Slope Stabilization Solutions Using Geosynthetics
Anjuran: Lembaga Lebuhraya Malaysia

Presented by,

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15th August 2014

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Area of solutions we provide

1) **Soft Ground Improvement** using geosynthetic

2) Nexus Wall with Geogrid and Earth Backfill

3) **Slope Stability Enhancement** by sustaining matrix suction during rainfall using geosynthetic and Geogrid Netting Solutions

4) Building **High Geogrid Retaining Wall on Soft/weak Ground** (Flexible Retaining Wall)

5) Rainfall Induce **Shallow Slope Failures Caused By Relict Joint**

6) Asphalt Reinforcement and **Light Weight Concrete** for Ground improvement (under R & D)
A. Soft Ground Improvement using Geosynthetic.

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Typical Soft Ground Site Condition

Typical very soft subsoil condition within the road alignment of about 15 ~ 25m with SPT of 0 blows/300mm
Subsoil Interpretation Before Design Works

CPT - total cohesion, Cu

Total Cohesion (Cu) Vs DEPTH (m)

SPT (N) Vs DEPTH (m)
Cone Penetration Test (CPT) Interpretation

Fissured Soil – Loose and not intact Soil, example of non engineered pond filling which could have adverse effect to pile foundation.
Conventional Type of Ground Treatment

- Insitu replacement
- Surcharging with and without vertical drain
- Piling woks
- Stone column
- Soil cement
Performance History of Conventional Ground Treatment (PVD)

Drainage blanket got buried due to Large settlement
Performance History of Conventional Ground Treatment

Pavement view, undulation to bridge approach
Performance History of Conventional Ground Treatment

Temporary Platform Filling Works

Voids under pile embankment
Performance History of Conventional Ground Treatment

Failed Stone Column

Failed Pile Embankment
Stone Column usage and design limitations

Minimum earth works required

Installation works can be done in rapid manner

Able to provide sufficient bearing resistance and minimize settlement
Stone Column usage and design limitations

Stone columns as ground improvement mechanism – design limitations;

a) Soil Shear Strength

- The recommended lower limit to the undrained strength of $C_u=15\text{kPa}$ is suggested for treatment with stone column (Bryan, 2007) and (MCR Davies, 1997),

- although there have been few situations where softer soils have been successfully improved (Raju et al, 2004).

- For very soft clay with $C_u$ between about 4-15 kPa soil with very low cohesion have relatively low radial support given to the stone columns by the soil (Thornburn S. 1975).

b) Soil Plasticity Index

- The plasticity index ($I_p$) of soil reflects the potential for volume change, UK National Building Council (NHBC, 1988) suggests that stone columns not recommended to be used when $I_p>40\%$ (Bryan, 2007).

- However only few successfully cases where high plasticity soils has been improved using stone column.
c) Soil Permeability

- The major difficulties in forming uncontaminated stone columns in very soft soils are due to radial displacement seriously distorts and remoulds the surrounding soil inducing excess pore water pressure which cannot dissipate rapidly even in a laminated soil because the distortions destroy the natural horizontal drainage laminae (Thornburn S, (1975)).

d) Ground Settlement

- With reference to research work of Hughes and Withers (1941) indicates that the ultimate stress in the stone columns were obtained only when the vertical displacement of the column was 58% of the column diameter. Field test results examined by S. Thornburn on full size stone columns indicate that the vertical displacement of the top of the stone columns at failure, were only of the order of 10 ~ 15 % of the diameter of the columns. (Thornburn S, (1975)).
High strength geotextile encasement:

Suitable for Soft Ground Improvement
- Higher bearing capacity reduced settlement
- Faster construction
- Less area required for construction (land acquisition)
- Vertical drains are not required
- Time for surcharging not required
## Selection of suitability construction technique

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<thead>
<tr>
<th></th>
<th>Construction time</th>
<th>(differential) Settlements</th>
<th>Feasibility</th>
<th>Hydraulic conditions</th>
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<td>Soil exchange</td>
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<td>PVD + horizontal rein.</td>
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<td>Geocell mattress</td>
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<td>Stone Columns</td>
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Time related settlement comparison
Typical Embankment Sectional Details

Cross-section 1, H = 10.5 m

Cross-section 2, H = 3.5 m
Installation Method

1. Pipe is vibrated down with the tip closed.
2. Soil encasement is initiated with Ringtrac and filling sand or gravel.
3. The pipe is pulled up under vibration to complete the GEC.
Placement of Ringtrac into Casing and Finished Column
Advantages of Geotextile Encased Columns (GEC)

- GEC’s act as a vertical drainage system on the surrounding soft soil and thus facilitates its consolidation.

- Horizontal ground water flow is not disturbed by GEC.

- Most of the settlement occurs within the construction period, i.e. negligible long term settlements.

- The system minimizes the need for import of additional fill material to compensate for excessive settlements.

- No stability problems during construction of embankments in combination with a horizontal reinforcement.

- GEC’s represent in many projects the only technically viable solution for completion within tight time frames.

- Embankments can be built fast, reliable and cost effective using Ringtrac® reinforced GEC’s.

> 25 successful projects in various countries since 1995.