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TC211 Workshop – Cancun 2019
XVI Pan-American Conference of Soil Mechanics and Geotechnical Engineering

State of Practice of Vibro Compaction in Asia

Dr Leong Kam Weng

- Overview of Vibro Compaction in Asia
- Applications of VC in Asia
- q_c Specifications
- Post testing practices
- Case project
- Conclusions

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Overview of Vibro Compaction in Asia

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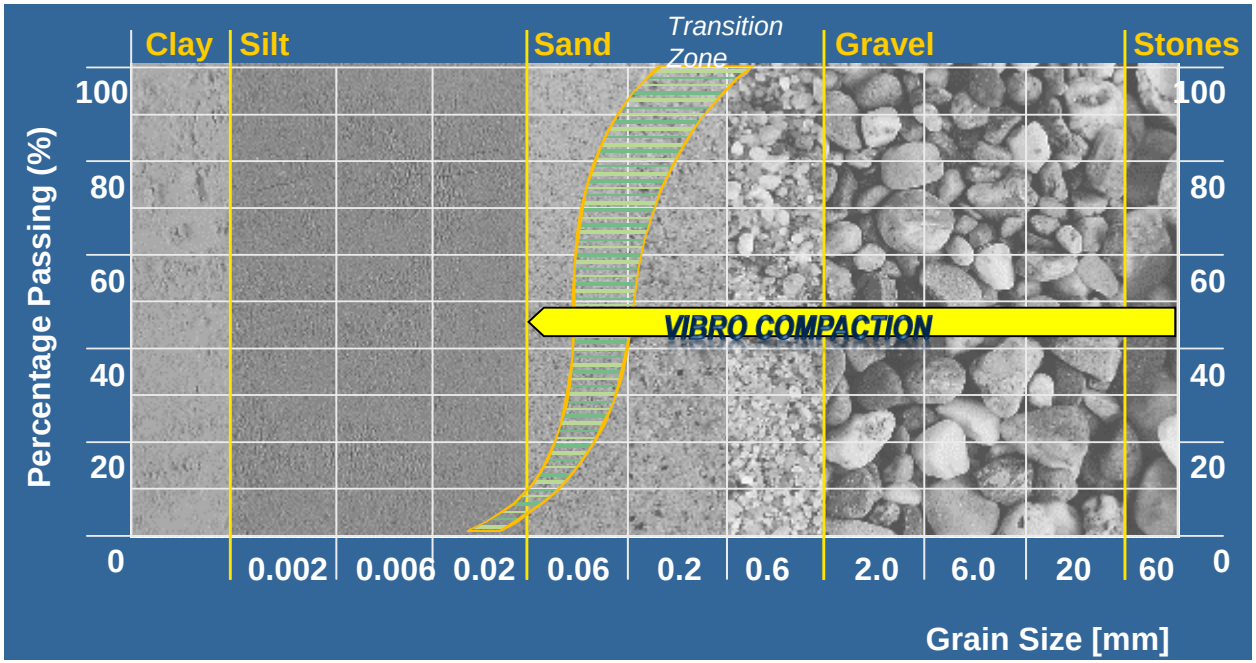
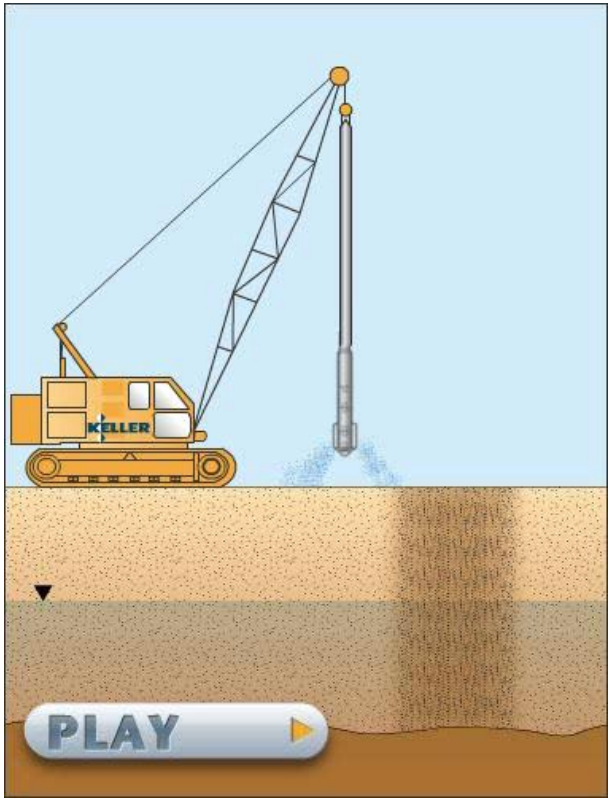
Vibro Compaction
(Deep Vibro Techniques - BS EN 14731:2005)





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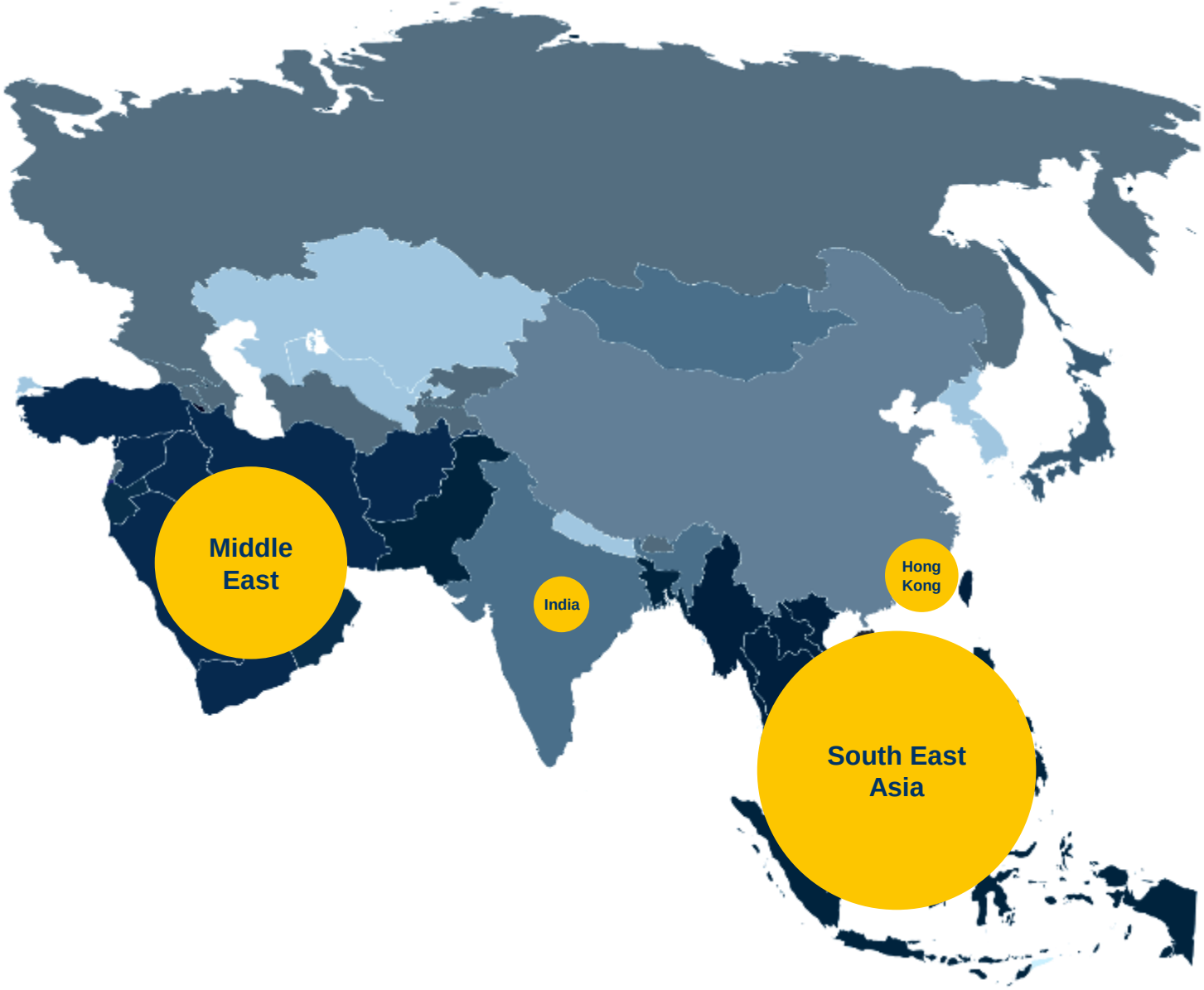
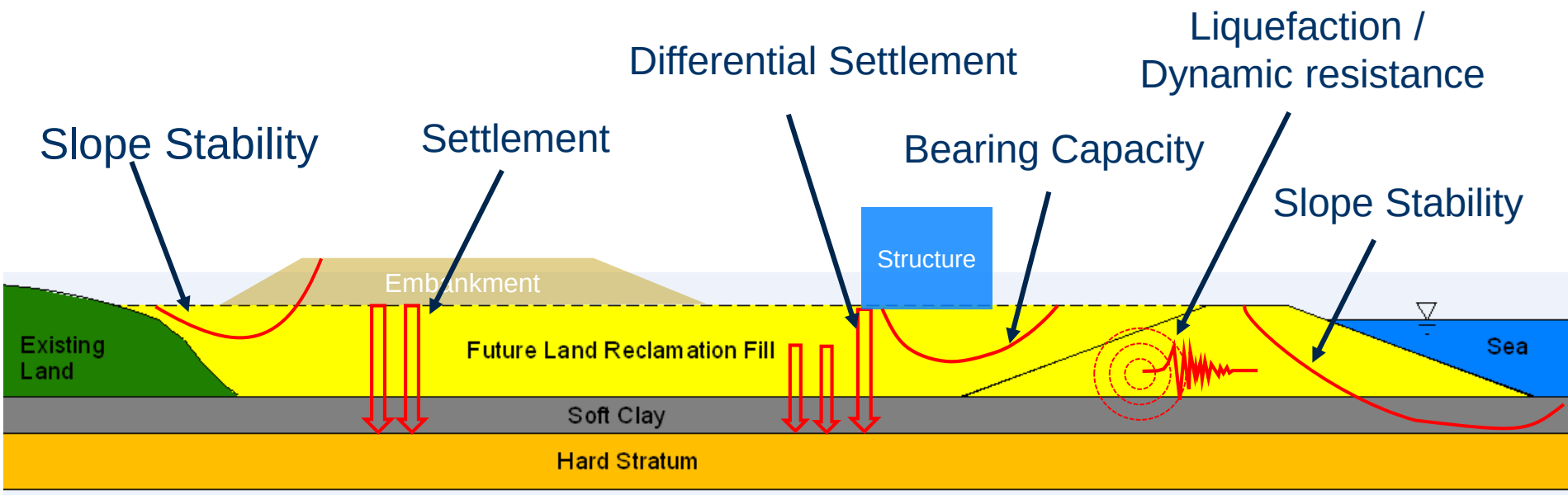
Vibro Compaction in Asia

50
mio m³



Engineering Functions of Vibro Compaction

- Slope Stability
- Bearing Capacity of Structure
- Settlement Control
- Liquefaction Mitigation
- Dynamic Resistance



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Applications of VC in Asia

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Palm Diera Island, UAE

- The 3rd & largest of the man-made islands in Dubai
- VC to achieve bearing capacity of 150kPa and liquefaction mitigation under PGA 0.2g

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Changi Airport T5, SG

- Land Preparation works for the future Changi Airport Terminal 5 and 3rd runway; increasing capacity from 66 mio to 135 mio per year

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Universal Terminal, Singapore

- 2.3mio m^3 oil storage terminal
- Foundations for 73 nos tanks (Ø = 13.6–78.6m, H = 15-22m), pump stations & manifolds. Total area ~ 200,000m^2.

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ExxonMobil JAC, Singapore

- Vibro Compaction treatment for Aromatics Complex
- 43nos tanks with diameter varies between 26m and 44m
- Other treatment area of 185,000 m^2 for pipe racks, bund walls and refinery structures

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Keppel Merlimau Cogen II, Singapore

- A Cogeneration Power Plant (Combined Heat and Power)
- Foundations of power plant and turbines

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VC for Liquefaction Mitigation

Polavaram Dam, India

- VC works below the Earth cum Rockfill (ECRF) Dam to mitigate liquefaction & enhancing overall stability of dam

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q_c Specifications

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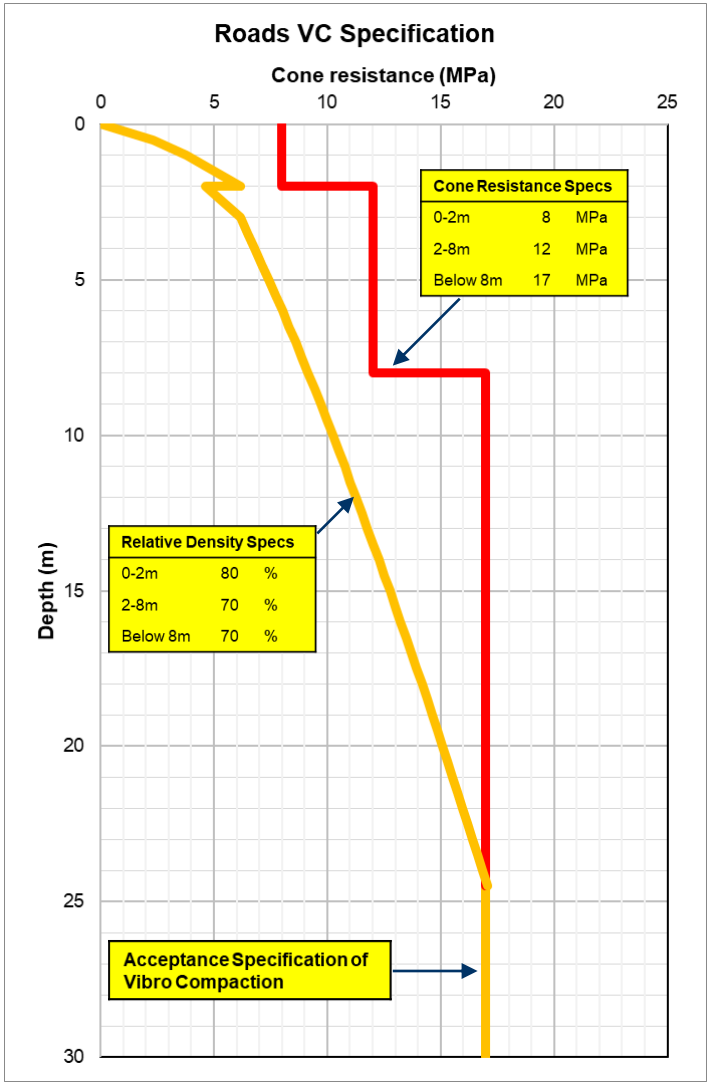
Specifying VC Performance

- Relative Density Specs (e.g. Schmertmann, 1976)

$$q_c = C_o \, \sigma_v'^{C_1} \, e^{(C_2 \, D_r\%/100)}$$

- Minimum CPT q_c Specs

Practical to specify a q_c cap value for RD Specs at deeper depths of sand !!!



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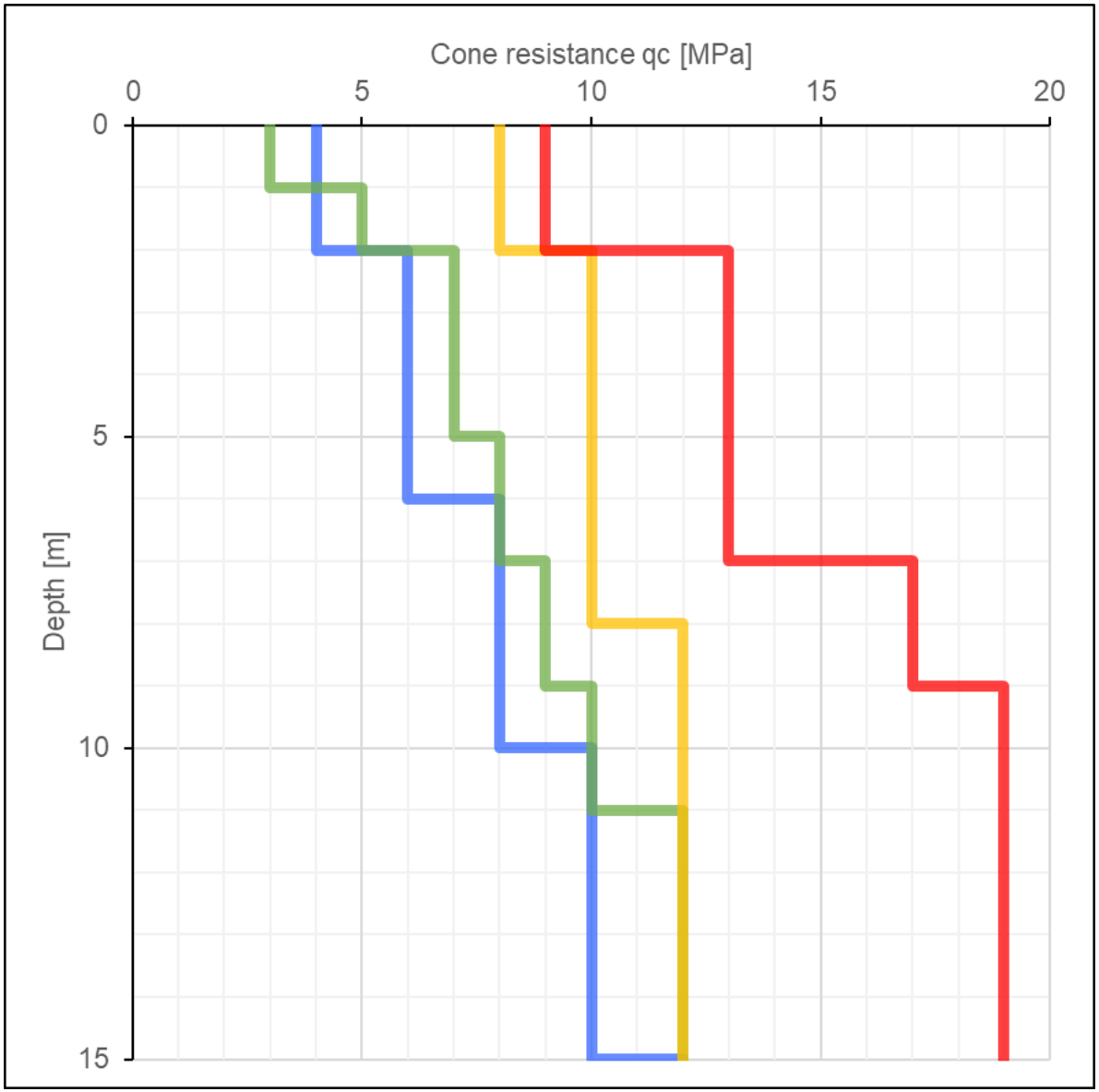
Examples of Vibro Compaction Specifications in Singapore



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Post testing practices

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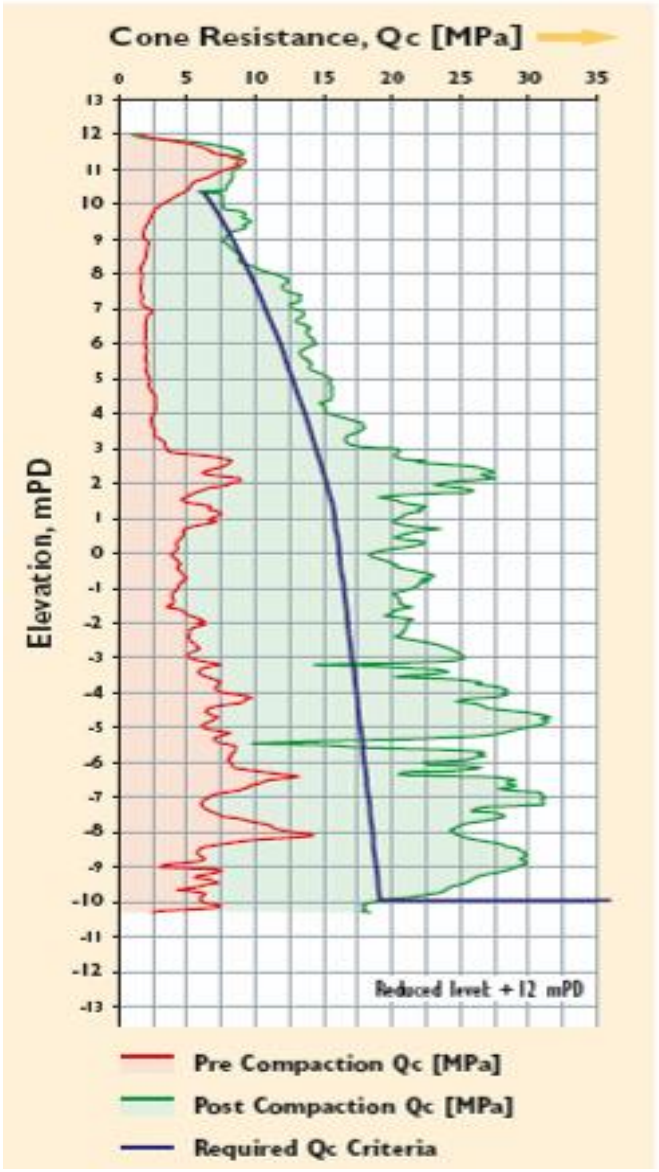
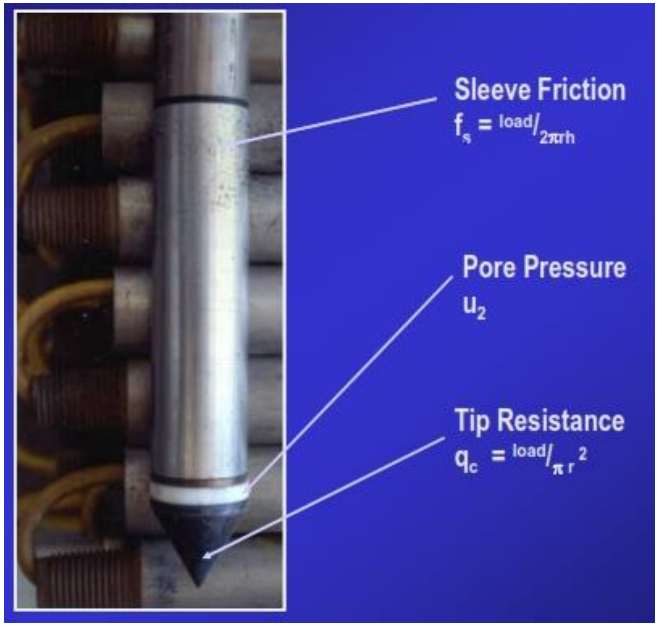
QA / QC – Pre/Post testing





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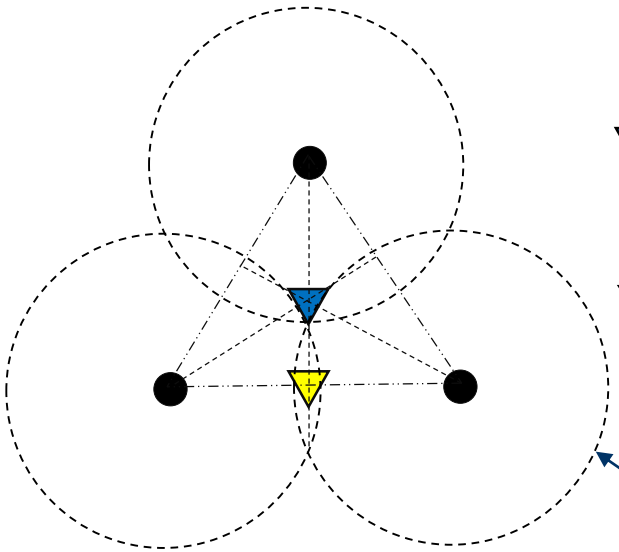
Post Treatment Testing



- Centre of compaction
- Post CPT A at *centroid* of VC points (weakest point)
- Post CPT B at *mid-point* of VC points

Zone of influence around VC point

- Generally, evaluation of VC works is done at weakest point or using average of the treated grid (e.g. centroid & mid-point of VC points).
- **Designer** must have the final say in the evaluation and acceptance of VC works aligning to their **design intent**.

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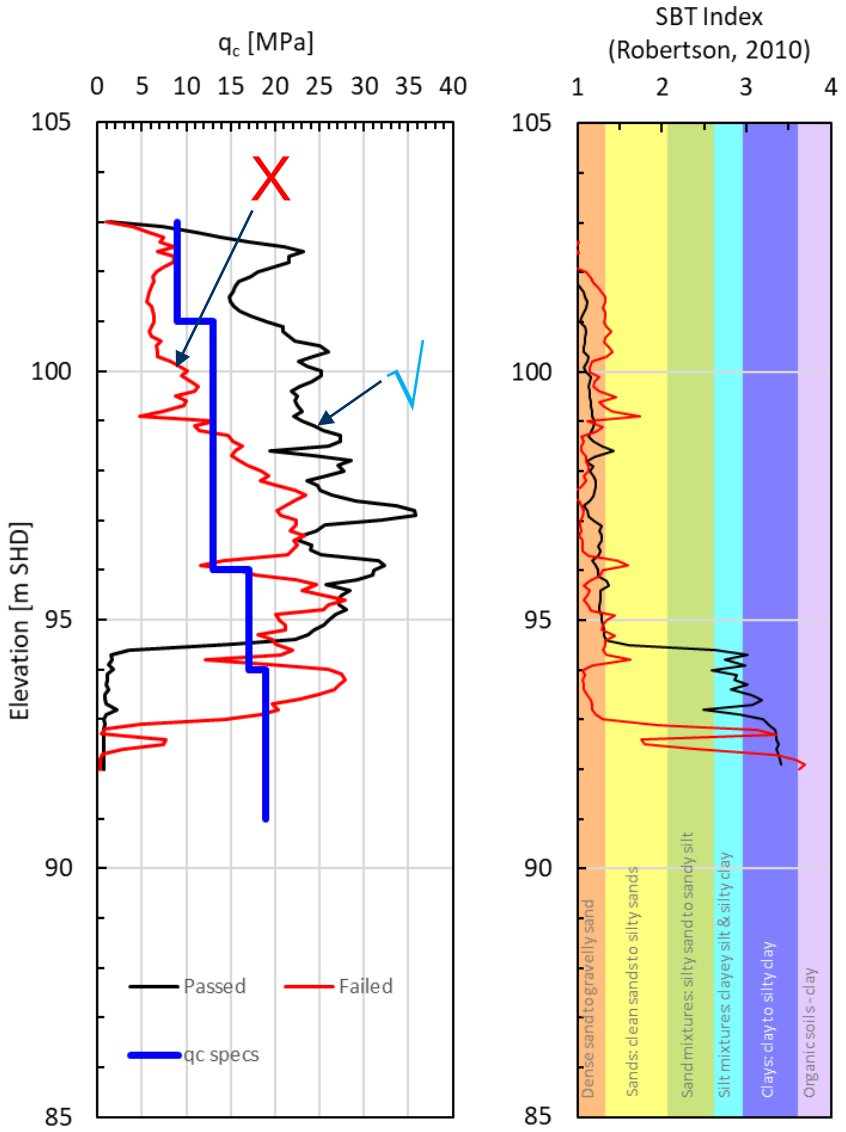
Example of Post Treatment Evaluation – Weakest Point



- Design Intent based on testing at the Weakest Point

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Example of Post treatment evaluation – Average of Treated Grid

- Structure : 2-storeyed operations building of a chemical plant
- Loading : 70 kPa
- Foundation : Raft 60 m x 57 m
- Allowable total settlement under raft = 50 mm
- Vibro Compaction is done with 30T centrifugal force vibrator at 3m triangular grid
- Design Intent based on average q_c results

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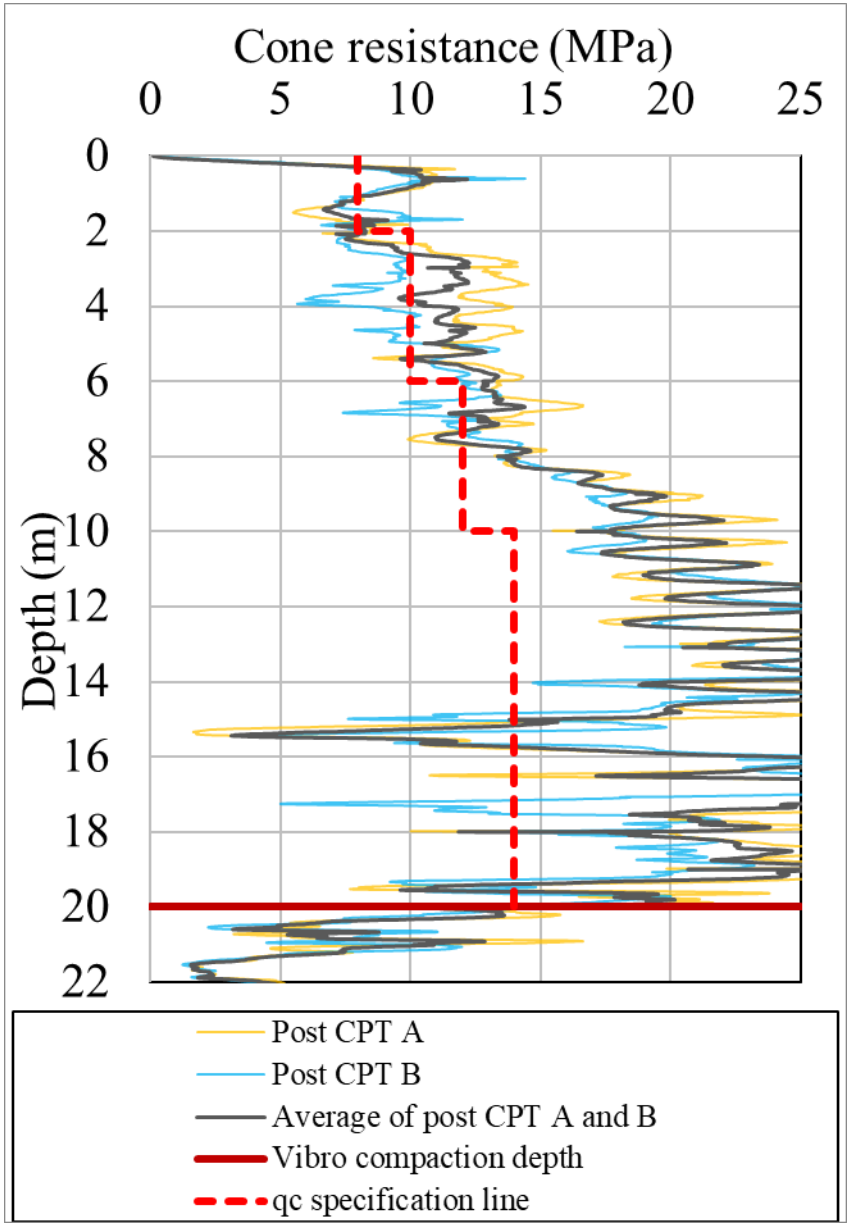
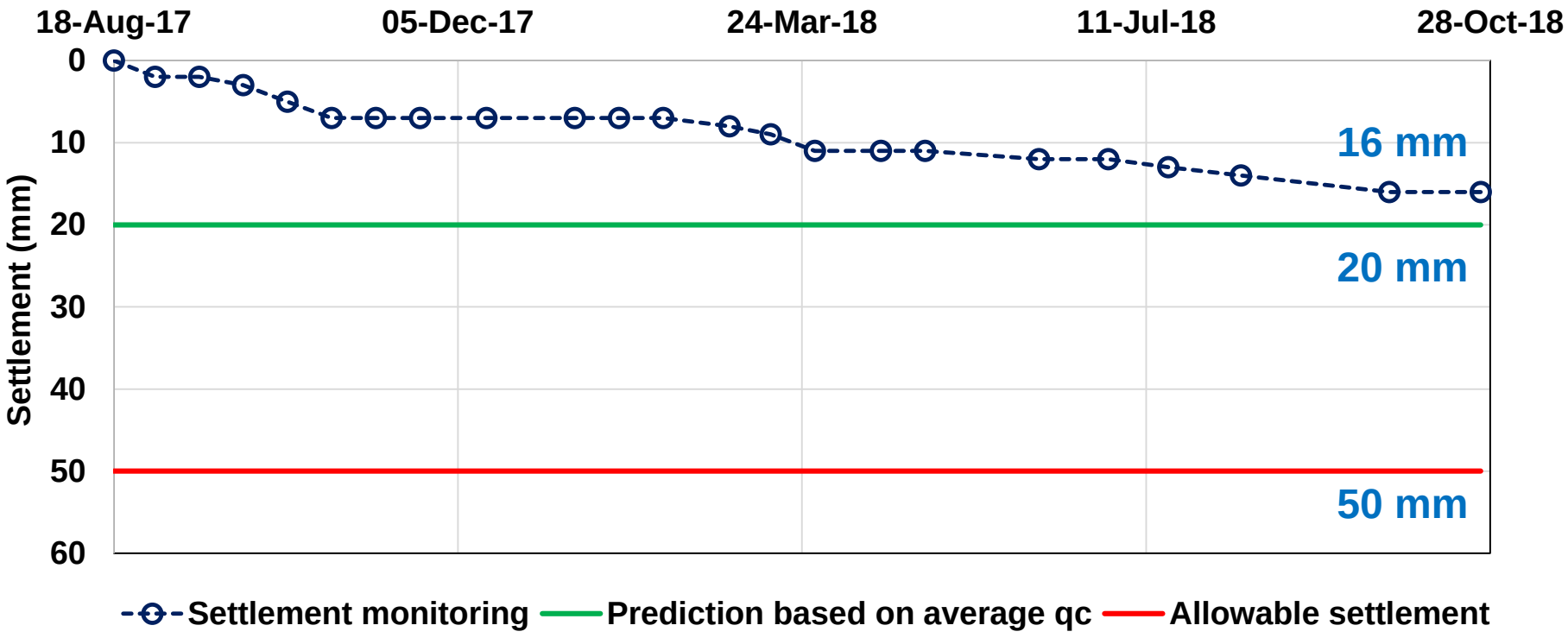
Average of Post CPTs

- Testing using numerical average of Post-CPTs at weakest and a slightly stronger location.
- Settlement predicted based on average of Post-CPTs ~ 20mm < 50mm O.K.



Long term settlement monitoring



Measured Settlement close to Predicted Settlement
….. Fulfilling the Design Intent

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Case project

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Tuas Mega Port, SG

- City port terminals (Tanjong Pagar, Keppel & Brani) shifting to this Mega Port
- When completed in 2040, will handle up to 65mio standard sized containers (current capacity is 40mio)

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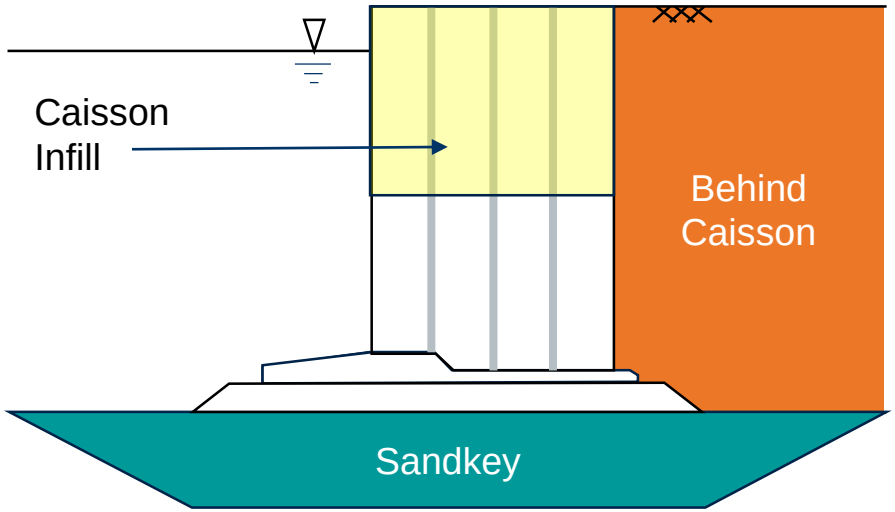
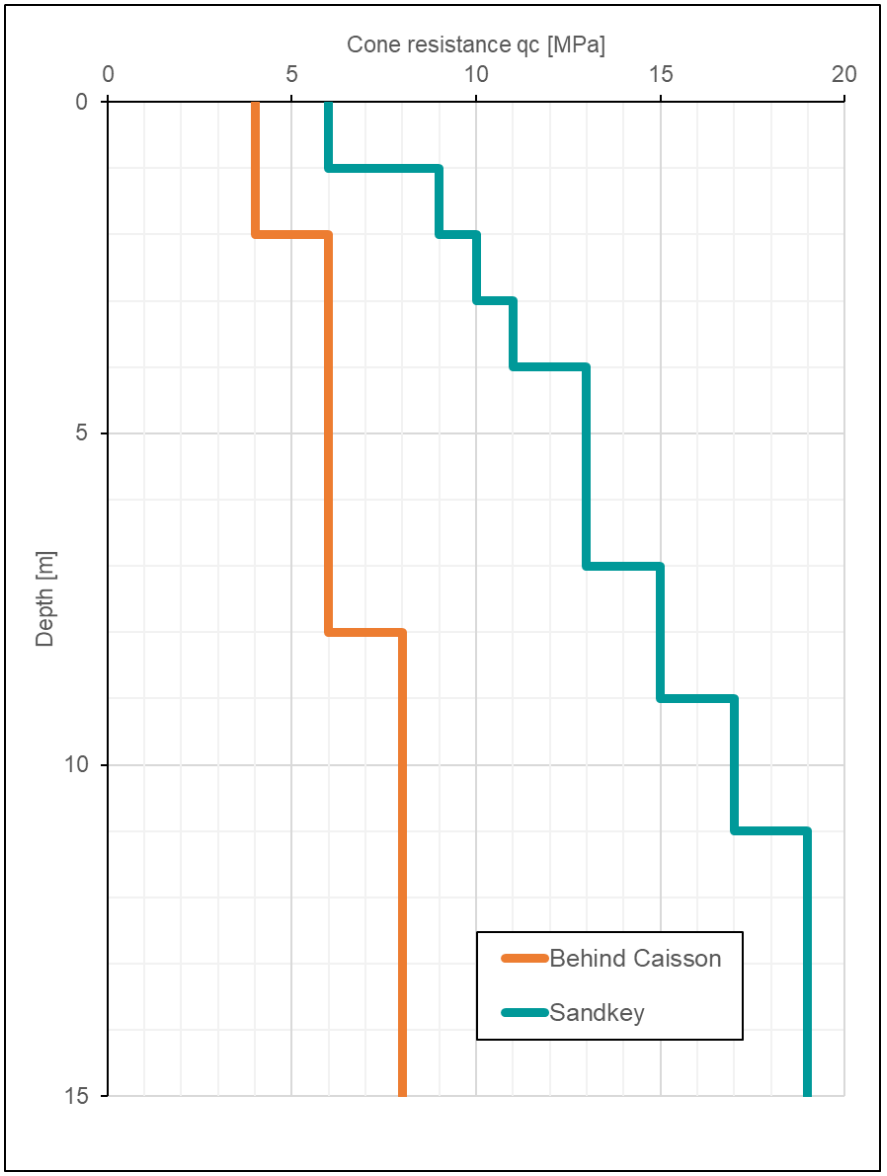
Multi use of Vibro Compaction





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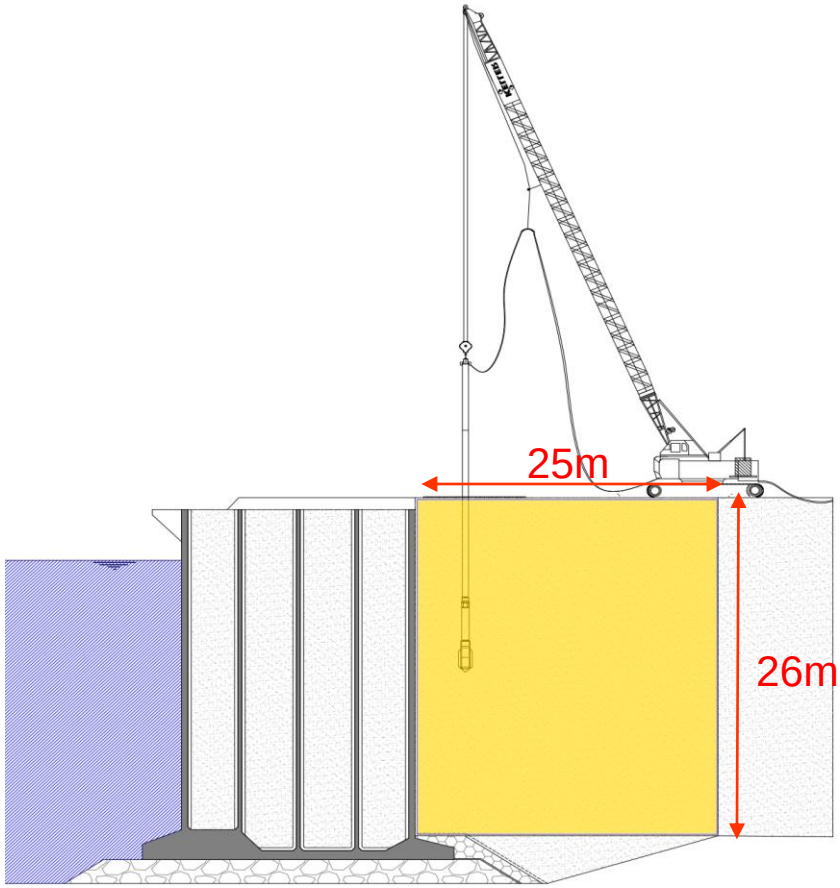
VC for Port

Deepest Marine Vibro Compaction down to 56m below sea level

Land VC for Behind Caisson



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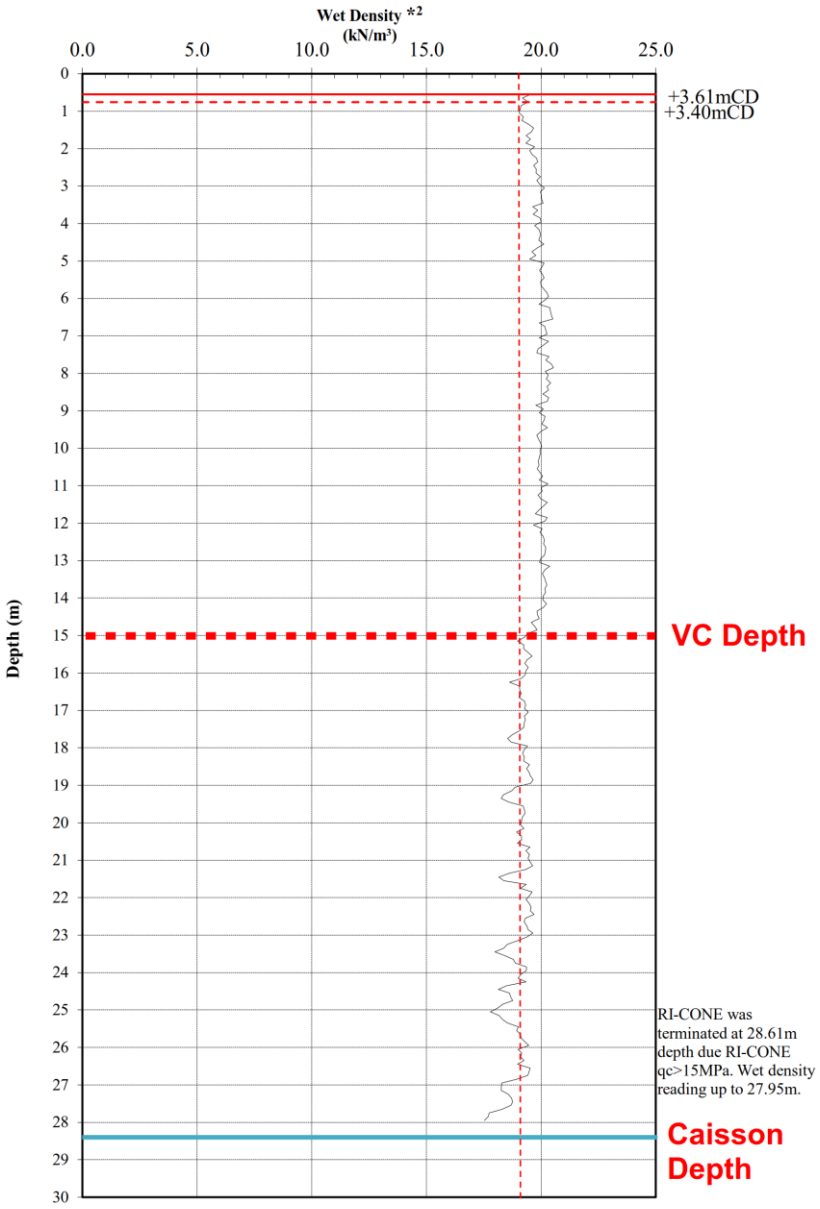
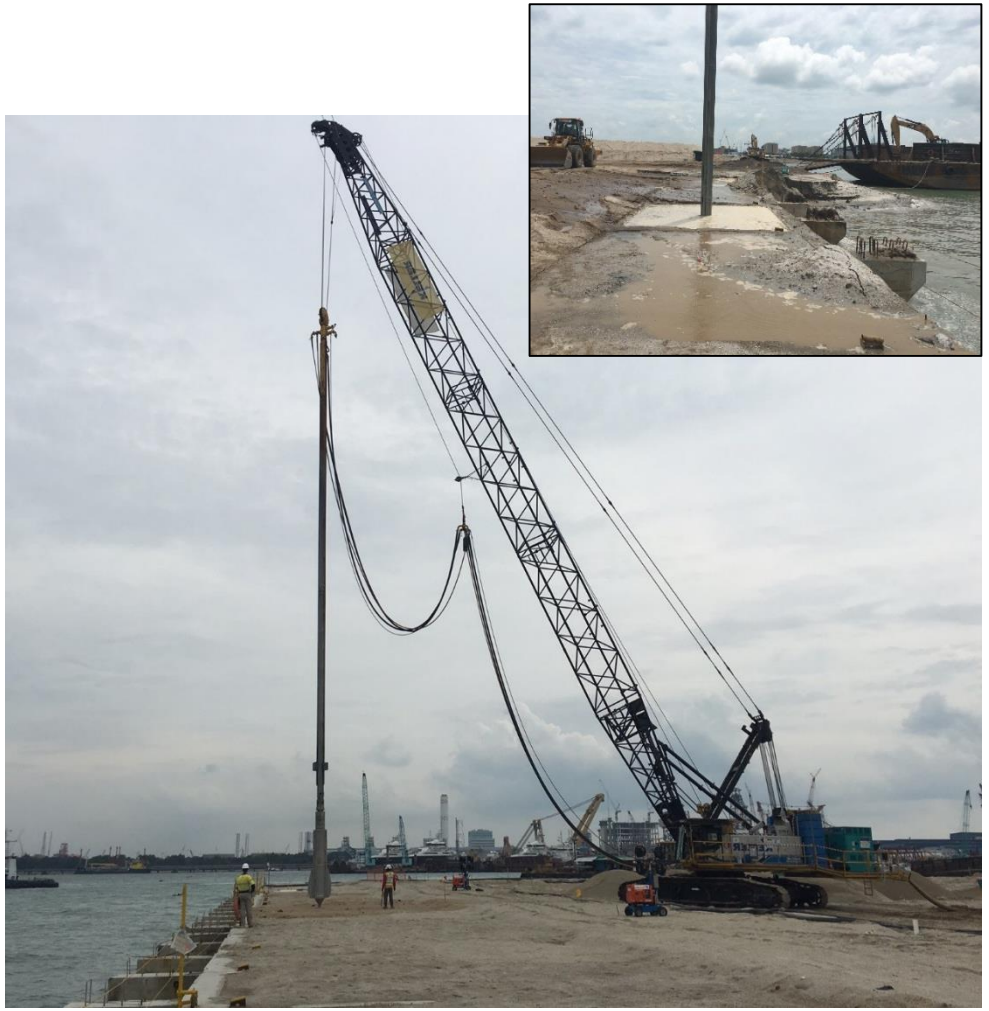
VC for Port

Land VC for Caisson In-fill





Conclusions

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Conclusions

- Vibro Compaction is used extensively in Asia predominantly for reclamation and developments on the reclaimed land (e.g. South East Asia & Middle East).
- Vibro Compaction is used for various engineering functions; slope stability, bearing capacity, settlement, liquefaction mitigation or dynamic resistance.
- Any specification and it's interpretation cannot be done in isolation from the design intent. The designer must have the final say in specifying testing locations, detail evaluation procedure and acceptance criteria.

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Thank You **Gracias**