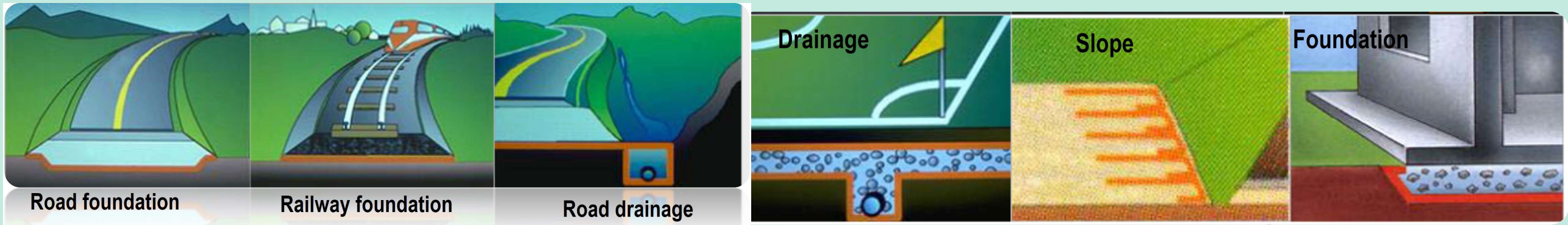
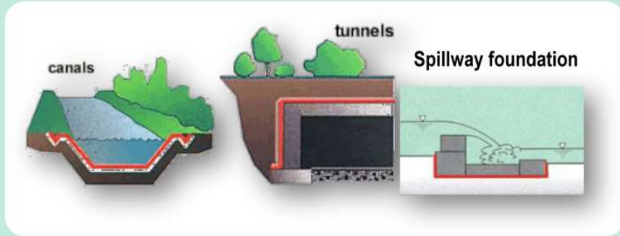




Geosynthetics-Based Solutions for Resilience and Sustainability of Civil Construction Works

Dr. Yu Maung
PE-0038 (Geo), ACPE-00564 (Civil), AE-9221
Design and Consulting Engineer, Dr. Yu And Associate (DYAA)

TIME: : 9:10 am to 10:10 am – Part-1
10:10 am to 11:30 am – Coffee Break
10:30 am to 11:30 am – Part-2

DATE: : 26-08-2023, Saturday

Scope of Presentation:

1. Introduction
2. Knowledge sharing for the Use of Geotextiles in various Geotechnical Design in Civil construction Works
3. Conclusion

9:10 am to 10:10 am
Part-1 (1hour)

Geosynthetics-Based Solutions for Resilience and Sustainability of Civil Construction Works

Date: *26*-08-2023, Saturday, for CPD hours

Geotechnical Engineering, Technical Division, Fed. MES

Synopsis

- Due to climate change, engineering structures must be designed to new load and foundation standards based on the new code of practice. The new code of practice will interact with current state of the Art. In foundation engineering structures, failures and disasters are mainly triggered by ***weather-related hazards and climate-related hazards, and earthquake hazards*** as well.
- In order to reduce/eliminate ***the risks***, the engineering design must be changed based on the current techniques. In Current State of the Art, for the Sustainable Development Goals (SDGs) adopted by all United Nations Member States in 2015, engineering designs reflect the three dimensions of sustainable development - *economic, social and environmental*. Myanmar also should introduce the application of geosynthetic to achieve the Goals.

- Additionally, construction and destruction activities cause significant land, water and air degradation due to environmental impacts including, deforestation, soil erosion and high water resources consumption. We must consider the benefits ***for the life cycle of engineered structures*** to achieve the **Resilience and Sustainability** for construction environment. Solution by geosynthetic application reduces most the environmental impacts and gives the many advantages in construction projects.
- The Author will present the application of geosynthetics in civil construction works and also share the knowledge from some of past experiences of Myanmar/Oversea Projects.

1. **Introduction**
    i. Resilience and
    ii. Sustainability

Engineering *Resilience:*

The situation of structures refers to the ability to continue functioning or recover quickly *in the face of external failure* such as water shortage, power failure, or a natural disaster.

Sustainability

To meet the needs of the present *without compromising* the ability of future generations to meet their own needs.

Ref: UN's 1987 World Commission on Environment and Development

Recommended Presentation: ***Geosynthetics in Civil Engineering and Construction Works***

Geosynthetics-Based Solutions

State-of-the-Art on the Applications of Geosynthetics

1. More practical and cost-effective solutions can be provided than with traditional building materials.
2. Consumption of raw materials is significantly reduced.
3. Cost effectiveness (e.g., sand and aggregates, are usually available a long distance from the application site.)
4. More beneficial in terms of cost when used with waste materials (In case, need to remove the waste soils)
5. Reducing the need to use some of the construction machinery than natural soils.
6. As a summary, reducing the environmental impact of construction through the use of geosynthetics.

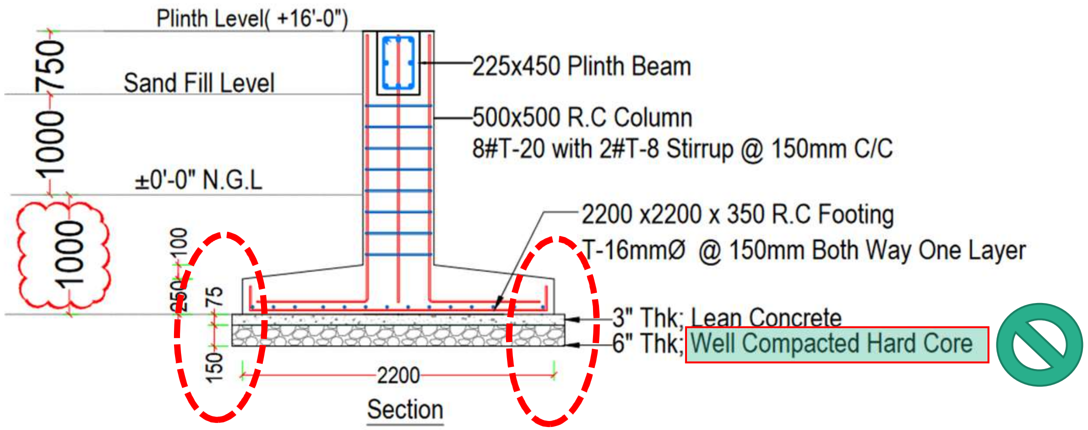
Therefore, the use of geosynthetics may significantly reduce greenhouse gas emissions during the construction and destruction of geotechnical structures.

Slope stability and erosion protection

Construction Materials

The basic construction materials used in civil engineering applications or in construction projects are:

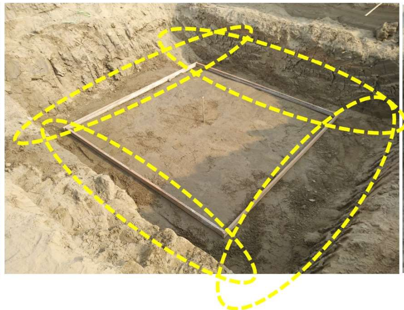
- Wood.
- Cement and concrete.
- Bitumen and bituminous materials.
- Structural clay and concrete units.
- Reinforcing and structural steels, etc.,
- Geosynthetics, etc.,



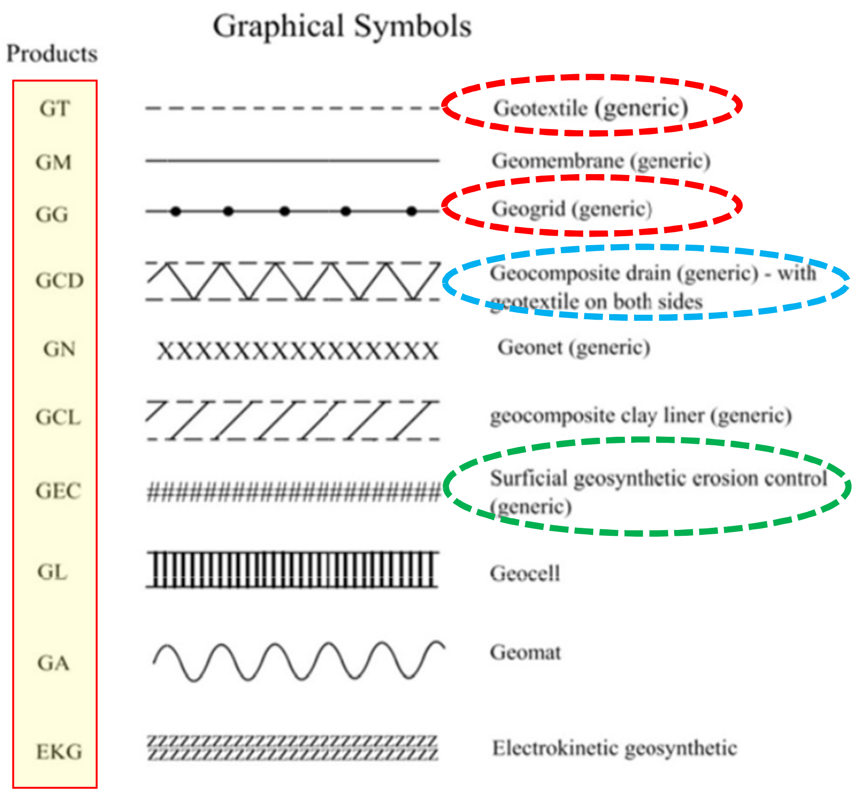
Quality control in Excavation & Construction of Foundation

Rock and Soil as Engineering Construction Materials

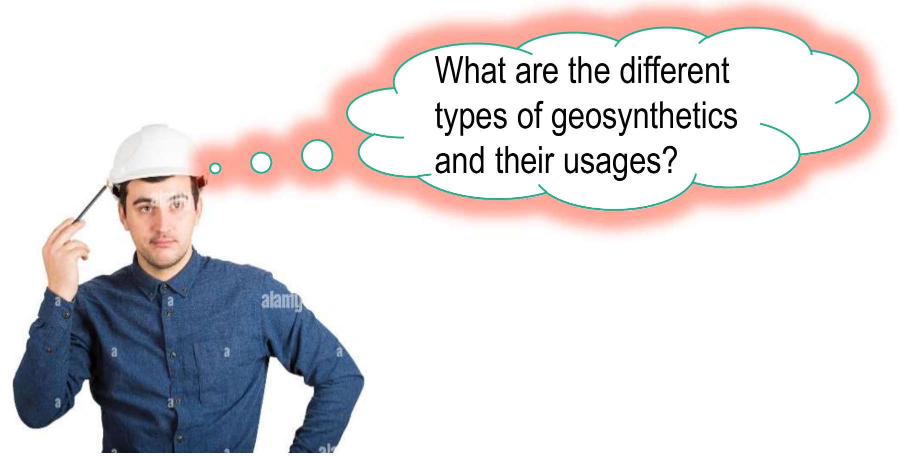
Earthwork → Hard core levelling work → Sand levelling work → Lean concrete casting work → Footing rebar & formwork → Footing concrete casting work



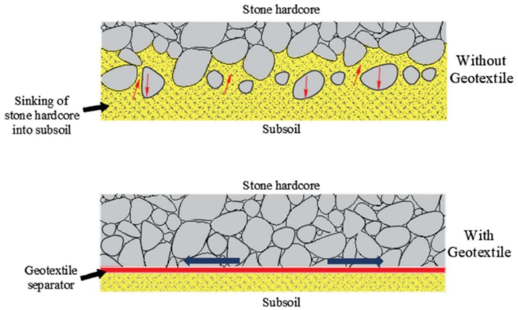
- *Use of Geosynthetics in Civil Construction Works*



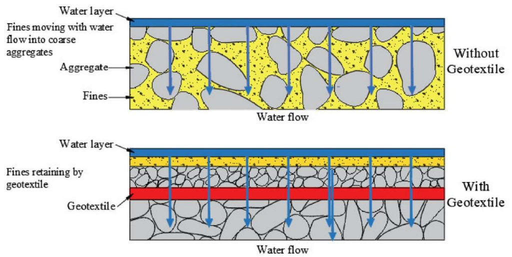
Different Varieties of Geosynthetic (International Geosynthetic Society)



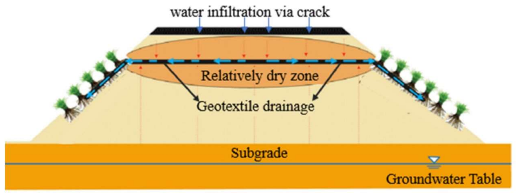
Function	Suitable geosynthetics
Barrier	Geomembranes
Protection	Thick nonwoven geotextiles
Drainage, Seepage control	Geotextiles, Geonets, Geomembranes, Geocomposites (geosynthetic clay liners (GCL))
Erosion control	Geocells, Geonets, Geotextiles, Geotubes, Gabion
Filtration	Geotextiles (Fluid flow across of the geosynthetic)
Reinforcement	Geogrids, Geotextiles, Polymeric strips
Separation	Geogrids, Geotextiles (Intermingling of dissimilar materials)



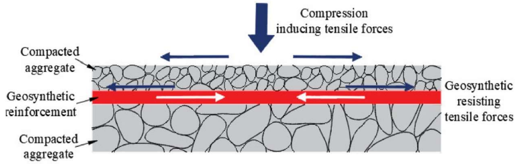
Separation function



Filtration function



Drainage function

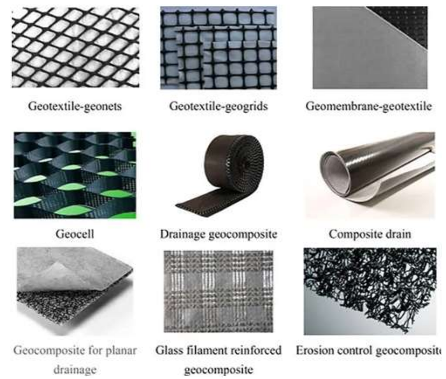


Reinforcement function

Erosion control function

Barrier function

Protection function for tear, abrasion, impact and puncture



Specifications of Geotextiles:

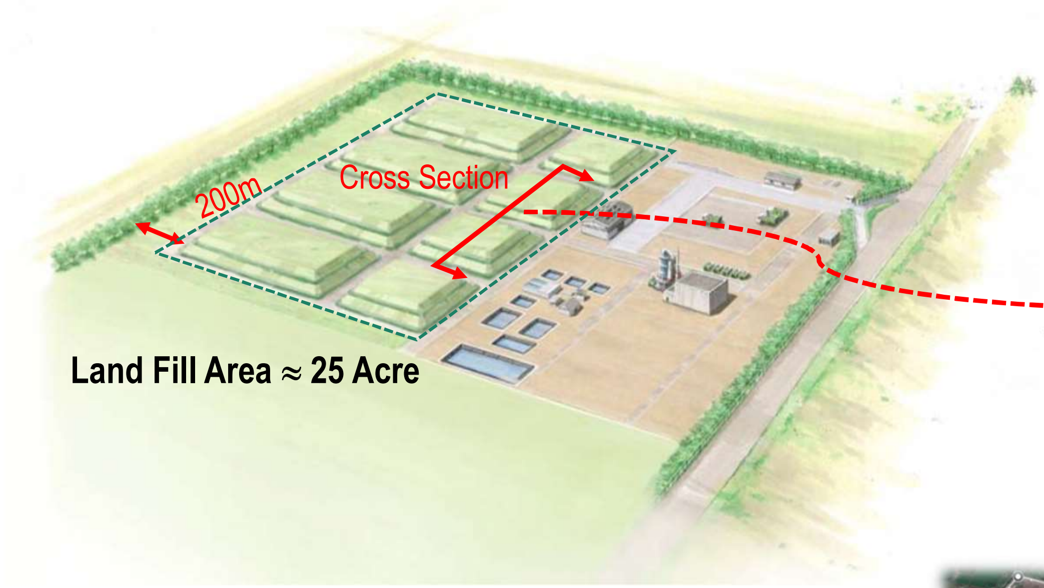
1. Mechanical Properties
2. Physical properties
3. Chemical
4. Durability (Design life)

Standard Test Method of Geotextiles:

- ASTM D-6637 for strength test
- ASTM D-7737 for Junction strength test
- ASTM D5261-10(2018) for Measuring Mass per Unit Area
- ASTM D5970-96(2002) for Deterioration from Outdoor Exposure
- Etc.

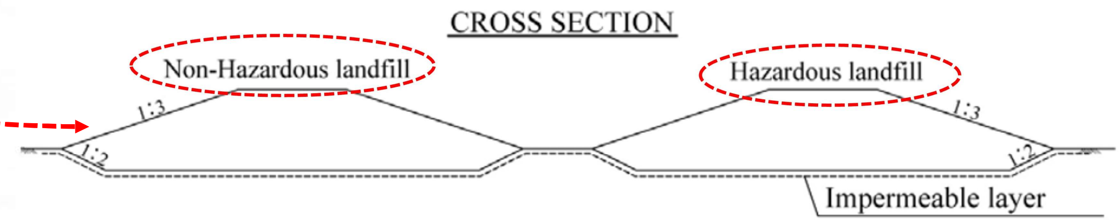
THILAWA SEZ Industrial Waste Management

- **Combined use of Geosynthetics in Land Fill**

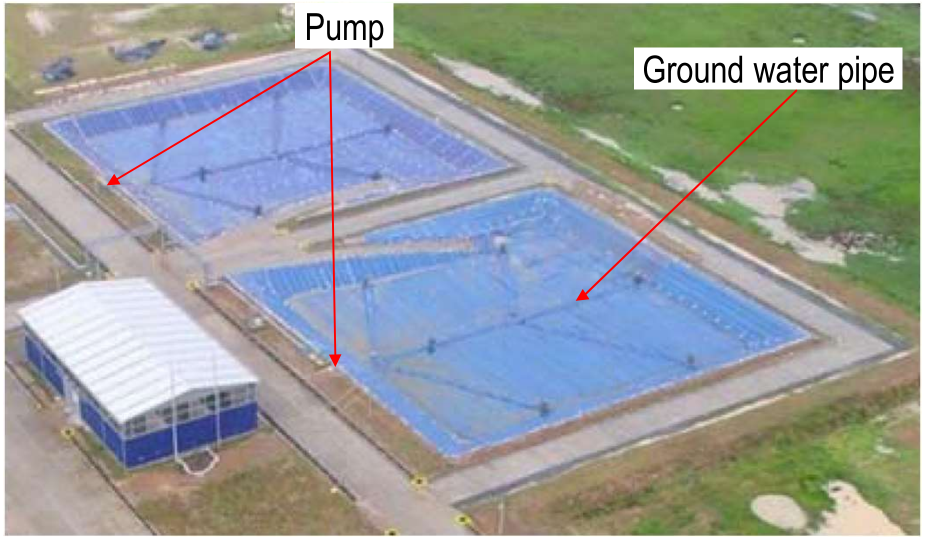


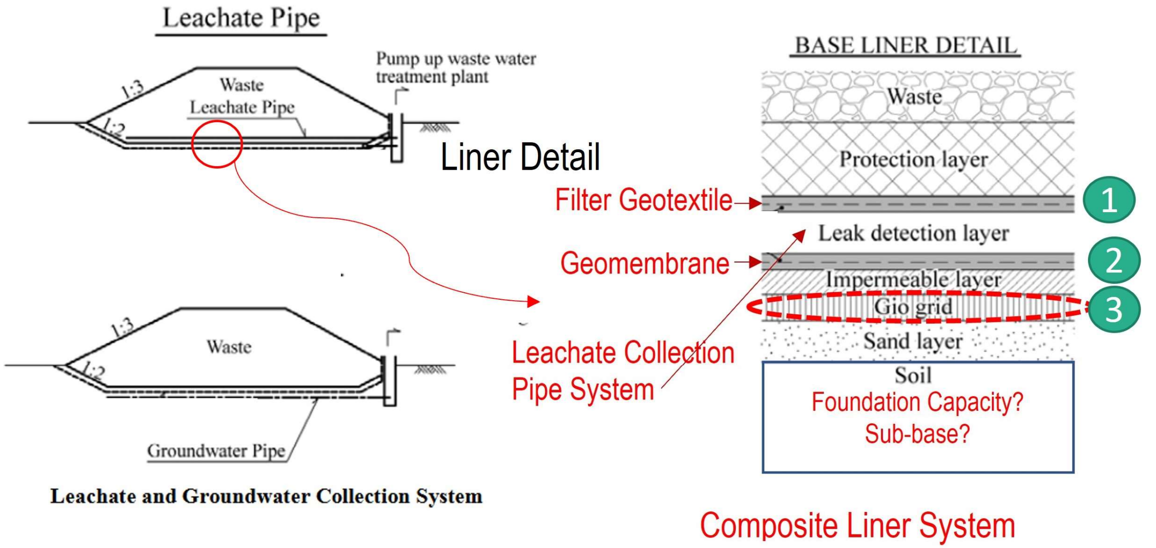
Item	Value
Height from site preparation	10 m
Size	83 m×83 m; 83 m×127 m (approximate)
Slope gradient	1 to 3.0

Source: DOWA Eco-System Co., Ltd.



Cross Section of the Proposed Landfill

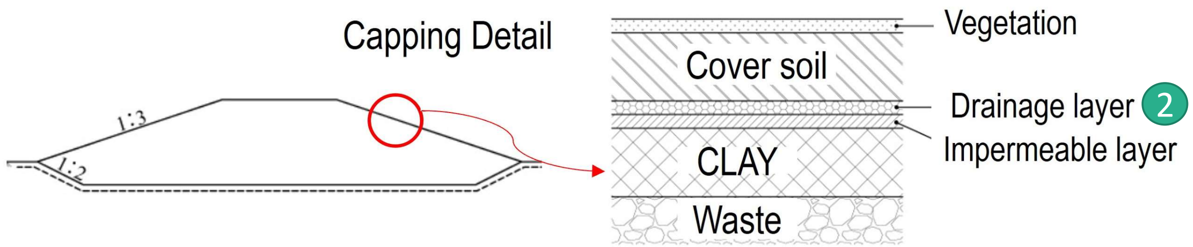




Water Collection System and Base Liner Structure

Combined use of Geosynthetics

1. Filtration
2. Barrier
3. Reinforcement



Structure of final cover

Cross Section of Land fill and Final Cover Structure

2. Knowledge sharing for the Use of Geotextiles in various Geotechnical Design in Civil construction Works

Wall Stability by Soil Reinforcement

Project: : Earth Retaining wall, 3.73 m – 4.37 m

Length: : Length 398 m, Backfilling area, 3.293 acres

Location: : Mandalay

DATE: : JULY, 2023

Construction Materials

Soil Properties (E, ν, c, ϕ) **:**

- Medium dense recent backfill soil
- Medium stiff silty CLAY
- Stiff silty CLAY
- Very stiff CLAY

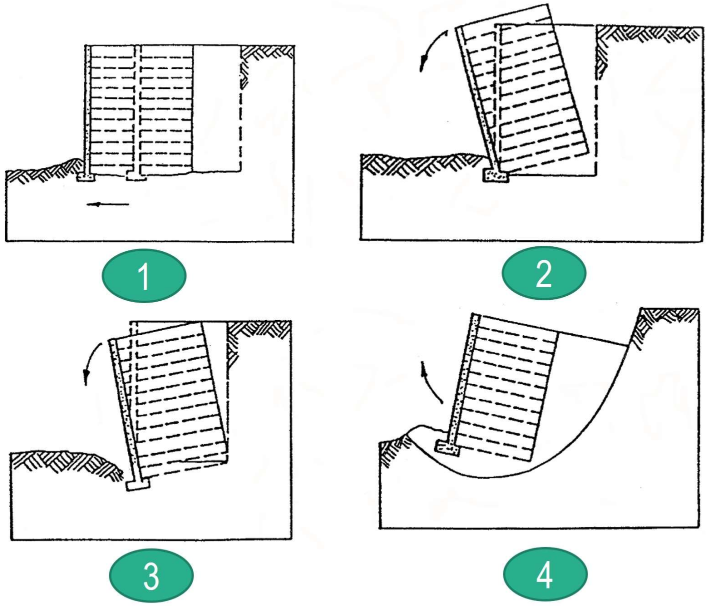
New back fill soil (CBR, c, ϕ):

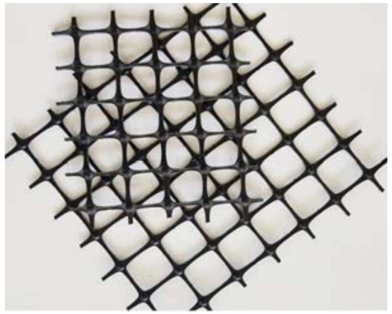
The main design requirements are discussed with Client:

1. To be stabilized the wall for additional backfilling
2. To control the differential settlement along the wall to prevent wall cracking
3. To reduce the long-term settlement of backfill surface
4. To check the roadway settlement

Wall Stability by Soil Reinforcement

No.	Key Factors	Remark	
1	Sliding	SF > 1.50	FHWA
2	Overturning (eccentricity at base)	Calculation results	
3	Bearing capacity of base soil	SF > 2.00	FHWA
4	Overall stability	SF > 1.30	FHWA

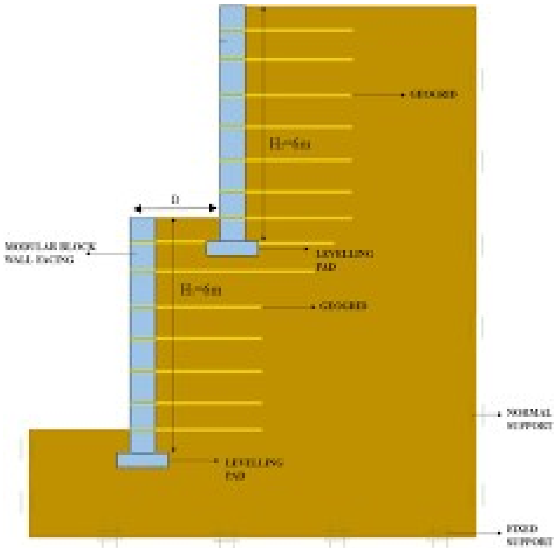




Biaxial PP Geogrid

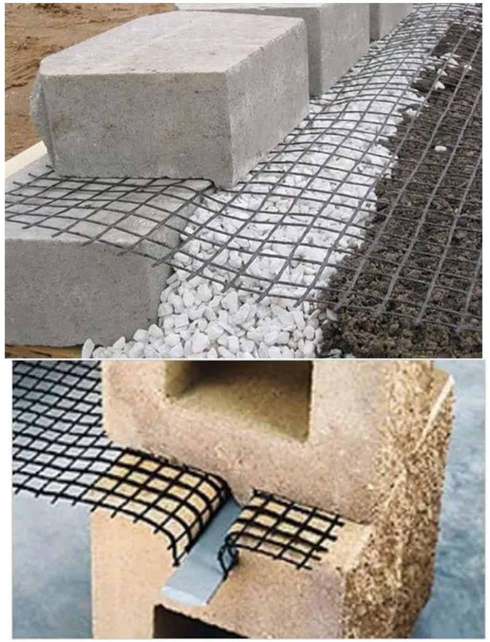
Design of Geogrid with Facing for vertical Wall (rigid or segmental facing wall)

- Geogrid segmental retaining wall is used where tall wall is required.
- Segmental retaining wall height is restricted due to stability issues: It can be increased with the help of using woven synthetic sheet or in another term geogrids as successive layers at the back face of the wall.
- Layers are positioned and anchored into the facing blocks in creating reinforced earth unit mass that acts against overturning and sliding actions.
- The geogrid segmental retaining walls can be constructed for height more than 12m.



Rigid Facing Wall


Segmental Retaining Wall


Engagement of geogrid by a lip of blocks

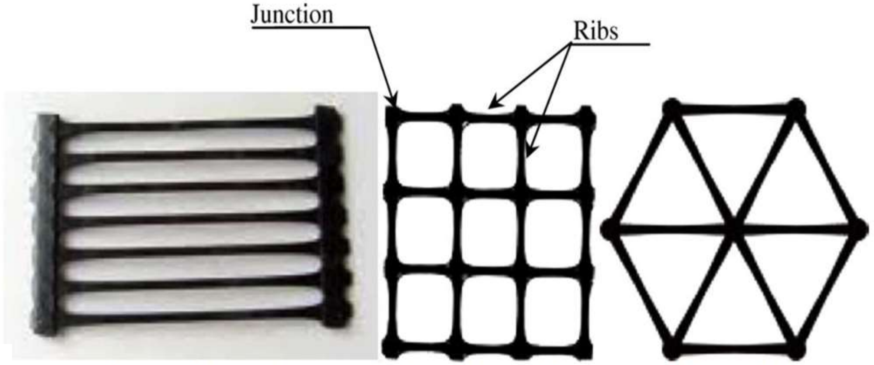
Selected Design Method: Mechanically Stabilized Earth Walls (MSEW)

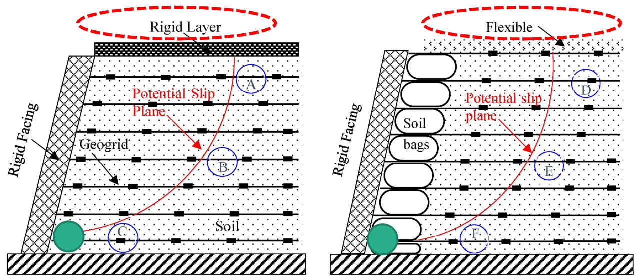
Application of Geogrid with Rigid concrete facing and Soldier pile

1. Lateral restraints between the geogrid and filled material, which will reduce design capacity of the rigid wall (due to Soil reinforced by geogrids)
2. Reducing the potential failure plane, and
3. Increasing the bearing capacity tension developed in geogrid and reducing the localized settlement.

Biaxial Geogrid (square pattern)

Types of Geogrids

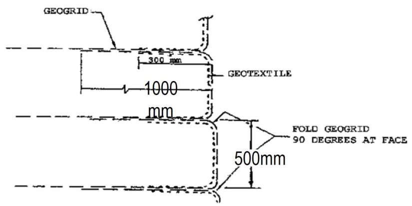




(a)

Properties of Geogrid:

- Mechanical, physical, durability
- Aperture size (36 x 34 mm)
- Strain rate , 13%
- Tensile Strength, 21 kN/m
- ASTM D-6637 for strength test and ASTM D-7737 for Junction strength test



Installation of Geogrid

Design Analysis Methods: Analytical Calculation and FEM

Design Analysis and Results using Analytical Calculation

Guideline:

1. Check for sliding at the base
2. Check for Soil Bearing Pressure
3. Soil bearing capacity

Meyerhof method is used to compute soil bearing pressure for segmental retaining wall. Where B is the total bearing width

$$e = \left[\frac{base\ width}{2}\right] - \left[\frac{[(resistance\ moment) - (overturning\ moment)]}{total\ vertical\ load}\right]$$

$$B_e = effective\ bearing\ width = B - 2e$$

Ultimate soil bearing capacity is computed by Terzaghi's equation and the cohesion is assumed to be zero:

$$Q_{ultimate} = \gamma d N_q + 0.5 \gamma B_e N_\gamma$$ → **Equation 15**

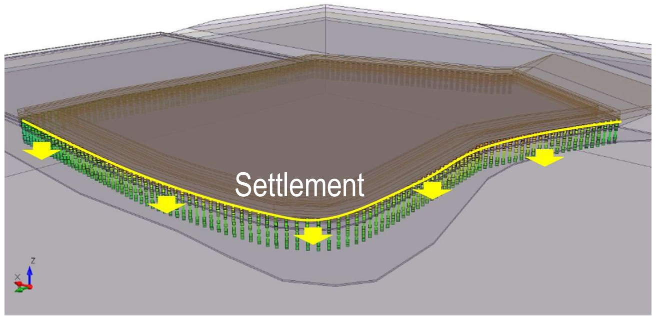
PROJECT NAME: : Design of Retaining Wall Construction and Consolidation Settlement Checking
LOCATION: :
Design Section: : DS-1
DATE: : 25-6-2023

Step	Design calculation procedure	Calculion	Remark
1	**Design height, external loads**		
	Total design height, H, m	4.37	
	Required panel height, m	4.37	
	Traffic/surcharge and fense required, Max. load, q, kPa	20.00	
	Seismic coefficient, g	0.30	
2	**Establish engineering properties of foundation soils**		
	Recent back fil, ϕ, deg.	26.00	
	Recent back fil, c, MPa	0.01	
	Allowable bearing capacity, kPa	359.00	See calculation results in separate sheet
	Allowable bearing capacity, TSF	3.35	
	Differential settlements on the order of 1/300 are estimated		
3	**Establish engineering properties for retained and reinforced backfill**		
	Retained fill, ϕ, deg.	30.00	
	γ_r, kN/m^3	18.80	
	Reinforced backfill, ϕ, deg.	34.00	
	γ_r, kN/m^3	18.80	
4	**Design factors of safety**		
	External Stability FS for sliding, Minimum	1.50	
	Global stability, Minimum	1.30	
	Internal Stability FS, Pullout, Minimum	1.50	
	Allowable stress - 0.55 Fy		
	Design life, years	75.00	
5	**Selection of facing type, reinforcement spacing and type**		
	Cast in place concrete wall		
	Allowable differential settlements along the wall are 1/500		
	Vertical spacing, m	0.60	
6	Determine the preliminary length for reinforcing strips		
	For horizontal backfill slope length, L = 0.7 H	4.00	
	Suppose, length of reinforcing strips, m	4.00	
7	**Checking the external stability**		
	Comput the $K_a = \tan^2(45-\phi/2)$	0.33	
	$V_1 = HL\gamma$, kN/m	328.62	
	Resisting force = $V_1 \tan\phi$, kN/m	189.61	
	$V_2 = qL$, kN/m	80.00	
	$F_1 = (\gamma H^2 K_a)/2$, kN/m	59.76	
	$F_2 = qHK_a$, kN/m	29.10	

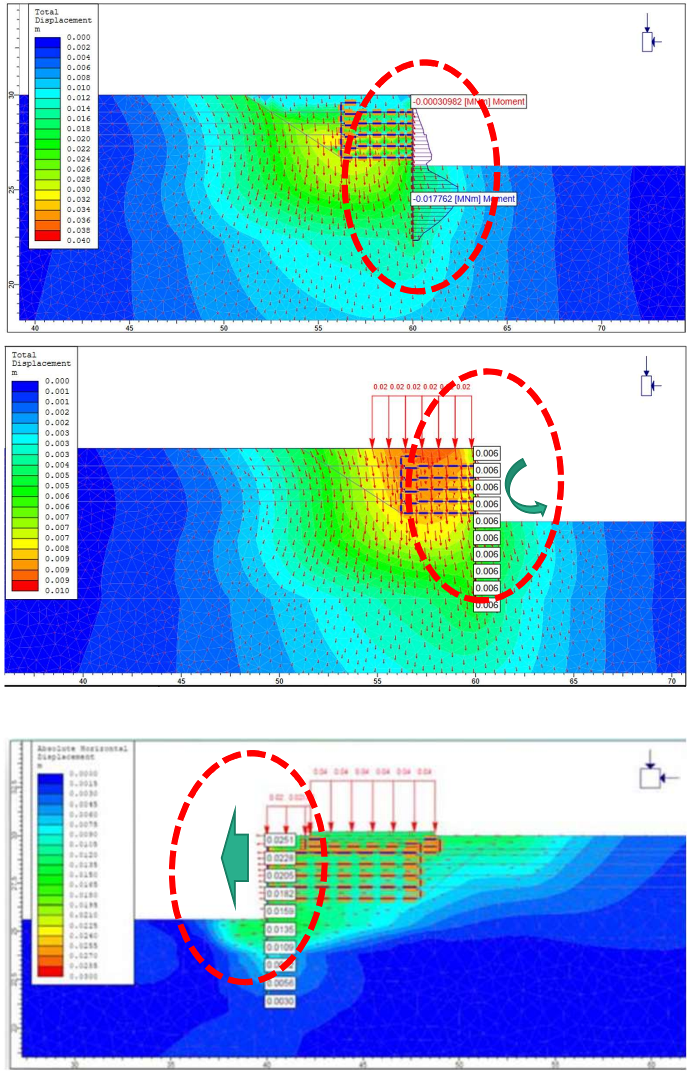
Stability check by Analytical Method (Hand calculation) - ok

Design Analysis and Results using FEM

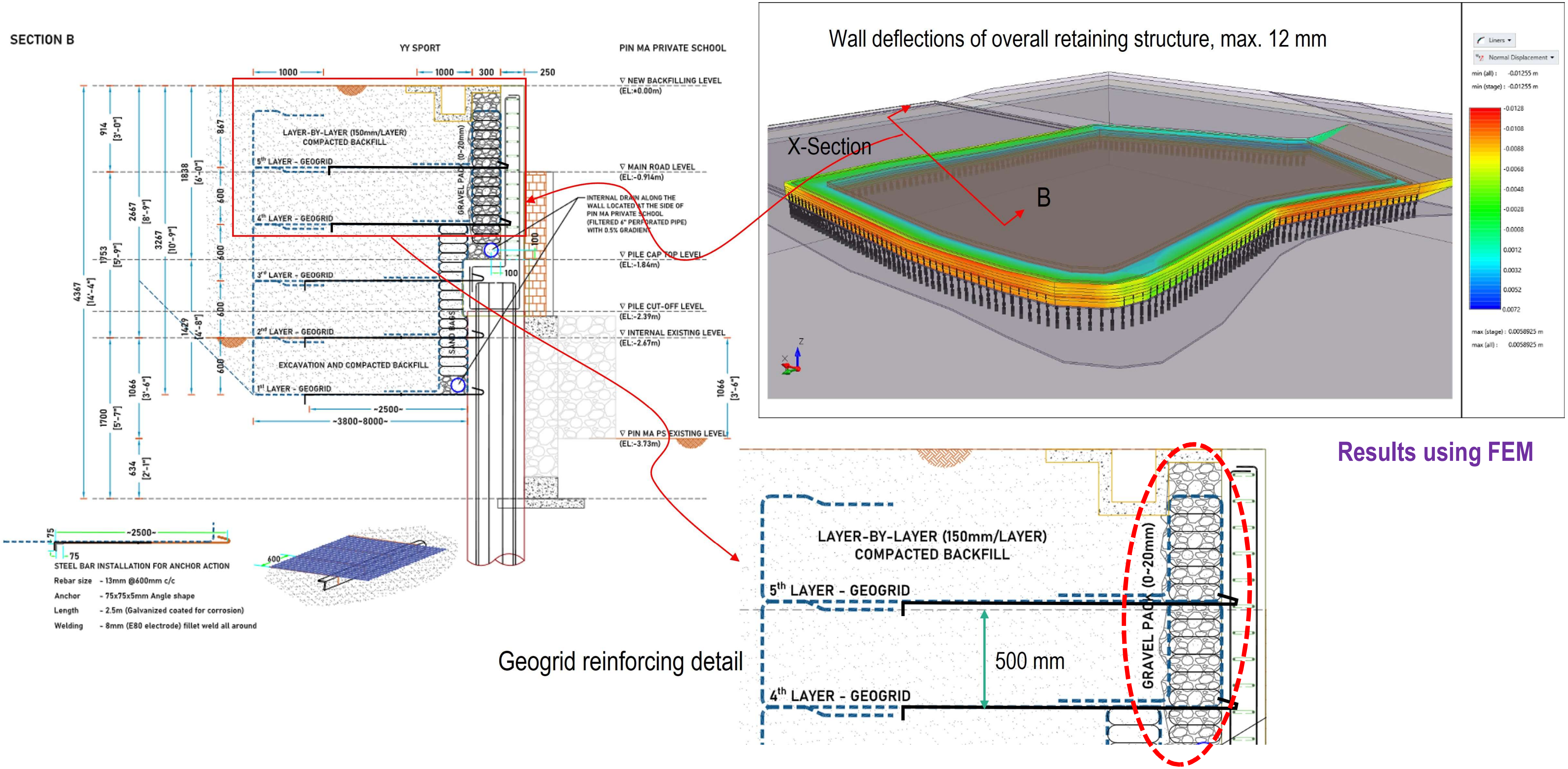
- Allowable wall deflection
- Allowable settlements (base and surface)
- Wall stability (Rigid or segmental facing)
  - i. Check the external stability,
  - ii. Check the eccentricity at base,
  - iii. Check the bearing pressure at base
  - iv. Allowable tensile strength of geogrid



Differential Settlement check along the wall
< 1/500 for Reinforced structures, ok



Results using FEM



SECTION B
YY SPORT
PIN MA PRIVATE SCHOOL
∇ NEW BACKFILLING LEVEL (EL:±0.00m)
∇ MAIN ROAD LEVEL (EL:-0.914m)
∇ PILE CAP TOP LEVEL (EL:-1.84m)
∇ PILE CUT-OFF LEVEL (EL:-2.39m)
∇ INTERNAL EXISTING LEVEL (EL:-2.67m)
∇ PIN MA PS EXISTING LEVEL (EL:-3.73m)
LAYER-BY-LAYER (150mm/LAYER) COMPACTED BACKFILL
5th LAYER - GEOGRID
4th LAYER - GEOGRID
3rd LAYER - GEOGRID
2nd LAYER - GEOGRID
1st LAYER - GEOGRID
EXCAVATION AND COMPACTED BACKFILL
GRAVEL PAD (0~20mm)
SAND BAGS
INTERNAL DRAIN ALONG THE WALL LOCATED AT THE SIDE OF PIN MA PRIVATE SCHOOL (FILTERED 6" PERFORATED PIPE) WITH 0.5% GRADIENT
~2500~
~3800~8000~
STEEL BAR INSTALLATION FOR ANCHOR ACTION
Rebar size - 13mm @600mm c/c
Anchor - 75x75x5mm Angle shape
Length - 2.5m (Galvanized coated for corrosion)
Welding - 8mm (E80 electrode) fillet weld all around
Wall deflections of overall retaining structure, max. 12 mm
X-Section
B
Normal Displacement
Results using FEM
Geogrid reinforcing detail
500 mm

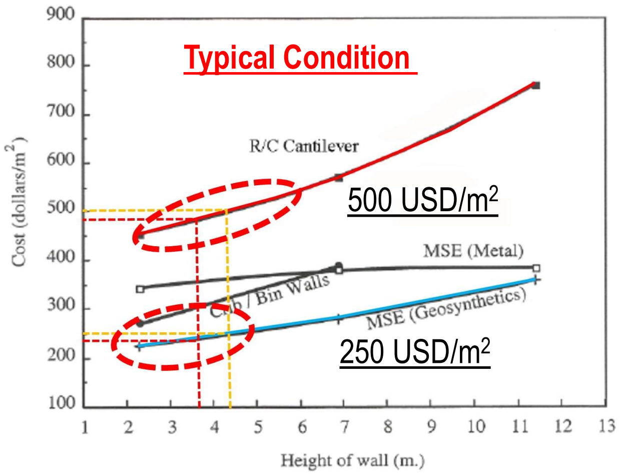
Suggestion

The geogrid reinforced retaining wall construction gain the following characteristics:

- The geogrid system is more flexible in nature. The retaining wall with the geogrid system has the *higher adapting ability with the deformation of the foundation*, when compared with *traditional construction*, which is very stiffer in nature.
- More flexibility implies they behave well as earthquake resistant.
- The onboard Geogrid arrangement has afforestation protection. This brings environmental benefits, which is an important parameter in sustainable construction.
- **It can be made *more economical, compared to traditional method*. *The landfill can be made steeper, which shows a cost reduction.*** More height in wall and steepness are designed with the help of reinforced soil system.
- The Geogrid retaining wall construction guaranty quality and *reduced cost of construction*.

With time the geogrid reinforcing retaining wall construction and its have advantages in the construction in *highways, railways, dams, ports*, planning city and projects focusing on the environment.

MOC Exp.



Relative Costs

Segmental Wall at Bridge Approach road

Use of Geogrids and Geotextiles

Project: : Approached Road Foundation Rectification, **Gone Nyin Dam Bridge,** **Maubin-phyapon Road**

Length: : Approached road, CH:42,850 m and CH:42,950 m**, Embankment height, $h_{max.}$ = 6.2 m**

Location: : Near Kyaiklat, Township, Ayeyarwady Region, Myanmar

Owner: : Ministry of Construction

Project management: : SMEC-OCG-PEG Joint Venture

Contractor: : SHWE TAUNG, WIKA, TOKYU, STK Joint Venture

Date: : 14.12.2020, [Monday]

Differential settlement along the roadway

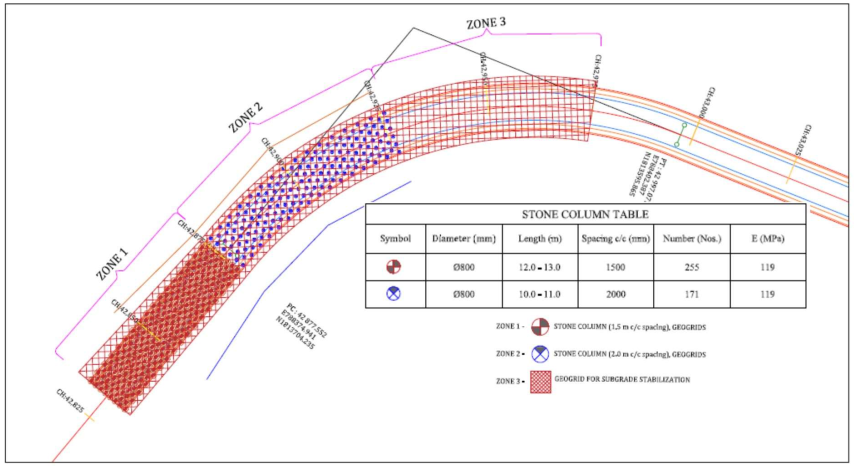
Maubin–Phyapon Road Rehabilitation Project, July – December 2019

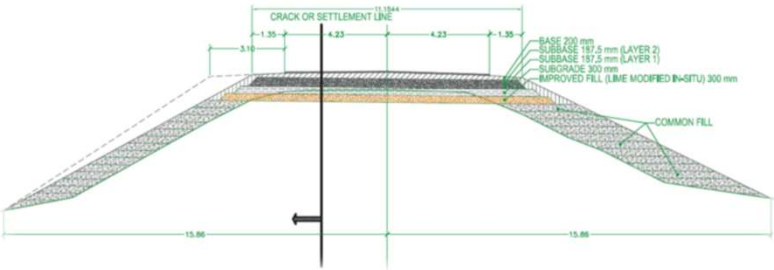
The proposed project aims to improve access to and within the Ayeyarwaddy Delta by rehabilitating 54.5 km of road between Maubin and Phyapon.

SMEC International Pty. Ltd., in joint venture with Oriental Consultants Global Co. Ltd., and Pyunghwa Engineering Consultants Ltd. for the Department of Highways, Ministry of Construction of Republic of Union of Myanmar, and the Asian Development Bank.

FHWA Distress Identification Manual identifies seven different types of road cracks:

1. Fatigue cracking - Repeated loading causes incremental damage. a group of interconnected road cracks form to break the road surface into multiple, irregular shaped pieces, usually less than 500mm in size.
2. Block cracking- Block cracking is a pattern that occurs as a series of roughly rectangular blocks, ranging from 0.3m to 3m in size.
3. Edge cracking- Edge cracking is long cracking in the outer 0.3 to 0.6m of a pavement that curves to the pavement edge.
4. Wheelpath Longitudinal cracking- parallel to the pavement's centerline, caused by fatigue.
5. Non-Wheelpath Longitudinal cracking- randomly located but still parallel to the centerline
6. Transverse cracking- thermally induced or due to underlying joints or cracks.
7. Reflection cracking- Reflection cracking describes cracking in asphalt overlay located in concrete pavements, or over shrinkage cracks in cement treated base layers.



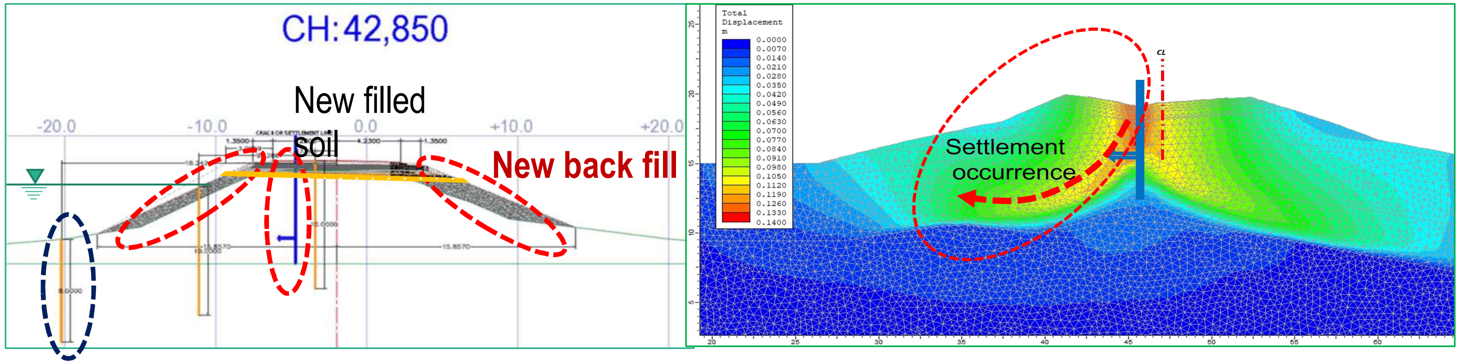


Causes of Foundation Settlement

Foundation Soil Properties (E, ν, c, ϕ) **:**

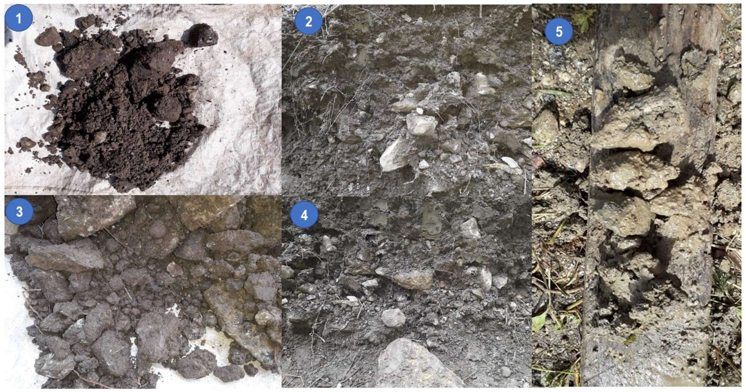
Soil Name	Consistency
Silty CLAY	Very soft
	Soft
	Medium Stiff
Clayey SILT	Very soft
	Soft
Silty SAND	Loose

- The roadway embankment between CH:42,850 m and CH:42,950 m is founded on the very soft clayey soil layers.
- **New back fill soil: Old soil layer and Lime stabilization**



Old embankment and New filled soil for the road widening along the road way

Differential settlement along the roadway



New filled soil conditions for the road widening portion of the road way

1. Selection of Structure Types: Rigid or Flexible Pavement
2. Selection of foundation Types: a comparative study for selecting foundation shall be also performed based on considering the subsoil conditions of the site.

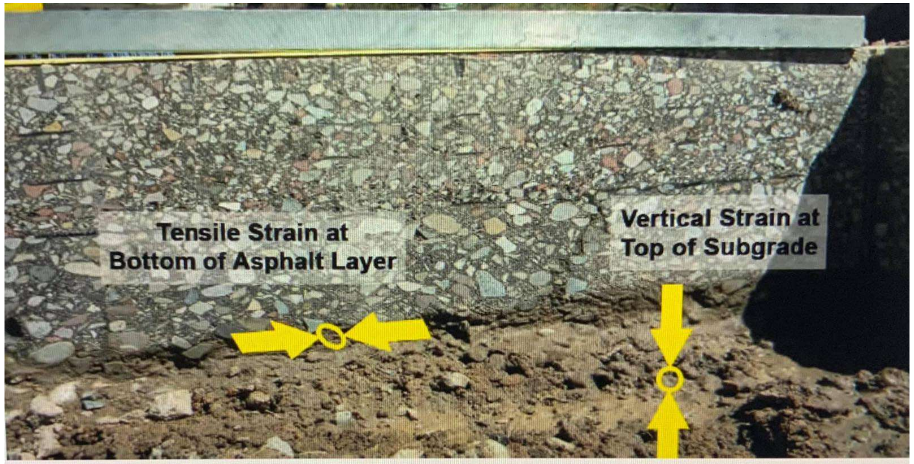


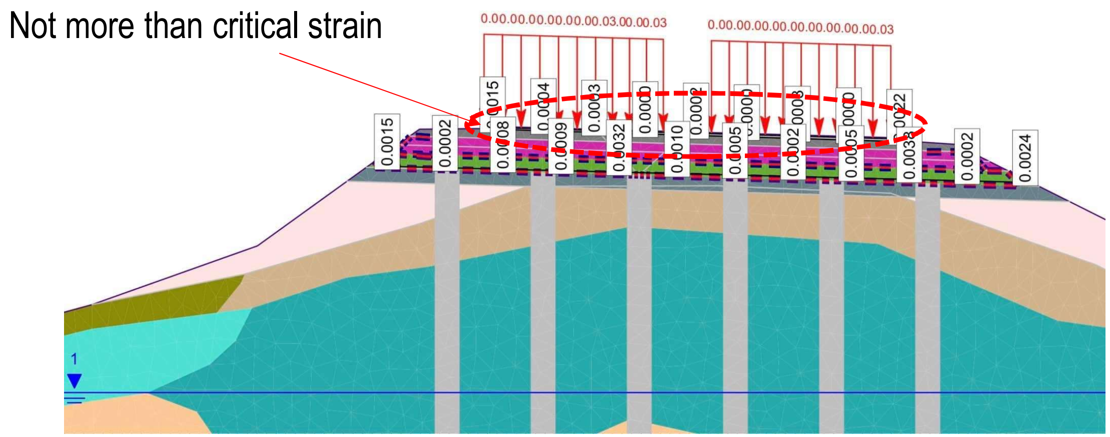
Figure 3-1. Location of Critical Strains in a Full-Depth Asphalt Pavement

Analysis Methodology

Three stages of design analysis were considered for road way foundation design;

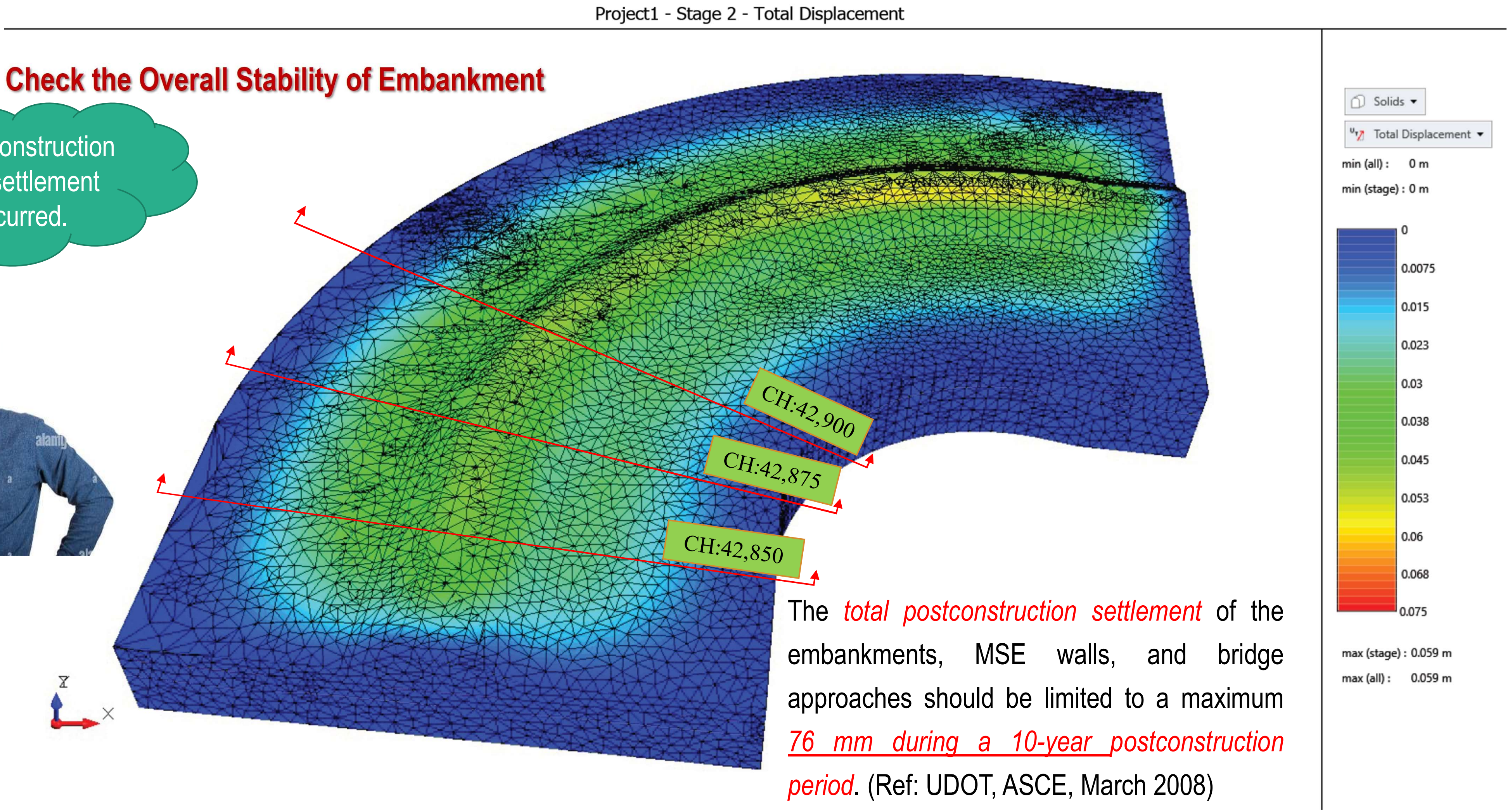
1. Check overall stability of embankment
2. Check the road way foundation excessive settlement
3. Check the Pavement Failure

Shear Strain at the bottom of Pavement and bottom of Subgrade Layers



Check the Overall Stability of Embankment

Excessive construction (primary) settlement was occurred.

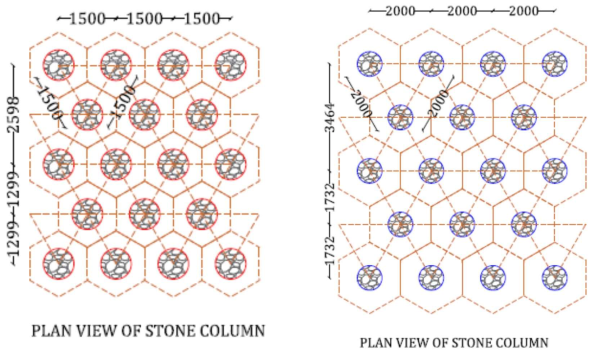


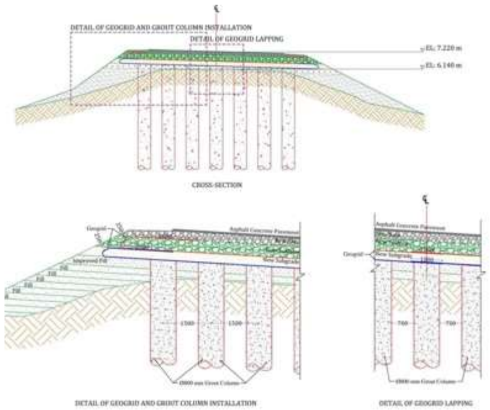
The *total postconstruction settlement* of the embankments, MSE walls, and bridge approaches should be limited to a maximum *76 mm during a 10-year postconstruction period*. (Ref: UDOT, ASCE, March 2008)

Method Selection for Foundation Rectification:

Combination of Stone Column/Jet grout and Reinforcement ***(CSE Method)***

1. Stone Column/Jet Grout:
   - Column Diameter = 800 mm diameter
   - Column spacing = 1.5 m x 1.5 m – 2.0 m x 2.0 m
   - Length of stone column = 10 m - 12 m
   - F_c' = 3 - 5 MPa., E = 14000 MPa
2. Use of Geosynthetics for Reinforcement: Geogrids and geotextiles

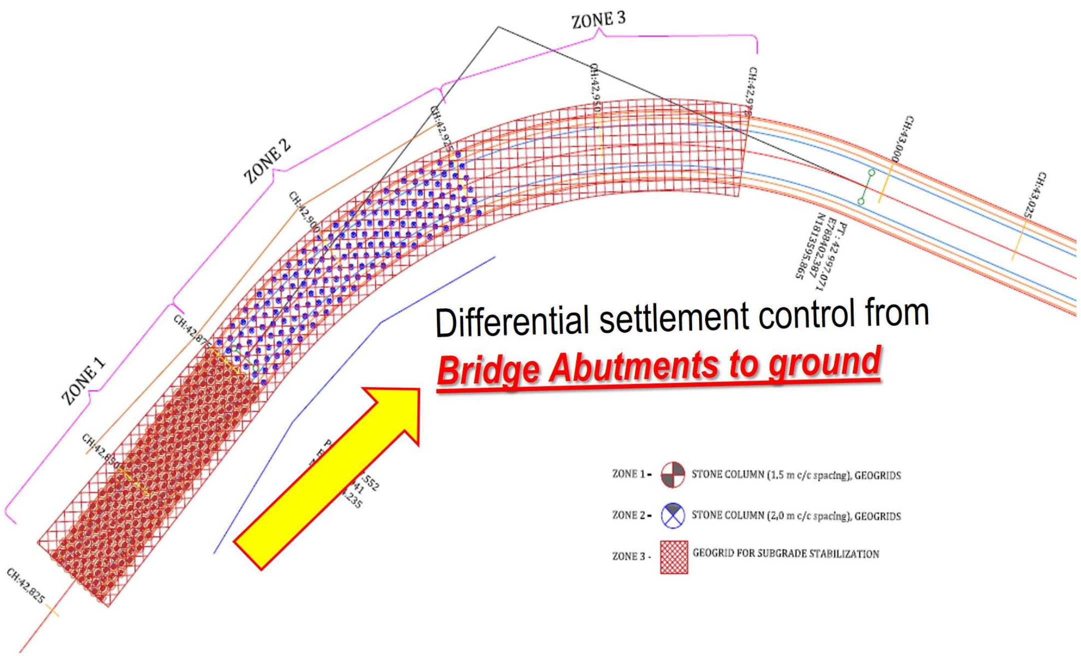




Spacing and Pattern of Stone Column

Use of Stone Column:

1. To control the overall settlement of road foundation due to the deep soft soil condition (recent soft soil deposit)
2. To control the overall slope stability of high embankment (approached road to bridge)
3. To act vertical drainage paths for settlement mitigation and to reduce the drainage path in a thick compressible soil layers.



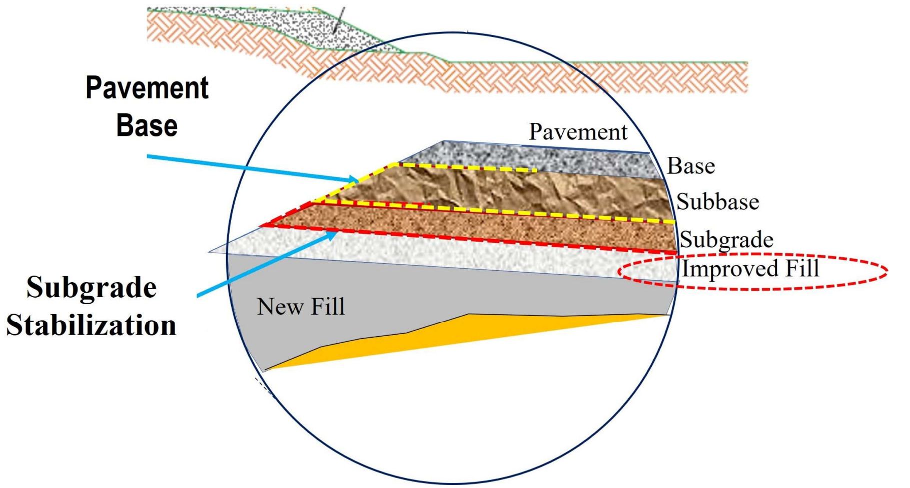
Use of Geogrid in Road Pavement Construction

The geogrid construction in pavement construction have following features:

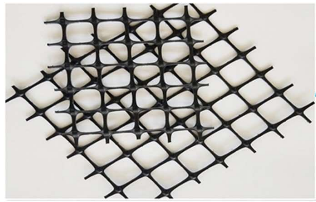
- **Improvement of subgrade:**
  1. The subgrade, which is the most important load bearing strata, is made solid and strong by the geogrids.
  2. The problem of soft subgrade can be solved by this method.

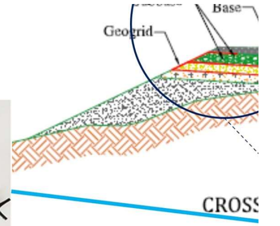
Use of Geogrids:

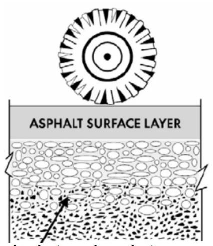
1. To control the lateral movement of the subgrade *aggregate to separate between the subgrade and improved soil*
2. To obtain the load distribution on *improved soil layer and stone column*
3. To increase in *bearing capacity*



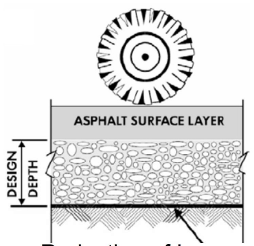
Reinforced Action for Subbase Layer





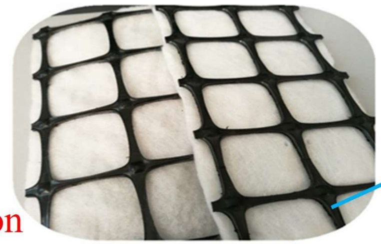


Subgrade intrusion into Improved soil



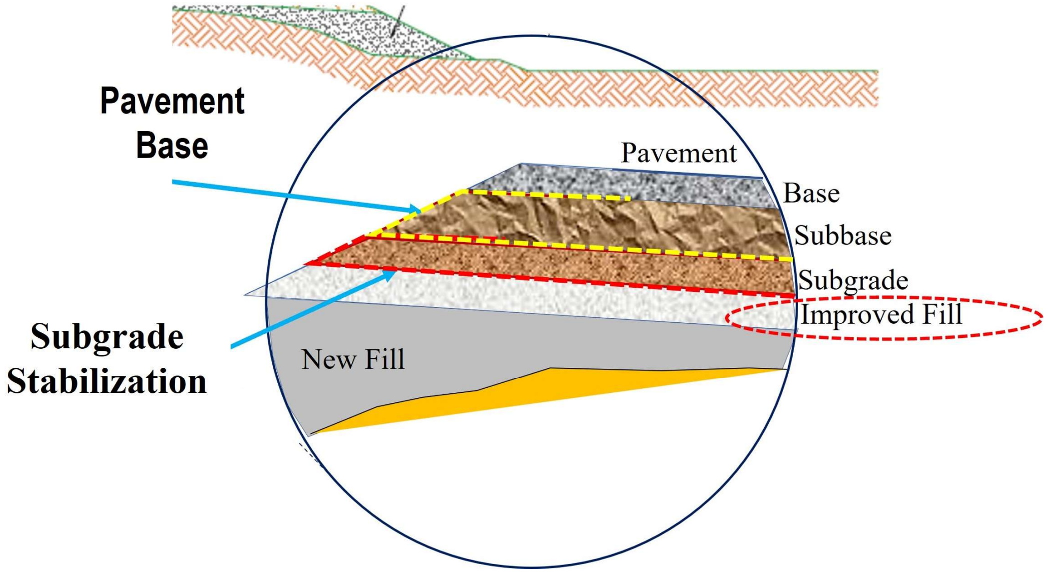
Reduction of Improved soil contamination

Combination of reinforced action and Separation Action for Subgrade Layer



Subgrade Stabilization

- **Reinforcement of pavement base:**
  1. To control the lateral movement of the subbase aggregate: The thickness of base if increased would increase the stiffness of base. But increasing thickness enormously is not economical.
  2. The reinforcement to a given base layer would give *adequate stiffening to reduce the thickness and time of construction*.
  3. This also helps in increasing the life of the pavement..



Properties of Geogrid:

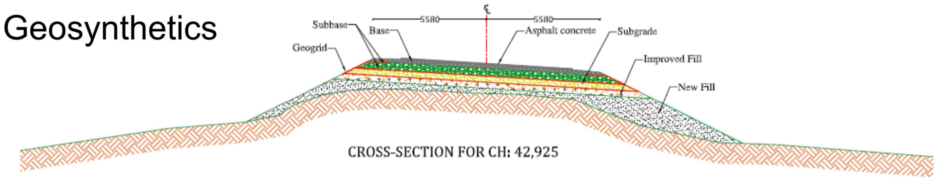
- Mechanical, physical, durability
- Aperture size (36 x 34 mm)
- Strain rate, 13%
- Tensile Strength, 21 kN/m
- ASTM D-6637 for strength test and ASTM D-7737 for Junction strength test

Properties of Subbase:

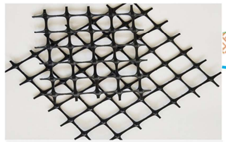
- The size distribution subbase aggregate is selected based on the aperture of geogrid to obtain sufficient frictional resistance.

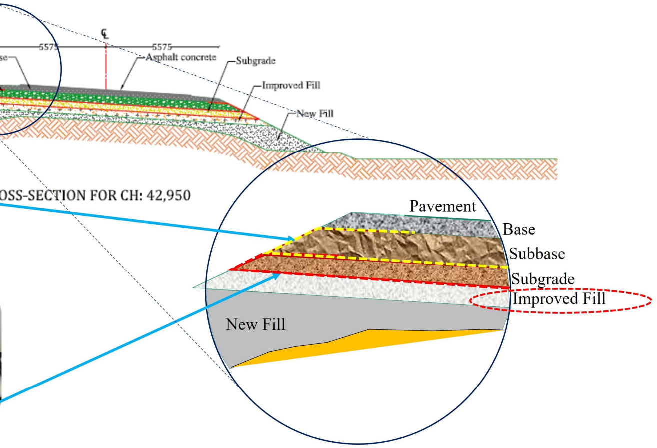
Load transfer platform select fill placement

Use of Geosynthetics

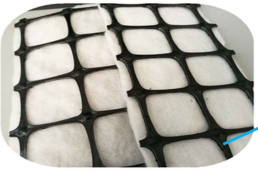


Reinforced Action for Subbase Layer



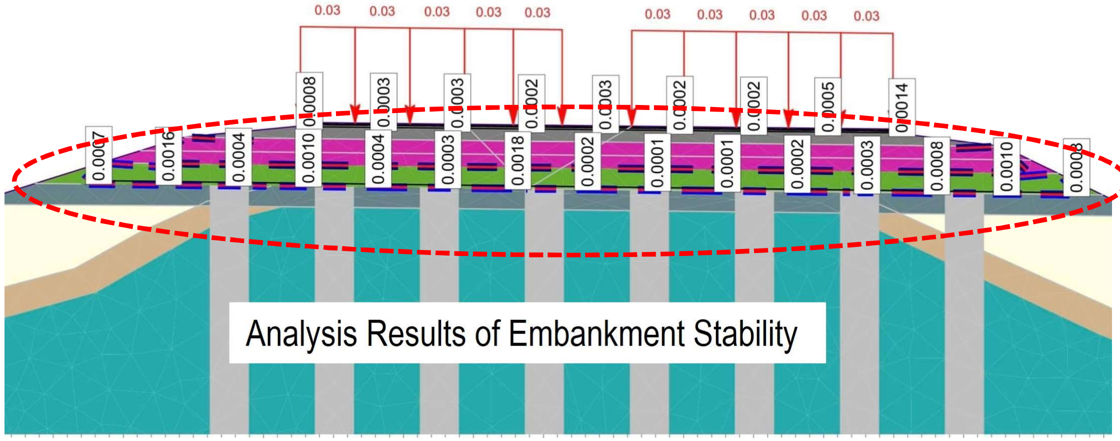


Combination of reinforced action and Separation Action for Subgrade Layer



Load transfer platform reinforcement placement

Shear strain at the bottom of Pavement and Bottom of Subgrade Layers



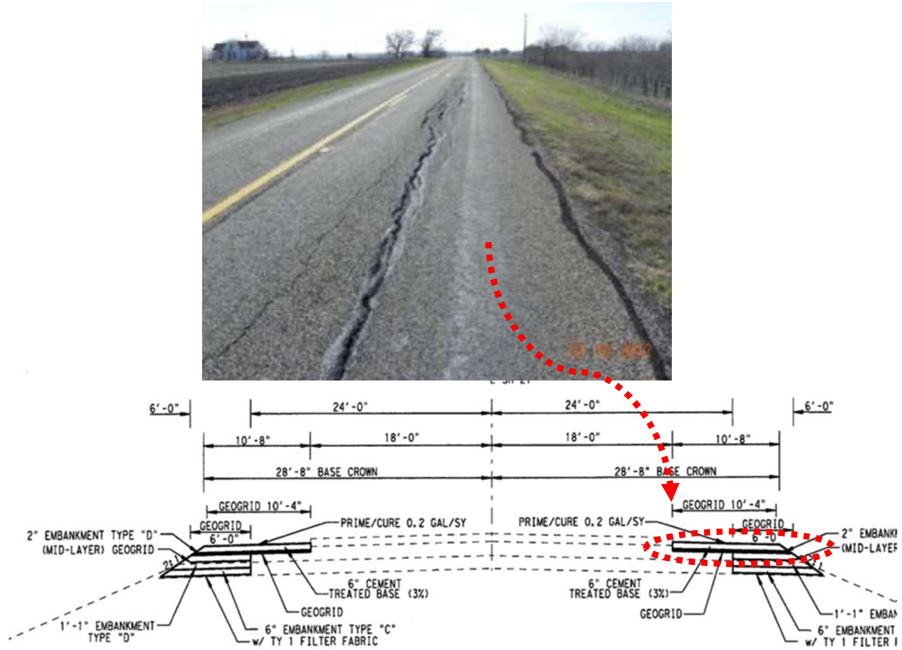
Analysis Results of Embankment Stability

Road Widening and Soil Stabilization

Excavation of unsuitable materials Km 19 to 22 and *Lime Stabilization*

The main objectives of the soil stabilization is to increase the bearing capacity of the soil, its resistance to weathering process and soil permeability.

1. The long-term performance of any construction project depends on the *soundness of the underlying soils.*
2. Unstable soils can create significant problems for pavements or structures, Therefore *soil stabilization techniques* are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially *in case of soil which are highly active*.
3. A lot of time and millions of money will be happened depended on the method of cutting out and *replacing the unstable soil.*

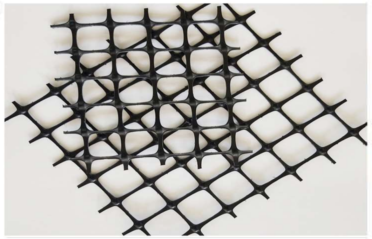


Foundation Condition for Road Widening

1. Differences between old and new foundation in structural thickness, Material properties and degree of compaction
2. Different stiffness
3. Foundation stability
4. Embankment Stability

Extruded Type of PP Biaxial Geogrid for *Road Base Reinforcement and Subgrade Stabilization*

Subbase Reinforcement



Subgrade Stabilization

Index for PPBG30-30	Test method	Units	MD values	TD values
Polymer	-	-	PP	-
Minimum carbon black	ASTM D4218	%	2	-
Tensile strength @ 2% Strain	ASTM D6637	kN/m	10.5	10.5
Tensile strength @ 5% Strain	ASTM D6637	kN/m	21	21
Ultimate Tensile Strength	ASTM D6637	kN/m	30	30
Strain @ Ultimate Strength	ASTM D6637	%	13	13
Structural Integrity				
Junction Efficiency	GRI GG2	%	90	90
Overall Flexural Rigidity	ASTM D1388	mg-cm	3,930,000	
Aperture Stability	COE Method	mm-N/deg	1432	
Dimension				
Aperture Dimensions	-	mm	36	34
Minimum Rib Thickness	ASTM D1777	mm	2.1	1.8
Roll width		m	3.95	
Roll length		m	50	

Index for PPBG C 30-30	Test method	Units	MD values	TD values
Polymer	-	-	PP	-
Minimum carbon black	ASTM D4218	%	2	-
Tensile strength @ 2% Strain	ASTM D6637	kN/m	10.5	10.5
Tensile strength @ 5% Strain	ASTM D6637	kN/m	21	21
Ultimate Tensile Strength	ASTM D6637	kN/m	30	30
Strain @ Ultimate Strength	ASTM D6637	%	13	13
Structural Integrity				
Junction Efficiency	GRI GG2	%	90	90
Overall Flexural Rigidity	ASTM D1388	mg-cm	3,930,000	
Aperture Stability	COE Method	mm-N/deg	1432	
Dimension				
Aperture Dimensions	-	mm	36	34
Minimum Rib Thickness	ASTM D1777	mm	2.1	1.8

Train Speed Control

Foundation Improvement for the differential settlement control:

- The differential settlement is **not more than 10 mm over 10m chord**, which is equivalent to angular distortion of 1:1000 (0.10%) along the rail line and uniform settlement in traverse line.

Design References:

1. Geotechnical Analysis and Design Guidelines, Technical Memorandum (TM 2.9.10), California High-Speed Rail Authority
2. Instruction of Myanmar Rail Way Department and JICA Project Management Team

Coffee break

10:30 am to 11:30 am

Part-2 (1 hour)

Road Foundation Improvement by Soil Reinforcement

Project: : Approached road foundation

Length: : Approached road for both sides

Location: : Thitsar Road, Nge Moe Yeik Bridge Construction Proj

South Okkalapa-north Dagon, Yangon

Client: : Ministry of Construction

DATE: : 14/JULY/2017

Soil Profile

<u>North Dagon side:</u>

- Recent filled sand layer about 2 m (N=24)
- Medium stiff clay soil with organic soil about 2 m (N=7), and
- Medium stiff clay soil layer about 13 m thick (N=5).

<u>South Okkalapa side:</u>

- Silty clay soil about 2 m thick (N=6),
- Lateritic about 1 m (N=9),
- Sandy clay 3.5 m (N=9) and
- Silty clay with N=9 were found and followed the higher N values of clayey silt, sandy clay soil layers.

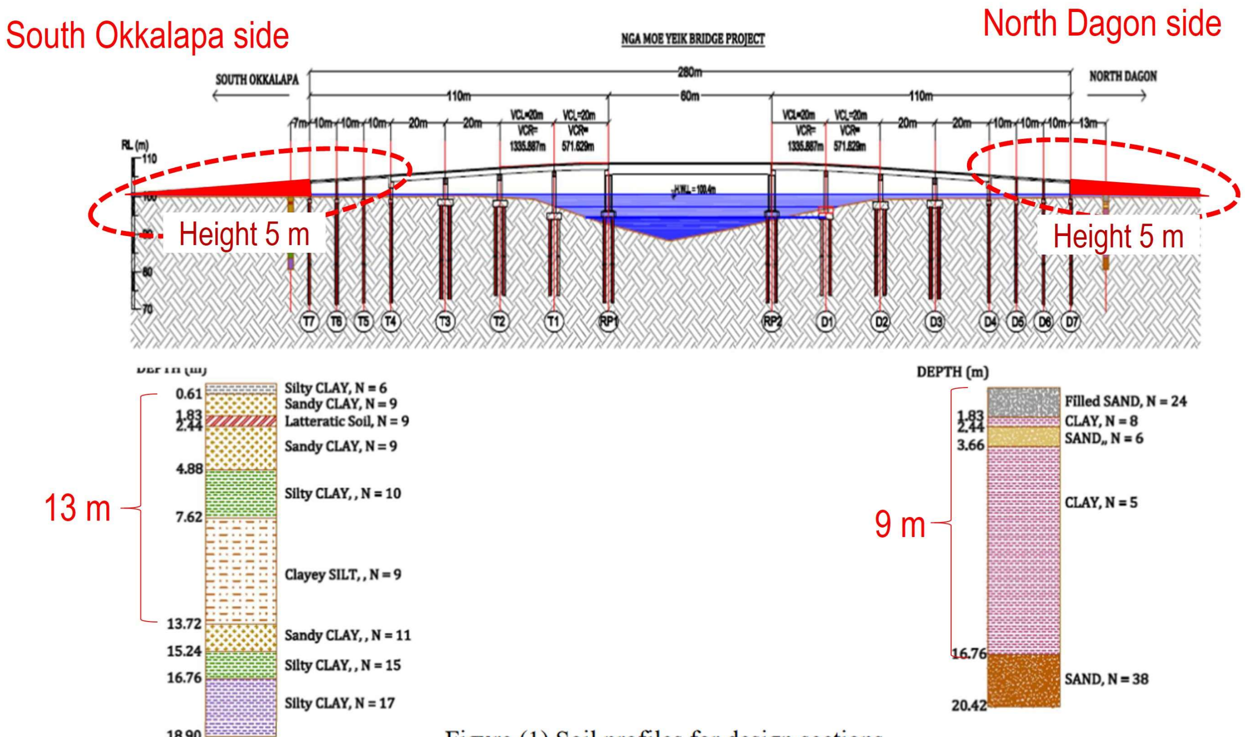


Figure (1) Soil profiles for design sections

Remark

1. ***Deep excavation is required to achieve the design soil bearing capacity***
2. ***Problem or costly excavation is required due to fluctuation of water level.***

The main design requirements are discussed with Client:

- To control settlement of bridge approach road
- Differential settlement control from ***ground to Bridge Abutments***

<u>Application of Sand Column(Sand Piles)</u>

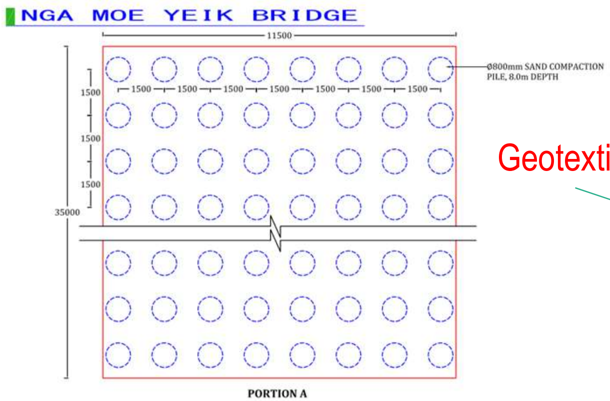
1. To achieve the bearing capacity and control road surface settlement
2. To avoid the liquefaction effect

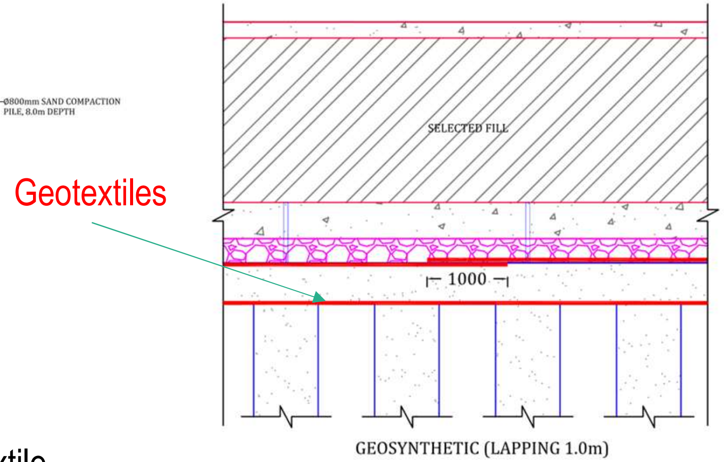
<u>Application of Geotextile</u>

1. To obtain the load distribution on foundation
2. To achieve the confinement the improved soil (reduction in lateral movement of the soil)

Steps of Construction:

1. Sand compacted pile
2. Reinforced compacted sand with geotextile
3. Reinforced RC based slab and reinforced wall
4. Filling the selected material and
5. Continue the reinforced road slab





Sand Column (Piles) with Geotextile

The maximum traffic load with 75 tons. In analysis, 45 kPa of traffic load with the dynamic load factor of 1.4 is adopted.

North Dagon side

SCP length = 8 -10 m

Spacing = 1.5 m x 1.5 m

SCP diameter = 800 mm

South Okkalapa side

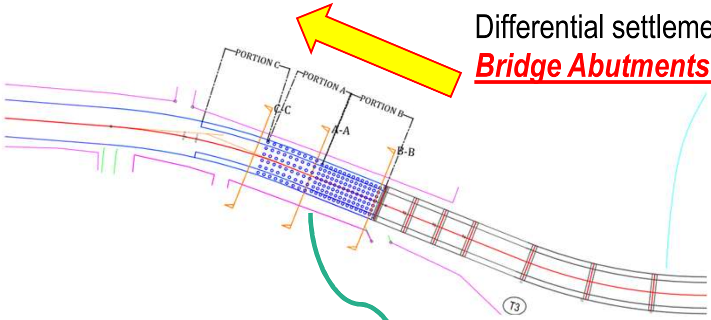
SCP length = 8 m

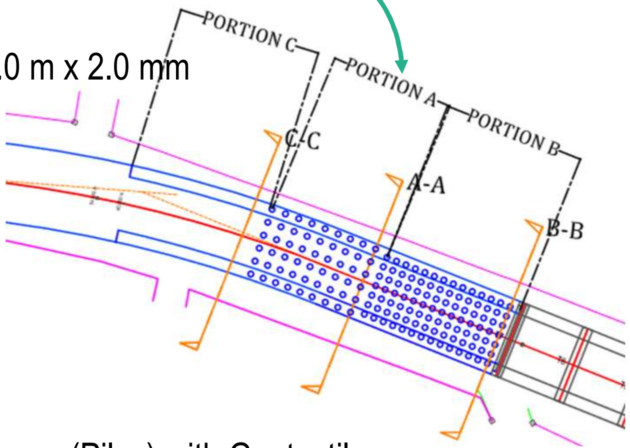
Spacing = 1.5 m x 1.5 m – 2.0 m x 2.0 mm

SCP diameter = 800 mm

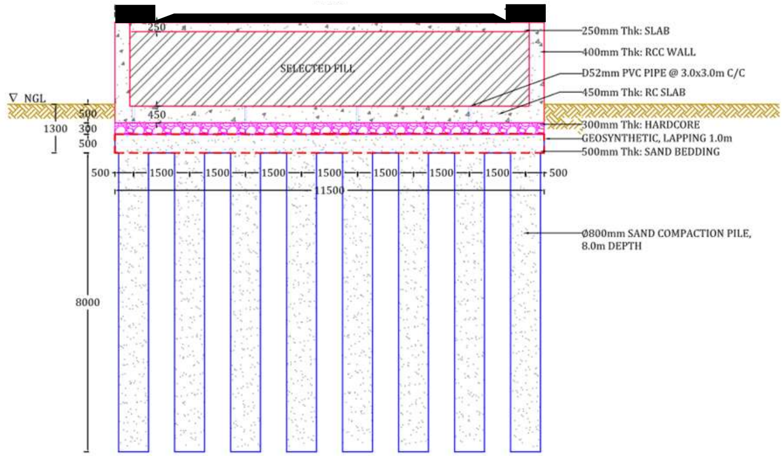
PILING PLAN OF SOUTH OKKALAPA SIDE

Differential settlement control from ***Bridge Abutments to ground***



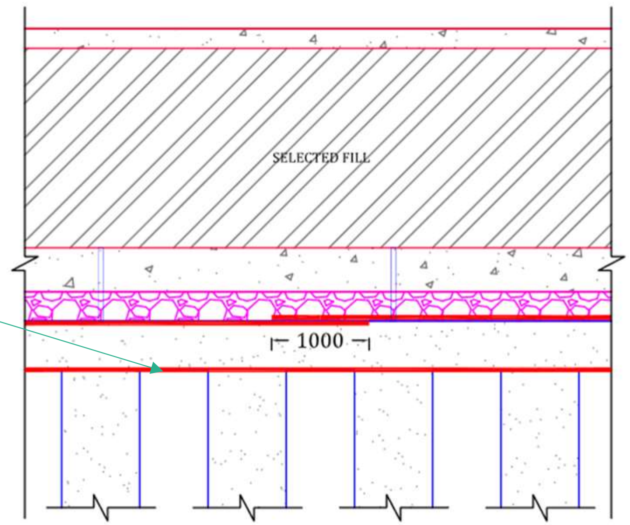


Sand Column (Piles) with Geotextiles



DESIGN SECTION A-A

Geotextiles



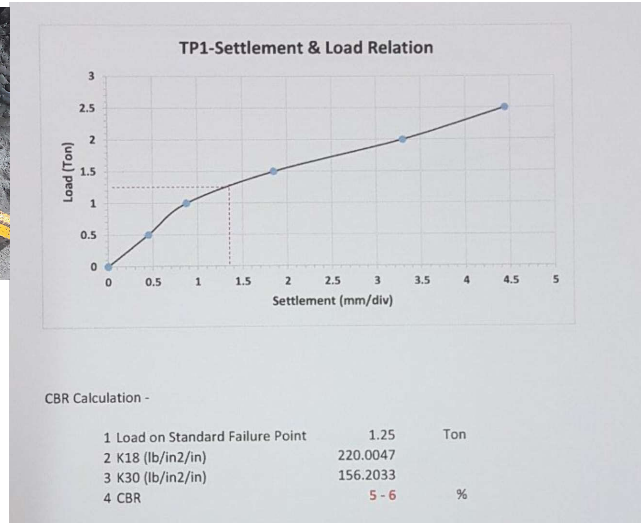
GEOSYNTHETIC (LAPPING 1.0m)

South Okkalapa side

North Dagon side

Load Tests of SCP, q_{all} = Area of plate in Sq-m x (γ_f x H + traffic load)

CBR Test



Slab Connections with Bridge Abutments

Allowable settlement limits of approached road:

- The required design length of *an approach slab (L)* can be estimated As (briaud et al., 1997, state dots):

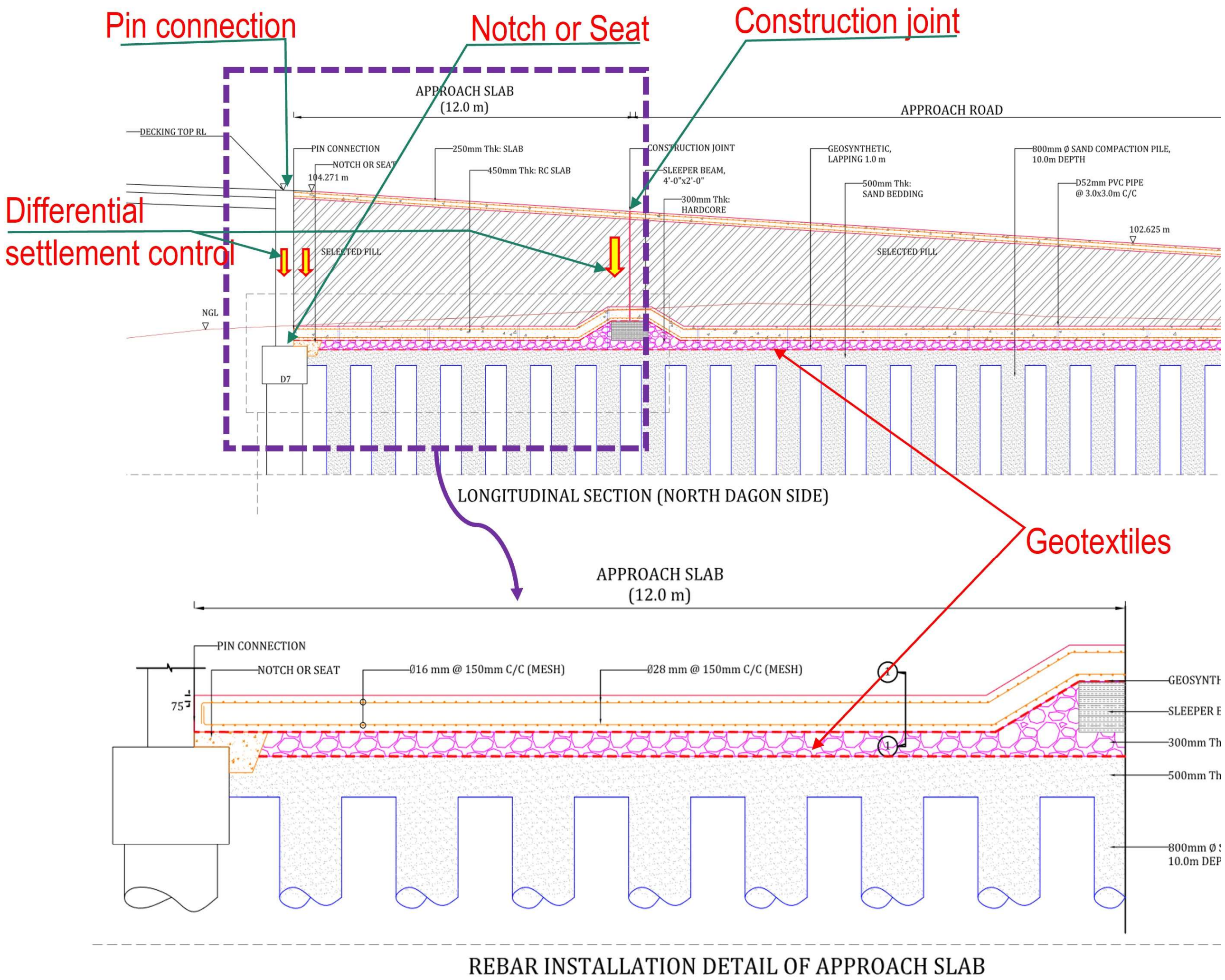
$$L \geq 200\ (s_f - s_a)$$

where s_f = the estimated total settlement at the end of the approach slab, and

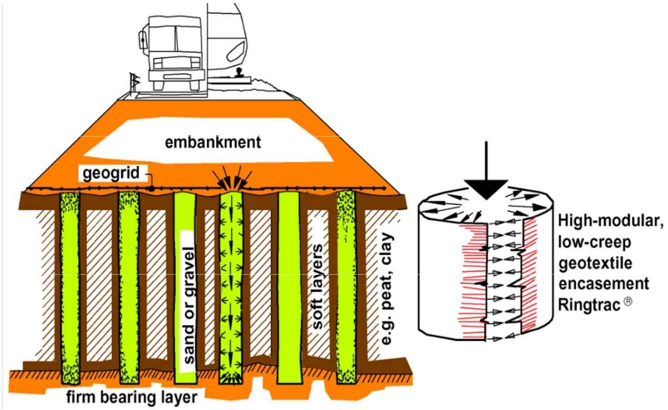
s_a = the estimated settlement of the bridge abutment. Here, s_a is adopted as zero.

Allowable settlement limits for this project:

- At North Dagon side, L shall be 12.0m for corresponding to acceptable differential settlement 60 mm (2.4 in).
- At South Okkalapa side, L shall be 6.0m for corresponding to acceptable differential settlement 30 mm (1.2 in).

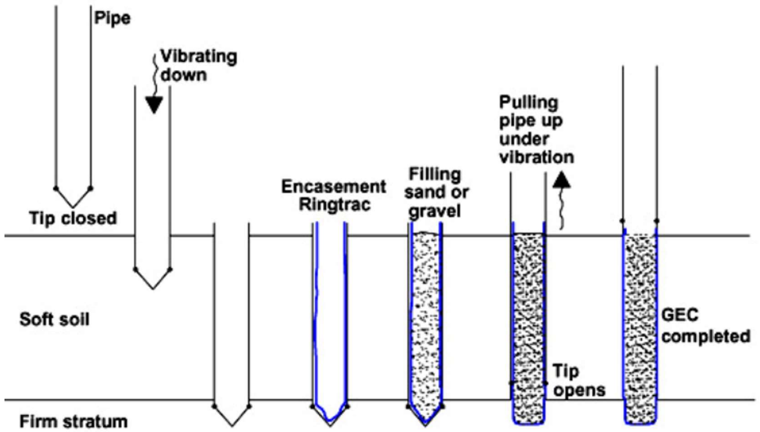


Geotextile Encased Column (GEC) Foundation System



General idea of embankment on soft soil set on Geosynthetic Encased Columns (GECs)

Confining capability of high strength geotextile encasement

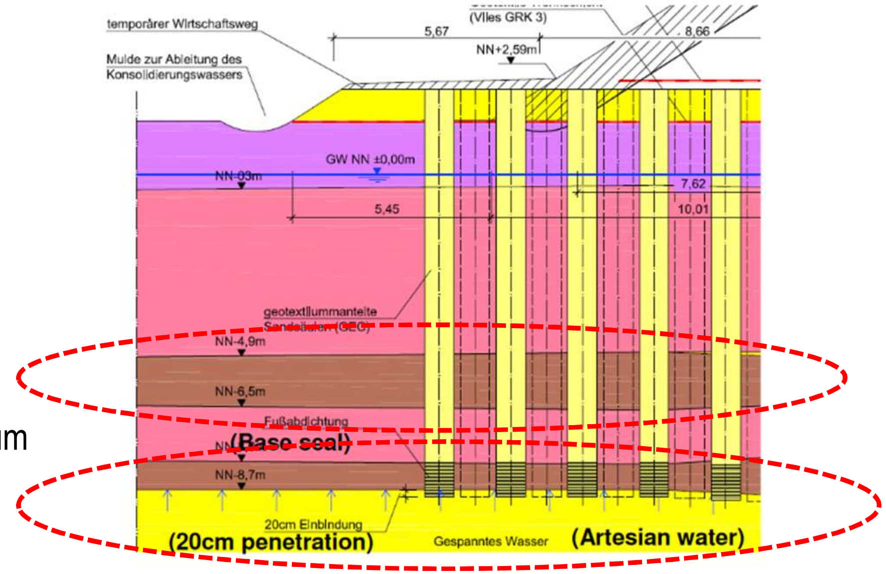


Displacement method of construction

Installation of geotextile encasement

Completed Geosynthetic Encased Columns

Firm stratum



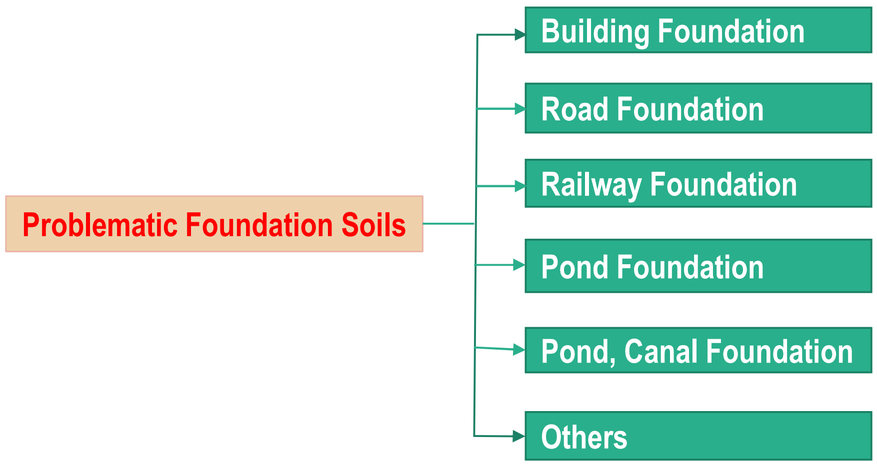
GEC with base seal – excerpt from highway production drawing

Geotextiles for Separation action, Filtration, Reinforcement, Barrier

Project: : Pump Station Mat Foundation

Location: : Mandalay

DATE: : JULY, 2019



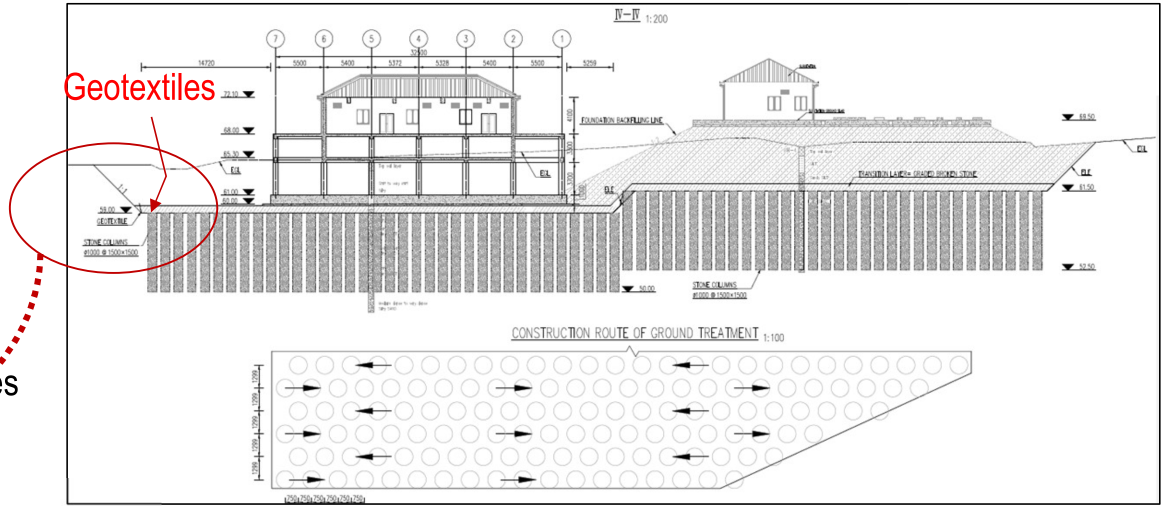
Solution for Problematic Soils (Collapsible soil, Expansive soil, Dispersive soil, Lateritic soil etc.)

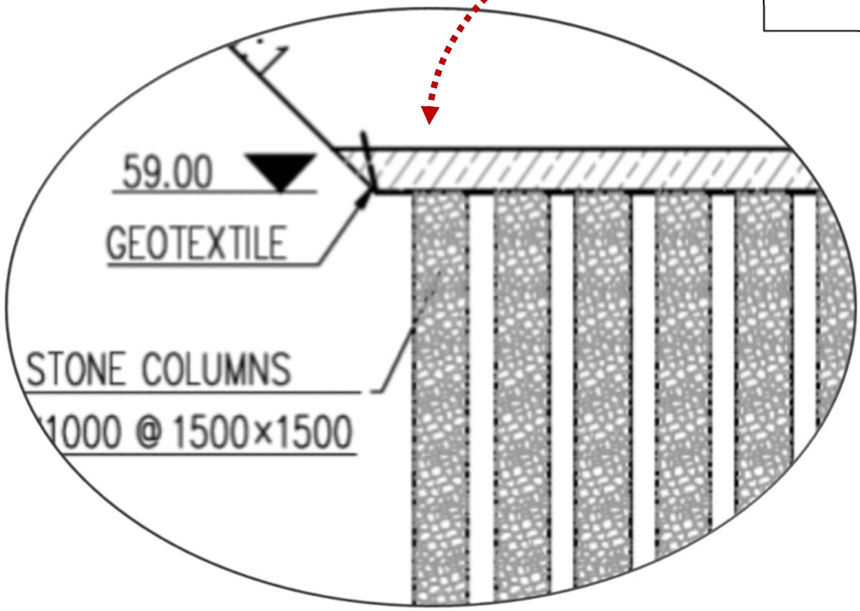
1. Where the thickness is thin layer, removal of **problematic soils** is a good option.
2. Chemical Soil Stabilization- Cement, lime, or any other chemical additives can be used for *soil treatment*.
3. Where the problematic soil layer is very thick and it will not be suitable for conventional deep foundation, mechanical *soil improvement* should be used.

NOTE: Sandy dispersive soil and expansive clay soils are commonly found in agricultural areas.

Combination of Stone Column and Separation action

1. Stone Column:
   - Stone Column Diameter = 1000 mm diameter
   - Stone column spacing = 1.2 m x 1.2 m and 1.5m x 1.5m
   - Length of stone column = 8 m
2. Use of Geosynthetics for Reinforcement: Geogrids and geotextiles





Applications of Geogrids in Building Foundation Soil

Stone Column Installation

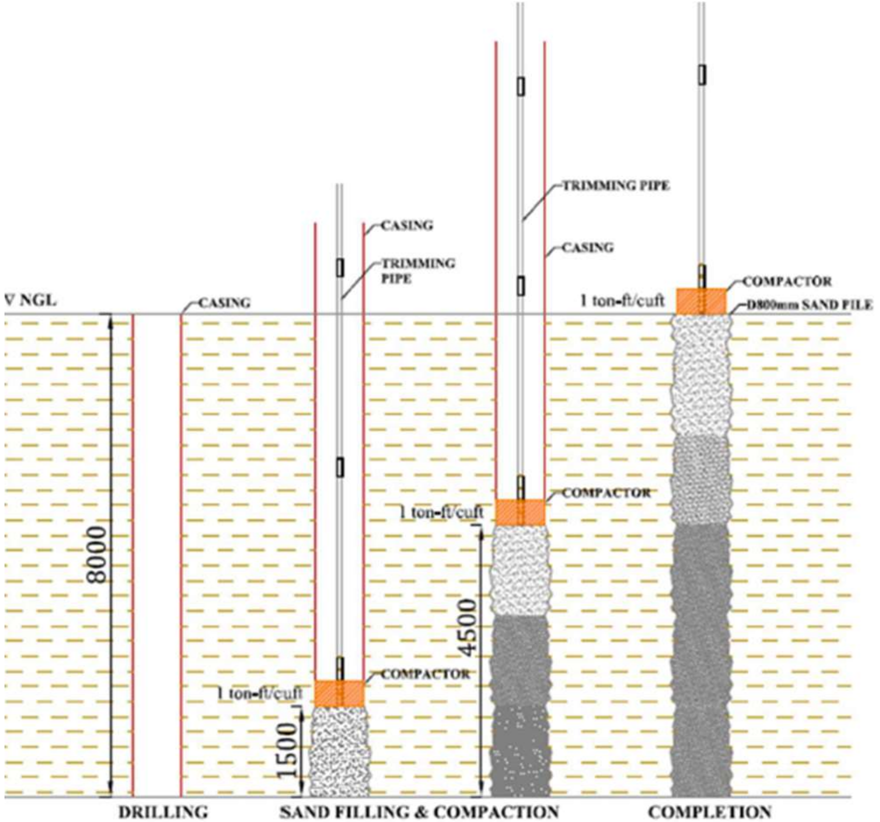
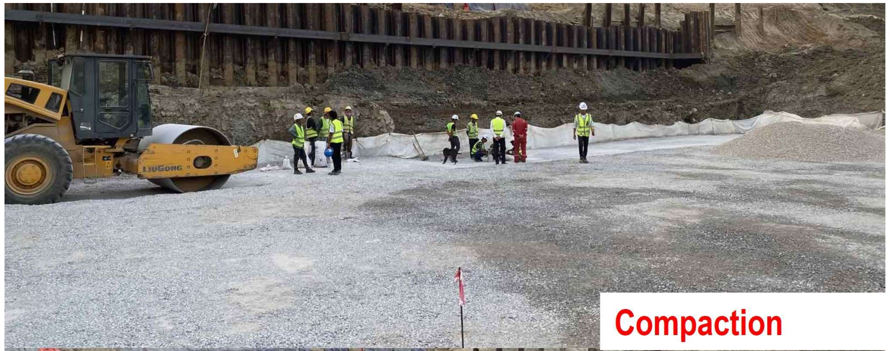


FIG: VIBRO-REPLACEMENT METHOD PROCESS

Placing the geotextiles

Sand cone test



Compaction

Preparation for Base Slab

Concreting for Base Slab

Geotextile for Erosion Protection

Project: **:** Jetty Construction

Location: : THAKETA, YANGON

Client: : Total E & P Myanmar

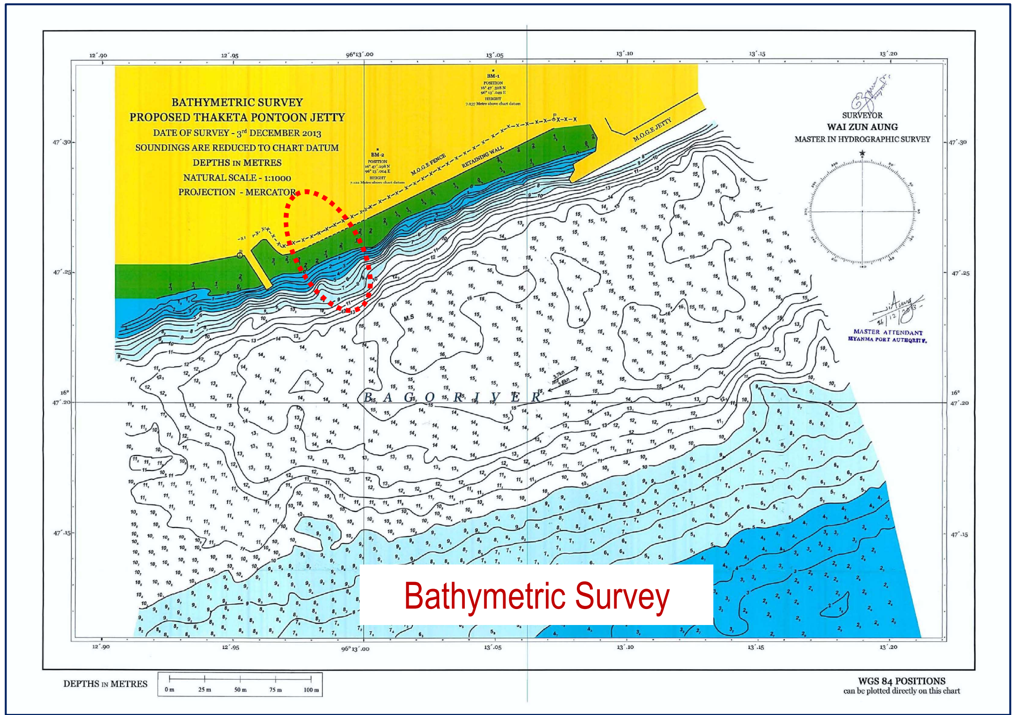
DATE: : JULY, 2013

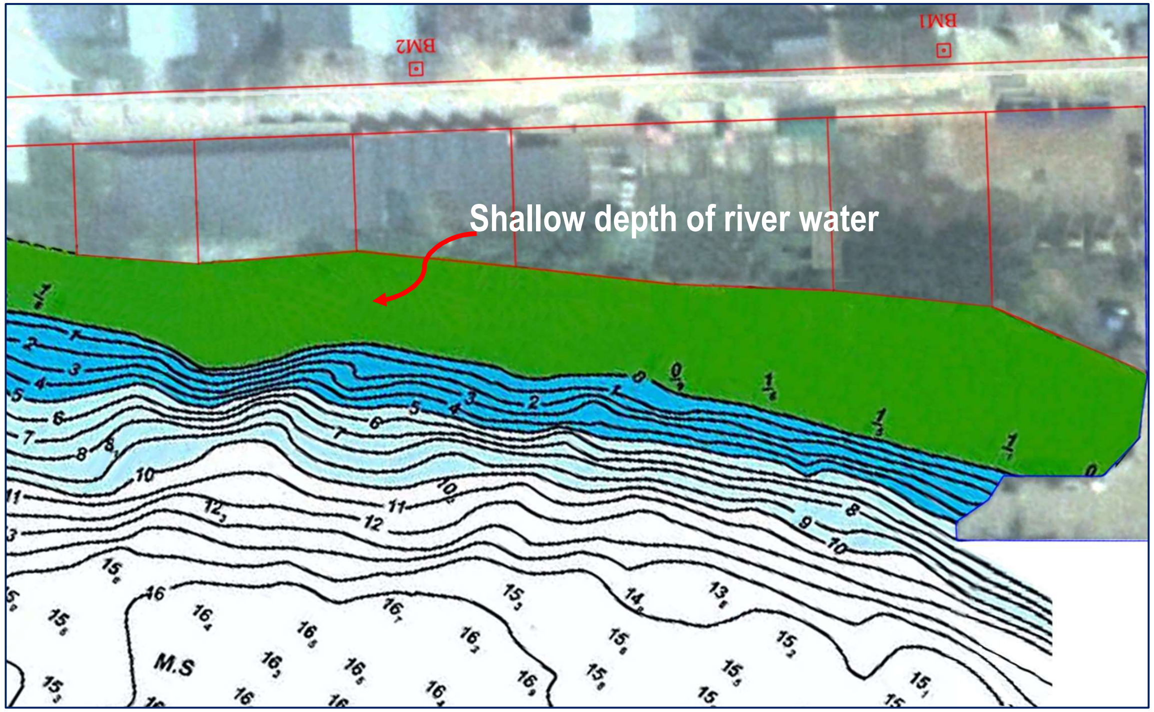
Design Consideration

Designs of support system which includes as:

1. Sheet pile and capping beam
2. Ground anchor pile and anchor beam
3. Reinforced pile with inclined strut for sheet pile support to resist the loading
4. Embankment erosion protection

Site Information





1.90344 m/s

1.852 m/s

8. Tidal Stream

8.1 The tidal stream observations were carried out by floating ball on 3rd December 2013during spring tides. The current is 3.7 knots toward 59 degree at high tide and 3.6 knots toward 248 degree at low tide.

Site Information

- Soil investigation
- Erosible soil condition

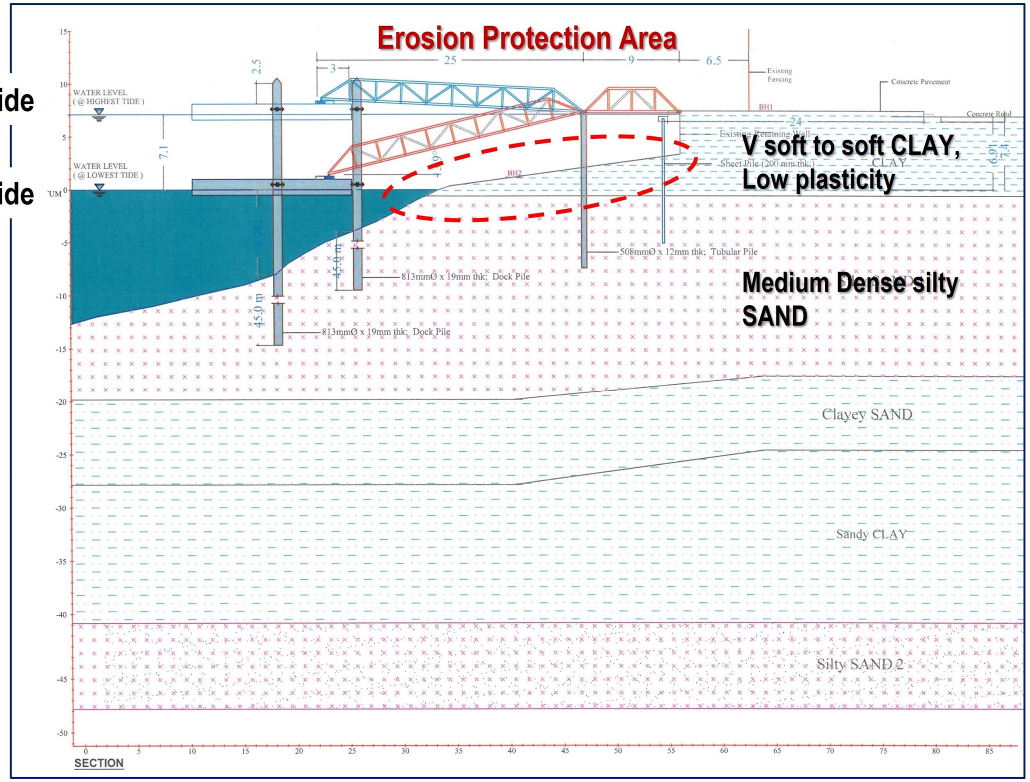
Erosion due to tidal wave

Site Information

- Geology of Site
- Soil Profiles
- Water Level

Water Level (@ Highest Tide

Water Level (@ Lowest Tide



Design of embankment erosion protection:

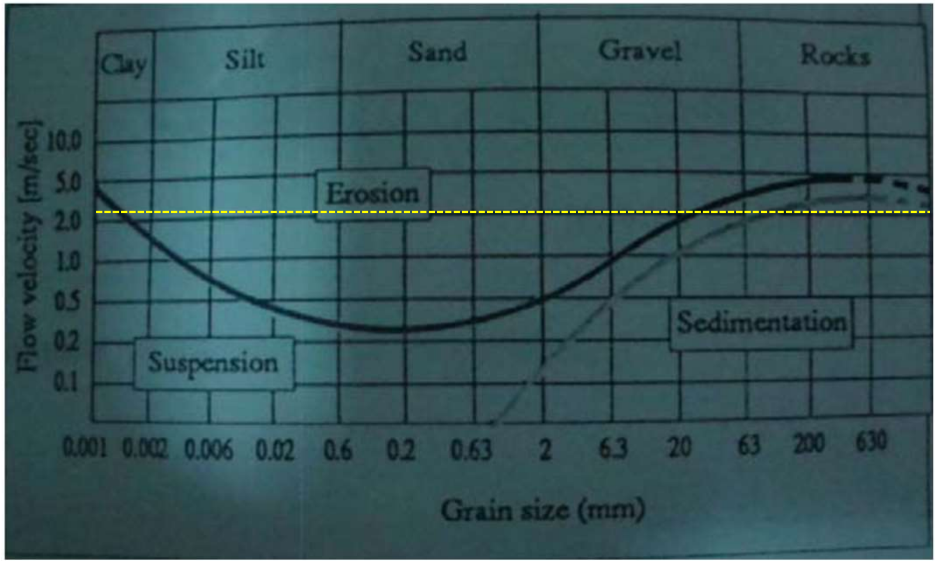
1. Slope stability
2. Geotextile application with required functions for mechanical and hydraulic filtration for slope stability

Function of geotextile:

1. Filtration
2. Resisting the punching force

Specification of geotextile:

1. Clogging criteria for selection of type of geotextile in cohesive soil was designed.
2. For clay layer, sand layer thickness of 200 mm is used for primary filter.
3. To avoid geotextile clog for long term, FHWA recommends the *minimum porosity of geotextile shall be greater than 60%.* Polyfelt geotextile has > 80%.
4. Polyfelt was selected having the lowest grade of polyfelt TS 600 for the required punching resistance.

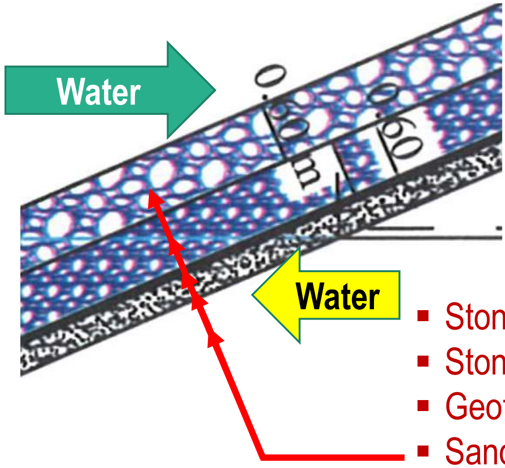


Susceptibility of soil particles to erosion, FHWA (1988)

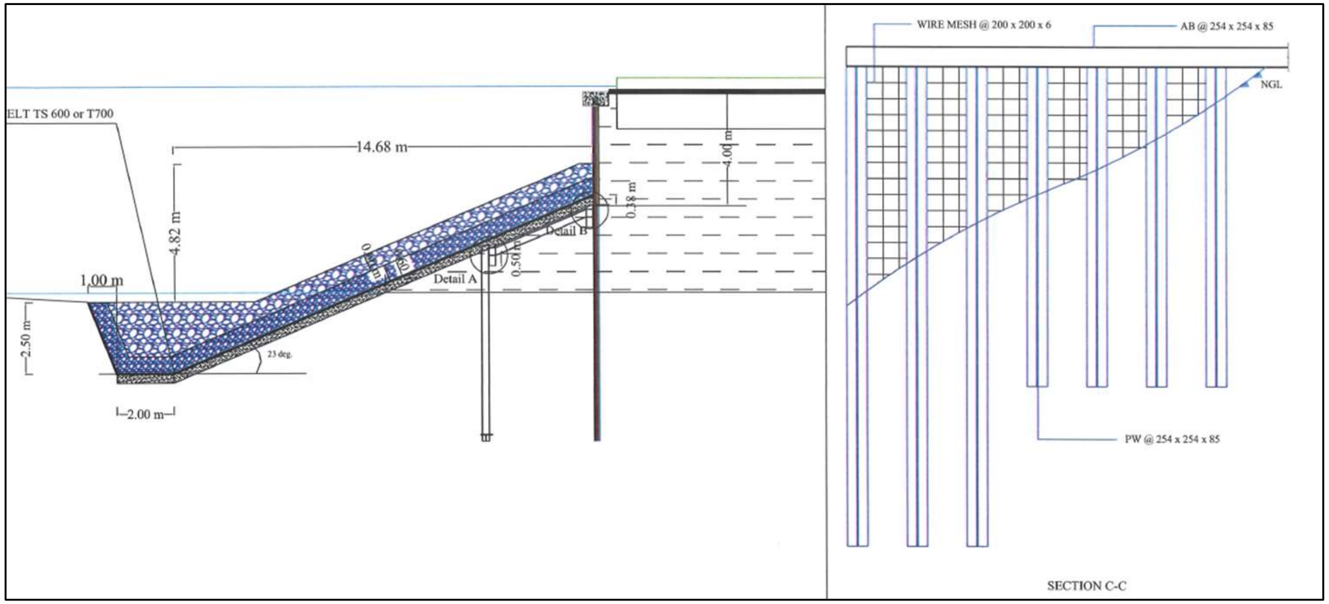
Permeability of sand layer	Permeability of geotextile
$1x10^{-5}$ cm/s	$1x10^{-3}$ cm/s

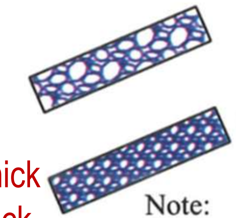
1. Design method of slope stability (Hoek, E, 1973) is adopted. For the safety factor of 2, the recommended slope angle is 23°.
2. The maximum acceptable weight of the stone block can be estimated as *the function of slope and wave height, h.*
3. Wave height of water, h = 1.0m.

$$W = \frac{350.\gamma_s.h^3.tan\alpha}{(\gamma_s - 10)^3}$$



- Stone, ϕ600 mm, 600mm thick
- Stone, ϕ300mm, 600mm thick
- Geotextile layer
- Sand layer, 200 mm
- Clay layer





Unit weight of stone	= 0.026 MN/m3
Maximum size of Primary armour stone	= 0.60 m
Maximum size of secondary armour stone	= 0.30 m
Minimum size of secondary armour stone	= 0.15 m

Note:

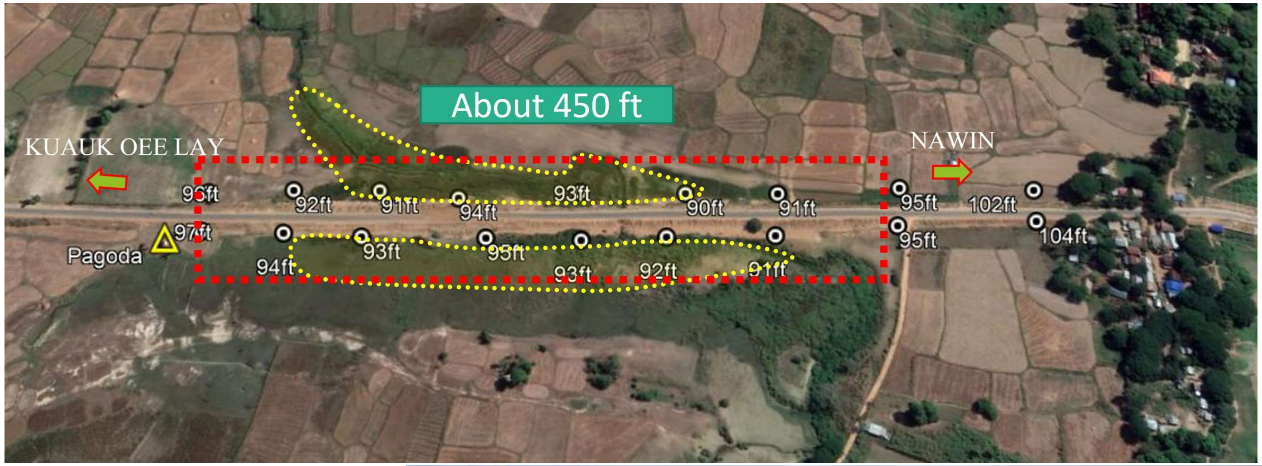
Sequential construction shall be carried out to obtain the design requirement of support capacity.

Pyay

Project: : Nawin-Kyauk Ooe lay Road, Pyay

Owner: : Ministry of Construction

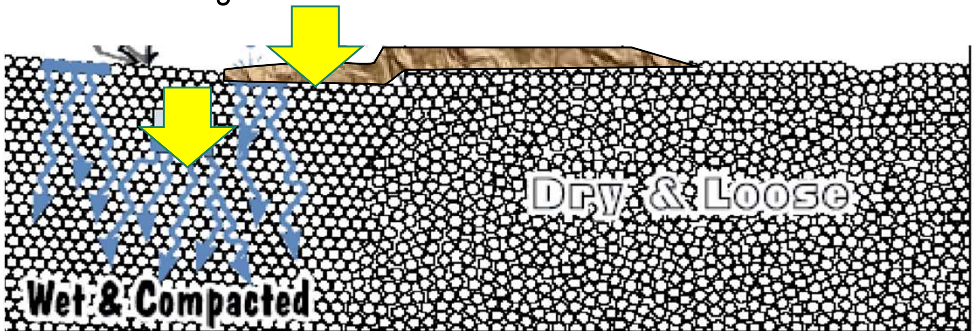
Date: : 12.6.2019



Road Foundation in Collapsible Soil

Collapsible Soil:

- Young or Recent altered deposit
- Open structure
- Consist of SILT and fine SAND
- High void ratio
- High porosity (> 50%)
- High sensitivity
- Low dry density (11 – 14 kN/m^3)
- Low interparticle bond strength of soil



The collapsible soil become great settlement when the soil gets wet.

Collapsible soil

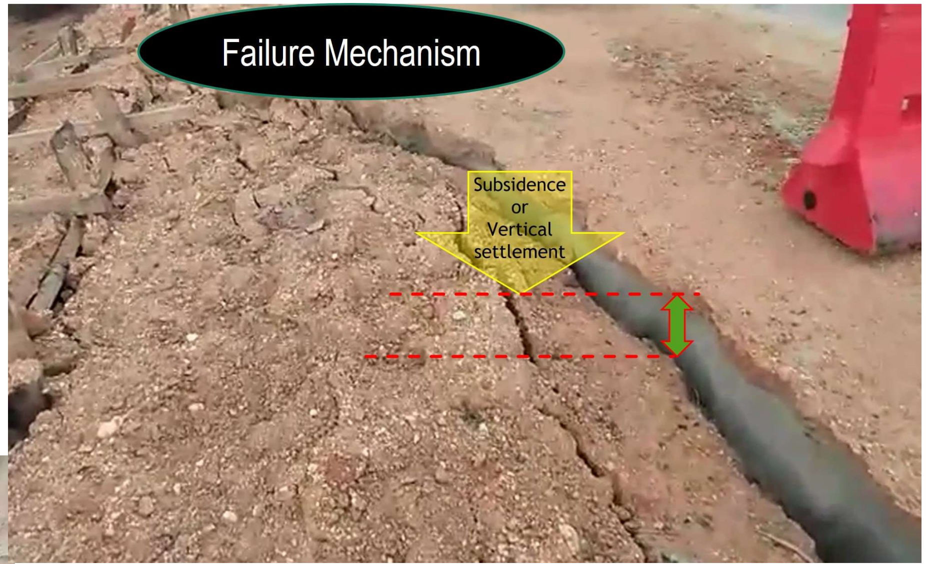
1. The road is located near to the rivers or the pools where the moisture limit going to be high and the saturation will exceeds the limit of collapse.
2. Problematic for structures due to its large settlement potential.

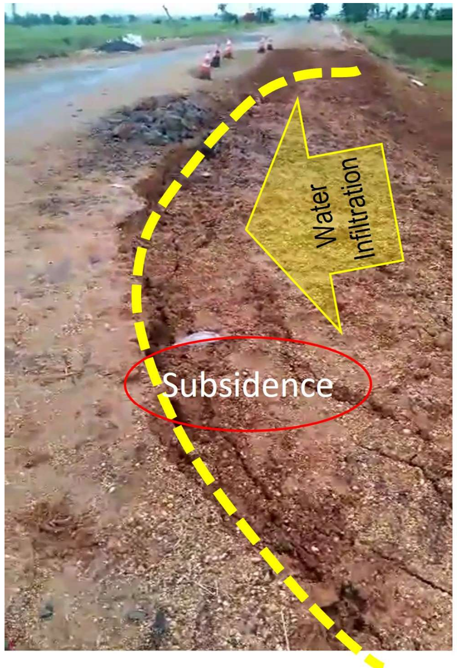
CP (collapse potential) values

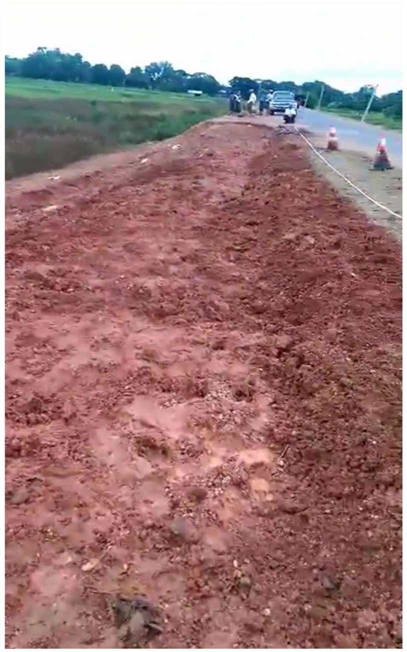
Percent volume change	Severity of problem
0 - 1	No problem
1 - 5	Moderate trouble
5 - 10	Trouble
10 - 20	Severe trouble
> 20	Very severe trouble

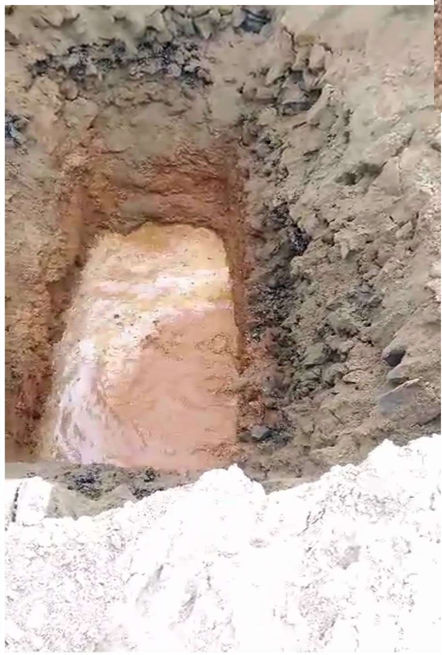
Site observation and soil investigation:

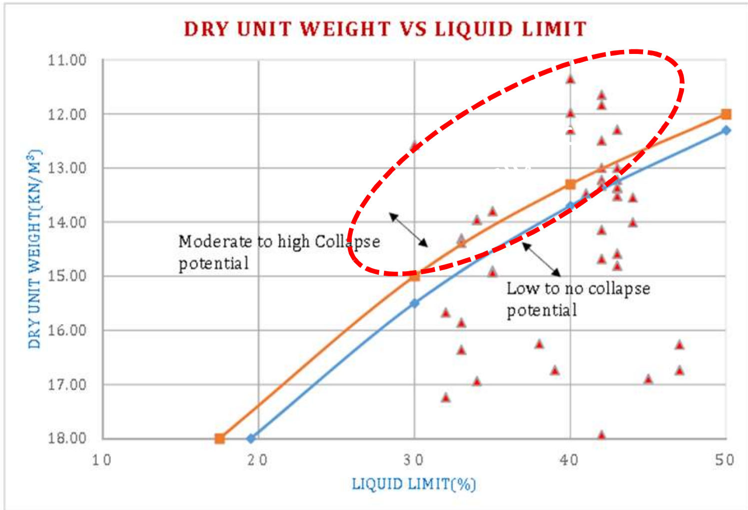
1. Site observation (in-situ testing)
2. 16 numbers of bore hole





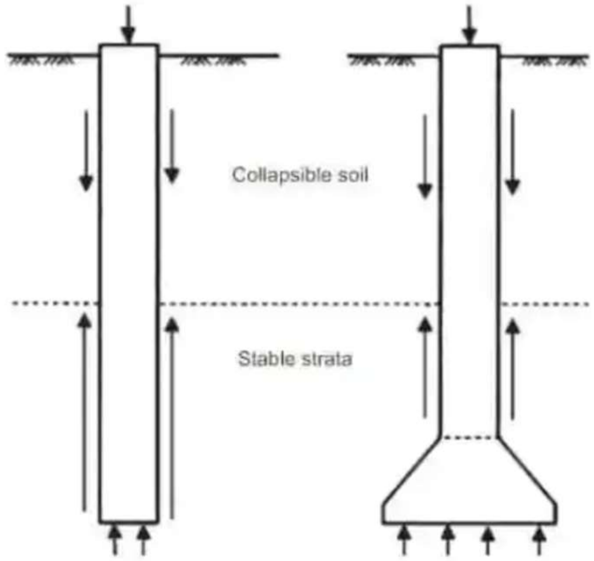




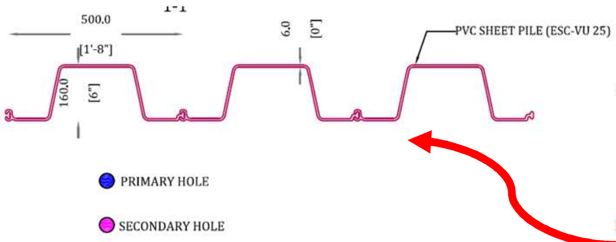


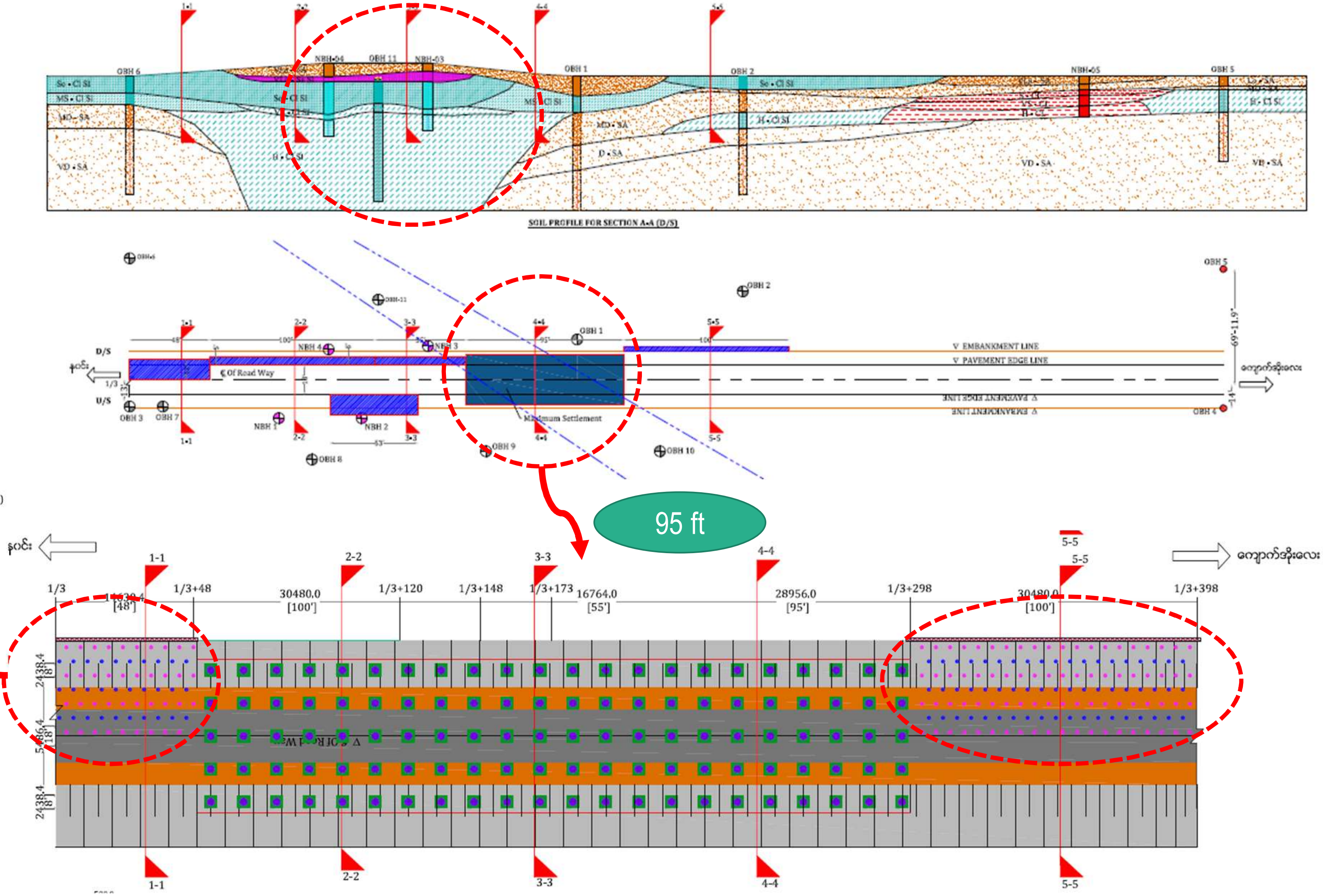
Solution for Problematic Soil

1. Removal of collapsible soil is a good option when the thickness is low.
2. Chemical Stabilization- Cement, lime, or any other chemical additives can be used for collapsible soil treatment.
3. Densify and reach equilibrium conditions as water moves through the soil. If the soil layer is thick, it should be treated to decrease settlement potential (compaction is one of the methods)
4. Select Suitable Foundation (Combination of deep foundation and geotextiles)
   - Sand or crushed stone column is a suitable material for collapsible soil replacement.
   - A deep foundation can bypass collapsible soil and transfer superstructure load to a hard soil layer.
   - Mat or raft foundation can withstand large expected settlement of the collapsible soil.

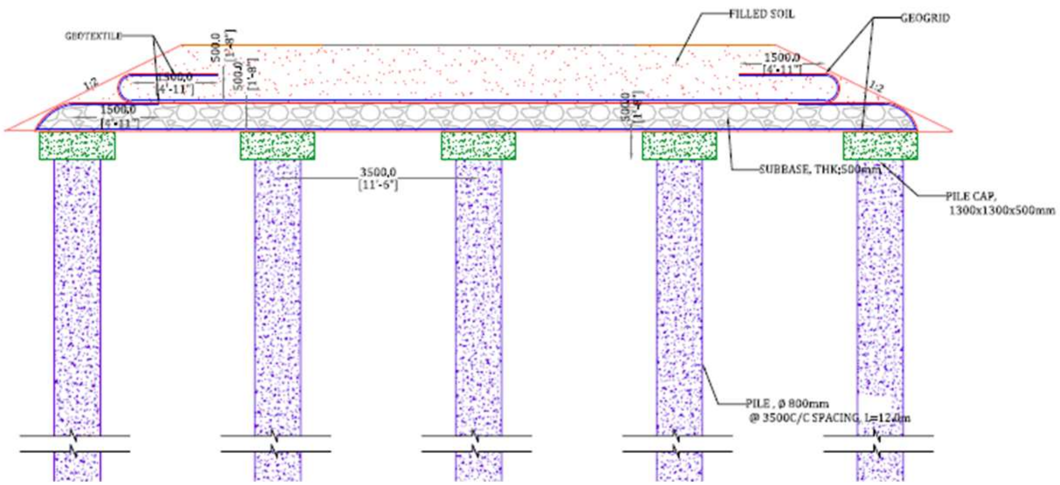


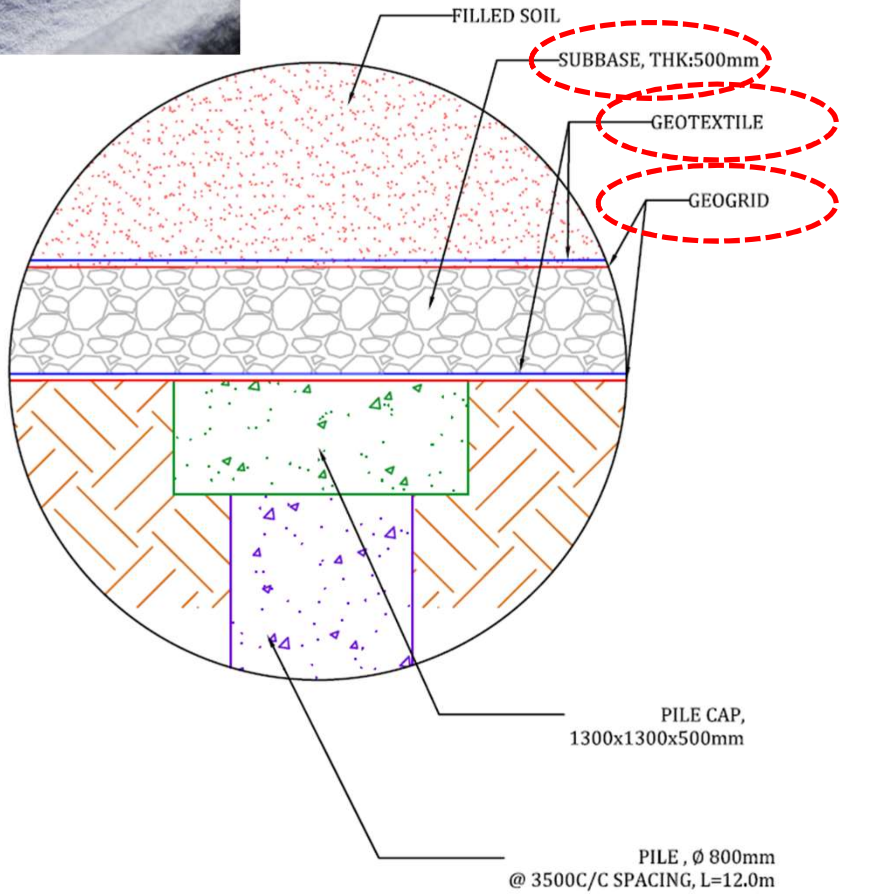
PVC sheet pile and grouting





- Polyfelt geotextile to filtration water
- Geogrid for reinforcement of subbase





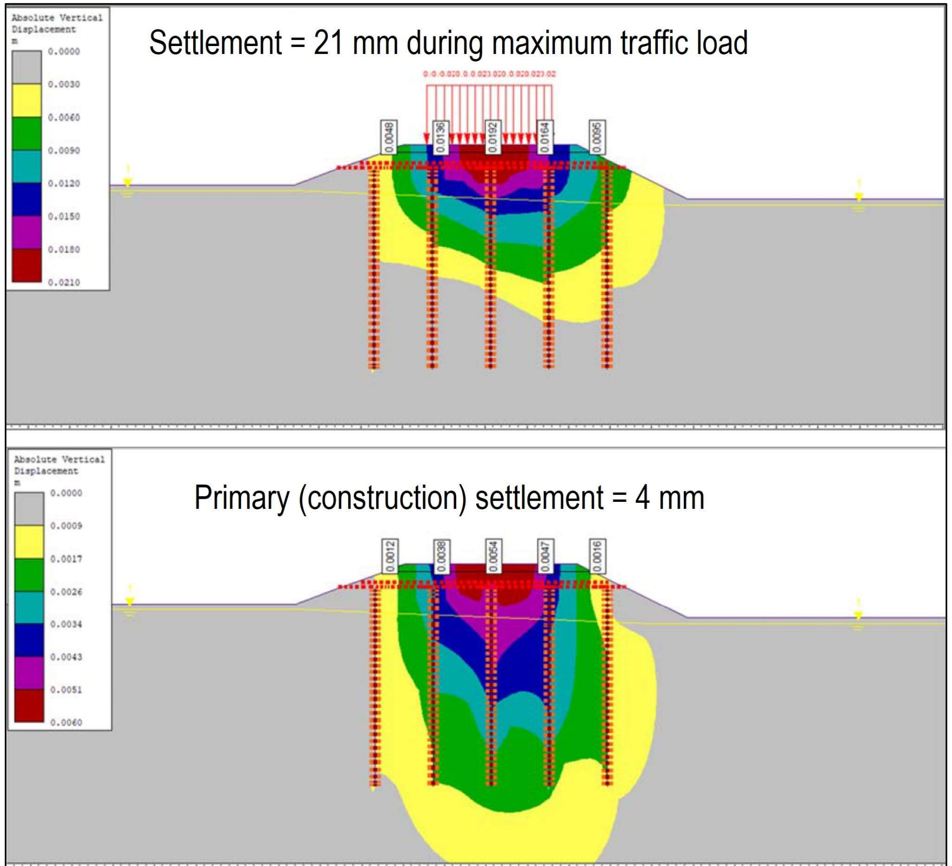
FHWA recommends the minimum porosity of geotextile shall be greater than 60%. Polyfelt geotextile has > 80%. Therefore, polyfelt shall be selected having the lowest grade of polyfelt TS 600.

- Permeability of geotextile = 1×10^{-3} cm/s
- Tension capacity = 20 kN/m

IV. Specification of Geogrid

Performance/ Specification	Specification	Remark
Tension capacity, kN/m	200	Longitudinal
	200	Crosswise
Break elongation ratio, %	5	
Grid (mm)	32 x 32	(or) 32 x 32
- Corrosion resistance, no long-term creep, long life span - Resistant to fatigue cracking, high-temperature track and low temperature shrinkage cracking.		

Pyay



Load-settlement results during maximum and no traffic loading condition

- Maximum traffic load with 35 tons (ref. typical design cross section of road).

3. Conclusion

1. Building Climate-Resilient Infrastructure using Geosynthetics become ***green infrastructure to build Resilience***. Incorporating geosynthetics into infrastructure can improve the ability of communities ***to withstand and recover*** from extreme weather events.

2. When used in load support, slope stabilization, waterway protection, and retaining wall applications, geosynthetics are a many advantages against the long-term effects of climate change.

3. Sustainability emphasizes the ***importance of increasing the resource efficiency of infrastructure***. The usage of geosynthetic materials in civil and environmental engineering can significantly influence sustainability at the planning and design stages of infrastructure construction projects.

Finally specking:

1. Reducing the environmental impacts of construction materials
2. Improvement of the existing resources for efficient use of resources in construction

END

Thank you!