Advanced techniques for land reclamation using soft fill materials

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No more sand fill
Straits Times, 17 July 2017

Singapore must find substitute for sand

Indonesia and Malaysia have banned sand exports to Singapore. Now, Cambodia has followed suit. Cambodia has been a major supplier to Singapore, which is under pressure from environmental groups. (July 13).

There is no guarantee that our other suppliers—such as China, Vietnam and Myanmar—will not do the same in future, citing environmental issues.

An additional 56 km² of land to be reclaimed from now to 2030

Use of dredged soft soil

Installation of PVD over slurry

Courtesy of Prof Yan and Prof Cai
No sand blanket, no membrane - Fish-bone vacuum preloading

Difficulties in using the above scheme (or PVD method)

- Soil improvement can only be carried out after all the fill materials have been placed and the working platform has been formed;
- Difficult and time consuming to form a working platform;
- Difficult to design. Due to large compressibility, more fill materials need to be placed and more reconsolidation… Difficult to estimate the final level. Time consuming;
- Vacuum can only be applied section by section. Partitions are needed which are difficult to built and expensive.
- The vacuum pressure is limited to 80 kPa

A better method is to use of horizontal drains

Use of prefabricated horizontal drains

Horizontal Drainage enhanced Geotextile sheet (HDeG)
Model tests for HDeG

- **Model tests for HDeG**
  - (a) Position of piezometer pressure transducers
  - (b) Position of the HDeG
  - (c) Fully filled by sludge
  - (d) Photo of the slurry after 19hr of treatment

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Model testing results

- **Model testing results**
  - Initial slurry w/c = 96.3%
  - Surface settlement versus time curves
  - Day 1
  - Day 2
  - Day 3

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Model testing results

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  - Initial height = 93.7 cm (including clean water = 6.2 cm on surface)
  - Final height = 72.5 cm
  - Strain ε = 22.6%
  - Time of consolidation t

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Advantages of horizontal drains

- **Advantages of horizontal drains**
  - Vacuum pressures can be applied layer by layer while the fill materials are placed;
  - The fills on top of the horizontal drains become surcharge;
  - No sand fill (or sand blanket) is required;
  - Save time: soil improvement is completed soon after the last layer of fill has been placed;
  - More reliable prediction of the settlement and the amount of fills to be placed to achieve the final ground level;
  - No bunds are required for subdivision;
  - Vacuum pressure of more than 80 kPa can be applied.
  - **Disadvantage**: need to install HDeG offshore

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Summary

• When soft or slurry materials are used for land reclamation, it is difficult and time consuming to use the conventional vertical drain + vacuum preloading methods.
• A better method is to use horizontal drains. A method using the drainage enhanced geotextile sheet is proposed.