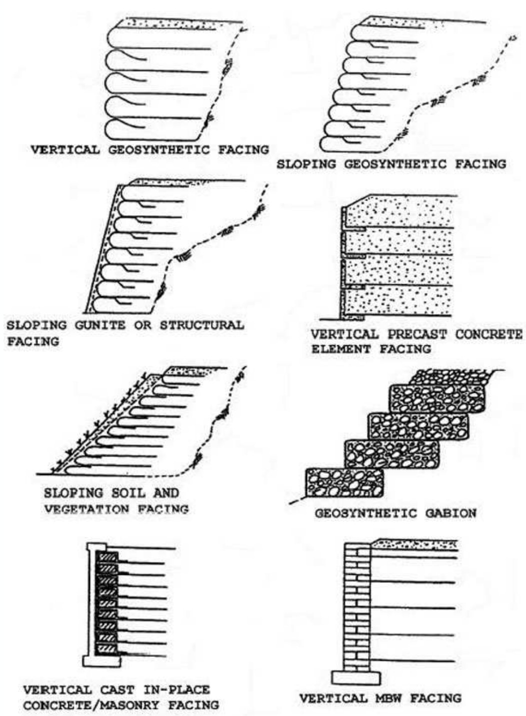
One-Day Seminar on "Design of Geosynthetic Reinforced Soil Structures with Latest R&D Updates"

By : *Engr. Simon Tan Siow Meng* *FIEM, P.Eng.*

The one-day seminar was organised by IEM with the assistance of IGS-SEAC (Malaysian Working Group). The seminar was held on 28 July 2005 at the IEM Conference Hall. It was conducted by Dr Barry R. Christopher who is an internationally recognised expert in the applications of geosynthetics in civil engineering. There were 55 participants.

Geosynthetics are widely used as structural reinforcement in steep slopes, retaining walls, embankments over soft ground and road base reinforcement. The application of geosynthetics in civil engineering has been more than 40 years. The application of reinforced soil structures has a history of some 5,000 years as found in a 79m high structure in Mesopotamia built of soil reinforced by reeds placed in horizontal layers.

Geosynthetic reinforced soil structures has come a long way in Malaysia. From its humble beginning in the early 70s, today it has become a norm structure due to its speedy and economic viability. The growth of such structures has been so dramatic over the past decades, that more sophisticated and challenging applications could be seen in some prestigious and landmark projects such as the reinforced soil retaining walls in Putrajaya. The economic viability of using reinforced soil structures is testified by its application as a temporary retaining system in the on-going double track railway project between Rawang - Ipoh.



Design Concepts

Dr Christopher started with an introduction of the design concepts. The degradation mechanisms on geosynthetics include time dependent creep, installation damage and ageing by oxidation or hydrolysis (reaction with water such as Polyester PET). For a preliminary or default design, Dr Christopher suggested:

$$Ta = Tult/7FS$$

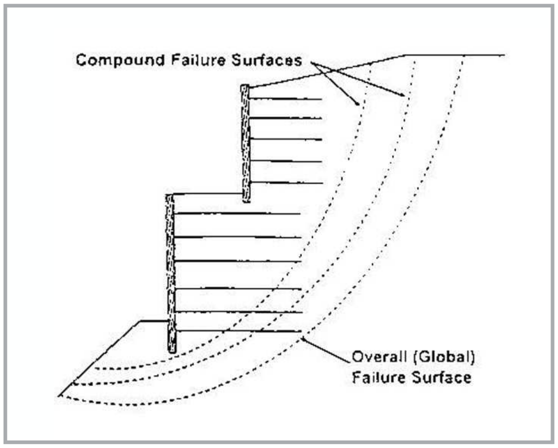
Where Ta and Tult is the allowable and ultimate tensile strength of the geosysthetic. FS is the overall stability, 1.5 for reinforced soil walls while 1 for reinforced soil slopes because the required FS is accounted for in the slope stability analysis.

Reinforced Soil Walls

He then covered the topics on Reinforced Soil Walls (or mechanically stabilised earth wall MSEW). The maximum height of a MSEW under construction in the US is 41m. He also revealed two 50m high walls that had been constructed in China but one had failed due to poor design illustrating the importance of proper design.

Dr Christopher mentioned the wall face of a high wall should be offset at every 5m to 10m vertical interval to reduce excessive pressure on the face elements. The minimum width of the offset is 1m and usually 2m are provided for maintenance access purposes. Dr Christopher reiterated the importance of drainage. Thus fine grain soils should be avoided unless there was very good control. Fine grain soils reduce soil friction angle, ϕ, and encourage clogging. Researches show that ϕ of soils drop significantly when fines exceed 20%. Thus fine grain soils should be limited to 15% and Plasticity Index, PI of fill should be less than 6. Compaction of fill is important. There are wall failures by dislocation of face elements due to poor compaction of fills near the wall faces.

A MSEW needs to deflect to mobilise resistance of the geosynthetic reinforcements. This results in wall deflection of 20mm to 35mm per every 3m high of the wall. Typical block width of an MSEW is 70% of the wall height. The top layer geosynthetic reinforcement should be



extended to a length equivalent to full wall height to control tension cracks on the ground surface. The minimum reinforcement length should be 2.5m considering construction practicality. While stability analyses are well established and documented, Dr Christopher highlighted that it is essential to check compound failures passing partially through the reinforced block and overall stability failures.

Some useful references were mentioned:

- FHWA-NHI-00-43, [*Mechanically stabilised earth walls and reinforced soil slopes design and construction guidelines* (*free download from http://www.fhwa.dot.gov/bridge/geopub.htm*).]
- FHWA HI-95-038, [*Geosynthetic design and construction guidelines*] (-ditto-).
- AASHTO, Standard specifications for highway bridges.
- Computer software MSEW, ReSSa, both from FHWA.

Reinforced Soil Slope

A Reinforced Soil Slope (RSS) has slope angles less that 70° as defined by FHWA. The highest RSS is about 50m according to Dr Christopher. He cautioned the potential of 'lateral squeeze failure' when clay layer underneath the slope is having:

$\gamma h/c_u \leq 3$

Unit weight of soil times slope height divided by undrained shear strength of the clay layer.

The slope stability for RSS can be analysed by computer programmes such as PCSTABL4, GSLOPE, UTEXAS3 and ReSSa, to name a few.

In the application for embankment over soft ground, Dr Christopher reminded a blanket of free draining material to be laid over the geotextile to prevent building up of excess pore water pressure and to enhance friction between geotextile and fill interface. Ta of the geosynthetic depends on the failure strain which is related to the soil materials. Geotextile in embankment application is mainly for slope stability. One must bear in mind it does not reduce but helps to get a more uniform settlement.

Application in Pavements

On geosynthetic applications in pavements, the functions of geosynthetics are: separation, stabilisation, drainage, and reinforcement. According to Dr Christopher, the introduction of geosynthetic reaps the most benefit when: subgrade CBR<8, road base < 250mm for moderate loads and asphalt concrete of 75mm thick.

Recent developments and researches

Towards the end, Dr Christopher shared some recent developments and advancement in researches:

- Design and analysis using finite element method is gaining popularity due to affordability of powerful personal computer and user-friendly FEM software. FEM enables modelling of complex cases beyond the capability of conventional design approach.
- New applications such as geocell capping layer for column supported embankments.
- Researches in wider choice of fill materials
- Innovation in instrumentation such as real time monitoring and remote area monitoring, bundling of instruments in geosynthetic during manufacturing to improve consistency and reliability of instruments and to eliminate wiring mess. ■