CONTINUOUS PROFESSIONAL DEVELOPMENT PROGRAMME

MYANMAR ENGINEER SOCIETY AND MYANMAR SOCIETY OF CIVIL ENGINEER

The Role of Quality Control for Sustainable Development of Construction Industry

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PE-0038 (Geo), ACPE-00564 (Civil), AE-9221

26-10-2024 (Saturday)

9:00 am – 12:00 noon

Topic: The Role of Quality Control for Sustainable Development of Construction Industry

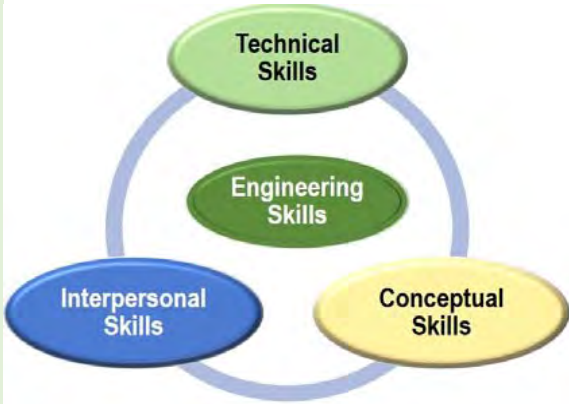
Abstract

The quality control is incorporated with the safety of building and future to sustainability of construction industry. Quality control means a process to improve all engineering works in the life cycle of building from design stages, construction stages to demolition of building based on the current technology and technique. The Engineer who is responsible to manage for achieving the standards and specifications of the respective work.

Practically, engineers should understand that quality control is not the extra work, and it is a value-added work that will give the cost-effective construction and many chances of avoiding the mistakes, delays and budget overrun.

Quality control practices ensures environmentally responsible construction, contributing to a greener future that means the overuse of natural resources, reducing consumption, and maximizing recycling. Therefore, the professional judgement is needed in quality assessment for respective works.

This seminar presents the role of quality control for engineers to deal with the technical aspects of construction of bored pile and press piling work, pile load testing work and basement construction.



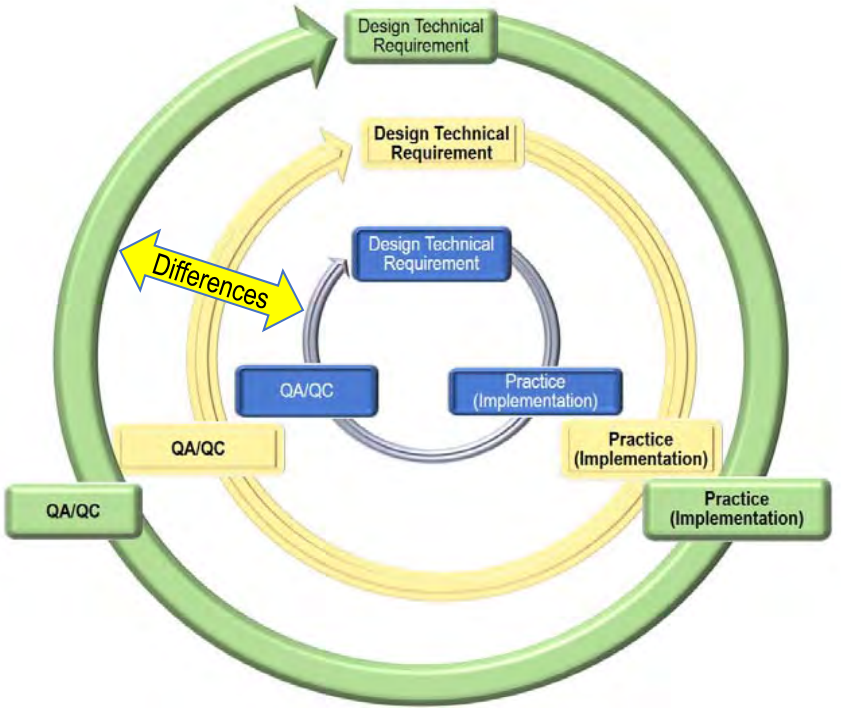
Quality Control Standard of Inspector or Inspection organization

1	▪ Competency	*The staff assigned to perform inspection work should collectively possess adequate professional competency*
2	▪ Independence	*Individual inspector should be free from personal, external, and organizational impairments to independence.*
3	▪ Professional Judgment	*Due professional judgment should be used in planning and performing inspections and in reporting the results.*
4	▪ Quality Control	Quality Standards for Inspection and evaluation, and other applicable policies and procedures.
5	▪ Planning	*Inspections are to be adequately planned.*
6	▪ Data Collection and Analysis	*Collection of information and data will be focused with the inspection objectives, and will be sufficient for a reasonable basis.*
7	▪ Evidence	*Evidence supporting inspection findings, conclusions, and recommendations should be sufficient, competent, and relevant.*
8	▪ Records Maintenance	*All relevant documentation should be retained for an appropriate period of time.*
9	▪ Timeliness	*Inspections should strive to deliver significant information in a timely manner.*
10	▪ Fraud, other Illegal Acts, and Abuse	*In inspection work, inspectors should be alert to possible fraud, other illegal acts, and abuse.*
11	▪ Reporting	*Inspection reporting shall present factual data accurately and fairly.*
12	▪ Follow-up	*Appropriate follow-up will be performed to ensure that any inspection recommendations.*
13	▪ Performance Measurement	*Mechanisms should be in place to measure the effectiveness of inspection work.*
14	▪ Relationships and Communication	*Inspection organization should seek to facilitate positive working relationships and effective communication*

Requirement of Quality Control

Quality Control inspection: is conducted at *various stages* of the working process to ensure that works meet *specified quality criteria*.

Level of Quality Control for different projects or different portions of a project



Evaluation of Level of Quality Control

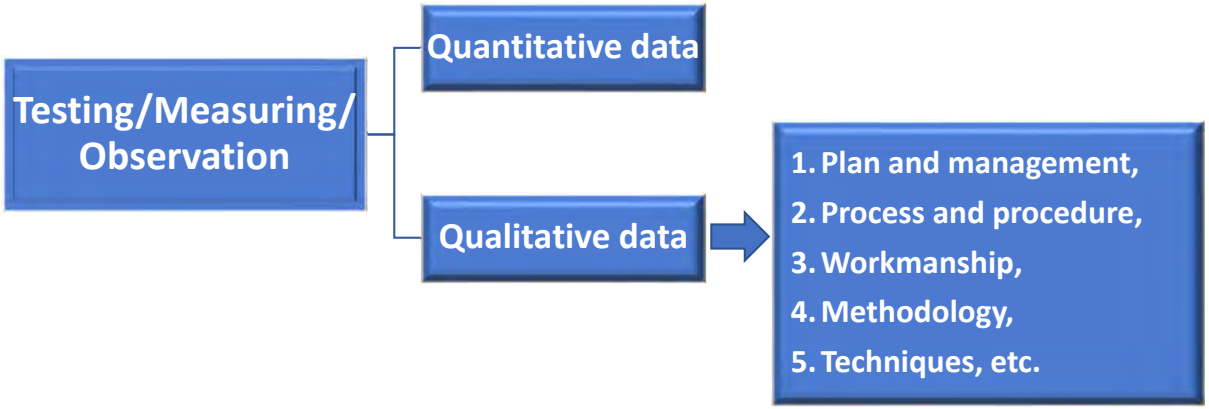
1. Supervision
2. Methodology
3. Workmanship
4. Materials (Mechanical, Physical (shape, size), Chemical properties)
5. Understanding the technical aspects (theories, codes)

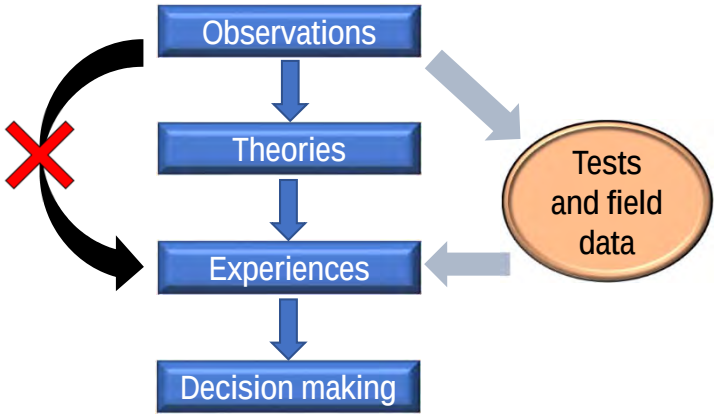
- Standard and specification

  -Ex., Concrete (*strength, deformation behavior depend on using aggregates; river shingle or crushed aggregate*)
- Practice (good, fair, poor, very poor)

Inspection Levels	Different projects or Different portions of a project	Services/ Responsibility
Level 1 - Full services inspection	This level of service may be; 1. Civil infrastructures where the consequences of failure are critical, 2. Innovative or complex construction procedures	1. Full Inspection services with adequate personnel 2. Full time on site to constantly review work procedures, materials of construction, materials testing frequency, and components for compliance with requirements of plans and specifications and review completed work prior to enclosure
Level 2 - Third party inspection	This level is only *a secondary service for the design consultant* to provide a higher level of construction monitoring or inspection during the period of construction.	1. Inspection for *the outputs from another party's quality assurance* for the requirements of plans and specifications. 2. Visiting the works at *the frequency agreed with the client to review* important materials of construction, critical work procedures, completed components.
Level 3 - Representative Sample inspection	This level of service may be deemed appropriate for smaller projects of a routine nature being undertaken by *an experienced and competent constructor.*	1. This level of service would be simply to inspect a representative sample of *each important completed work* prior to enclosure or completion.
Level 4 - Inspection of random samples of important work procedures	Small projects of a routine nature	1. Inspection for the extent agreed with the client, 2. Inspection for random samples of important work procedures, 3. Inspection for compliance with the requirements of the plans and specifications and review important completed work.
Level 5 - Regular inspection of completed work prior to closure	Small projects of a routine nature	1. This Inspection level would include review at a frequency agreed with the client, 2. Regular samples of work procedures, materials of construction and components for compliance with the requirements of the plans and specifications, and 3. Inspection on the majority of completed work prior to the enclosure or on completion.

Inspection process of QC for Geotechnical Works





Concept:

Observations, Theoretical Modeling, Application of Experience, and Decision Making Engineering

Professional Judgment in QC

1. Professional judgment should be used in planning and performing inspections and in reporting the results. The exercise of professional judgment allows inspectors to obtain *reasonable assurance that material misstatements or significant inaccuracies in data will likely be detected*.
2. Inspectors should use the *technical knowledges, skills, and experiences* called for by their profession to diligently gather evidence and objectively evaluate its sufficiency, competency, and relevancy.

Quality Control Procedures

1. To ensure the best manner including the requirements for quality and safety, EIET and Contractors will thoroughly discuss and review for construction *method statements*.
2. Every change of methods for construction *will then be documented into method statements*. The method statements will provide the details on:
   - Manpower (Workmanship; Technical management persons, operator, labor etc.)
   - Work methodology,
   - Materials to be used,
   - Schedule, and
   - Also include any special precautions to be taken for safety & health and environmental protections.

Method Statement

A document where in it state a procedure of an activity including safety. It also includes materials, site preparation, equipment and tools etc. Risk assessment is usually included.

1. The responsibility for preparing a method statement typically lies with the execution department, but the QA/QC department may also be involved in the process.
2. The Client/The Engineer reviews the method statement to ensure that it meets their specific requirements.
3. Once the method statement has been approved by all Client/The Engineer, it can be used to guide the work and ensure that it is done safely and to the required standards.

Remember: Everyone involved in the construction is responsible for the quality of work, its contractor, The Engineer, Designer, Employer too

Objectives of Presentation :

This presentation is intended to share *the technical aspects during the inspection to make the professional judgement in inspection checklists.* Everyone involved in the construction is responsible for the quality of work, its Contractor, The Engineer, Designer, Employer too.

Therefore, Quality inspection is *the positive working process* and it should be solved the problems together with all parties to meet the predetermined standards and codes or required quality. For this matters, professional judgement is the important part of the inspection work. Understanding the professional judgement will help you *for preventive and corrective action and planning* in your construction works. *All inspection checklists should be recorded and maintained properly.*

Scope of Presentation:

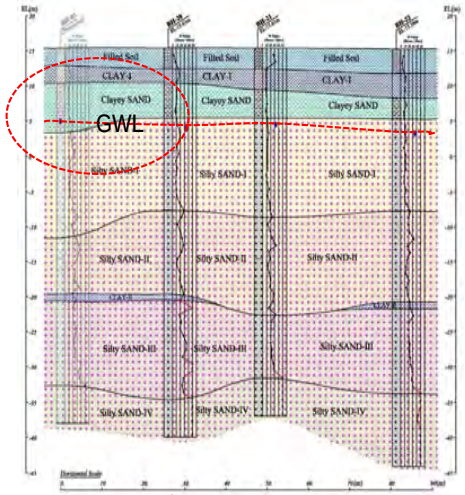
Technical Aspects for:

1. Bored piling work,
2. Press piling work,
3. Pile Load Test,
4. Basement construction work, and
5. Strutting Work

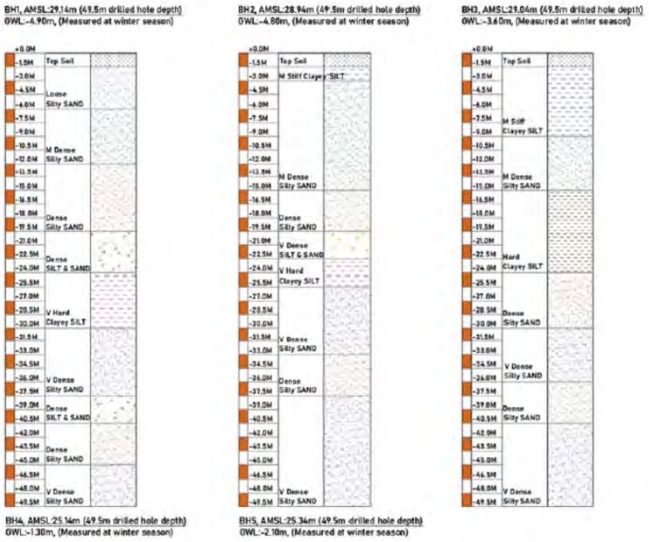
Bored Pile Installation Checklist

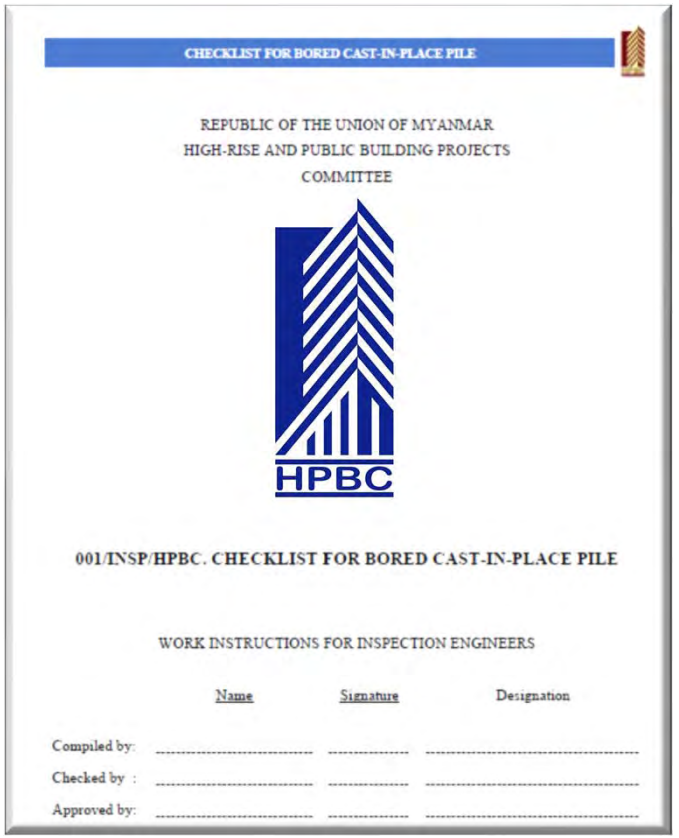
Prerequisite understanding before QC:

- Geological profile
  - Geological condition (soil & rock levels)
- Geotechnical profile & drilling process
  - Geotechnical parameters
  - Piling methods and sequence
  - Testing (Concrete, steel, bentonite, slurry, etc.)
  - Measuring (allocate the pile position, verticality, depth, etc.),
  - Base cleaning methods
  - Concreting method
  - Duration of piling



Geological profile through the project area
(D ~ D')





CHECKLIST FOR BORED CAST-IN-PLACE PILE

REPUBLIC OF THE UNION OF MYANMAR
HIGH-RISE AND PUBLIC BUILDING PROJECTS
COMMITTEE

HPBC

001/INSP/HPBC. CHECKLIST FOR BORED CAST-IN-PLACE PILE

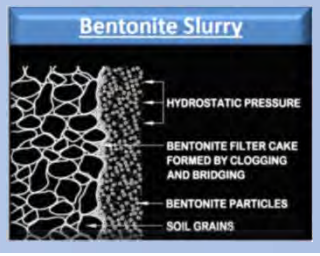
WORK INSTRUCTIONS FOR INSPECTION ENGINEERS

	Name	Signature	Designation
Compiled by:			
Checked by :			
Approved by:			

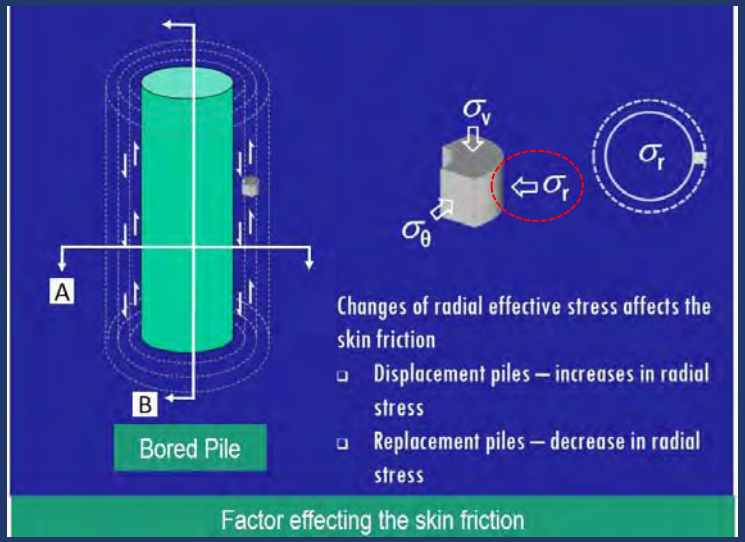
General Technical Aspects of QA/QC during Bored Piles Installation

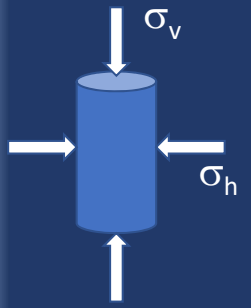
Factors Affecting Skin Friction during Bored Piles Installation

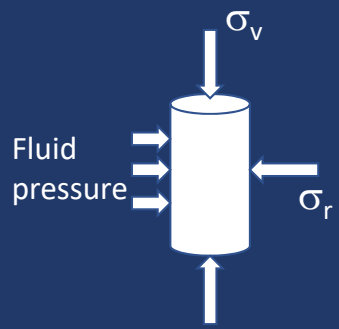
- Reduction in friction angle
  - ✓ Presence of weak materials at pile/soil interface (e.g. bentonite filter cake)
  - ✓ Loosened/disturbed soil
  - ✓ Slaking on bore hole wall
- Reduction in confining stress in bored piles
  - ✓ Stress relief
  - ✓ Arching effect (depended on pile diameter, *Small dia. Pile > Large dia. Pile*)
  - ✓ Loosening of soil due to poor construction control
- *Pile construction Time*



Proper Pile Base Cleaning







1. Technical Aspects of QA/QC during pile installation

In the View of Changes of Geotechnical Design Parameters

O'Neill (1999) found that details of pile installation can produce resistances that differ by ***a factor of 3 to 10***.

Reasons!

1. Stress relief
2. Geomaterials
3. Borehole roughness
4. Borehole smear

← Geological conditions (Engineering geological data and geotechnical data)

Drilling fluids ←

1. Excessive *filter cake* from bentonite mineral, slurry
2. Synthetic polymer drilling fluids (hydrolyzed polyacrylamide)

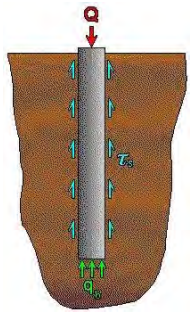
Temporary casing ←

1. Tendency for higher in situ lateral stresses and/or densification from installation of the casing in advance of excavation in cohesionless soil.
2. However, significantly reduced side shear capacity for piles constructed using casing advanced ahead of the excavation in a cohesive soil due to a reduction in sidewall roughness.

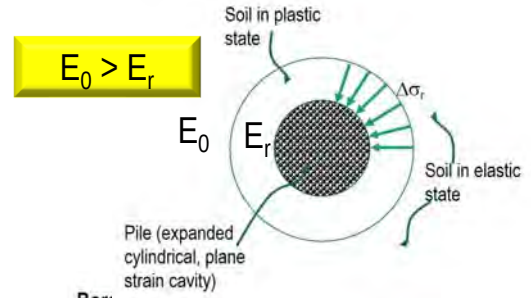
Installation time

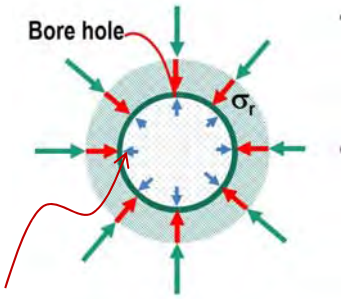
Soil/concrete interface immediately adjacent to the Bored Pile

Effect of drilling fluid and installation time on pile capacity

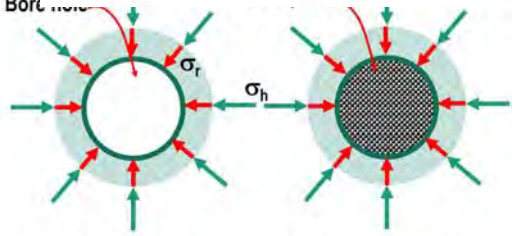


$E_0 > E_r$





Drilling fluid pressure



Stress relief or deformation of soil around bore hole

Technical knowledges;

1. Causes and Effects
2. Why?, Reasons!

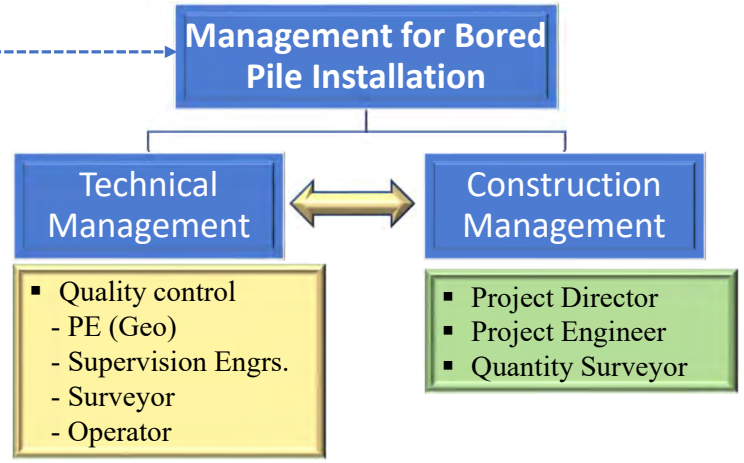
Bored Pile Installation Checklist

No.	Checked List Items	Checked by Inspectors	Remark
	Project Name: ---------- Location: ---------- ---------- Date: ----------		
1	Piling Company: ----------		
	Geotechnical Engineer: ----------, PE----------		
	Experienced engineer for supervision: Name; ----------		
	Surveyor: Name; ----------		
	Skillful operator: Name; ----------		
	Submission of Method Statement (MS)	☐	
2	SPECIFICATIONS OF PILING WORK		
	▪ Total Numbers of Pile Points; ----------		
	▪ Finished numbers of Pile Points; ----------		
	▪ Pile Diameters or Pile Sizes; ----------		
	▪ Pile Lengths; ----------		
	▪ Concrete grade; ----------		
	▪ Concrete Strength Test with adequate number of samples	☐	
	▪ Slump Test with adequate number of samples	☐	
	▪ Rebar grade	☐	
	▪ Rebar strength test with Adequate number of samples	☐	
	▪ Pile portion setting up (three reference points to be set up to the proposed Pile location	☐	
3	CONSTRUCTION METHODS AND TECHNIQUES		
	▪ Grab construction (using crane, casing oscillator, etc.)	☐	
	▪ Rotary drilling (CFA, Twin head rotary drive, etc.)	☐	
	▪ Rock coring (Chisel, Core barrel, cross head cutter, etc.)	☐	
	▪ Direct circulation drill ▪ Indirect circulation drill	☐ ☐	
	▪ Slurry Type		
	▪ Concreting methods: 1. Pouring with tremie pipe for wet holes construction 2. Injected	☐ ☐	
	▪ Reinforcement 1. Main: ---------- (ex. 32T20) 2. Link: ---------- (ex. T12 @ 150 spiral) 3. Lapping type and length: ---------- 4. Concrete cover/Spacer: ----------		Ex.: T – 460 N/mm² Y = 410 N/mm² R = 250 N/mm²

Duty and Responsibility

Specification of pilling work

Design specification



Guide to Evaluation of Test Results (ACI 214R-11):

- Variations on concrete strength: batch-to-batch, within batch and overall variation
- Analysis of strength data-
  1. Evaluation for mixture submittal purposes;
  2. Evaluation of level of control; and
  3. Evaluation to determine compliance with specifications

ASTM E178 provides criteria for *rejecting the test result for one specimen in a set of specimens*. A single specimen in a set of three or more specimens can be discarded if its *deviation from a test mean is greater than three times the previously established within-batch standard deviation.*

4	PILING EQUIPMENT AND ACCESSORIES		
	▪ Crawler crane (Grab method) ▪ Rotary drive (CFA, Twin rotary head)	☐ ☐	
	▪ Temporary casing: Length and size: ----------		
	▪ Drilling fluid (Bentonite or other slurry: ----------		
	▪ Tremie pipe length for wet holes ▪ Hover with short length of chute (direct discharge methods)	☐ ☐	
5	BORED PILE CONSTRUCTION		
	▪ To determine bored pile length ▪ To check vertically ▪ Deviation in the distance of Pile Point	☐ ☐ ☐	
	Stability of Bored hole ▪ Temporary steel casing with appropriate size and length with minimum 1.0 m below the unstable ground. ▪ Bored hole to be filled with drilling fluid for hole stabilization ▪ Slurry Test	☐ ☐	
	Airlifting (base cleaning) ▪ Use cleaning bucket to clean the base before carrying out the airlifting ▪ To ensure the cleanliness of loose ground and caving in soil at base ▪ Make sure the hose is at the base of pile (not suspended)	☐ ☐ ☐	
	Reinforcement case ▪ The length of the cage shall match with bored hole depth	☐	

Pile Toe Cleaning Prior to Concreting;

- Due to the time taken for the installation of the cage/or high pore-water pressure presence beneath, checking will be carried out.
- Checking at pile toe shall not exceed 500mm difference with the earlier recorded depth.
- If exceeding 500mm, the air-blow method to pile toe will be carried out to stir up the sediments and to provide a reasonably clean pile toe.

- The bottom of the drilled hole using; an airlift system and/or cleaning buckets

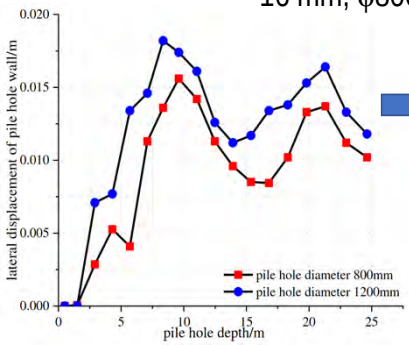
Confirming toe level

Base cleaning using bucket

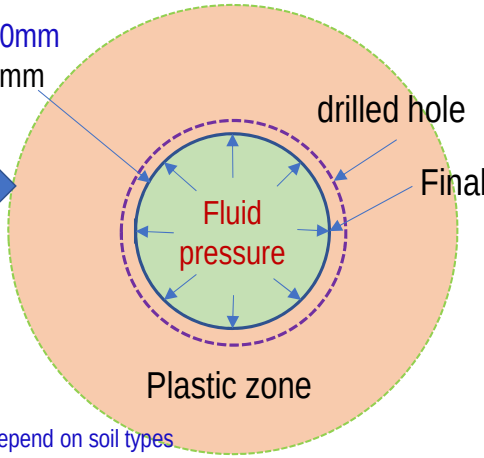
Base cleaning using airlift

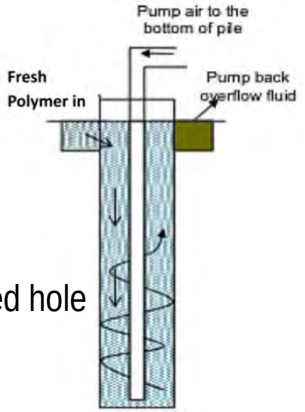
Drilling Fluid: Bentonite, Slurry

- Viscosity degradation by fluid recirculation



19 mm, ϕ1200mm
16 mm, ϕ800mm

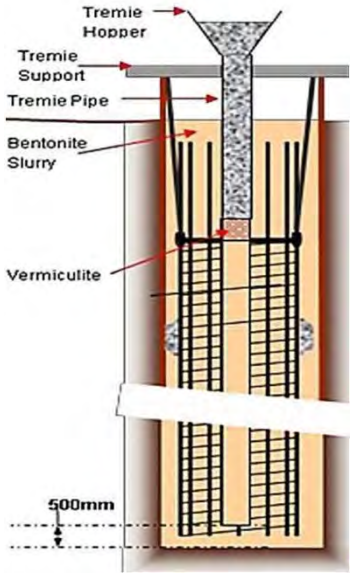




The inner wall displacement during drilling depend on soil types

6	CONCRETING		
	▪ Concrete overbreak after each batch of concreting ▪ Check the density of the fluid as in the specification ▪ The bottom of the tremie pipe is always 2 m or approved length submerged below the level of concrete ▪ Record any interruption on concreting 1. Numbers of truck; ---------- 2. Discharge per truck; ---------- 3. Time between discharge; ---------- 4. Slump test; ----------	☐ ☐ ☐	▬ ▬ ▬ ▬
7	COMPUTATION		
	▪ Calculate the amount of concrete volume per pile; ---------- ▪ Compare to actual concrete volume; ----------	☐	▬

Note: Conditions of boring, cage placing, concreting, and periods of work



Concrete Overbreak Estimation

- The *concrete overbreak* estimation for bored piles due to bored hole's expansion beyond its theoretical volume.

Slump test shall be undertaken for every truck load of concrete. Slump measured at the time of discharge into pile shaft or at the time of discharge into the concrete pump hopper shall be in accordance with the standards shown below unless otherwise

Workability of slump (Typical)

Class of Workability	Slump (mm)	Typical Conditions of Use
A	100 ± 25	Where concrete is to be placed in water-free shaft.
B	175 ± 25	Where concrete is to be placed by tremie method under drilling fluid.

- Sidewall Over-reaming
- Over drilling
- Wall collapse

Drilling Fluid/Slurry Test

Specific recommendations of the stabilizing fluid quality parameters

Parameters	Fresh water mix	Readjusted fluid	Before casting with concrete
Viscosity (API Marsh Cone (s))	>60	>55	>50
Density (g/cm³)	1.00-1.04	≤1.08	≤1.06
Sand Content (%)	-	<2%	≤2% DWall ≤3% Bored Pile
pH	7 < pH < 12	7 < pH < 12	7 < pH < 12

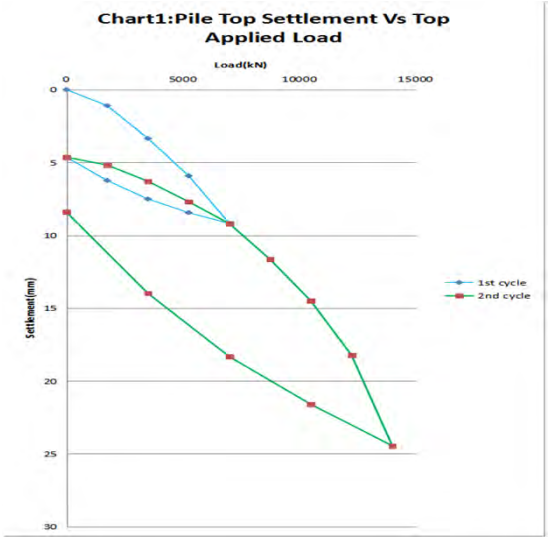
Construction time; boring (use of slurry, bore hole stability), base cleaning, cage placing, concreting

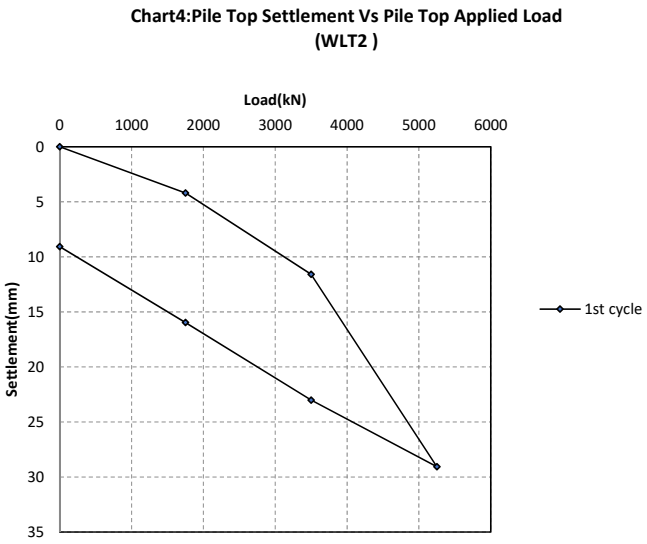
Case Study:

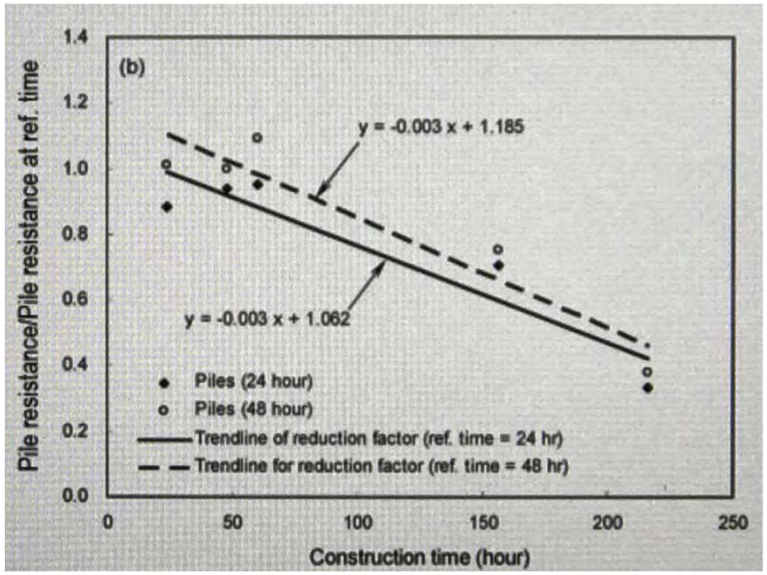
- Two numbers of working pile load tests at a site
- Working Load = 7,000 kN

Load test failed

- Construction time – 36 hours
- Not proper base cleaning
- Borehole smear





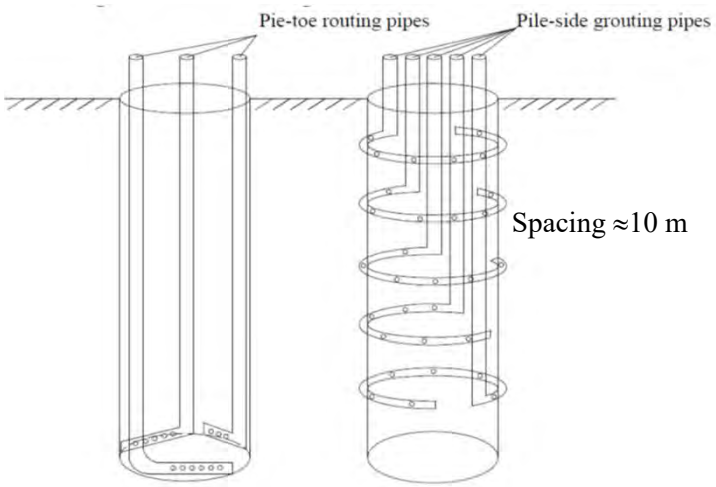


Time of production piling ≤ Time of piling of Test pile

Post-base Grouted Piles

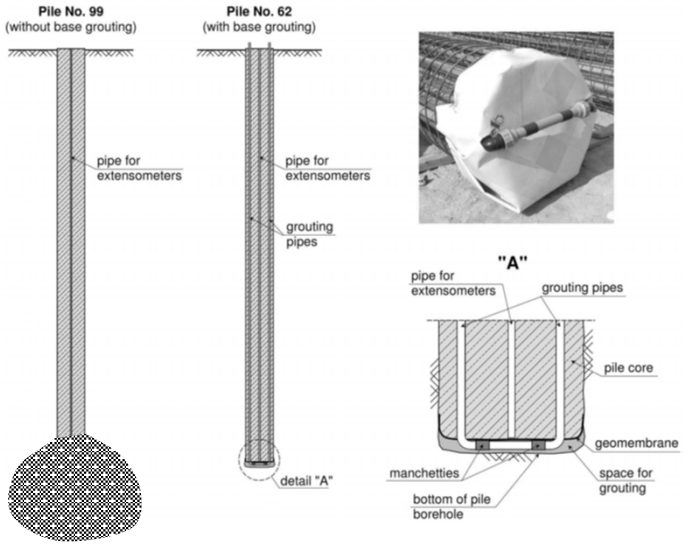
1. Increase base resistance; Preloading the base, improving the soil below base (compaction/permeation), increasing tip area, the upward mitigation of grout increasing side resistance in lower portion of pile.
2. Decrease settlement
3. Improve reliability in base resistance
4. Reduce pile length and diameter
5. Reduce construction risks
6. Save the time and money

Design & Construction for Post-grouted Pile Capacity



Setting of pile-base and pile-side grouting pipes

Post-Grouting



Post-base Grouting

2.Mix design of cement grouting

1) The cement use 325# (Cemento Portland 325R), and the single pile cement consumption is 5.74 tons.
2) The water-cement ratio of the cement grouting is between 0.45 and 0.65.
3) The prepared cement grouting must be filtered with a wire mesh before entering the grouting pump and the *mesh size must be less than 40µm*.

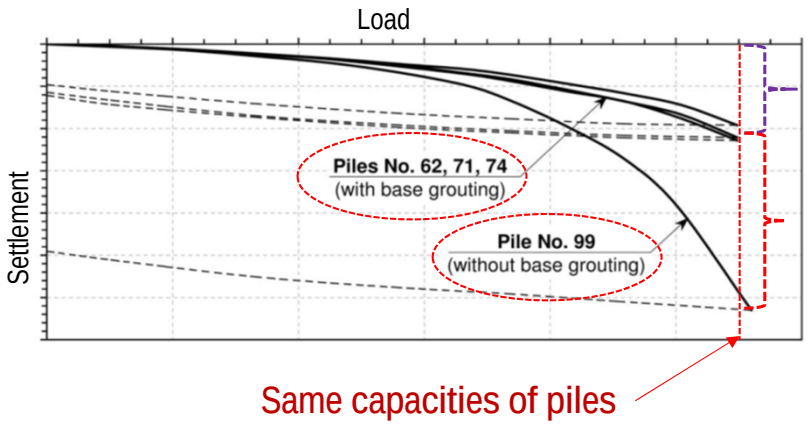
Mesh Number	Microns	Material
28	700	Course Sand
60	250	Fine Sand
325	44	Silt
400	37	Pollen a fine powdery substance
12000	12	Red Blood Cells
48000	2	Cigarette Smoke

Sand: 2000 - 63 µm. Silt: 63 - 2 µm. Clay: **< 2 µm**.
Clay particles are smaller than 2 *micron* (2 x 10^{-3} mm)

Geological and Geotechnical conditions in Vietnam,

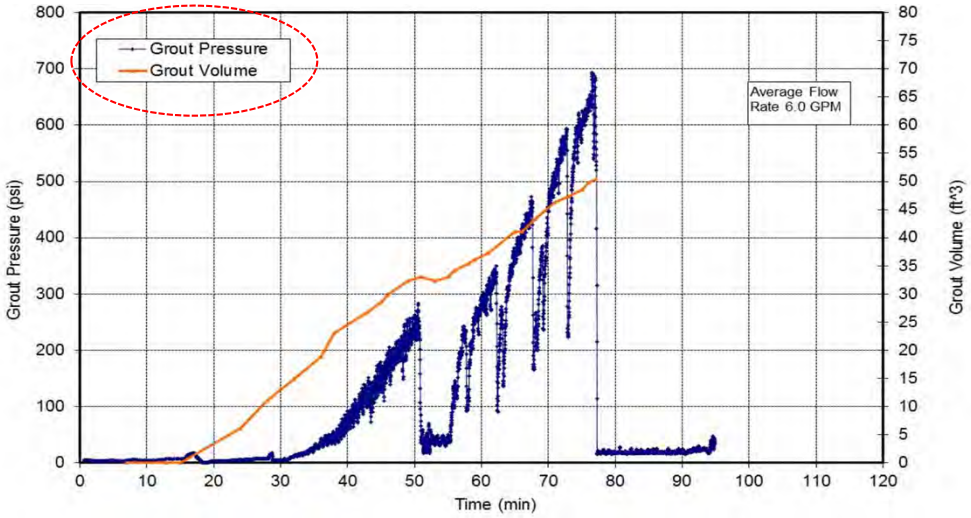
- Post-grouting technology can increase the bearing capacity of single pile up to 50-75%.
- Reduce 20-25% total price foundation of project.

The axial force distribution in piles
(Load-Settlement curves)



Same capacities of piles

Grout Pressure and Grout Volume

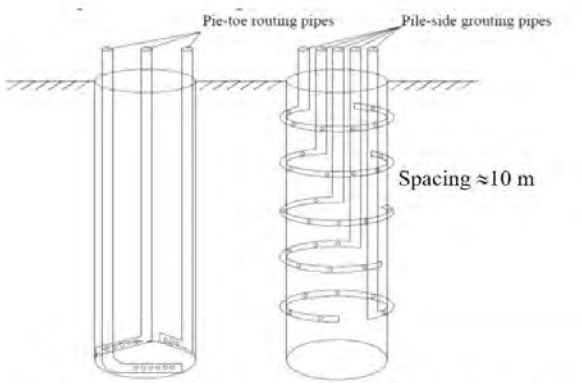


Grouting Sequence;

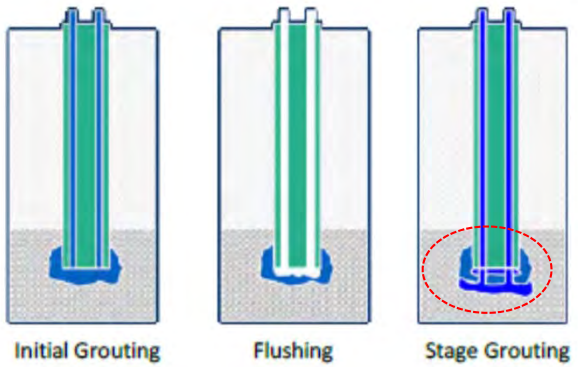
1. Pile-side grouting first, and pile-toe grouting second; and
2. Multi-section pile-side grouting should be processed from top to bottom.

Grout Mix Design:

- Portland cement and water (no Sand)
- W/C = 0.4 – 0.75
- Admixtures sometimes
- Typical strength requirement, 2000 psi-2500psi
- Sampling and testing as per ACI



Setting of pile-toe and pile-side grouting pipes

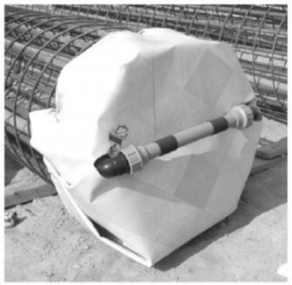


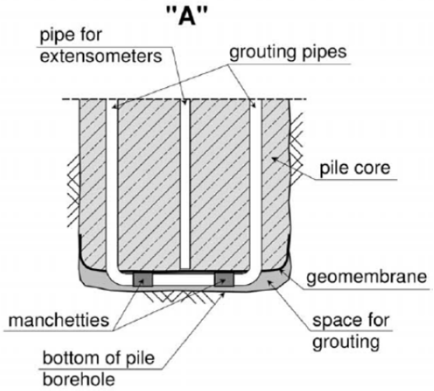
Stage grouting sequence (FHWA)

2. Importance of QA/QC for Acceptance criteria of post-base grouted piles (FHWA)

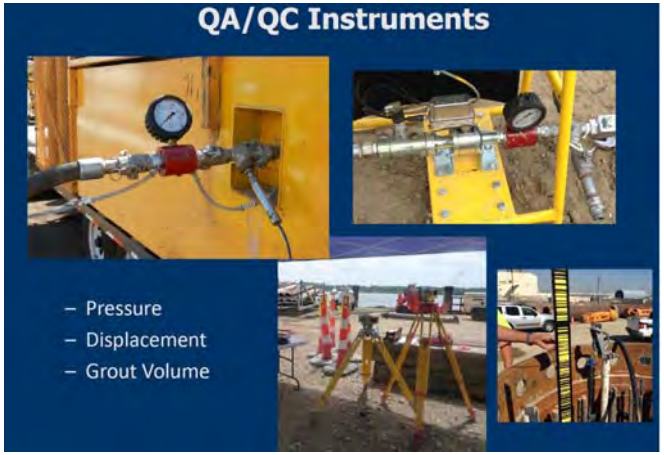
The criteria to be determined during post-grouting are:

1. Grout pressure *(The grouting pressure is normally 1 to 3 MPa and the maximum pressure is 6 MPa under special conditions)*
2. Bore pile uplift (*Vertical displacement of pile top, 3 mm – 6 mm during grouting process)*, and
3. Grout volume
4. *Strain gauge installed near the base (limitation of strain gauge estimated the base resistance)*
5. *Creep (Creep displacement under the large load (prestress) applied to soil of pile base, creep must be considered in design.)*





- Parameter monitoring trends must be stable during post-grouting.
- If grout pressure and shaft uplift criteria are met, the post-grouting work should be acceptable.



QA/QC Measurements during Grouting

- **Grout Pressure**
- **Upward displacement**
- **Grout Volume**
- **Strain gauges (optional)**
- **Multi-Axis plots (Real time monitoring)**
- **By experienced person who can interpret data in the field and make decision immediately**

Press Piles Installation Checklist

General Technical Aspects of QA/QC during Press Piles Installation

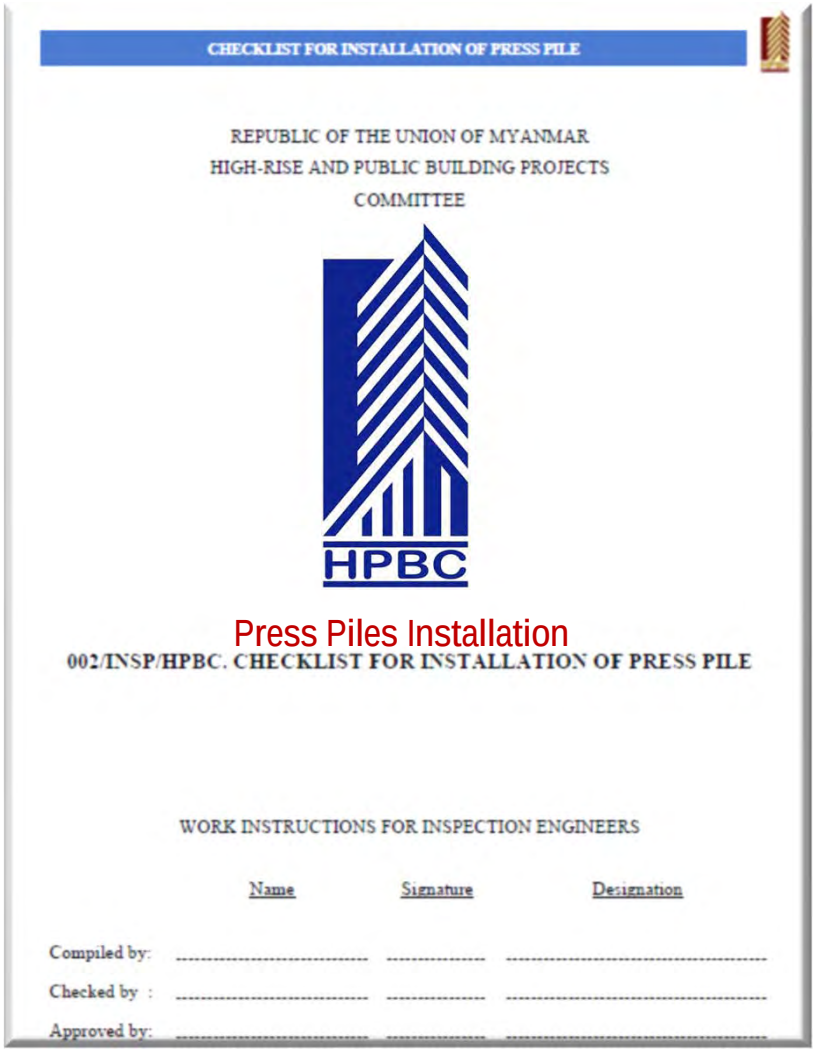
1. Termination criteria
2. *Pile structural capacity (as mentioned MNBC defined by designer)*
3. Structure requirement of connection joints (axial capacity (flat), lateral capacity)
4. Pile defects
5. Verticality, Position
6. Impacts on adjacent piles
7. Environmental impacts during pile installation

Excavation

If practical, piles shall not be driven *until after the excavation is complete*. (Installation Specification, (*Recommended by PDCA (Pile Driving Contractors Association),* co-distributes FHWA's National Highway Institute's Design and Construction of Driven Pile Foundations, *2007*)

4.9.2.1.4 Installation

Piles shall be handled and driven so as not to cause injury or overstressing, which affects durability or strength. (MNBC)



CHECKLIST FOR INSTALLATION OF PRESS PILE

REPUBLIC OF THE UNION OF MYANMAR
HIGH-RISE AND PUBLIC BUILDING PROJECTS
COMMITTEE

HPBC

Press Piles Installation

002/INSP/HPBC. CHECKLIST FOR INSTALLATION OF PRESS PILE

WORK INSTRUCTIONS FOR INSPECTION ENGINEERS

	Name	Signature	Designation
Compiled by:			
Checked by :			
Approved by:			

Importance of Press Pilling Contract

Specification and Contract

Press Pile - Myanmar RSE Group (Facebook)

မင်္ဂလာပါဗျာ။

Press piling work တခုမှာ

Design penetration depth

60 feetဟုသတ်မှတ်ထားသော်လည်း

တကယ်ရိုက်ရသည့်အခါ

20 feet,40 feetသာအများစုဝင်ပါသည်။ 1/3, 2/3

Liquefactionကြောင့်joint connection နေရာတွင် splice box ပါထပ်စွတ်

ပေးရပါသည်။

Pile length 2ခုကိုweldingစော်ပြီးမှ

boxကိုweldingထပ်စော်ခြင်းဖြစ်ရာ

jointဆက်တစ်ဆက်လျှင်ပျမ်းမျှ1နာရီနီးပါး

ကြာသောကြောင့်သဲကိုက်၍frictionရသွားပြီး

မြေဝင်မရတော့ခြင်းလားမသိပါ။

soil testတွင်လည်းred sandဟု

ဖော်ပြထားသော်လည်း

ထို layerတွင်ရှိသောN valueမှာ10မကျော်ပါ။

Piling ပြုလုပ်စဉ်တွင်contractorဘက်မှ

သတ်မှတ်pressureရသည်အထိဖိပါသည်။

ထိုကဲ့သို့ဖိထားကြောင်းကို

clientဘက်မှconsultantမှစစ်ထားပြီးကြောင်း

installation recordတွင်

လက်မှတ်ရေးထိုးထားပါသည်။

Pile designမှာclientဘက်မှ

designer၏designဖြစ်ပါသည်။

ယခုအခါload testလုပ်သောအခါfailဖြစ်ပါသည်။

ထိုအခါclientဘက်မှdesigner,

client consultantနှင့် Specification

piling contractorဘက်မှာconsultantတို့ဆွေးနွေးပြီး

pile capacity ကိုdown gradeလုပ်၍

additional pile pointများထပ်တိုးရိုက်ရန်

ဆုံးဖြတ်ကြပါသည်။

အဆိုပါadditional pile pointများနှင့်

pile cap enlargement

ကုန်ကျစရိတ်များသည်

contractorတစ်ဦးထံပေါ်တွင်

တာဝန်ရှိပါသလားဗျာ။

1 contractorမှclient designကိုရိုက်ပေးရခြင်း,

2 သတ်မှတ်ထားသော pressureပြည့်၍ pilingထပ်လုပ်၍မဖြစ်နိုင်သောကြောင့် installationရပ်ရခြင်းကို QA/QC

3 client ဘက်မှ QC team၏witnessယူပြီးရိုက်ခဲ့ခြင်း

contractတွင်လည်းEcc outသောpileများကိုသာ compensateပြန်ရိုက်ပေးပြီး

အဆိုပါကုန်ကျစရိတ်ကိုသာcontractorမှ

တာဝန်ယူမည်ဟုပါရှိသောကြောင့်,

design depthထိမြေမဝင်

(soil capacityကြောင့်ဟုယူဆရ)၍pilefail

ဖြစ်ရခြင်းဟုယူဆနိုင်သောအခြေအနေတွင်

additional pile pointများ၏ကုန်ကျစရိတ်အတွက်

မိမိအပေါ်တွင်တာဝန်မရှိဟု

contractorမှ

ငြင်းဆိုနိုင်ပါသလားဗျာ။

ကျေးဇူးပြု၍

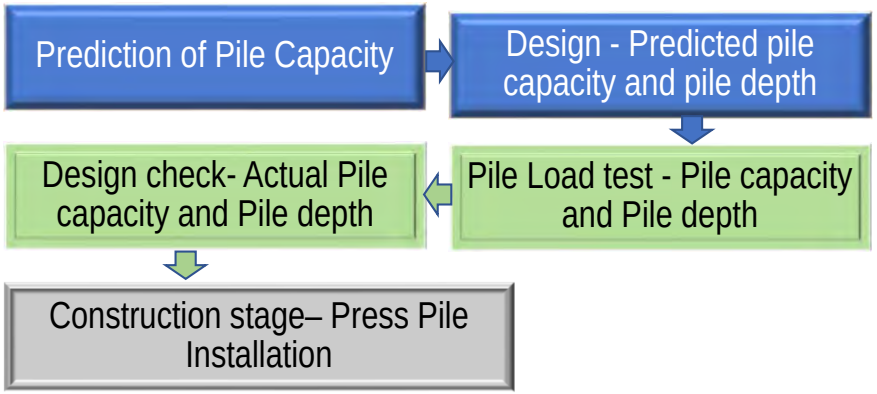
ဆွေးနွေးလမ်းညွှန်ပေးကြပါဗျာ။ Contract law

Design depth?
Understanding of design depth ?

Test piles Vs Production piles Contract law

Note: 1) QA/QC team should not decide for pile depth unless designer define the specification.
2) Contractor fails for the understanding the scope of work (specification, pile depths, nos. of pile etc.).
3) Client/designer fails to define the design and construction procedure. *Therefore, negotiate the issues*.

Design and Construction Procedure of Press Pile



1. Termination criteria of Press Pile

No.	Termination criteria	Reliable or Not
1	2 times, 2.5 times of Applied loads	Fully not reliable
2	2/3 times of Depth	Not ok
3	*Test depth*	Reliable

Predrilling to Facilitate Driving

When required by the contract documents, the Contractor shall predrill holes of a size specified, at pile locations, and *to the depths shown in the contract documents or approved in writing by the Engineer.* (*Recommended by PDCA (Pile Driving Contractors Association), 2007*)

Methods;

1. Jetting is the use of water and air to facilitate pile penetration by displacing the soil.
2. *Predrilling can also be used to facilitate the penetration of the pile.*

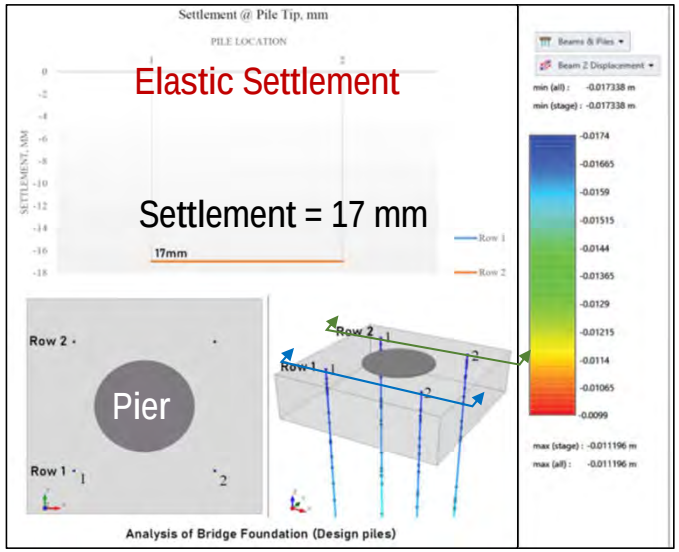
Example

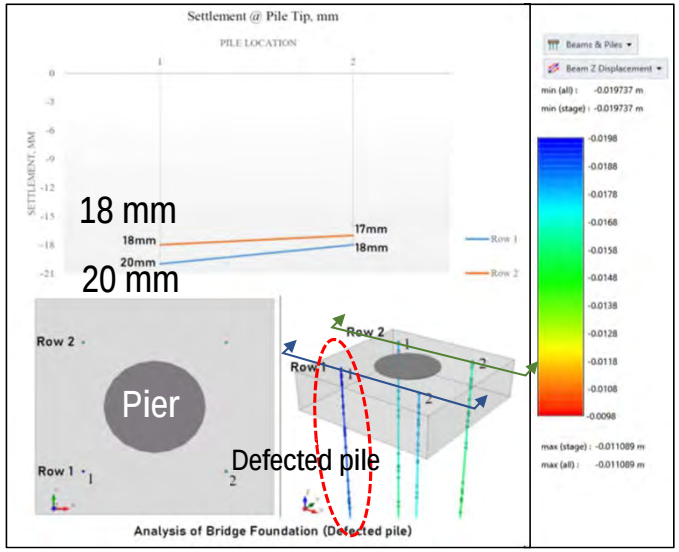
The causes and reasons not to be reached to press the design length:

1. Depending on pile volume and porosity of soil, the soil will become very stiff.
2. The dynamic stiffness is much more than the static stiffness of soil.

Adverse effect on pile capacity

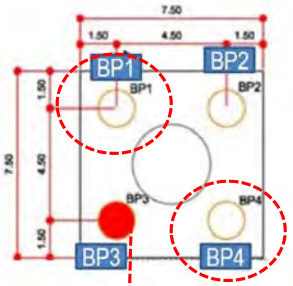
1. The pile capacity will be changed within the design life (short duration in some cases).
2. The settlement will be occurred depending on different depths and location of pile.





Avg., ton	Q_{all}, ton	@Depth below surface (m)	Length of pile (m)
767.18	767	54.00	50
288.08	288	39.00	36

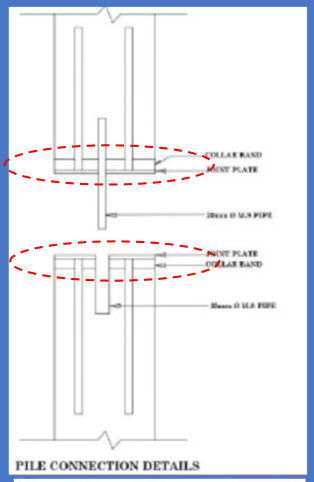
≈ 2/3

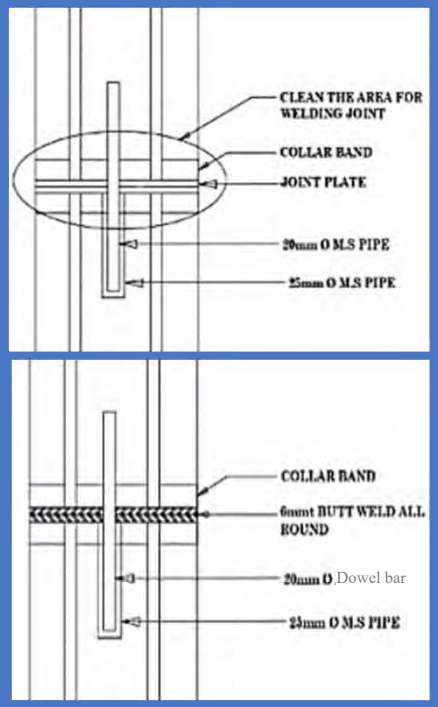


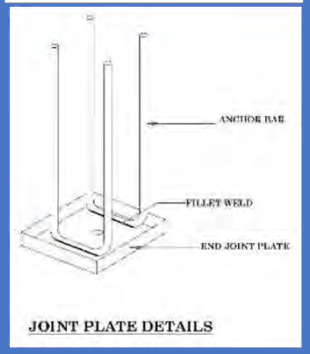
Pile No.	Design*		Defected Case	
	Axial Force, kN	Bending Moment, kN-m	Axial Force, kN	Bending Moment, kN-m
BP1	7622	354	8326	497
BP2	7574	343	7007	490
BP3	7591	419	6609	260
BP4	7704	407	8284	319

3. Structure requirement of connection joints (axial capacity (flat), lateral capacity)

Solid Piles

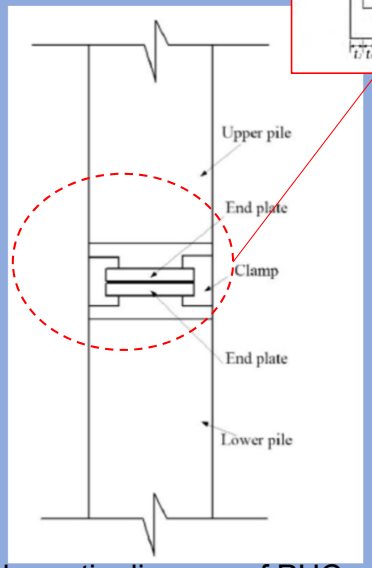




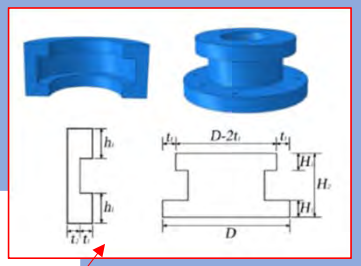


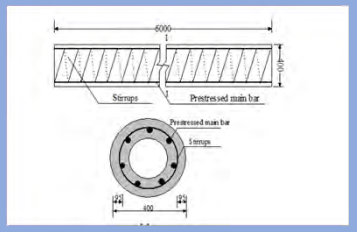
After welding, the slag will be chipped off and wire brushed to receive red – oxide paint.

Spun Piles

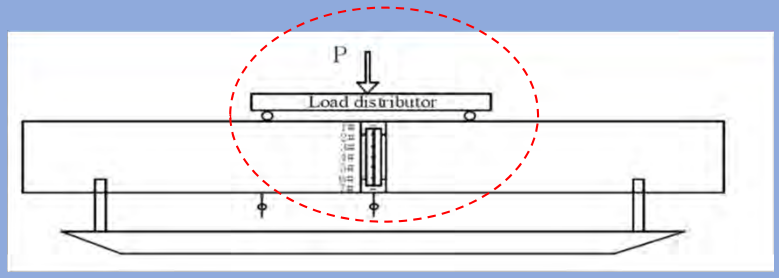


Schematic diagram of PHC pipe pile hoop connection

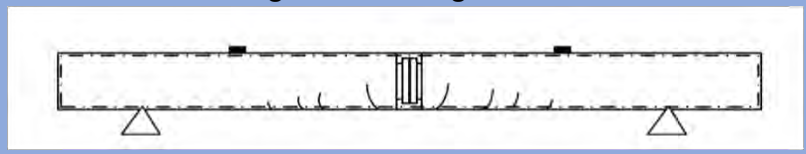




Schematic diagram of the reinforcement of PHC pipe pile (*pile diameter=400 mm*)



Schematic diagram of loading device



Crack pattern

Pre-stressed high-strength concrete (PHC) pipe Piles

No.	Checked List Items	Checked by Inspectors	Remark
	Project Name: ---------- Location: ---------- ---------- Date: ----------		
1	Press Piling Company: ----------		
	Geotechnical/Construction Engineer: ----------, PE-------		
	Experienced engineer for supervision: Name; ----------		
	Surveyor: Name; ----------		
	Skillful operator: Name; ----------		
	Submission of Method Statement (MS)	☐	
2	SPECIFICATIONS OF PRESS PILING WORK		
	▪ Pile Types (Square or Spun piles) : ----------		
	▪ Total Numbers of Pile Points: ----------		
	▪ Finished numbers of Pile Points: ----------		
	▪ Square pile sizes or Pile diameters, thickness (Spun pile)		
	▪ Pile Lengths: ----------		
	▪ Concrete grade: ----------		
	▪ Concrete Strength Test with adequate number of samples	☐	
	▪ Slump Test with adequate number of samples	☐	
	▪ Reinforcement 1. Main: ---------- (ex. 25T4) 2. Link: ---------- (ex. T12 @ 150) ▪ Concrete cover: ----------mm		Ex.: T – 460 N/mm² Y = 410 N/mm² R = 250 N/mm²
	▪ Rebar strength test with Adequate number of samples	☐	
	▪ Press pile defects	☐	
	▪ Pile portion setting up (three reference points to be set up to the proposed Pile location	☐	
	▪ Pile Manufacture Factory: ----------		
3	CONSTRUCTION METHODS AND TECHNIQUES		
	▪ Design working capacity: ----------		
	▪ Pile Length: ----------		
	▪ Design Penetration depth (Test depth)	☐	
	▪ Pile cutoff level	☐	
	▪ Proper cutoff level	☐	

Method Statement (MS)

Duty and Responsibility

Quality Control

1. Cement, sand, gravel, reinforcing bars, tendon wires and etc., will be inspected on factory before fabrication.
2. Finished product will again be inspected before delivery to the site.
3. The *inspection report* must be submitted before piles will be delivered on site.
4. When piles arrive on site, these will be inspected again for *its physical conditions, quantity and quality in accordance with specification or standards.*

Survey Works

1. To be prepared pre-con survey reports with proper photo record before piling.
2. Boundary survey must be carried upon possession of site based on the pre-computation available.
3. Coordinates of piles which were approved by the consultant are set out on the ground.
4. The pile locations are marked.

	▪ Pile toe level	☐	
	▪ Joint detail	☐	■
	▪ Pile shoe for starter (flat or cross etc.)	☐	■
	▪ Within the X, Y coordinate tolerances		
4	PRESS PILING EQUIPMENT AND ACCESSORIES		
	▪ Jack in Rig ▪ Self-weight of rig: ----------	☐	
	▪ Total number of Kentledge: ---------- Blocks: steel or concrete blocks		
	▪ Total weight of Kentledge block: ----------		
	▪ Numbers of jack cylinder: ---------- ▪ Diameter of jack cylinder: ---------- ▪ Max. pressure of each jack cylinder: ---------- ▪ Max. jack in Capacity: ----------		
	▪ Calibration of pressure gauge according to HPBC requirement: ----------months ▪ Reading scale must be more than applied pressure	☐	■
5	REJECTION OF PILE ON SITE		
	▪ Pile horizontal or vertical cracks ▪ Low quality of concrete (honeycomb or spalling) ▪ End plates of Pile which are tilted or uneven or eccentric) ▪ Pile delivered to site are fully cured after 28 days	☐ ☐ ☐ ☐	
6	TERMINATION CRITERIA		
	▪ Pile Working Load Capacity (PWL): ---------- ▪ Max. jacking force: ---------- ▪ Max. pile depth: ---------- ▪ Final pile penetration depth: ---------- ▪ Holding time (Minimum 30 sec or HPBC approval)	☐	
7	WELDING		
	▪ Welding type (fillet or butt): ---------- ▪ Welding thickness: ---------- ▪ Cooling time: ---------- min ▪ Application of anti-rust protection paint: ----------	☐	■

As per test results (Solid press pile, Spun)

Solid press pile detail connection

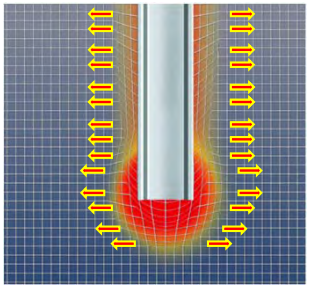
Note: The record should be taken as;

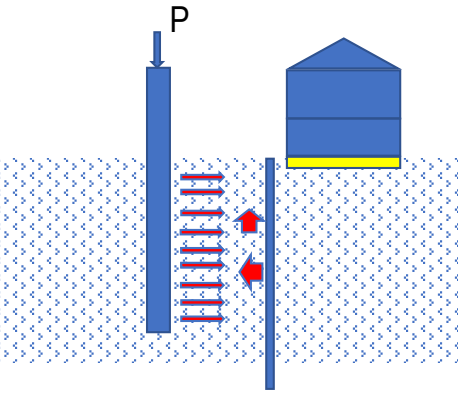
1. number and size of pile,
2. date of production, date of driving,
3. ground level,
4. depth driven,
5. blow counts in relation to penetration,
6. type and particulars of hammer,
7. interruptions of driving,
8. period of driving and,
9. any other important observations to be report.

Technical Aspects of QA/QC during Press Piles Installation

7. Environmental impacts during pile installation

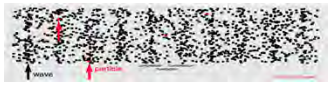
1. Ground Vibration due to press piling work
2. Ground displacement due to press piling work



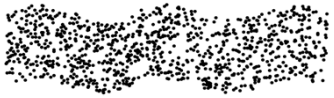


Sheet pile

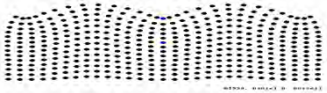
Reference codes	Allowable limits, PPV, mm/s	Remarks
Netherlands	3.00	Residential buildings
USA	2.5 - 4.3	Residential buildings



P- wave



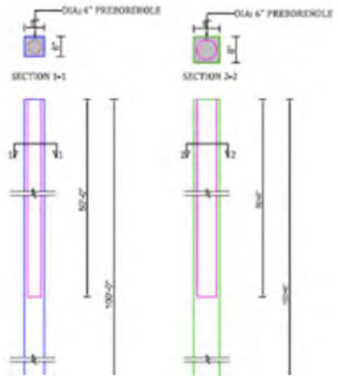
S- wave



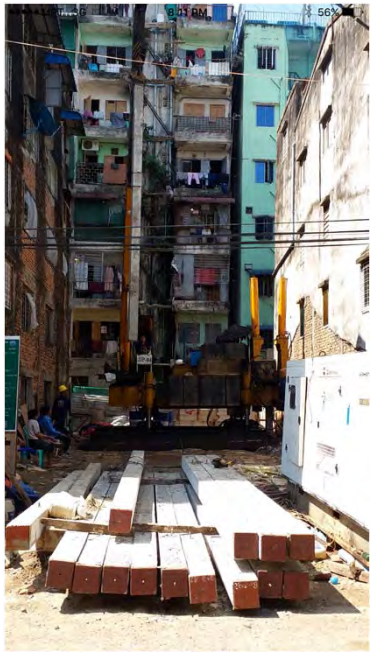
Surface-wave

In order to achieve the effectiveness of skin friction of piles, the size of pre-bore shall not be larger than the predetermined pre-bored size (less than 70% of pile size area).

Ground Vibration



Ground displacement

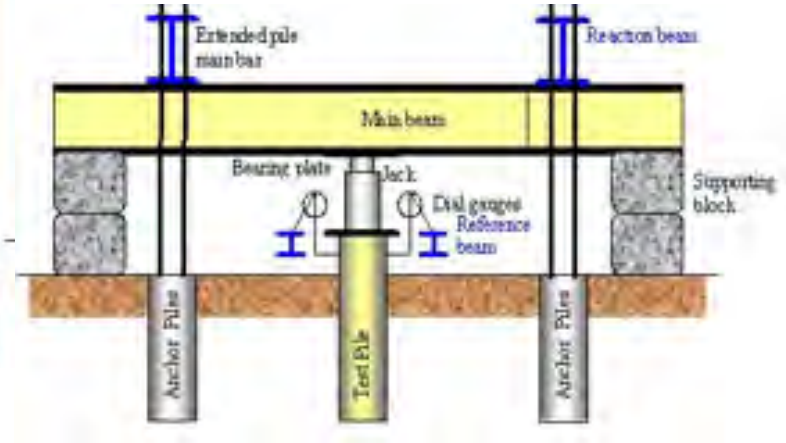


15 MINUTES

Static Pile Load Test Checklist

Different Methods of Static Pile Load Test

1. Gravity load
2. Anchor load
3. Combination of gravity and anchor loads
4. Crow anchor



CHECKLIST FOR STATIC PILE LOAD TEST

REPUBLIC OF THE UNION OF MYANMAR
HIGH-RISE AND PUBLIC BUILDING PROJECTS
COMMITTEE

HPBC

004/INSP/HPBC. CHECKLIST FOR STATIC PILE LOAD TEST

WORK INSTRUCTIONS FOR INSPECTION ENGINEERS

	Name	Signature	Designation
Compiled by:	.....	.....	.....
Checked by :	.....	.....	.....
Approved by:	.....	.....	.....

CHECKLIST FOR STATIC PILE LOAD TEST

No.	Checked List Items	Checked by Inspectors	Remark
	Project Name: ---------- Location: ---------- ---------- Date: ----------		
1	Pile Test Company: ----------		
	Geotechnical Engineer: ----------, PE----------		
	Experienced engineer for supervision: Name; ----------		
	Surveyor: Name; ----------		
	Skillful operator: Name; ----------		
	Submission of Method Statement (MS) of Static Pile Load Test	☐	
2	SPECIFICATIONS OF LOAD TEST		
	▪ Type of pile load test: ULT or WLT: ---------- ▪ Pile load test number: WLT----------		
	▪ Pile diameter (bored): ------ mm, (Square): ----mm x ---- mm		
	▪ Pile capacity: ----------tons		
	▪ Anti-pulling capacity/pile; ----------tons		
	▪ Numbers of anchor pile; ----------Nos.		
	▪ Maximum pile test capacity: ----------tons		
	▪ Pile integrity, Test result;	☐	
3	TEST FOUNDATION PREPARATION		
	▪ Check the excavate or fill surface level to the final pile elevation (*clear distance from ground surface*);	☐	
	▪ Check the cleaning any disturbing material around the test pile;	☐	Photos
4	SPECIFICATIONS OF LOAD DEVICES		
	▪ Check the jack load capacity: *(Rated load capacity exceeding the maximum anticipated jack load by at least 20 %);*	☐	
	▪ For the use of *two or more jack*- Check same make, model, capacity and size, and supply jack pressure *from common manifold and each jack with a pressure gage;*	☐	
	▪ Check the Load Cell or Equivalent devices. *If installed, the load cell with the calibration certificate and specifications as per MS.*	☐	
	▪ Check the set up/placement of *Load Cell or Devices (Ensure the load cell is eccentric with the Test Pile)*	☐	
	▪ Check the serial number of Hydraulic Pressure Gauge with the *calibration certificate and specifications* as per MS.	☐	

PIT

Contact with pile cap

Jack capacity

With or without load cell

GUIDELINES FOR HIGH-RISE AND PUBLIC BUILDING PROJECTS, 2020

2.5.4 Instructions for Performing the Pile Load Tests

1. The minimum C/C spacing of all working piles shall be 2.5 times of pile diameter.
2. In performing the ultimate pile load test, the minimum C/C spacing between test pile and anchor pile shall be 3 times of larger pile diameter.
3. In performing the working pile load test, the minimum C/C spacing between test pile and anchor pile shall be 2.5 times of larger pile diameter.
4. Structural tension capacity of anchor pile reinforcement shall be 0.6 fy.
5. Safety factor for geotechnical tension capacity of anchor pile shall be 3.
6. If the whole system is calibrated, the pile load test can be performed without load cell.
7. The calibrated time of load cell, hydraulic jack, pressure gauges & pressure transducers, dial gauge, level instrument and linear vibration displacement transducers (LVDT) shall be within 6 months.

CHECKLIST FOR STATIC PILE LOAD TEST

5	PILE HEAD MOVEMENT MONITORING DEVICE		
	Dial Gauges		
	▪ Check the dial gauges precision (ref: MS); ok or not ok	☐	
	▪ Check the attachment of dial gauges rigid to IRB; *(dial gauges must be rigidly fixed to the IRB)*	☐	
	▪ Coincide the diagonal distances; *(Four dial gauges attached to the IRB and the needle seating on the glass plate at the bearing plate on test pile)*	☐	
	▪ Check the initial reading: *check the initial reading that was recorded the reading before loading the first load increment.*	☐	
	Optical		
	▪ Correction for IRB ruler with equal distances	☐	
	▪ Check the proper conditions of Fixed datum;	☐	
	▪ Pile head Movement-ruler on pile	☐	
	▪ Reaction Pile Movement-ruler on pile	☐	
	▪ Ruler Arrangement; (tick below)		
	1. Increasing values - settlement ☐		
	2. Decreasing value - settlement ☐		
	Miscellaneous		
	▪ Standardized stop watch or clock	☐	
	▪ Standardized leveling equipment	☐	
	▪ Proper arrangement of lighting in night measurement	☐	
6	CHECK THE CPACITY OF FRAME OR KENTLEDGE		
	▪ Check the structural and geotechnical of reaction piles as per MS or Estimate the weight of block	☐	
	▪ Check the arrangement of primary and secondary girders and check to make sure no tilting of reaction frame or ground support block	☐	
	▪ Check the Reaction Frame which is positioned in orientation for safety of personal	☐	
	▪ Ensure that there are two diagonally opposite points one or each IRB with equal distances from the center of test pile	☐	
	▪ Check Independent Reference Beam (IRB) *(Minimum clear distances of IRB from piles ----------m, Rigid, planting of IRB legs, IRB legs shall not be affected by test pile and reaction piles*	☐	
	▪ Check pile head preparation; *(Smoothness, Leveled with tension connection, perpendicular to the pile axis)*	☐	

Responsibility of pile load test contractor

Without load cell

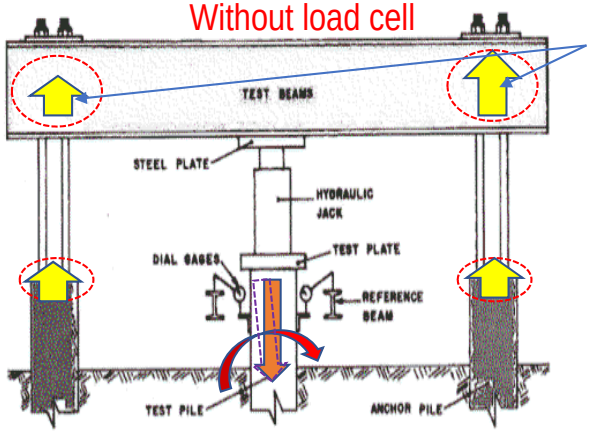
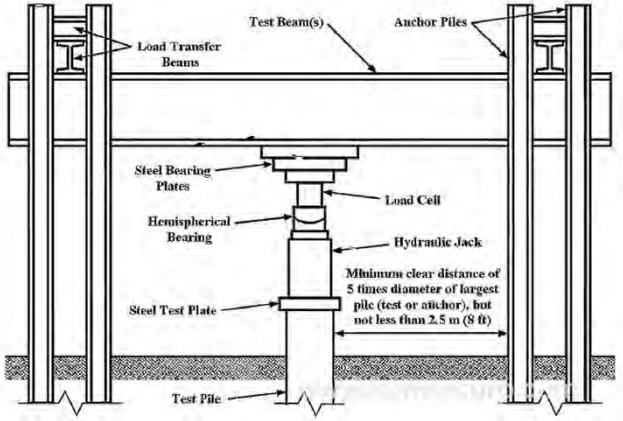
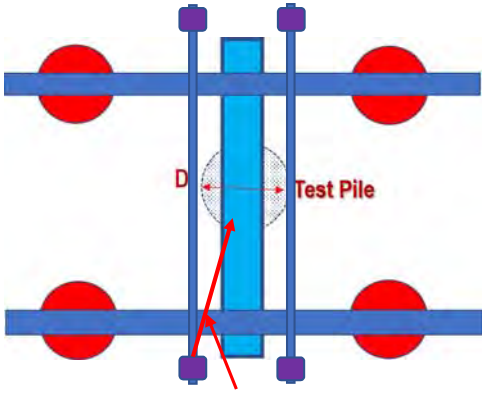


Figure 4. Test Pile Static Load Test Setup.

Tension rods;
$F = k\delta$
$\delta = F/k$

With load cell





> 5D of diameter of the test pile(s) or > 2.5 m (8 ft)

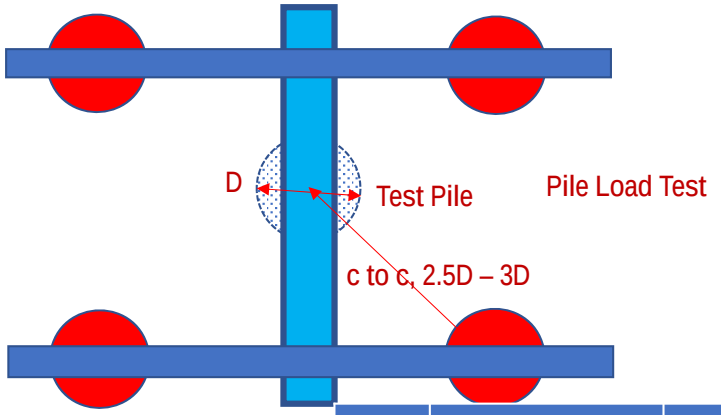
CHECKLIST FOR STATIC PILE LOAD TEST

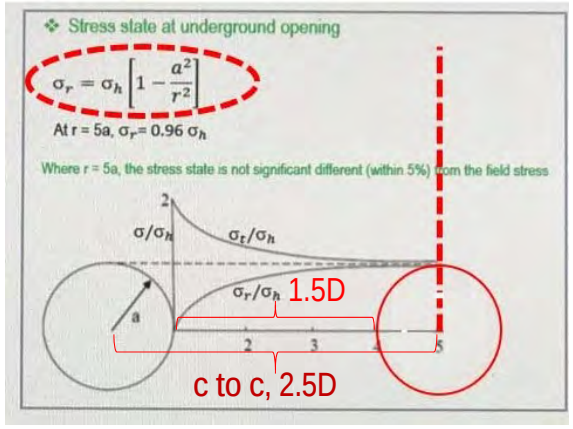
	▪ Check bearing plate; no compressible materials; (solid steel)	☐	
	▪ Check the serial number of the hydraulic jack with the calibration certificate as per MS.	☐	
	▪ Check the clear distances between test pile and reaction piles as per MS; -------m, ------m, -------m, ------m	☐	
	▪ Checking the capacity of Rebar in anchor piles (ref: MS, Size and Numbers of rebar).	☐	
	▪ Check the dimensions of main beam and secondary beam (ref: MS, Size, Length).	☐	
7	LOADING SEQUENCE		
	▪ Follow the loading sequence and time interval (ref: MS)	☐	
	▪ Take reading and record every ---------- min (take the reading every 15 min or ------- of the dial gauges, optical survey of IRB and measurement of load cell pressure gauge) 1. Check the pressure gauge for each jack to detect malfunctions and imbalances. -------, ------, -------,------- 2. Check the dial gauge readings. -------, ------, ------, ------ 3. Optical survey.	☐ ☐ ☐	
	▪ Check the minimum holding time -----, ------, ------, ----- min ▪ Check the rate of pile head movement (< 0.25 mm/hour)	☐ ☐	
8	RECORDS		
	▪ Check all necessary information sheets *(pile and pile set up detail, field record sheets after taking the reading for before/after load increments.* After completed the static load, qualified geotechnical engineer shall interpret and report the test results to HPBC.	☐	

☑ ok or ☒ not ok

Note: Short note for records and site conditions: ----------

Effect on skin friction of bore pile due to changes of normal stiffness of soil





No.	Plastic zone radius	Clear spacing bet. piles	c to c	% of effect on skin friction of bore pile
1	2r	0.5D	1.5D	25.00
2	3r	1.0D	2.0D	11.11
3	4r	1.5D	2.5D	6.25
4	5r	2.0D	3.0D	4.00
5	6r	2.5D	3.5D	2.78

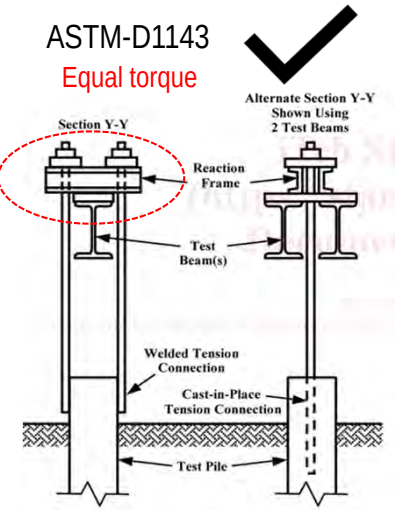
After applying the maximum load (200%) and reaching an overall test duration of at least 12 hr, begin unloading when the axial movement measured over a period of 1 hour does not exceed 0.25 mm (0.01 in); otherwise allow the maximum load *to remain on the pile or pile group for 24 hr*. (D-1143)

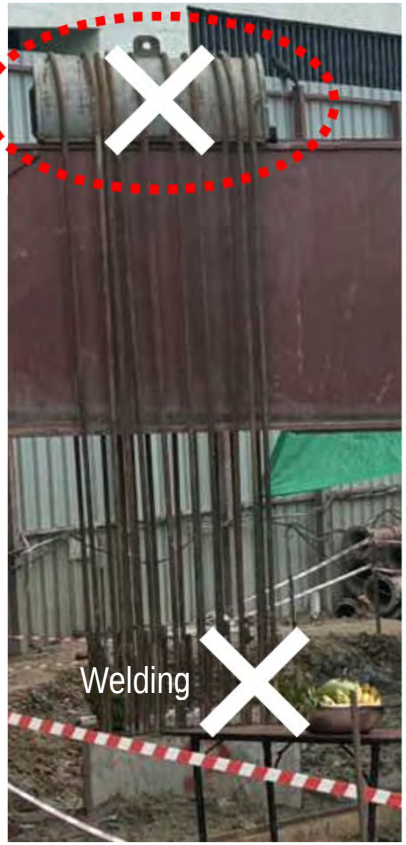
Project Case Study in Myanmar

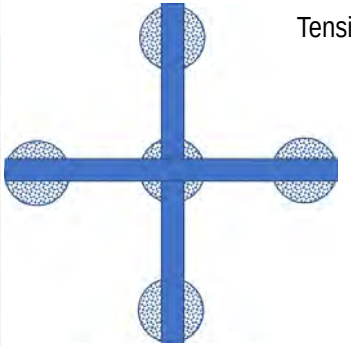
Adverse effect on pile capacity

ASTM-D1143

Equal torque



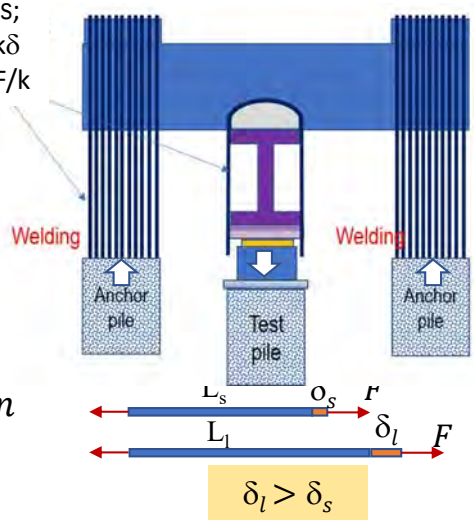




Tension rods;

F = kδ

δ = F/k



Tension rod extension

$$\delta = \frac{FL}{AE}, \quad k = \frac{AE}{L}$$

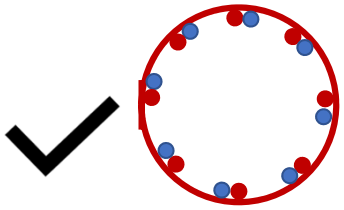
$\delta \propto L$

$k \propto 1/L$

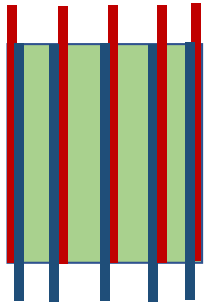
Antipilling system;

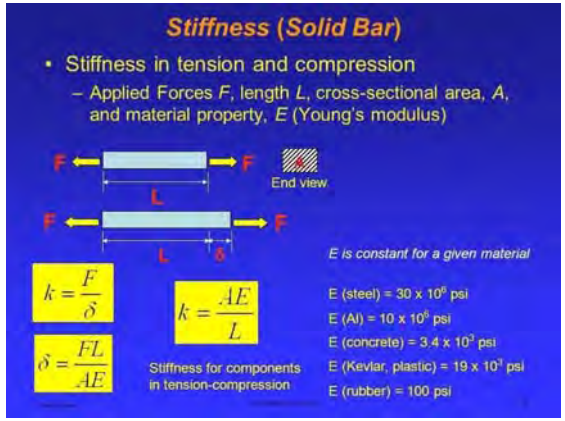
To achieve the good antipilling system;

- Equal size and strength of tension rods
- Equal welding length and welding thickness
- Equal torque
- Symmetric primary and second girders



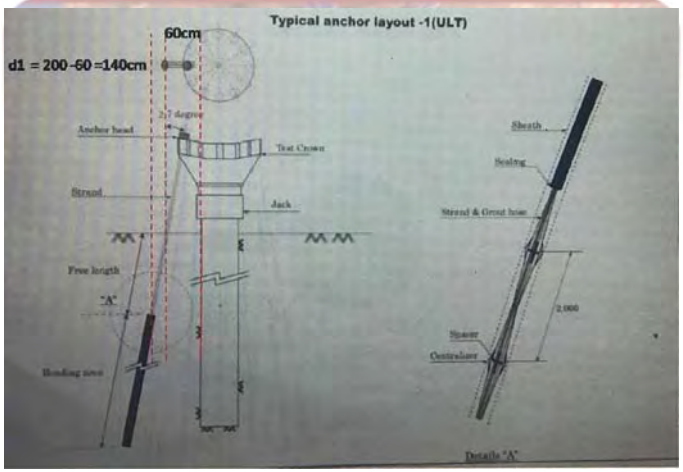
Good practice for welding connection



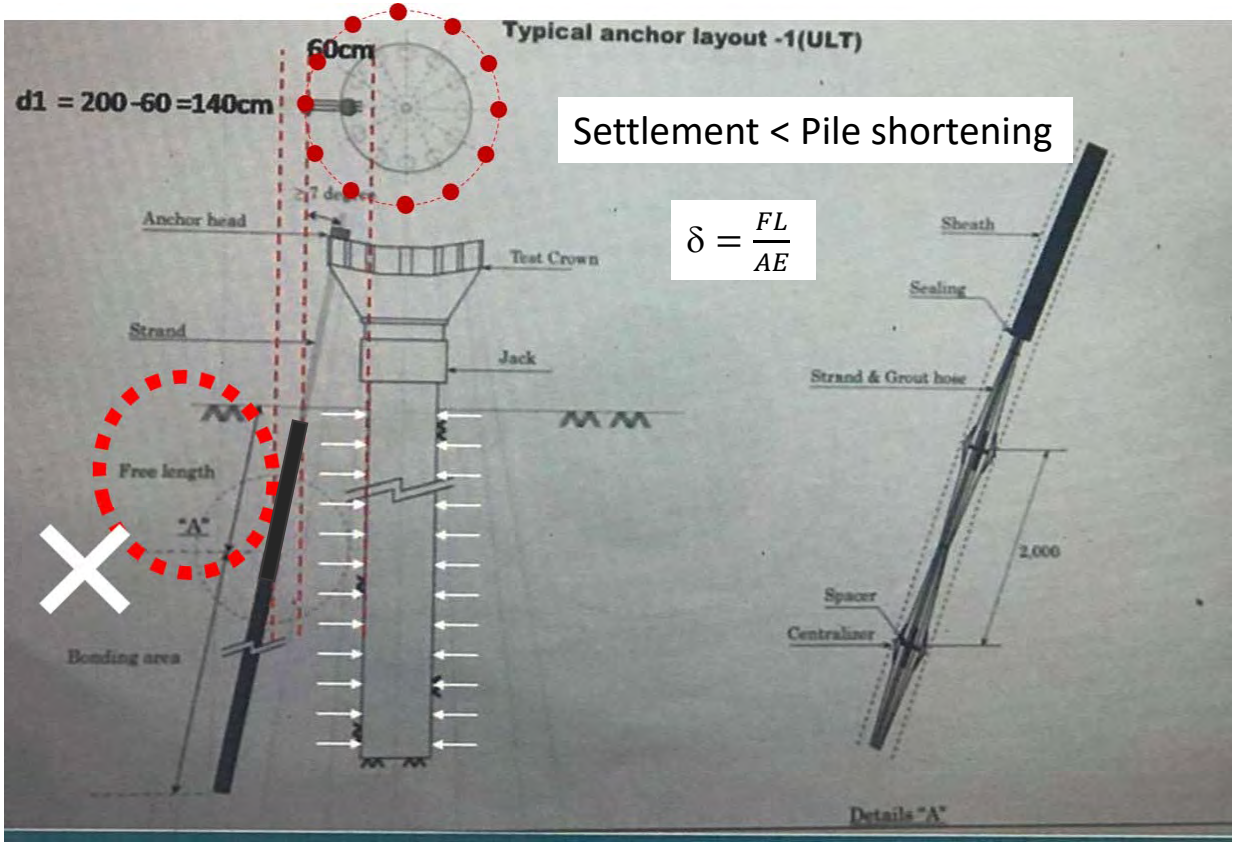


Project Case Study in Myanmar

Adverse effect on pile capacity



Pile load test with Crown Method



Effect of clear spacing on pile capacity in pile load test

1. Retaining Wall Pile Installation and Deep Excavation (Basement Construction)

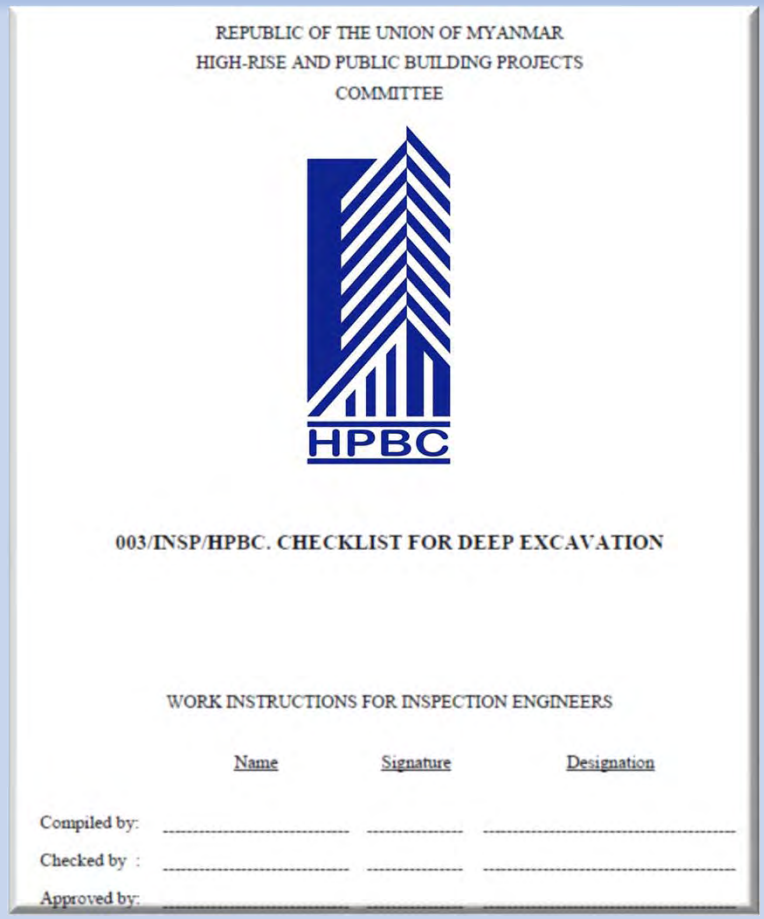
GUIDELINES ON SAFE AND EFFICIENT BASEMENT CONSTRUCTION

BASEMENT CONSTRUCTION PROJECTS UNDERTAKEN BELOW OR NEAR TO EXISTING STRUCTURES

Basement construction is a complex form of building. Main factors for Consideration in Quality Control;

1. • Geotechnical Design
   • Structural Supports (Temporary or Permanent)
2. • The effects of Hydrological Conditions
   • The importance of QA/QC Management
3. • Hazards and Risks
   • Reduce impacts of basement construction

Only responsible, competent and experienced contractors should be appointed.



REPUBLIC OF THE UNION OF MYANMAR
HIGH-RISE AND PUBLIC BUILDING PROJECTS
COMMITTEE

HPBC

003/INSP/HPBC. CHECKLIST FOR DEEP EXCAVATION

WORK INSTRUCTIONS FOR INSPECTION ENGINEERS

	Name	Signature	Designation
Compiled by:			
Checked by :			
Approved by:			

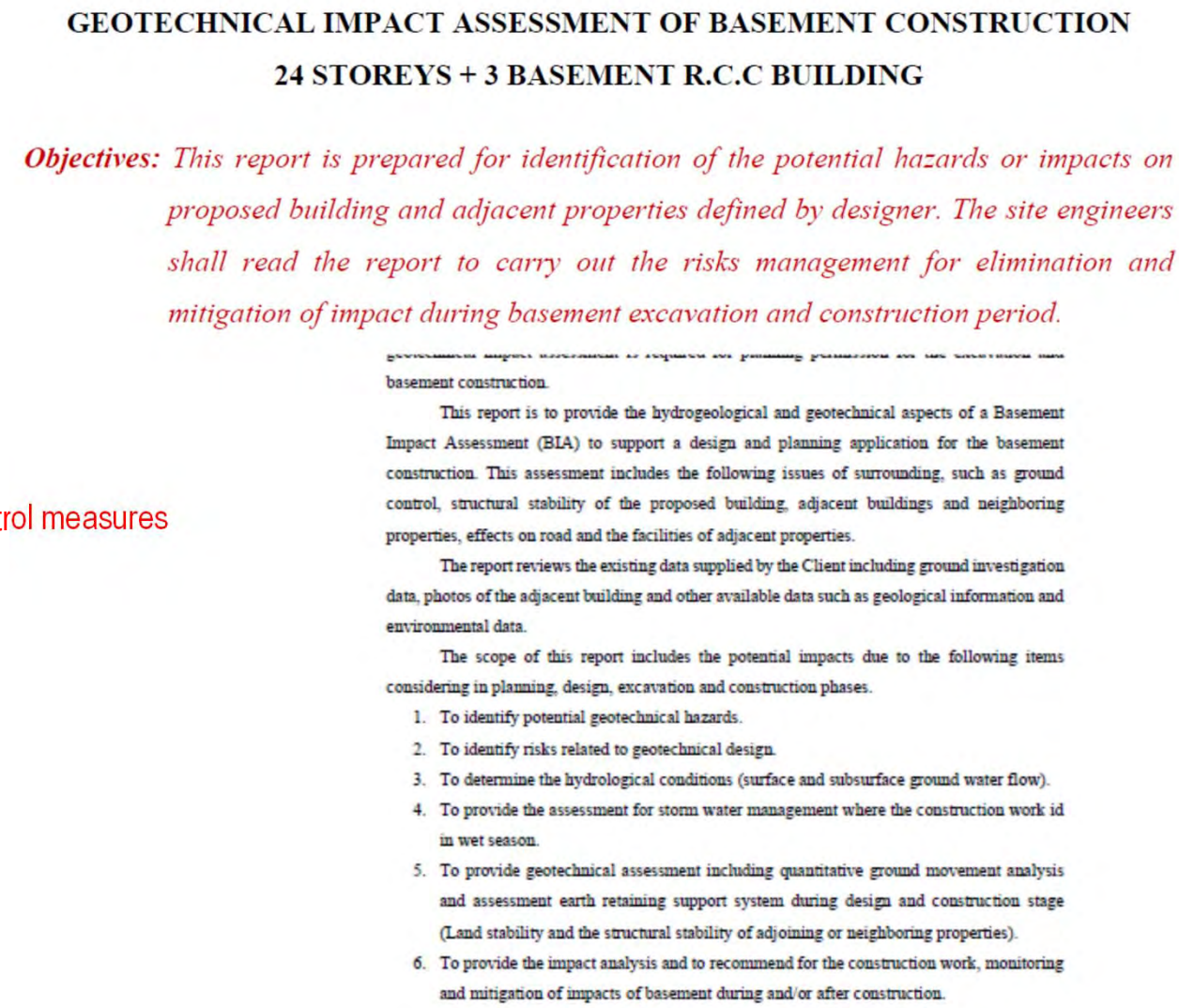
Basement construction can have a significant negative impacts

The main negative impacts come from:

- Damage to structures and surrounding buildings
- Vibration

Risk must be managed by quality control:

- Avoiding risk *where possible preferably by design*
- Reducing risk throughout by selection of suitable quality control measures
- Developing safe methods and systems of work
- Managing and monitoring risk throughout
- Using only suitably trained and experienced personnel



GEOTECHNICAL IMPACT ASSESSMENT OF BASEMENT CONSTRUCTION

24 STOREYS + 3 BASEMENT R.C.C BUILDING

Objectives: *This report is prepared for identification of the potential hazards or impacts on proposed building and adjacent properties defined by designer. The site engineers shall read the report to carry out the risks management for elimination and mitigation of impact during basement excavation and construction period.*

basement construction.

This report is to provide the hydrogeological and geotechnical aspects of a Basement Impact Assessment (BIA) to support a design and planning application for the basement construction. This assessment includes the following issues of surrounding, such as ground control, structural stability of the proposed building, adjacent buildings and neighboring properties, effects on road and the facilities of adjacent properties.

The report reviews the existing data supplied by the Client including ground investigation data, photos of the adjacent building and other available data such as geological information and environmental data.

The scope of this report includes the potential impacts due to the following items considering in planning, design, excavation and construction phases.

1. To identify potential geotechnical hazards.
2. To identify risks related to geotechnical design.
3. To determine the hydrological conditions (surface and subsurface ground water flow).
4. To provide the assessment for storm water management where the construction work id in wet season.
5. To provide geotechnical assessment including quantitative ground movement analysis and assessment earth retaining support system during design and construction stage (Land stability and the structural stability of adjoining or neighboring properties).
6. To provide the impact analysis and to recommend for the construction work, monitoring and mitigation of impacts of basement during and/or after construction.

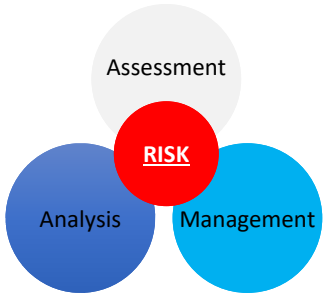
QC Management on Basement Construction Works

Geotechnical Impact Assessment and Construction Risk Management during QA/QC work

Identification, Mitigation and Prevention of Potential Hazards

- ***Identified the potential hazards and risks depending on the allowable limits of particular facilities or buildings.***
- ***Construction engineer will strictly perform in project risk's management to eliminate or mitigate the impacts during excavation and construction.***
- Potential impacts and prevention of impact on environment during basement construction would be considered as below.

1. Ground control (Basement wall movement, settlement & ground stability)
2. Ground water level changes
3. Surface water and storm water effects
4. Effect of excavation method
5. Excessive Loadings
6. Vibration effects on adjacent buildings
7. Noise

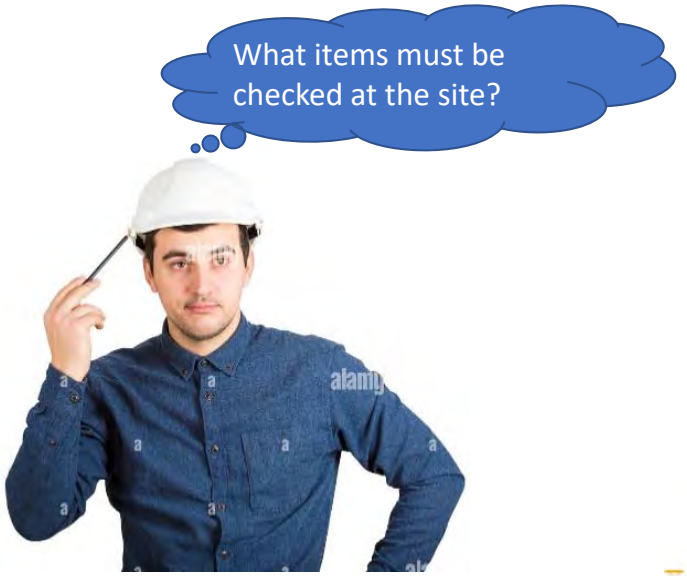


Delay of Support Installation Time

Basement Construction Works

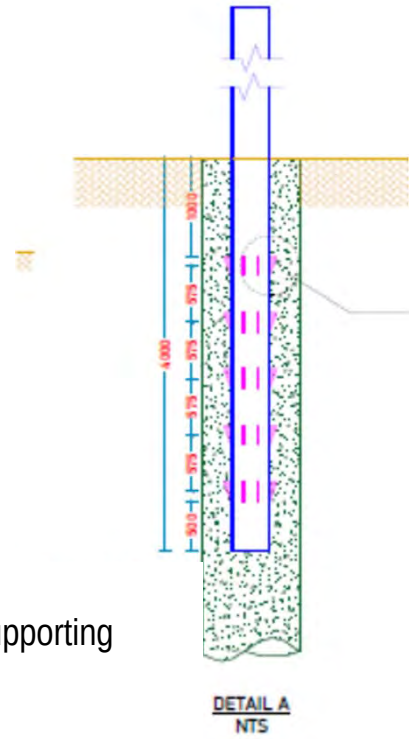
Summary of Checking items

1. Design Specifications
2. Basement Construction sequence
3. Working process;
   - Drainage work
   - Excavation and Supporting sequence,
   - Safety and health (ventilation, PPT, hazards, etc.)
   - Concreting work; quality control with good practicing,
   - Monitoring management considering QA/QC,
4. Working procedure considering QA/QC



Supporting

Placing the king post

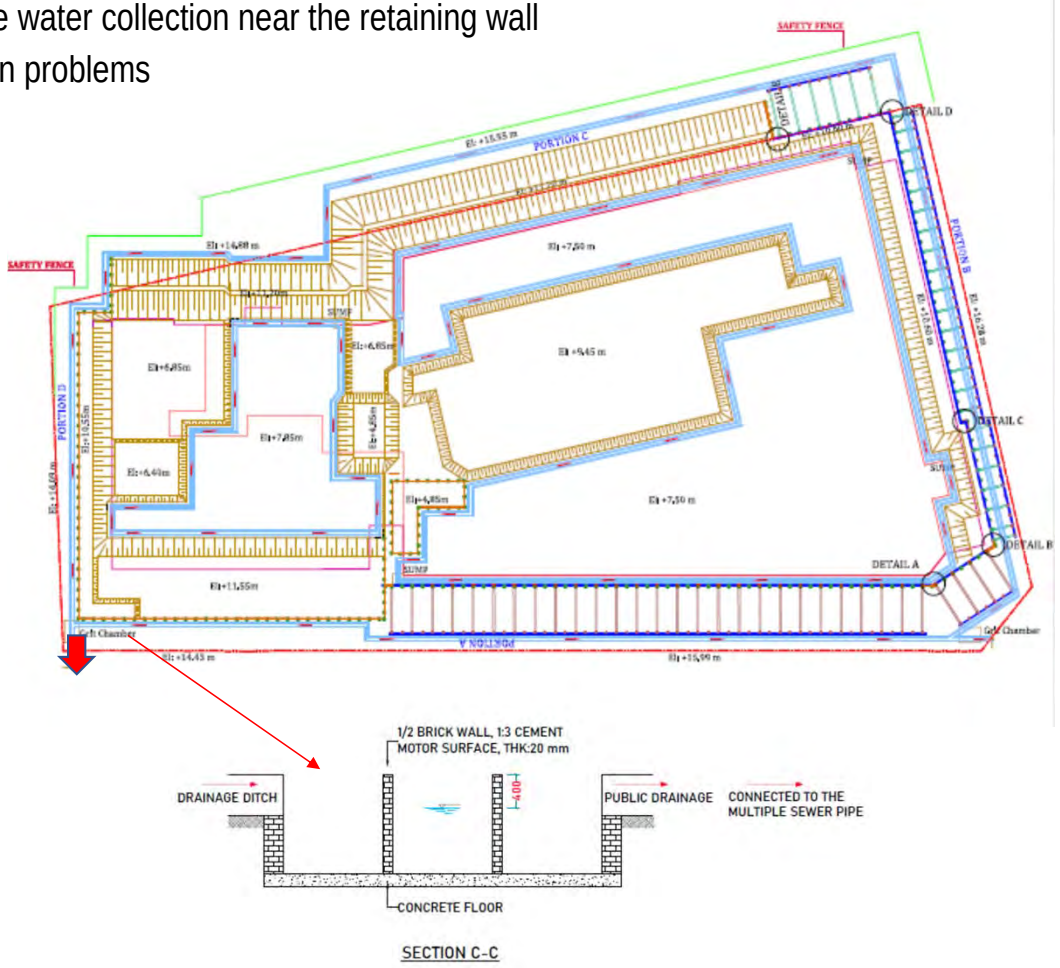


CHECKLIST FOR DEEP EXCAVATION

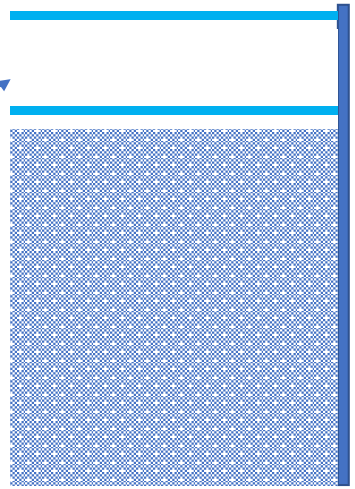
No.	Checked List Items	Checked by Inspectors	Remark
	Project Name: ---------- Location: ---------- ---------- Date: ----------		
1	SPECIFICATIONS OF DEEP EXCAVATION		
	▪ ERSS Types (the construction of walls shall be inspected by separate checklists)" ok or Not ok	☐	
	▪ Basement layers or depth: ----------		
	▪ Excavation dimensions: L x W (avg) ----------		
	▪ Basement construction method: Top down or bottom up		
	▪ Construction company: ----------		
	▪ Geotechnical designer: ----------, PE----------		
	▪ Structural designer: ----------, PE----------		
	▪ National counterpart: ----------, PE----------		
	▪ National counterpart: ----------, PE----------		
	▪ Support types: Steel beams or concrete, ---------- 1. Steel beams (Size, shape and grade based on design) 2. Concrete beams (concrete grade, reinforcement steel grade etc.)	☐ ☐	
	▪ Concrete Strength Test with adequate number of samples	☐	
	▪ Strength Test or specifications steel	☐	
2	TEMPORARY DRAINAGE		
	▪ The contractor shall provide the temporary drainage 1. Provide proper settled pond to clean polluted water 2. Proper connection to public drainage lines	☐ ☐	
	▪ All filled ground shall be leveled to gradient to facilitate the discharge of surface water runoff	☐	
	▪ All exposed cut and fill ground slope shall be covered by the plastic sheet of suitable materials to protect the duct or rain water.	☐	
	▪ To check appropriate dewatering	☐	

The reasons of provision of proper drainage lines;

1. To reduce the effect on water on soil properties
2. To avoid the water collection near the retaining wall
3. Construction problems

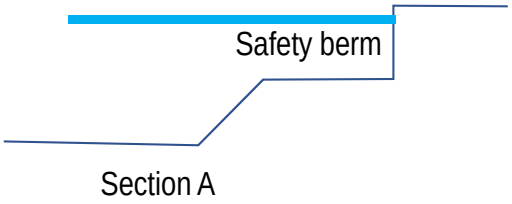


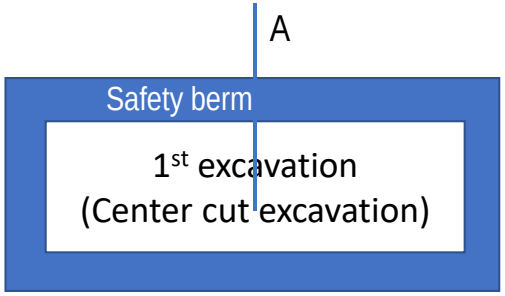
3	EXCAVATION AND SUPPORTING		
	▪ EXCAVATION 1. To check the excavation, supporting and concreting sequence as mentioned in design report or not.	☐	■
	2. To check the predetermined excavation depths of each layer as mentioned design drawings; ok or not ok	☐	■
	▪ Excavation property barricaded	☐	
	▪ Walkway provided	☐	
	▪ Access & Egress	☐	
	▪ Lighting and Ventilation provided	☐	
	▪ SUPPORTING 1. To check the soil types of excavated area: ---------- 2. To check the elapsed time between the excavation and time of complete support installation: ---------- days 3. To check the dimensions of support as mentioned design drawings; ok or not ok	☐	
	▪ To check the final excavation level as mentioned design drawings of ERSS; ok or not	☐	
	▪ To check the preloading work as mentioned in design (if required) for the displacement control design)	☐	■



Stage Construction and Stage Analysis for excavation

Sr. no.	Description	Construction stage
1	Initial stress calculation	1
2	Install SBP	2
3	Excavate to AMSL 24.75	3
4	Install S2 at AMSL 25.25	4
5	Excavate to AMSL 21.75	5
6	Install S3 at AMSL 22.25	6
7	Excavate to AMSL 18.75	7
8	Install S4 at AMSL 19.25	8
9	Excavate to FEL AMSL 15.56	9
10	Cast pile raft foundation & GT slab	10
11	Remove S4	11
12	Cast B3 slab	12
13	Remove S3	13
14	Cast B2 slab	14
15	Remove S2	15





4	▪ CONCRETING THE COLUMN, SLAB AND WALL 1. To check the elapsed time between the support removal and time of concrete slab for required strength of concrete: ---------- days 2. To check the back-fill materials (if required) between ERSS wall and basement wall as mentioned in design or not 3. To check the adequate concrete strength before removal of support as mentioned in design: ok or not ok:	☐ ☐ ☐	
5	WELDING		
	▪ Welding type (fillet or butt): ---------- ▪ Welding thickness: ---------- ▪ Cooling time: ---------- min		
6	INSTRUMENTATION AND MONITORING		
	▪ To check the instrumentation as per design or not 1. Types of instrumentation 2. Numbers of location 3. Monitoring frequency ▪ To check the reliability of monitoring process	☐ ☐ ☐ ☐	

Elapsed time for support removal

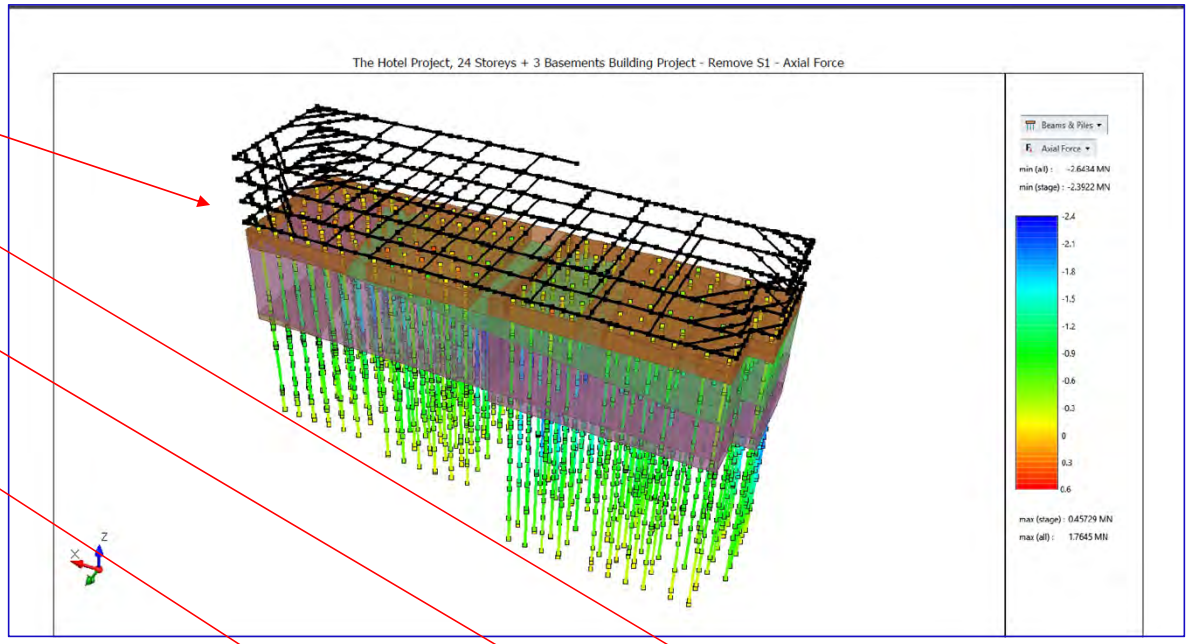
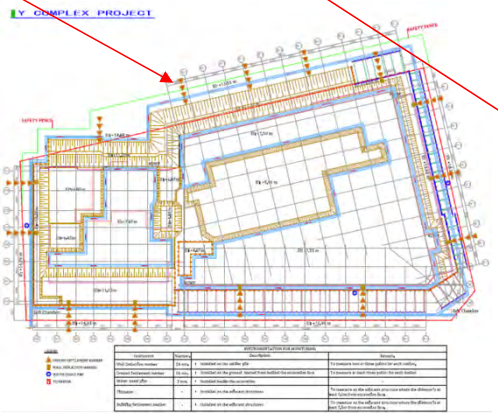
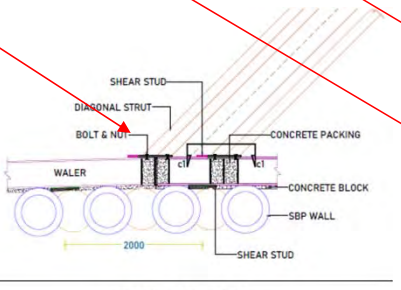
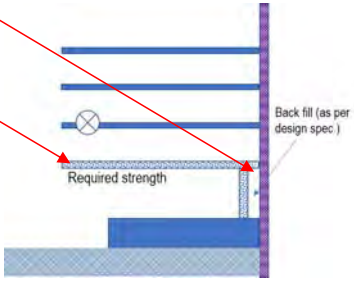


TABLE OF MONITORING PLAN				
Instruments	Prior to excavation	During excavation	During basement construction	After basement construction
Inclinometer	Weekly	Weekly	Weekly	Weekly
Strain gauge	Weekly	Weekly	Weekly	Weekly
Water standpipe	Weekly	Weekly	Weekly	Weekly
Ground settlement marker	Weekly	Once daily	Once daily	Weekly
Building settlement marker	Weekly	Once daily	Once daily	Weekly
Tiltmeter	Weekly	Once daily	Once daily	Weekly





DETAIL 3 (S1 LAYER)

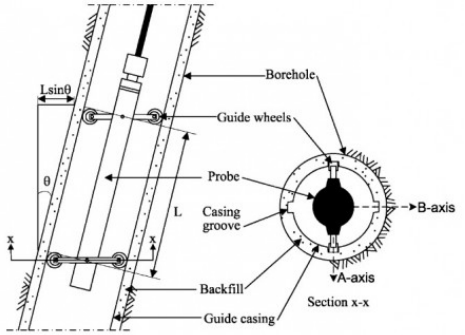


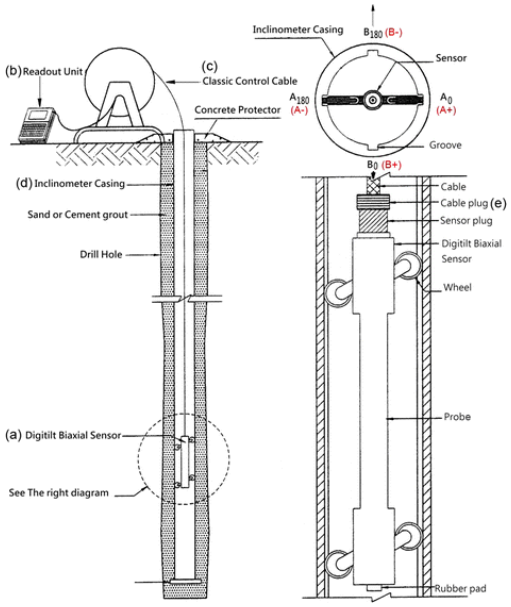
CHECKLIST FOR DEEP EXCAVATION

7	MONITORING MANAGEMENT		
	▪ To check the proper management based on the supporting procedure and monitoring results, ok or Not ok ▪ To check the results; Ground Settlement Marker, Building Settlement Marker, Tilt Meter, Inclinometer, strain gauge, Water Standpipe, etc.,	☐ ☐	■ ■
8	UTILITIES		
	▪ To check the Protection of Adjacent Existing Utilities ▪ To check the monitoring results is ok or not as per mentioned in allowable limits ▪ To check the adjacent structure's condition	☐ ☐ ☐	■ ■ ■

Note:

After installation of ground settlement marker





CHECKLIST FOR STRUTTING WORKS

No.	Checked List Items	Checked by Inspectors	Remark
	Project Name: ---------- Location: ---------- ---------- Date: ----------		
1	Construction Company: ----------		
	Geotechnical Engineer: ----------, PE---------- Construction Engineer: ----------, PE----------		
	Experienced engineer for supervision: Name; ----------		
	Surveyor: Name; ----------		
	Skillful Welder: Name; ----------		
	Submission of Method Statement (MS)	☐	
2	SPECIFICATIONS OF MATERIALS		
	▪ Specifications of steel or concrete as per design - Sizes, yield strength of steel beam - Compressive strength of concrete, reinforced steel - Depth of section, width and thickness of flange, web thickness - The conditions of materials shall be noted.	☐	
	▪ Dimension or interval of strut as per design	☐	
	▪ Positions of strut as per design	☐	
	▪ Welding details - Ensure the sufficient welding length, trough size as per design provided by good workmanship - Connection specification with good practicing	☐ ☐	

QC;

- Precision with good practicing
- Specification
- Workmanship
- Process & procedure

28.1.2019 Photo Record

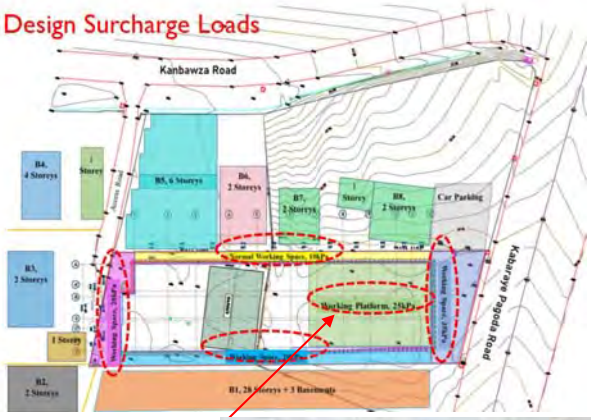
Joint of waler beam

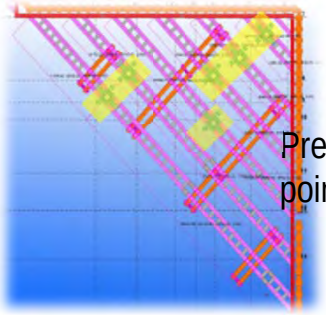
Anchor bar tightening

Between soldier pile and waler beam

3	SITE CONDITIONS		
	▪ Check the proper access ways and Note for the conditions - Ladder, stairways, ramps, or other provided access readily accessible from any position of excavation face	☐	
	▪ Check the ventilation (gases or smell from welding/machines for deep excavation)	☐	
	▪ Check the predetermined design loads of machines or storage of construction materials as mentioned in design drawings.	☐	
	▪ No excavated material is placed at the edge of excavation and working platform.	☐	
	▪ Machine used at site are placed away from the excavation boundary.	☐	

4	STEEL OR CONCRETE STRUT INSTALLATION		
	▪ The following members shall be checked; - Strut, waler, king post shall be free from defects - Strut, waler, king pile is mentioned as design - Design depth of king post as per design (from site installation records and noted)	☐ ☐ ☐	
	▪ Check the working platform as per design specifications (where the working platform is used.) ▪ Check the loads of machines and storage of construction materials as per predetermined design loads on platform.	☐ ☐	
	▪ Check the verticality of retaining piles, sheet piles or D-wall	☐	
	▪ Check the contact surface between walers and retaining wall (It shall be full contact between walers and wall, if not, check the remedial measures.)	☐	
	▪ Check the loads of construction material over the installed struct which is less than allowable load as mentioned in design load.	☐	
	▪ Check the preloading records	☐	
	▪ Check the period between the strut installation and excavation	☐	------ days





1 momth

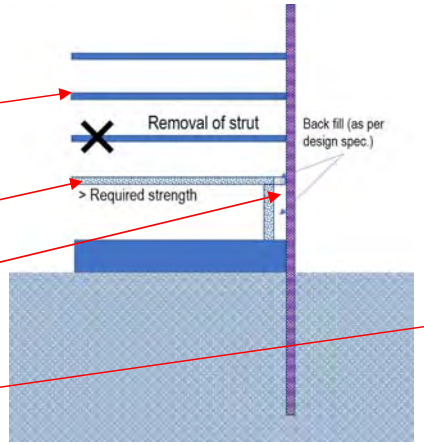
Preloading points

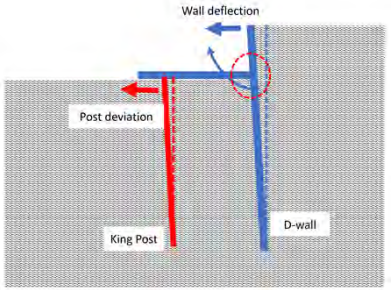
5	CONDITIONS OF STEEL OR CONCRETE STRUT		
	▪ Check the struct members (frequently or during inspection) - buckling, weak welding, settlement and king post deviation	☐	
	▪ Check the bracing members (*NO removal or replacement* is allowed without approval of designer)	☐	
	▪ Check the destressed or other sign and Note in the checklist for the conditions and remedial measures approved by designer.	☐	
6	REMOVAL OF STEEL OR CONCRETE STRUT		
	▪ Check the removal of strut according to the proposed construction sequence after required strength of slab	☐	
	▪ Check the fill materials or temporary support (if necessary) between the basement wall and retaining wall before strut removal (as mentioned in design specifications)	☐	
	▪ Check the allowable limits of records after removed the struts. - The wall deflection - The strut force (if measured strain gauge) - Settlement around excavation	☐ ☐ ☐	
	▪ Check the remedial measures of any issues and state the conditions	☐	

☑ ok or ☒ not ok

Remark: Some information and data shall be checked based on the checklists of on-site quality control records. All changes of design specifications need approval of designer/assigned professional engineer for submission to authority (HPBC).

Note: Short note for records and site conditions: ----------





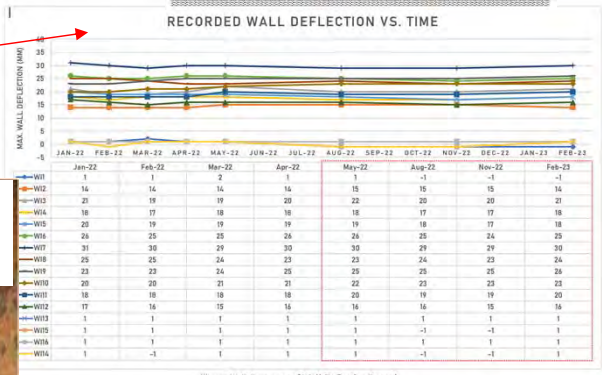
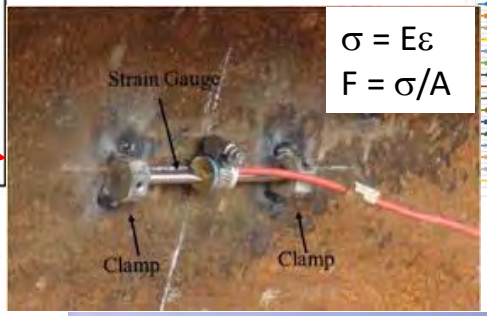
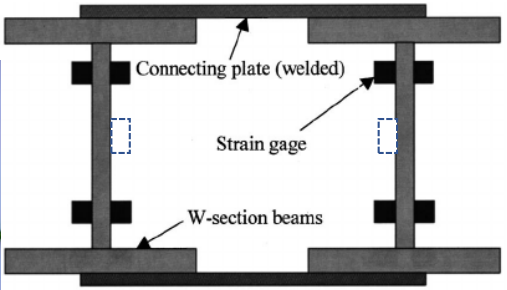


Figure (2.4) Summary of Wall Deflection Records



$\sigma = E\varepsilon$

$F = \sigma/A$



Building-5 (6-Storey building):

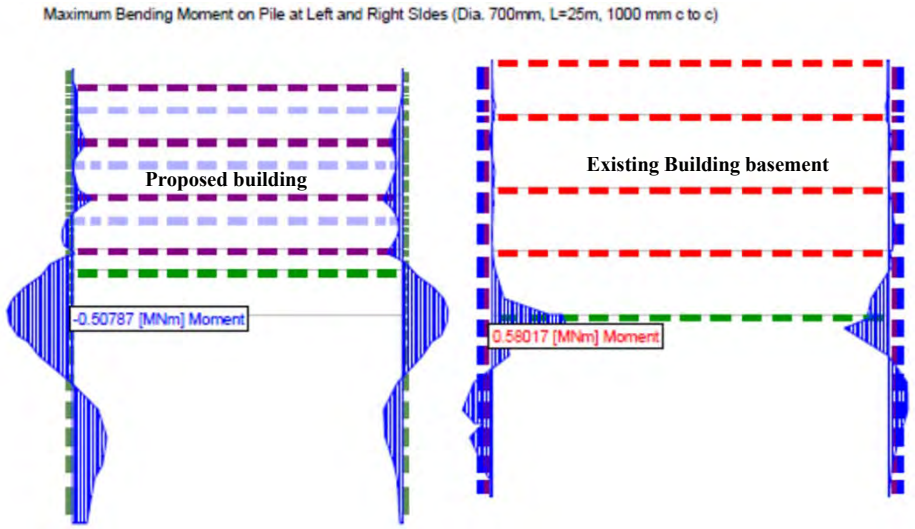
Potential impacts:

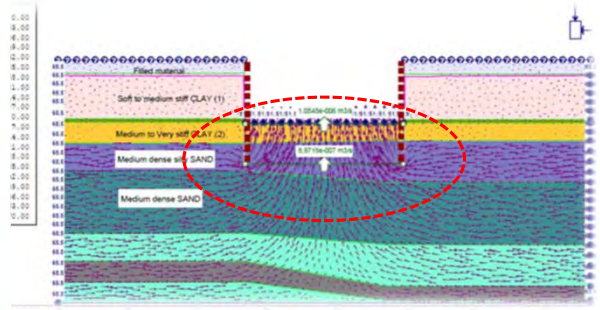
1. Wall deflection
2. Ground settlement
3. Excessive GWL reduction

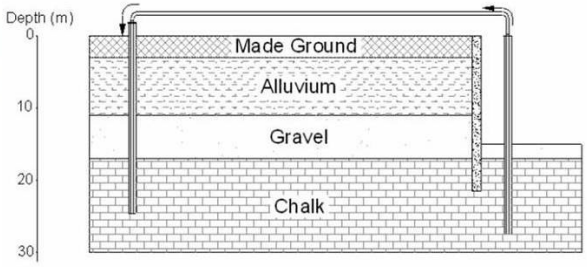
Check for Impacts on Adjacent Buildings

Check for the Effect of Excavation on Building 1

	Induced maximum bending moment and Shear force	Capacity of Adjacent Wall*	Checking
Bending moment	580.17 kNm/m	894.99 kNm/m (phase: 9)	< ok
Shear Force	356.38 kN/m	587.18 kN/m (phase: 9)	< ok







Recharge wells may be required outside the walls if drops in water level are not allowed.

Estimation of ground water seepage (Maximum dewatering volume, Stages: 3 Stages

The estimated dewatering volume from FEM analysis is shown in below table:

Second Struct Layer Excavation					
Ground water seepage/m			2.5260E-07	m^3/s	DS-A
			Actual rate	Hydraulic gradient after excavation	SF
Ground water seepage/m	7.5780E-07	m^3/s	7.5780E-07		3.00
	6.55E-02	$m^3/day/m$	(FEM results)		
	264.17	$gal/m^3/m$			
	1.73E+01	gal/day/m			
Length of seepage	68.38	m			
Total seepage of ground water	4.48	m^3/day			
Total seepage of ground water	1.183	gal/day		-4.56	(FEM results)
Third Struct Layer Excavation					
Ground water seepage/m	1.7409E-06	m^3/s	5.8030E-07		3.00
	0.15	$m^3/day/m$	(FEM results)		
	264.17	$gal/m^3/m$			
	39.73	gal/day/m			
Length of seepage	68.38	m			
Total seepage of ground water	10.29	m^3/day			
Total seepage of ground water	2,717	gal/day		-5.89	(FEM results)
Final Excavation Level					
Ground water seepage/m	3.3960E-06	m^3/s	1.1320E-06		3.00
	0.29	$m^3/day/m$	(FEM results)		
	264.17	$gal/m^3/m$			
	77.51	gal/day/m			
Length of seepage	68.38	m			
Total seepage of ground water	20.06	m^3/day			
Total seepage of ground water	5,300	gal/day		-8.14	(FEM results)

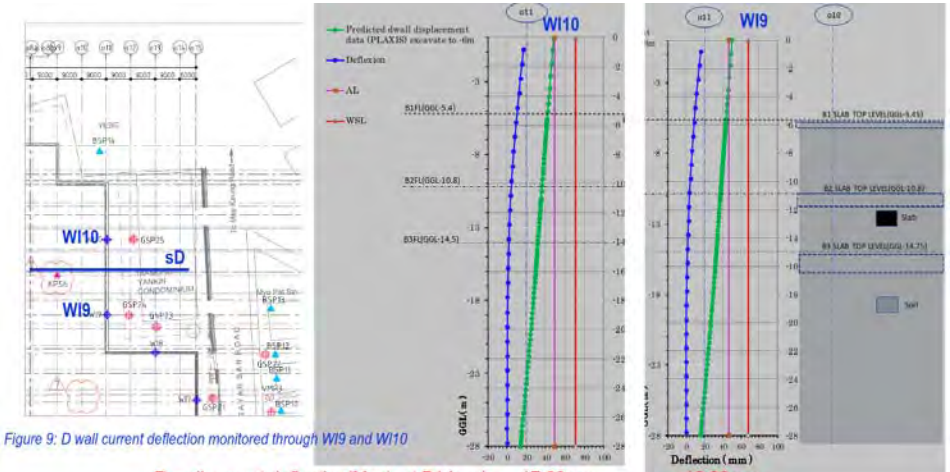
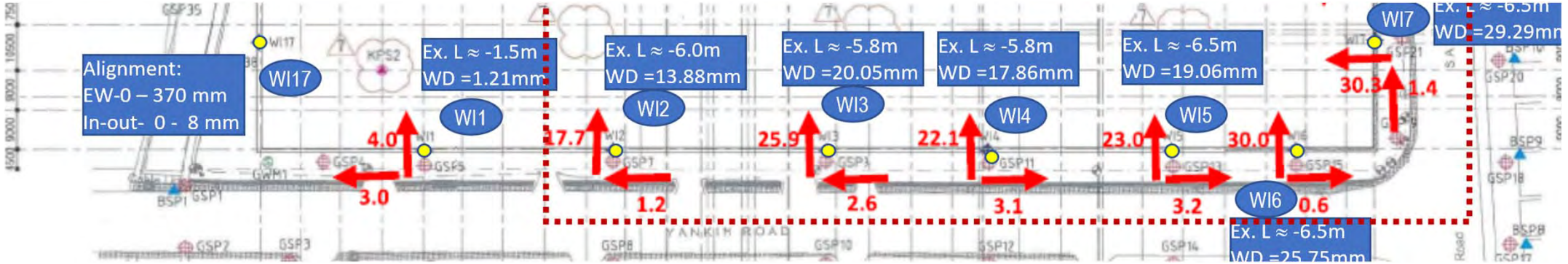


Figure 9: D wall current deflection monitored through WI9 and WI10

D-wall current deflection(Max) at B1 level =	17.29mm	16.28mm
AL at B1	=	38.0mm	34.0 mm
WSL at B1	=	55.0mm	49.0 mm

Wall Deflection Compared with HPBC guideline (Normal Case)

Design Section	Wall Deflection, mm	Exc. Depth, m	% of Depth	Remark	Max. Limits (MNBC)	Side
DS-A	18	13.60	0.13	< 0.5 ok	68	
DS-A	19	13.60	0.14	< 0.5 ok	68	
DS-B	15	13.60	0.11	< 0.5 ok	68	
DS-B	10	13.60	0.07	< 0.5 ok	68	
DS-D	37	13.60	0.27	< 0.7 ok	95	
DS-C	23	9.60	0.24	< 0.5 ok	48	
DS-C	7	9.60	0.07	< 0.5 ok	48	
DS-E	34	9.60	0.35	< 0.7 ok	67	



Submission of QC Completion Report for Geotechnical Work

(Completion of Construction up to Ground Floor Level)

CONTENT

COMPLETION REPORT

7th March, to 30th September,

Dr. Yu Maung
PE-0038 (Geo)
ACPE-00564 (Civil)

Phoo Pwint Zaw
ERSS Assistant Design Engineer
Geotechnical Consultant Team

END

Thank for your attention