Indonesia

Characteristics of Patimban soft marine clay and soil improvement techniques at Patimban Port Project

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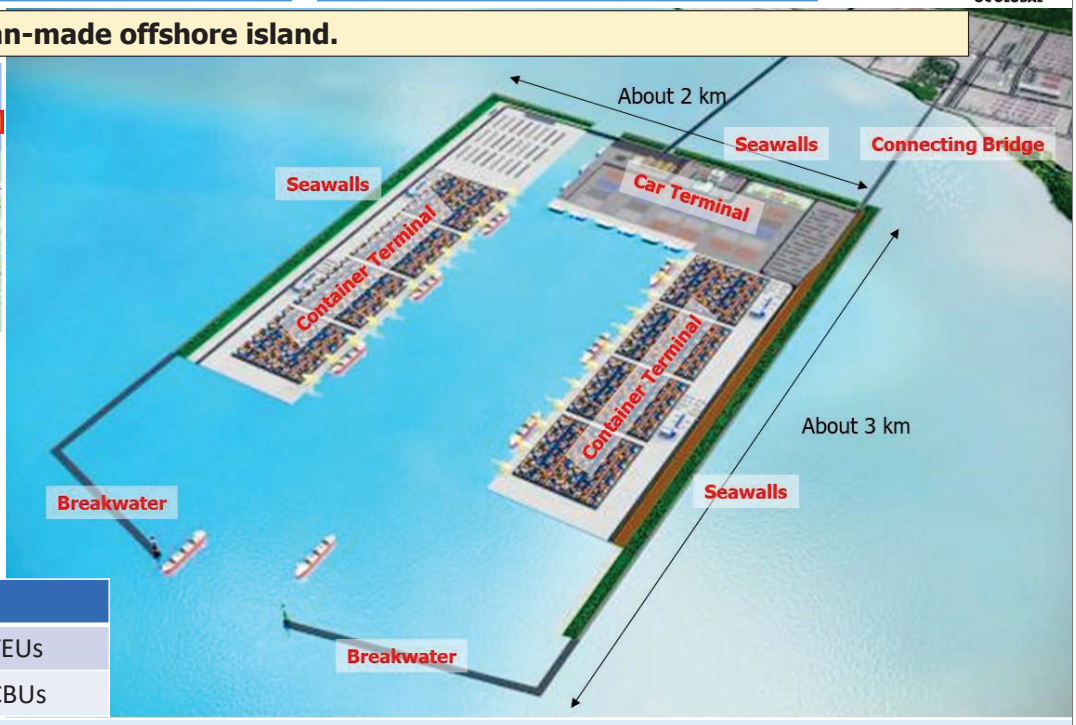
Soft soil treatments at Patimban Port project

CONTENT

1. **Introduction**
2. **Patimban Clay**
3. **CDM-CPM method**
4. **Bamboo pile foundation**

The project will construct man-made offshore island.



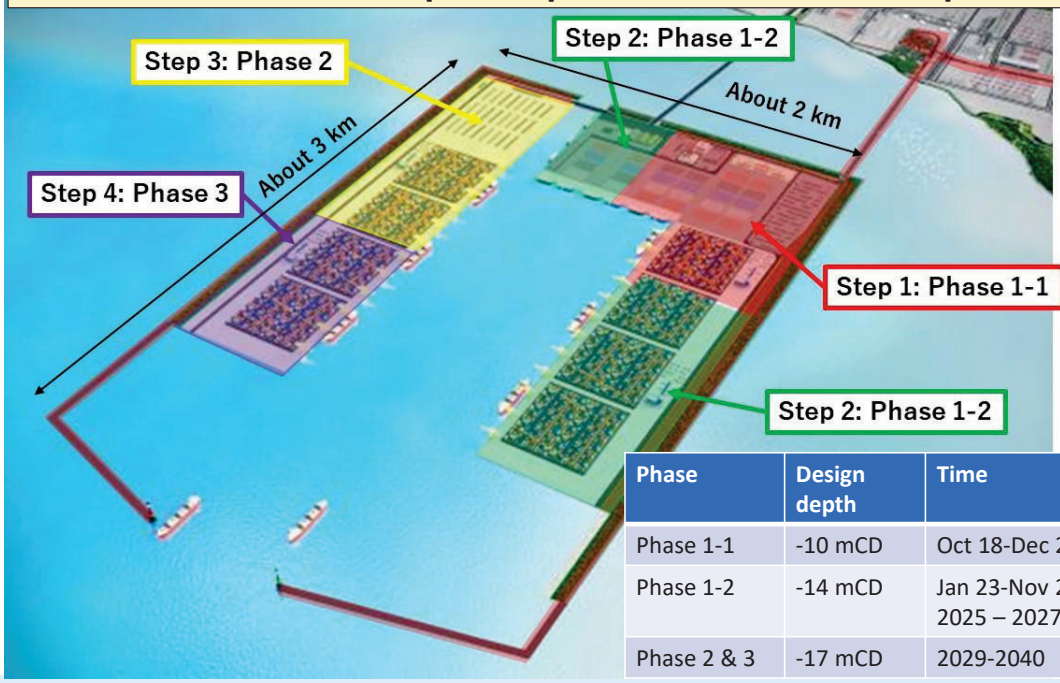
☐ Development Plan

Construction Scale	Plan
Terminal Area	320 ha
Berth Length	4,000 m

☐ Handling plan

Terminal	Plan
Container Terminal	7.5 million TEUs
Car Terminal	0.6 million CBUs

Patimban Port will be developed in 3 phases scheduled to be completed in 2040.



Phase	Design depth	Time	Funding
Phase 1-1	-10 mCD	Oct 18-Dec 21 (completed)	Japanese ODA
Phase 1-2	-14 mCD	Jan 23-Nov 25 (PKG5 & PKG6) 2025 – 2027 (PKG7a & PKG7b)	Japanese ODA
Phase 2 & 3	-17 mCD	2029-2040	N/A

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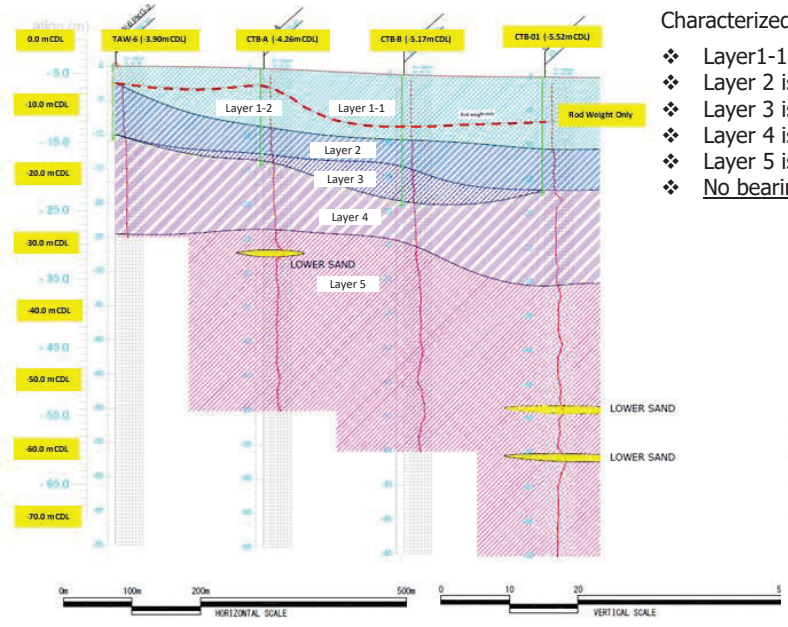
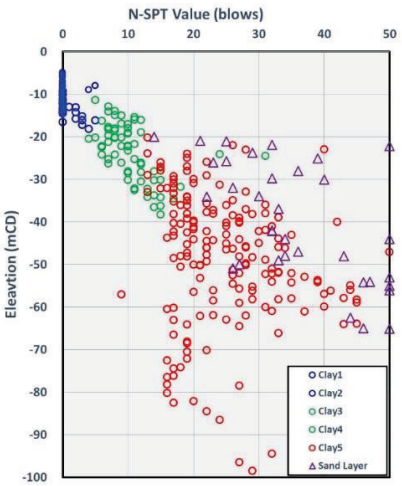
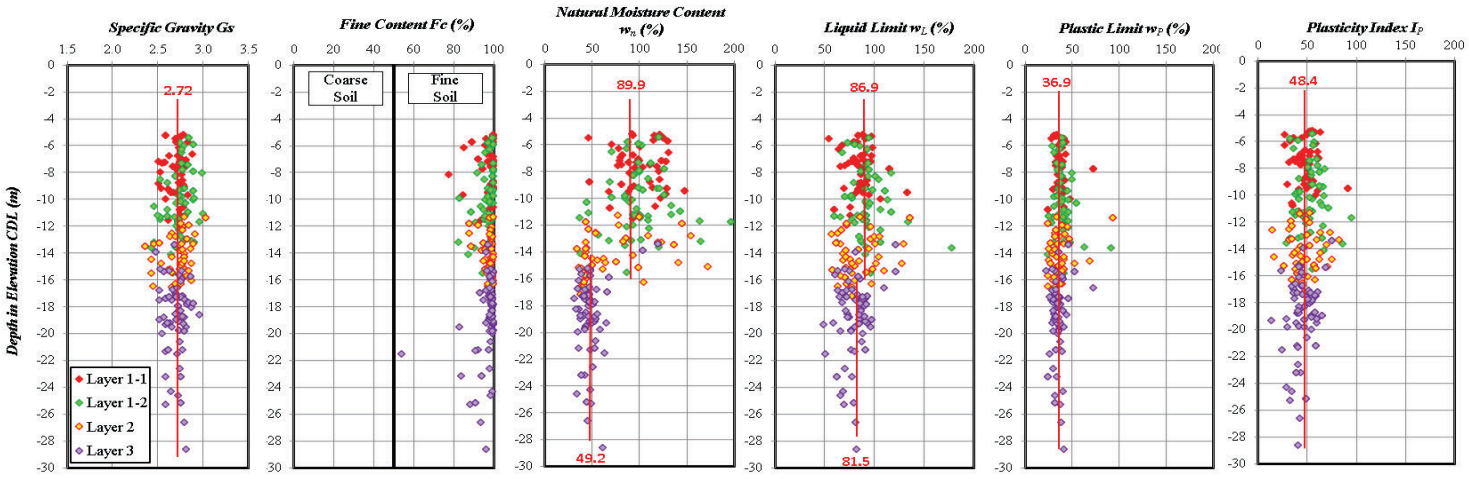
02 PATIMBAN CLAY > Soil Strata



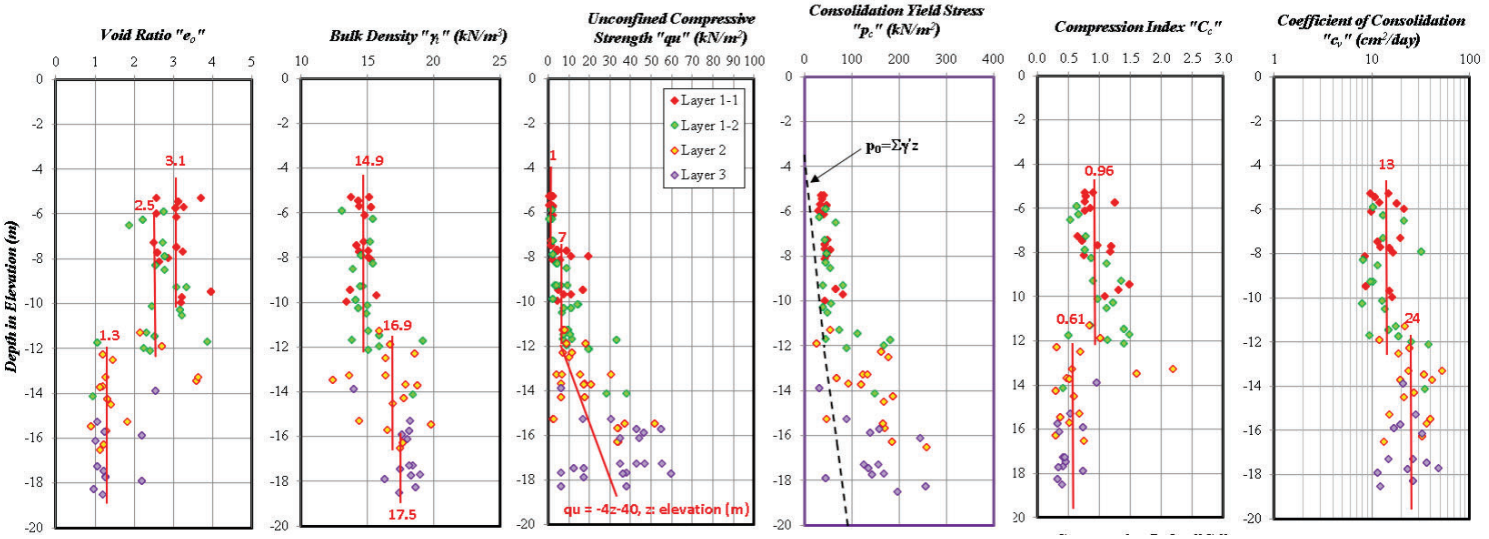
Characterized by young volcanic clay

- Layer1-1 and Layer1-2 are problematic **very soft clay layer**. (SPT N=0)
- Layer 2 is soft clay layer (SPT N=1 to 4) that contains organic matter.
- Layer 3 is firm clay layer (SPT N=4 to 8).
- Layer 4 is medium stiff clay (SPT N=9 to 15)
- Layer 5 is stiff to hard clay (SPT N=16-30)
- No bearing layer is found even at 100m depth



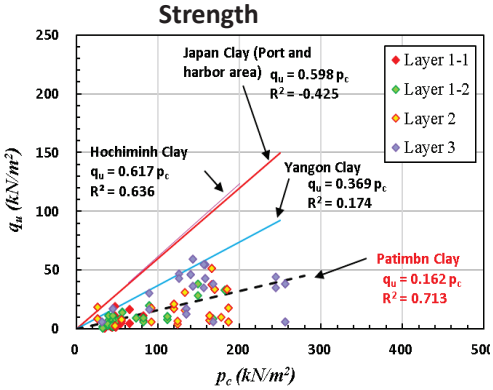


- Very fine material (>90%)
- Layers 1 & Layer 2 appears to be unstable ($W_n > W_L$)

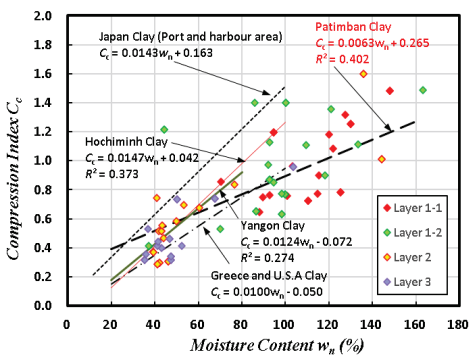


- High compressibility, very low shear strength (<10kPa) with low permeability (Cv = 10-25 cm^2/day)

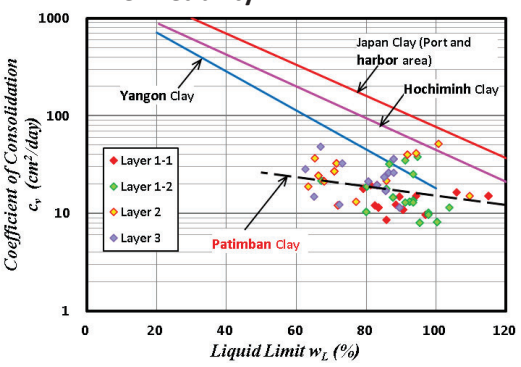
Strength



Consolidation



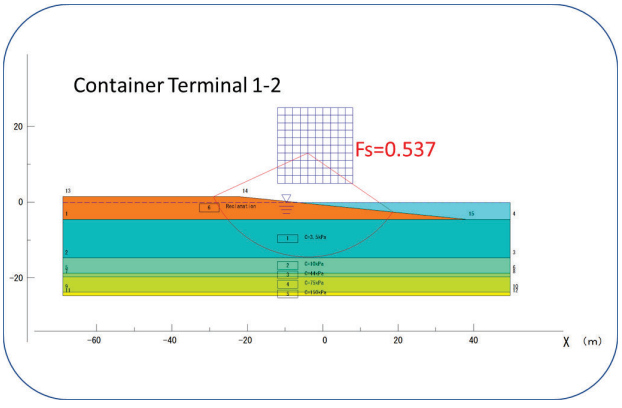
Permeability

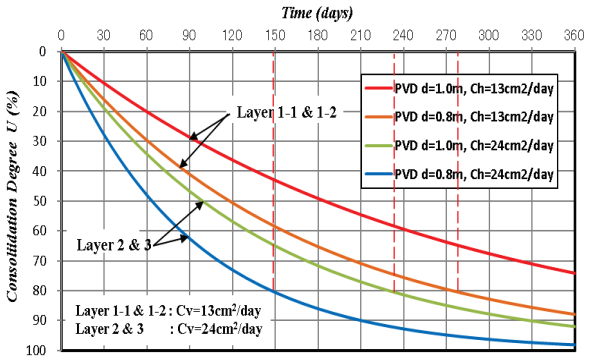


Ref: The characteristics of soft clay for ground improvement distributed at Patimban port development area in Indonesia (Yamada et.al.,2023)

Compare with marine clays in other countries:

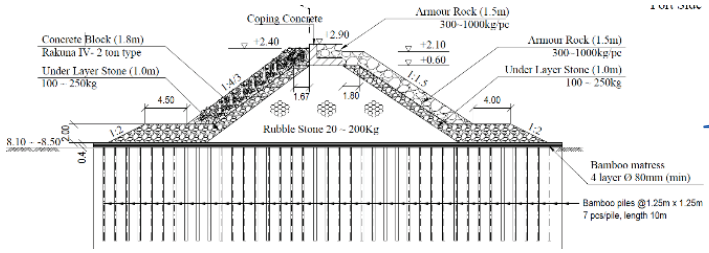
- More sensitive and lower strength
- Compression index at w_n>80% located lower than other clays, indicates younger clay
- Lower permeability



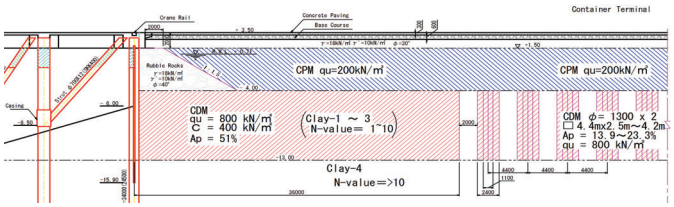


- It is impossible to reclaim the land in Patimban without soft soil improvement.
- Very weak characteristics poses tremendous difficulties for any offshore reclamation project since geotechnical failure might start at a small surcharge height, (i.e., 1.5m-2m)
- Very low permeability characteristics make the use of conventional dewatering method (i.e, PVD) for Patimban Clay become almost impossible because PVD needed to be installed at impractical small interval of 0.8-1.0m and it still needs a lot of time (240-270 days) to reach U80%.

- **Bamboo pile foundation at Breakwater (higher allowance for settlement)**



- **Cement Deep Mixing (CDM) combined with Cement Pipe Mixing (CPM) at terminal area (restricted settlement)**



Soft soil treatments at Patimban Port project

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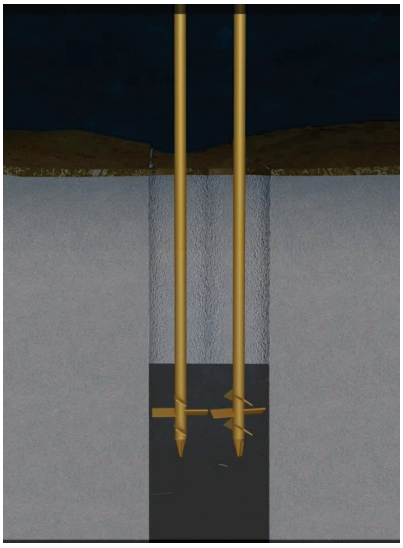
- Cement Deep Mixing (CDM) is a deep in-situ soil solidification technique using cement or lime.
- Cement slurry shall be injected directly into the natural ground via boring process

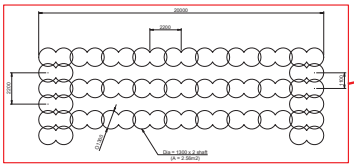


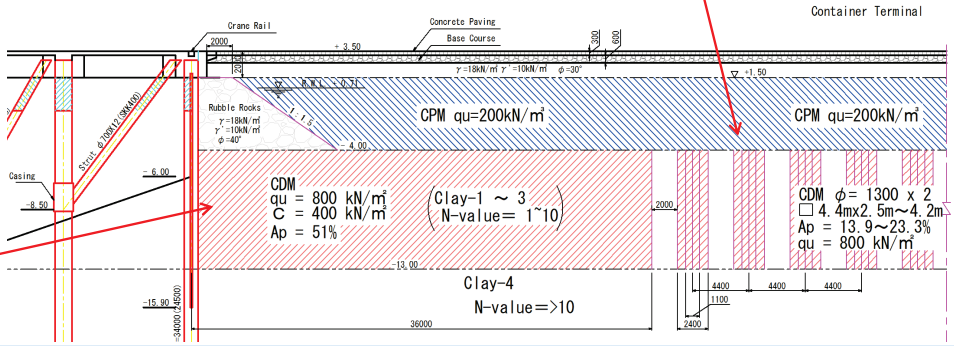
- Cement Pipe Mixing (CPM) is a recycled solution to use disposal dredged soil (light weight) for reclamation work and/or backfills behind bulkhead.
- Dredged soil, after fracturing shall be added with solidifier (cement) and the mixture will be well mixed by the pumping energy (turbulent flow) before placement.

- The **very first project worldwide** that combined two different soil solidification techniques in practice:
  - **Low/Normal Improvement ratio CDM** for the stabilization of the soft ground
  - **Cement Pipe Mixing (CPM)** for the solidification and reuse of dredged material for reclamation
- Treated soil by CPM method is **directly put** on top of CDM columns.

❖ **Low Improvement ratio Pile type CDM** is applied at Terminal area

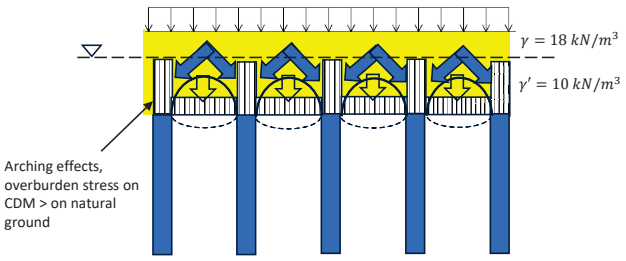
❖ **Wall type CDM** is applied at behind berth area to reduce earth pressure on the retaining structure





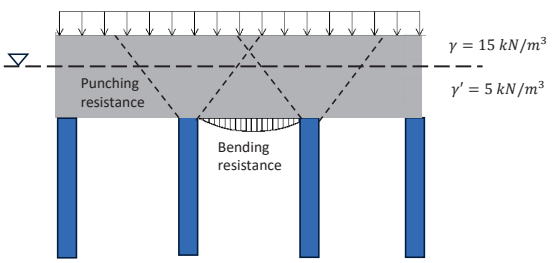
- ❑ The CPM treated soil's unit weight is about 20% (above water) – 30% (below water) lighter than sand. Thus, it will significantly reduce the over burden pressure on CDM column
- ❑ CPM is strong (qu= 200kPA) thus when combined with CDM it works as a "rigid" structure → partially bearing the load via punching and bending resistance → Settlement can be reduced significantly
- ❑ No need to wait for consolidation settlement, thus rapid construction can be expected
- ❑ Cost of CPM is cheaper than sand
- ❑ Very environmentally friendly as it reduces reliance on sand and furthermore slag cements can be used

Sand on CDM column (ALiCC)



ALiCC – Arch action Low improvement Ratio Cement Column

CPM on CDM

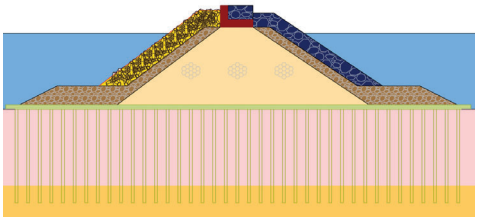


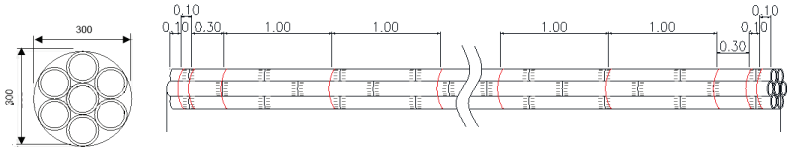
- 64 ha is successfully reclaimed within a year
- After 2 years, the average settlement is measured at 1-3cm

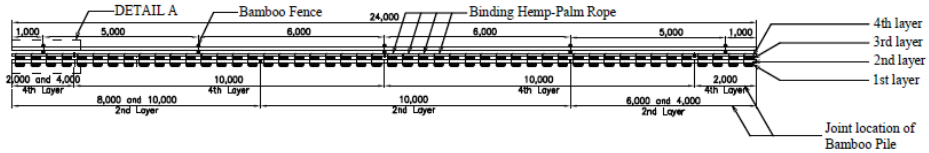
Soft soil treatments at Patimban Port project

CONTENT

- Indonesian traditional method for soft soil treatment in coastal region
- Bamboo pile often refer to a single pile or cluster of 3-7 single piles
- Bamboo mattress is made from 3 – 5 layer of bamboo piles



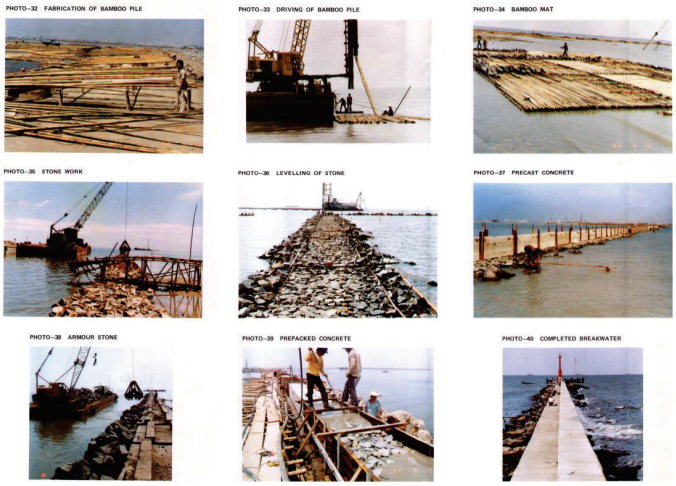




- Local practice and long-time experience
- Rich availability
- Proven durability if submerged
- Economically
- Environmentally friendly

Bamboo extracted from Breakwater Dam Citra constructed in 1961 (Courtesy Toyo Construction)

Jakarta Fishing Port's breakwater (1980~1982)



04 **Bamboo Pile foundation** | Challenges at Patimban water

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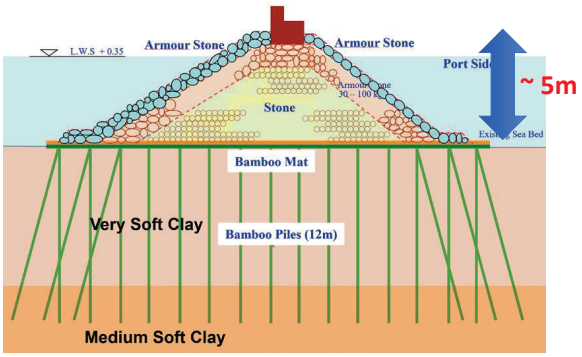
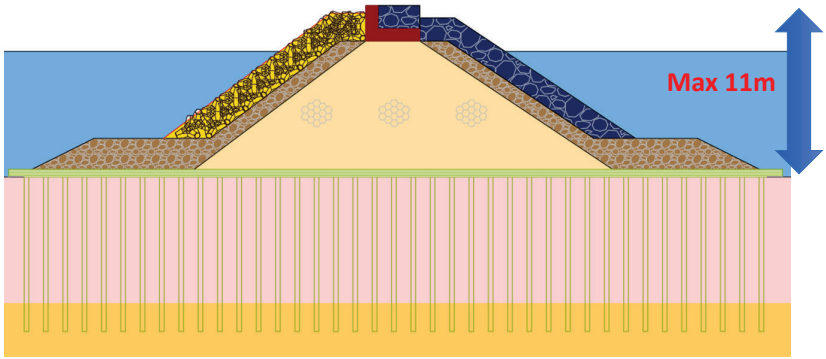
JKT Fishing port and elsewhere in Indonesia



- ❑ No industrial guidelines available
- ❑ Some failed attempts to raise body height more than 7m

Patimban's breakwater



- ❑ Double the normal height
- ❑ Double the breakwater's footprint

04 **Bamboo Pile foundation** | Lesson 1 – sophisticated design approach

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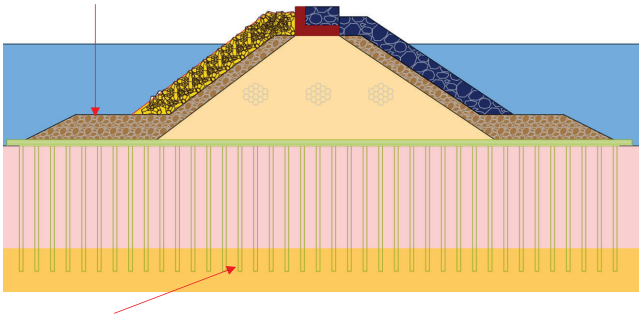
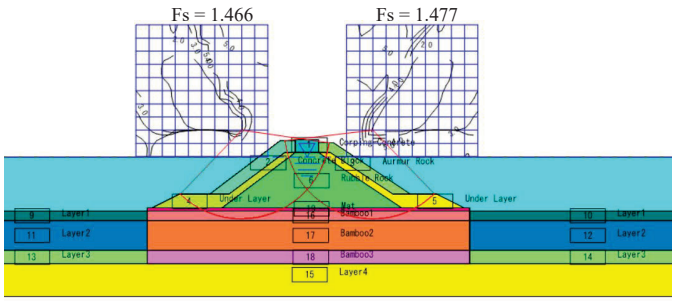
CONCEPT

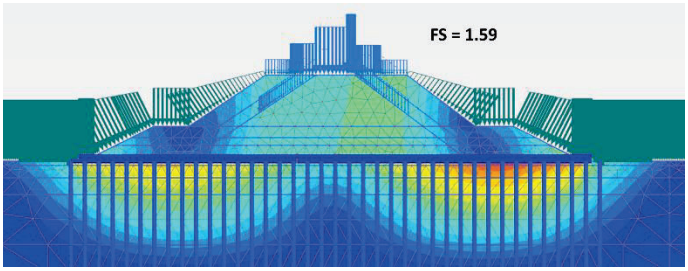
- ❑ Wider and thicker toe (to enhance counter-weight stability)



- ❑ Bamboo must be embedded into medium stratum (NSPT>4) (i.e, avoid floating on veryy soft clay)

CAREFUL MODELLING WORKS



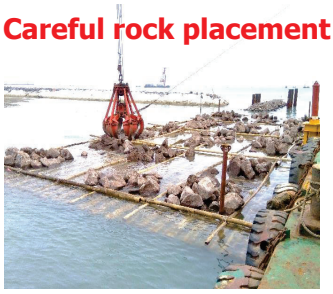


Pile (7pcs) fabrication

Bending and shear test was conducted once every 100,000 pcs

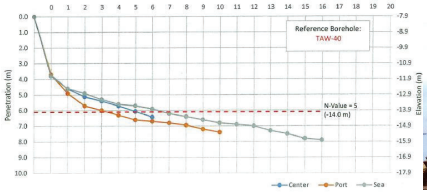
Mattress fabrication

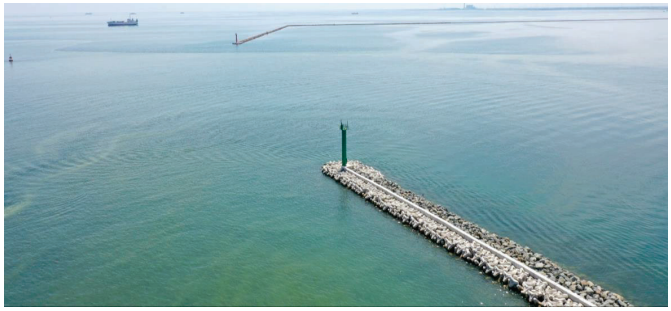
Careful rock placement



Careful furnishment

Pile driving controlled by RTK GPS, blow count, penetration rates





- Patimban & Java Clay is quite unique as it is young, very soft with low permeability
- We succeeded to solve this difficult ground by applying the most advanced JP port technology (CDM-CPM) and a local bio-geotechnical solution (bamboo piles) but at higher scale thanks to the Japanese Quality control mark
- The project is successful to significantly reduce the reliance on sand for reclamation work (80% reduction), reuse 40% of softest dredged material (N=0-3) and only medium and hard material (N>4) is disposed to environment. (GREEN solution)
- All CDM & CPM work used slag cement (55%) instead of conventional Portland cement
- However, further studies are still in need to standardize these methods for a subsequent projects.

Thank you !!!

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