GEOTECHNICAL INSTRUMENTATION: Ensuring Safety & Stability of ERSS

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Content:

- Over view
- Type of wall
- Design Consideration & Failure modes
- Objective in Instrumentations and Types
- Main Application of JGP in Deep Excavation
- Authority Guideline
- How to Access/ Interpret Instrumentation & Monitoring Data & Report

(a). Before collapse

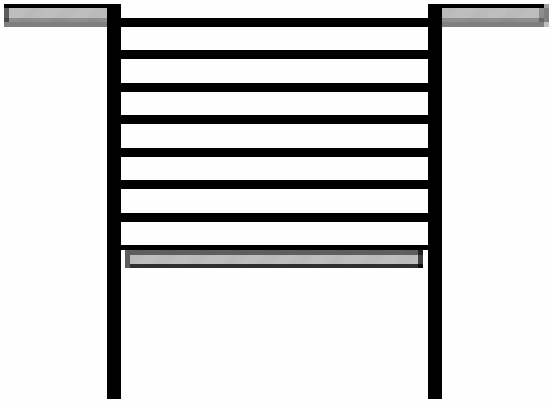
(b).After collapse

The collapse was caused by

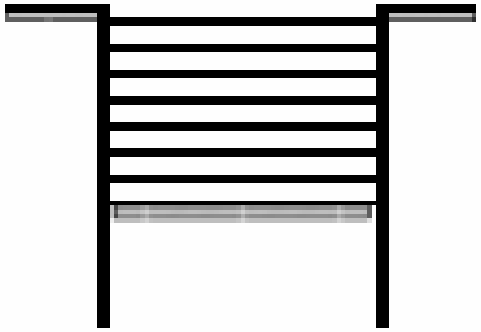
- poorly designed strut-waler support system,
- lack of monitoring and proper management of data caused by human error,
- organisational failures

Inexperienced personnel had been appointed to monitor the safety of the retaining wall system

- higher standard of reliability and accuracy in monitoring data



A robust design is the most important step towards a successful excavation.



A poor design brings…

Headache

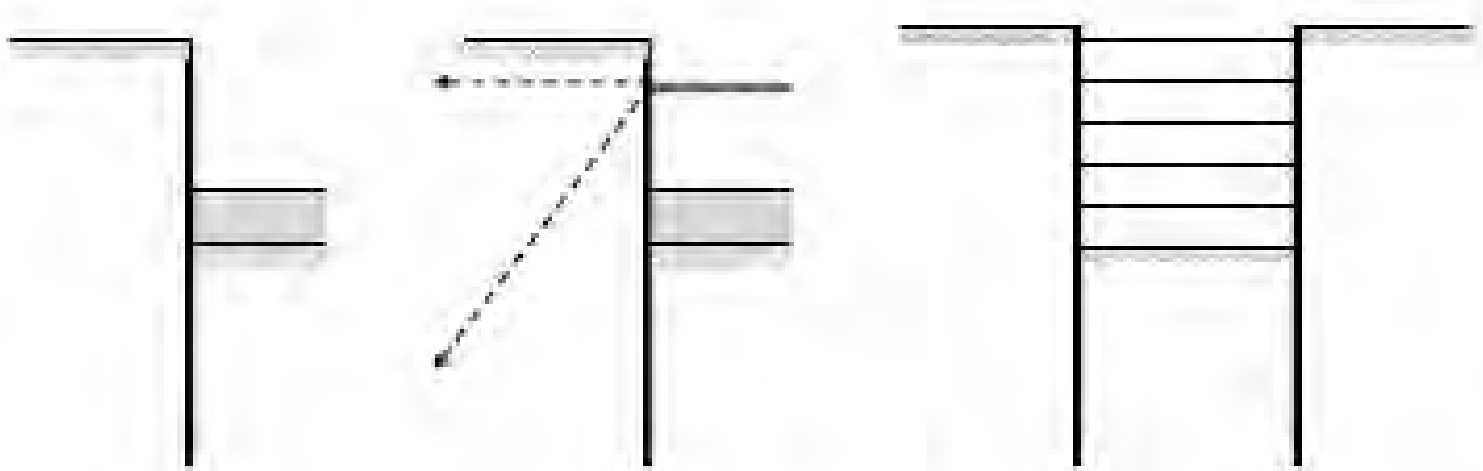
Trouble

Disaster !!!

The end result is **cost over-run** and **time delay**!

TYPE OF WALL FOR DEEP EXCAVATION

Types of Retaining Walls for Excavation



Cantilever Wall

Anchored or
Propped Wall

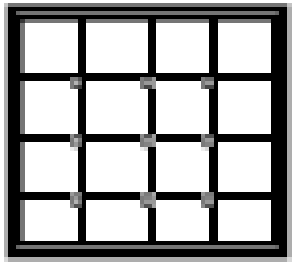
Braced Wall

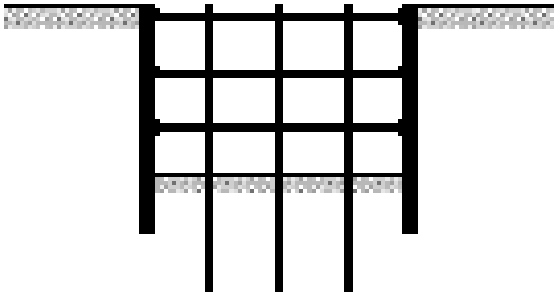
WHAT IS A BRACED CUT?

An excavation supported by suitable bracing system are called braced cut. These excavation support systems are used to,

- Minimized the excavation area,
- Keep the sides of deep excavations stable, and Ensure that movements of soil
- Will not cause damage to neighboring structures or utilities
  in the surrounding ground.

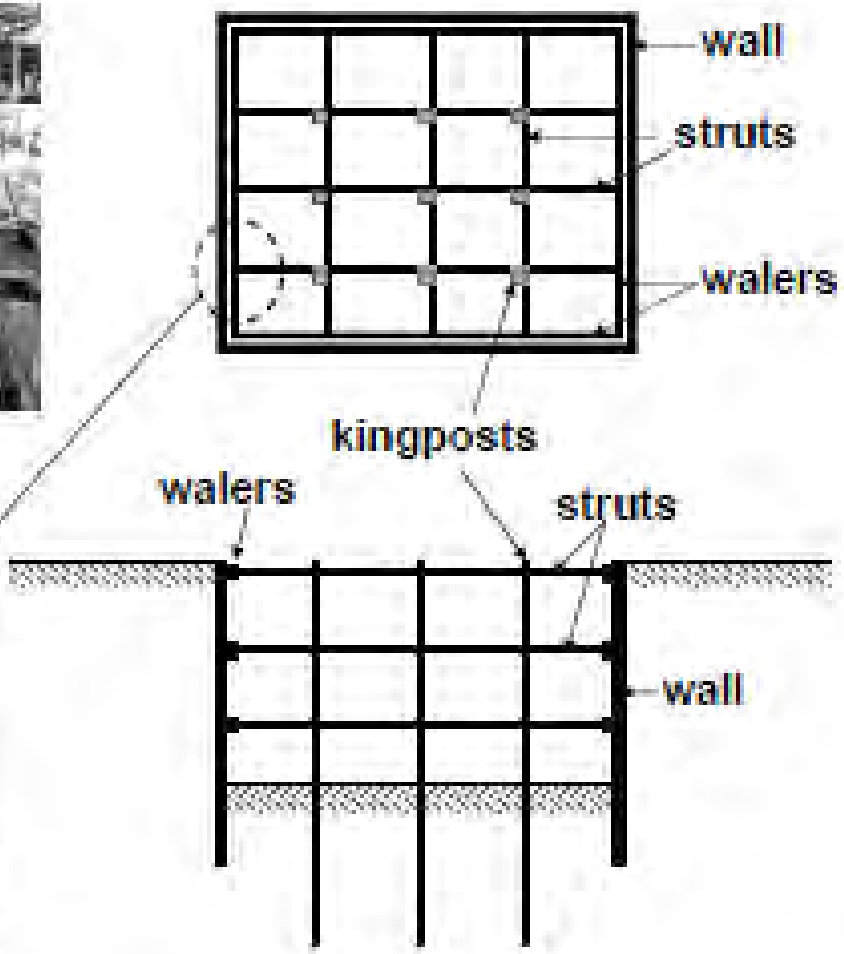
Wall Types of Deep Excavations

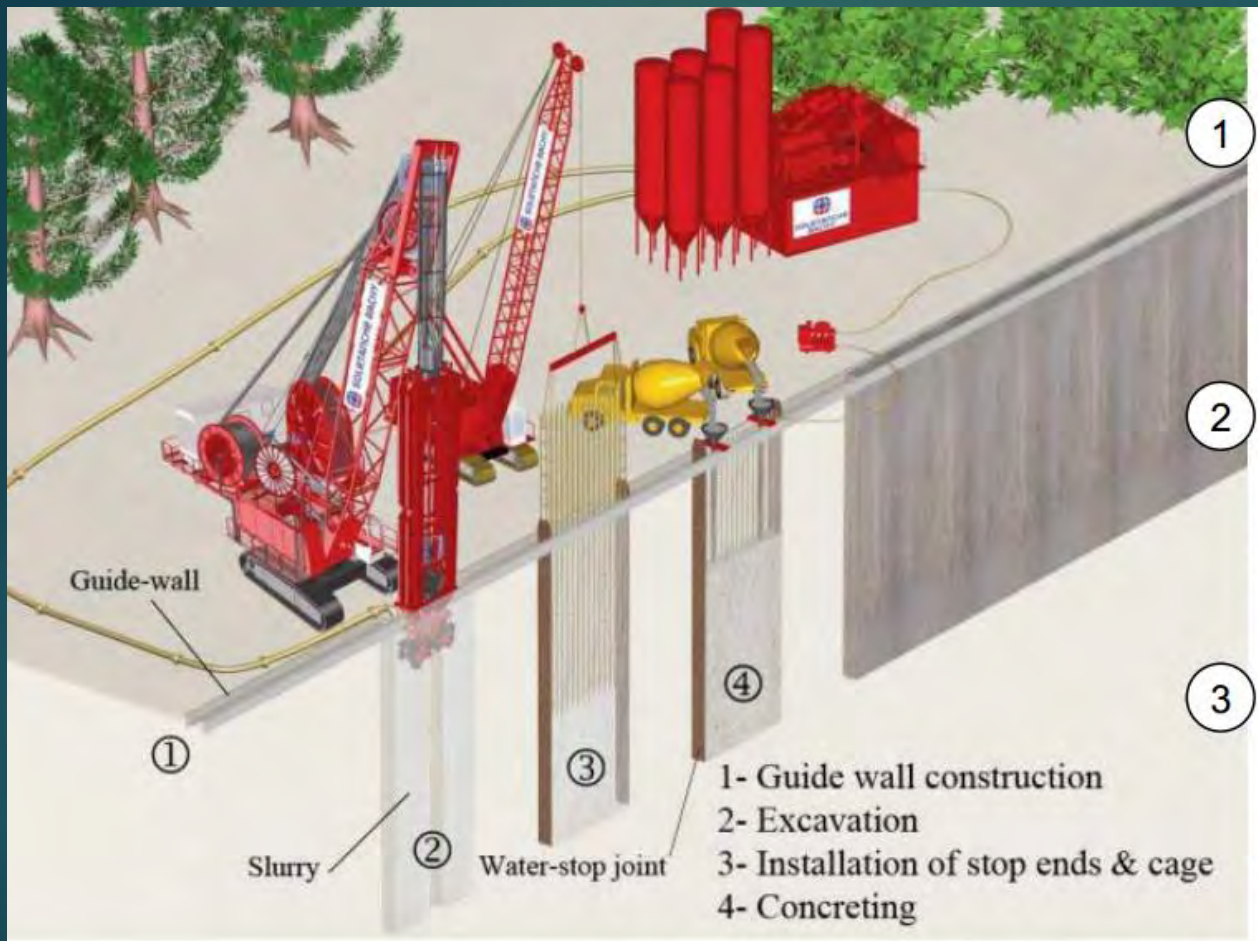




- Diaphragm Wall
- Sheetpile Wall
- Bored Pile Wall
- Soldier Pile Wall
- DCM or Grout Mixed Pile Wall

Braced Excavation with Diaphragm Wall




Guide-wall
①
②
③
④
Slurry
Water-stop joint
1- Guide wall construction
2- Excavation
3- Installation of stop ends & cage
4- Concreting

1

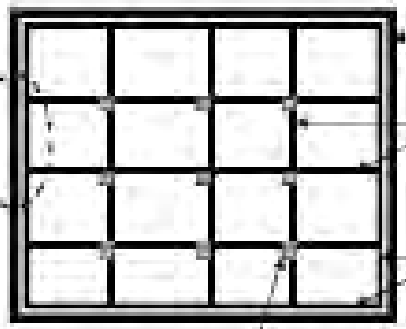
2

3

4

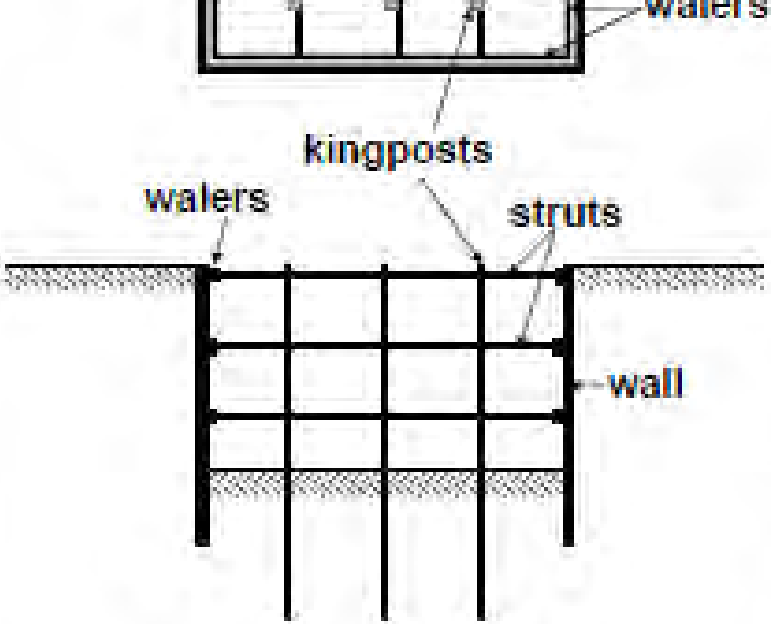
DIAPHRAM WALL CONSTRUCTION (5:30 MINUTES)

Braced Excavation with Sheetpile Wall



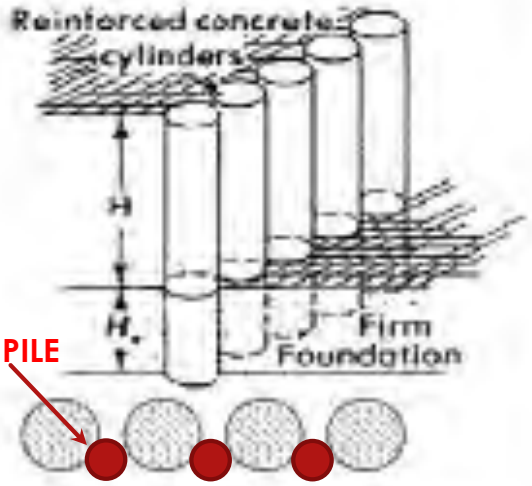
U-Section

CV633 Section



SHEET PILE WALL

Bored Pile Walls



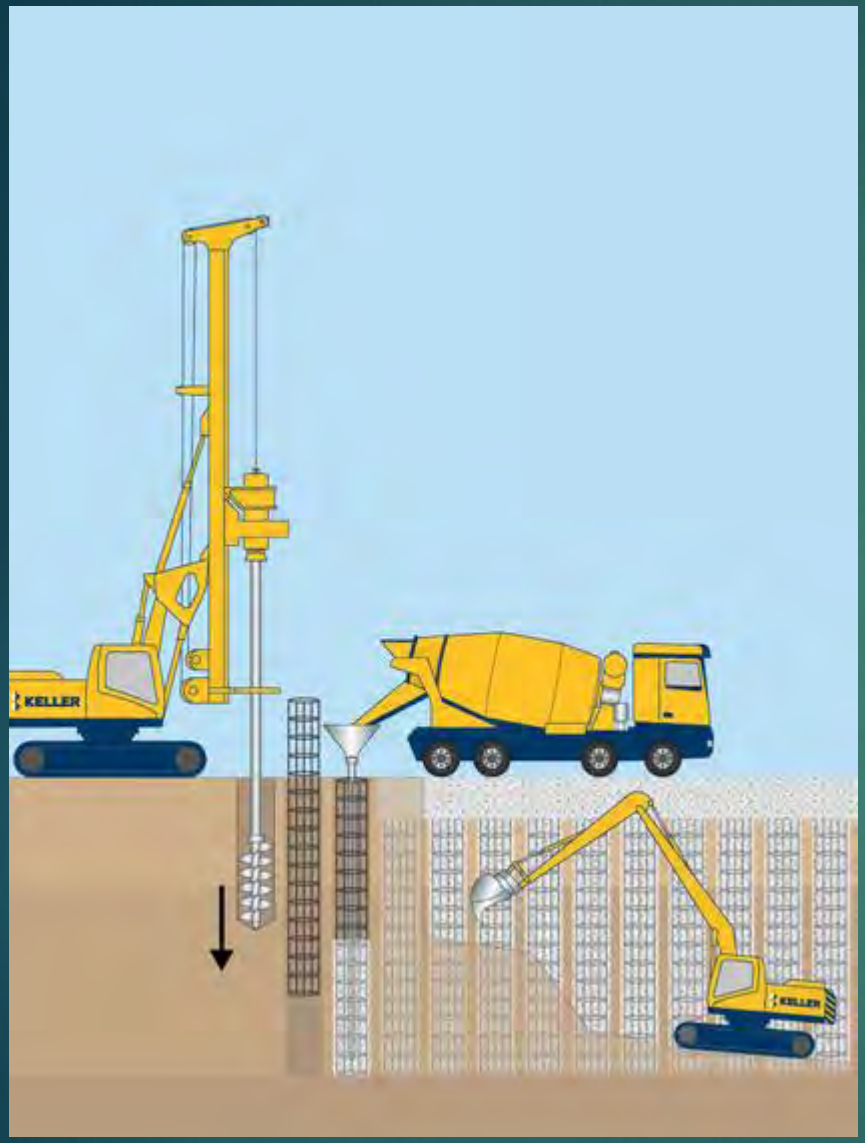
GROUT PILE

Contiguous Bored Pile Wall

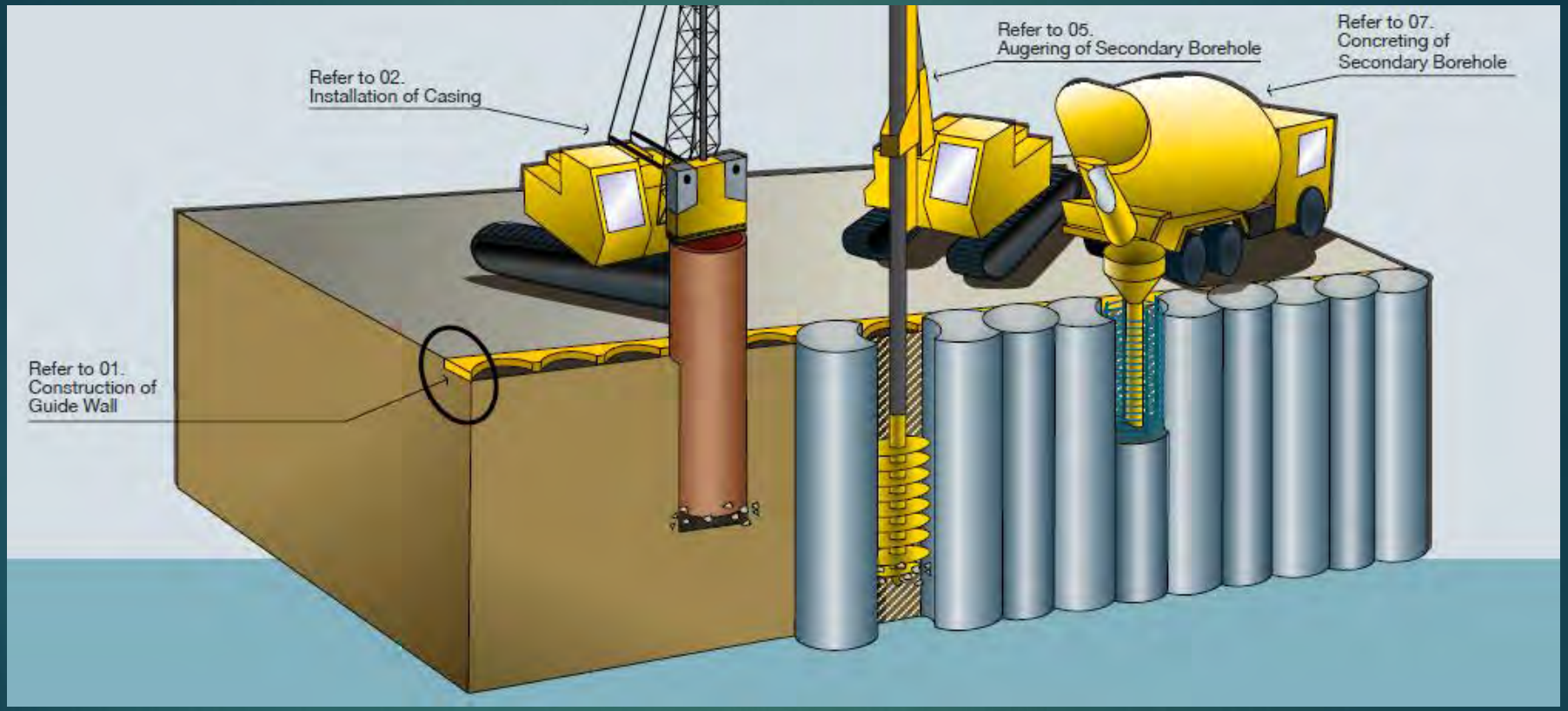
SOFT & HARD PILE ALTERNATE

Secant Bored Pile Wall

CONTINUOUS BORED PILE WALL

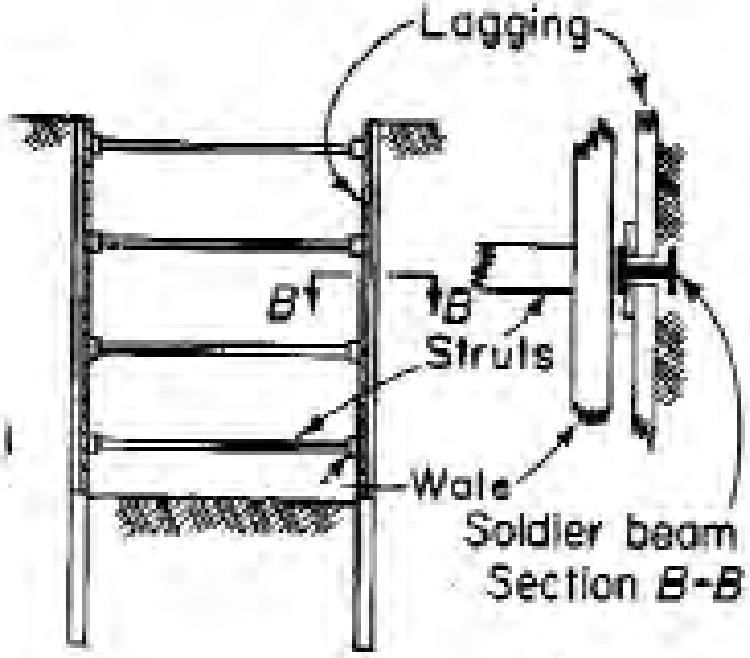


SECANT PILE WALL

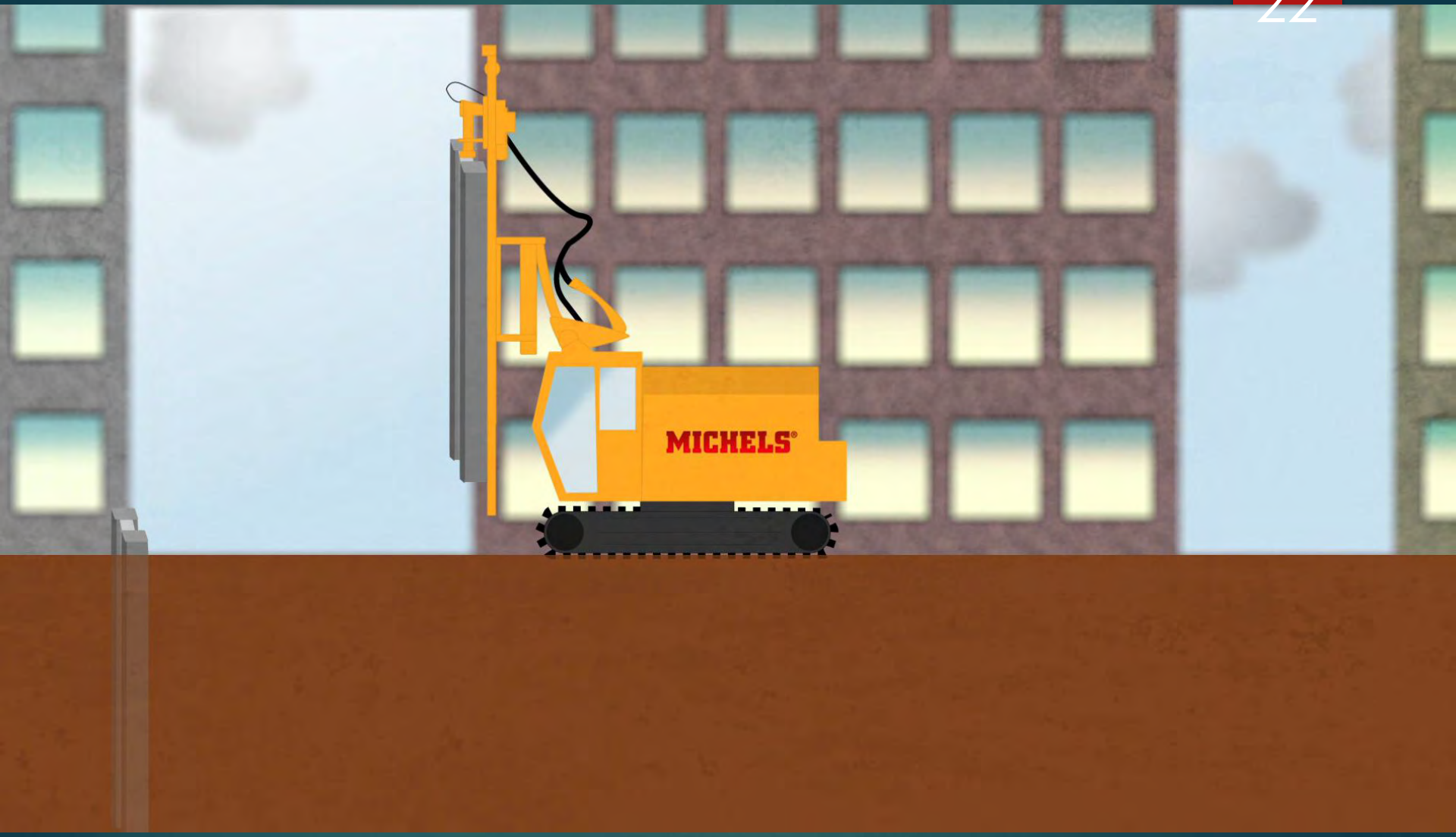


SECANT PILE WALL CONSTRUCTION (2:45 MINUTES)

Braced Excavation with Soldier Pile Wall

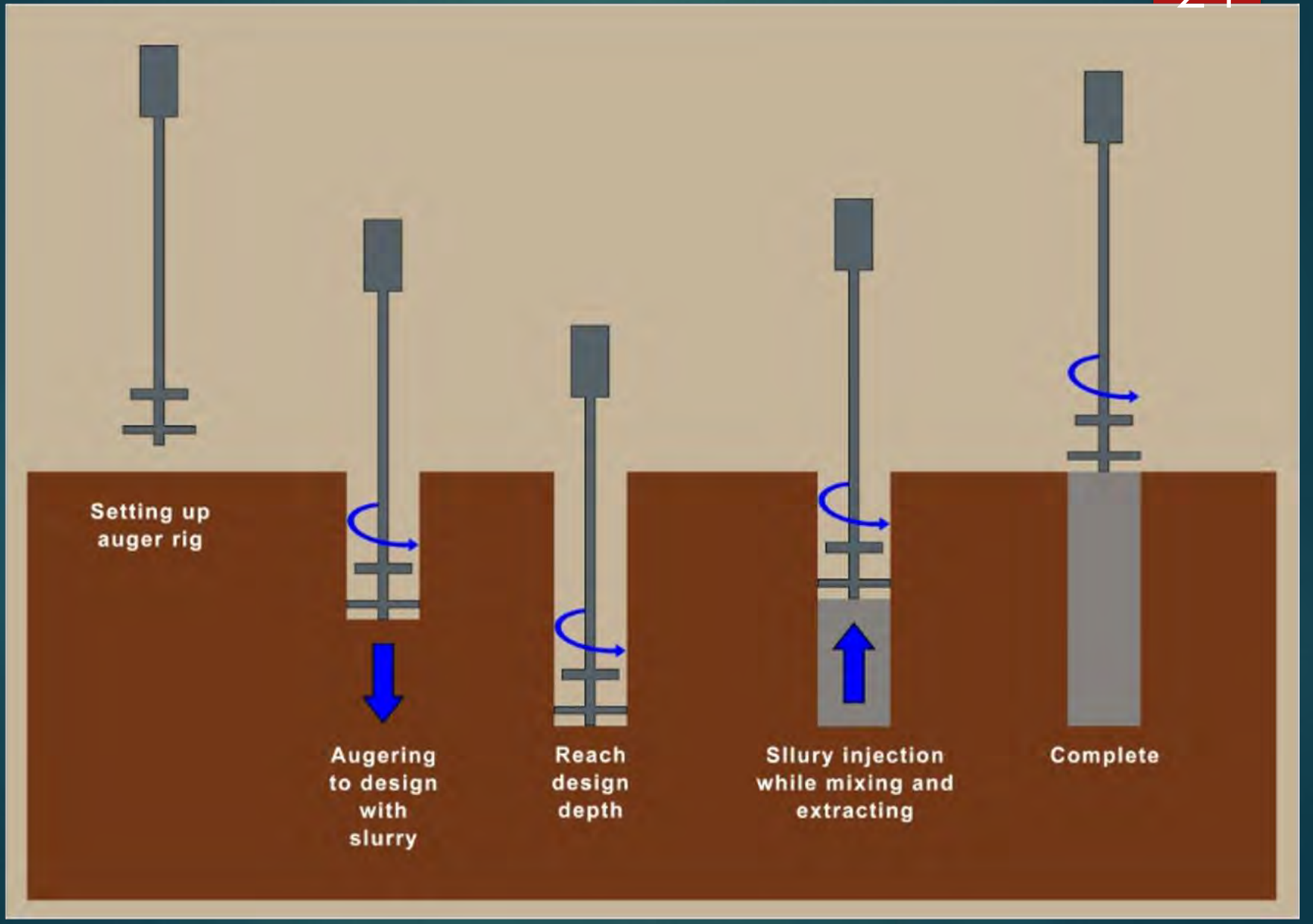


SOLDIER PILE CONSTRUCTION (0:27 MINUTE)



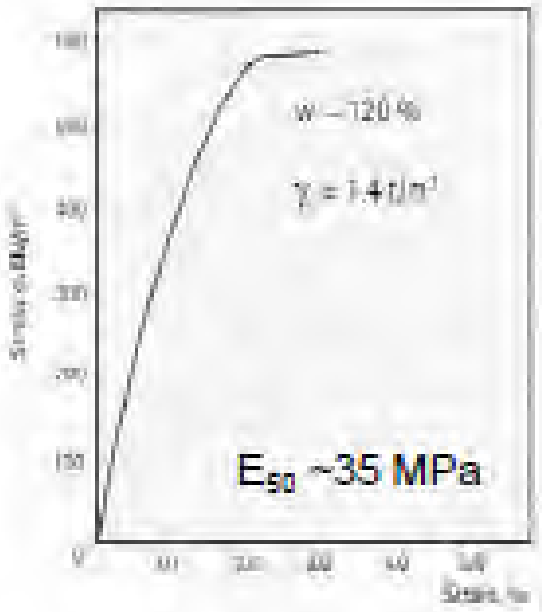
SOILDER PILE WALL WITH GROUND ANCHOR

CONSTRUCTION OF DCM OR GROUT MIXED PILE WALL



CONSTRUCTION OF DCM OR GROUT MIXED PILE CONSTRUCTION (1:38 MINUTES)

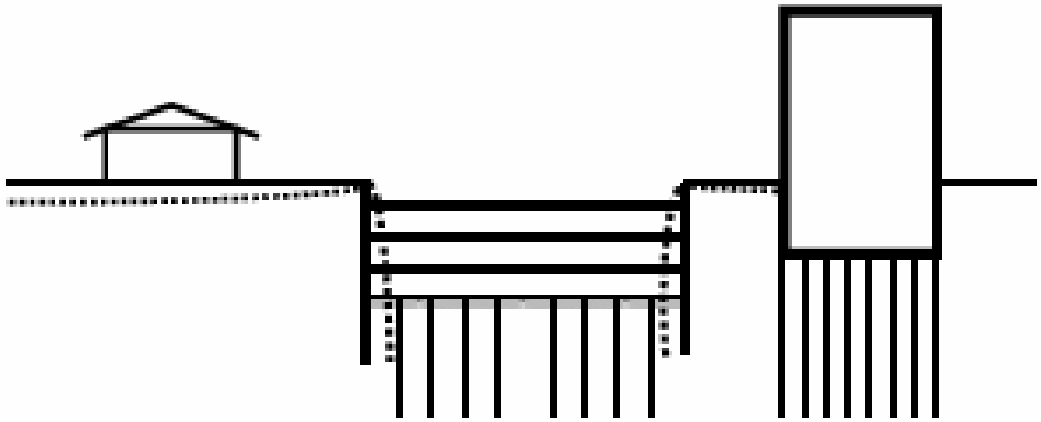
Properties of DCM or Grout Mixed Pile Wall



Soil Type	Amount of Cement (kg/m^3)	q_u (kPa)
Peaty Clay	250 - 500	400 - 700
Sandy Clay	200 - 350	700 -1000
Marine Clay	100 - 250	200 - 700

DESIGN CONSIDERATION & FAILURE MODES

Major Design Considerations in Deep Excavations



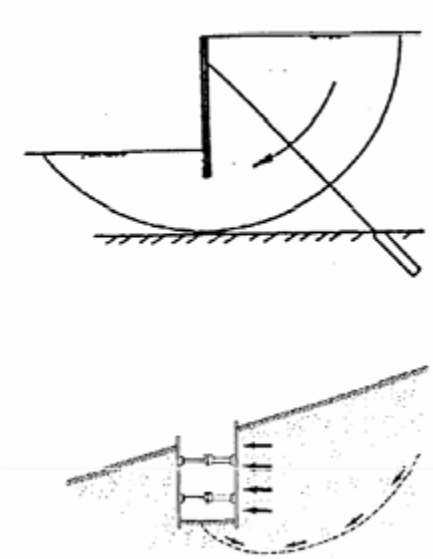
Total collapse

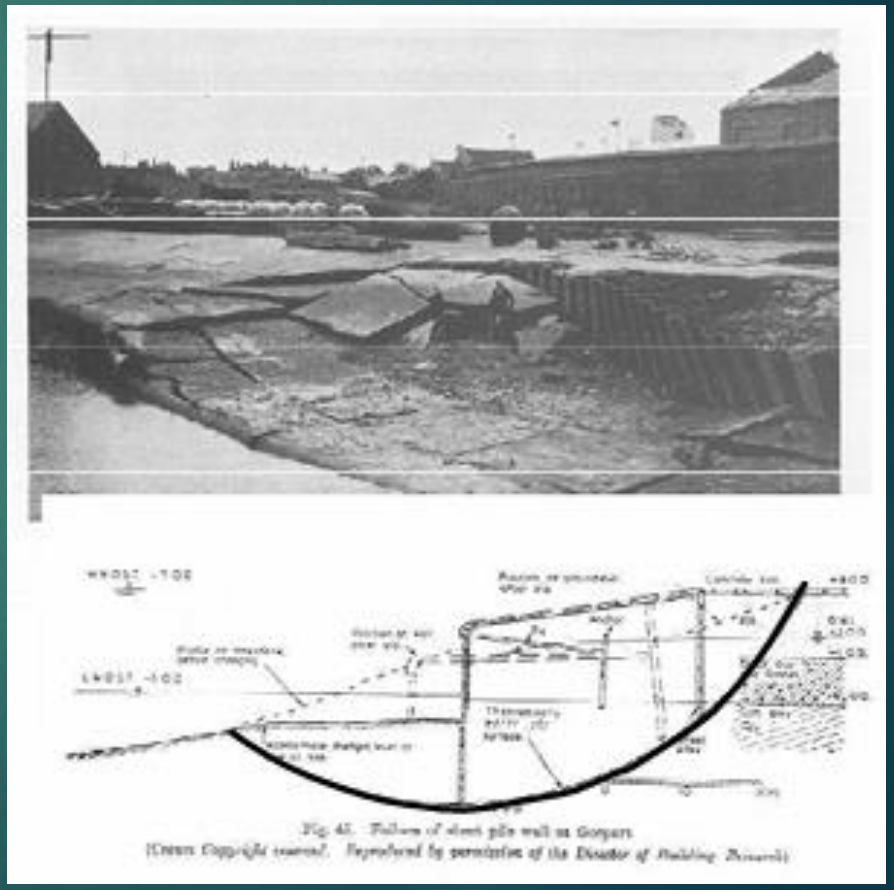
- Overall stability
- Basal heave
- Uplift or blow-out failure
- Toe stability
- Strutting system failure

Excessive movements

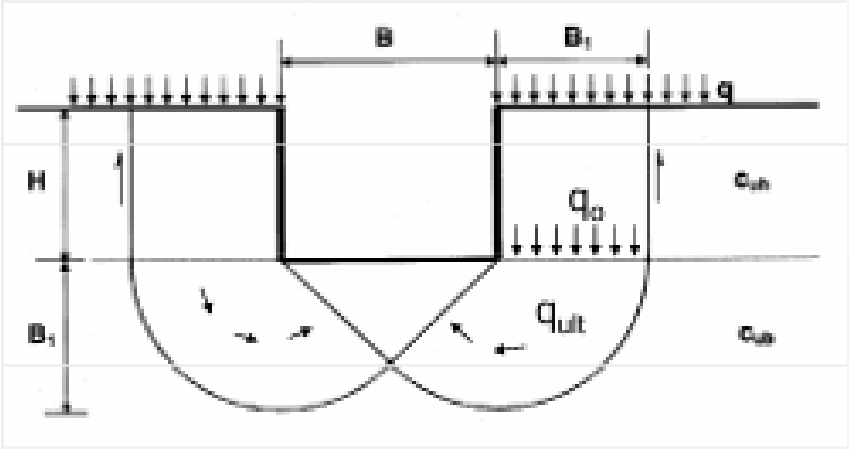
- Wall deflections
- Ground settlement
- Effect on adjacent structures

Overall Stability





Basal Heave Stability

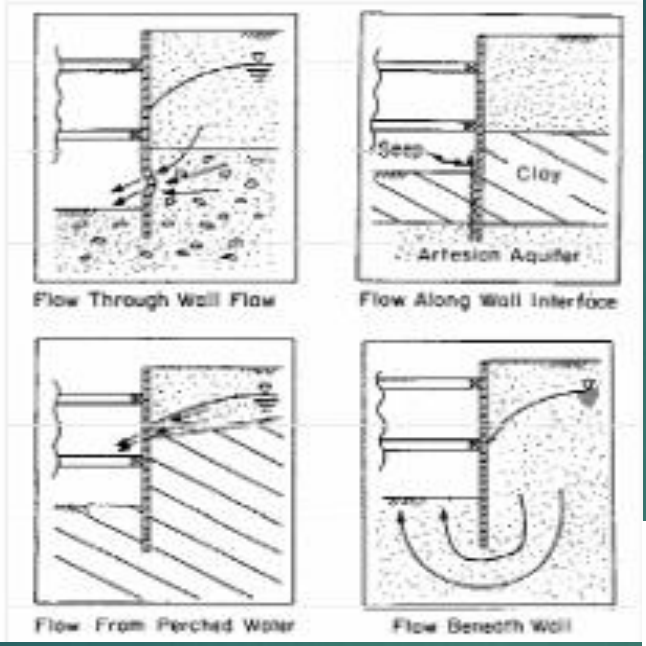


When $q_o > q_{ult}$, failure in imminent.

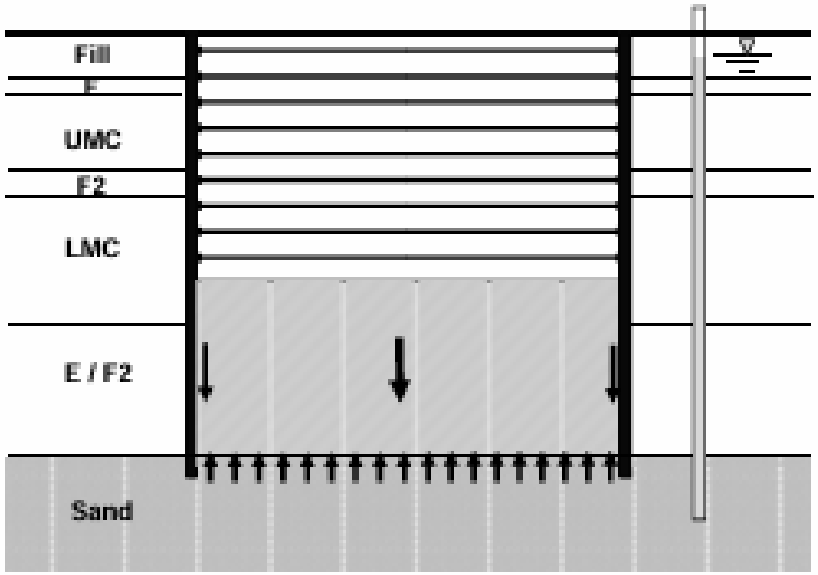
Lifting of Kingpost due to Bottom Heave

Basal Heave Failure due to Stockpiling

Piping & Loss of Fines

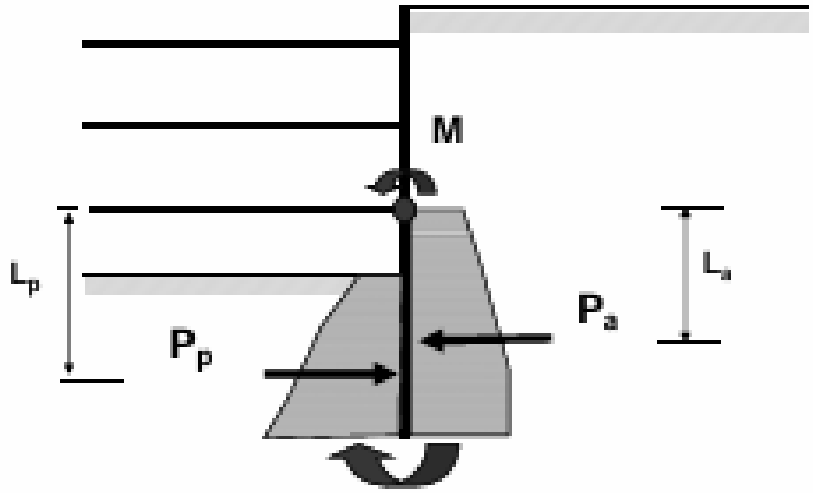


Uplift Instability or Blowout Failure

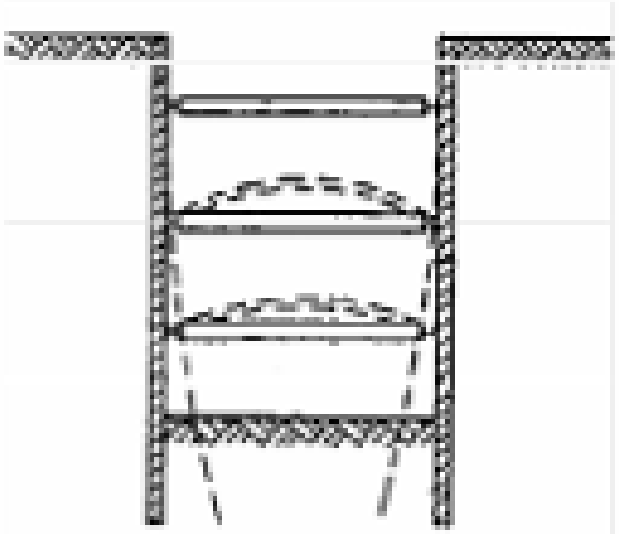


1. What is the permeability of the sand?
2. Is there a free supply of water?

Toe Kick-out Stability



Strut Failure



Objective in Instrumentations
&
Type of Instruments/ Sensors

Objectives in Instrumentation

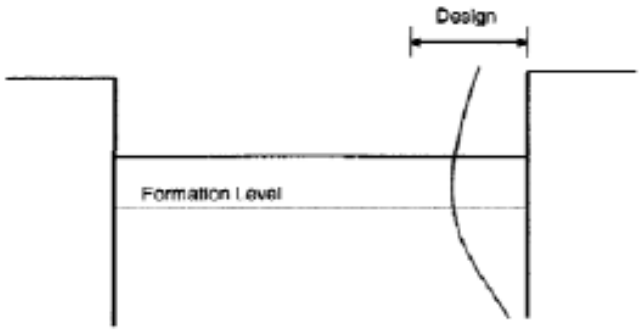
1. To check whether the retaining wall system is in danger of impending failure.

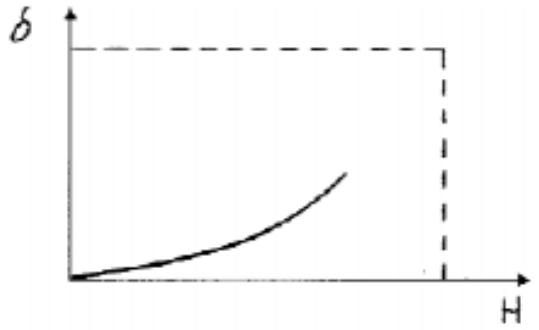
2. To check whether the performance criteria set forth in the specifications are met.

3. To facilitate the implementation of the ***Observational Method.***

4. To check the effectiveness of any preventive and remedial measures.

5. To protect against any unwarranted claims.





Wall Deflections :	In-wall inclinometers
	In-soil inclinometers
	Surveying points on wall top
Strut Forces :	Load cells
	Vibrating wire strain gauges
	Thermometers
Ground Settlements :	Surveying points
	Settlement plates
Movements at Surrounding Buildings :	Surveying points for vertical and horizontal movements
	Tilt plates
	Crack meters
Groundwater Level :	Water standpipes

Others : wall bending moment; excess pore pressure; bottom heave; tunnel movements and vibration

In-soil Inclinometer

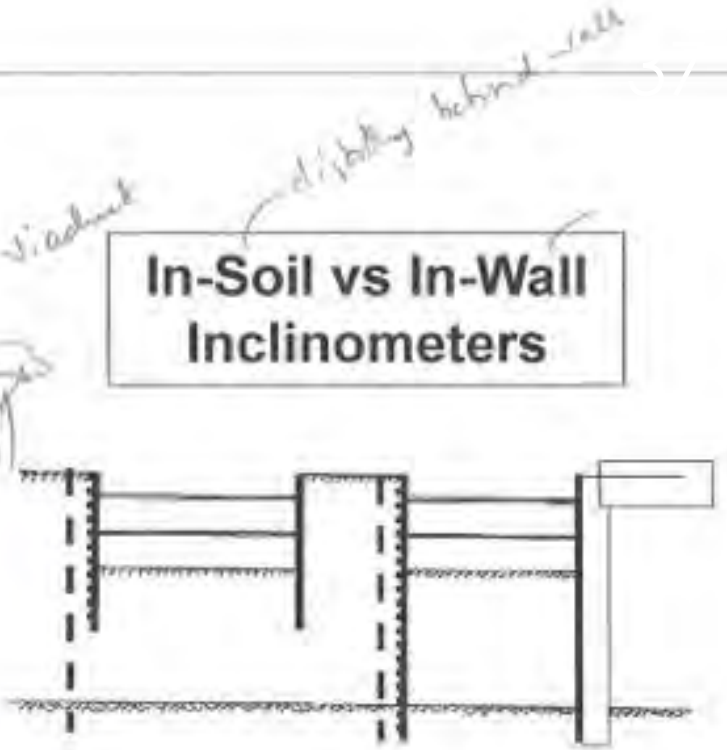
In-wall Inclinometer

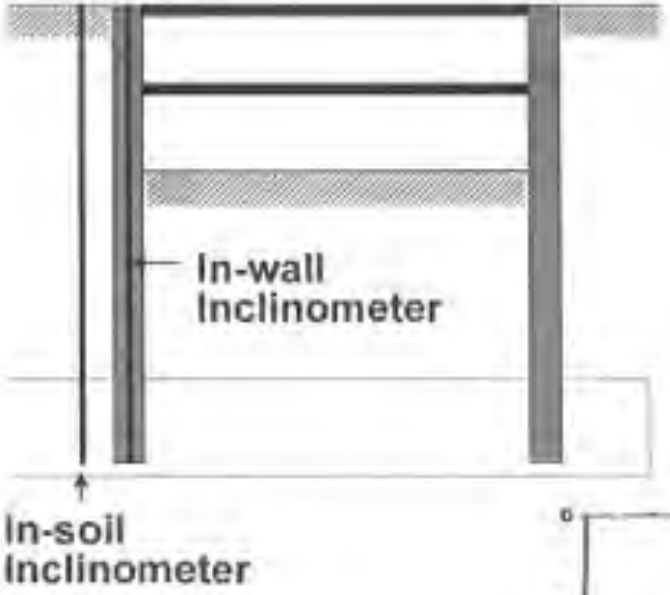
In-Soil Inclinometers

- Measure soil movements during:
  - (i) wall construction
  - (ii) jet grouting
  - (iii) excavation
  - (iv) basement slab construction
- The tip should be anchored into the hard stratum.
- It should be located within 2 m from the wall.
- The A-axis should be set perpendicular to the wall.
- In most cases, use resultants from the A and B axes.

In-Wall Inclinometers

- Measure soil movements during:
  - (i) jet grouting
  - (ii) excavation
- Indirect measurement of bending moment in wall
- The A-axis should be set perpendicular to the wall. Use resultants from the A and B axes to compute wall movements.



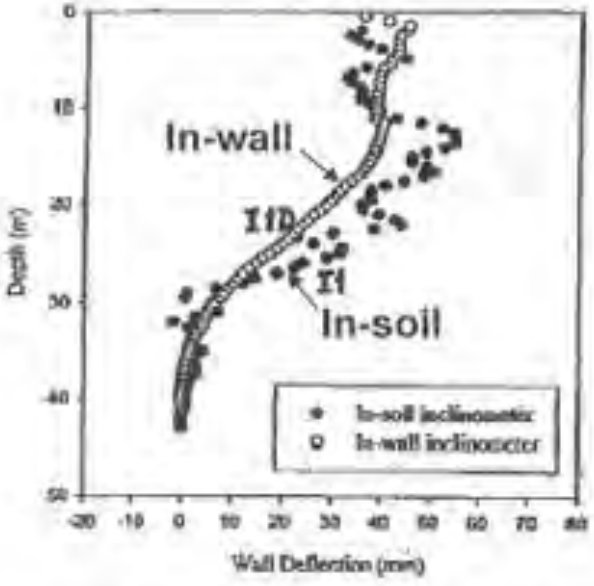


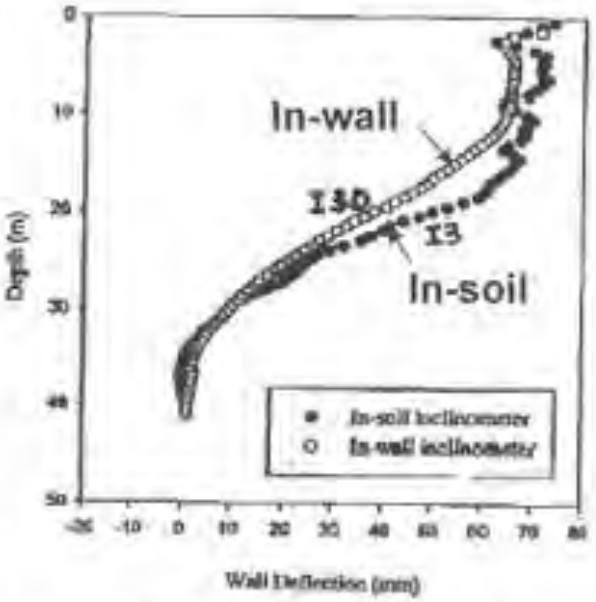
Interpretation of Inclinometer Data

In-wall inclinometer gives an accurate wall deflection profile.

In-soil inclinometer gives approximately the same deflection but the profile is more erratic.

Data from basement excavation at the Esplanade



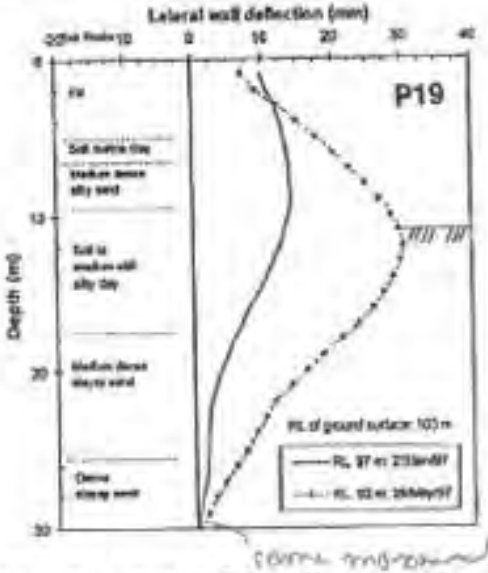


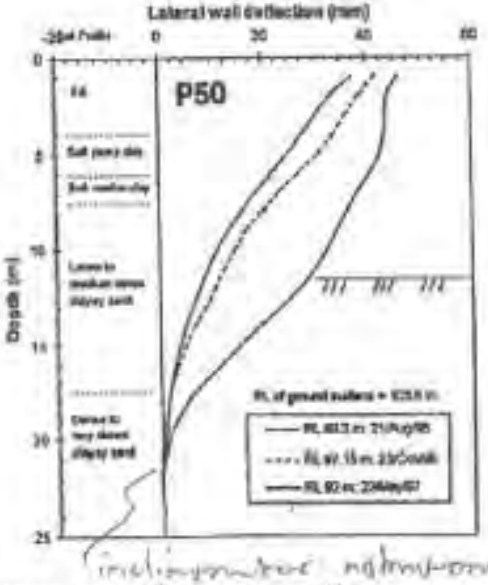
Install in-wall inclinometer whenever possible.

Interpretation of Inclinometer Data

P19 - Actual wall deflection is uncertain. Amount of toe movement is unknown.

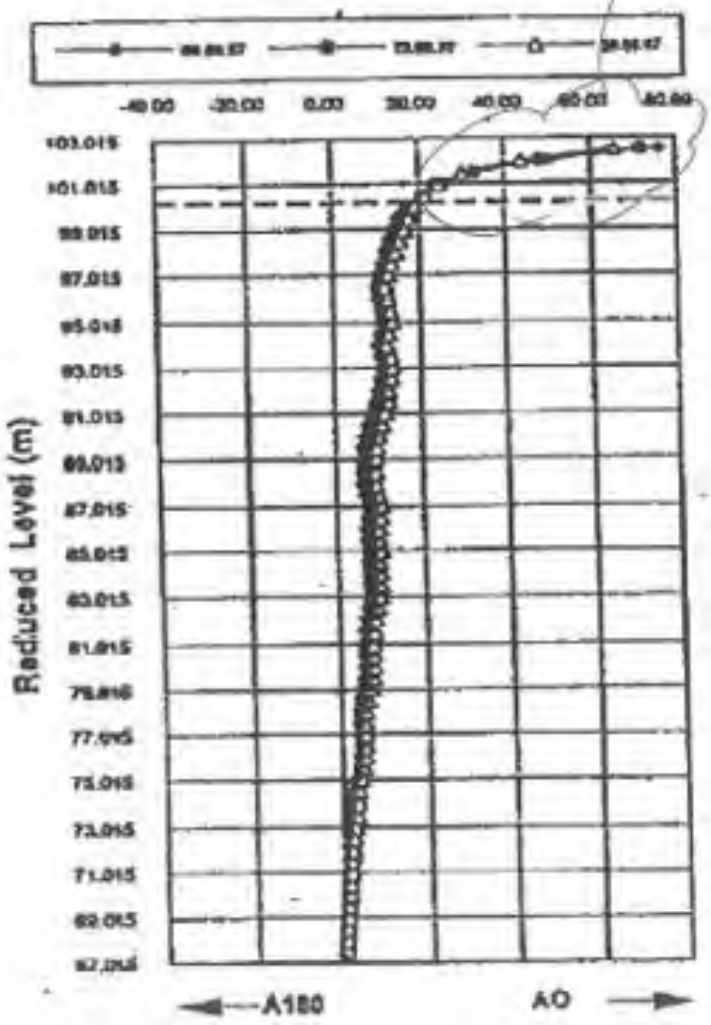
P50 - Measured wall deflection is reliable. The toe did not moved.





Data from car park excavation at the Esplanade

Monitor the movements at top of inclinometer as a routine practice.



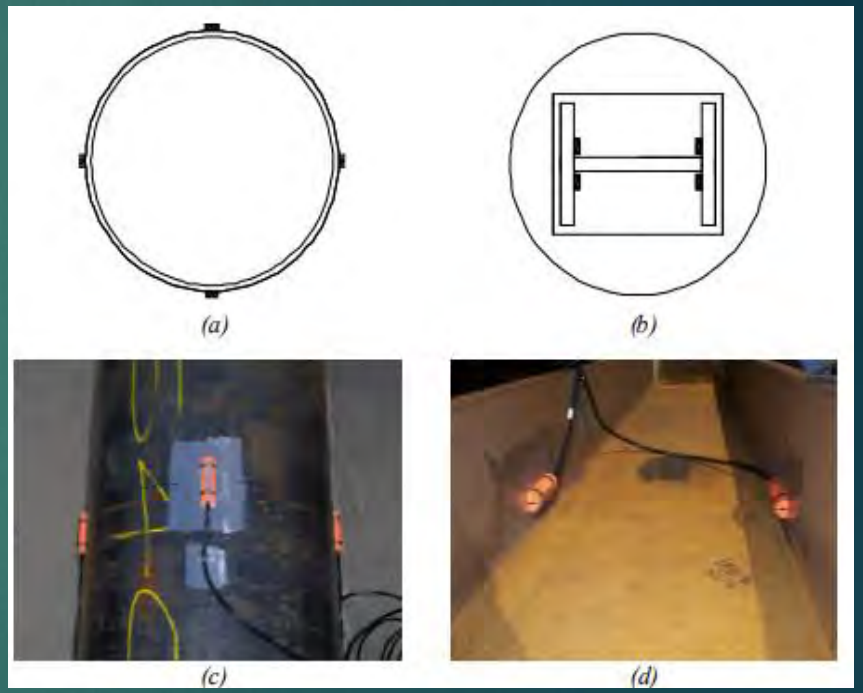
Interpretation of Inclinometer Data

Don't be alarmed by the deflection near the top of inclinometer. It gets disturbed easily during construction.

Need Proper protection!

Load Cell

Strain Gauge



Building & Ground Settlement Marker

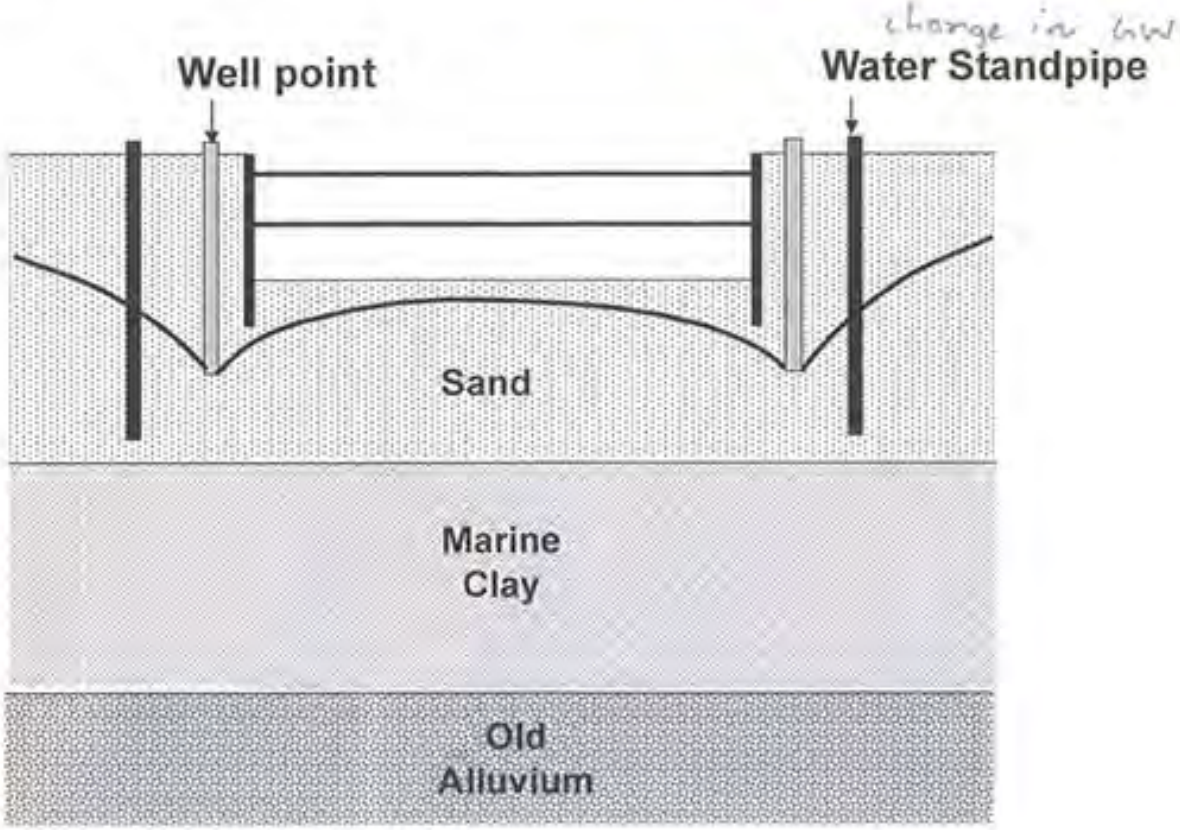
Tilt Plate & Portable Tilt-meter

Paper Prism

Cracked Meter

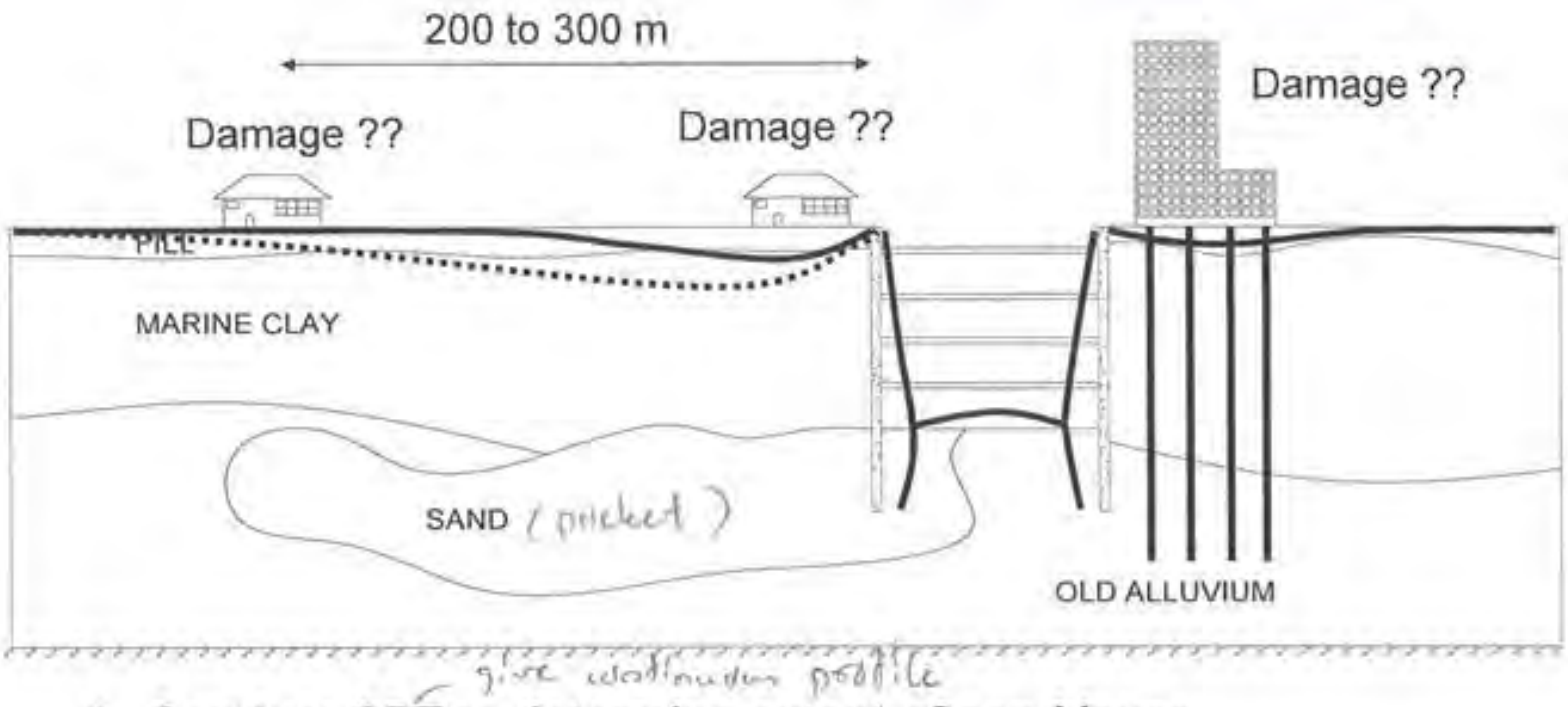
Vibration Meter

Where should we install the water standpipes?



To monitor lowering of water level due to pumping or leakage as well as the effectiveness of recharging.

Where should we install the piezometers?



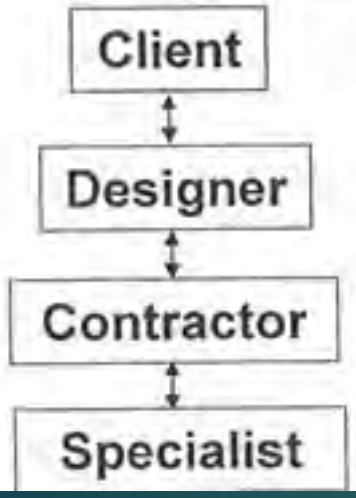
1. Conduct CPT to determine extent of sand layer.
2. Conduct pumping test to check connectivity of the sand layer.

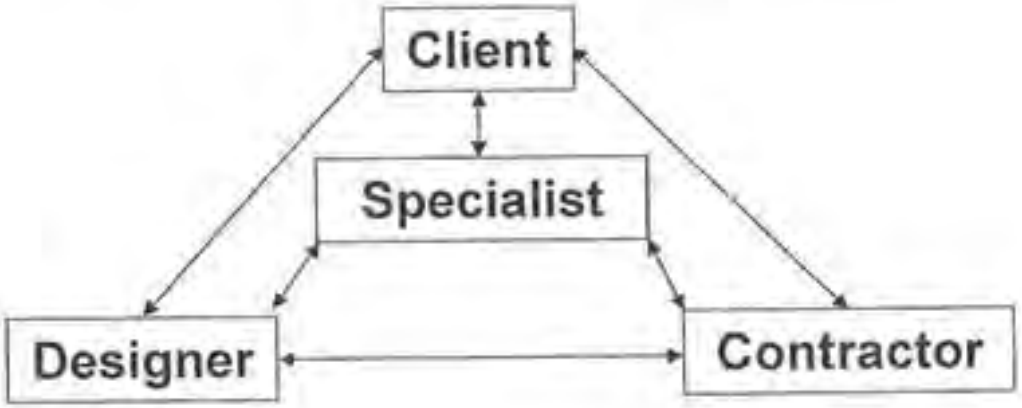
- The water level inside the standpipes simply represents the level of the **free groundwater table,**

- The water level inside the piezometers represents the **pore water pressure** at the depth of the piezometer tip, ...

What is the contractual arrangement?

- The instrumentation specialist (IS) should be employed directly by the client/developer. They should protect the client's interest.
- This arrangement improves the communication between the IS and client, designer and contractor.
- If the contractor is IS's pay master, there may be a conflict of interest. There are known incidences of foul plays.





Instrumentation

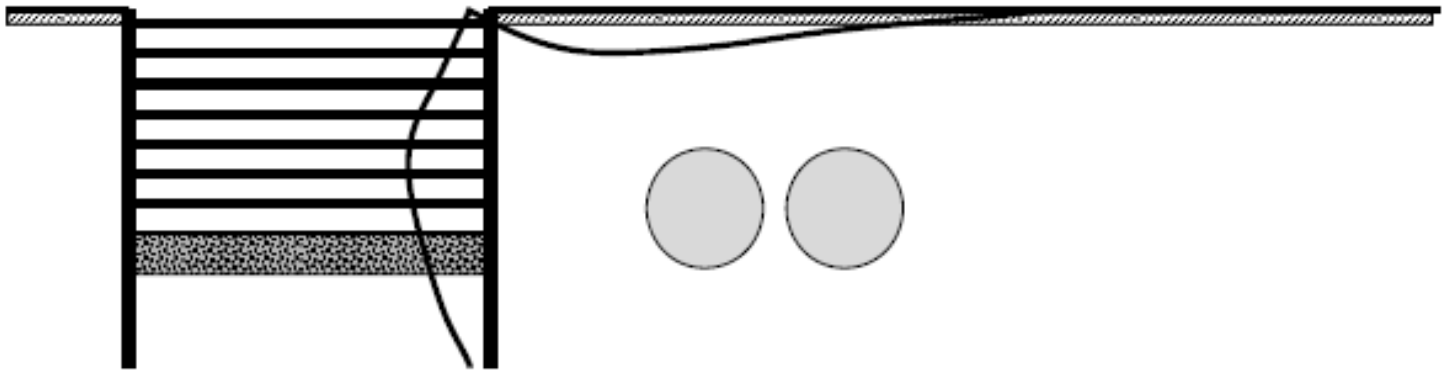
1. Don't skim on instrumentation.
   Penny wise but dollar foolish!

1. Engage a ***reputable*** company to install & monitor.
2. Engage a ***qualified*** engineer to review the data.
3. Designer should be one of the key players.
4. Review the data diligently.
5. Investigate causes of any sudden increases.
6. Add more instruments whenever necessary.
7. The instrumentation specialist should be employed directly by the client and not the contractor.

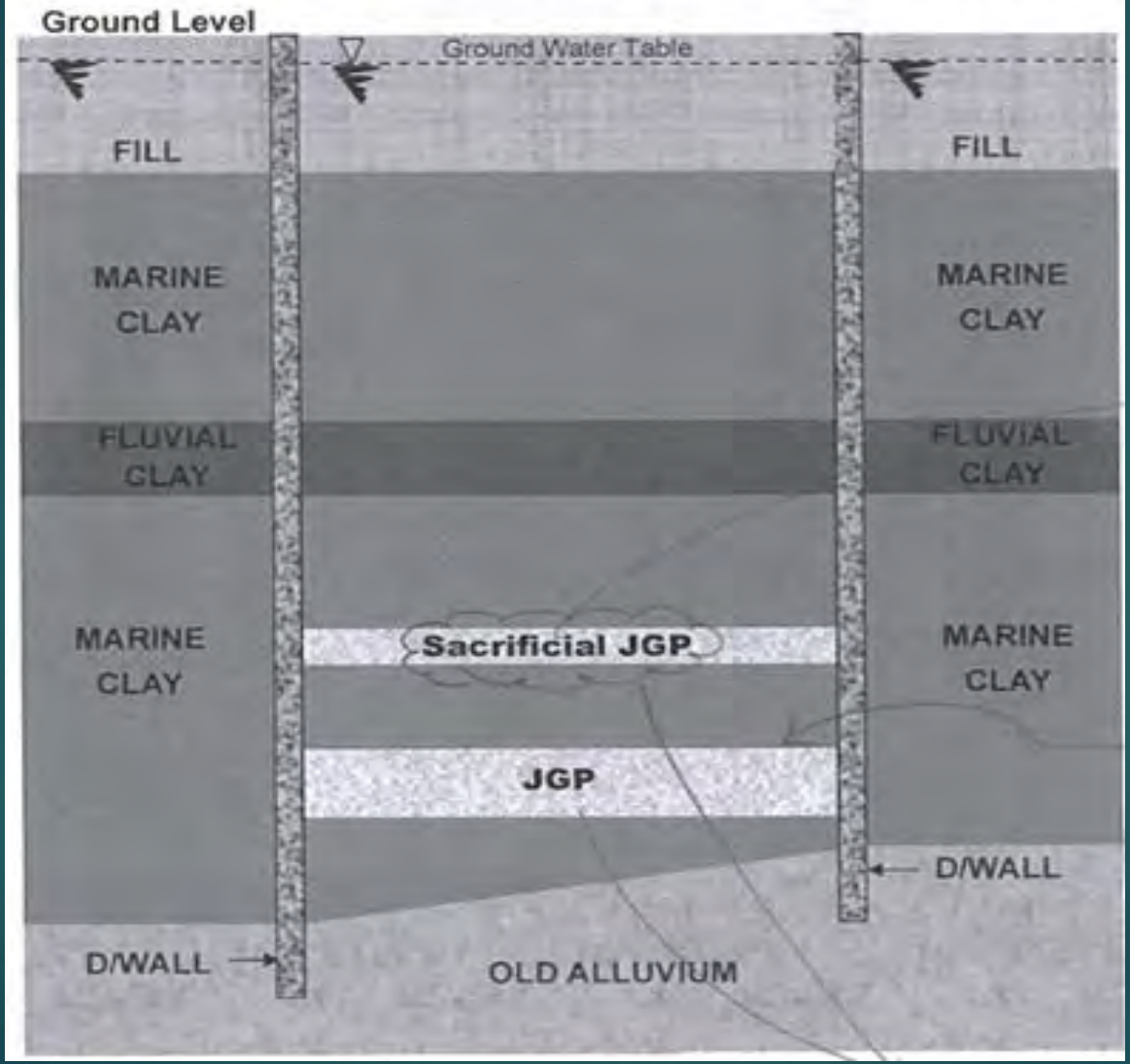
Main Application of JGP in Deep Excavation

Main applications of JGP in deep excavation are:

1. To reduce wall deflection & ground settlement
2. To minimize CST & MRT tunnel movements
3. To improve basal heave stability
4. To improve toe kick-in stability
5. To control seepage



Completed JGP Slabs prior to Excavation

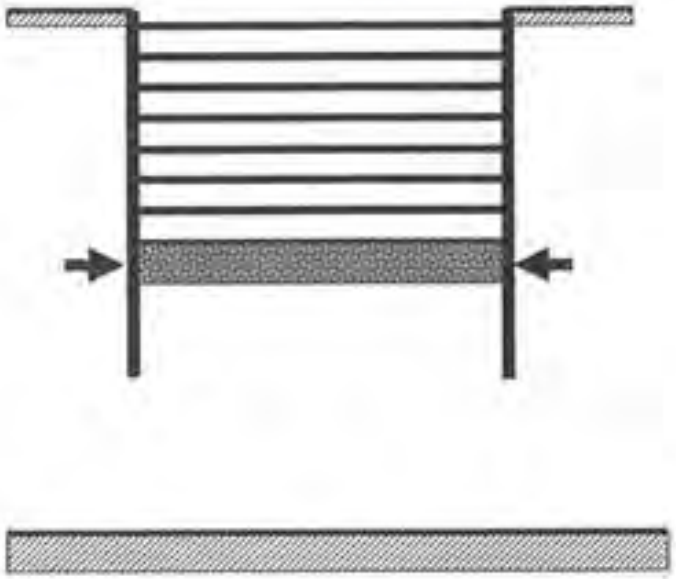


SPRING singapore

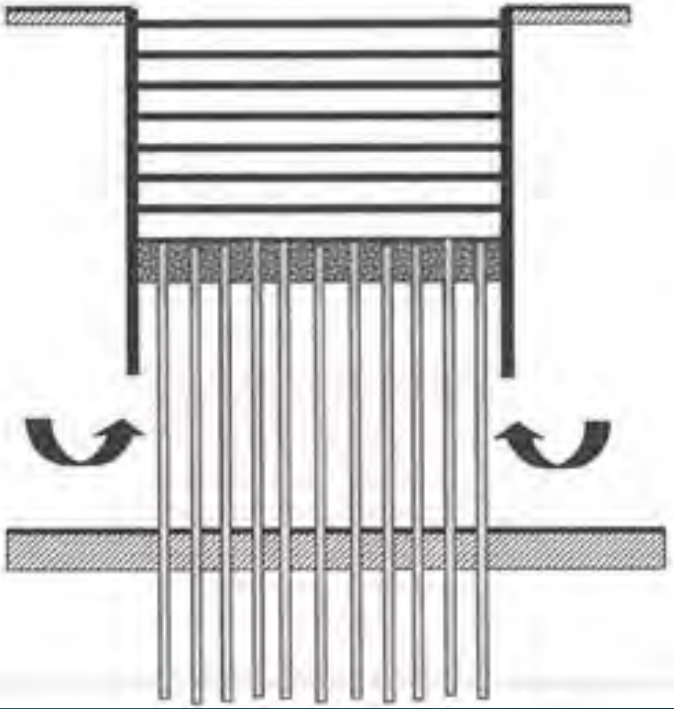
Jet Grouting

How does it work?

It acts as a **compression member** to reduce wall deflection.



In addition, it can also act as an **anchored slab** to minimize bottom heave.



GUIDELINE FROM AUTHORITY?

Submission Requirements for Earth Retaining or Stabilizing Structures for High Rise Buildings with Basement Construction

1. Deep excavation analysis and design
2. Instrumentation and monitoring system
3. Calculation of ERSS design
4. Submission Document Check-List
5. Presentation
6. Geotechnical Impact Assessment (GIA)
7. Letter from YCDC (to be attached)

HPBC

Basement Construction:

General Requirements for Excavation and Lateral Support (ELS)

1. ELS plans submission document shall include the geotechnical assessment, geotechnical details and calculations, site investigation reports.
2. Designer shall prepare and sign the plans and structural design as well as the structural assessment report of the effects of the excavation and dewatering on adjoining structures.
3. ELS design report shall explain the references for recognized specifications and code of practice for design calculation.
4. Construction methodology shall explain, for example, detail excavation and support installation sequence and then removal of temporary support, construction of permanent structure for each stage.
5. Designer shall prepare the impact assessment of surrounding building and facilities, monitoring plan and instrumentation. The impact assessment shall include hydrological assessment including surface and subsurface ground water flow, ground movement during and/after construction, vibration due to construction and mitigation of impacts on surrounding buildings and facilities.
6. The followings shall be included in detail drawings of basement:
   a) Detail drawings of all structural elements, joint connection, reinforcement and technical notes.
   b) Detail site layout plan with adjacent buildings and bored hole location.
   c) The construction structural details of the lateral support system, including detailing of the structural supports (struts, anchorage etc.) for each stage of excavation.
   d) Detail excavation depth including localized pits and sloping ground.
7. Adjacent building survey shall be done according to the survey form in the guideline.

Table (2A) Allowable Wall Deflection Limits

No.	Distance	Zone	Allowable maximum wall deflection limits, δ_w/H
1	H > d	Zone 1	< 0.5 % H
2	2H > d > H	Zone 2	< 0.7 % H
3	d > 2H	Zone 3	0.7 % H for ground type A 1.0 % H for ground type B

Where, δ_w = maximum wall deflection

H = Excavation depth,

d = distance between existing structure and the edge of the excavation

Ground Type A = over-consolidated stiff clays and silts, residual soils, and medium to dense sands

Ground Type B = soft clays, silts or organic soils.

Allowable displacement: Near existing building with allowable displacement shall be **< 0.5 H%.**

Geotechnical Design Requirement

1. The surcharge load shall be considered a minimum value of 10 kN/m^2. Additional surcharge loading shall be used in the design to take account of incidental loading arising from adjacent buildings, working area, construction plant and stacking of materials.

Building and Construction Authority

What is Geotechnical Building Works (GBW)?

- **Tunneling Works**
  - Any excavation or other building works to make a tunnel with a diameter, width or height or more than 2 m
- **Excavation Works and Earth Retaining Structures**
  - Any excavation, or other building works to make a caisson, cofferdam, trench, ditch, shaft , well with a depth of more than 6 m
  - Any building works for constructing, altering or repairing any earth retaining structures in or for a trench, ditch, shaft, well with a depth or height or more than 6 m
  - Any earthwork or other building works for constructing or stabilising a slope with a height of more than 6 m (measured as vertical distance between the highest level to the lowest level of the slope)
- **Foundation Works**
  - Foundation for buildings of 30 or more storeys

Building and Construction Authority

Advisory Note 1/09 on ERSS

Key points

Movement control limit

Table 1: Allowable maximum ERSS wall deflection limits

Wall deflection limits/Zones where x = distance from excavation face H = excavation depth δ_w = wall deflection	Locations of buildings, structures and critical utilities			
	Zone 1 (x/H < 1)	Zone 2 (1 ≤ x/H ≤ 2)	Zone 3 (x/H > 2)	
			Ground Type A	Ground Type B
Allowable maximum ERSS wall deflection limits (δ_w/H)	0.5%	0.7%	0.7%	1.0%

Ground Type A refers to over-consolidated stiff clays and silts, residual soils, and medium to dense sands; and Ground Type B refers to soft clays, silts or organic soils extending to or below formation level (e.g. Kallang Formation) and loose fills.

10 In any case, the allowable wall deflection limits shall also be determined by the prevention of structural damage to neighbouring buildings or structures arising from ground deformations.

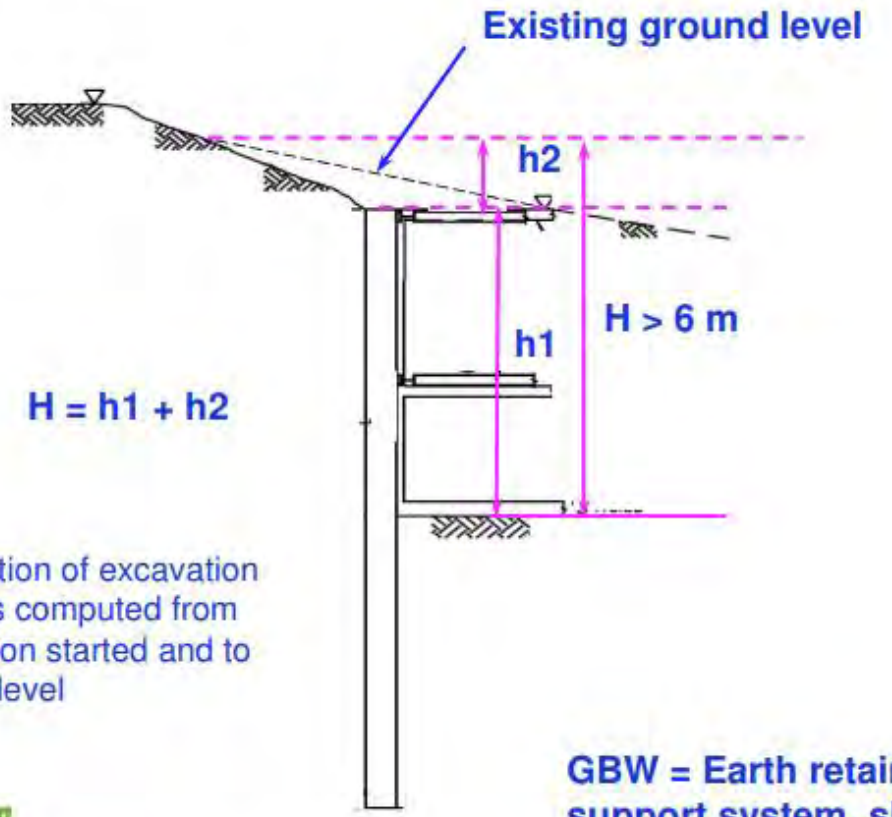
Table 2: Control strategies guides for ERSS.

Zone 1	Allowable limits		
	Alert level	Work suspension level	
	70% WSL	Allowable wall deflection limit	
Zones 2 and 3	Allowable limits		
	Check level	Alert level	Work suspension level
	50% WSL	70%WSL	Allowable wall deflection limit

Critical limit

Building and Construction Authority

Excavation Works in sloping ground



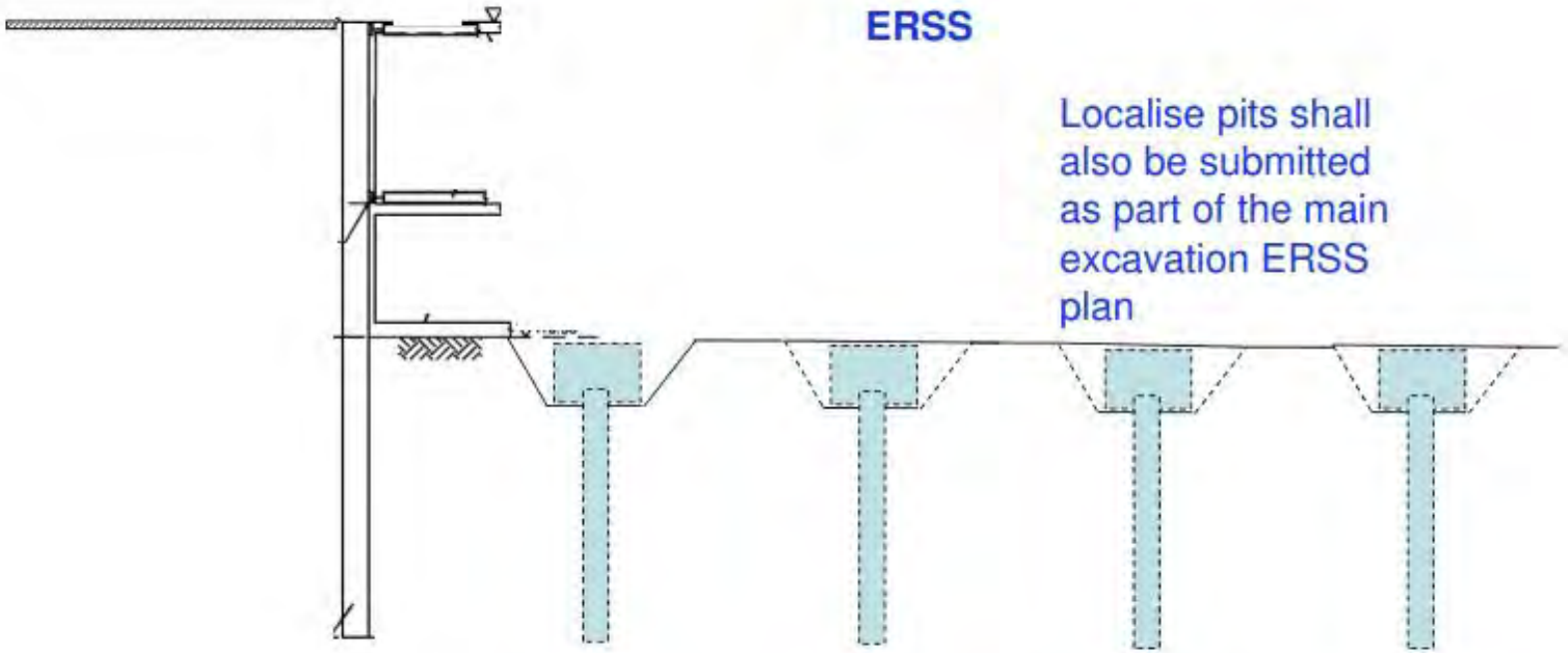
H = h1 + h2

Note: For computation of excavation depth of GBW, H is computed from where the excavation started and to the final formation level

GBW = Earth retaining & support system, slope

Building and Construction Authority

Excavation Works: Basement Construction



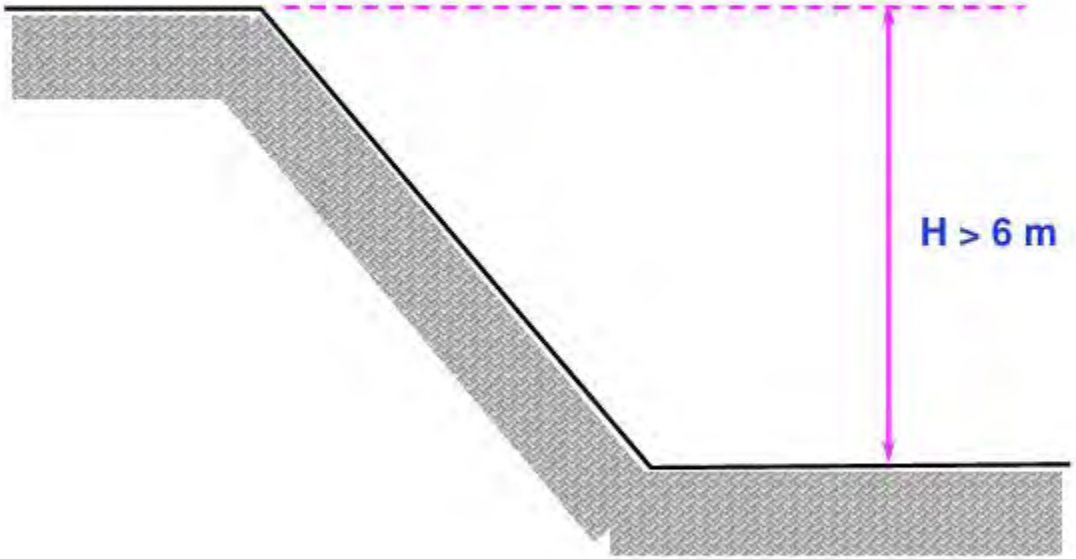
ERSS

Localise pits shall also be submitted as part of the main excavation ERSS plan

Building and Construction Authority

Basement Excavation Works: Open cut method

Single tier open cut slope

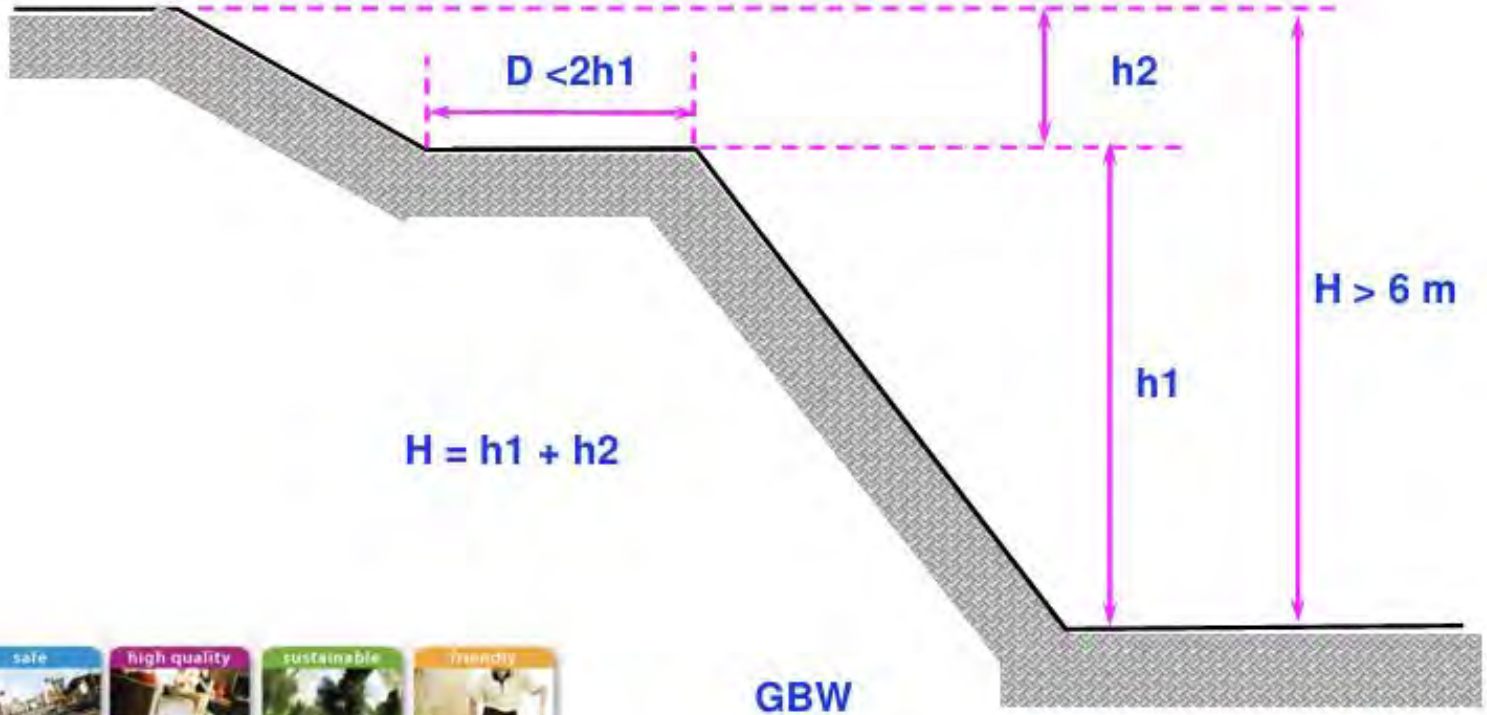


GBW

Building and Construction Authority

Basement Excavation Works: Open cut method

Multi-tier open cut slope in stiff soils



GBW

Building and Construction Authority

Submission Requirement for ERSS

All permanent or temporary building works that involve	Appointments Required	
	Qualified Person (QP)	Accredited Checker (AC)
Excavation/ERSS ≤ 1.5 m** deep	Plan approval is not required	
1.5 m** < Excavation/ERSS ≤ 4 m deep	QP(ST)	AC is not required
4 m < Excavation/ERSS ≤ 6 m deep	QP(ST)	AC
Excavation/ERSS > 6 m deep and not classified as Geotechnical Building Works (GBW): e.g. excavation for sewer manhole associated with pipe diameter of 2 m or less	QP(ST)	AC
Excavation/ERSS > 6 m deep and classified as GBW. E.g. basement excavation.	QP(ST) QP(Geo)	AC AC(Geo)

Notes:
Plan approval is not required for insignificant building works listed on First Schedule of Building Regulation 3A.
** If the structure that retains earth is not constructed of reinforced concrete or steel, then the applicable depth is 1 m instead of 1.5 m.
Planning approval is no longer required for any retaining wall or earth-retaining structure for supporting the face of an excavation made for the purpose of constructing any pile cap, footing, sump, lift pit or trench, provided that the size of these structures does not exceed 10 square meters in area and 2 meters in depth.

Building and Construction Authority

Re-used of structural steel material

Engineer to specify specification of steel material on plan and check the condition of steel material at site.

Where re-used structural steel is used, the structural design shall fully consider any imperfections and conditions of such materials

Quality assurance scheme developed for "reused struts" for bracing excavations has been incorporated into the BC1:2012.

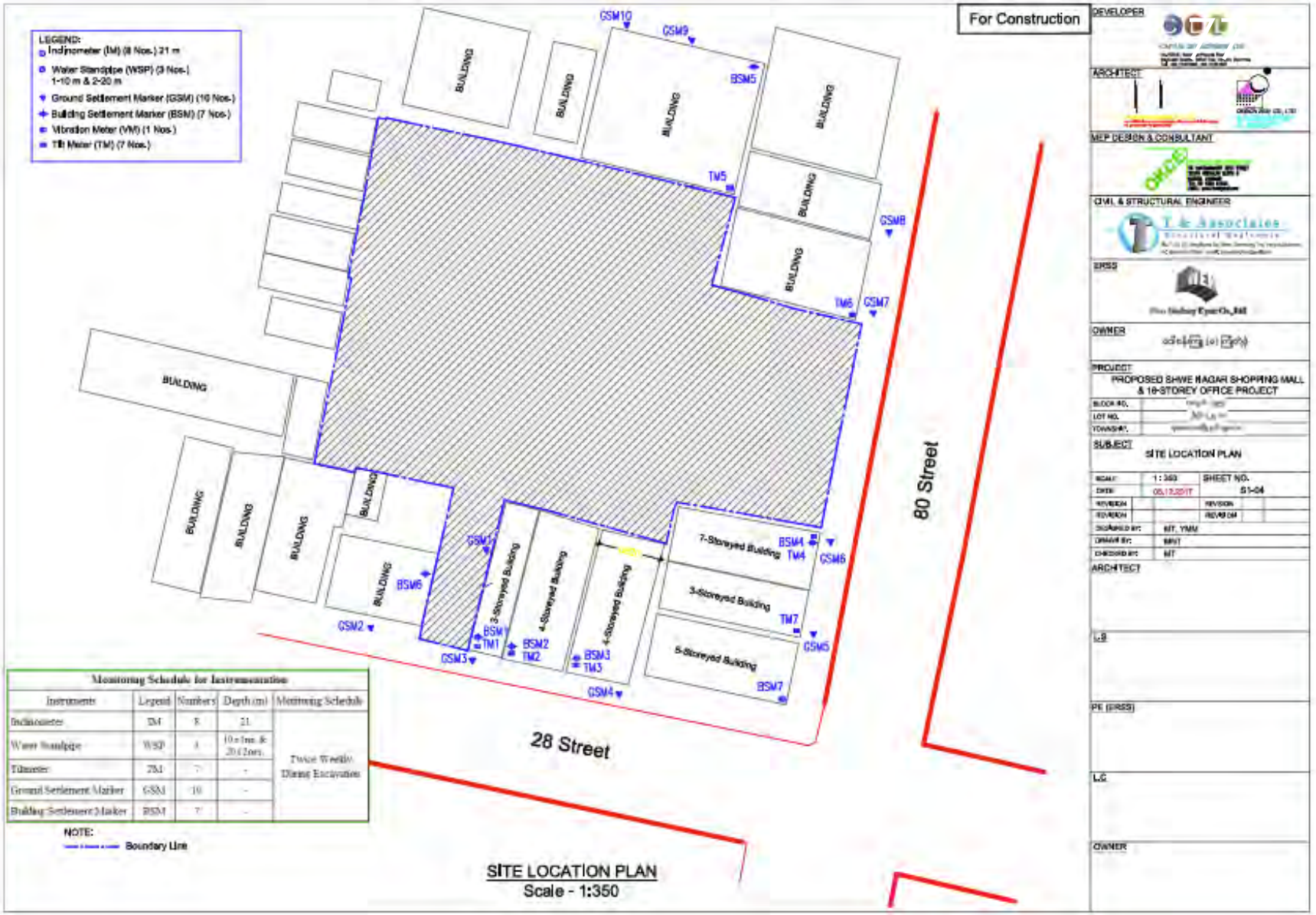
INTERVAL

How to Access/ Interpret Instrumentation & Monitoring Data & Report (Case Study)

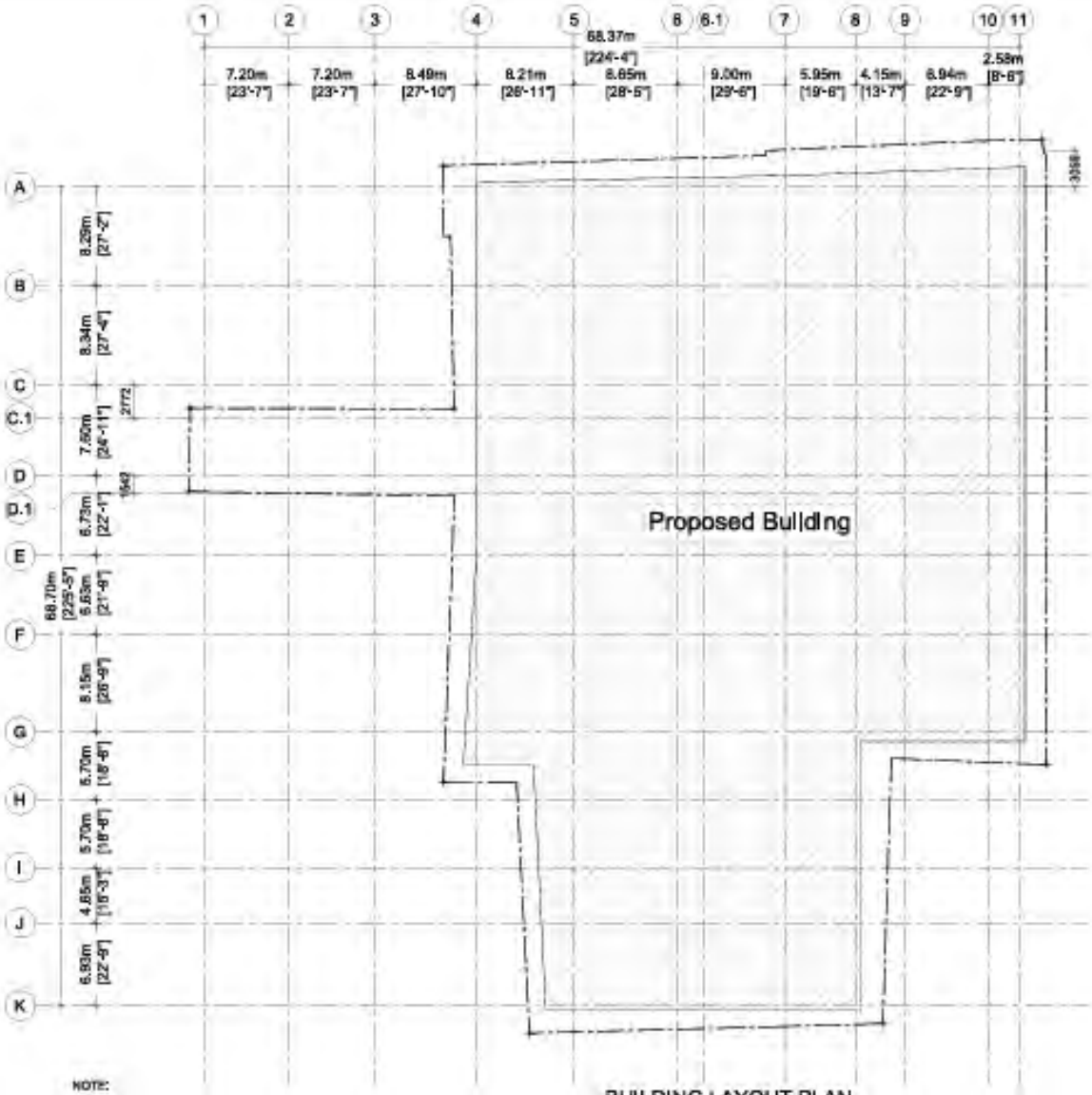
CAPITAL CENTRE PROJECT

26-STOREY WITH 2-BASEMENT


ZOOMLI N



Monitoring Schedule for Instrumentation				
Instruments	Legend	Numbers	Depth (m)	Monitoring Schedule
Inclinometer	IM	8	21	Twice Weekly During Excavation
Water Standpipe	WSP	3	10 x 1nos. & 20 x 2nos.	
Tiltmeter	TM	7	-	
Ground Settlement Marker	GSM	10	-	
Building Settlement Marker	BSM	7	-	



BUILDING LAYOUT PLAN
Scale - 1:350

DEVELOPER

ARCHITECT

MEP DESIGN & CONSULTANT

CIVIL & STRUCTURAL ENGINEER

ENGG

OWNER

PROJECT
PROPOSED SHWE NAGAR SHOPPING MALL
& 15-STOREY OFFICE PROJECT

BLOCK NO.	
LOT NO.	
TOWNSHIP	

SUBJECT
BUILDING LAYOUT PLAN

SCALE	1 : 350	SHEET NO.	
DATE	23-5-2017	S1-05	
REVISION		REVISION	
REVISION		REVISION	
DESIGNED BY	MT, YMM		
DRAWN BY	MMT		
CHECKED BY	MT		

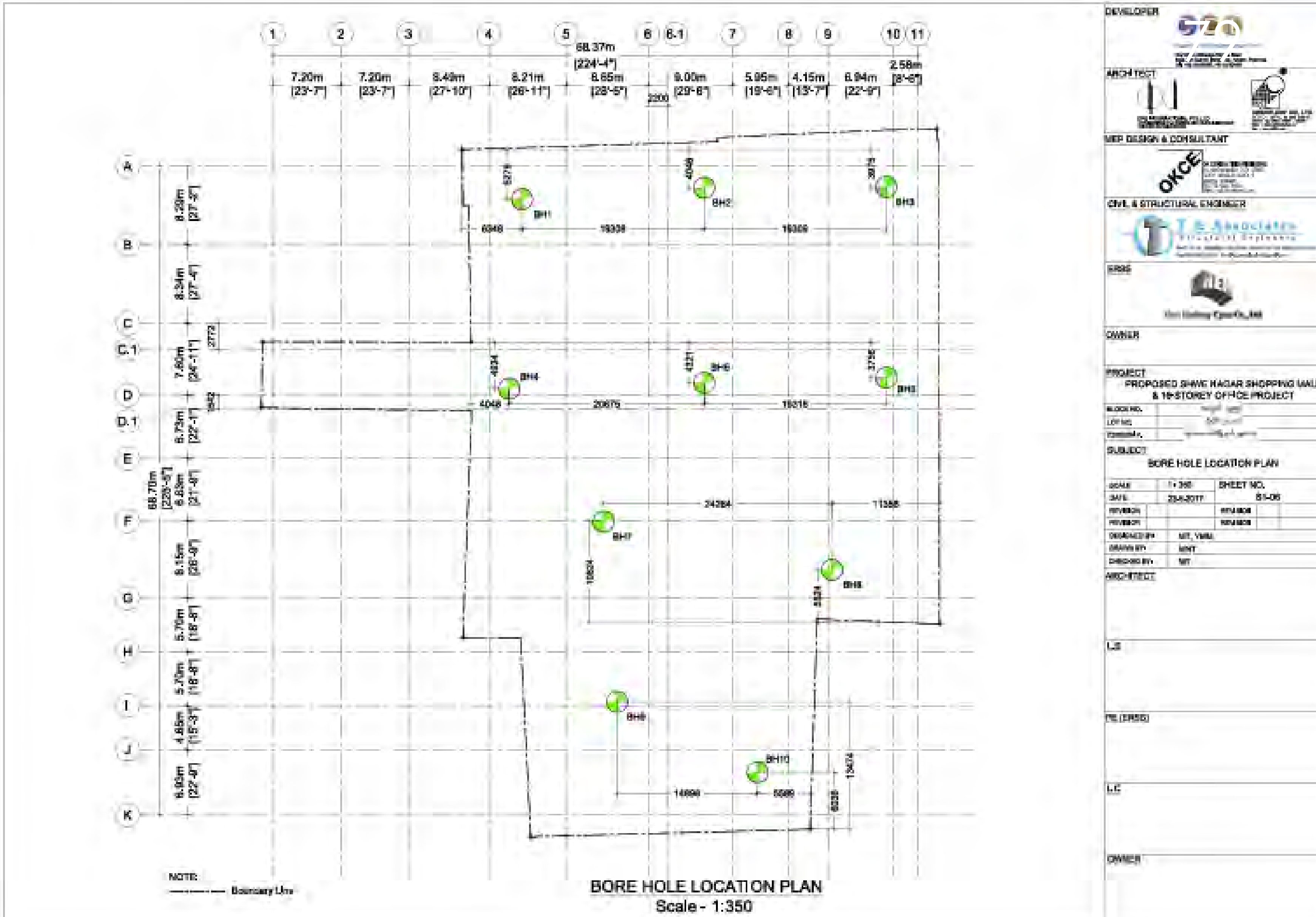
ARCHITECT

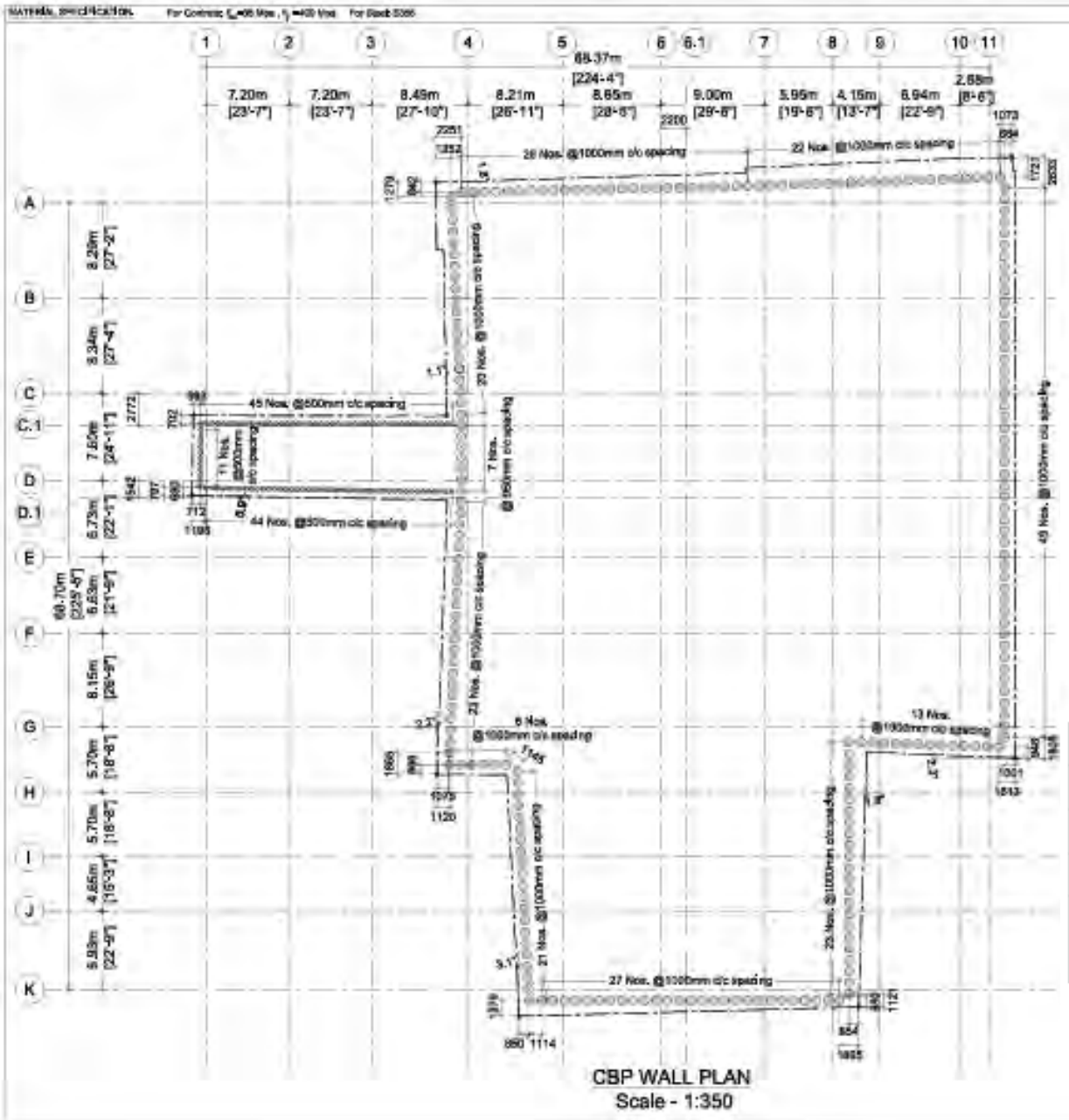
L.S

PE (ENGG)

L.C

OWNER


DEVELOPER
ARCHITECT
MEP DESIGN & CONSULTANT
OKCE
CIVIL & STRUCTURAL ENGINEER
T & Associates
ERSS
OWNER
PROJECT
PROPOSED SHWE NAGAR SHOPPING MALL & 16-STOREY OFFICE PROJECT
SUBJECT
BORE HOLE LOCATION PLAN
SHEET NO.
68.37m [224'-4"]
68.70m [225'-5"]
BH1
BH2
BH3
BH4
BH5
BH6
BH7
BH8
BH9
BH10
NOTE:
Boundary Line
BORE HOLE LOCATION PLAN
Scale - 1:350



CBP WALL PLAN
Scale - 1:350

Contiguous Bored Pile(CBP) Wall			
Pile Dia. (Ø)	800 mm		400 mm
Pile Symbol			
Nos. of Pile	230	7	100
Pile Level	NGL To -17 m level	-4 m level To -17 m level	NGL To -12 m level

NOTE:
—·—·— Boundary Line

DEVELOPER

ARCHITECT

MEP DESIGN & CONSULTANT

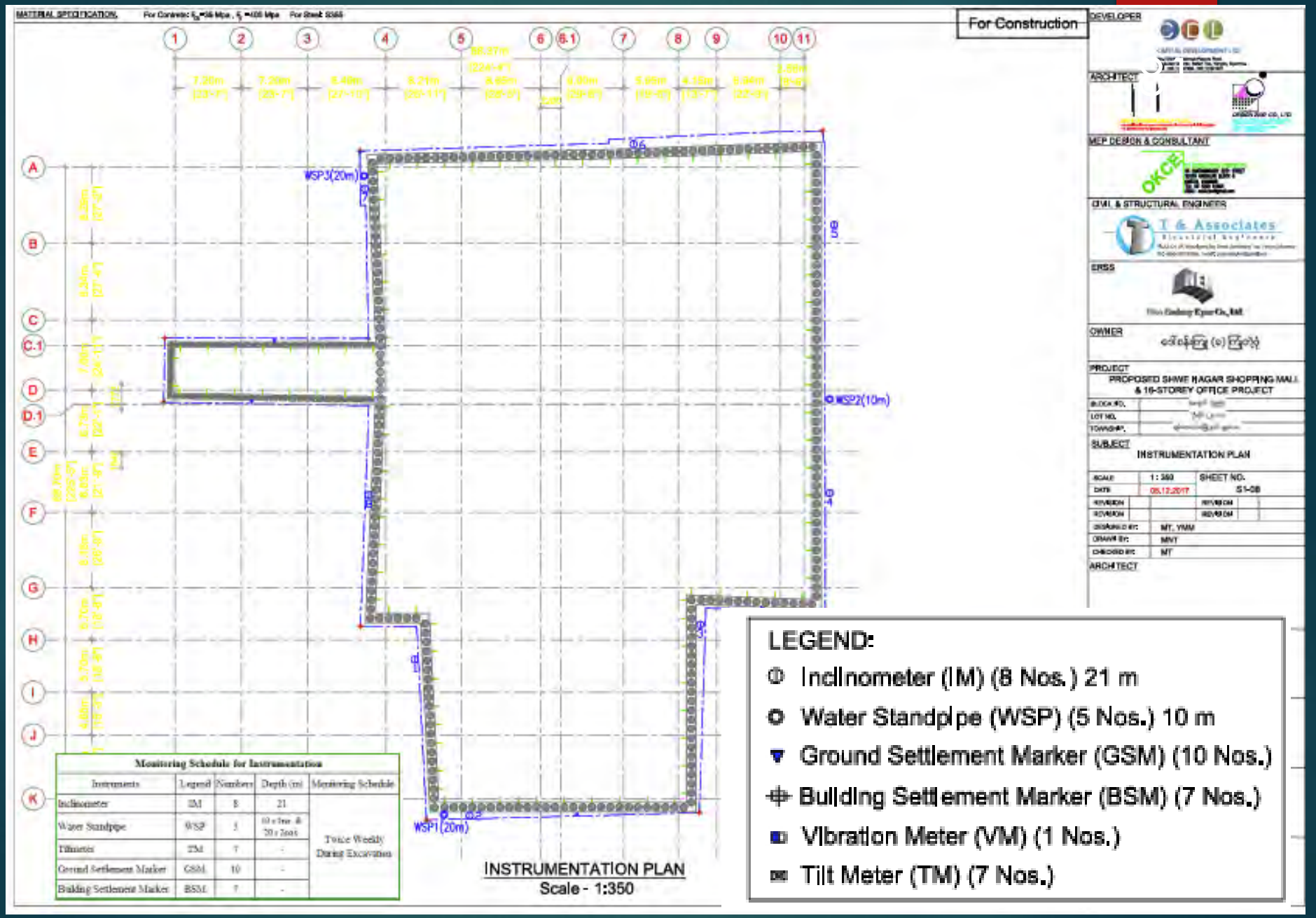
CIVIL & STRUCTURAL ENGINEER

OWNER

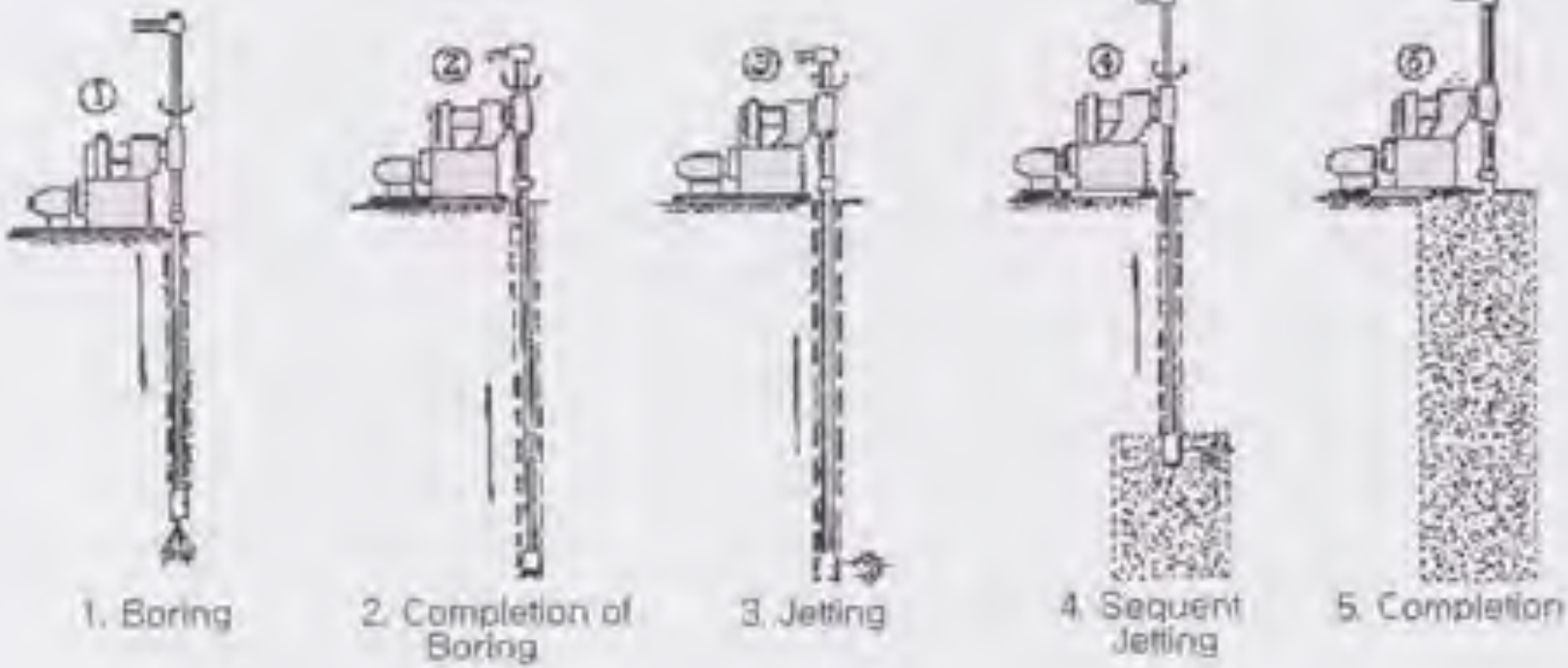
PROJECT
PROPOSED SHWE NAGAR SHOPPING MALL & 18-STOREY OFFICE PROJECT

SUBJECT
CBP WALL PLAN

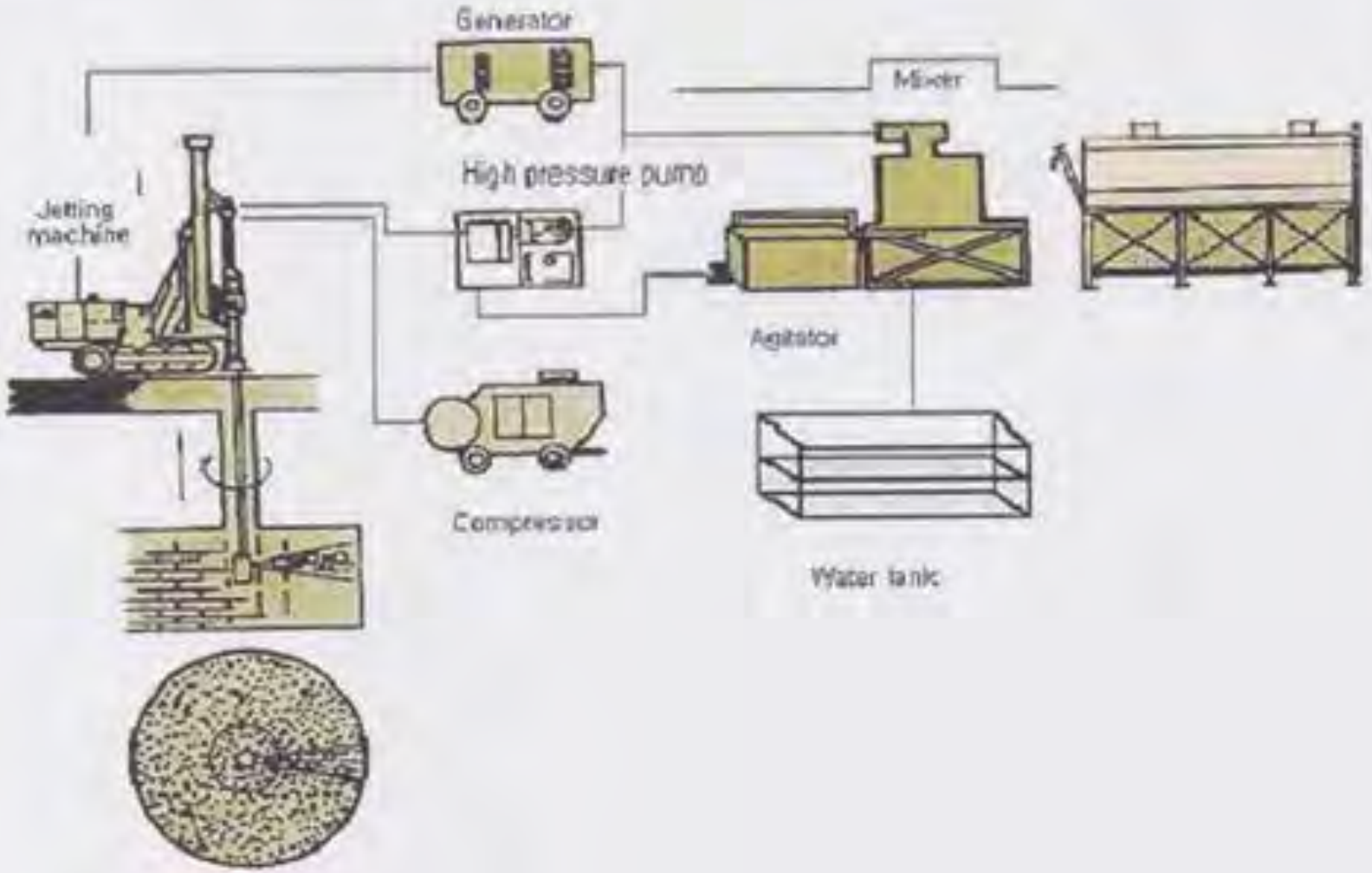
SCALE	1 : 350	SHEET NO.
DATE	23.8.2017	A1-07
	MT. YMM	
	MHT	
	MT	
ARCHITECT		


MATERIAL SPECIFICATION
For Construction
DEVELOPER
ARCHITECT
MEP DESIGN & CONSULTANT
CIVIL & STRUCTURAL ENGINEER
T & Associates
ERSS
OWNER
PROJECT
PROPOSED SHWE HAGAR SHOPPING MALL & 16-STOREY OFFICE PROJECT
SUBJECT
INSTRUMENTATION PLAN
SCALE 1 : 350
SHEET NO. S1-08
DATE 05.12.2017
ARCHITECT
WSP3(20m)
WSP2(10m)
WSP1(20m)
Monitoring Schedule for Instrumentation
Instruments | Legend | Numbers | Depth (m) | Monitoring Schedule
Inclinometer | IM | 8 | 21 | Twice Weekly During Excavation
Water Standpipe | WSP | 5 | 10 x 5nos & 20 x 2nos
Tiltmeter | TM | 7 | -
Ground Settlement Marker | GSM | 10 | -
Building Settlement Marker | BSM | 7 | -
INSTRUMENTATION PLAN
Scale - 1:350
LEGEND:
Inclinometer (IM) (8 Nos.) 21 m
Water Standpipe (WSP) (5 Nos.) 10 m
Ground Settlement Marker (GSM) (10 Nos.)
Building Settlement Marker (BSM) (7 Nos.)
Vibration Meter (VM) (1 Nos.)
Tilt Meter (TM) (7 Nos.)

JET GROUT BETWEEN BORED PILES TO SEAL OFF *CBP*


1. Boring
2. Completion of Boring
3. Jetting
4. Sequent Jetting
5. Completion

5.3. Arrangement of Equipments



6. Grouting Materials & Their Mixing Ratios

6.1. **Cement :** Portland Cement Type I, in conformance with ASTM C150, packaging in a 50 kg/bag

Water : Clear Water from Site Location

Admixture : Water Reducing Admixture, Conmix Brand – SP1C

Intraplast : ZX (Extra Expanding Grout Admixture)

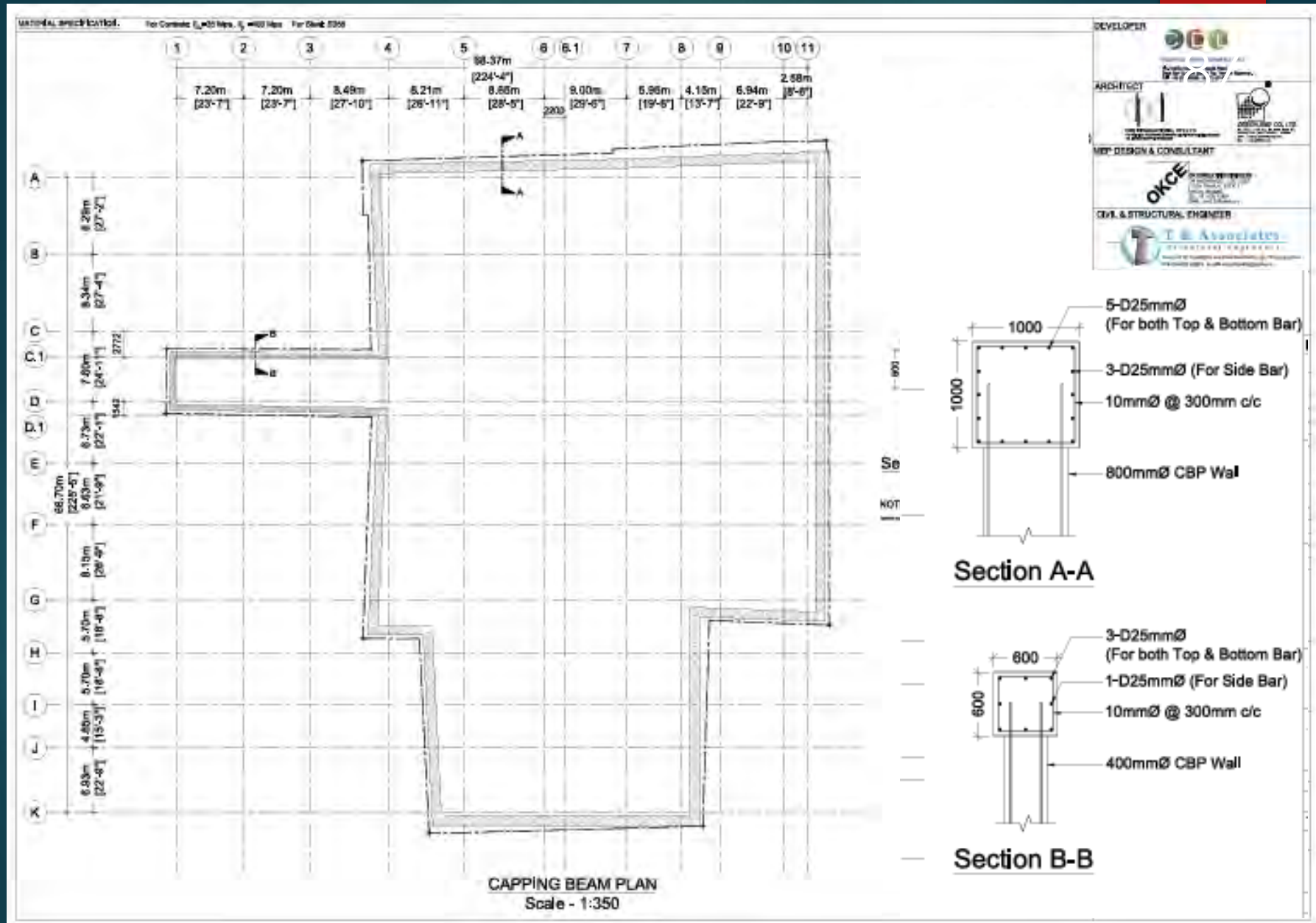
Mix No.	Grout Mix Ratio (By Weight)	Type of Grout
SCG-SP1C-ZX-01	W:C:A:ZX = 1 : 1 : 0.005 : 0.005	Jet Grouting
SCG-SP1C-ZX-02	W:C:A:ZX = 0.7 : 1 : 0.005 : 0.005	Jet Grouting

7. Jetting

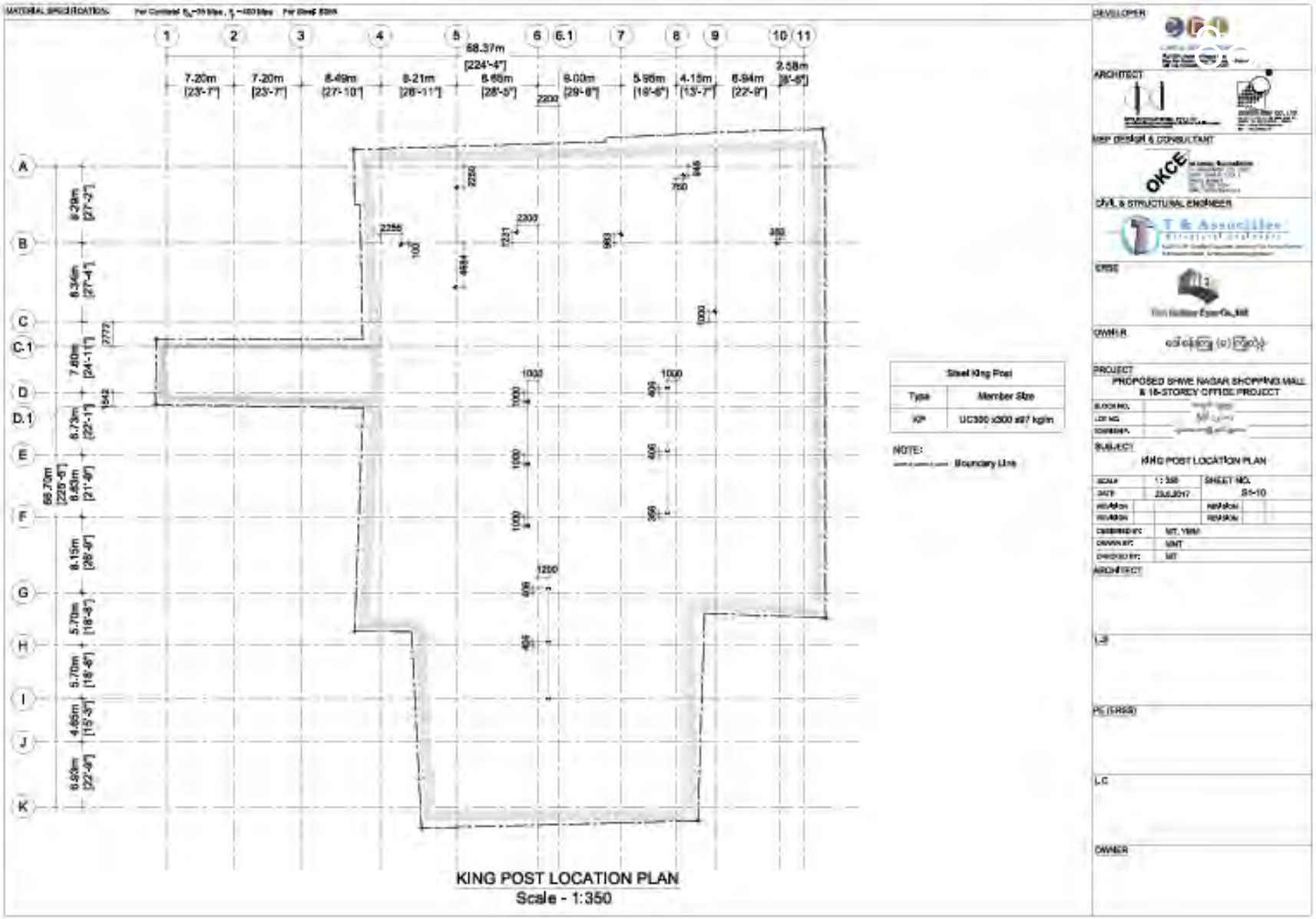
7.1. After completion of Boring up to 17.00m, operating mode will be converted 'boring mode' to 'jetting mode'.

7.2. Injection pressure shall be increased to the designed, 50kg/cm2 and or 200kg/cm2 gradually. After that, jetting will be set to. In this project, planned injection system is as follows :

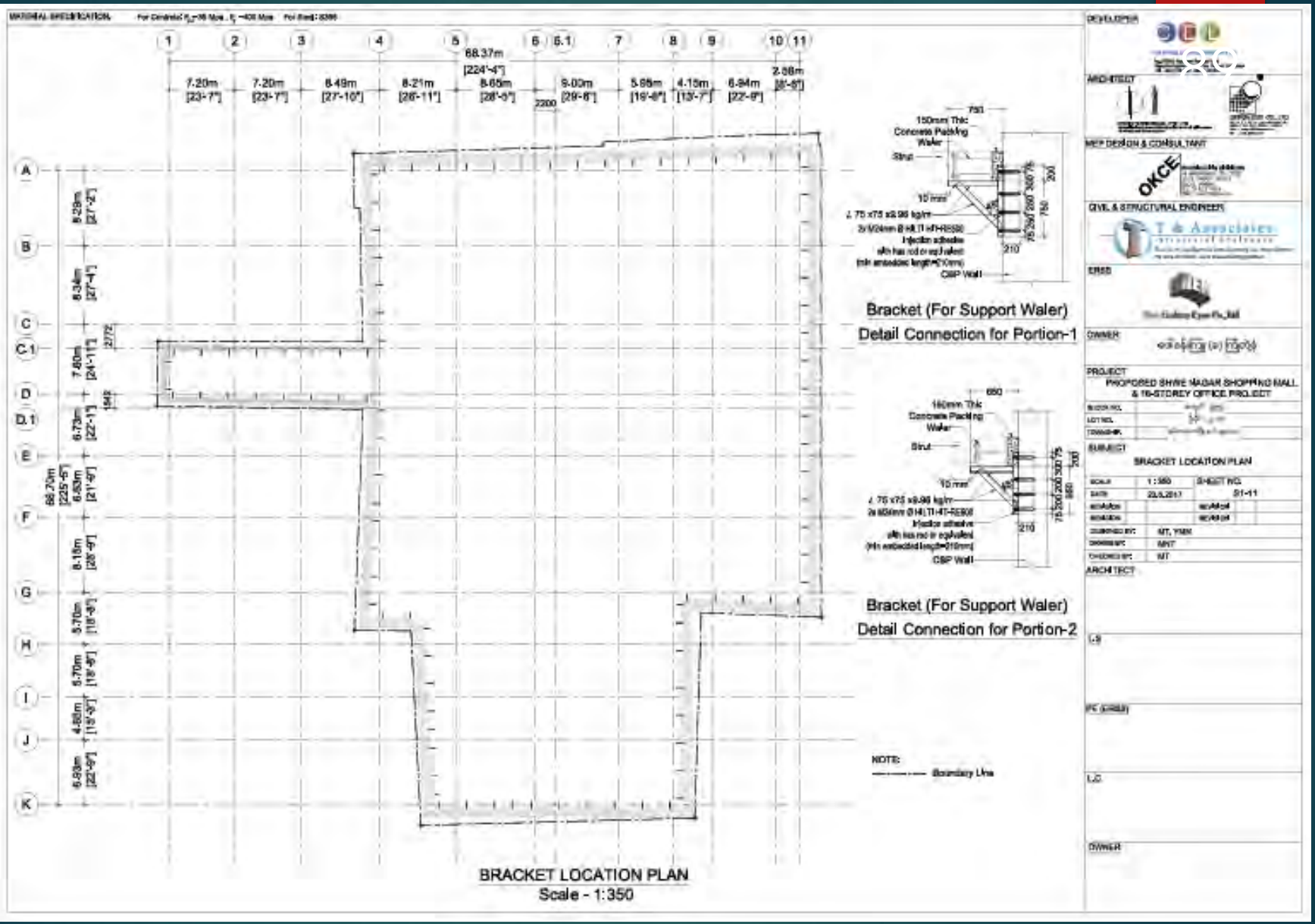
Double Tube Jet Injection (Diameter of Nozzle: 2.3 ~ 4 mm)	
Injection Pressure: $50Kg/cm^2$	□ Classification of PUMP : YBM SG-30SV □ Extracting Length of 1 Step : 5 ㎝ (20 Step / 1meter) □ Jetting Time for 1 Step : Designed Quantity 354Kg/m→7.5sec □ Flow rate per minute : 180 ℓ/min ± 10 ℓ/min □ r.p.m : 45 rpm ~ 75 rpm



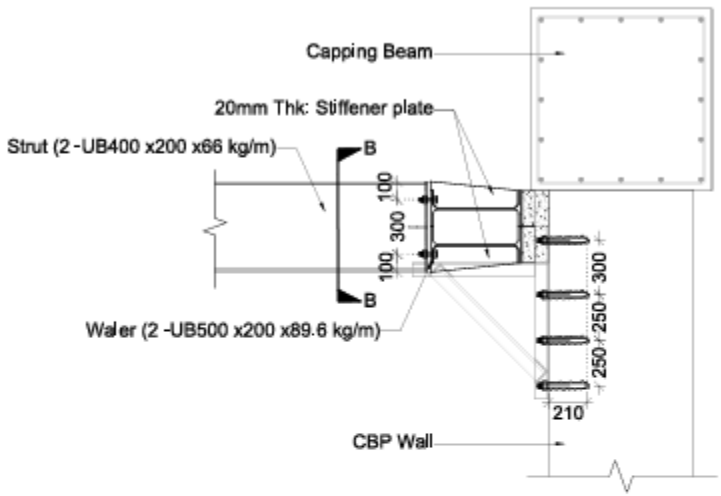
CAPPING BEAM PLAN
Scale - 1:350



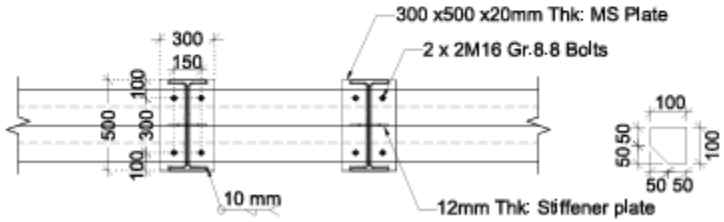
KING POST LOCATION PLAN
Scale - 1:350


1 2 3 4 5 6 6.1 7 8 9 10 11
68.37m [224'-4"]
7.20m [23'-7"]
7.20m [23'-7"]
6.49m [27'-10"]
8.21m [26'-11"]
8.65m [28'-3"]
2200
9.00m [29'-6"]
5.85m [19'-6"]
4.15m [13'-7"]
6.84m [22'-9"]
2.56m [8'-6"]
A
B
C
C.1
D
D.1
E
F
G
H
I
J
K
8.29m [27'-2"]
8.34m [27'-4"]
7.60m [24'-11"]
2772
6.73m [22'-1"]
1848
6.63m [21'-9"]
86.70m [225'-5"]
8.18m [26'-9"]
5.70m [18'-8"]
5.70m [18'-8"]
4.66m [15'-3"]
6.93m [22'-9"]
150mm Thk Concrete Packing Waler
Strut
10 mm
CBP Wall
210
Bracket (For Support Waler)
Detail Connection for Portion-1
Bracket (For Support Waler)
Detail Connection for Portion-2
NOTE:
Boundary Line
BRACKET LOCATION PLAN
Scale - 1:350
DEVELOPER
ARCHITECT
MEP DESIGN & CONSULTANT
OKCE
CIVIL & STRUCTURAL ENGINEERS
T & Associates
EIRSB
OWNER
PROJECT
PROPOSED SHWE NAGAR SHOPPING MALL & 16-STOREY OFFICE PROJECT
SUBJECT
BRACKET LOCATION PLAN
SCALE 1:350
SHEET NO. S1-11
DATE 22.5.2017
DRAWN BY MT, YMH
CHECKED BY MT
ARCHITECT
C.E
PC (CIVIL)
L.O
OWNER

Plan

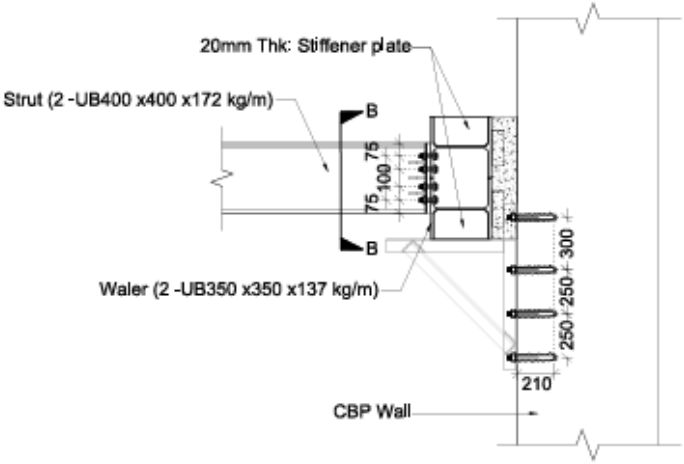


Section A-A

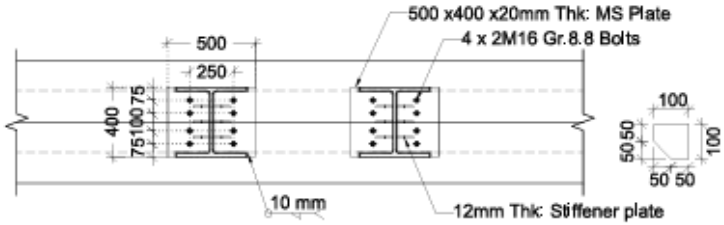


Section B-B

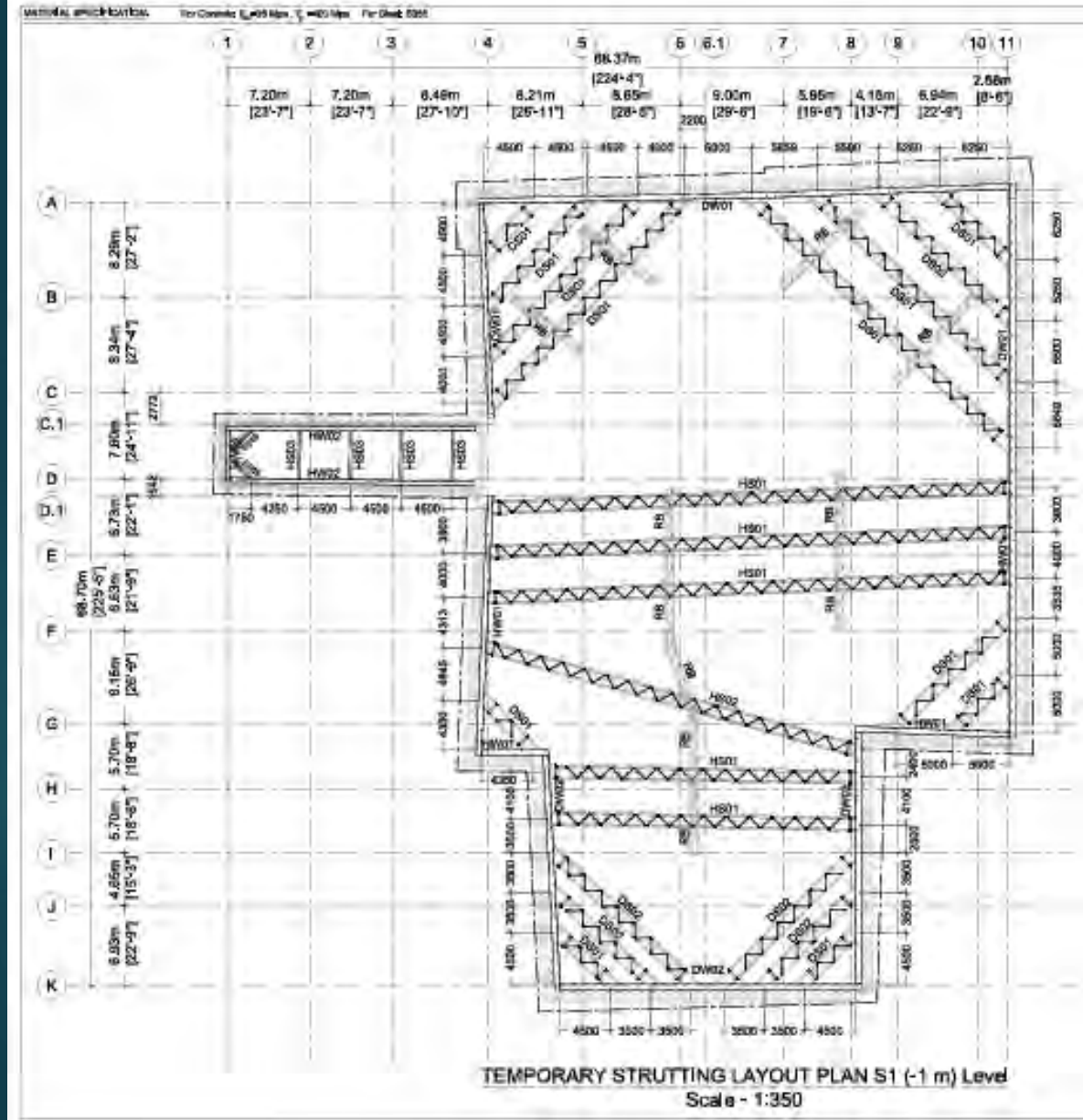
Plan



Section A-A



Section B-B



TEMPORARY STRUTTING LAYOUT PLAN S1 (-1 m) Level
Scale - 1:350

Steel Water	
Type	Member Size
HW01	2 -UB500 x200 x89.6 kg/m
HW02	1 -UC400 x400 x172 kg/m
DW01	2 -UB500 x200 x89.6 kg/m
DW02	2 -UB500 x200 x89.6 kg/m
Steel Strut	
Type	Member Size
HS01	2 -UB500 x200 x89.6 kg/m
HS02	2 -UB500 x200 x89.6 kg/m
HS03	1 -UC300 x300 x97 kg/m
DS01	2 -UB400 x202 x60 kg/m
DS02	2 -UB500 x200 x89.6 kg/m
DS03	1 -UC300 x300 x97 kg/m
Steel Tie Beam	
Type	Member Size
TB	Tapered C-Channel 150 x75 x17.9 kg/m
Steel King Post	
Type	Member Size
KP	UC300 x300 x97 kg/m
Steel Runner Beam	
Type	Member Size
RB	2 -UC300 x300 x97 kg/m

DEVELOPER

ARCHITECT

WET DESIGN & CONSULTANT

CIVIL & STRUCTURAL ENGINEER

OWNER

PROJECT
PROPOSED SHWE NAGAR SHOPPING MALL & 18-STOREY OFFICE PROJECT

SUBJECT
TEMPORARY STRUTTING LAYOUT PLAN (S1 - 1 m Level)

SCALE	1:350	SHEET NO.	
DATE	23.6.2017		S1-12
REVISION		REVISION	
REVISION		REVISION	
CHECKED BY	MT. YMM		
DRAWN BY	MNT		
CHECKED BY	MT		

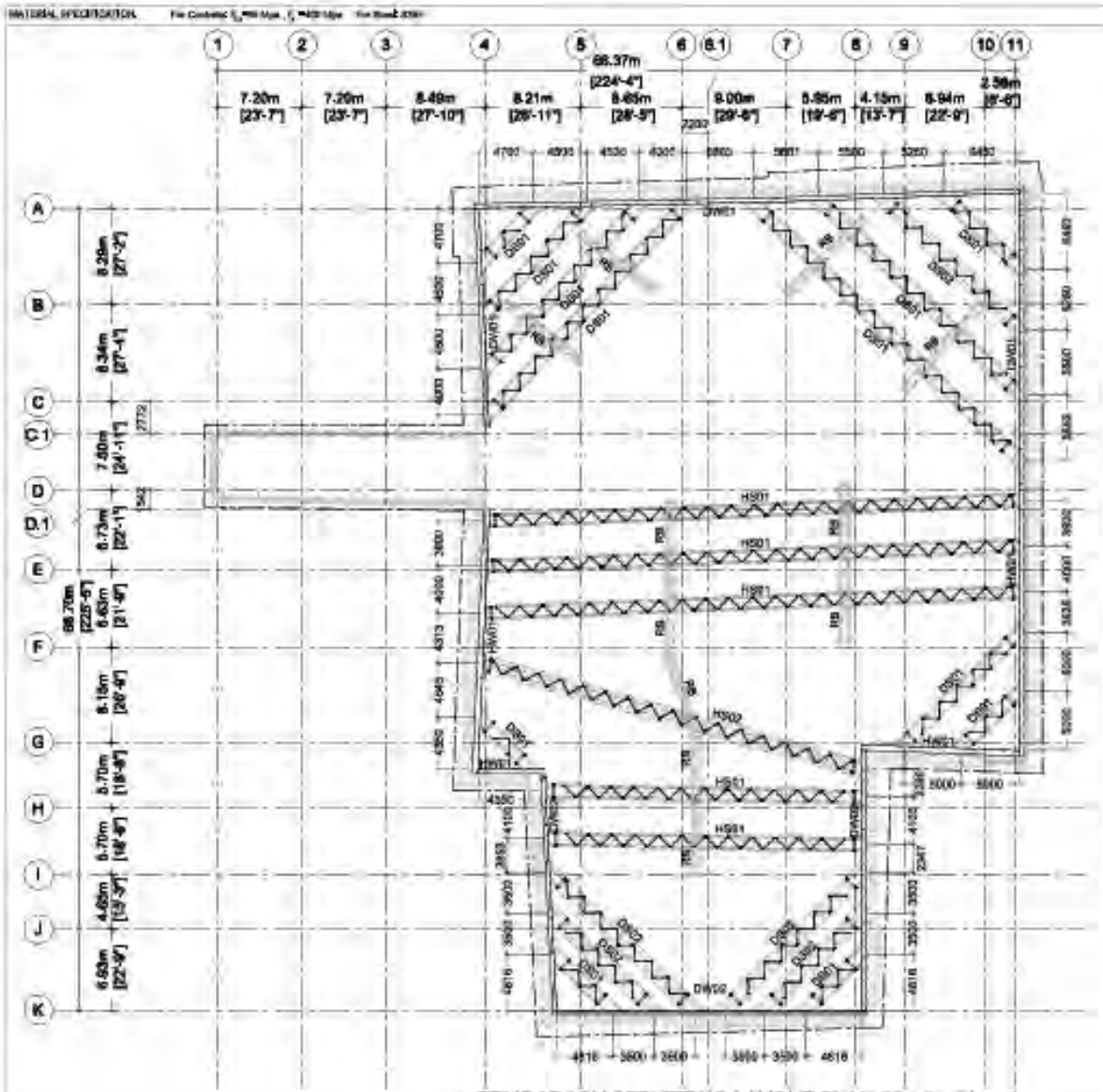
ARCHITECT

LS

PE (CIVIL)

LS

OWNER



TEMPORARY STRUTTING LAYOUT PLAN S2 (-5 m) Level
Scale - 1:350

Steel Wale	
Type	Member Size
HW01	2-UB800 x200 x66.8 kg/m
DW01	2-UC400 x400 x172 kg/m
DW02	2-UC360 x360 x137 kg/m
Steel Strut	
Type	Member Size
HS01	2-UB800 x200 x66.8 kg/m
HS02	2-UC400 x400 x172 kg/m
DS01	2-UB800 x200 x66.8 kg/m
DS02	2-UC400 x400 x172 kg/m
Steel Tie Beam	
Type	Member Size
TB	Tapered C-Channel 150 x75 x17.9 kg/m
Steel King Post	
Type	Member Size
KP	UC300 x300 x97 kg/m
Steel Runner Beam	
Type	Member Size
RB	2-UC300 x300 x97 kg/m

DEVELOPER

ARCHITECT

M/F DESIGN & CONSULTANT
OKCE

CIVIL & STRUCTURAL ENGINEER

ERSS

OWNER

PROJECT
PROPOSED SHRE NAGAR SHOPPING MALL & 16-STOREY OFFICE PROJECT

BLOCK NO.
UNIT NO.
DIMENSION

SUBJECT
TEMPORARY STRUTTING LAYOUT PLAN (S2 -5 m Level)

SCALE	1:350	SHEET NO.
DATE	28.6.2017	S1-13
REVISION		REVISION
REVISION		REVISION
DESIGNED BY	MT, YMM	
DRAWN BY	MMT	
CHECKED BY	MT	

ARCHITECT

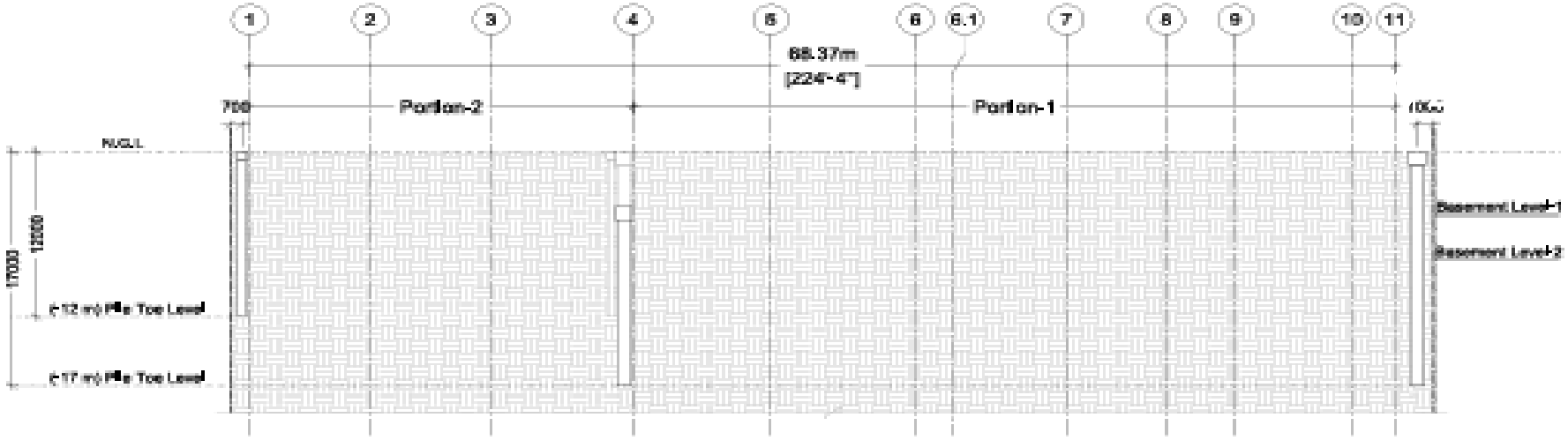
L.S

PE (ERSS)

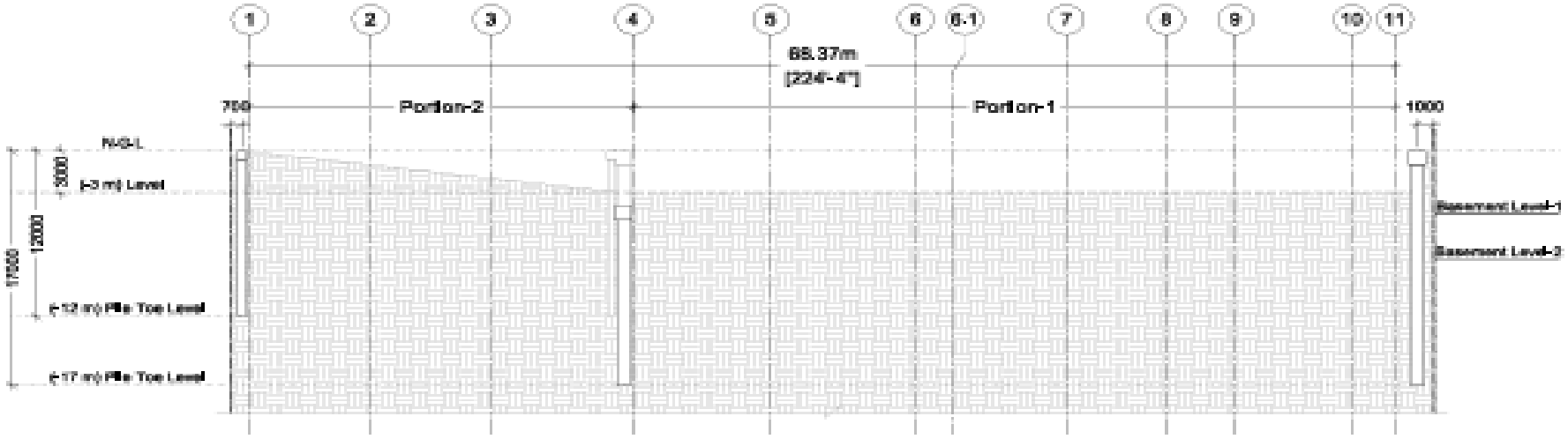
L.C

OWNER

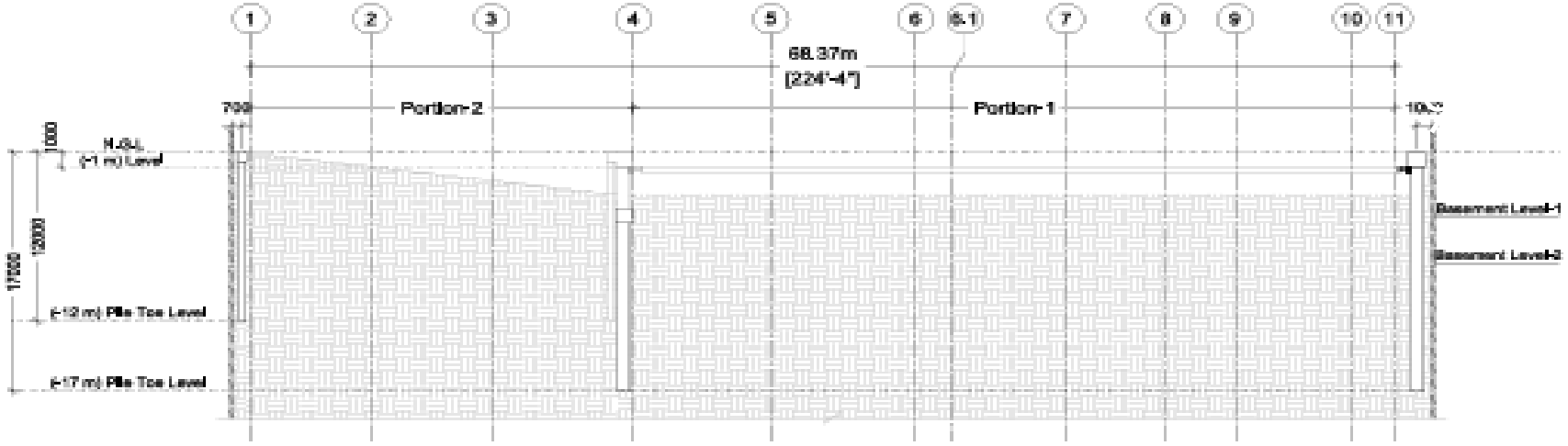
CONSTRUCTION SEQUENCE FOR DEEP EXCAVATION



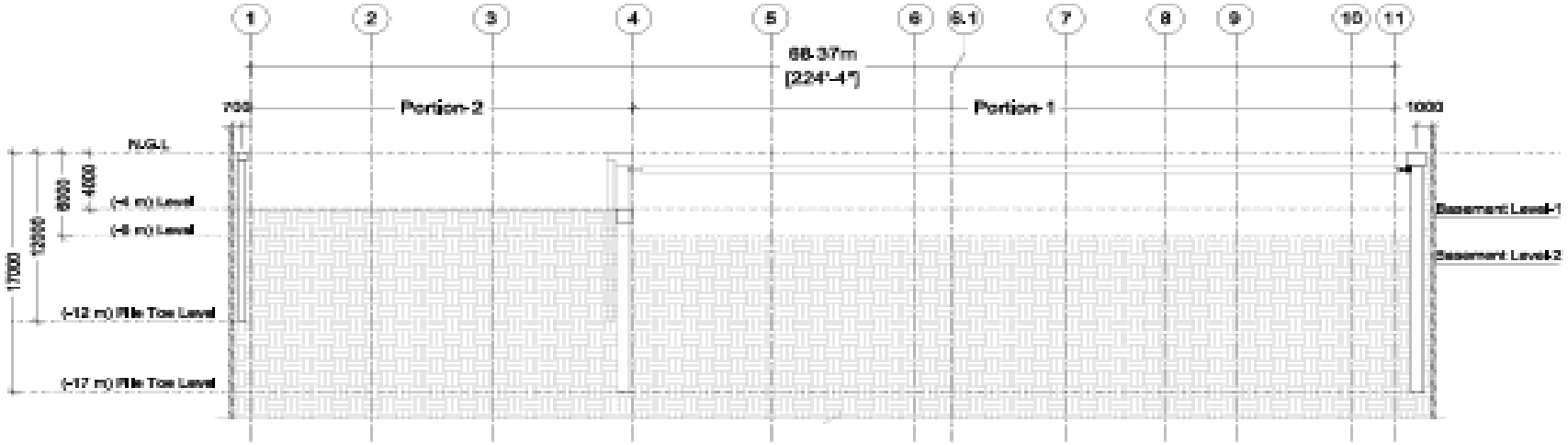
Stage.1 - Install CBP Wall and capping beam for Portion-1 & Porion-2.



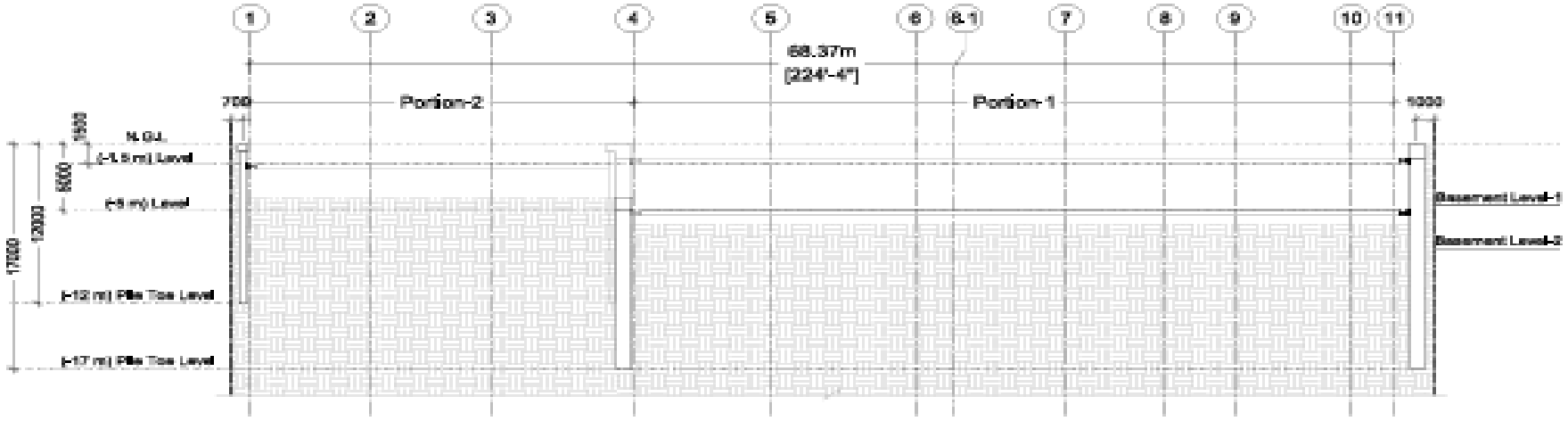
Stage.2 - Excavate upto (-3 m) Level Below N.G.L



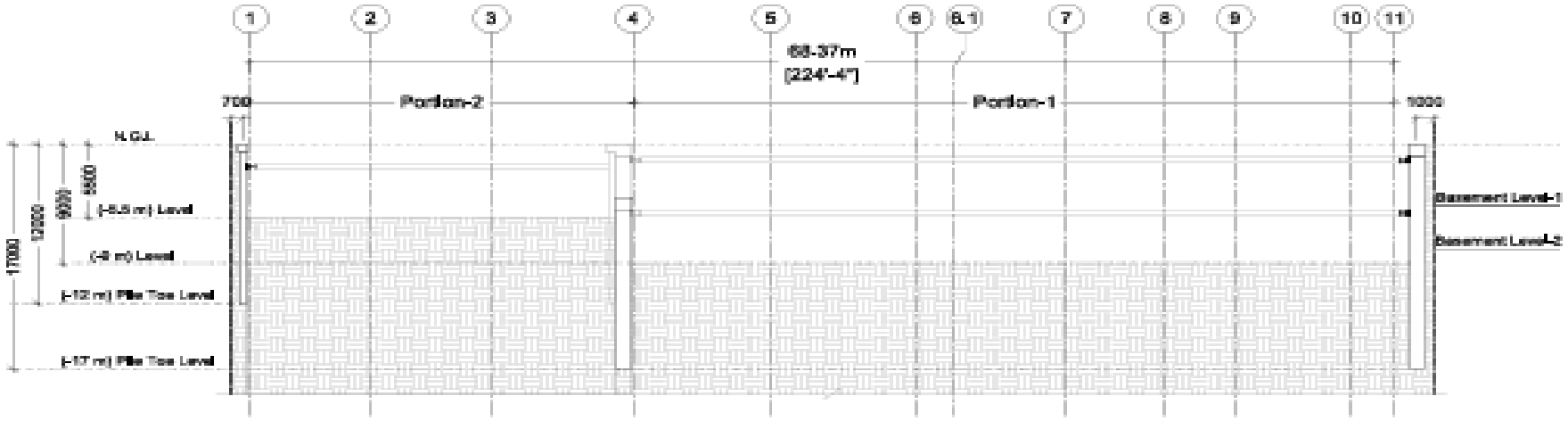
Stage-3 - Install 1st Layer Waler & Strut (-1 m) Level for Postion-1 Below N.G.L



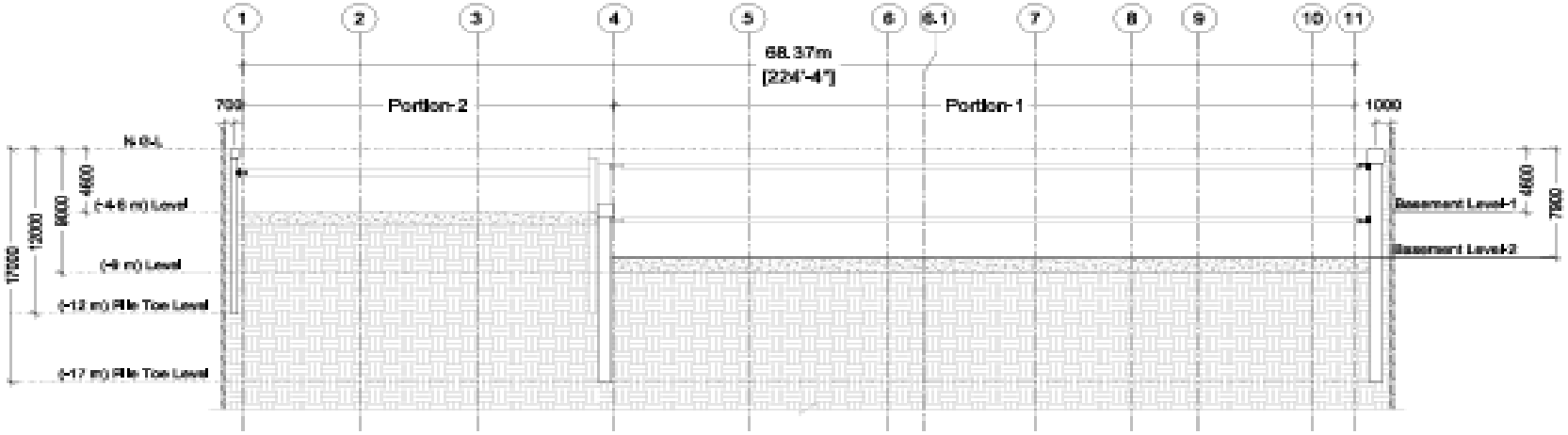
Stage-4 - Excavate upto (-6 m) Level for Postion-1 Below N.G.L
& Excavate upto (-4 m) Level for Postion-2 Below N.G.L



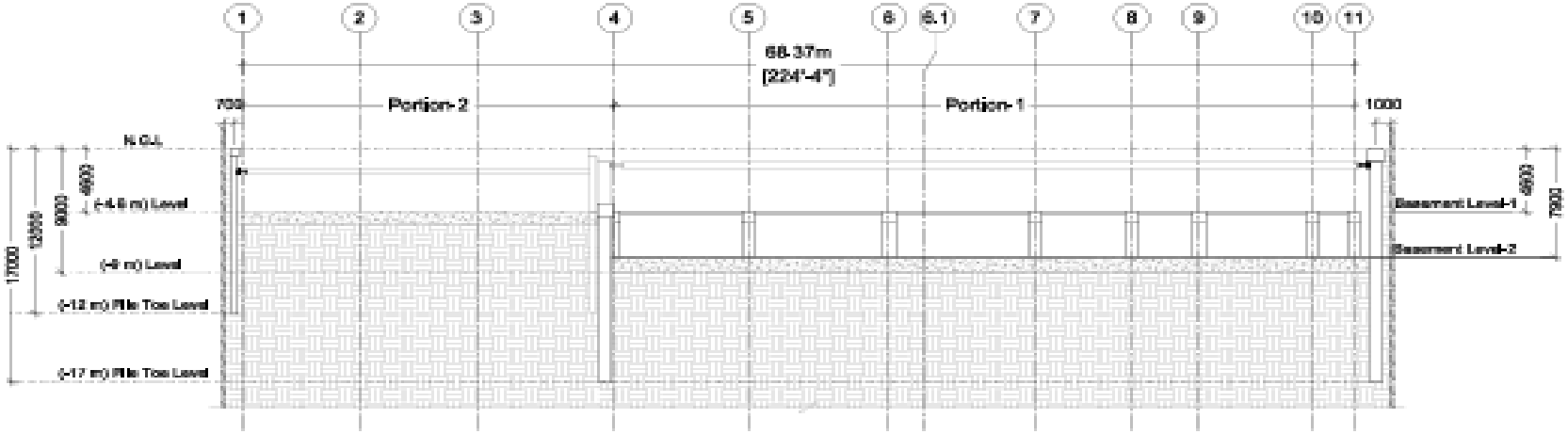
Stage-5 - Install 2nd Layer Waler & Strut (-5 m) Level for Postion-1 Below N.G.L
& Install Waler & Strut (-1.5 m) Level for Postion-2 Below N.G.L



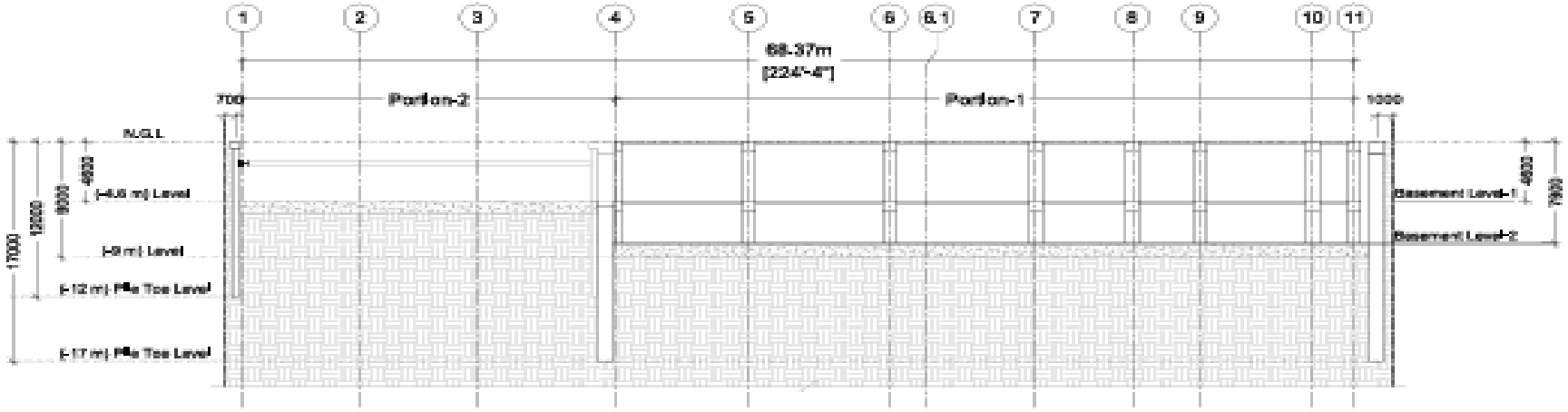
Stage-6 - Excavate upto (-9 m) Level for Postion-1 Below N.G.L
& Excavate upto (-5.5 m) Level for Postion-2 Below N.G.L



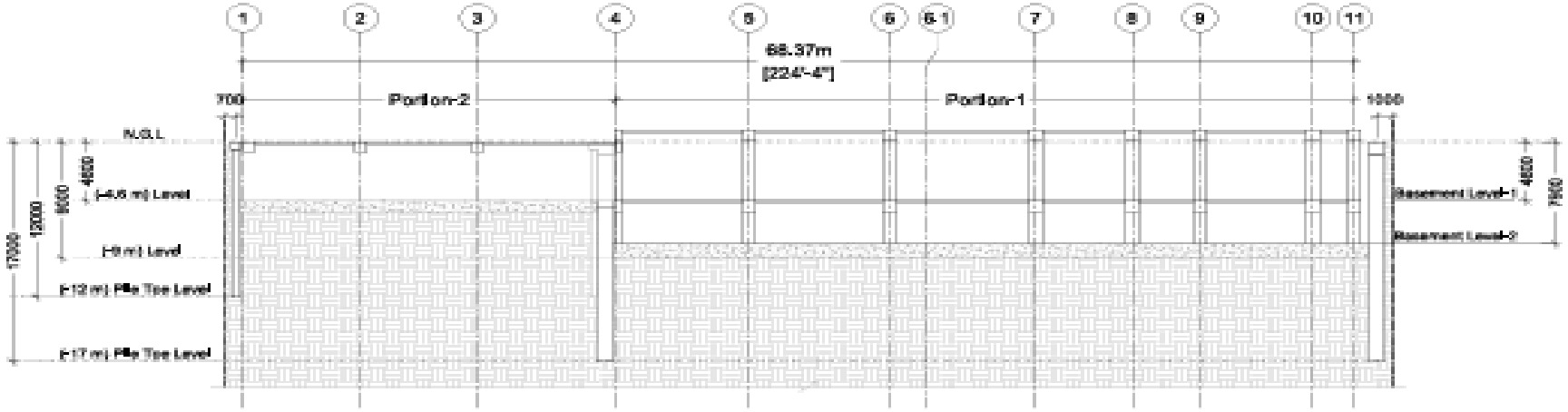
Stage-7 - Cast Footing for Basement-2 (-7.9m) Level for Postion-1
& (-4.6m) Level for Postion-2



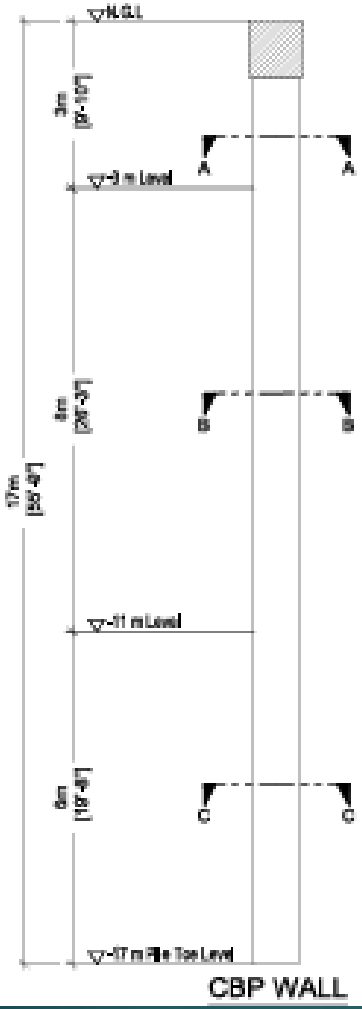
Stage-8 - Remove 2nd Layer Waler & Strut (-5 m) Level &
Install Column ,Beam & Slab (-4.6m) Basement Level-1 for Postion-1

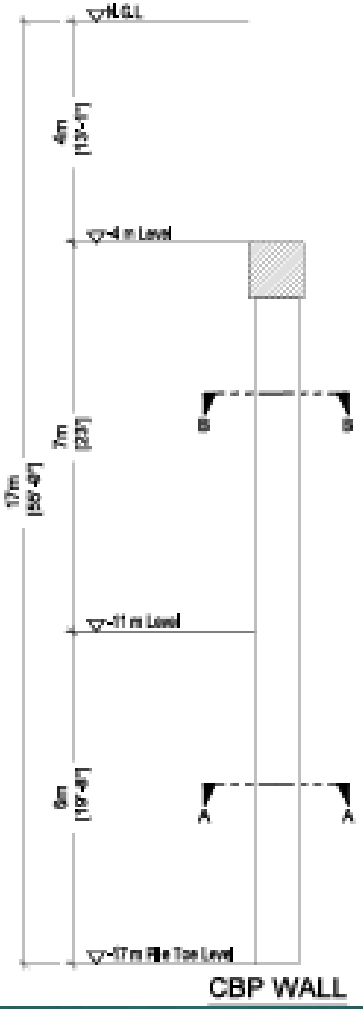


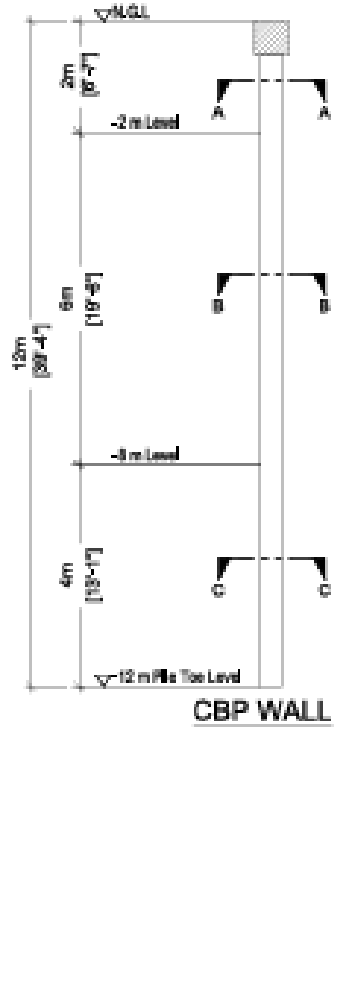
Stage 9 - Remove 1st Layer Waler & Strut (-1 m) Level &
Install Column ,Beam & Slab for Ground Level



Stage 10 - Remove Waler & Strut (-1.5 m) Level &
Install Column ,Beam & Slab for Ground Level


N.G.L
3m [9'-10"]
-3 m Level
6m [20'-3"]
17m [55'-9"]
-11 m Level
6m [19'-8"]
-17 m Pile Toe Level
A
B
C
CBP WALL


N.G.L
4m [13'-1"]
-4 m Level
7m [23']
17m [55'-9"]
-11 m Level
6m [19'-8"]
-17 m Pile Toe Level
A
B
CBP WALL


N.G.L
2m [6'-7"]
-2 m Level
6m [19'-8"]
12m [39'-4"]
-8 m Level
4m [13'-1"]
-12 m Pile Toe Level
A
B
C
CBP WALL

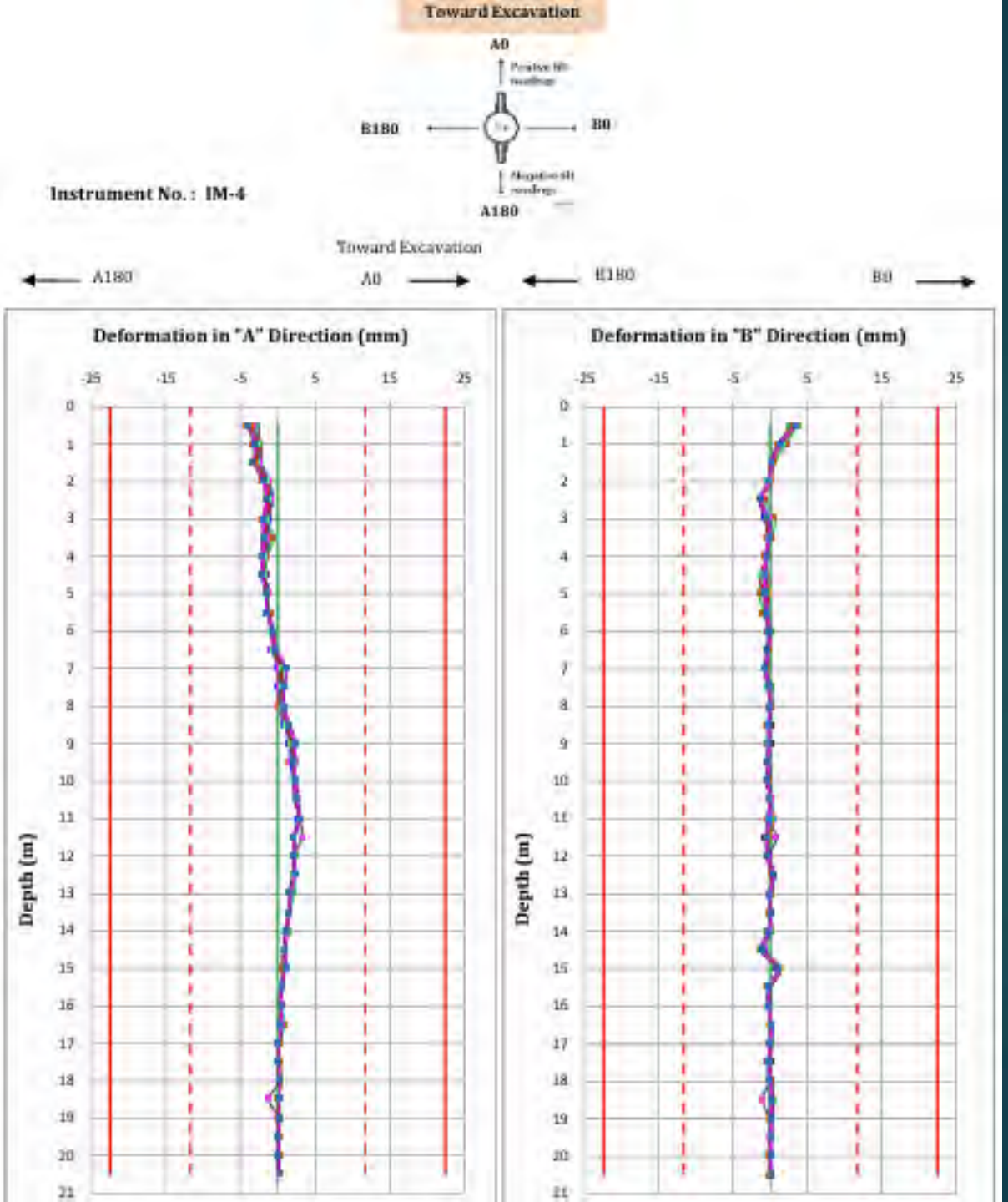
GEO-FRIENDS
Engineering & Construction Co. Ltd.

Inclinometer Monitoring Results

Client : Capital Development Ltd.
Project : Geotechnical Instrumentation for Shwe Nagar Project
Date of Installed : 25/1/2018
Reduced Level of Top of Pipe :

Reading No. : 70
Instrument No. : IM-4
Date of Initial Reading : 29/1/2018
Date of Monitoring : 16/11/2018

Depth (m)	A0	A180	D (mm)	B0	B180	D (mm)	Res D (mm)
0.5	111	-147	-4.04	853	-818	3.54	5.37
1.0	191	-234	-3.00	757	-746	1.22	3.24
1.5	204	-247	-3.15	735	-739	0.24	3.16
2.0	250	-293	-1.90	769	-755	-0.22	1.91
2.5	295	-337	-1.53	726	-721	-1.39	2.07
3.0	287	-325	-1.90	643	-650	-0.42	1.95
3.5	187	-231	-1.95	597	-593	-0.18	1.96
4.0	150	-186	-2.06	587	-591	-0.61	2.15
4.5	143	-183	-2.07	644	-629	-0.77	2.21
5.0	155	-193	-1.60	696	-696	-0.76	1.77
5.5	119	-155	-1.49	765	-761	-0.57	1.60
6.0	152	-187	-0.57	736	-743	-0.28	0.64
6.5	169	-201	-0.28	625	-640	-0.31	0.42
7.0	217	-261	1.11	591	-580	-0.71	1.32
7.5	216	-253	0.95	669	-655	-0.24	0.98
8.0	216	-256	0.78	688	-690	-0.07	0.78
8.5	205	-245	1.57	666	-663	-0.20	1.58
9.0	193	-224	2.37	624	-626	-0.16	2.38
9.5	208	-249	2.24	576	-597	-0.47	2.29
10.0	200	-241	2.36	527	-522	-0.38	2.39
10.5	259	-303	2.53	565	-598	-0.17	2.54
11.0	315	-361	2.95	473	-490	-0.21	2.96
11.5	327	-360	2.18	449	-455	-0.48	2.23
12.0	431	-476	2.20	557	-575	-0.41	2.24
12.5	418	-455	2.28	662	-672	0.43	2.32
13.0	331	-365	1.63	667	-660	-0.15	1.64
13.5	242	-272	1.56	679	-676	0.00	1.56
14.0	263	-292	1.29	628	-635	-0.18	1.30
14.5	414	-449	0.95	573	-597	-1.17	1.51
15.0	276	-302	1.12	788	-810	1.17	1.62
15.5	116	-161	0.47	525	-537	-0.24	0.53
16.0	162	-226	0.63	581	-584	-0.18	0.66
16.5	175	-219	0.41	583	-577	0.03	0.41
17.0	200	-242	0.13	540	-537	-0.05	0.14
17.5	247	-297	0.14	596	-605	-0.17	0.22
18.0	249	-286	0.22	610	-608	-0.06	0.23
18.5	198	-241	0.27	539	-535	0.22	0.35
19.0	58	-97	0.27	414	-414	0.00	0.27
19.5	-19	-29	0.17	374	-370	0.02	0.17
20.0	-44	4	0.15	343	-322	-0.01	0.15
20.5	-50	9	0.25	301	-292	0.15	0.29


Toward Excavation
A0
B180
B0
A180
Instrument No. : IM-4
Toward Excavation
A180
A0
B180
B0
Deformation in "A" Direction (mm)
-25
-15
-5
5
15
25
Depth (m)
Deformation in "B" Direction (mm)
-25
-15
-5
5
15
25
Depth (m)

WATER LEVEL MONITORING RECORD SHEET

GEO-FRIENDS
Engineering & Consultation Co., Ltd.

CLIENT : Capital Development Ltd.
PROJECT : Geotechnical Instrumentation for Shwe Nagar Project
LOCATION : 80th Street, Between 27th & 28th Street, Mandalay

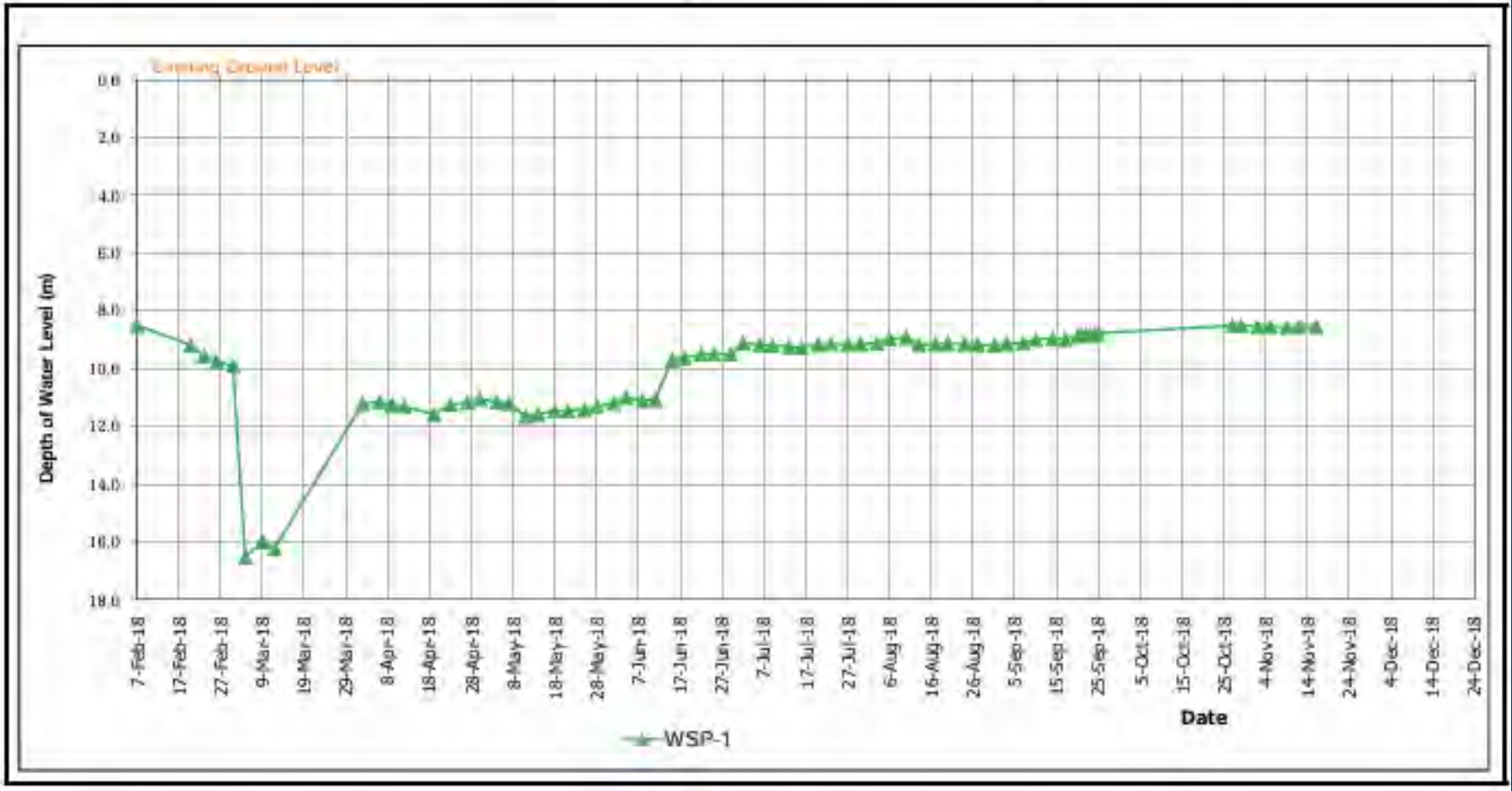
INSTRUMENT NO. : WSP-1
INSTALLED DATE : 4.12.2017
LENGTH OF WATER STANDPIPE : 20.00 m
PIPE ABOVE GROUND LEVEL : 0.15 m

DATE	TIME	INTERVAL (day)	ELAPSED TIME (day)	WSP-1		REMARK
				WATER TABLE LEVEL Below Ground Level(m)	CUMULATIVE CHANGE(m)	
07-Feb-18	7:58	0	0	8.490	0.000	Initial Reading
22-Sep-18	10:00	1	227	8.830	0.340	58th Reading
23-Sep-18	9:15	1	228	8.850	0.360	59th Reading
24-Sep-18	9:27	1	229	8.830	0.340	60th Reading
25-Sep-18	9:35	1	230	8.780	0.290	61st Reading
27-Oct-18	13:20	32	262	8.520	0.030	62nd Reading
29-Oct-18	8:52	2	264	8.500	0.010	63rd Reading
02-Nov-18	10:40	4	268	8.540	0.050	64th Reading
05-Nov-18	9:45	3	271	8.540	0.050	65th Reading
09-Nov-18	10:05	4	275	8.560	0.070	66th Reading
12-Nov-18	9:30	3	278	8.550	0.060	67th Reading
16-Nov-18	9:11	4	282	8.540	0.050	68th Reading

WATER LEVEL MONITORING RECORD SHEET

GEO-FRIENDS
Engineering & Construction Co., Ltd.

CLIENT : Capital Development Ltd.	WATER TABLE MONITORING GRAPH	INSTRUMENT NO. : WSP-1
PROJECT : Geotechnical Instrumentation for Shwe Nagar Project		INSTALLED DATE : 4.12.2017
LOCATION : 80th Street, Between 27th & 28th Street, Mandalay		LENGTH OF WATER STANDPIPE : 20



GEO-FRIENDS
Engineering & Construction Co., Ltd.

CLIENT : Capital Development Ltd.

PROJECT : Geotechnical Instrumentation for Shwe Nagar Project

LOCATION : 80th Street, Between 27th & 28th Street, Mandalay

AL = 0.115 deg (1/500) WSL = 0.191 deg (1/300)

TILTMETER MONITORING RESULTS

INSTRUMENT NO. : TM 1

INSTALLED DATE : 29-Jan-18

INITIAL DATE : 20-Feb-18

DATE	INTERVAL (day)	PEG 1	PEG 3	CUMULATIVE CHANGE	TILT ANGLE (Deg)	TILT ANGLE (Deg, Min, Sec)	GRADIENT
20-Feb-18	0	-32	107	0	0.0000	00°00'00"	0
14-Sep-18	206	-20	99	10	0.0229	00°01'23"	1/2500
17-Sep-18	209	-22	98	10	0.0218	00°01'18"	1/2632
18-Sep-18	210	-17	92	30	0.0344	00°02'04"	1/1667
20-Sep-18	212	-21	95	23	0.0264	00°01'35"	1/2174
21-Sep-18	213	-19	97	23	0.0264	00°01'35"	1/2174
22-Sep-18	214	-22	97	20	0.0229	00°01'23"	1/2500
23-Sep-18	215	-20	95	24	0.0275	00°01'39"	1/2084
24-Sep-18	216	-20	94	25	0.0286	00°01'43"	1/2000
25-Sep-18	217	-19	95	25	0.0286	00°01'43"	1/2000
27-Oct-18	249	-22	97	20	0.0229	00°01'23"	1/2500
29-Oct-18	251	-18	97	24	0.0275	00°01'39"	1/2084
2-Nov-18	255	-15	95	29	0.0332	00°02'00"	1/1725
5-Nov-18	258	-17	97	25	0.0286	00°01'43"	1/2000
9-Nov-18	262	-15	96	28	0.0321	00°01'56"	1/1786
12-Nov-18	265	-12	94	33	0.0378	00°02'16"	1/1516
16-Nov-18	269	-10	95	34	0.0390	00°02'20"	1/1471

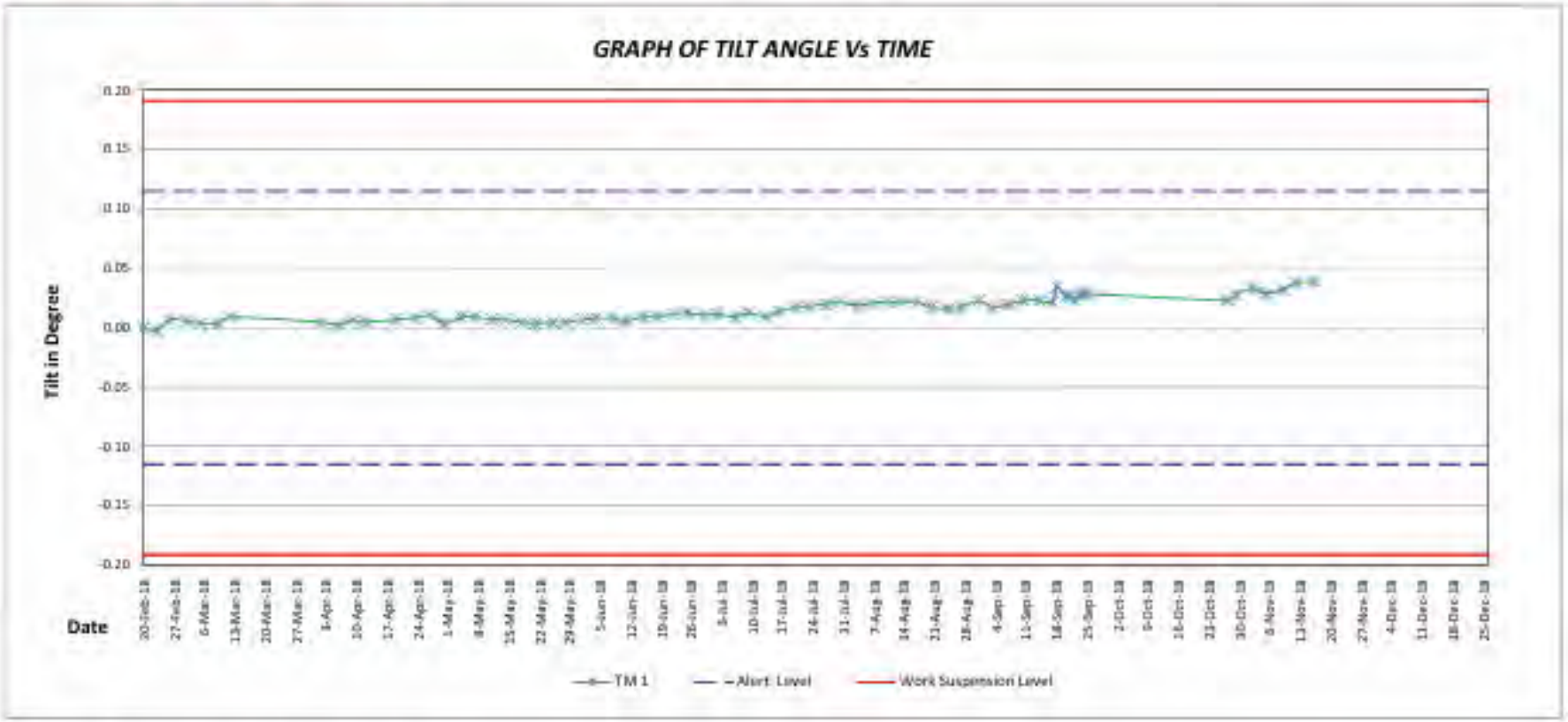
Note: + Tilt = Tilting Forward relative to base reading

- Tilt = Tilting Backward relative to base reading

GEO-FRIENDS
Engineering & Construction Co., Ltd.

Tiltmeter Monitoring Results

CLIENT -	Capital Development Ltd.	INSTRUMENT NO. -	TM 1
PROJECT -	Geotechnical Instrumentation for Shwe Nagar Project	INSTALLED DATE -	29-Jan-18
LOCATION -	80th Street, Between 27th & 28th Street, Mandalay	INITIAL DATE -	20-Feb-18
AL = 0.115 deg (1/500)	WSL = 0.191 deg (1/300)		



Note: + Tilt = Tilting Forward relative to base reading

- Tilt = Tilting Backward relative to base reading

GEO-FRIENDS
Engineering & Construction Co., Ltd.

Ground Settlement Marker Monitoring Results

Client : Capital Development Ltd.

Project : Geotechnical Instrumentation for Shwe Nagar Project

Location : 80th Street, Between 27th & 28th Street, Mandalay — Installed Date : 26/1/2018

Survey Date	31-Jan-18	02-Nov-18	05-Nov-18	09-Nov-18	12-Nov-18	16-Nov-18				Diff from	Diff from
Point No.	Initial Reading (m)	64th Reading (m)	65th Reading (m)	66th Reading (m)	67th Reading (m)	68th Reading (m)	69th Reading (m)	70th Reading (m)	71st Reading (m)	Previous (mm)	Initial (mm)
GSM 1	99.938	99.940	99.940	99.940	99.941	99.939				-2	1
GSM 2	99.800	99.794	99.795	99.796	99.795	99.795				0	-5
GSM 3	99.807	99.802	99.802	99.801	99.802	99.801				-1	-6
GSM 4	99.918	99.919	99.918	99.917	99.918	99.918				0	0
GSM 5	99.880	99.882	99.883	99.884	99.882	99.882				0	2
GSM 6	99.879	99.879	99.880	99.879	99.879	99.878				-1	-1
GSM 7	99.770	99.764	99.765	99.764	99.764	99.765				1	-5
GSM 8	99.770	99.769	99.770	99.769	99.768	99.768				0	-2
GSM 9	101.102	101.101	101.100	101.099	101.100	101.100				0	-2
GSM 10	100.677	100.676	100.676	100.675	100.677	100.676				-1	-1

Note: * (-) Sign is Settled (+) Sign is Heaved

* Reference RL value = Assumed 100m

Alert Level = 17.50 mm

Work Suspension Level = 25.00 mm

Remark: GSM 1 was reinstalled and reinitialized

GEO-FRIENDS
Engineering & Construction Co.,Ltd.

Client : Capital Development Ltd.

Project : Geotechnical Instrumentation for Shwe Nagar Project

Location : 80th Street, Between 27th & 28th Street, Mandalay

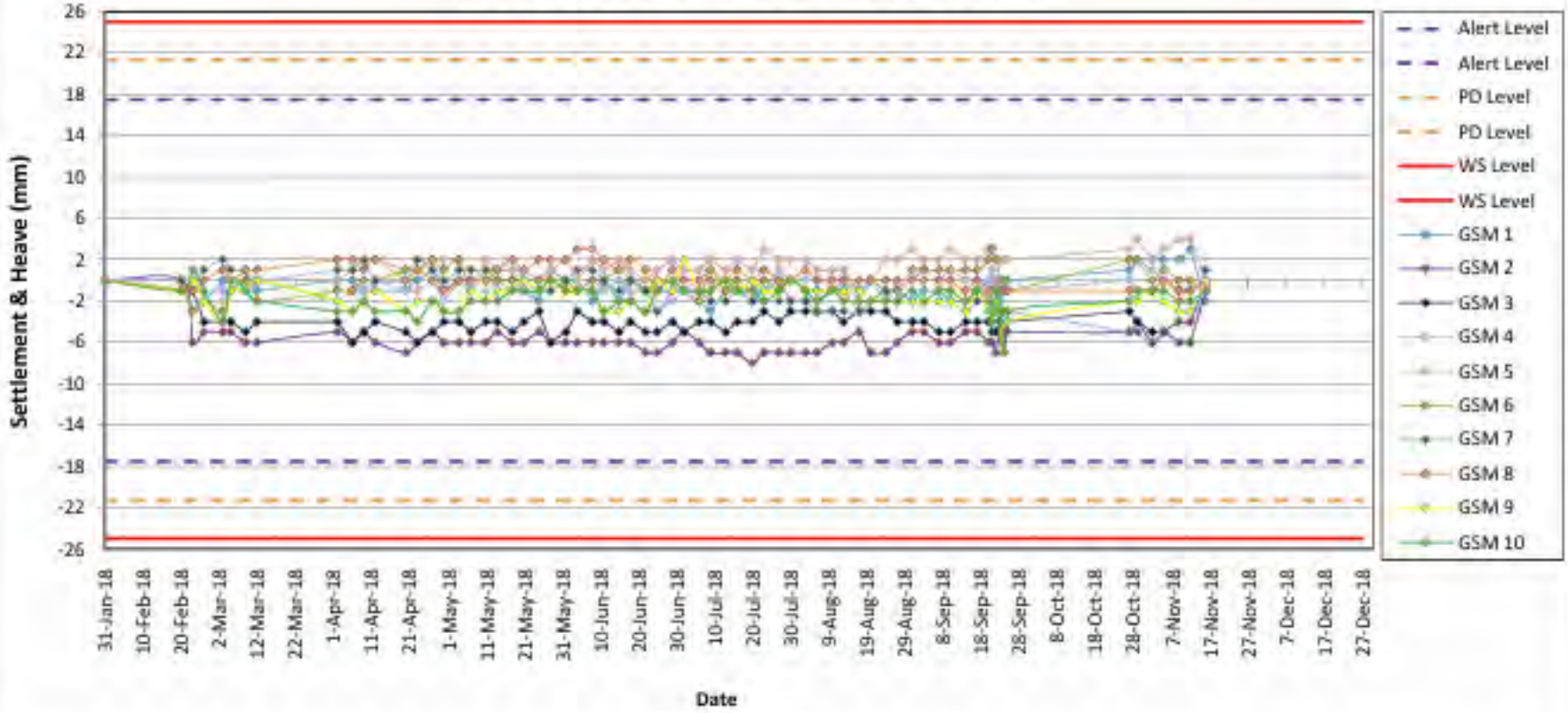
Installed Date : 26/1/2018

Alert Level = 17.50 mm

Work Suspension Level = 25.00 mm

Predetermine Level = 21.50 mm

Graph of Settlement & Heave Vs Time



GEO-FRIENDS
Engineering & Construction Co., Ltd.

Building Settlement Marker Monitoring Results

Client : Capital Development Ltd.

Project : Geotechnical Instrumentation for Shwe Nagar Project

Location : 80th Street, Between 27th & 28th Street, Mandalay — Installed Date : 27/1/2018 & 28/1/2018

Survey Date	31-Jan-18	02-Nov-18	05-Nov-18	09-Nov-18	12-Nov-18	16-Nov-18				Diff from	Diff from
Point No.	Initial Reading (m)	64th Reading (m)	65th Reading (m)	66th Reading (m)	67th Reading (m)	68th Reading (m)	69th Reading (m)	70th Reading (m)	71st Reading (m)	Previous (mm)	Initial (mm)
BSM 1	101.180	101.179	101.178	101.178	101.179	101.180				1	0
BSM 2	101.281	101.273	101.274	101.273	101.274	101.275				1	-6
BSM 3	101.210	101.212	101.211	101.213	101.211	101.214				3	4
BSM 4	100.898	100.895	100.895	100.897	100.895	100.895				0	-3
BSM 5	101.789	101.789	101.790	101.787	101.789	101.787				-2	-2
BSM 6	100.560	100.560	100.558	100.559	100.558	100.558				0	-2
BSM 7	101.057	101.056	101.056	101.058	101.056	101.057				1	0

Note: * (-) Sign is Settled (+) Sign is Heaved

* Reference RL value = Assumed 100m

Alert Level = 10.50 mm Predetermine Level = 12.75 mm

Work Suspension Level = 15.00 mm

GEO-FRIENDS
Engineering & Construction Co.,Ltd.

Client : Capital Development Ltd.

Project : Geotechnical Instrumentation for Shwe Nagar Project

Location : 80th Street, Between 27th & 28th Street, Mandalay

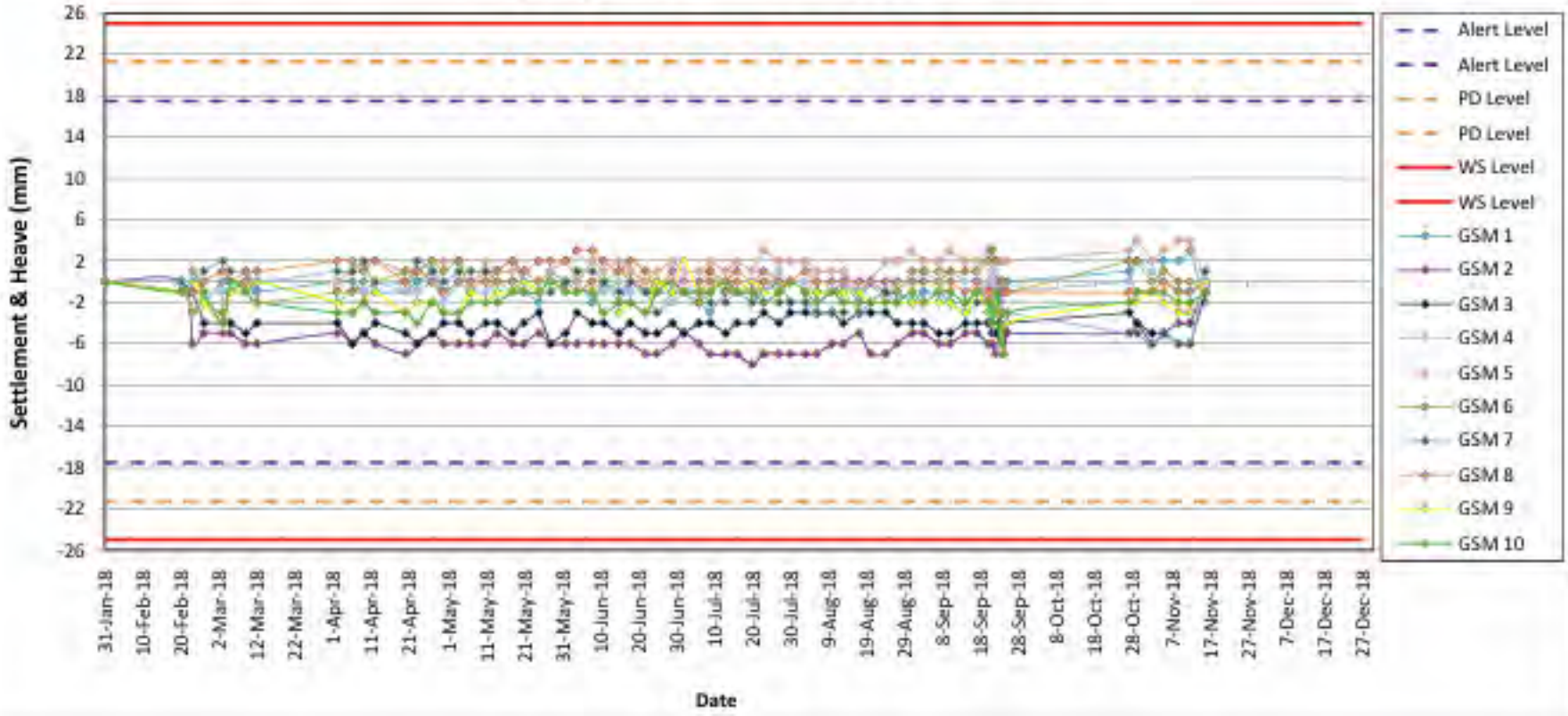
Installed Date : 26/1/2018

Alert Level = 17.50 mm

Work Suspension Level = 25.00 mm

Predetermine Level = 21.30 mm

Graph of Settlement & Heave Vs Time



Don’t skim on instrumentation.
Penny wise dollar foolish!

THANK YOU!
&
DISCUSSION.