REMINDERS

- Questions will be entertained during the Q&A session
- Use the chat box to send your comments or questions
- E-certificate request link will be provided right after the session

APPLICATION OF GEOSYNTHETICS IN GROUND IMPROVEMENT

Date 2024 November 14

Author Glenn S. Silang

GSY Technical Business Development Engineer

MACCAFERRI

TOPIC OUTLINE

MACCAFERRI

- INTRODUCTION TO MACCAFERRI
- CONVENTIONAL METHODS
- GROUND IMPROVEMENT USING GEOSYNTHETICS

TOPIC OUTLINE

MACCAFERRI

INTRODUCTION TO MACCAFERRI

CONVENTIONAL METHODS

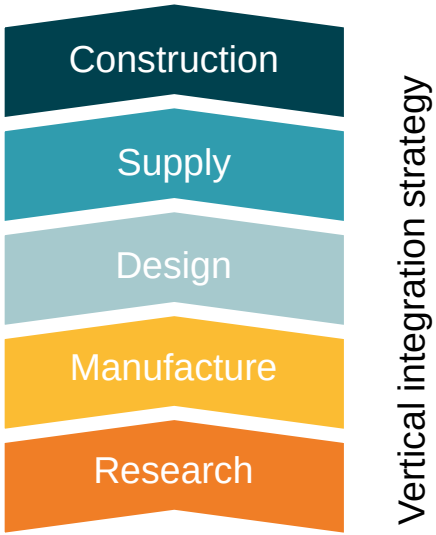
GROUND IMPROVEMENT USING GEOSYNTHETICS

Bologna, Italy
Global Headquarters

MISSION AND VISION

MISSION

To become a ***leading international provider of advanced solutions*** to the civil, geotechnical and environmental construction markets.



VISION

We strive to be a ***technical reference*** solving our client's problems through innovation, collaboration and best-value environmental solutions.

ENDURING HISTORY

> For over 140 years, we have researched, designed and developed solutions to solve technical problems within the Civil Engineering, Geotechnical and Environmental Construction Markets.

1879

The origins

On May 3, 1879 Raffaele Maccaferri established “Ditta Maccaferri Raffaele, Officina da Fabbro” in Lavino (Bologna) for the production of wrought iron items.

1893

The gabion invention

‘‘Ditta Maccaferri” invented the famous gabion. The old craft trade grows into an industrial enterprise.

1907

Beginning of expansion

The original “sack” gabions were followed by the new box-shaped design, which was used in many large public work projects.

1914-1940

Diversification

Start of the diversification process: 18 new companies set up, through mergers and new acquisitions.

1946-1966

New launch and products

Reorganisation and re-launch of production. Creation of new products: Maccaferri was the first company in Europe to introduce ‘heavy duty’ galvanising. In 1966 Florence was hit by disastrous floods. Gabions proved to be extremely efficient for the reconstruction of roads and water courses.

ENDURING HISTORY

1967-1995

Five continents

Operations expanded over 5 continents. Sharp acceleration in geographical and product diversification. New market approach in compliance with international standards and specifications. Overseeing presence of our engineers at the most important sites in every part of the world.

1996-2005

Evolution

Start of systematic partnerships to offer to customers a full range of durable and cost-effective environmental solutions. Maccaferri enters the Geosynthetic market with its own portfolio of solutions.

2006-2018

Expansion

Geographical expansion through localization and further widening of the portfolio of environmental engineering solutions.

Today

New challenges

Development of new value-added solutions: Geosynthetics specialities, Rockfall protection and smart early-warning systems, applications for tunnelling and solutions in the defence and security sectors.

WHO WE ARE

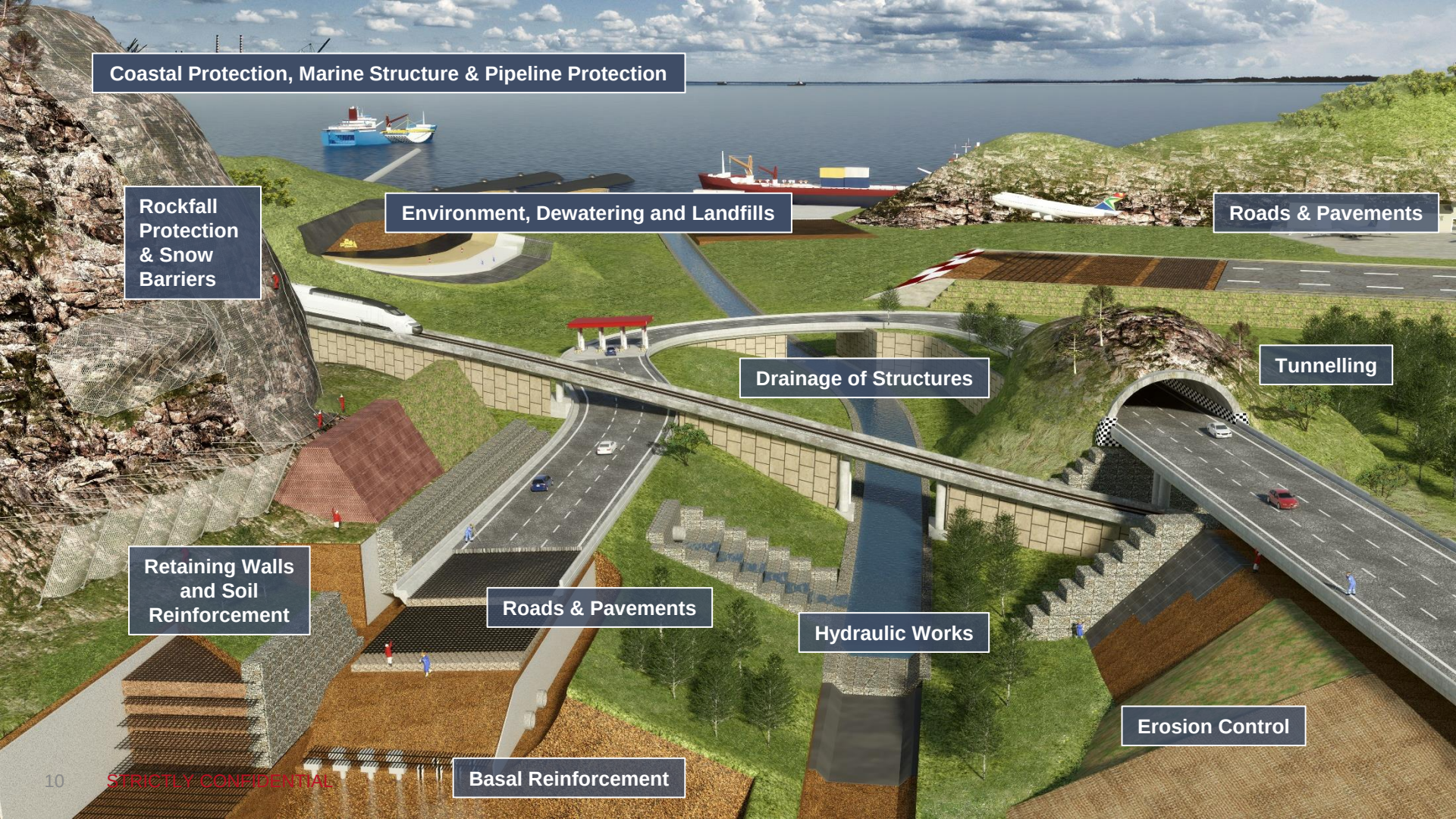
Sales in **100+** countries

Revenues ~ **500** M€

3,000+ employees

25+ factories

60+ subsidiaries



TOPIC OUTLINE

MACCAFERRI

INTRODUCTION TO MACCAFERRI

CONVENTIONAL METHODS

GROUND IMPROVEMENT USING GEOSYNTHETICS

GROUND IMPROVEMENT

MACCAFERRI

CONVENTIONAL METHODS

Driven Piles

vulcanhammer.info

Sheet Piles

marineconstructionmagazine.com

Raft Foundations

researchgate.net

Caisson Piles

dailycivil.com

Bored Piles

bauerfoundation.net

TOPIC OUTLINE

MACCAFERRI

INTRODUCTION TO MACCAFERRI

CONVENTIONAL METHODS

GROUND IMPROVEMENT USING GEOSYNTHETICS

GROUND IMPROVEMENT

MACCAFERRI

GEOSYNTHETICS

- PREFABRICATED VERTICAL DRAINS
- BEARING CAPACITY IMMPROVEMENT USING GEOGRID RAFT FOUNDATION
- BASAL REINFORCEMENT FOR EMBANKMENTS ON SOFT SOIL
- GEOSYNTHETIC ENCASED STONE COLUMNS

PREFABRICATED VERTICAL DRAINS

Consolidation by Drainage System

MACCAFERRI

USE OF PREFABRICATED VERTICAL DRAINS (WICK DRAINS)

MACCAFERRI

PVDs

- PVDs are band-shaped (rectangular-shaped) materials consisting of synthetic geotextile jackets surrounding an inner plastic core.
- The jackets are of non-woven polyester or polypropylene geotextile

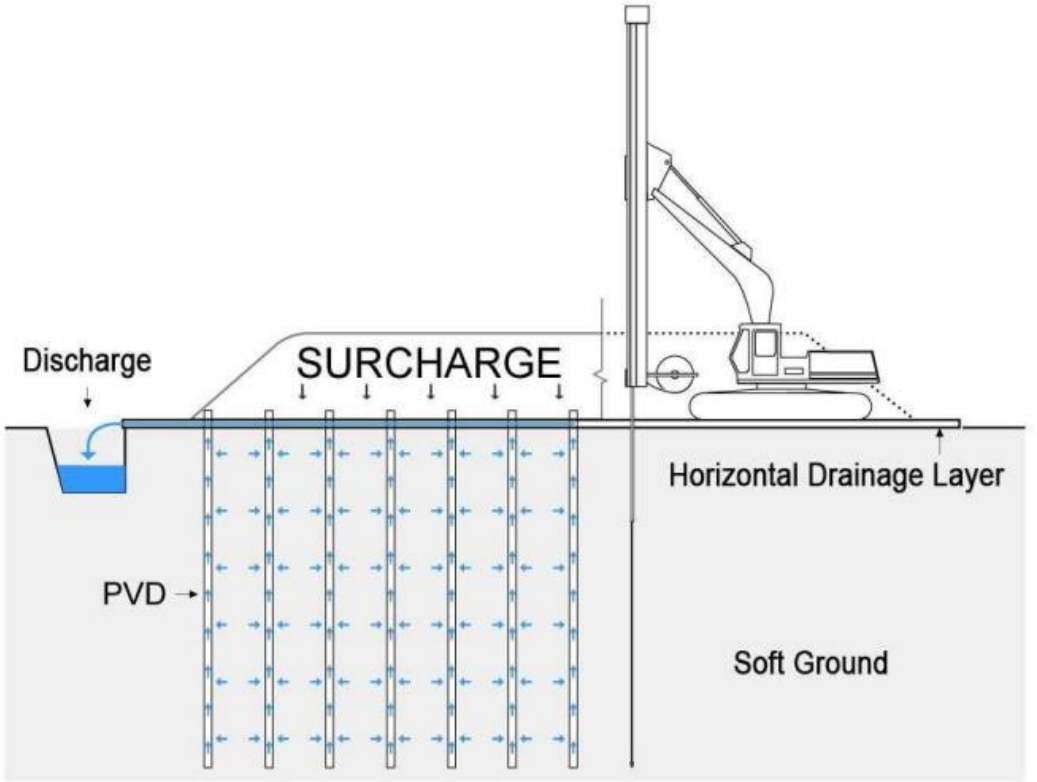
USE OF PREFABRICATED VERTICAL DRAINS (WICK DRAINS)

MACCAFERRI

PVDs

The main function of PVD is to **accelerate the primary consolidation settlement**.

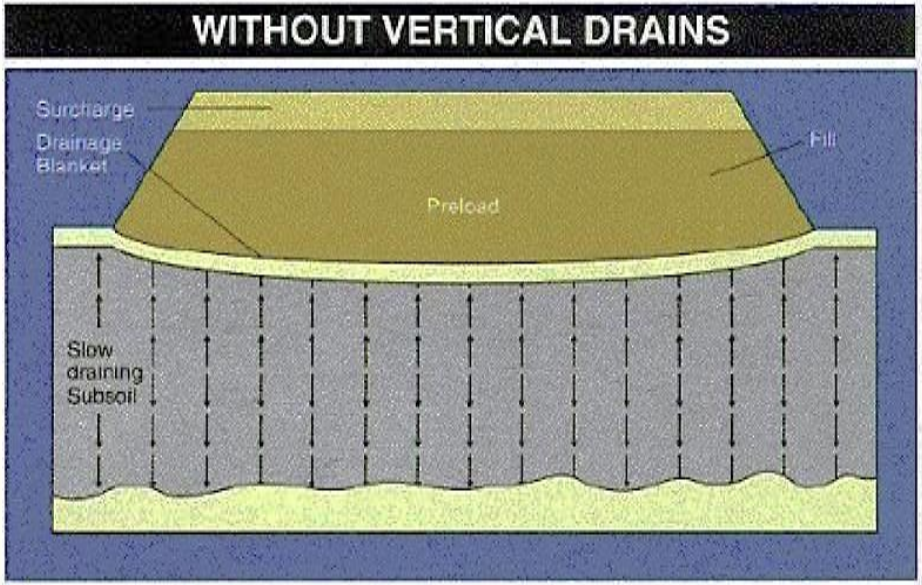
- The surcharge will increase pore water pressure initially, but with time the water will drain away (due to the very low permeability of clay).
- The PVDs are used to shorten pore water travel distance reducing preloading time.
- The pore water will flow laterally to the nearest drain and then discharge through the PVD.



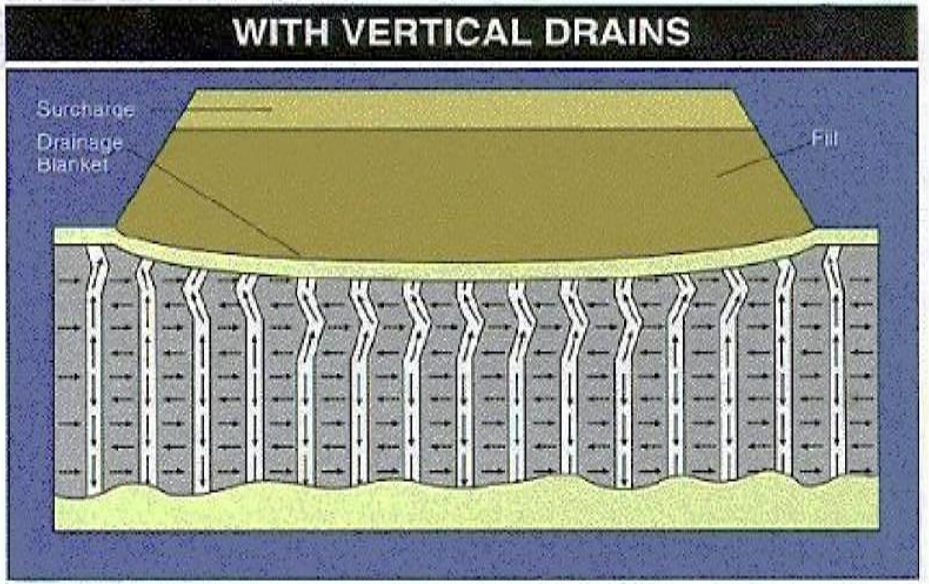
USE OF PREFABRICATED VERTICAL DRAINS (WICK DRAINS)

MACCAFERRI

PVDs



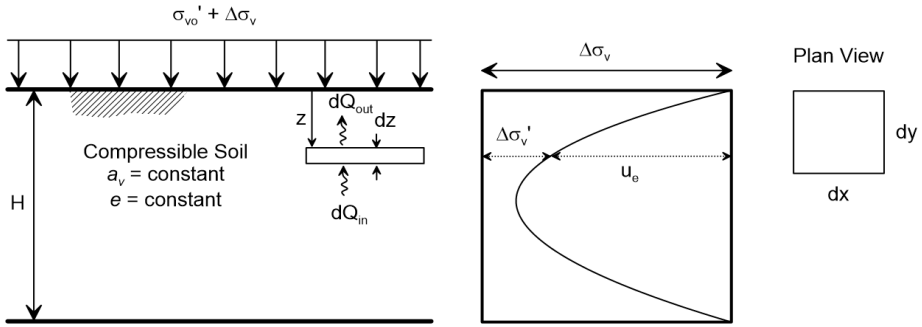
Without inserting PVD, dissipation of excess pore pressure is a slow process.



With PVD the excess pore pressure dissipates quickly through shorter drainage paths.

USE OF PREFABRICATED VERTICAL DRAINS (WICK DRAINS)

TERZAGHI'S 1-D THEORY OF CONSOLIDATION



$$\rho_c = RR * H * \log\left(\frac{\sigma'_f}{\sigma'_o}\right) + CR * H * log\left(\frac{v_f}{v}\right)$$

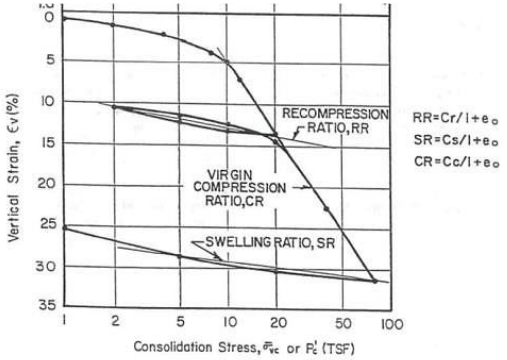


Figure 8-44 Compression Curves and Definition of Compressibility Indices

Primary Consolidation Settlement

USE OF PREFABRICATED VERTICAL DRAINS (WICK DRAINS)

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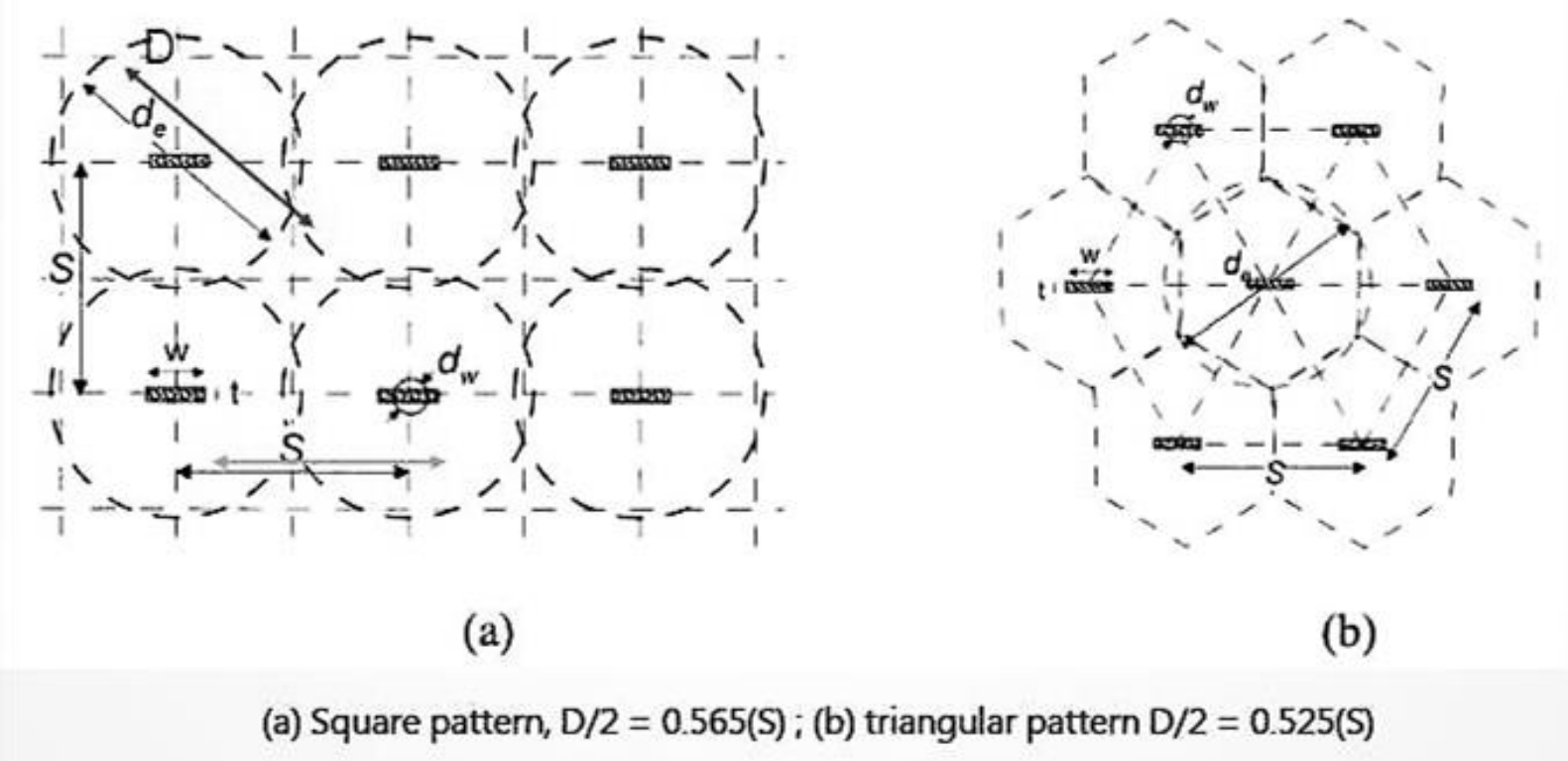
PVDs



(a) Square pattern, D/2 = 0.565(S) ; (b) triangular pattern D/2 = 0.525(S)

USE OF PREFABRICATED VERTICAL DRAINS (WICK DRAINS)

MACCAFERRI

PVDs

MACCAFERRI

TECHNICAL DATA SHEET
Rev. 03, Date 16.08.2019

MACDRAIN™ VD
PREFABRICATED VERTICAL DRAIN

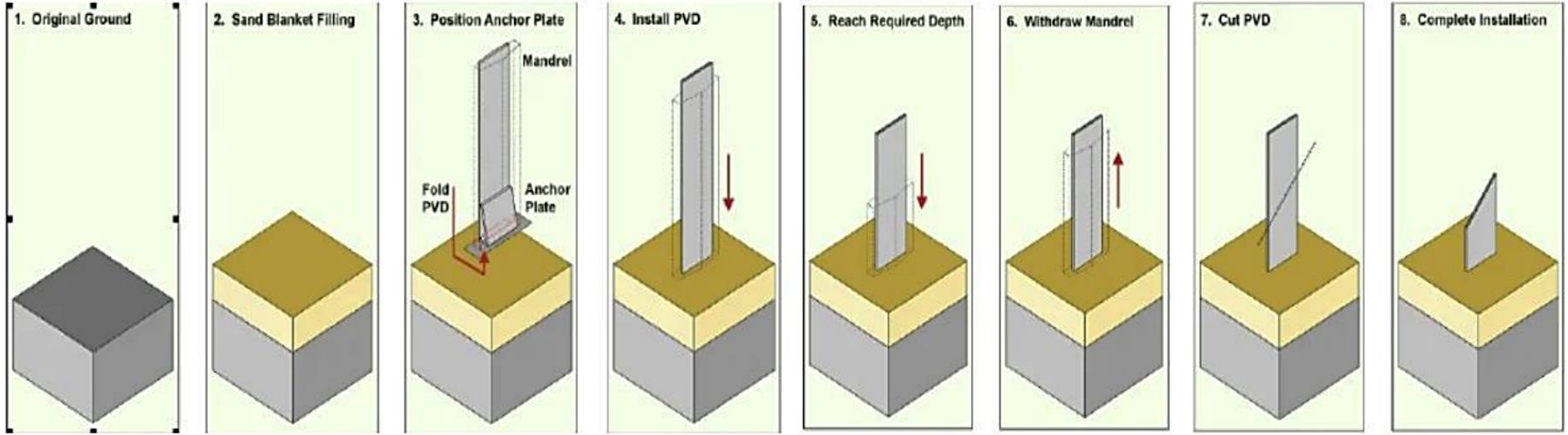
MacDrain™ VD prefabricated vertical drain is appropriate for most ground improvement projects requiring vertical drain. MacDrain™ VD is a two-part prefabricated soil drain consisting of a polypropylene core covered with a spun bonded polyester filter fabric. The fabric allows water to pass into the drain core while restricting the movement of soil particles which might clog the core, thus allowing faster consolidation.

	Standard	Unit	VD-I	VD-II	VD-III	VD-IV
DRAIN						
Core configuration						
Core material			PP	PP	PP	PP
Width	ISO 22198	mm	100±5	100±5	100±5	100±5
Thickness	ISO 9863-1	mm	3	3	4.0±0.5	4.0±0.5
Tensile strength, full width	ISO 10319	kN	2	2.5	2.4	2.5
Tensile strength at 10% strain	ISO 10319	kN	1.5	2	2	2
Discharge capacity, 350kPa, i=0.5	ASTM D 4716	cm^3/sec	80	80	90	90
FILTER						
Wide width tensile strength, MD	ISO 10319	kN/m	6	7	6	7
Grab tensile strength, MD	ASTM D 4632	N	500	500	500	500
Coefficient of permeability, k	ISO 11058	cm/sec	1 x 10-2	-1 x 10-2	1 x 10-2	1 x 10-2
Apparent opening size, O90	ISO 12956	µm	< 75	< 75	< 75	< 75
Puncture resistance	ASTM D 4533	N		100	100	
Puncture resistance	ASTM D 4583	N		100	100	
Mullen burst strength	ASTM D 3786	kPa		900	900	

USE OF PREFABRICATED VERTICAL DRAINS (WICK DRAINS)

MACCAFERRI

Installation of PVDs



Consolidation by Drainage System | MacDrain® PVD | Taganito Mines, Surigao del Norte

GEOGRID RAFT FOUNDATION

Bearing Capacity Improvement Using Geogrid Raft Foundation

MACCAFERRI

INTRODUCTION TO GEOGRIDS

WHAT IS A GEOGRID?

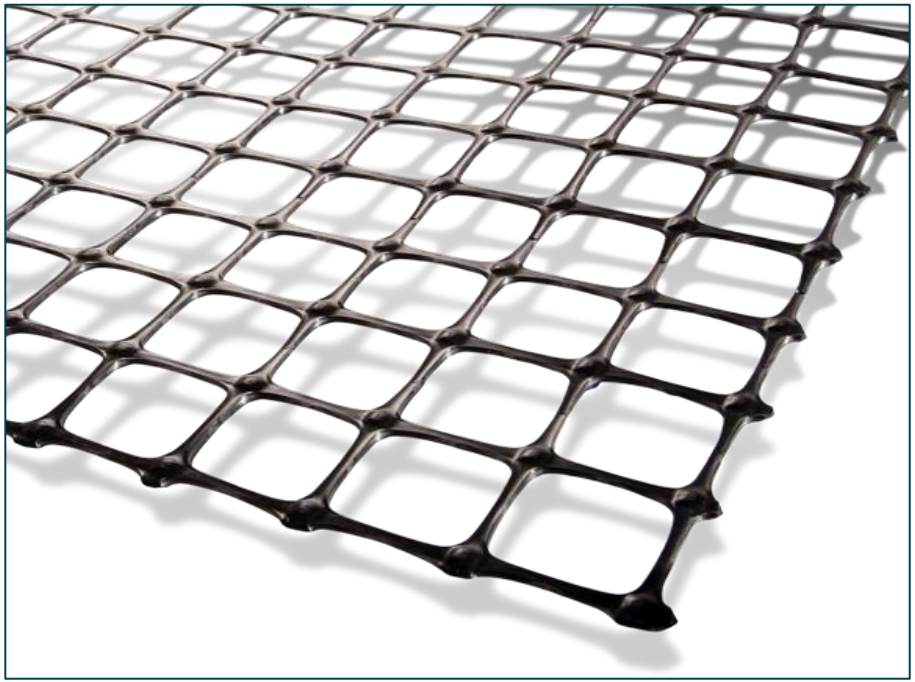
GEOGRIDS

“A geosynthetic formed by a regular network of integrally connected elements with apertures greater than 6.35 mm (1/4 in.) to allow interlocking with surrounding soil, rock, earth, and other surrounding materials to function primarily as ***reinforcement***.” (ASTM D 4439).

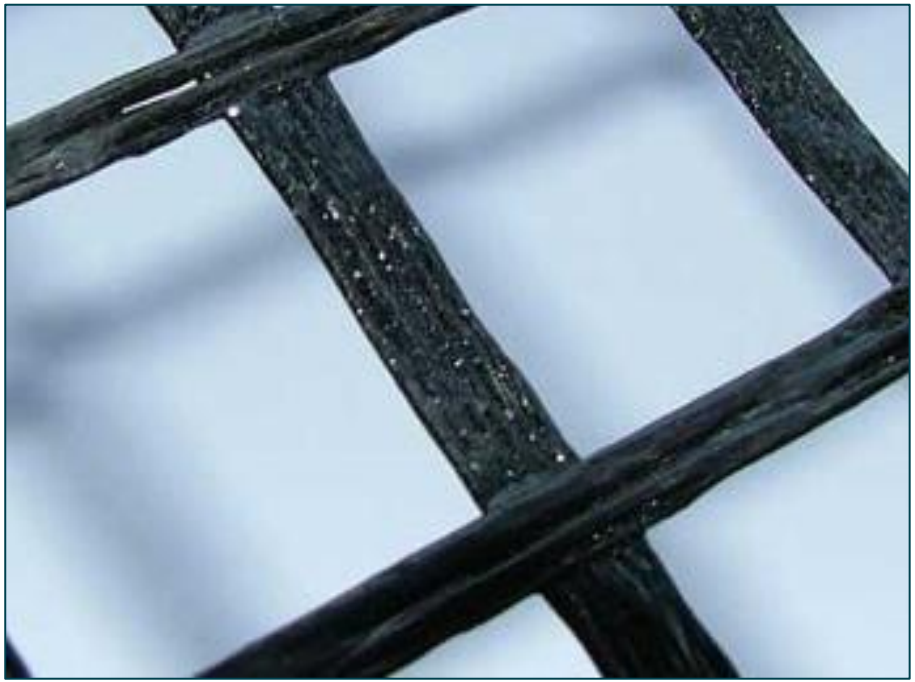
MacGrid EG30S is used in warehouse flooring to improve the mechanical properties of the base course material.

MACCAFERRI GEOGRIDS

MACGRID



Extruded - (MacGrid EG)



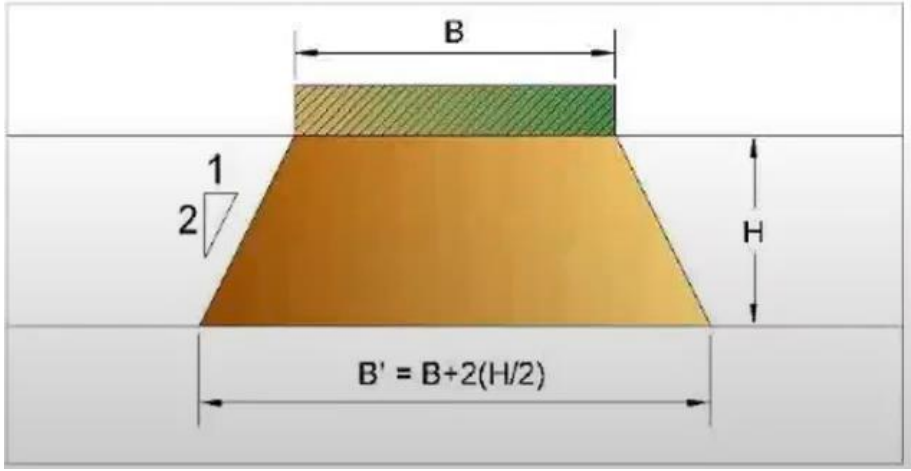
Woven - (MacGrid WG)

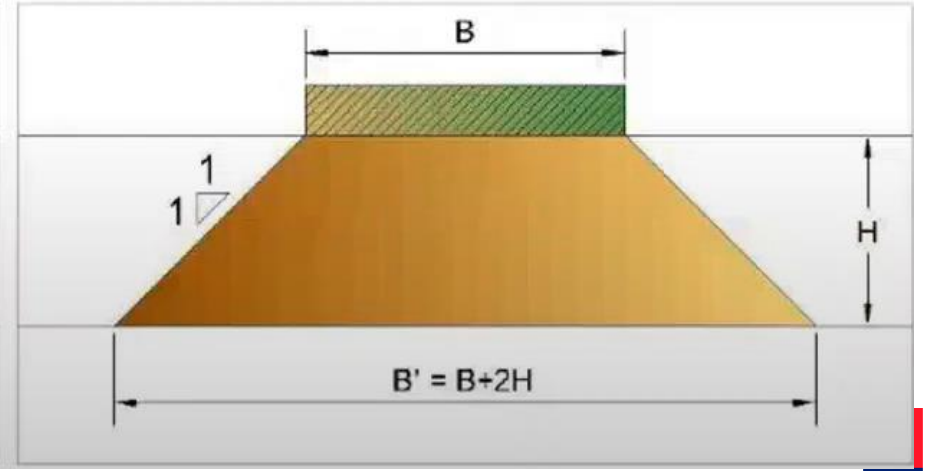
DESIGN APPROACH OF GEOGRID FOUNDATION

MACCAFERRI

BEARING CAPACITY AND SETTLEMENT

Geogrids widen the load distribution area from a ratio of 2V:1H without geogrids to a 1V:1H ratio with geogrids. Furthermore, the widened distribution area for the load helps in improving the bearing capacity of by reducing the bearing capacity and the settlement of the soil





DESIGN APPROACH OF GEOGRID FOUNDATION

REINFORCEMENT MECHANISMS

CEBU-CORDOVA LINK EXPRESSWAY WORKING PLATFORM
Cebu, Philippines

MACCAFERRI

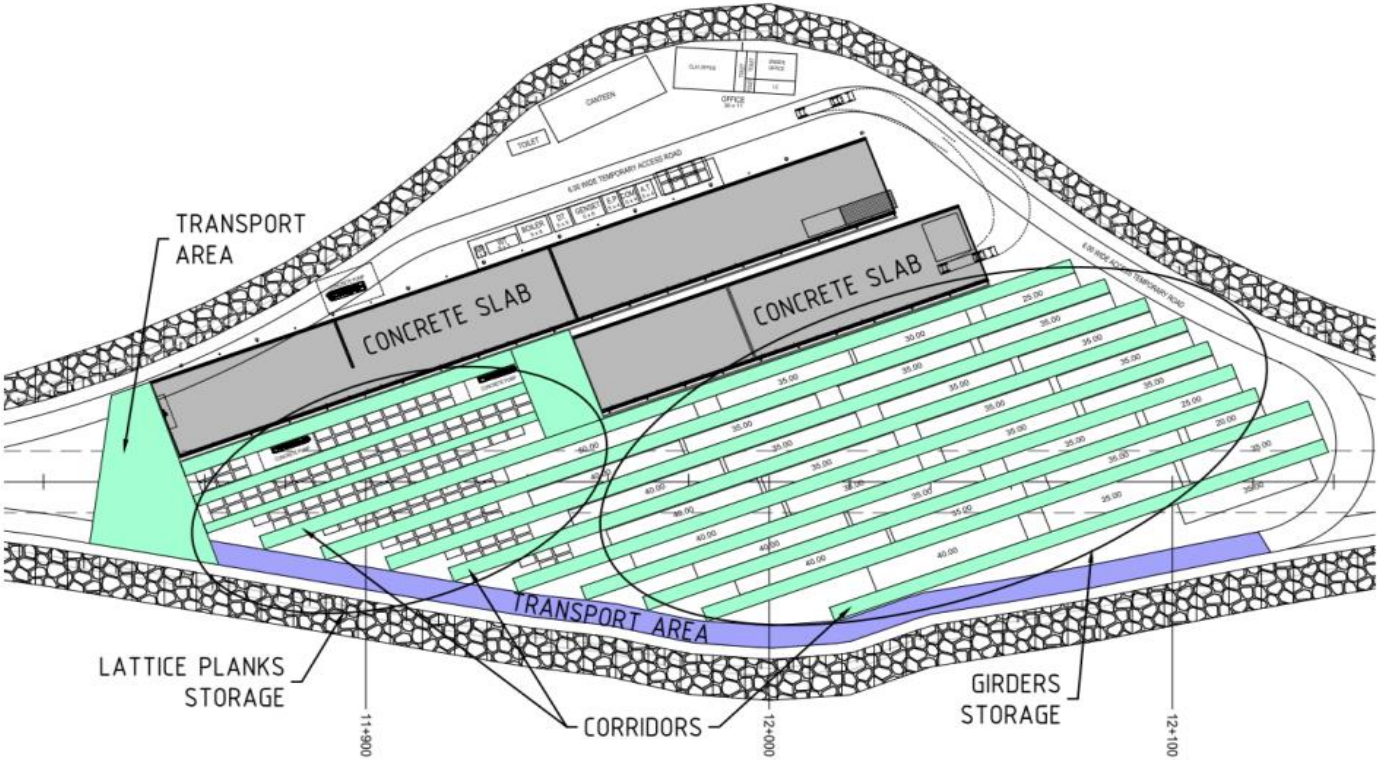
CEBULINKJV

acciona First Balfour D.M. CONSUNJI, INC.

SUBGRADE REINFORCEMENT

MACCAFERRI

CASE HISTORY: CEBU-CORDOVA LINK EXPRESSWAY



SUBGRADE REINFORCEMENT

CASE HISTORY: CEBU-CORDOVA LINK EXPRESSWAY

MACCAFERRI

Maccaferri Philippines proposed a solution to stabilize the granular working platform of the reclaimed grounds of the Cebu-Cordova Bridge for a safe and convenient expressway experience.

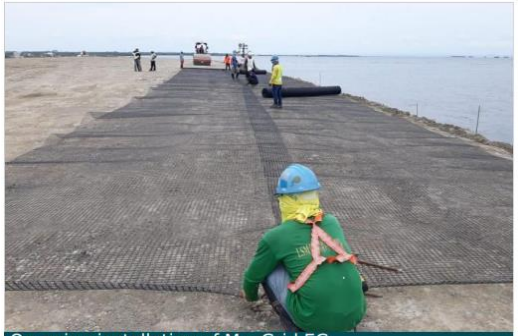
We have supplied 23000 sqm of MacGrid EG20S and 16000 sqm of MacGrid EG30S.


Project site

SUBGRADE REINFORCEMENT

MACCAFERRI

CASE HISTORY: CEBU-CORDOVA LINK EXPRESSWAY



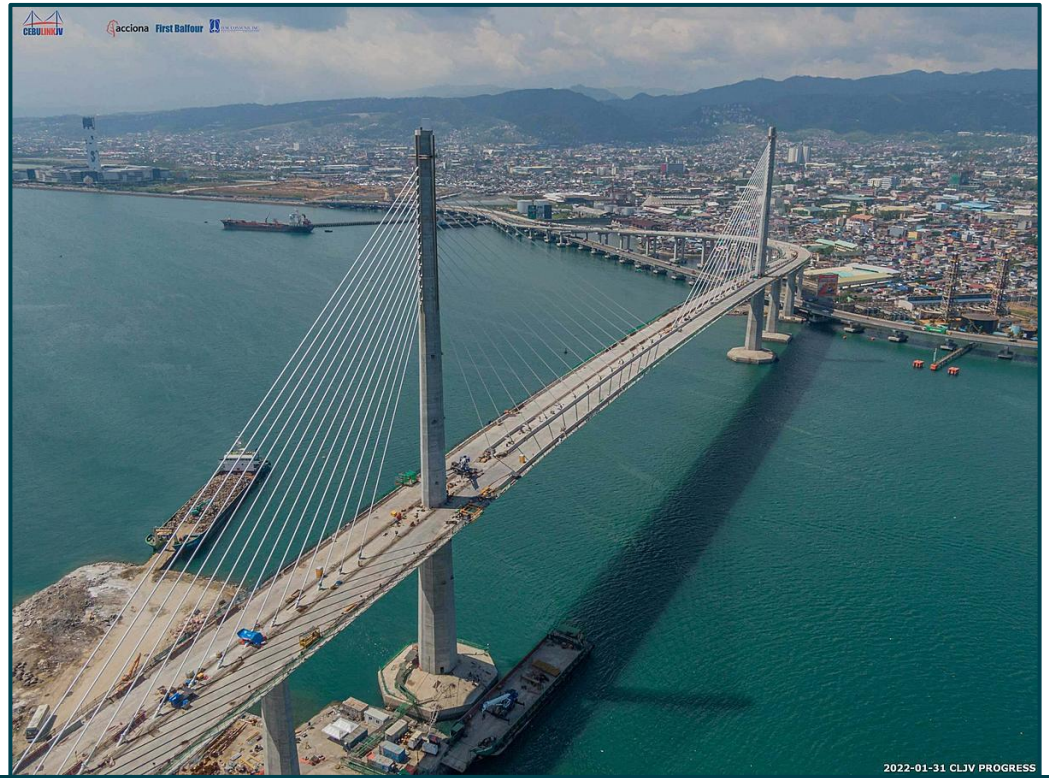
On-going installation of MacGrid EG

On-going installation of MacGrid EG

MacGrid EG for the Bridge Girder Straddle Carriers on Reclaimed Grounds

SUBGRADE REINFORCEMENT

CASE HISTORY: CEBU-CORDOVA LINK EXPRESSWAY



FGEN LNG MULTIPURPOSE JETTY & GAS RECEIVING FACILITY Temporary Working Platform
Batangas, Philippines

MACCAFERRI

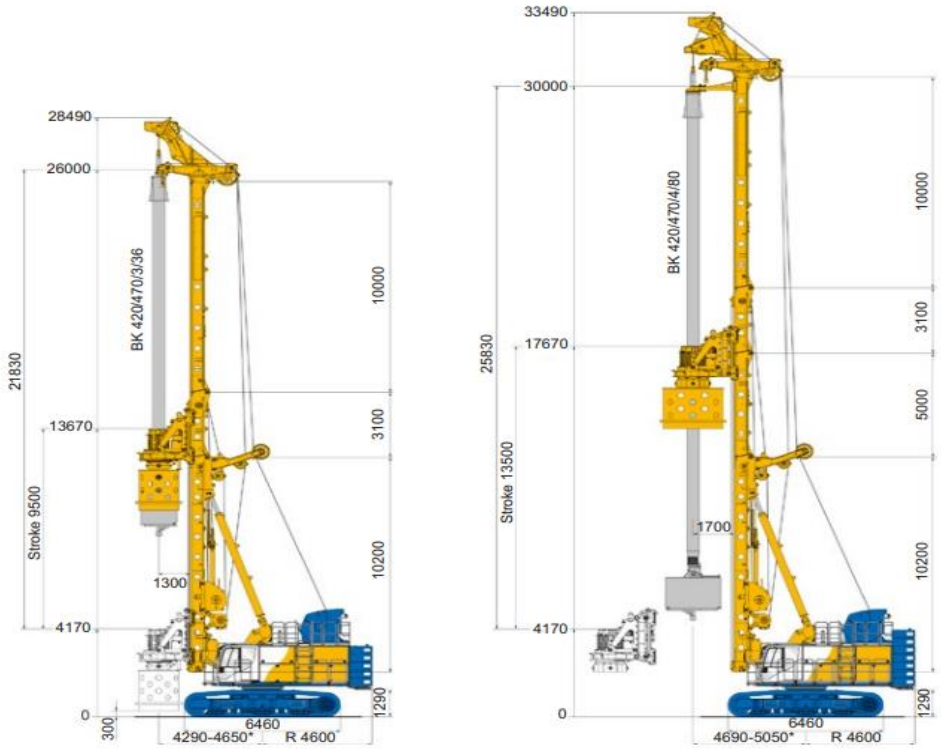
First Gen

McCONNELL DOWELL

First Balfour

SUBGRADE IMPROVEMENT

CASE HISTORY: FGEN LNG MULTIPURPOSE JETTY & GAS RECEIVING FACILITY



SUBGRADE IMPROVEMENT

MACCAFERRI

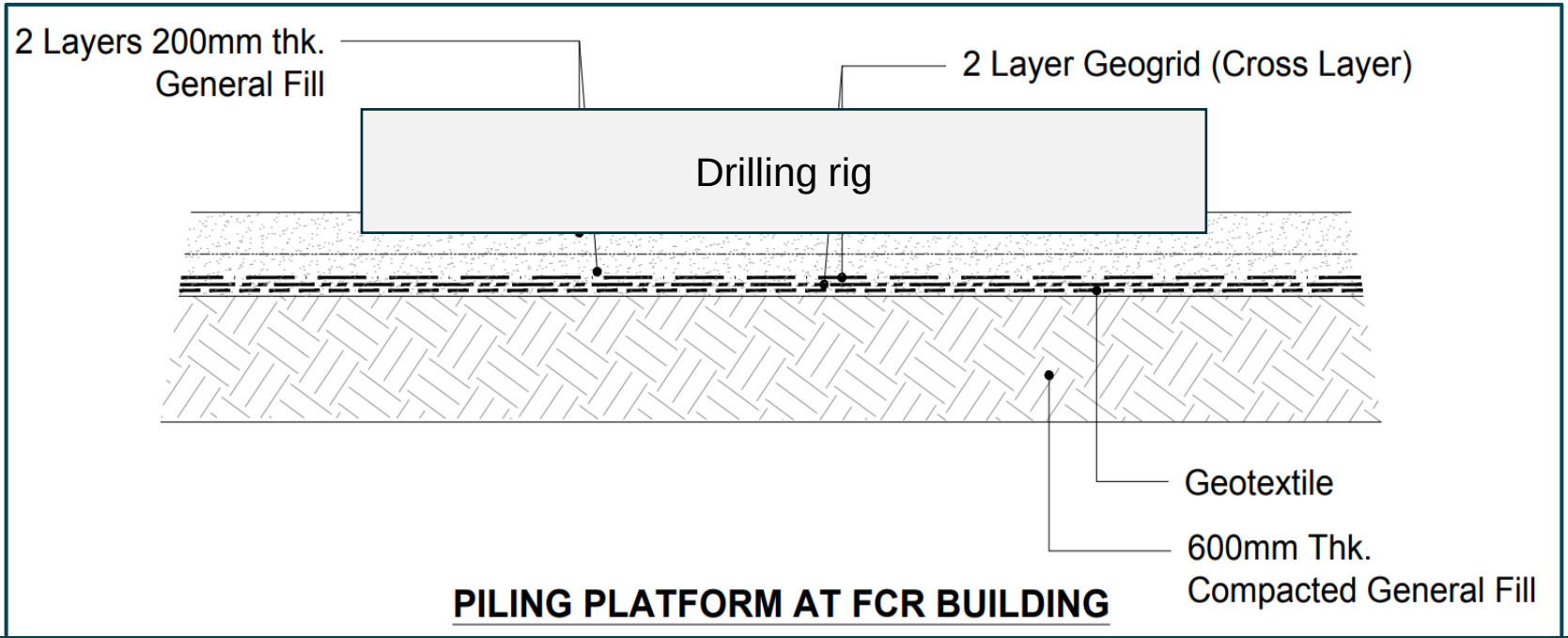
CASE HISTORY: FGEN LNG MULTIPURPOSE JETTY & GAS RECEIVING FACILITY

	Basic version		Upgraded version	
Mast extension	without		5 m	
Upper Kelly guide	without		with	
Drilling axis	1,300 mm	1,550 mm	1,700 mm	2,000 mm
Max. drilling diameter				
uncased	2,300 mm	2,800 mm	3,100 mm	3,700 mm
cased	2,000 mm	2,500 mm	2,800 mm	3,400 mm
Operating weight approx.	150 t	180 t	180 t	185 t
with Kelly BK 420/470/...	...3/36	...4/94	...4/80	...4/80
with bucket	Ø 1,500 mm	Ø 1,800 mm	Ø 2,320 mm	Ø 3,500 mm
with counterweight *	19.7 t	29.4 t	29.4 t	34.3 t

SUBGRADE IMPROVEMENT

CASE HISTORY: FGEN LNG MULTIPURPOSE JETTY & GAS RECEIVING FACILITY

Typical section of the piling platform with geogrid reinforcement.



SUBGRADE IMPROVEMENT

MACCAFERRI

CASE HISTORY: FGEN LNG MULTIPURPOSE JETTY & GAS RECEIVING FACILITY

DCP result without geogrids

#	Number of Blows	DEPTH OF TEST (mm)	CBR (%)	BEARING CAPACITY (KPa)
1	0	0	---	0.00
2	1	116	1	47.50
3	1	193	2	54.07
4	1	255	3	58.93
5	1	310	3	62.16
6	1	367	3	61.16
7	1	423	3	61.65
8	1	477	3	62.70
9	2	565	4	69.42
10	2	642	5	74.68
11	2	713	5	78.27
12	2	775	6	84.99

DCP results with geogrid reinforcement

#	Number of Blows	DEPTH OF TEST (mm)	CBR (%)	BEARING CAPACITY (KPa)
1	0	0	---	0.00
2	3	63	10	110.60
3	3	127	9	109.35
4	3	177	13	131.40
5	5	246	15	152.29
6	5	312	16	157.78
7	5	363	22	194.54
8	7	418	29	241.11
9	7	472	30	244.76
10	19	522	99	501.26
11	8	575	35	277.02
12	6	628	25	218.98
13	8	689	30	247.11
14	5	756	16	155.90

SUBGRADE IMPROVEMENT

MACCAFERRI

CASE HISTORY: FGEN LNG MULTIPURPOSE JETTY & GAS RECEIVING FACILITY

1000 t

Subgrade Improvement | MacGrid® , MacTex® | Batangas, Philippines

12 Units x 1,500 MT Grain Silos
Talavera, Nueva Ecija

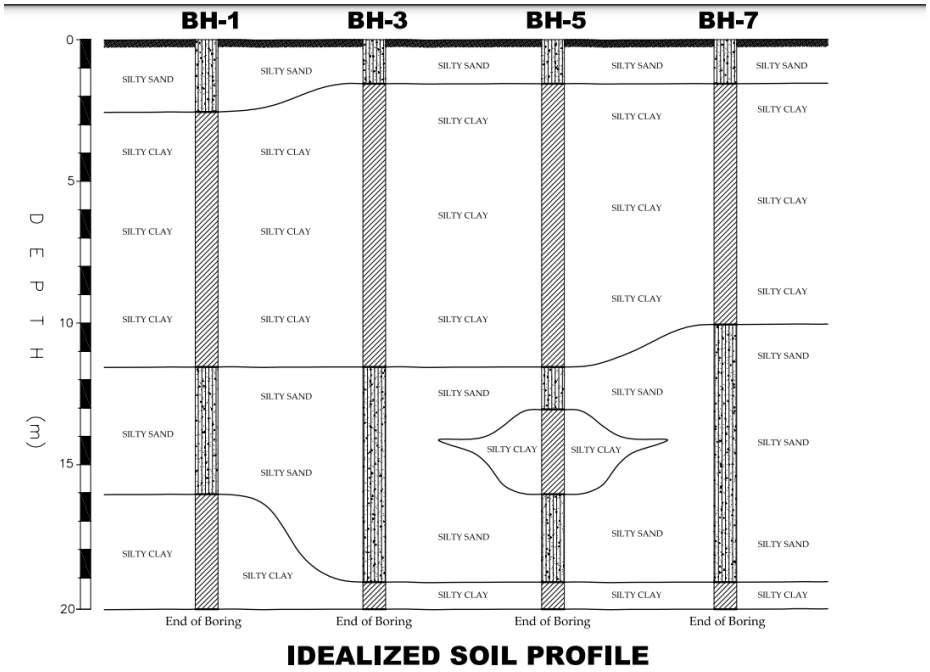
MACCAFERRI

HG Silos

BEARING CAPACITY

Allowable Bearing Capacity is 175 KPa at Talavera, Nueva Ecija

An allowable bearing capacity of **175 KPa for shallow foundation** was recommended by the geotechnical engineer.



IDEALIZED SOIL PROFILE

PROPOSED SECTION OF GEOGRID RAFT FOUNDATION

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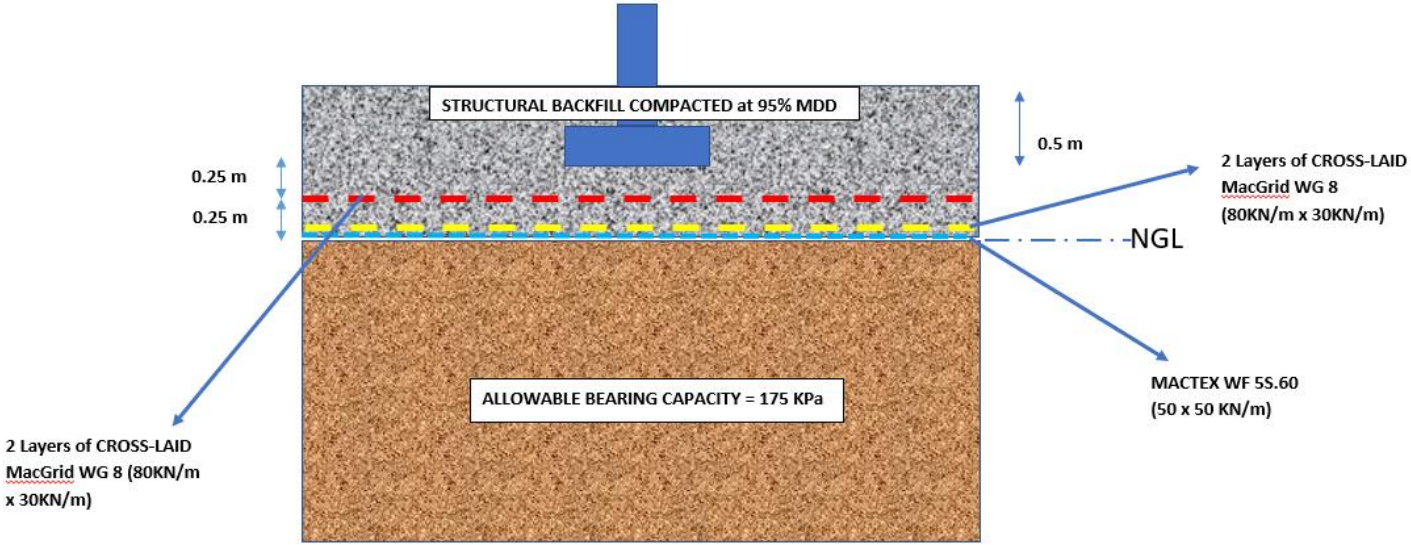
Minimum of 260 KPa Allowable Bearing Capacity



Gravel Pad With a Thickness of 0.50 meters

Target Allowable Bearing Capacity : 260 KPa

Design calculation reference: FHWA/LA.07/423, Abu-Farsakh, Chen, Yoon, ***Use of Reinforced Soil Foundation to Support Shallow Foundation****, Louisiana Transport Research Center, Baton Rouge, La,, US Department of Transportation, Federal Highway Administration, November 2008*

Subgrade Improvement | MacGrid® , MacTex® | Nueva Ecija, Philippines

Subgrade Improvement | MacGrid® , MacTex® | Nueva Ecija, Philippines

1000 t

Ground Improvement | Plate Load Test BS EN 1377 Part 9:1990 | Philippines



Ground Improvement | Plate Load Test BS EN 1377 Part 9:1990 | Philippines

PLATE LOAD TEST RESULTS

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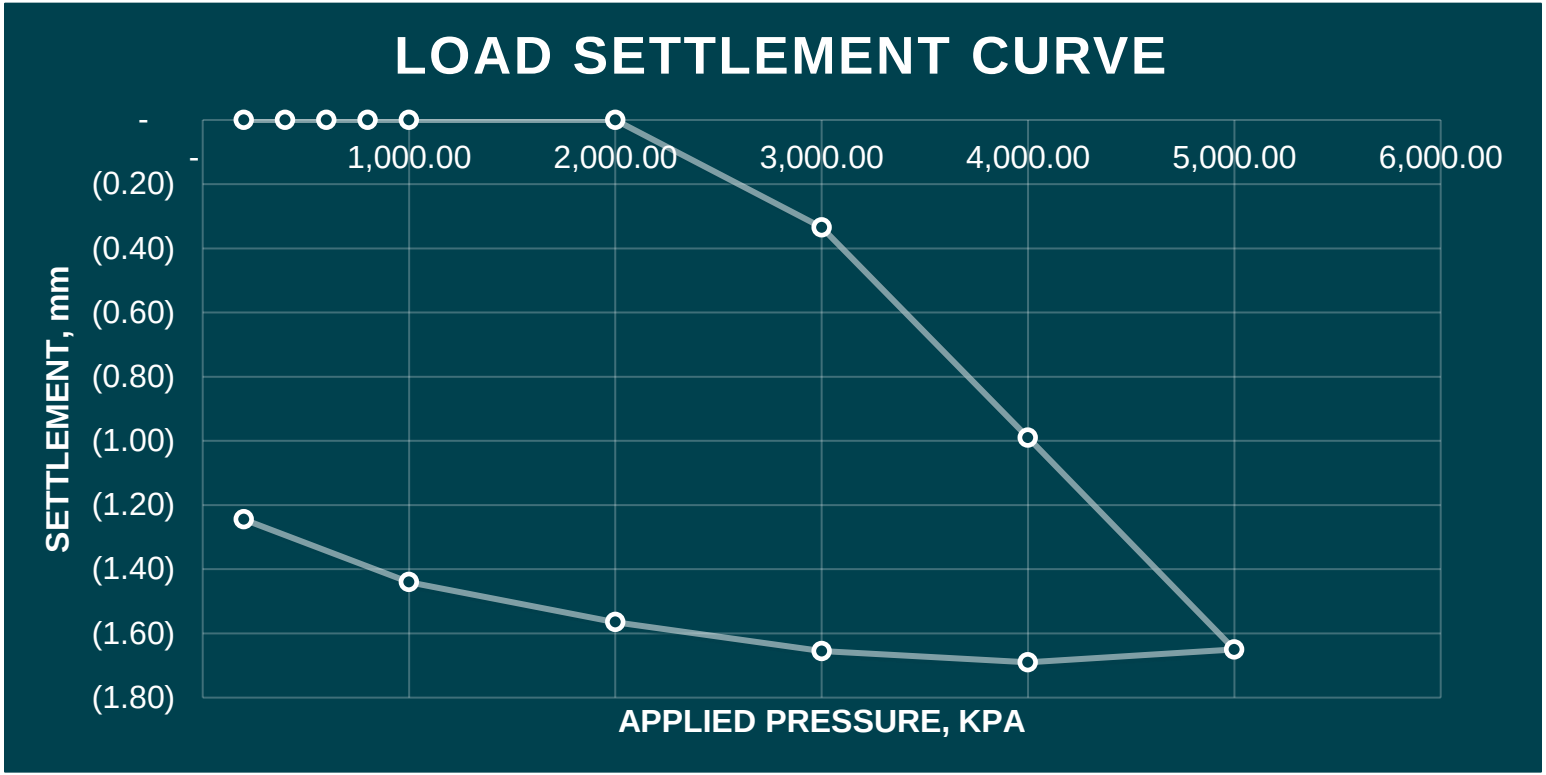
Maximum pressure of **5,000 KPa was reached @ 1.65 mm settlement only**



PROJECT EPIC
Tank Farm Facility and Site Development
San Roque, Bauan, Batangas

MACCAFERRI

AG&P
ATLANTIC, GULF & PACIFIC COMPANY OF MANILA INC.

STA. CLARA INTERNATIONAL

SUBGRADE IMPROVEMENT USING GEOGRIDS

MACCAFERRI

CASE HISTORY: D&L, BAUAN, BATANGAS

A site in Bauan, Batangas started with a very soft soil full of discarded matter. The soil needs to be improved because a warehouse will be situated above the finished grade of the soil with a load-bearing capacity of 60 kPa.

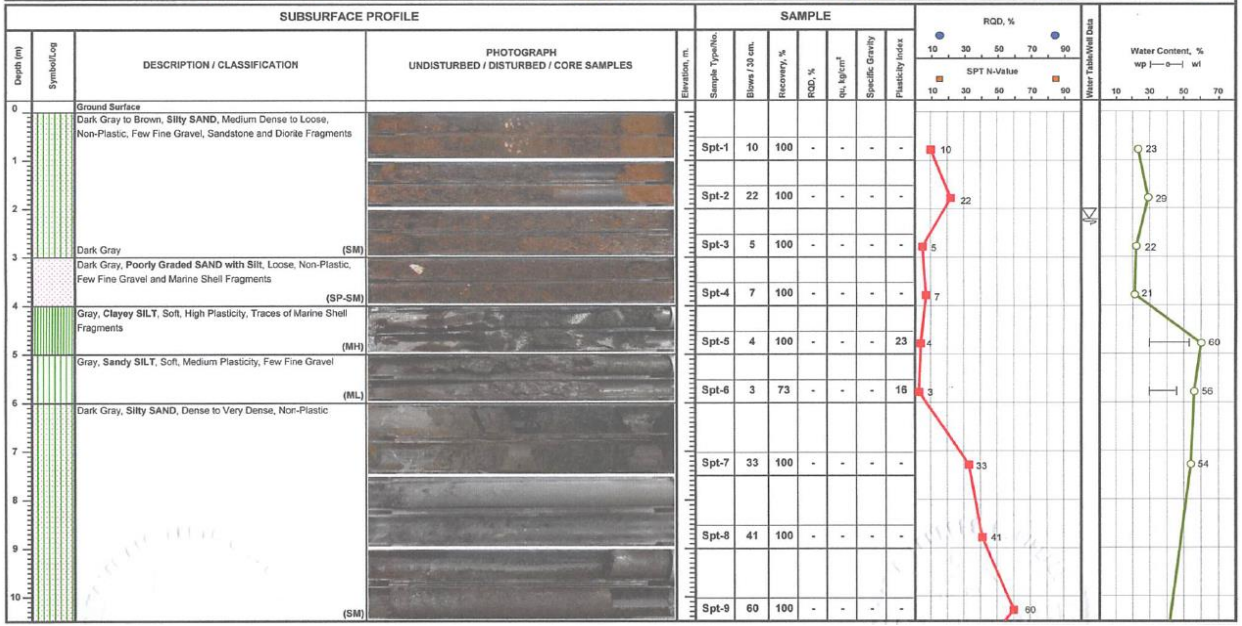
The soil full of discarded material was excavated and the remaining soil was installed with a layer of geotextile first to separate the natural soil from the backfill material. The backfill material was installed with layers of geogrids spaced at 0.30 m.

SUB-SURFACE SITE CONDITIONS

MACCAFERRI

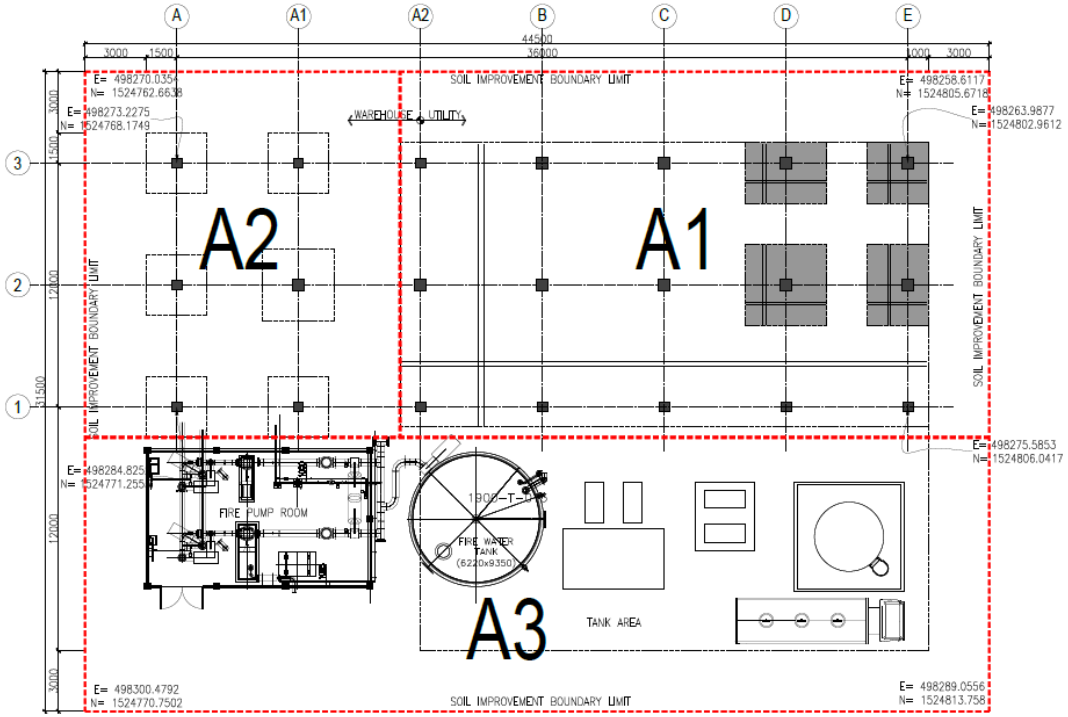
BOREHOLE LOG

Drilling Date Started:	6-Dec-20		Drilling Date Completed:	8-Dec-20	Depth of casing (NW)	16.00 m	Final Depth	21.00 m	Drilling Machine Specs	
Type of Sampler	Diameter	Length	Water Level after 24 hours		Depth of casing (BW)	~	Hole Size	82 mm	Make	Japan
Split Spoon	51 mm	600 mm	Depth	2.25 m	Hammer Type	Donut	Surface Elevation	~	Type	Rotary
Shelby Tube	~	~	Date	9-Dec-20	Hammer Weight:	64 Kg	Northing	~	Model	YBM
Core Barrel	~	~	Time	2:25 PM	Hammer Drop	760 mm	Easting	~	Serial No.:	~



The site is underlain by six(6) meters of very soft (SPT<10) sandy/clayey silt layers (SM/MH/ML)

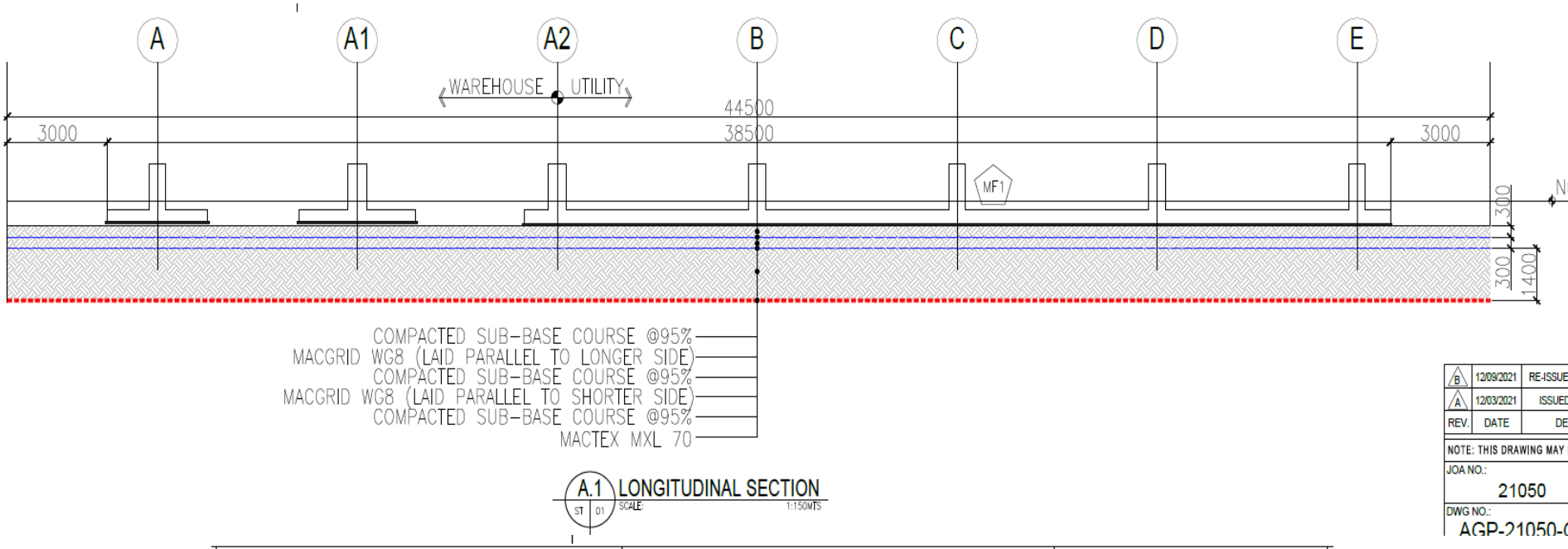
FOUNDATION PLAN



A FOUNDATION PLAN
ST 01 SCALE: 1:150MTS

FOUNDATION PLAN

MACCAFERRI



A.1 LONGITUDINAL SECTION
ST 01 SCALE: 1:150MTS

REV.	DATE	DE
B	12/09/2021	RE-ISSUE
A	12/03/2021	ISSUED

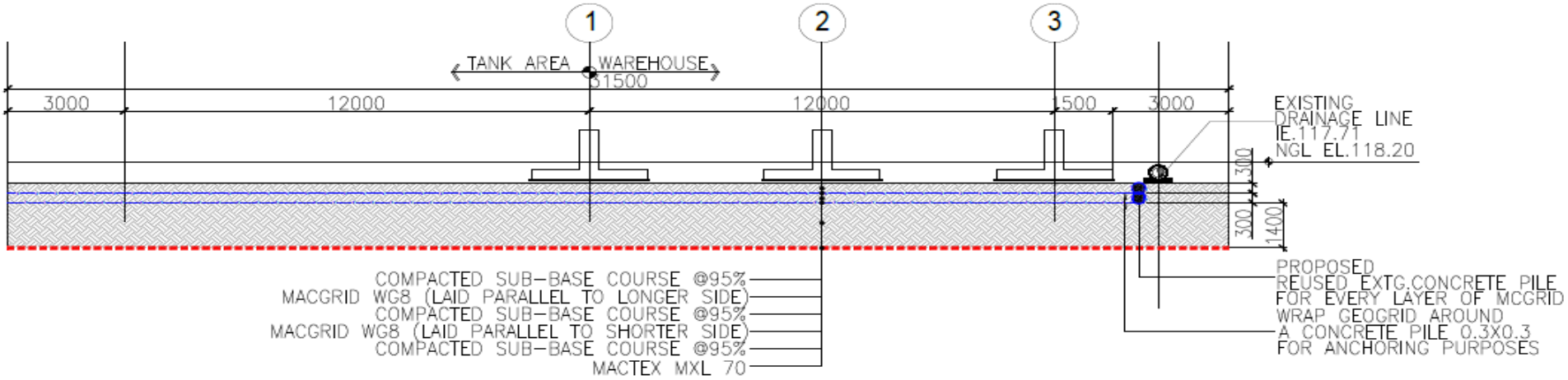
NOTE: THIS DRAWING MAY

JOA NO.: 21050

DWG NO.: AGP-21050-

AG&P ATLANTIC, GULF & PACIFIC COMPANY OF MANILA INC.	PROJECT: PROJECT EPIC TANK FARM FACILITY & SITE DEVELOPMENT LOCATION: SAN ROQUE, BAUAN BATANGAS	OWNER: ECOZONE PROPERTIES INC. 122 Progress Avenue, Carmelray Industrial Park 1, Special Economic Zone, Canlubang, Calamba City, Laguna, 4028

FOUNDATION PLAN



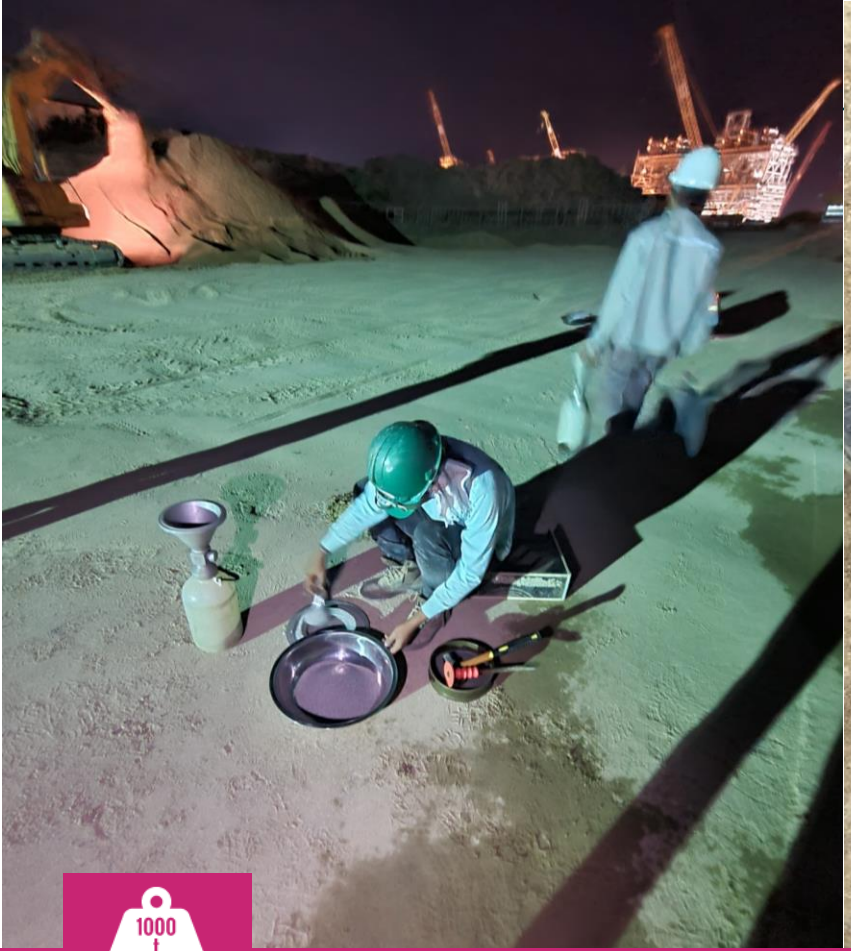
A.2 TRANSVERSE SECTION
ST 01 SCALE: 1:150MTS

AG&P ATLANTIC, GULF & PACIFIC COMPANY OF MANILA INC.	PROJECT: PROJECT EPIC TANK FARM FACILITY & SITE DEVELOPMENT LOCATION: SAN ROQUE, BAUAN BATANGAS	OWNER: ECOZONE PROPERTIES INC. 122 Progress Avenue, Carmelray Industrial Park 1, Special Economic Zone, Canlubang, Calamba City, Laguna, 4028

Ground Improvement | Original Site Condition | Batangas, Philippines

1000 t

Ground Improvement | MacTex MXL | Separation Geotextile | Batangas, Philippines



Ground Improvement | Field Density Test (95% MDD) | Batangas, Philippines

Ground Improvement | MacGrid WG | Installation | Batangas, Philippines

1000 t

Ground Improvement | MacGrid WG | Installation | Batangas, Philippines

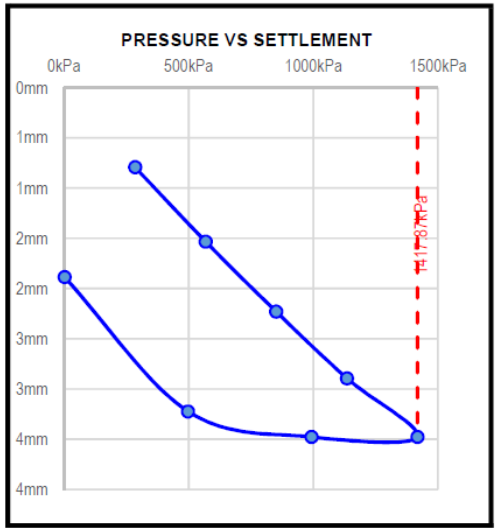
Ground Improvement | Completed building above the foundation pad | Philippines

RESULTS OF PLATE LOAD TEST

MACCAFERRI

IN-SITU PLATE LOAD TEST (BS 1377 PART 9 : 1990 STANDARD)	
PARAMETERS AND RESULTS	**VALUE**
EXCAVATION DEPTH	2.00m
WIDTH OF FOUNDATION	10.00m
PLATE DIAMETER	300.00mm
UNIT WEIGHT OF SOIL	18.00kN/m3
WEIGHT OF JACK	10.50kg
WEIGHT OF PLATE	12.30kg
WEIGHT OF SAND BAG & PLATFORM	10000.00kg
MATERIAL CLASSIFICATION	-
MAX. PERMISSIBLE FOUNDATION SETTLEMENT	50.00mm
MAX. RECORDED PLATE SETTLEMENT	3.48mm
PLASTIC SETTLEMENT	1.76mm
ELASTIC SETTLEMENT	1.72mm
MAX. RECORDED FOUNDATION SETTLEMENT	13.11mm
ALLOWABLE DIFF. SETTLEMENT	9.83mm
FACTOR OF SAFETY	3.00
REQUIRED ALLOWABLE BEARING CAPACITY	60.00kPa
MAX. APPLIED PLATE STRESS	1417.87kPa
ULTIMATE BEARING CAPACITY	1417.87kPa
ALLOWABLE BEARING CAPACITY	472.62kPa

THE RECOMMENDED ALLOWABLE BEARING CAPACITY IS 470kPa



GEOINNOVATIVE SPECIALISTS INC.
DESIGN, GEOTECHNICAL INVESTIGATION, MATERIALS TESTING
GEOINNOVATIVE COMPOUND LOT 6111-G MAGUEY ROAD, SITIO RADAR SAN LUIS, ANTIPOLO CITY, RIZAL
M : (+63) 961 095 9258 or (+63) 955 188 4420 | T : 8298 9455 | E : sales@geoinnovative.com

CLIENT:	STA/ CLARA INTERNATIONAL CORP.	TEST NO.	2022-02-PLT-002B
PROJECT:	PROJECT EPIC	DATE TESTED:	11/02/2022
LOCATION	BAUAN, BATANGAS	NORTHING:	
TESTED BY:	ROEL TALAVERA - LAB TECH	EASTING:	

LUDO LUYM OIL STORAGE TANKS
Lahug, Cebu

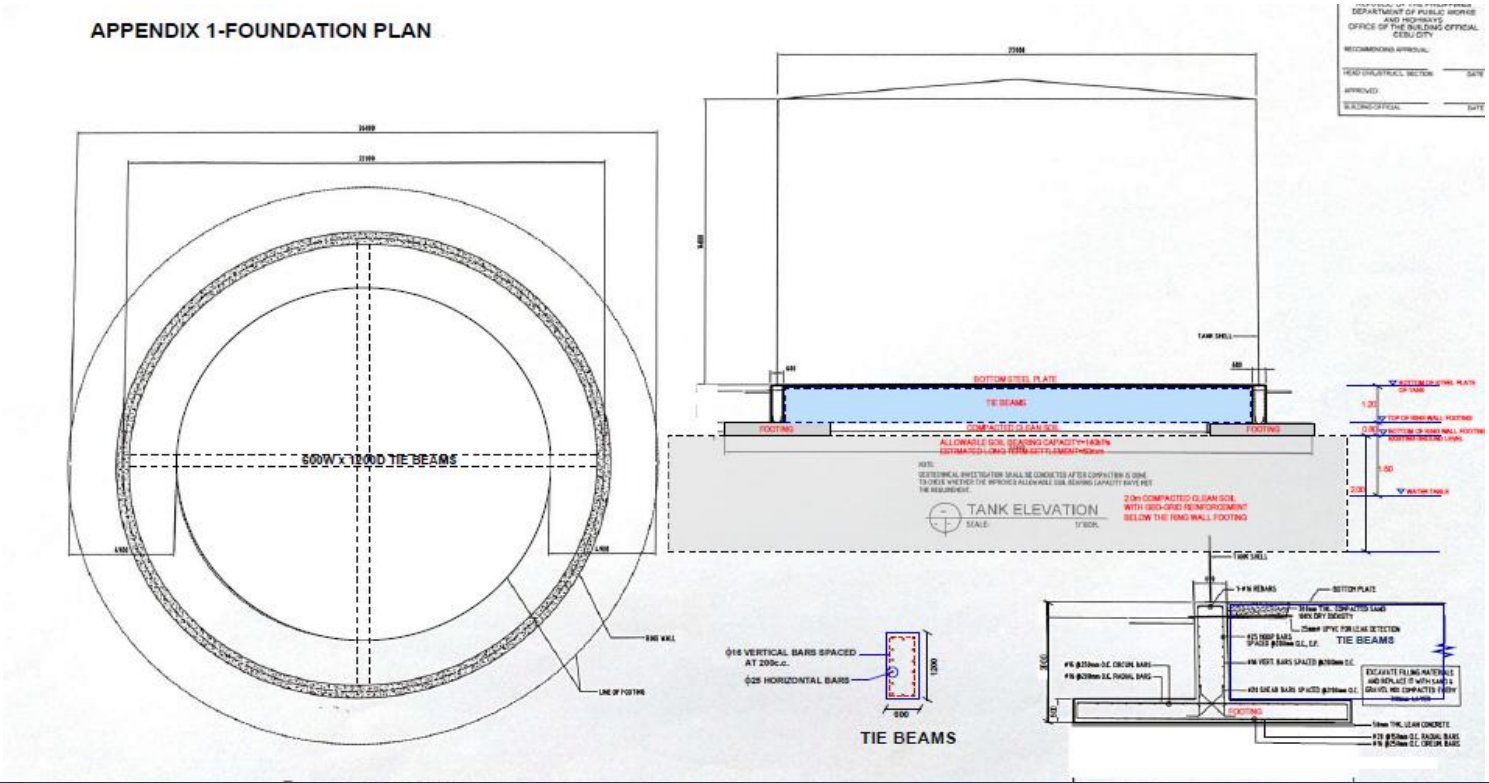
MACCAFERRI

LUDO & LUYM CORPORATION

E.C. CALDERON CONSTRUCTION DEVELOPMENT, INC.

LUDO LUYM OIL STORAGE TANK

MACCAFERRI



1000 t

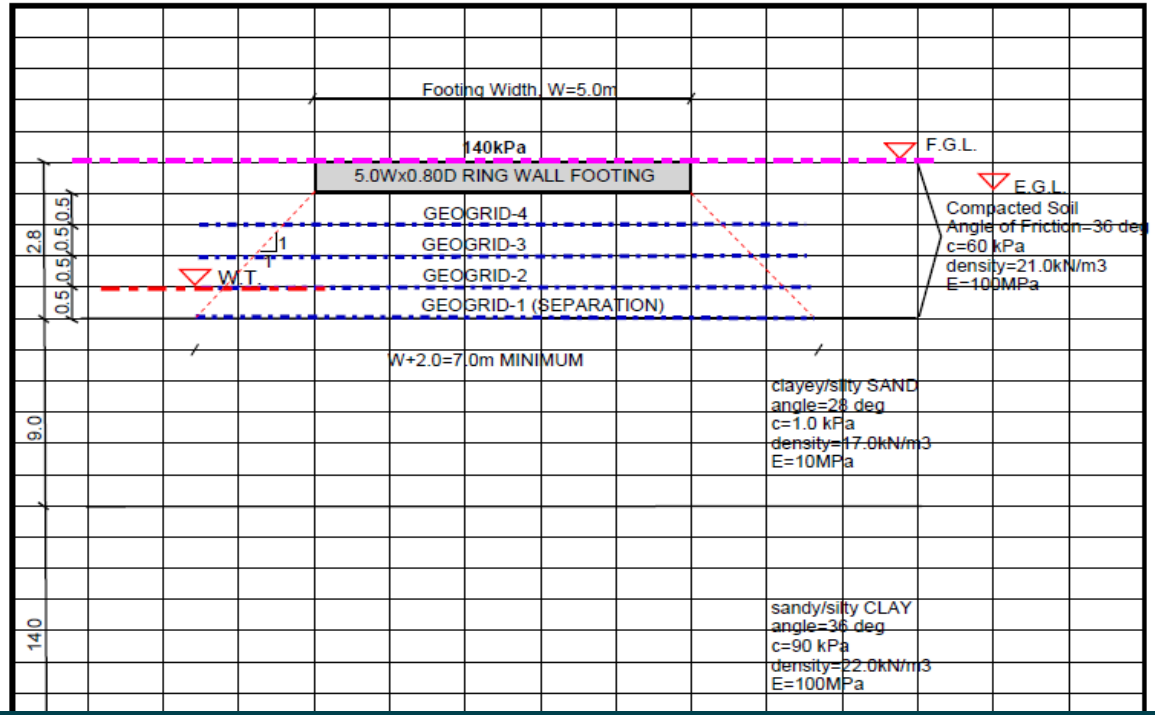
Subgrade Improvement | MacGrid® , MacTex® | Cebu, Philippines

LUDO LUYM OIL STORAGE TANK

MACCAFERRI

CALCULATION SHEET

OPTIMUM ENGINEERING CONSULTANTS



PREPARATION FOR GEOGRIDS INSTALLATION

MACCAFERRI

First Layer

1000 t

Ground Improvement | Installation | Cebu, Philippines

GEOGRIDS INSTALLATION

MACCAFERRI

Second Layer

1000 t

Ground Improvement | Installation | Cebu, Philippines

GEOGRIDS INSTALLATION

Third Layer

1000 t

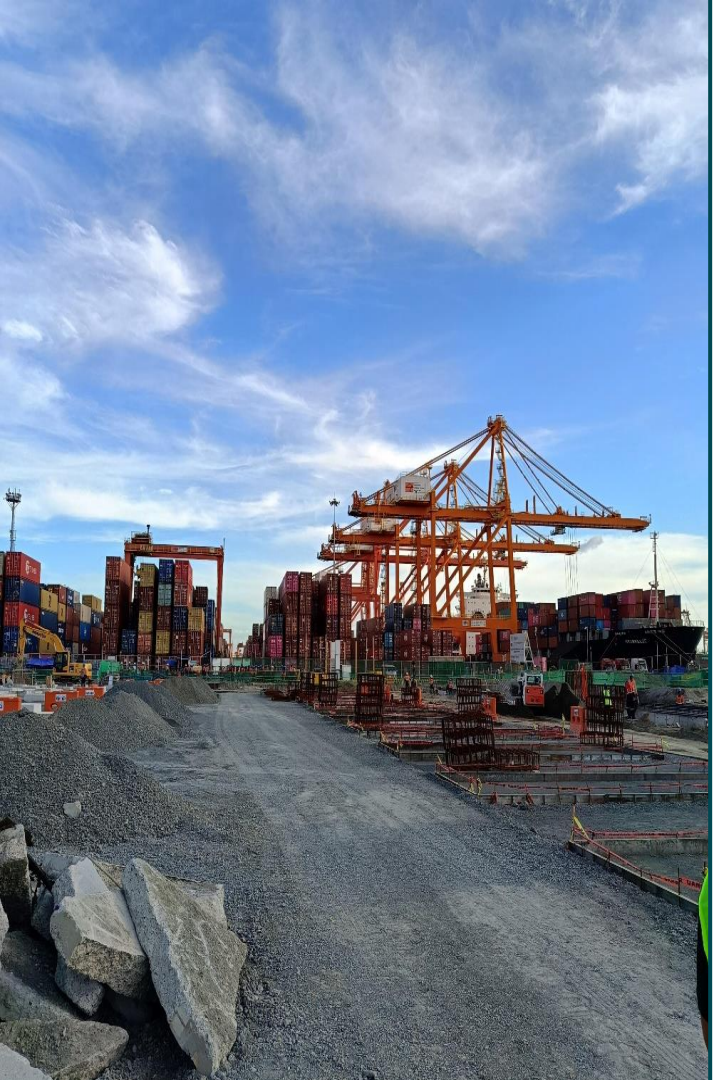
Ground Improvement | Installation | Cebu, Philippines

GEOGRIDS INSTALLATION

Third Layer

GEOGRIDS INSTALLATION

Third Layer



MICT Berth 8 Expansion Ground Improvement using Geogrids
Tondo, Manila

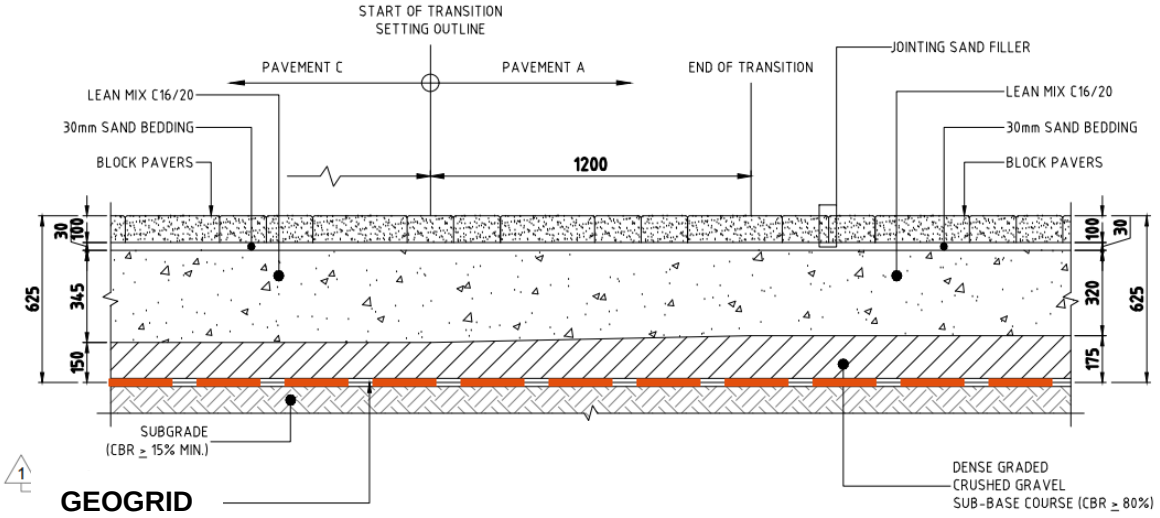
MACCAFERRI

International Container Terminal Services, Inc.

PRIME BMD

SOIL STABILIZATION

MICT Berth 8 Expansion



1000 t

Ground Improvement | MacGrid EG | Manila, Philippines

SOIL STABILIZATION

MICT Berth 8 Expansion

Ground Improvement | MacGrid EG | Manila, Philippines

NEW MANILA INTERNATIONAL AIRPORT
Wharf and Pavement Subgrade Improvement
Bulakan, Bulacan

MACCAFERRI

SAN MIGUEL CORPORATION

PRIME BVP

SOIL STABILIZATION

New Manila International Airport

1000 t

Ground Improvement | MacGrid EG | Manila, Philippines

Subgrade Improvement | MacCell® | Balesin Island, Quezon Province

BASAL REINFORCEMENT

For Embankments on Soft Soil

MACCAFERRI

INTRODUCTION & OVERVIEW

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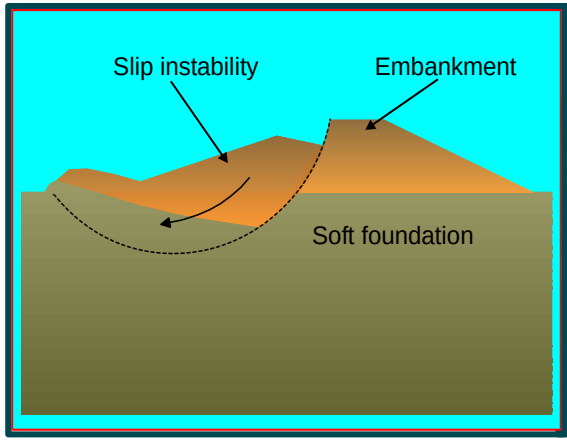
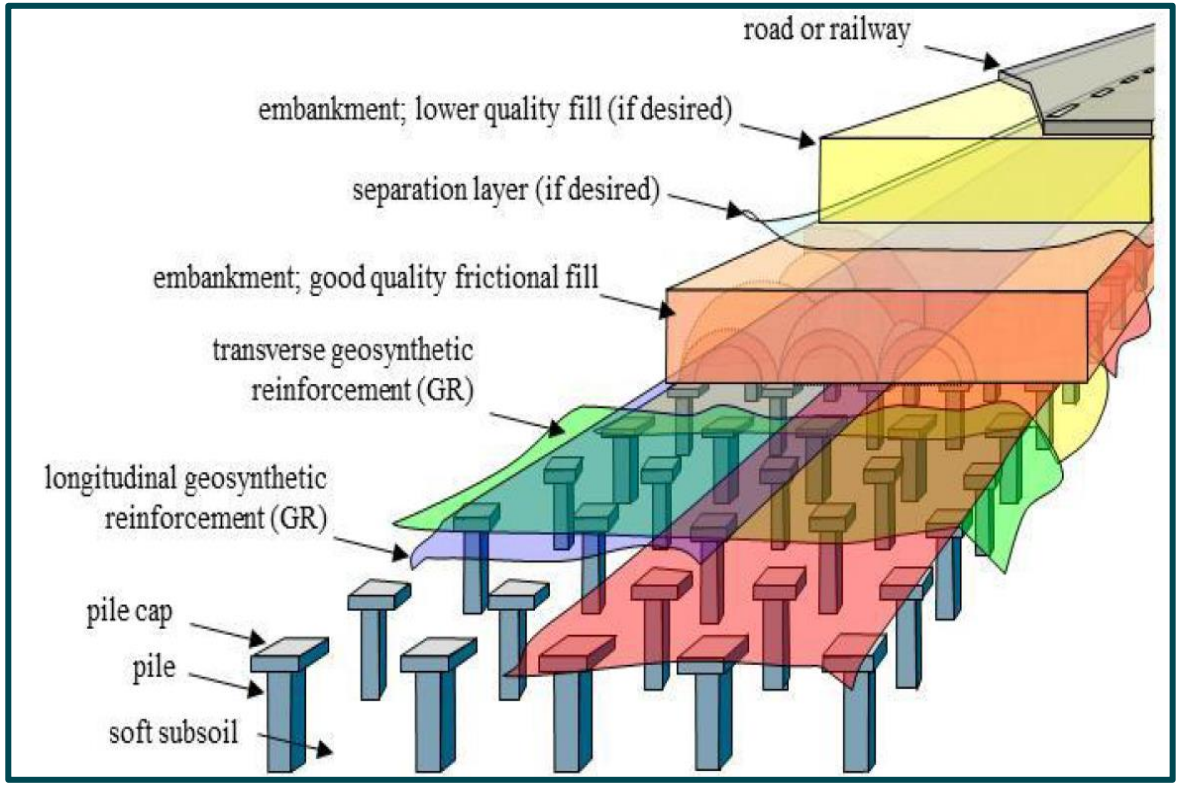
BASAL REINFORCEMENT

- Low initial undrained shear strength (bearing capacity)
- High water table
- Stability of embankment
- High compressibility
- Settlement
- Very low permeability



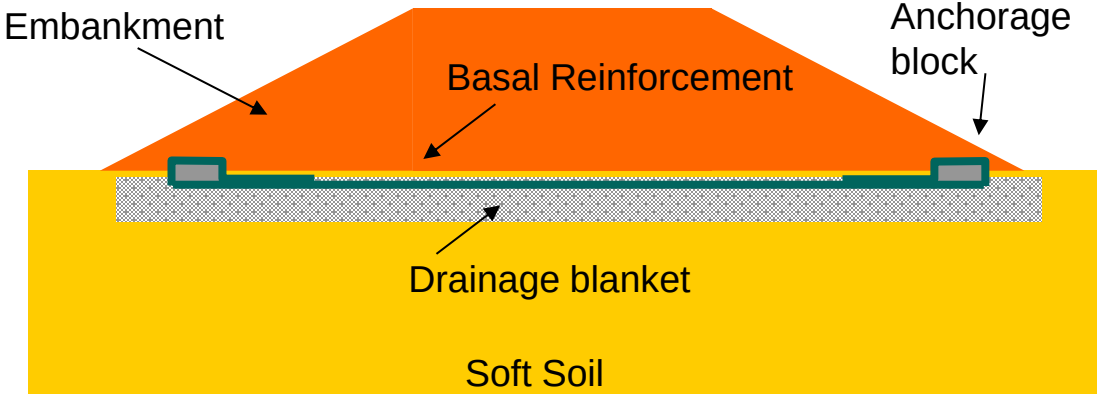
INTRODUCTION & OVERVIEW

BASAL REINFORCEMENT



INTRODUCTION & OVERVIEW

BASAL REINFORCEMENT



What can geosynthetics do?

to increase the safety factors against catastrophic failure	Yes
to limit the magnitude of overall settlements	No **(Can be)**
to control differential settlements	Partly

BASAL REINFORCEMENT

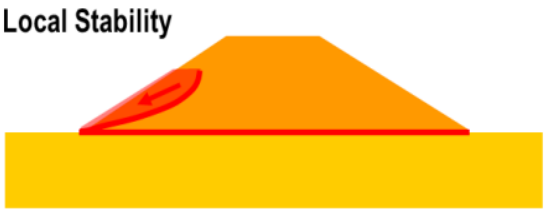
AS PER BS 8006

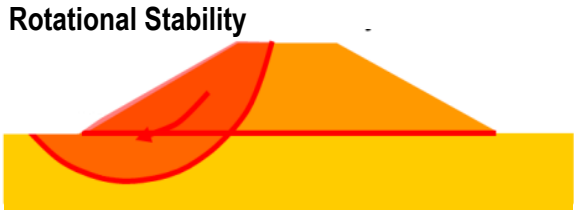
Ultimate Limit States considered in BS 8006 are:

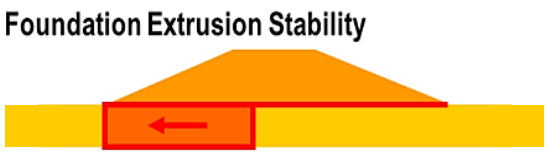
- Rotational Stability of embankment.
- Lateral Sliding Stability of the embankment fill.
- Foundation Extrusion Stability.
- Global Stability (Overall).

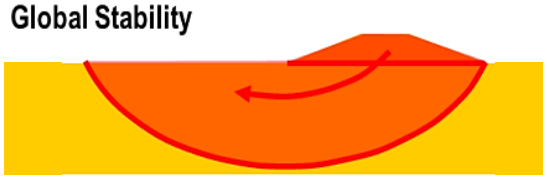
Serviceability Limit States considered in BS 8006 are:

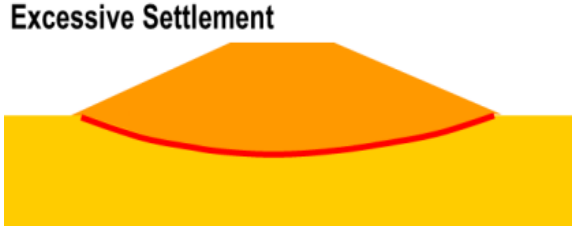
- Settlement of the foundation.
- Excessive strain in the embankment











BASAL REINFORCEMENT

PARALINKS HIGH PERFORMANCE GEOGRIDS

- In use since 1977 and with strengths up to **1200 kN/m**, Maccaferri's Paralink® are unique planar structures consisting of a monoaxial array of composite geosynthetics strips.
- Paralink geogrids are amongst the most tried and tested geogrids in the world offering 120-year design life and high performance.
- The incredibly tough polyethylene sheath is resistant to physical, chemical and biological conditions found in reinforced soil structures.

Paraproduct
Geogrid
Reinforcement

MacGrid®WG
Geogrid
Reinforcement

MacTex® W
Woven Geotextile

Basal Reinforcement | ParaLink® | India: Mundra Port

1000 t

Basal Reinforcement | ParaLink® | India: Mundra Port

1000 t

Basal Reinforcement | ParaLink® | South Africa

1000 t

Basal Reinforcement | ParaLink® | Russia

1000 t

Basal Reinforcement | ParaLink® | Slovakia

1000 t

Basal Reinforcement | ParaLink® | South Africa

Basal Reinforcement | ParaLink® | United Kingdom

1000 t

Basal Reinforcement | ParaLink® | Canada

1000 t

Basal Reinforcement | MacTex® | Davao del Norte, Philippines

Basal Reinforcement | MacTex® | Davao del Norte, Philippines

1000 t

Basal Reinforcement | MacTex® | Davao del Norte, Philippines

Basal Reinforcement | MacTex® | NSCR – Pampanga, Philippines

Basal Reinforcement | MacTex® | NSCR – Pampanga, Philippines

GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

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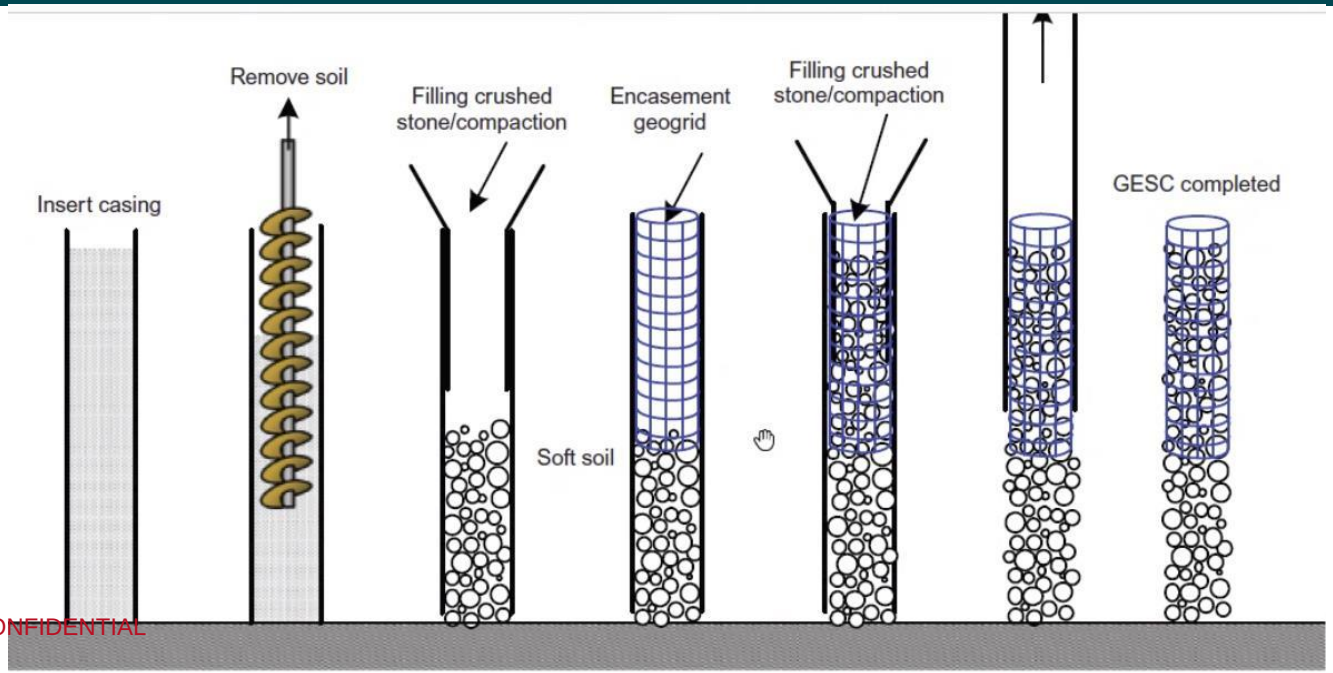
INTRODUCTION AND OVERVIEW

GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

- Stone columns are used for both cohesive soils and silty sands to increase strength and decrease compressibility.
- This method involves discrete inclusions that reinforces soil and is suited for wide spread loads.



GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

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ADVANTAGES OF STONE COLUMNS

- Reduces shallow foundation settlement.
- Increases bearing capacity, allowing a reduction in footing size.
- Mitigates liquefaction potential.
- Provides slope stabilization.
- Permits construction on fills.
- Permits shallow footing construction.
- Prevents earthquake-induced lateral spreading.

GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

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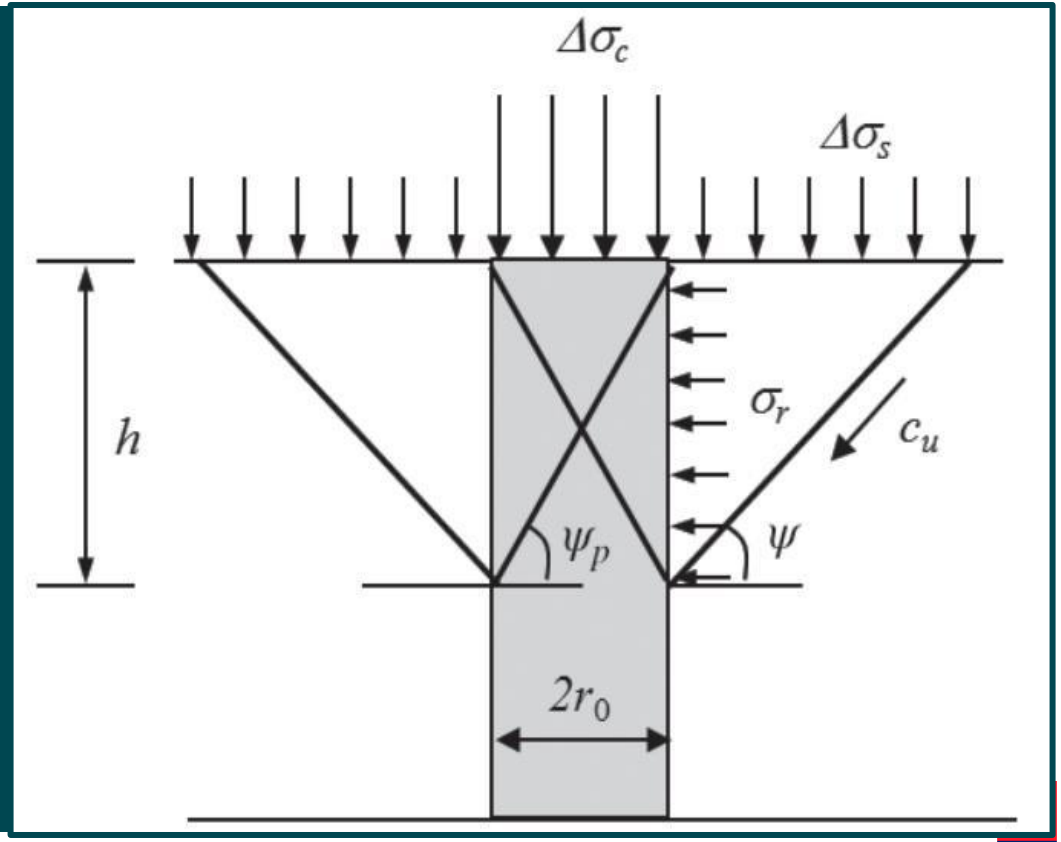
BEARING CAPACITY OF STONE COLUMNS

- Brauns (1978) proposed a simplified method to estimate the ultimate bearing capacity of an individual stone column in saturated soft soil under an undrained condition based on an asymmetrical model.
- This method considers a passive shear failure from the column to the surrounding soil. It is assumed: (1) the interface between the column and the soil is smooth, (2) no circumferential (hoop) stress exists, and (3) no self-weight is considered for the column and the soil.



GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

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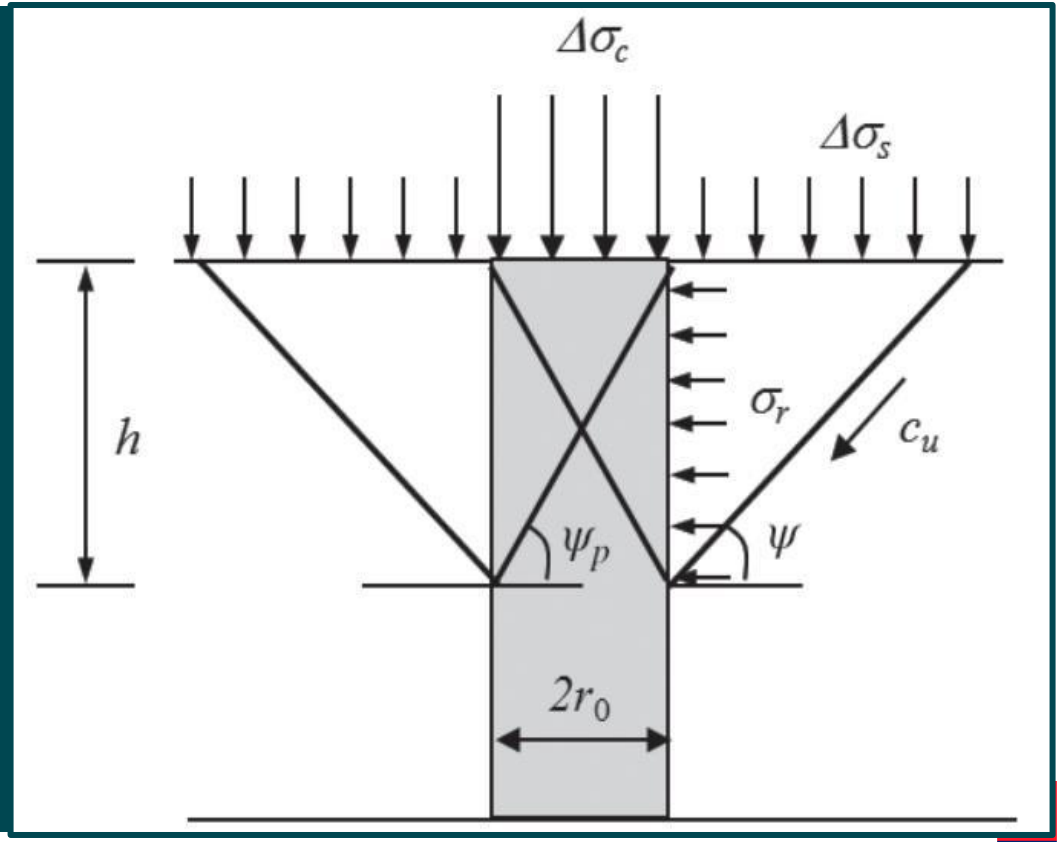
BEARING CAPACITY OF STONE COLUMNS

Since stone columns and the surrounding soil mobilized their strengths at a similar strain level, the ultimate bearing capacity (q_{ult}) of a granular-column-reinforced composite foundation can be estimated as follows:

$$q_{ult} = q_{ult,c}a_s + q_{ult,s}(1 - a_s)$$

Where q_{ult} is the ultimate bearing capacity of the surrounding soil, which can be estimated as $5c_u$ as suggested by Barksdale (1987).



GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

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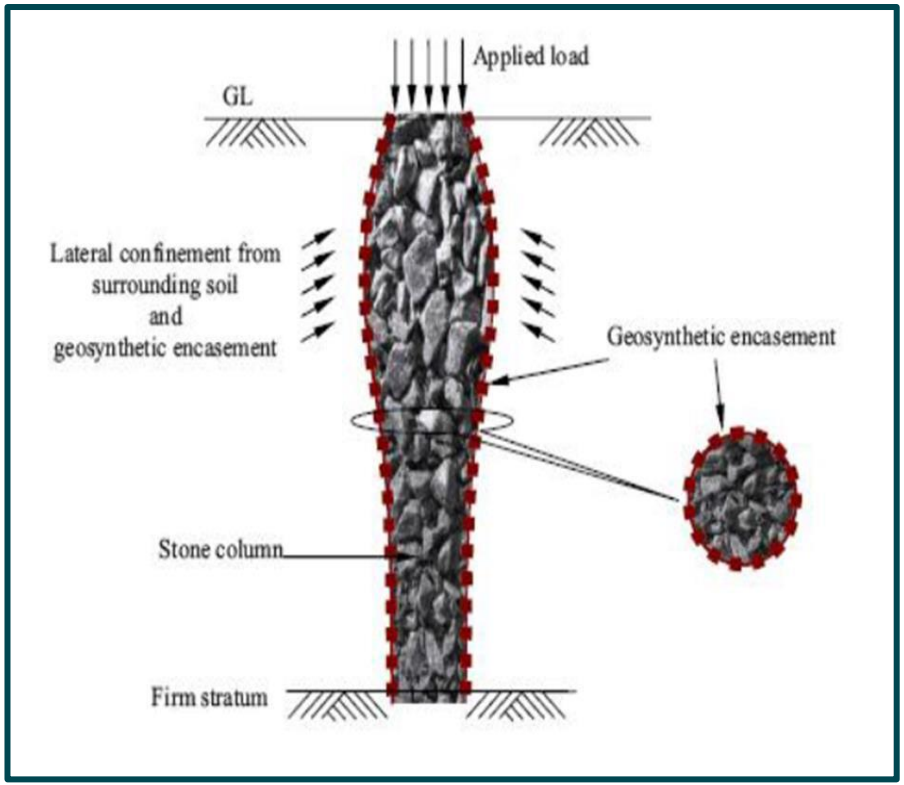
SOLUTIONS USING GESCs



FUNCTIONS

- End bearing element transferring loads to firm stratum with radial confinement of bearing column
- Separation, filtration, drainage
- GESCs are water permeable that may also perform as high capacity vertical drains but they practically do not influence the flow of ground water streams.
- GESC systems cannot be completely settlement-free; hence widely used for flexible structures.

GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

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CALCULATIONS

In addition to the lateral confinement by surrounding soil, Murugesan and Rajagopal (2010) considered additional confinement by geosynthetic encasement for the ultimate bearing capacity of an individual stone column due to possible bulging failure with a bulging length of four times the column diameter as follows:

$$q_{ult,c} = \left(\sigma_{r0} + 4c_u + \sigma_{r,g}\right)K_p$$

Where σ_{r0} = lateral soil stress induced by the overburden stress at the middle point of the column bulging length; σ_{r0} = additional confining stress by geosynthetic encasement; K_p = coefficient of passive earth pressure of the column.

The additional confining stress was calculated by considering the hoop tensile force in the geosynthetic encasement as follows:

$$\sigma_{r,g} = \frac{2T_g}{d_c}$$

Where T_g is the hoop tensile force of the geosynthetic.

GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

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TYPICAL DESIGN PARAMETERS

- Suitable for compressible silts and clays (undrained shear strength, c_u = 15−50 kPa)
- Typical spacing: 1.5 - 3.5 m
- Typical diameter: 0.8 - 1.1 m
- Typical depth: 10 - 15 m (max. 30 m)
- Replacement ratio: 0.2 - 0.4
- Stress concentration ratio: 2 - 5 (rigid footing) & 1.5 to 3.0 (embankment)
- Settlement improvement factor: 1.5 – 6
- Column loads: < 500 kN/column

GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

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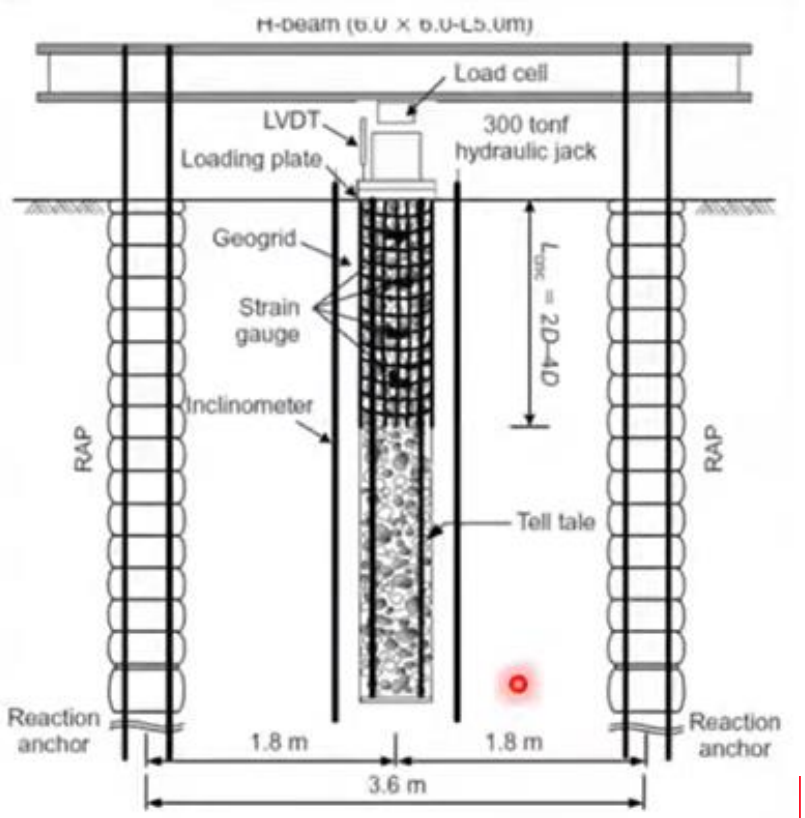
RESEARCH ARTICLE

Performance of geogrid-encased stone columns in soft ground: full-scale load tests.

C. Yoo and D. Lee

The geogrid-encased stone column (GESC) system, which increases the confinement effect, has been developed to improve the load-carrying capacity of stone columns. This paper presents the results of an investigation on improvement in load-carrying capacity and settlement reduction of a GESC using field-scale load tests. Also, the effect of the geogrid encasement length and column strain is investigated. In addition, isolated GESC behavior was compared to rammed aggregate pier (RAP) and conventional stone column (CSC) behavior. The results show that additional confinement provided by the geogrid encasement increased the stiffness of the stone column and reduced the settlement of the soft ground. Also, bulging of the GESC was observed to occur directly beneath the base of the geogrid encasement. The improvement in the performance of GESC was found to be significant, even with partial encasement.



GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

RESEARCH ARTICLE

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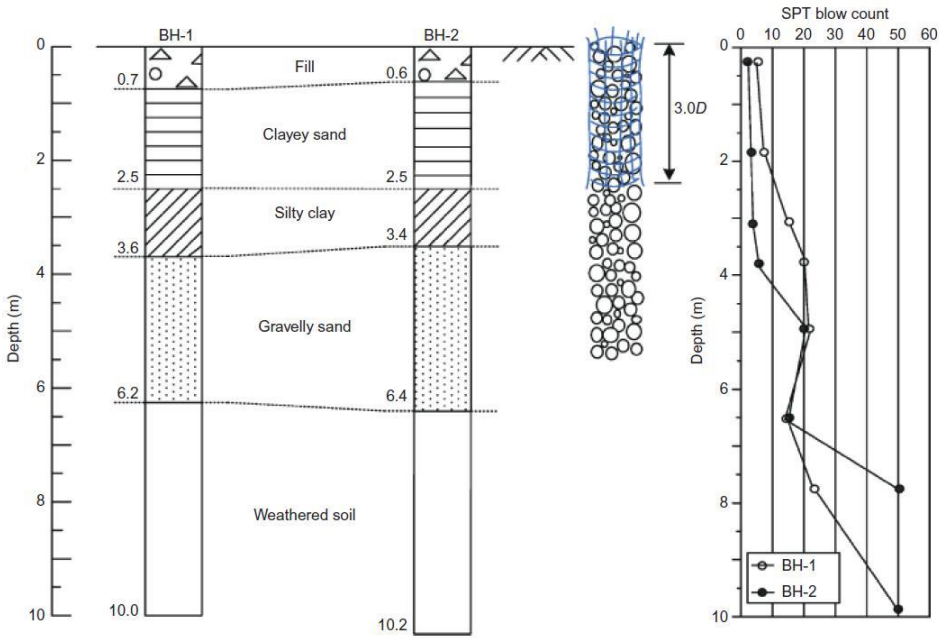
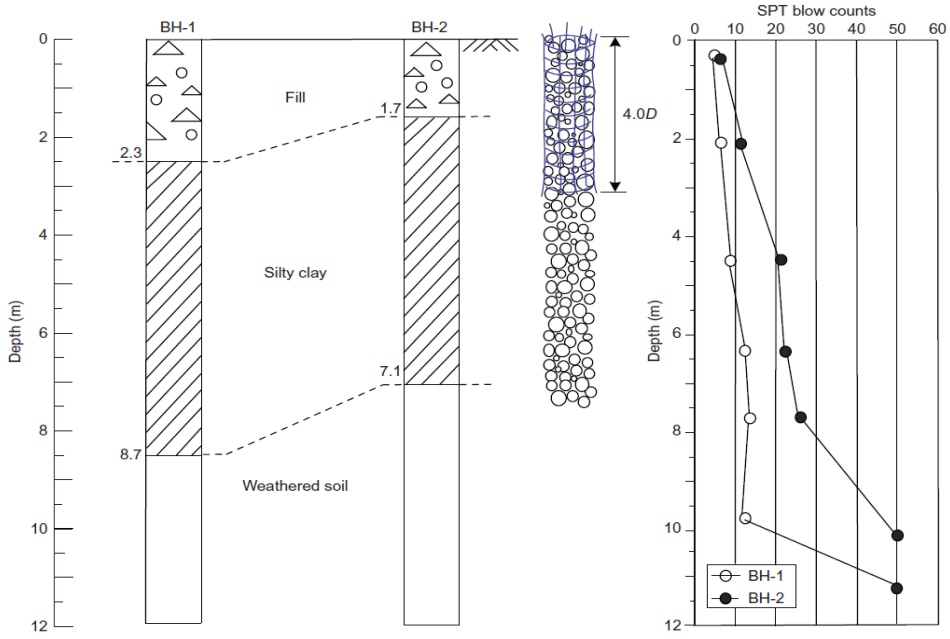
GIMHAE SITE



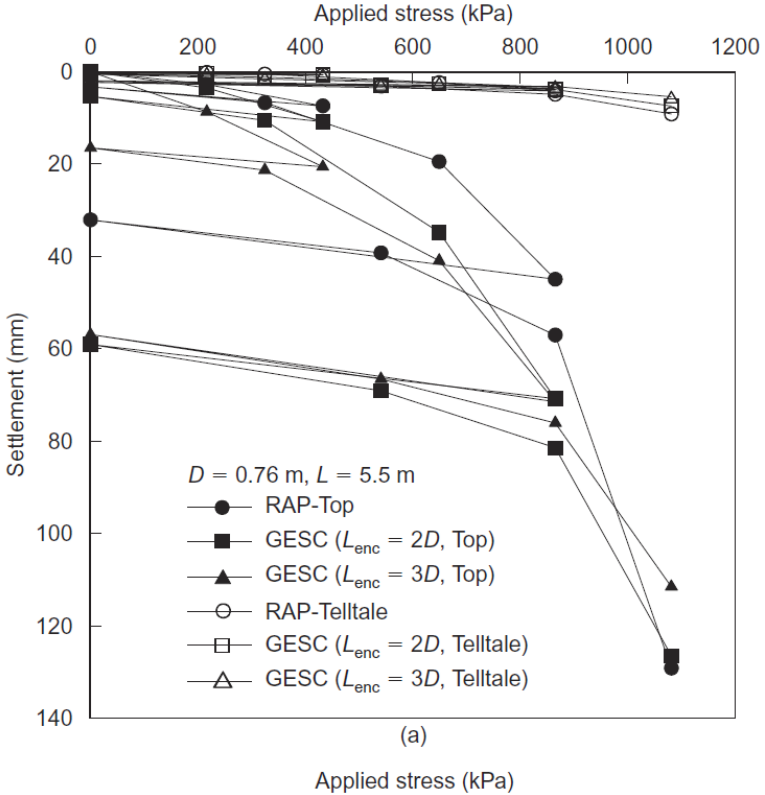
POHANG SITE



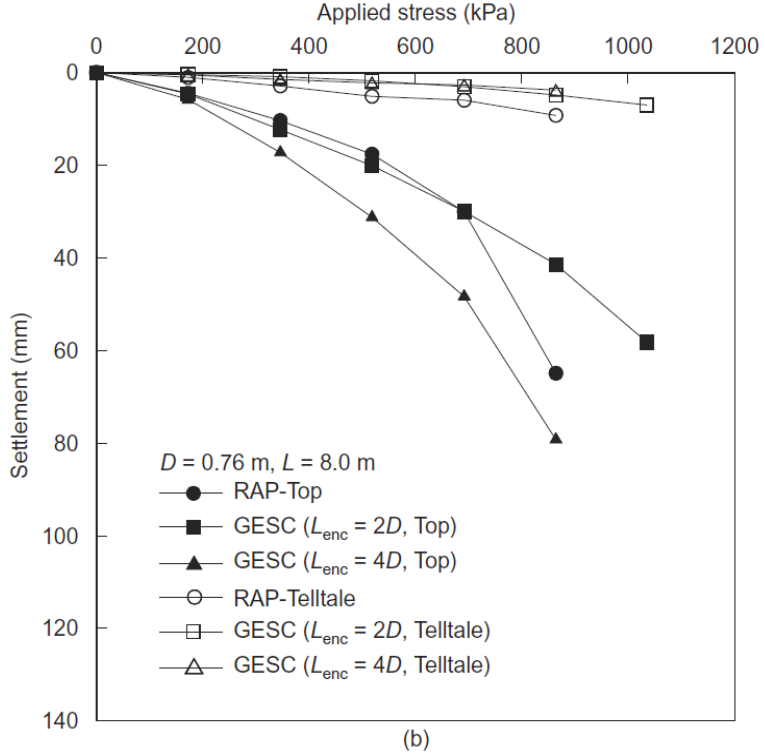
GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

RESEARCH ARTICLE

GIMHAE SITE



POHANG SITE



GEOSYNTHETIC ENCASED STONE COLUMNS (GESCs)

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CASE STUDY CONCLUSION

- The lateral bulging is considerably decreased due to the added confinement by the geogrid encasement.
- The failure mode of the RAP is bulging failure. The confining effect provided by the geogrid encasement controls bulging failure in unreinforced stone columns, thus improving their load-carrying effect by reducing settlement and preventing rapid column failure.
- In the case of GESCs, maximum deflection within the geogrid-encased region was within 5 mm, thus showing approximately 3 times the lateral deflection reduction effect of RAPs.
- It is recommended that at least 4.0D from the top is encased with geogrid to maximize the reinforcement effect of the geogrid.
- Geogrid hoop strain reaches its maximum value within a depth of 1.0D from the top of the column and decreases as the depth increases.
- It can be seen that the critical encasement length of geogrid is at 3D.

CERTIFIED QUALITY

MACCAFERRI

Our design process is focused on test campaigns and investments in performance evaluation of our solutions.

Approval on the product quality including testing in laboratories, onsite evaluations, quality management checks and inspections of production

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HITEC

Highway Innovative Technology Evaluation Center – an evaluation performed by a panel of experts - final report is the result of an impartial, consensus-based approach to evaluating the system

Rigorous certification procedure to ensure that the performances of commercial kits conform to predefined performances criteria

PAR AFNOR CERTIFICATION

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GROUND IMPROVEMENT USING GEOSYNTHETICS

MACCAFERRI

SUMMARY

PREFABRICATED VERTICAL DRAINS

BEARING CAPACITY IMMPROVEMENT USING GEOGRID RAFT FOUNDATION

BASAL REINFORCEMENT FOR EMBANKMENTS ON SOFT SOIL

GEOSYNTHETIC ENCASED STONE COLUMNS

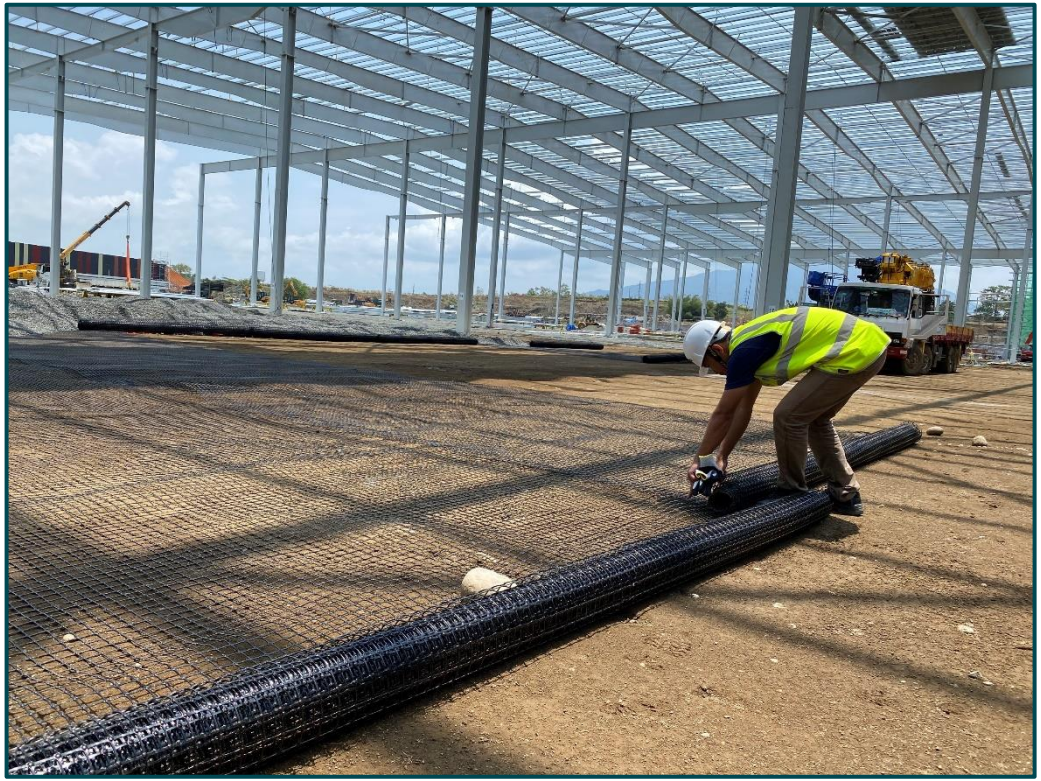
We can support you in your projects in every phase of the projects, from design support to material supply, site technical assistance, and installation support.

- Advance & Flexible System
- Cost-effective, sustainable, and environment-friendly solutions
- Saving natural materials producing less carbon
- Increase in speed of construction due to easy method of installation
- Easier to execute & unskilled labor can be used for a major part
- Reduce construction and operational costs

MACCAFERRI SOLUTIONS FOR GROUND IMPROVEMENT

SUMMARY

- PREFABRICATED VERTICAL DRAINS
- BEARING CAPACITY IMMPROVEMENT USING GEOGRID RAFT FOUNDATION
- BASAL REINFORCEMENT FOR EMBANKMENTS ON SOFT SOIL
- GEOSYNTHETIC ENCASED STONE COLUMNS



THANK YOU!

Q & A

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g.silang@maccaferri.com
0939-903-6654 / 0995-156-5517

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