AGSSEA

BAMBOO PILE-MATTRESS SYSTEM AS AN ALTERNATIVE OF SOFT GROUND IMPROVEMENT FOR COASTAL EMBANKMENT IN INDONESIA

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On behalf of:

The Indonesian Society for Geotechnical Engineering (HATTI)

Acknowledgement:

The Organizing Committee

AGSSEA

Part of this material has ben presented in:

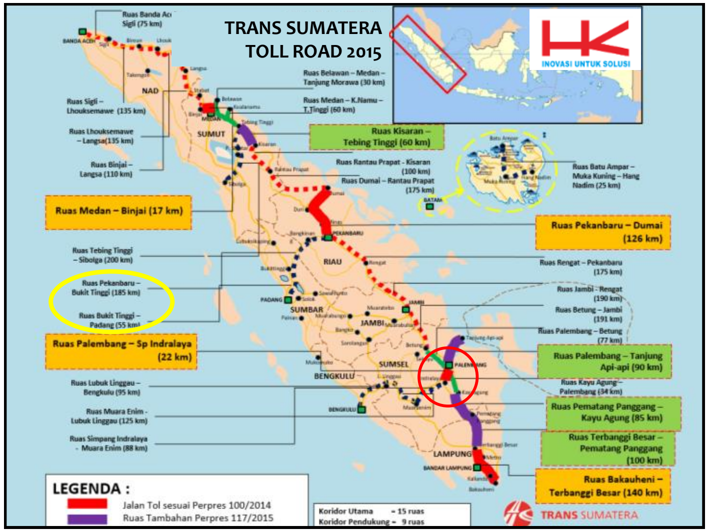
TU Graz
Graz University of Technology
PLAXIS
ITENAS

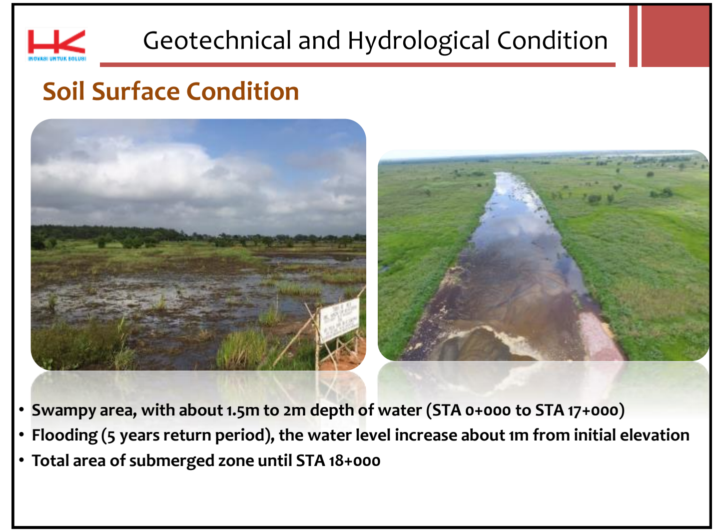
Indonesian Plaxis User Meeting
The Application of Plaxis in Solving Various Geotechnical Problems in Indonesia
Tempat: Jakarta Design Center, Jl. Jendral Gatot Subroto kav. 53., Petamburan, Jakarta Pusat 10260

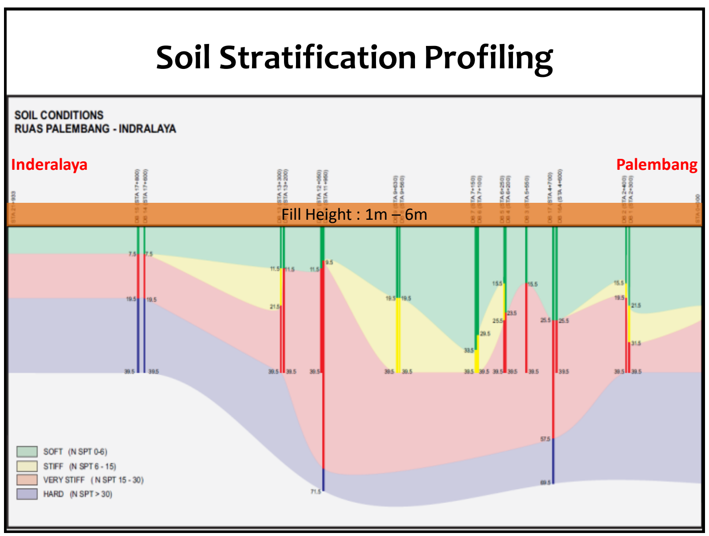
Main Organizer:
Co-organizer: TAIWAN TECH, University of Southern Queensland
Supporting Institution: Indonesian Society for Geotechnical Engineering
INTERNATIONAL CONFERENCE ON GEOTECHNICS
Yogyakarta, Indonesia
July 24 – 26, 2018

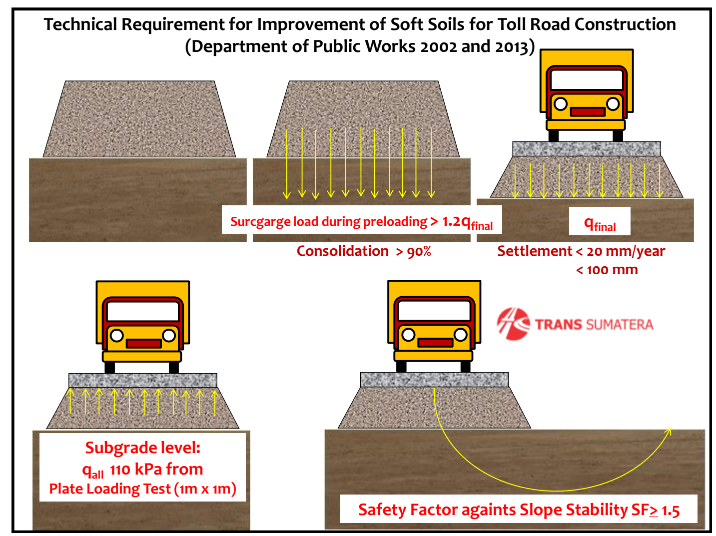
AGSSEA

Content:

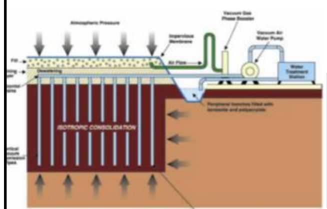

TRANS SUMATERA
TOLL ROAD 2015
INOVASI UNTUK SOLUSI
Ruas Medan – Binjai (17 km)
Ruas Kisaran – Tebing Tinggi (60 km)
Ruas Pekanbaru – Dumai (126 km)
Ruas Palembang – Sp Indralaya (22 km)
Ruas Palembang – Tanjung Api-api (90 km)
Ruas Pematang Panggang – Kayu Agung (85 km)
Ruas Terbanggi Besar – Pematang Panggang (100 km)
Ruas Bakauheni – Terbanggi Besar (140 km)
LEGENDA :
Jalan Tol sesuai Perpres 100/2014
Ruas Tambahan Perpres 117/2015
TRANS SUMATERA


Geotechnical and Hydrological Condition
Soil Surface Condition
• Swampy area, with about 1.5m to 2m depth of water (STA 0+000 to STA 17+000)
• Flooding (5 years return period), the water level increase about 1m from initial elevation
• Total area of submerged zone until STA 18+000

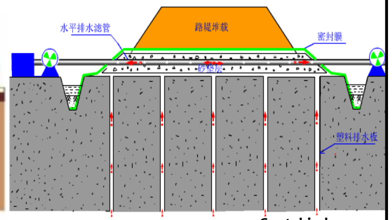

Soil Stratification Profiling
SOIL CONDITIONS
RUAS PALEMBANG - INDRALAYA
Inderalaya
Palembang
Fill Height : 1m – 6m
SOFT (N SPT 0-6)
STIFF (N SPT 6 - 15)
VERY STIFF (N SPT 15 - 30)
HARD (N SPT > 30)


Technical Requirement for Improvement of Soft Soils for Toll Road Construction
(Department of Public Works 2002 and 2013)
Surcgarge load during preloading > 1.2q final
q final
Consolidation > 90%
Settlement < 20 mm/year
< 100 mm
Subgrade level:
q all 110 kPa from
Plate Loading Test (1m x 1m)
Safety Factor againts Slope Stability SF≥ 1.5
TRANS SUMATERA

SELECTED SOLUTION



Masse et al, 2001



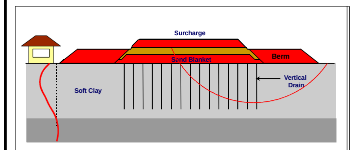
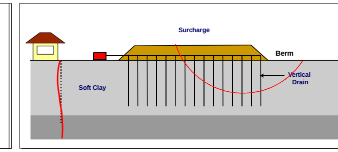
Geotekindo, 2015

VACUUM PRELOADING

- Negative pressure from vacuum will generates negative pore water pressure, increase effective stress in the soils, and results in accelerating consolidation process
- Much smaller amount of fill material that is needed
- There is no slope instability problem because the soil is in isotropic consolidation condition
- Shorter time for construction

Chu Jian, Guo Wei, Yan Shuwang, 2015

Comparison: Soil Preloading and Vacuum Preloading

Soil Preloading	Vacuum Preloading
	
Wide ROW	Narrow ROW
High soil surcharge	Lower or no soil surcharge
Need thick horizontal drain	Relatively thin horizontal drain
Lower Stability	Better Control of Stability
Greater Lateral Movement	Lesser Lateral Movement
Longer Construction Time	Shorter Construction Time

GEOTEKINDO

CONSTRUCTION OF VACUUM PRELOADING

1. Geotextile

2. Sand Filling

3. PVD Installation

4. PHD Installation

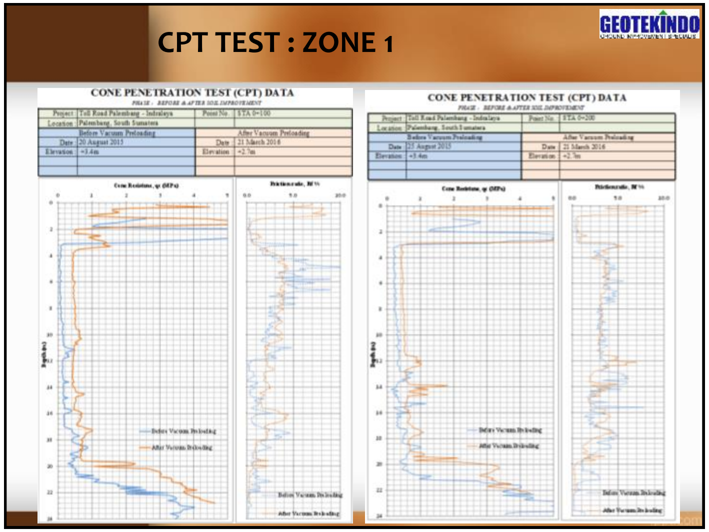
CONSTRUCTION OF VACUUM PRELOADING

5. Geo Membrane Installation

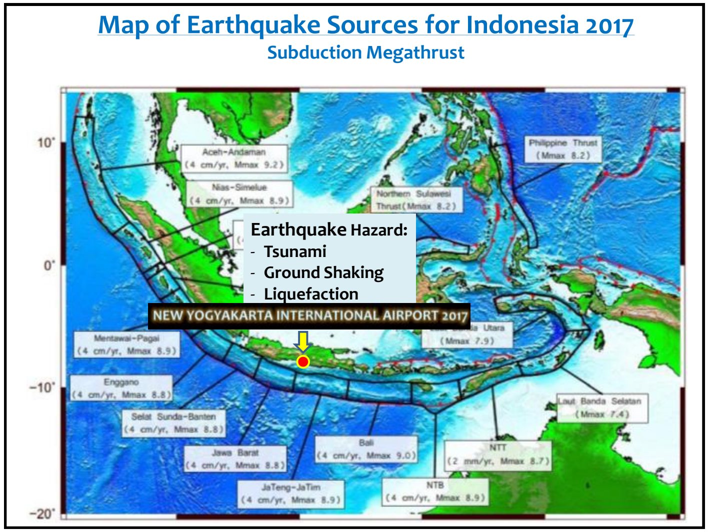
6. Instrumentation

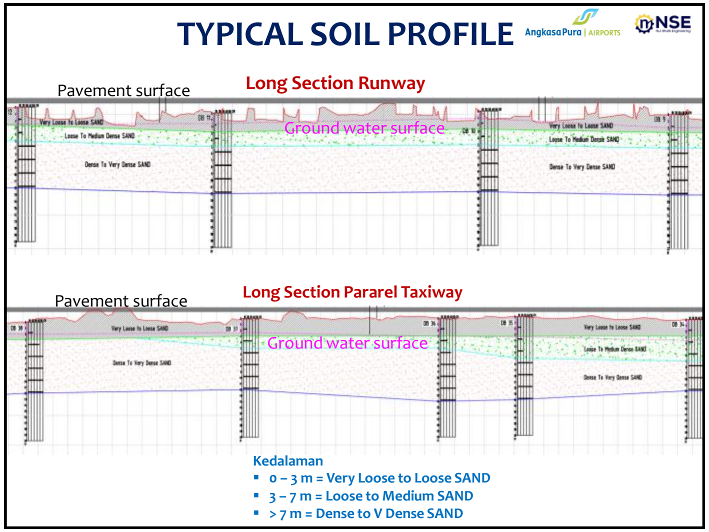
7. Vacuum Process

8. Backfilling during vacuum

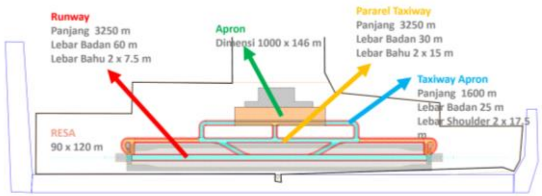

CPT TEST : ZONE 1
GEOTEKINDO
CONE PENETRATION TEST (CPT) DATA
CONE PENETRATION TEST (CPT) DATA


NEW YOGYAKARTA INTERNATIONAL AIRPORT 2017
Angkasa Pura | AIRPORTS
PP


Map of Earthquake Sources for Indonesia 2017
Subduction Megathrust
Earthquake Hazard:
- Tsunami
- Ground Shaking
- Liquefaction
NEW YOGYAKARTA INTERNATIONAL AIRPORT 2017
Aceh-Andaman (4 cm/yr, Mmax 9.2)
Nias-Simelue (4 cm/yr, Mmax 8.9)
Mentawai-Pagai (4 cm/yr, Mmax 8.9)
Enggano (4 cm/yr, Mmax 8.8)
Selat Sunda-Banten (4 cm/yr, Mmax 8.8)
Jawa Barat (4 cm/yr, Mmax 8.8)
JaTeng-JaTim (4 cm/yr, Mmax 8.9)
Bali (4 cm/yr, Mmax 9.0)
NTB (4 cm/yr, Mmax 8.9)
NTT (2 mm/yr, Mmax 8.7)
Laut Banda Selatan (Mmax 7.4)
Philippine Thrust (Mmax 8.2)
Northern Sulawesi Thrust (Mmax 8.2)
(Mmax 7.9)
10°
0°
-10°
-20°


TYPICAL SOIL PROFILE
Angkasa Pura | AIRPORTS
NSE
Pavement surface
Long Section Runway
Ground water surface
Pavement surface
Long Section Pararel Taxiway
Ground water surface
Kedalaman
▪ 0 – 3 m = Very Loose to Loose SAND
▪ 3 – 7 m = Loose to Medium SAND
▪ > 7 m = Dense to V Dense SAND

PAVEMENT FOR AIR SIDE AREA



Design Criteria:

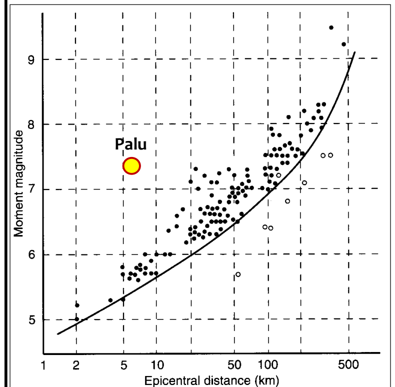
- Safety Factor for Liquefaction ≥1.30 based on NCEER method with PGA 0.4g.
- Settlement < 10cm in future 10 years
- Post Improvement requirements:

Depth (m)	N-SPT	q_c (Mpa)	Dr (%)
2	16	7	>70
4	22	9	>70
6	26	13	>70
8	30	15	>70

Dynamic Compaction for Counter Measure of Liquefaction

Liquefaction Susceptibility

Historical Criteria



Relationship between limiting epicentral distance of sites at which liquefaction has been observed and moment magnitude for shallow earthquakes (Ambrassey, 1988)

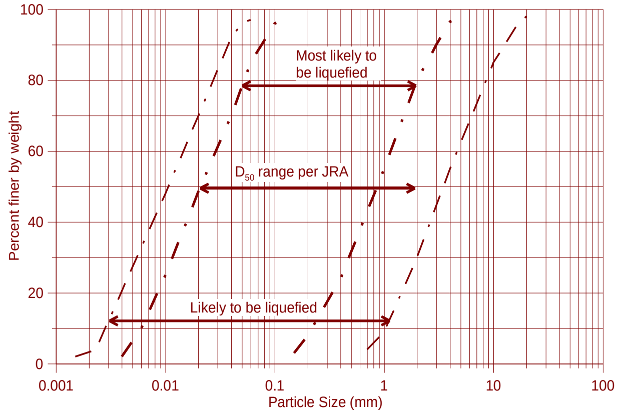
Necessary Conditions:

1. Potentially liquefiable soil (soil type, condition)
2. Saturation
3. Undrained loading:
   - -Earthquake
   - -Blasting
   - -Pile driving
   - -Trains, etc

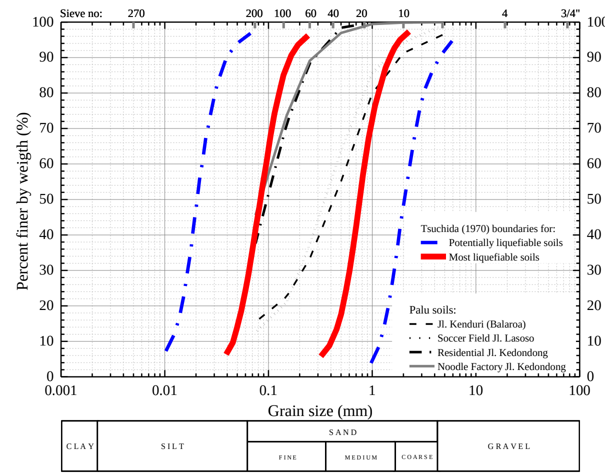
Liquefaction Susceptibility

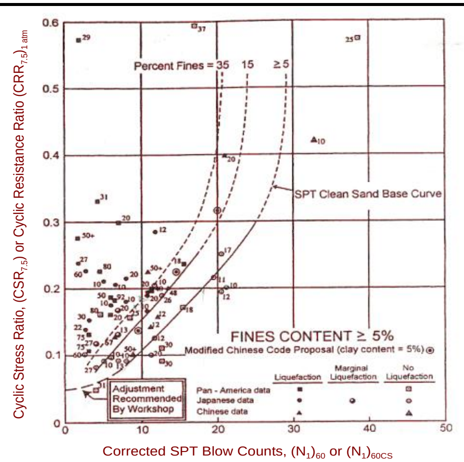
Compositional criteria

1. Sands (and Silty Sands and Clayey Sands), if fine content ≤ 15%
2. Silt:
   Low Plasticity (PI ≤ 15%)↑
   Higher Plasticity↓
3. Clays:
   - -Fraction finer than 0.005 mm ≤ 15%
   - -Liquid limit, LL ≤ 35%
   - -Natural water content ≥ 0.9 LL

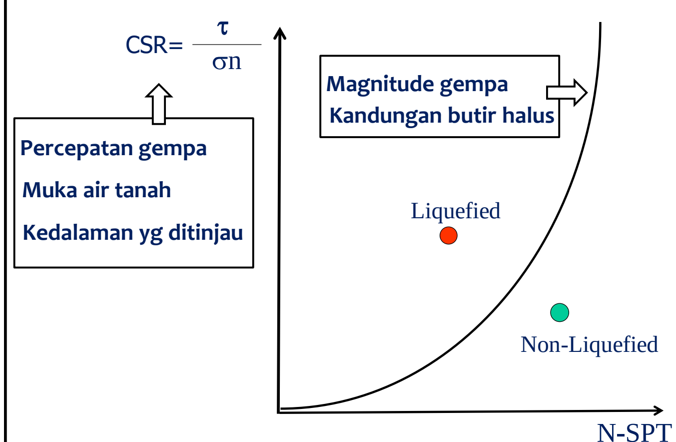


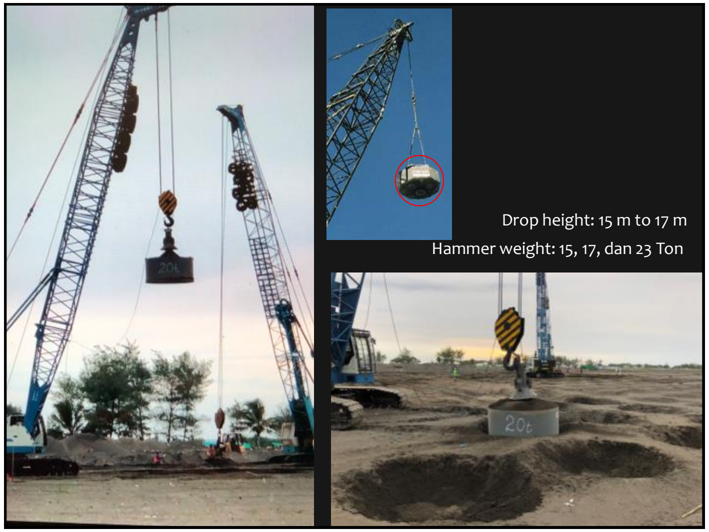
Gradation Range for Potentially Liquefiable Sand (Hatanaka et al., 1997)





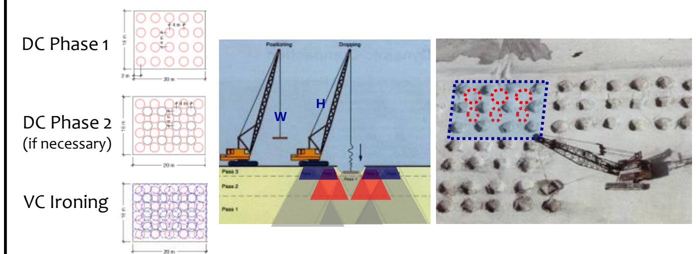
Correction Due to Fine Content
(Seed et al., 1985 and Youd et al., 2001)



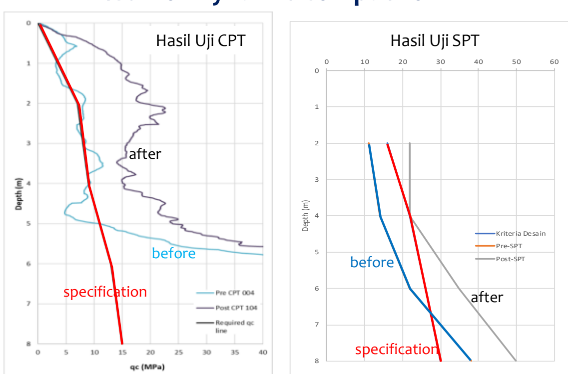


TRIAL TEST OF OF DYNAMIC COMPACTION

- Pelaksanaan dilakukan dengan menentukan konfigurasi jumlah pukulan yang harus dilakukan melalui tahapan percobaan.
- Dari proses tersebut, jumlah pukulan jika diperlukan dapat dibagi menjadi **beberapa tahap pemukulan** dan **fase *ironing*.**



Result of Dynamic Compaction

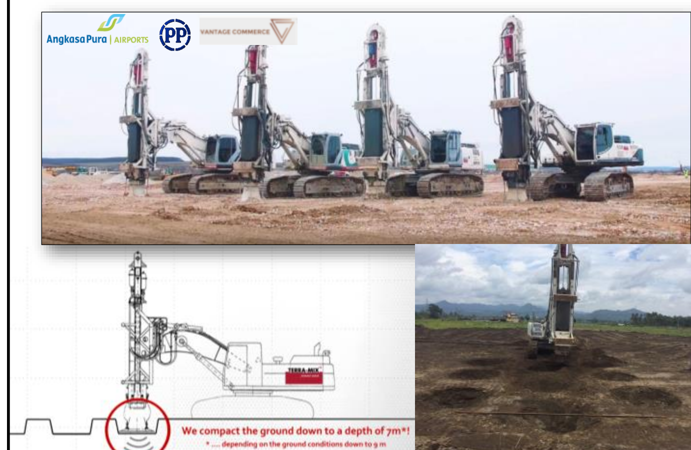


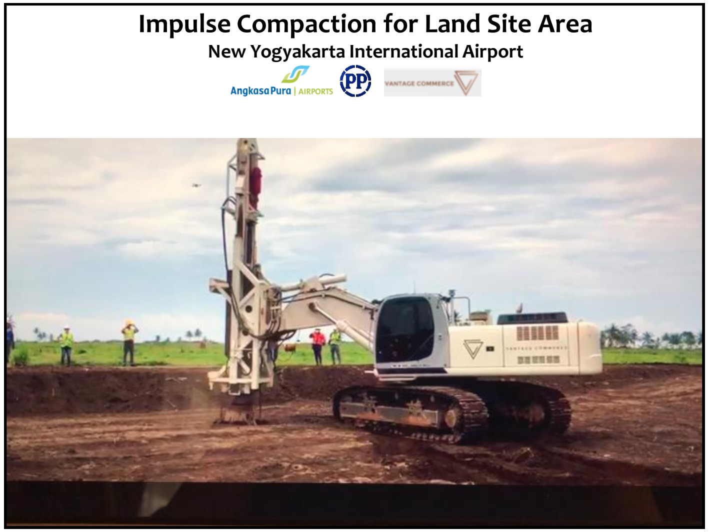
Proses Trial (Percobaan) menghasilkan konfigurasi pemukulan sebagai berikut:

1. Berat tamper: 17 Ton
2. Tinggi jatuh: 15 m
3. Jumlah pukulan: 6 pukulan

New Yogyakarta International Airport

Rapid Impulse Compaction for Land Site Area, 2018




Impulse Compaction for Land Site Area
New Yogyakarta International Airport
Angkasa Pura | AIRPORTS
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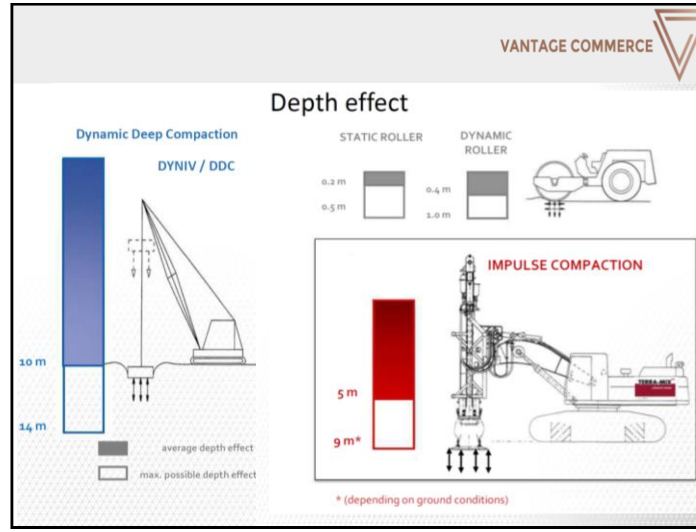
VANTAGE COMMERCE
Depth effect
Dynamic Deep Compaction
DYNIV / DDC
STATIC ROLLER
DYNAMIC ROLLER
0.2 m
0.5 m
0.4 m
1.0 m
10 m
14 m
average depth effect
max. possible depth effect
IMPULSE COMPACTION
5 m
9 m*
* (depending on ground conditions)


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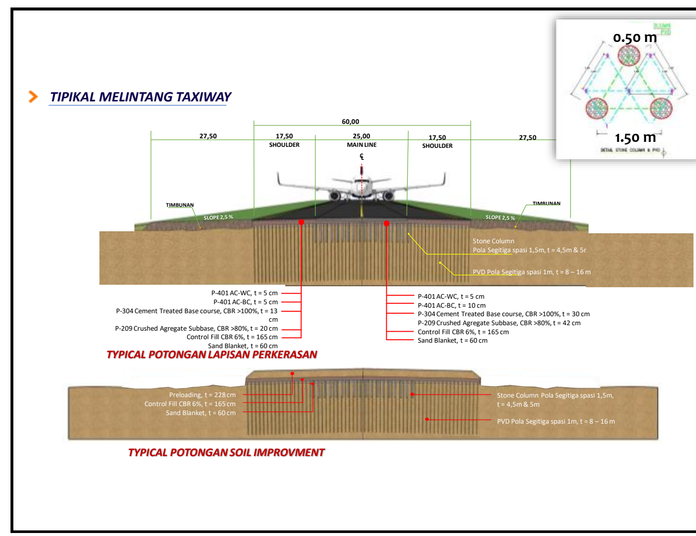
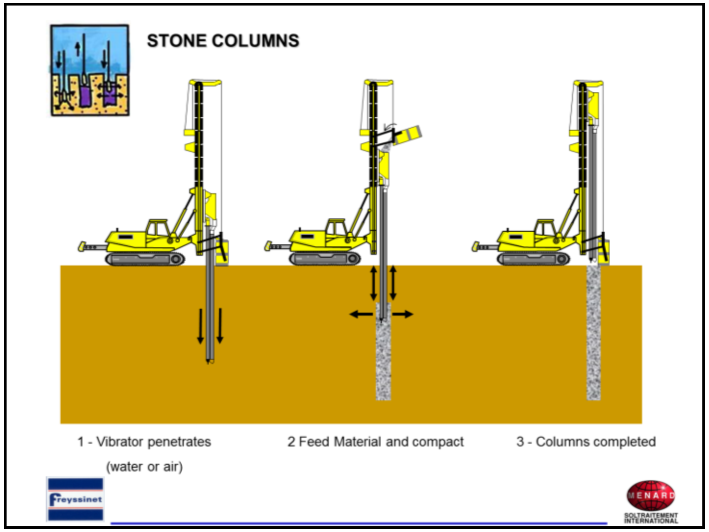
PP
GEOTEKINDO
CONSTRUCTION OF RUNWAY 3
SOEKARNO – HATTA INTERNATIONAL AIRPORT SECTION 1
JAKARTA 2018
Saluran-1
Saluran-2
Saluran-3
RUNWAY 3
TAXIWAY
RUNWAY 2
Kolam retensi
KETERANGAN
Jalan Perimeter
Jalan Inspeksi
Saluran
Gardu Catu daya listrik
Liquefaction → Stone Column
Consolidation → PVD


TIPIKAL MELINTANG TAXIWAY
0.50 m
1.50 m
60,00
27,50
17,50 SHOULDER
25,00 MAIN LINE
17,50 SHOULDER
27,50
TIMBUNAN
SLOPE 2,5 %
TIMBUNAN
SLOPE 2,5 %
Stone Column
Pola Segitiga spasi 1,5m, t = 4,5m & 5r
PVD Pola Segitiga spasi 1m, t = 8 – 16 m
P-401 AC-WC, t = 5 cm
P-401 AC-BC, t = 5 cm
P-304 Cement Treated Base course, CBR >100%, t = 13 cm
P-209 Crushed Agregate Subbase, CBR >80%, t = 20 cm
Control Fill CBR 6%, t = 165 cm
Sand Blanket, t = 60 cm
P-401 AC-WC, t = 5 cm
P-401 AC-BC, t = 10 cm
P-304 Cement Treated Base course, CBR >100%, t = 30 cm
P-209 Crushed Agregate Subbase, CBR >80%, t = 42 cm
Control Fill CBR 6%, t = 165 cm
Sand Blanket, t = 60 cm
TYPICAL POTONGAN LAPISAN PERKERASAN
Preloading, t = 228 cm
Control Fill CBR 6%, t = 165 cm
Sand Blanket, t = 60 cm
Stone Column Pola Segitiga spasi 1,5m, t = 4,5m & 5m
PVD Pola Segitiga spasi 1m, t = 8 – 16 m
TYPICAL POTONGAN SOIL IMPROVMENT



Angkasa Pura | AIRPORTS

East Connection Taxiway
Soekarno Hatta International Airport
Jakarta – Indonesia
2018

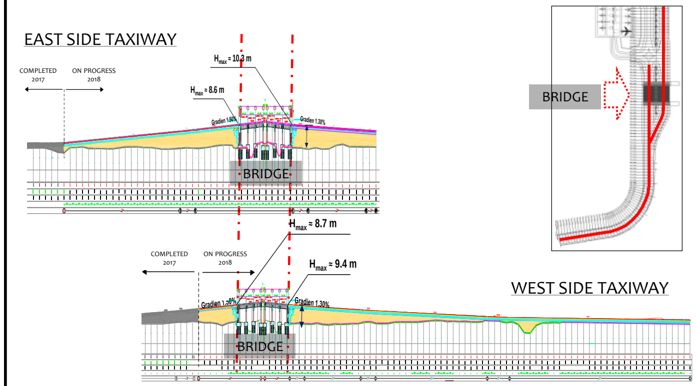
Application of
Full Displacement Column ϕ 32 cm
for solving Bearing Capacity and
Consolidation problems

HK Inovasi Untuk Solusi

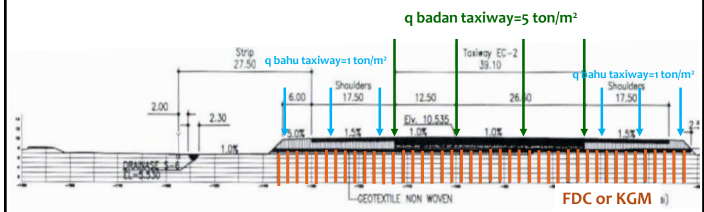
BAUER

DETAIL PROJECT LOCATION

LONG SECTION
PROFILE OF CONSTRUCTION HEIGHT



Pembebanan berdasarkan Spesifikasi Teknis dan Gambar Rencana Pekerjaan Perbaikan Tanah

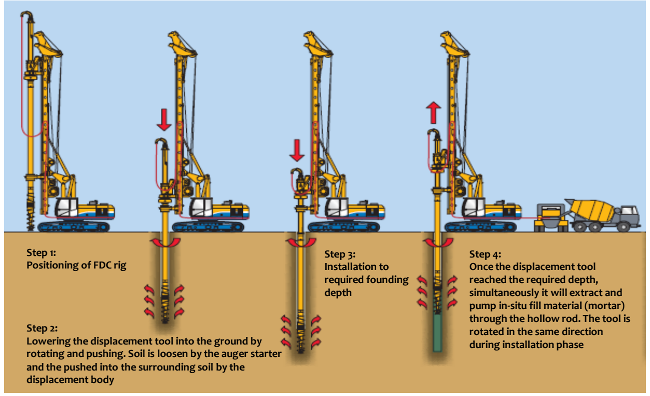


FDC = Full Displacement Column
KGM = Kolom Grout Modular

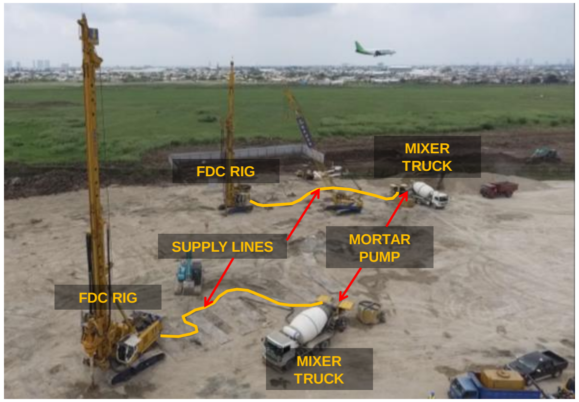
Design Criteria:

- Minimal Subgrade CBR 6%
- Settlement post construction ≤ 100mm
- FS static ≥ 1.5 and FS earthquake ≥ 1.0

SEQUENCE OF WORK



▶ FDC TYPICAL SETUP



Full Displacement Column (FDC)

Full Displacement Column (FDC)

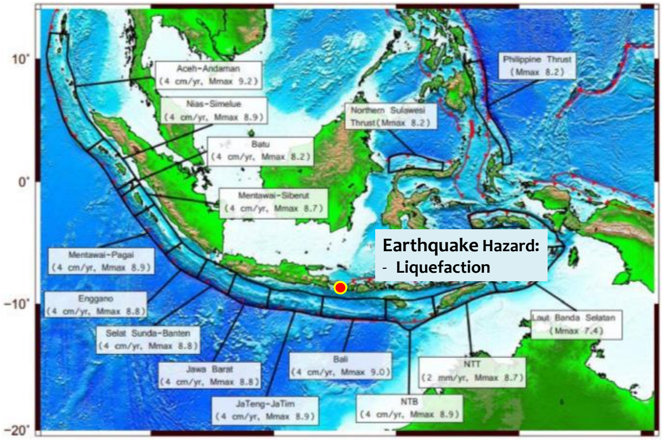
- Konsep Desain

1. Pemasangan FDC dan LTP
2. Pembebanan dan distribusi tegangan oleh LTP ke FDC dan tanah sekitarnya
3. Selama proses konsolidasi. Pada saat displacement tanah terjadi lebih besar daripada displacement FDC, sebagian tegangan pada tanah tertransfer pada FDC akibat negative skin friction pada bagian atas FDC
4. Pada saat tercapai kondisi displacement tanah mengecil sehingga kurang dari displacement FDC pada kedalaman tertentu, terjadi transfer tegangan kembali dari FDC ke tanah sekitarnya. Hal ini memobilisir positive skin friction dan tahanan ujung bawah FDC
5. FDC dan tanah sekelilingnya bersama-sama menahan beban secara komposit

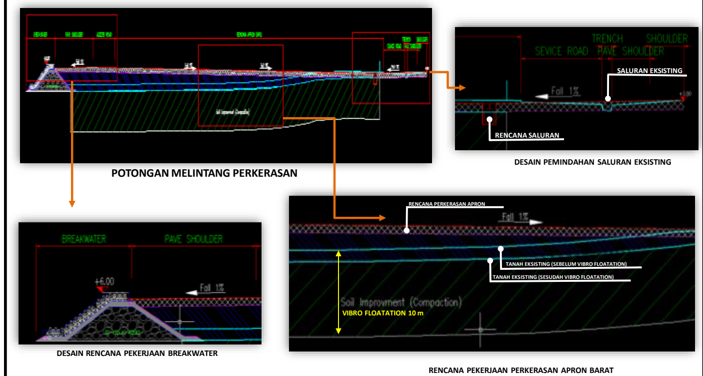
GROUND IMPROVEMENT WORK FOR WEST APRON DEVELOPMENT
I GUSTI NGURAH RAI AIRPORT, BALI

Map of Earthquake Sources for Indonesia 2017

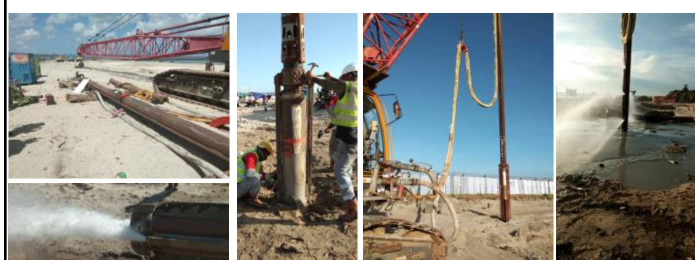
Subduction Megathrust



RENCANA DESIGN



Working Progress



Assembly and testing of Vibro-Flotation Equipment

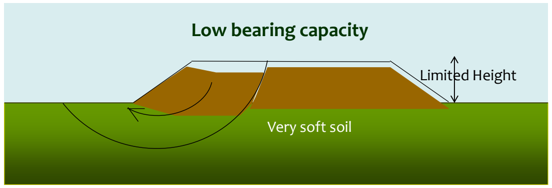
11/2/2018 Presentation for PT Pembangunan Perumahan (Persero)

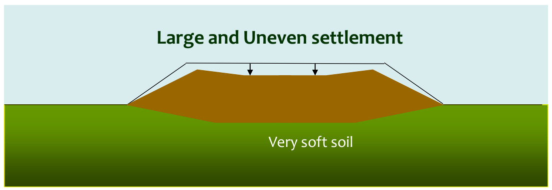
PP CONSTRUCTION & INVESTMENT menard

Content:

1. Ground Improvement Methods for Recent Infrastructure Projects in Indonesia
2. Previous Experiences Using the Bamboo Pile-Mattress System
3. Utilization of Bamboo Pile-Mattress System for Soil Improvement:
   a. For Railway Embankment
   b. For Container Yard
4. Modelling of Load Transfer Mechanism in Bamboo Pile-Mattress System
5. Conclusions

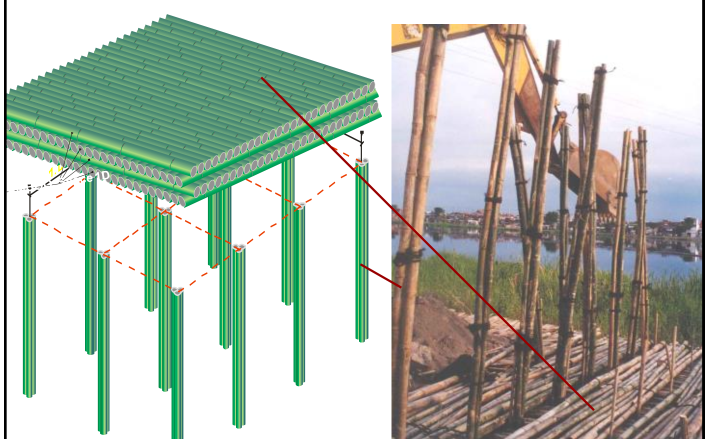
Embankment on Soft Soils



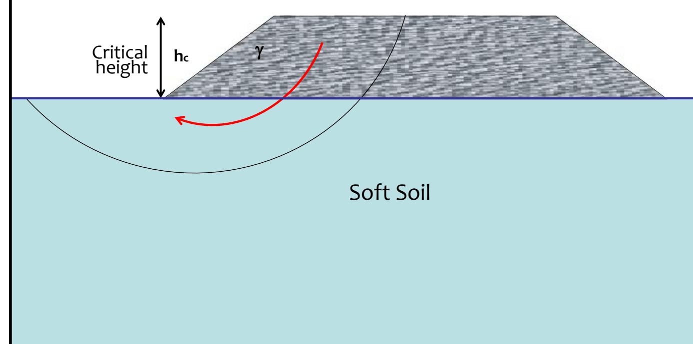


For:
- Embankment with limited height
- Embankment in submerge area
- Embankment with tolerable settlement
- Embankment in remote area

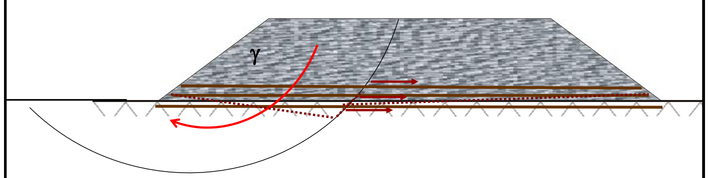
BAMBOO PILE-MATTRESS SYSTEM



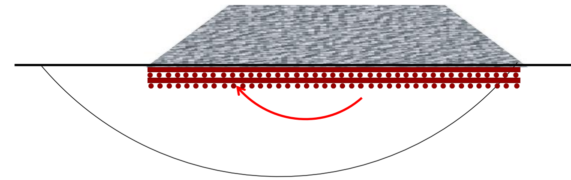
Stability of Embankment Without Reinforcement



Stability of Embankment With Geotextile

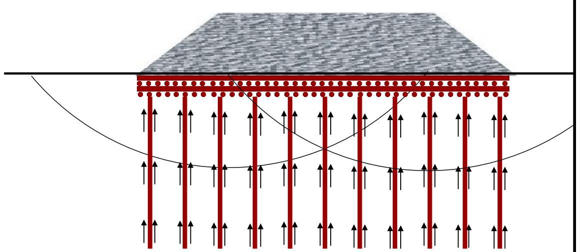


Stability of Embankment With Bamboo Mattress



- It enforces the failure surface not to pass through middle of the embankment
- Distribute embankment load more uniformly
- Reduce differential settlement due to it stiffness
- Provides buoyancy

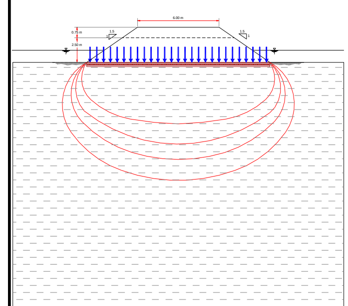
Stability of Embankment With Bamboo Pile- Mattress



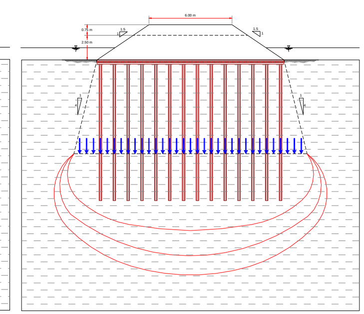
Increase resistance due to side friction from bamboo piles

However, embankment is still subjected to consolidation settlement!!!

Consolidation Settlement



Bamboo mattress only



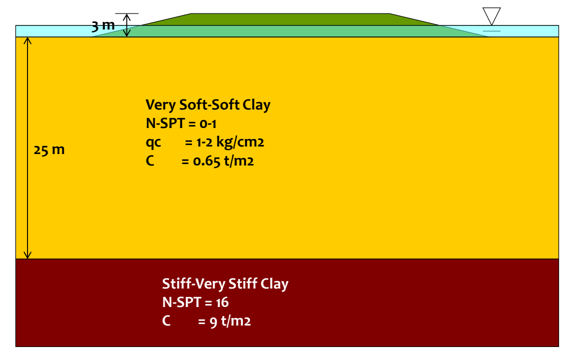
Bamboo pile-mattress system

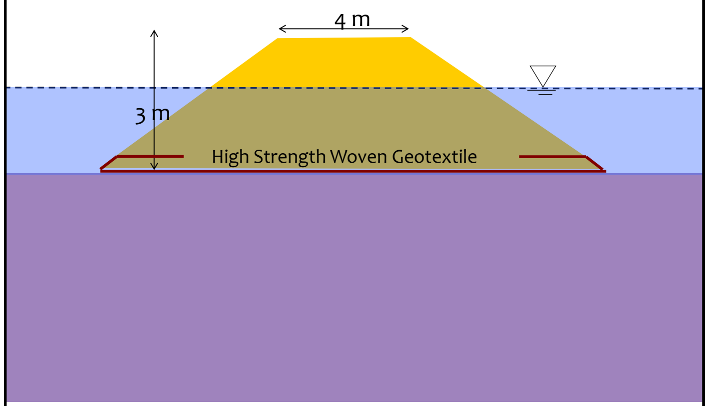
Durability?

Bamboo is durable
as long as it is always saturated

Appropriate for embankment in
coastal and swampy area where
it is always saturated

Coastal Embankment 1995



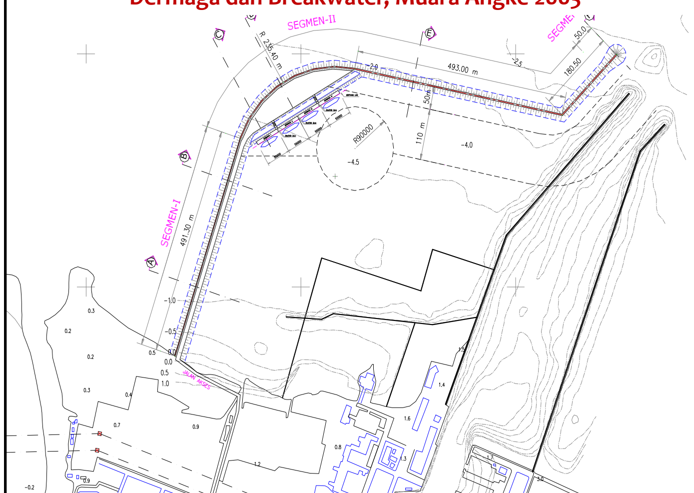


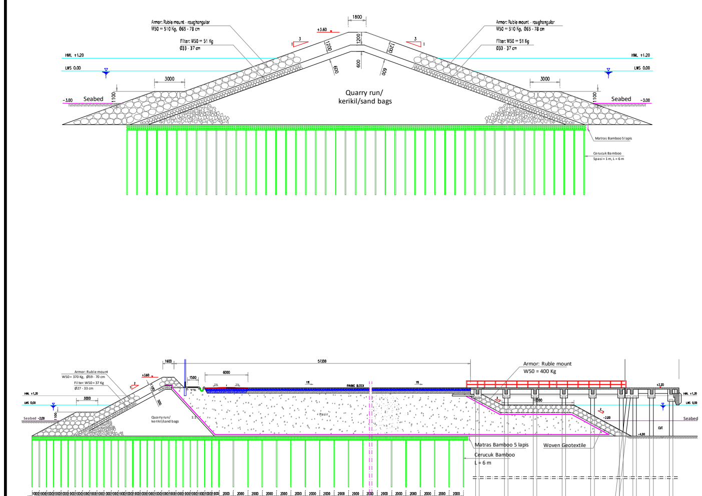
Utilization of Bamboo Mattress for Coastal Embankment
at Tambaklorok - Semarang

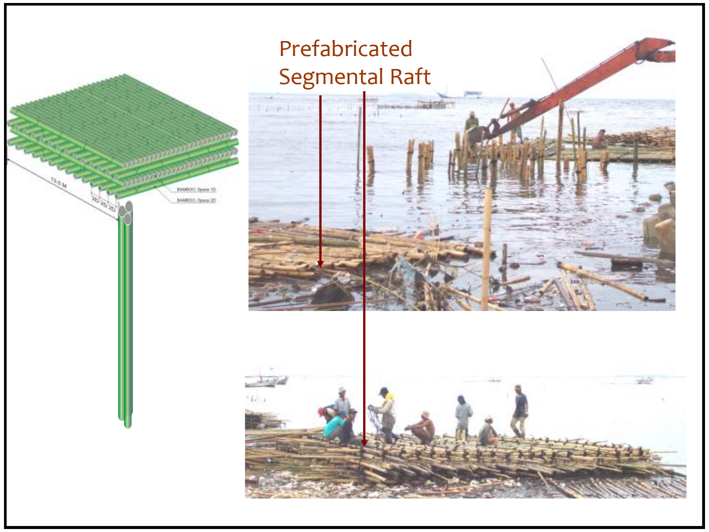
Laboratorium Geoteknik
Pusat Penelitian Antar Universitas, PPAU
Institut Teknologi Bandung

Embankment for Land Reclamation on Very Soft Soil
Morokrembangan-Surabaya 1999

Dermaga dan Breakwater, Muara Angke 2003







Content:

1. Ground Improvement Methods for Recent Infrastructure Projects in Indonesia
2. Previous Experiences Using the Bamboo Pile-Mattress System
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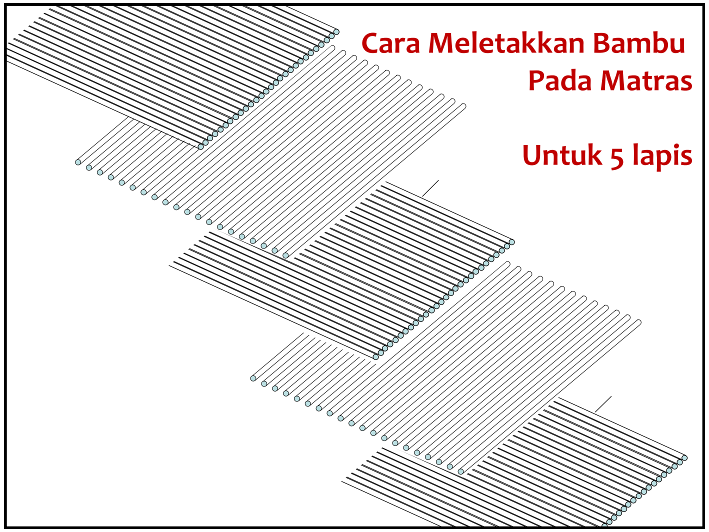
5. Conclusions

UTILIZATION OF BAMBOO PILE-MATTRESS SYSTEM FOR RAILWAY EMBANKMENT ON VERY SOFT SOIL CONDITION SEMARANG –TAWANG, 2012-2013

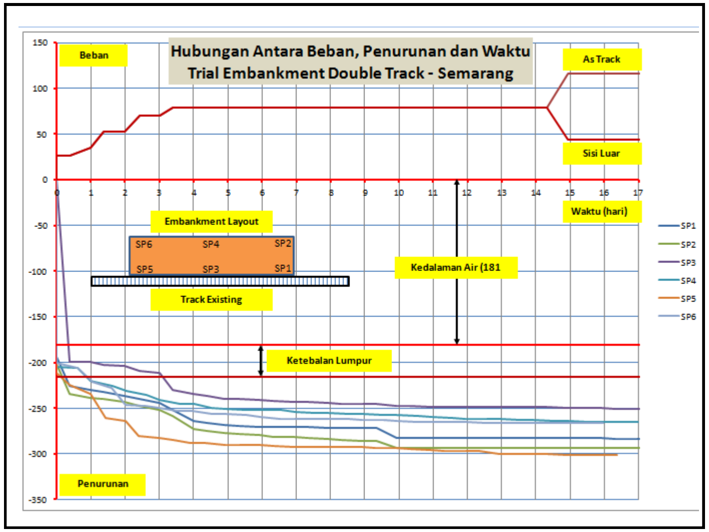

04/08/2012


Cara Meletakkan Bambu
Pada Matras
Untuk 5 lapis

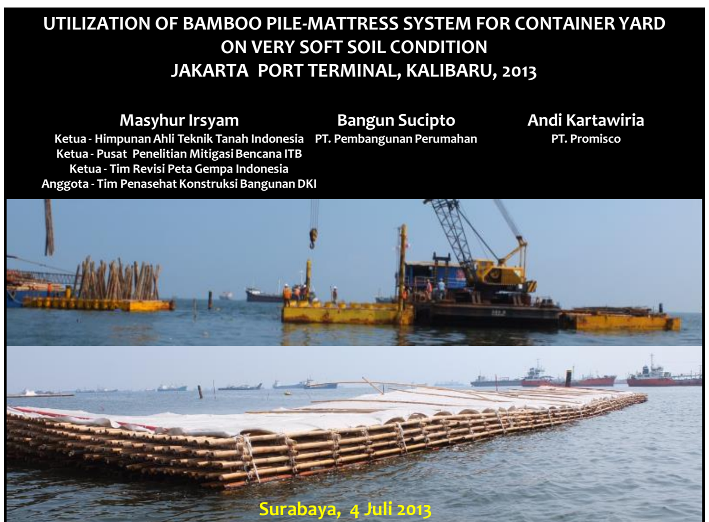

02/10/2012

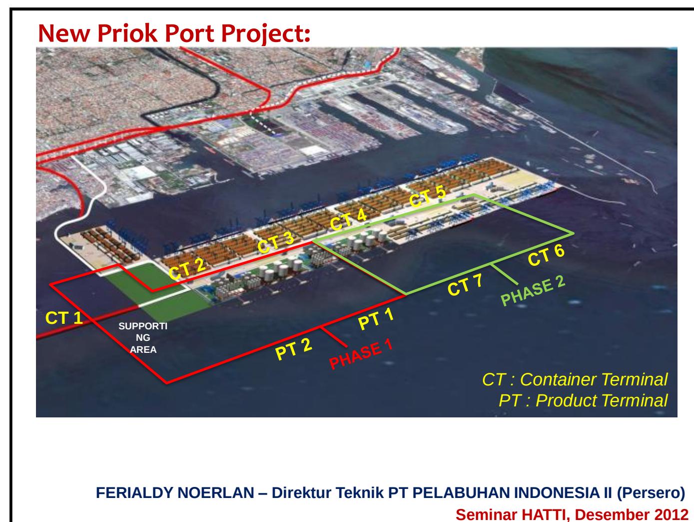

KOMATSU


KOMATSU


Hubungan Antara Beban, Penurunan dan Waktu
Trial Embankment Double Track - Semarang
Beban
As Track
Sisi Luar
Waktu (hari)
Embankment Layout
SP6
SP4
SP2
SP5
SP3
SP1
Track Existing
Kedalaman Air (181
Ketebalan Lumpur
Penurunan
SP1
SP2
SP3
SP4
SP5
SP6
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Loading Test Cargo Train

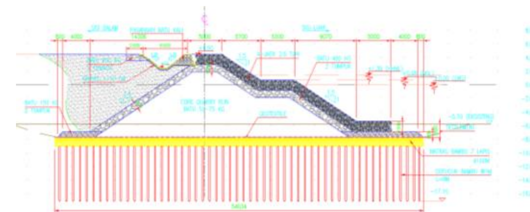




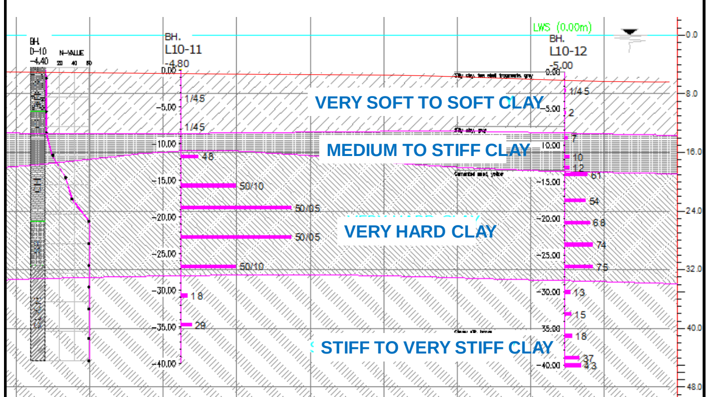
Owner	**: PT PELABUHAN INDONESIA II (Persero)**
Konsultan	**: direncanakan oleh PT LAPI ITB**
Kontraktor	**: PT Pembangunan Perumahan (Penulis terlibat sbg Geotechnical Expert PT PP)**

Reklamasi:

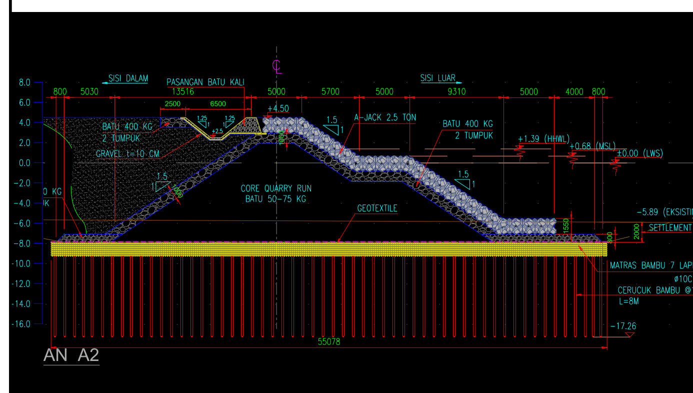
- Sebagian besar area yang tersedia untuk reklamasi berada di atas tanah lunak → complicated design (matras bambu untuk pondasi revetment);
- Permasalahan ketersediaan pasir untuk material reklamasi;



FERIALDY NOERLAN
Seminar HATTI, Desember 2012



FERIALDY NOERLAN
Seminar HATTI, Desember 2012



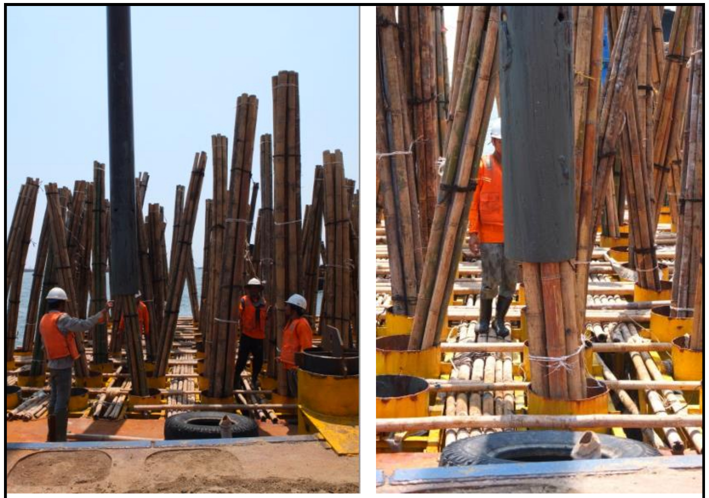
Panjang daerah yang diperkuat dng cerucuk matras bambu > 5.0 km
Jumlah matras > 360 ribu

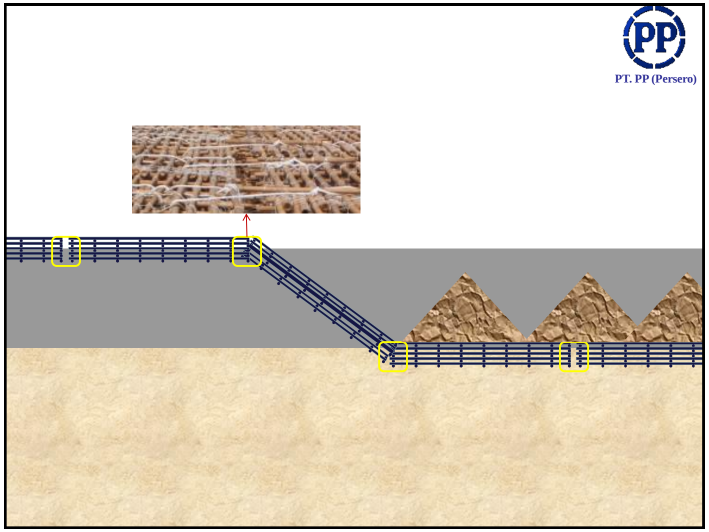
PROYEK PEMBANGUNAN TERMINAL PETI KEMAS KALIBARU UTARA TAHAP I
PELABUHAN TANJUNG PRIOK


PP
PT. PP (Persero)

Alat pancang cerucuk cluster bambu dipatenkan oleh PT .PP

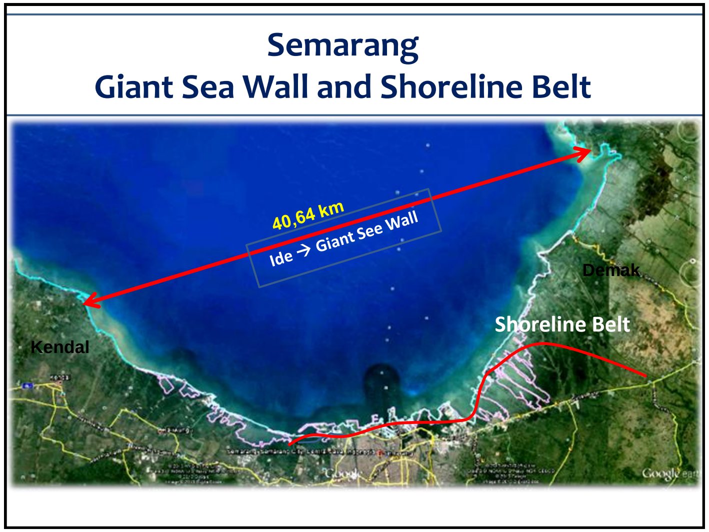
Alat pancang cerucuk cluster bambu dipatenkan oleh PT. PP


Alat pancang cerucuk cluster bambu dipatenkan oleh PT. PP

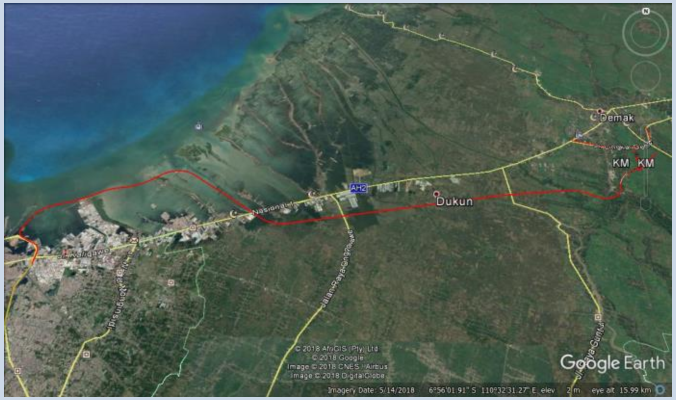

PT. PP (Persero)


PP
PT. PP (Persero)

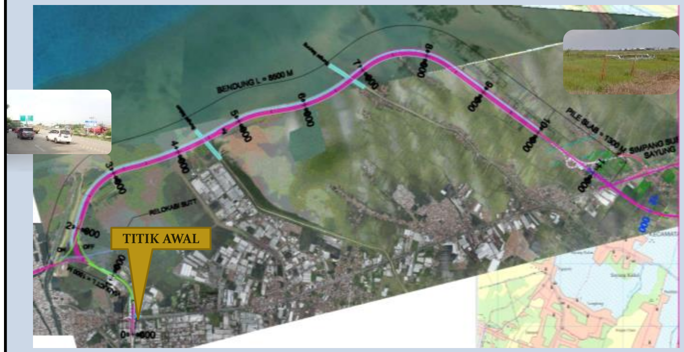

PT. PP (Persero)
KOMATSU


Semarang
Giant Sea Wall and Shoreline Belt
40,64 km
Ide → Giant See Wall
Demak
Shoreline Belt
Kendal

Semarang-Demak Toll Road and Sea Dyke

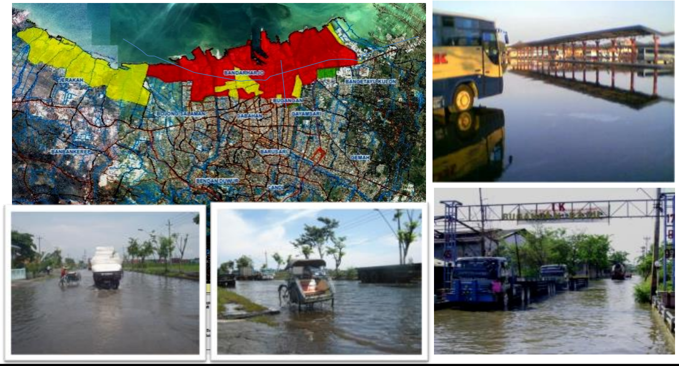


Semarang-Demak Toll Road and Sea Dyke

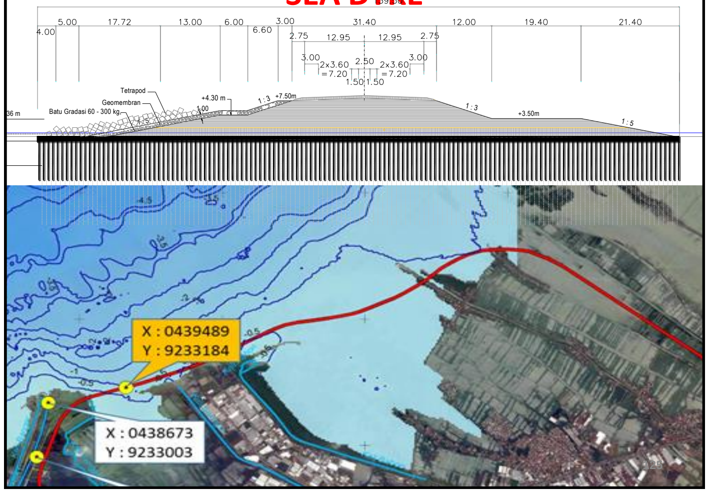


INUNDATION DURING HIGH TIDE

Luas genangan ROB ± 4.500 ha (2007), dan akan meningkat terus
Penyebab : penurunan muka tanah (*land subsidence*); abrasi pantai; dan kenaikan muka air laut (SLR).

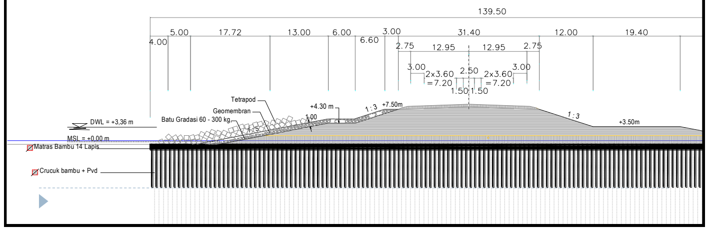


SEA DYKE



Sea Dyke

- Tahapan :
  - Urug pasir 1 m
  - Pasang cerucuk cluster bamboo L = 10 m, spasi 1.0 m
  - Pasang matras bambu 14 lapis
  - Pasang PVD L = 20 m
  - Timbunan bertahap 1 m (termasuk batu dan tetrapod) dengan waktu konsolidasi 14 hari per tahap hingga elevasi + 5.70 (as). Pada tahap akhir hingga elevasi + 7.20 as, waktu konsolidasi selama 90 hari sebelum pelaksanaan perkerasan fleksibel.



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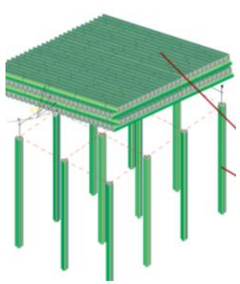
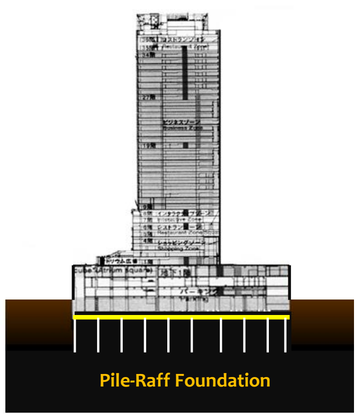
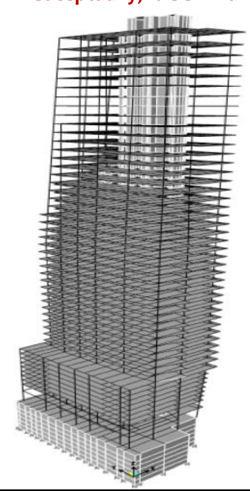
How to calculate?

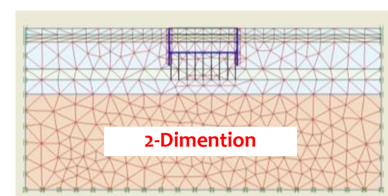


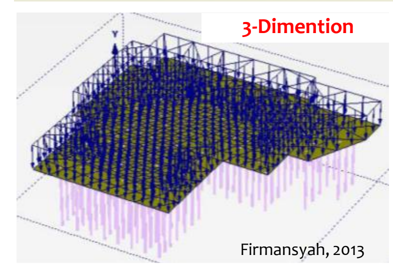
BAMBOO PILE-MATTRESS SYSTEM



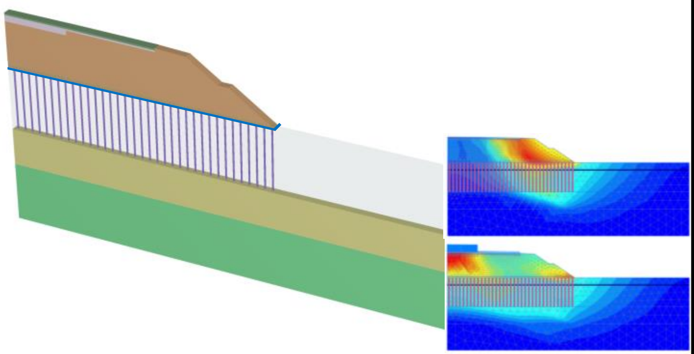
Coceptually, it is similar with pile-raft system for high rise buildings



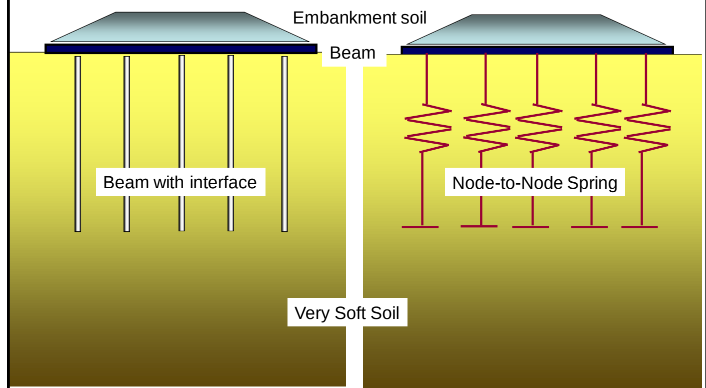




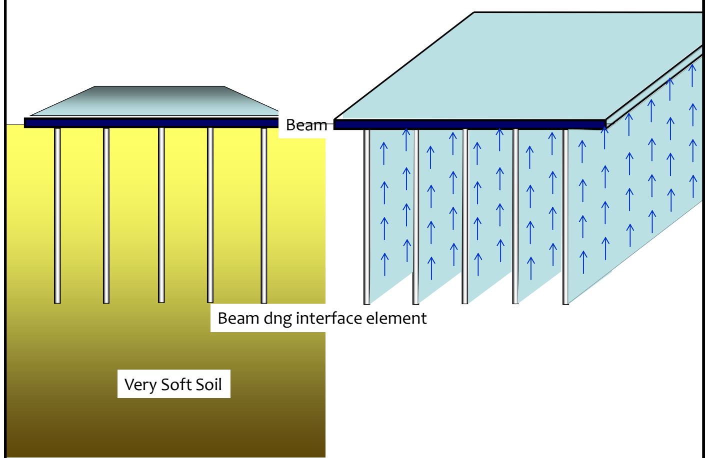
Analisis Stabilitas Lereng dengan 3D



FEM Modelling

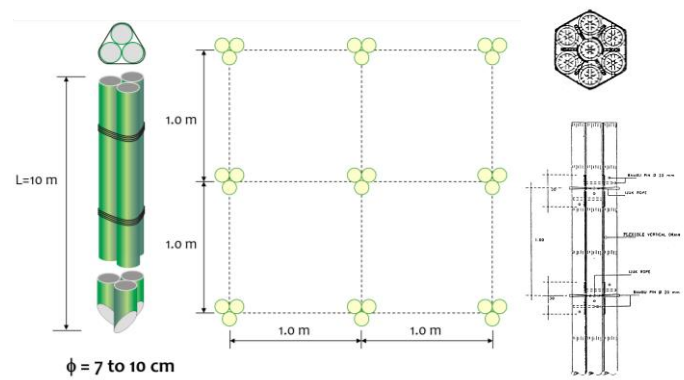


FEM 3D **FEM 2D**

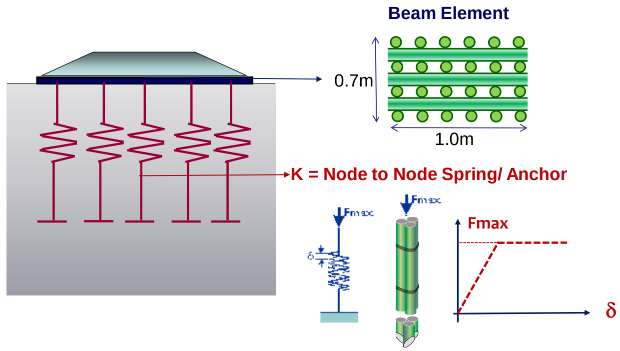


FEM 2D

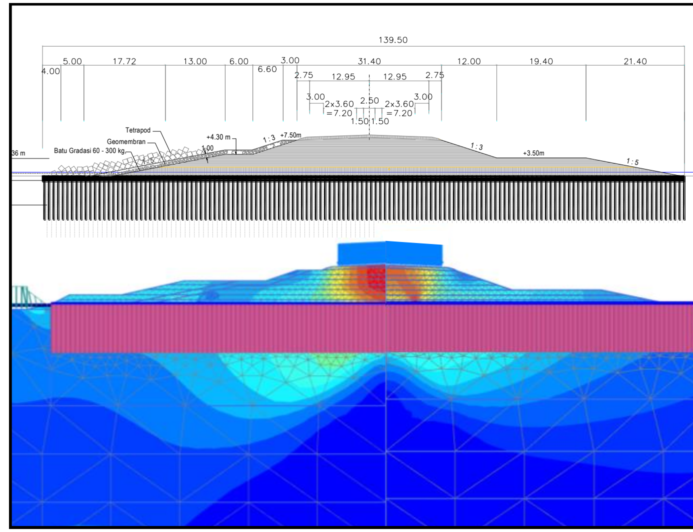
Configuration of bamboo cluster pile



Matt and Pile Properties



FEM 2D



Verification and Numerical Modeling By Using Instrumented Trial Embankment at Tambak Oso Surabaya

Pembuatan Matras bambu

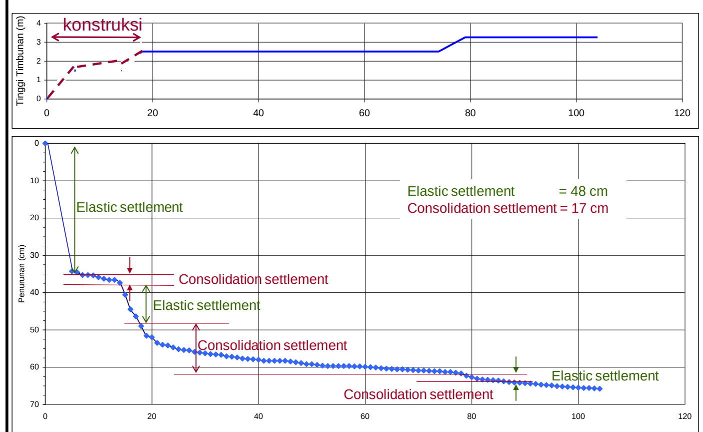
Pemasangan Instrumentasi di lapangan :

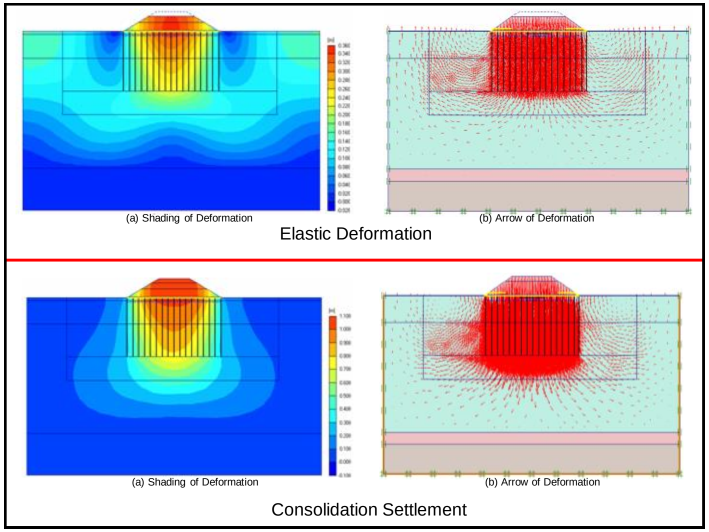
Pemasangan Settlemetn Plate

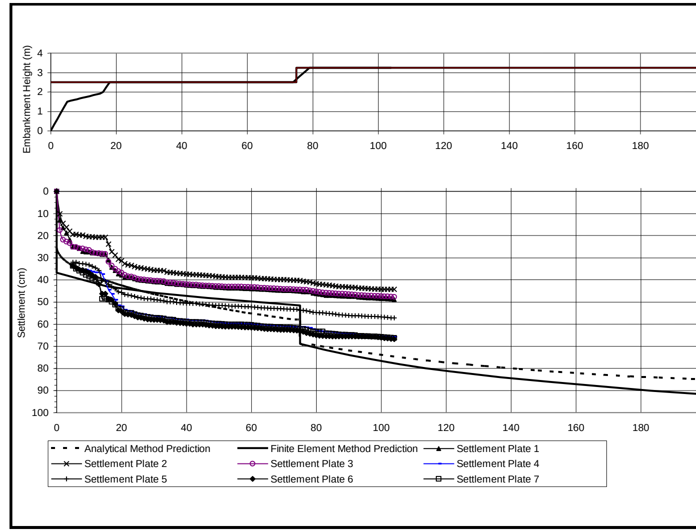
Pemasangan Instrumentasi di lapangan :

Pemasangan Piezometer dan tipe alat baca

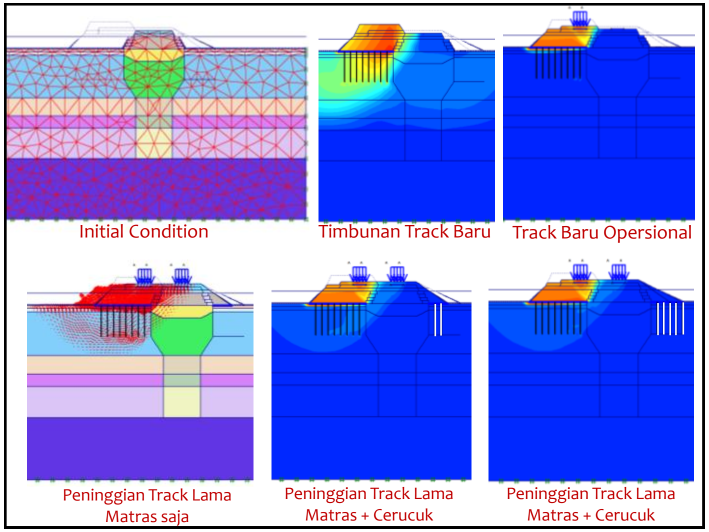
Grafik Penurunan-Waktu pada Settlement Plate 4







Analisis Stabilitas Timbunan Double Track
Tawang, Semarang



PENGUJIAN BEBAN KERETA PADA

JALAN KERETA API JALUR GANDA PAKET 1 (TAWANG-ALASTUA)

KOTA SEMARANG

Uji Beban Kerta Penumpang Blora Jaya Ekspress, jam 8.10 (ke arah Tawang).

Content:

Conclusions

- Recent major infrastructure projects in Indonesia used Vacuum Consolidation, Dynamic Compaction, Rapid Impulse Compaction, Stone Column, and Full Displacement Column etc.
- Bamboo pile-mattress system is proven to be reliable, and therefore, can be used as ground reinforcement for coastal/ swampy embankment on soft soil layer.
- Performance of the system can be predicted accurately as long as it is modeled correctly.
- Consolidation settlement has to be accounted for during the design life.

Thank You


ONE DAY WORKSHOP
SOUTH EAST ASIAN GEOTECHNICAL CONFERENCE
AGSSEA CONFERENCE
HATTI ANNUAL SCIENTIFIC MEETING