

Case History: Polymeric Reinforced Fill Slope in Yuen Long

Contract No.	HY/2002/19
Project Title	Widening of Yuen Long Highway Between Tan Kwai Suen and Shap Pat Heung Interchange
Client	Highways Department, the Government of the HKSAR
Consultant	Scott Wilson Ltd.
Reinforced Earth Consultant	Benaim (HK) Ltd.
Main Contractor	Paul Y. Construction Company Ltd.
Commencement Date	July 2003
Geosynthetics Supplier	G and E Company Ltd.
Scope of Work	Design and Supply of Geogrid for Seven Reinforced Fill Slopes
Material	50,400 m ² of Tenax TT090 SAMP (Primary Geogrid) 6,800 m ² of Tenax LBO202 SAMP (Secondary Geogrid)



Figure 1 – Plan view for details of the extent of the works for contract no. HY/2002/19

Project Description

The 6.8 km long Yuen Long Highway to be widened connecting Tuen Mun and Yuen Long. At present, the highway is operating near its capacity. Extra lanes are necessary to cope with the committed developments in the North West New Territories and the increase in the cross border (China - Hong Kong) traffic.



Figure 2 – Laying of Tenax TT090 geogrid (Slope SE5)



Figure 3 – Laying of Tenax TT090 geogrid (Slope SE3)

The project includes construction of seven reinforced fill slopes along the highway, in which noise barriers will be erected at top of the reinforced fill slope. Slope profiles are at a maximum angle of 45 degree with maximum slope height of 6.5 metres.

The method of construction of reinforced fill slope is by overfill and cut back with the use of Tenax TT090 SAMP primary geogrid. Maximum spacing of primary geogrids is set to 600mm where minimum spacing is set to 300mm. Maximum base width is 9 metres. Type II fill material was used as selected fill for the reinforced fill slopes, and 300mm granular filter material was placed at the base of slopes as drainage layer.

All slopes are designed to prevent raveling and allow the establishment of green vegetation for long term erosion protection with the use of erosion control mat together with layers of secondary reinforcement between the primary reinforcement.



Figure 4 – Laying of erosion control mat



Figure 5 – Cutting back of slope facing

Internal Stability Analysis

Internal stability analysis of the reinforced fill slope is based on Geoguide 6: Guide to Reinforced Fill Structure and Slope Design (2002) published by Geotechnical Engineering Office (GEO) of the Government of the HKSAR.

Internal stability is concerned with the integrity of the reinforced block. Failures due to rupture and pullout of the reinforcement are considered in the design. In checking against internal instability limit state, the use of partial safety factors is adopted to evaluate if the design loading is less than the design resistance.

For tension in reinforcement, the total horizontal force to maintain a slope in equilibrium was determined by considering a sufficient number of potential failure planes to obtain the worst case for design by computing program SLOPE/W.

For rupture of reinforcement, the design tension of every individual layer of reinforcement at different levels within the reinforced block is obtained from the above and checked against design strength of reinforcing elements. The long-term design strength of i -th level reinforcement is to be larger than the total design tension to be resisted by that layer.

For pullout of reinforcement, the design tension of every individual reinforcing element at different levels within the reinforced block is obtained from the above and checked against pullout resistance of that layer. The design pullout resistance of the i -th level reinforcement is to be larger than total design tension to be resisted by the i -th level reinforcement. The effective bond length of the reinforcing element is taken as that which protrudes beyond the potential failure surface under consideration.

For the design value of tensile strength of geogrids, the long-term design tensile strength is obtained from the GEO Reinforced Fill Product Certificate - Tenax geogrids issued by the director of the Civil Engineering and Development Department of the Government of the HKSAR.

The Material

Tenax TT090 SAMP was used as the primary reinforcing element with a short-term characteristics strength of 90 kN/m. Tenax TT090 SAMP geogrids are manufactured by extruding and mono-directional drawing of high-density polyethylene (HDPE) grids. This technology produces products having important technical properties that permit their usage in structural applications. Tenax TT SAMP geogrids, being chemically inert and having a high tensile strength and modulus are specifically produced for the reinforcement of soil. Soil and aggregate interlock within the geogrid openings, which, confine the soil and limit its relative displacements and increase the soil's shear stress resistance. Soil compaction produces an interlock between the soil and both faces of the geogrid layer, thus it's necessary to reach a higher level of tension in order to overcome such an interlock and give rise to movement.

Erosion control mat was used for all slopes to prevent raveling. Secondary reinforcement Tenax LBO202 SAMP between primary reinforcement was also used to maintain surface stability. The width of LBO202 SAMP is 1 metre.

The Overview

The construction was fast and economical with the use of geogrid. However, this reinforced fill construction is still not very common and hence most engineers were not familiar with this type of construction. Long time was taken for approval of design and numerous trivial problems were raised during installation.



Figure 6 – During construction (Top) and after construction (Bottom) of reinforced fill slope