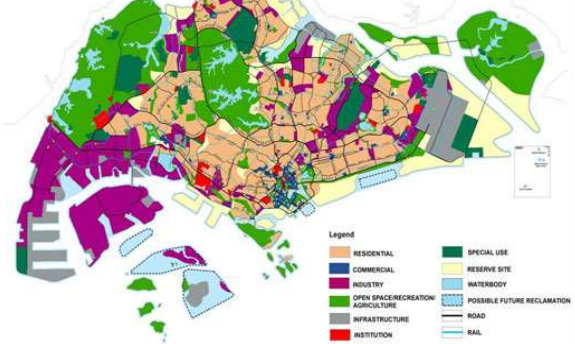


Advanced techniques for land reclamation using soft fill materials

CHU, Jian

Nanyang Technological University, Singapore

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



FORUM
No more sand fill
Straits Times, 17 July 2017

Singapore must find substitute for sand

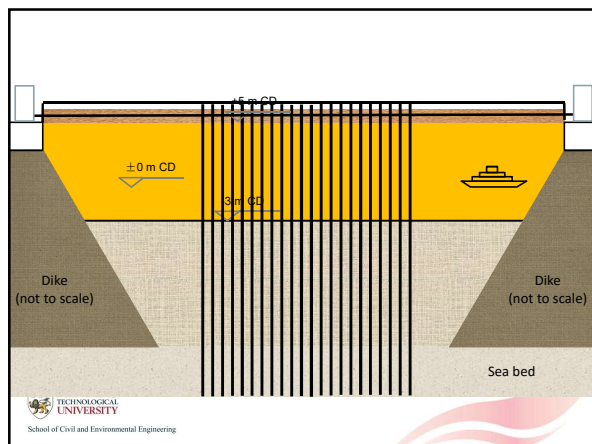
Indonesia and Malaysia have banned sand exports to Singapore. Now, Cambodia has followed suit (Cambodia bans sand exports to Singapore after pressure from environmental groups; July 13). There is no guarantee that our other suppliers – such as China, Vietnam and Myanmar – will not do the same in future, citing environmental issues. As sea levels rise and urban populations swell, sand can be considered a strategically important material. It is needed in the construction industry and reclamation work. Much of the modern global economy depends on it. With limits on the export of sand, the prices will rise. Illegal sand mining has also been taking place in nearby countries. Singapore must think of a substitute for sand and prepare to be self-reliant. For instance, mud could be used for reclamation, straw and wood for building houses, and crushed rock for concrete. Asphalt, concrete and glass can also be recycled. Artificial or manufactured sand is fast emerging in other countries as an alternative as well. Environmentalists in many places are calling on their governments to rein in sand mining. Singapore needs to plan ahead for alternatives.

Francis Cheng

Use of dredged soft soil



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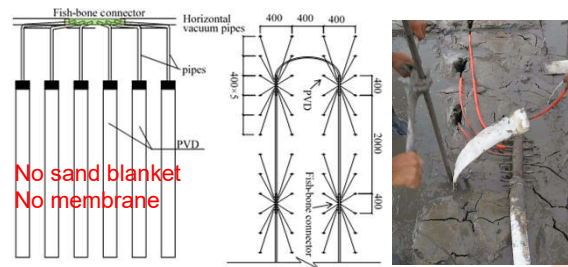


Installation of PVD over slurry



Courtesy of Prof Yan and Prof Cai

No sand blanket, no membrane - Fish-bone vacuum preloading



No sand blanket
No membrane

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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 build and expensive.
- The vacuum pressure is limited to 80 kPa

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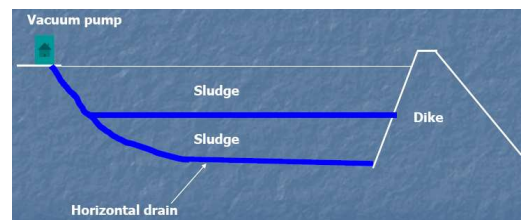
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Horizontal drains method

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A better method is to use of horizontal drains



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Use of prefabricated horizontal drains



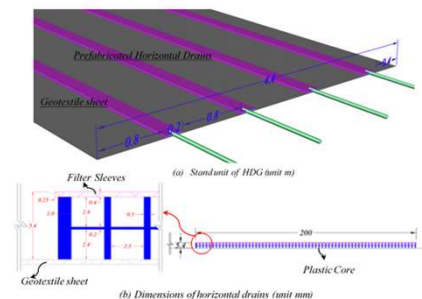
After
https://geosistem.co.id/product_horizontal_strip_drain.php#anchor

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Horizontal Drainage enhanced Geotextile sheet (HDeG)



Model tests for HDeG



(a) Position of piezometer pressure transducers



(b) Position of the HDeG

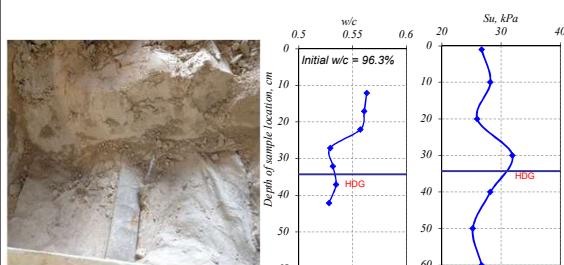


(c) Fully filled by sludge

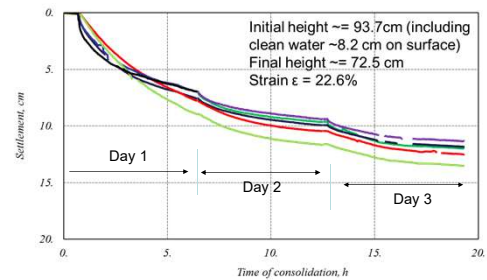


(d) Photo of the slurry after 19hr of treatment

Model testing results



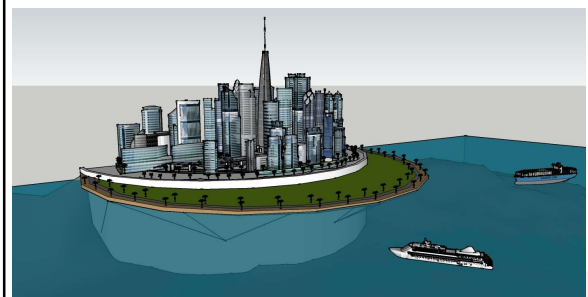
Model testing results



Surface settlement versus time curves

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





Artist impression of a proposed new Tanjong Pagar Commercial Centre and Residential Area created using the above proposed methods (After Dr Ho, 2016)



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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.



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