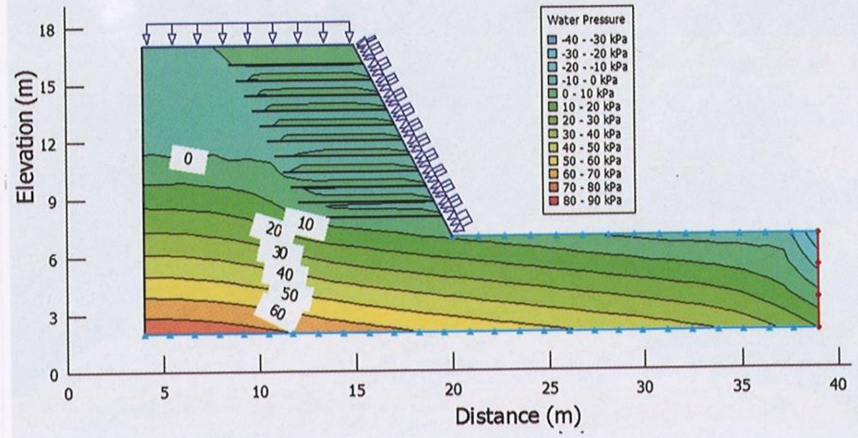
The analysis was done with and without hybrid-geosynthetic layers embedded in a slope having 3V:1H inclination with a rainfall intensity of 50 mm/day. Silty soil was used with co-efficient of permeability 2.08 x 10-7 m/s at a maximum dry density of 16.8 kN/m3 and optimum moisture content of 20%. The effective shear strength parameters were c'= 10kPa and ϕ'= 30. The thickness of the hybrid geosynthetics considered is 2.4 mm and in-plane permeability is 4.25 x 10-3 m/s. The ultimate tensile load was 22 kN/m. As shown in the figure (Fig. 2), there is a build up of excess positive pore water pressure within the unreinforced slope; whereas the pore pressure reduced with the inclusion of hybrid geosynthetics. The results indicate that, the inclusion of hybrid-geosynthetic layers was effective, as it lowered the phreatic surface by causing a reduction in excess pore water pressure. Figure 3 shows the variation of normalised pore water pressure (u/γh) obtained by dividing pore pressure value (u) measured along the base of the slope by the unit weight of the soil (γ) times the height of the slope (h).

As shown in figure 3, there is almost four times reduction in the normalised pore water pressure of unreinforced soil slope when reinforced with hybrid geosynthetics layers. The results demonstrate the effectiveness of hybrid geosynthetics in providing drainage and pore pressure dissipation during rainfall event. This helped in increasing the factor of safety of geosynthetic reinforced soil slopes, though not covered in this article.

Thus, hybrid geosynthetics which can perform dual functions of drainage and reinforcement would be an ideal solution to improve the stability of slopes subjected to rainfall rather than depending solely on drainage layers or on reinforcement layers since drainage function of hybrid geosynthetics help in pore pressure dissipation and the reinforcement function help in increasing the stability of slopes.



Unreinforced slope



Geosynthetic reinforced slope

Figure 2. Distribution of pore pressure in kN/m2 for 48 hrs of rainfall for unreinforced and hybrid geosynthetic reinforced slope

Photographs of landslides at different places in Kerala during August 2018

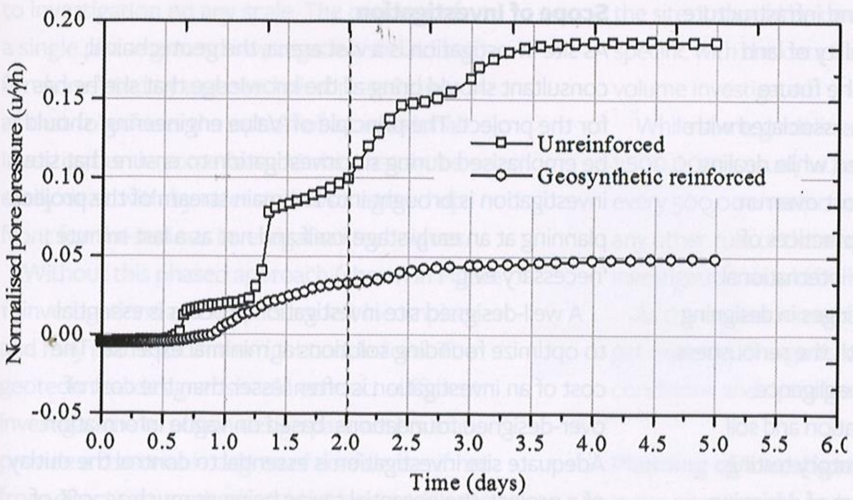


Figure 3. Variation of normalised pore water pressure with time