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Foundation Supervision Guide



ACES/IES

For Qualified Site

Supervisors (QSS)

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For Qualified
Site Supervisors (QSS)

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Foundation Supervision Guide

For QSS - REs and RTOs

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The retail price for this book is \$20.

MATERIALS IN THIS GUIDE HAVE BEEN CONTRIBUTED BY RESOURCES SUPPLIED BY THE ABOVE.

This guide shall serve only as a quick guide to facilitate construction supervision for Resident Engineers (RE) and Resident Technical Officers (RTO).

RE and RTO must still refer to approved drawings, building specifications, codes, other relevant documents and relevant authorities' requirements for the execution of the works.

Technical Editor: Er. Kok King Min

Foreword by President, ACES

The importance of our QSS as part of our consultancy work cannot be underestimated in the Built Environment. We depend heavily on the professionalism of our QSS on the ground to help ensure that our designs are followed through on sites and the products delivered safely and according to specifications to our ultimate clients.

In this regard, I must commend the JAC for the superb work that they have contributed in these two sets of guide books that will assist our QSS in their daily work.

This is part of the journey towards even more professionalism in our work and I look forward to more such initiatives in the Built Environment.

Thank You.



Er. Koh Boon Liang

President

Association of Consulting Engineers Singapore

Foreword by President, IES

Dear Resident Engineer / Resident Technical Officer,

A good and solid foundation is the core of any building structure, without which no building will be able to stand firm. Compromised foundation and building quality will be undermined if site supervisors do not adhere to the stipulated guidelines lay down by the authorities.

The aim of this Foundation Supervision Guide is to familiarise the site supervisors with the correct and proper procedures when doing foundation work such as deciding on the choice of foundation systems to be used, pre-construction survey, testing of piles, ensuring that foundation works do not have undesirable impact on adjacent structures or services, etc.

This Guidebook has been divided into three sections: Section 1 is an introduction to foundation and piling at construction worksites; section 2 touches on deep foundation works while the final section looks at shallow foundation works. REs and RTOs will be able to pick up the necessary information from this guidebook for application in their daily work.

We would also like to thank Er. Kok King Min for editing this Foundation Supervision Guide.



Er. Ho Siong Hin

President

The Institution of Engineers, Singapore

Section One – Introduction

1.1 Scope

The choice of foundation system depends on the types of the proposed development, the anticipated loadings and on the strength and stiffness of the ground strata. In general, the foundation system must satisfy the following two principles:

- i. Adequate factor of safety against Ultimate Limit State Criteria.
 - i.e. To transmit the worst possible combinations of dead, live, lateral or other forms of loads from the structure to the ground without causing soil or foundation failure.
- ii. Adequate factor of safety against Serviceability Limit State Criteria.
 - i.e. To withstand the design load without causing excessive total settlement and such that differential settlement is within tolerable limits.

The proposed foundation works should not give rise to undesirable effect on adjacent structures or services. The choice of a particular type of foundation depends on the column load, ground conditions, availability of foundation materials and acceptable workmanship, environmental considerations and the constraints of the site.

Issues on site with regards to the supervisory and interfacing roles of the QSS with the other stakeholders such as the Builder, Builder's PE and the design Qualified Person (QP) in foundation works would be discussed in this guide.

1.2 Pre-Construction/ Pre-Condition Survey

- Pre-construction/ Pre-condition survey shall be carried out by the builder on the surrounding buildings or structures before execution of works
- This helps the builder to differentiate and identify the damages that could arise from the proposed works
- Whenever the QP deemed necessary, selected monitoring measures shall be carried out during the course of the works
- The builder shall carry out all necessary protective and strengthening measures to ensure that surrounding structures and facilities are not damaged

1.3 Setting Out

- Sufficient lines and level pegs to enable each column, footing, pile, etc., to be accurately positioned shall be set out by the builder
- The site supervisor shall check the accuracy of the setting out
- Certification from a registered surveyor shall also be obtained for the setting out of foundations
- The responsibility of the setting out shall lie with the builder

1.4 Site Investigation Report

- A set of site investigation report shall be kept on site

1.5 Safety, Nuisance and Damage

- Reference shall be made to the statutory provisions in the Building Control Act and Regulations, the Workplace Safety and Health Act and the Environmental Pollution Control (Control of Noise at Construction Sites) Regulations

Section Two - Deep Foundations Works

Deep foundation work includes the construction of structural elements in the soil for transferring of superstructure loadings through weaker or compressible soil strata onto a stiffer bearing layer beneath the surface. This section covers the general supervision requirements of all types of deep foundation systems but is not limited to small and large displacement driven piles, non-displacement bored piles, barrettes or diaphragm walls.

2.1 General roles and duties of QSS in Deep Foundation Works

The following items shall be supervised and controlled during the various phases of construction:

- Check the location of proposed deep foundations, materials, reinforcement cages (dimensions, assembly and length) and other elements
- Determination of penetration depth based on actual site conditions under the direction of the QP
- Check foundation eccentricities plan and report to QP (where applicable)
- Obtain soil sample at every 3m (approximate) interval
- Keep records of all works done, including records of tests, inspections, status of work, material tests, etc. on site
- Check overall building orientation, dimensions and corner pegs as set out by registered surveyor
- Check platform levels before commencing works and after backfilling
- Check that steel cover and other materials are in accordance to specifications / drawings
- Take level of pile or barrette before and after load test
- Standing supervision to ensure boring operation is installed according to the approved method statement (concrete characteristics; concrete placement: quantity, duration, rise and final level recovery of the tremie pipe, etc.)
- Keep a complete record of every foundation installed (Refer to the recommended forms and checklist in the Appendices)

- Check ready-mixed concrete plant batching time for concrete delivered to the site (usually less than 2 hours including concreting into bored hole)

2.2 Setting Performance Criteria and Tolerances

- QP shall set the performance criteria
- Settlement of a deep foundation member depends on the load distribution between the shaft and the base
- Pile group effects could also govern the settlement of working piles
- Specific requirements of the structure could influence the total tolerable settlement and differential settlements
- Permitted positional and verticality tolerance of a single bored pile or bored pile group with a cut off level at or below the commencing level could be given as 75mm and 1:75 respectively (or to QP's design specifications) in any direction
- Permitted positional and verticality tolerance of a single driven RC pile or RC pile group with a cut off level at or below the commencing level could be given as 50mm and 1:75 respectively (or to QP's design specifications) in any direction
- QP shall take into account the combined positional and the allowable positional tolerance when the cut off level at some depth below the commencing level
- For projects that requires more stringent measures, QP could adopt a verticality tolerance of 1:100, as a recommendation

2.3 Foundation Schedules and Drawings

A set of approved plans shall be kept on site. The sequence of installation should follow CP4 recommendations.

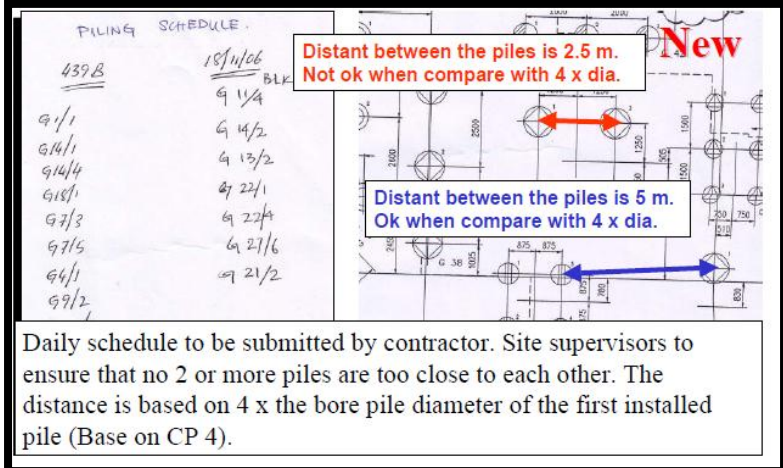


Figure 2.3.A

2.4 Damage to Underground Services

- Underground services must be thoroughly checked by the Builder on its existing conditions prior to piling or any excavation works
- The depth of the services shall be accurately determined on site prior to any piling or excavation works
- Services may include but not limited to water pipes, electrical cables, telecommunication services, gas pipes, railway and road facilities tunnels
- Cable detection services shall be handled by qualified and experienced professionals
- Statutory requirements on the protection of underground services and the detection of such services shall be strictly followed

2.5 Non-Displacement Piles (including Barrettes and Diaphragm Walls)

2.5.1 Quality Control in Piling Work

The Builder shall provide sufficient details to the QP for him to assess the suitability of the construction method, in relation to the design, specification and site conditions. Appendix 3 could serve as a reference for pile installation record.

1. Temporary steel casing
2. Dry vs. Tremie method
3. Checking of pile base and pile verticality
4. Soil strata and final pile depth penetration
5. Steel reinforcement
6. Concreting
7. Usage of support fluids
8. Inspection forms

2.5.1.1 Temporary steel casing

- Check that minimum overall length is provided (usually 5m) or to the minimum depth of any collapsible soil layers
- Check vertical alignment of the temporary steel casing (eg. by using plumb line and spirit level)
- Check a minimum length of 1m of the steel casing is protruded above ground level to serve as a safety barrier
- The condition of the casing should be acceptable (i.e. no dents, gaps and misalignment etc.)

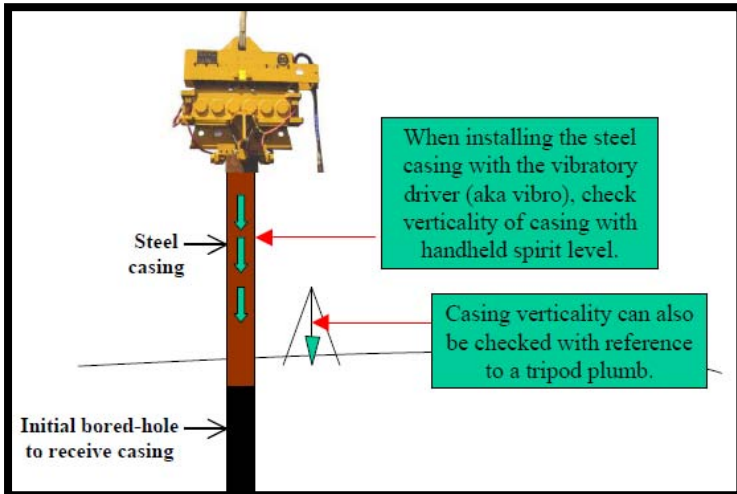
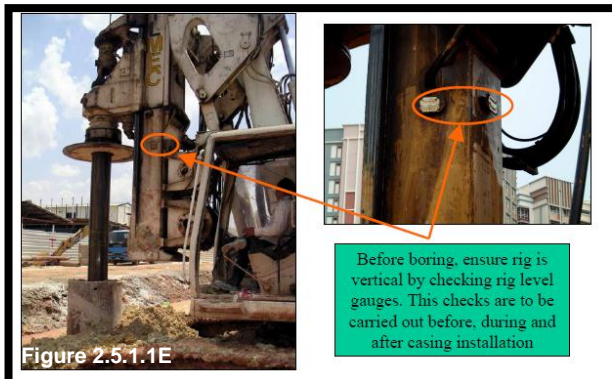


Figure 2.5.1.1A



Ensure verticality of casing with handheld spirit level when vibro is driving casing into ground.

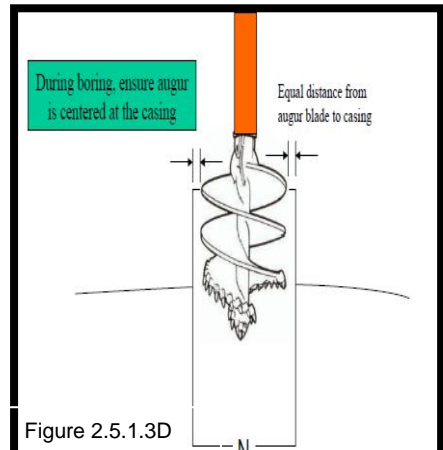
- The extraction of temporary casings shall not begin until the concrete has reached a sufficient height inside the casing to generate an adequate excess pressure to protect against inflow of water or soil at the tip of the casing; and to prevent the reinforcement cage from being lifted
- The extraction shall be carried out while concrete is still of the required consistency
- During the continued extraction, a sufficient quantity and head of concrete shall be maintained inside the casing to balance the external pressure, so that the annular space vacated by the removal of the casing is filled with concrete



2.5.1.2 Dry vs Tremie method

- Dry method to be used where possible
- QSS to supervise the boring operation
- Tremie (wet) method is to be used if the stability of the soil in the hole cannot be maintained i.e. the soil collapses and ingress of water occurs, making the dry method unsuitable
- Supporting fluid (water or other fluids, eg. sodium bentonite) is to be used in tremie method
- Supporting fluid should comply with properties specified by the QP (eg. density)

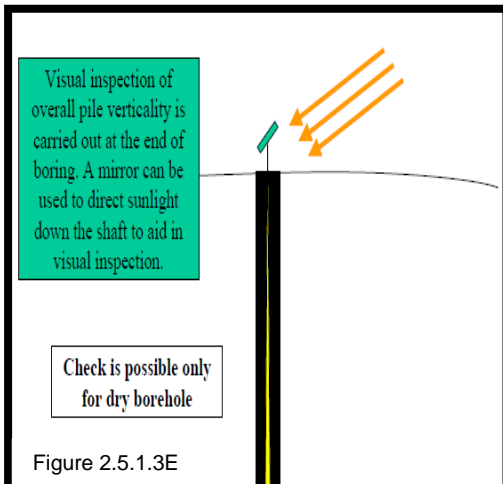
2.5.1.3 Checking of pile base and pile verticality



In the event that adverse soil condition is encountered, QSS is to feedback to QP for a decision on the final pile penetration depth based on site condition.

• Checking of pile base:

- cleaning bucket is used to properly clean and remove debris from the pile base to prevent soft toe problem (eg. a high power torchlight or reflected sunlight from a mirror is used to illuminate the pile to check for a full round base)
- pile shaft and base is cleaned of loose material by shining the pile base and shaft using a high powered torchlight
- pile verticality of 1 in 75 (or other criterion to QP's discretion) is not exceeded (using a plumb line)



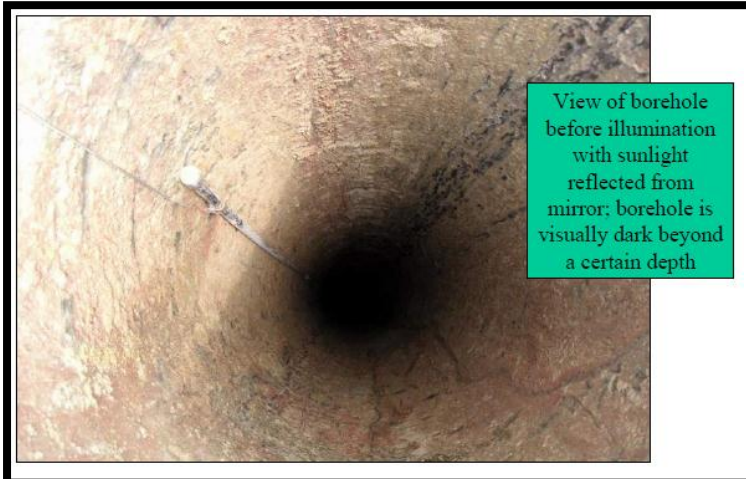


Figure 2.5.1.3G

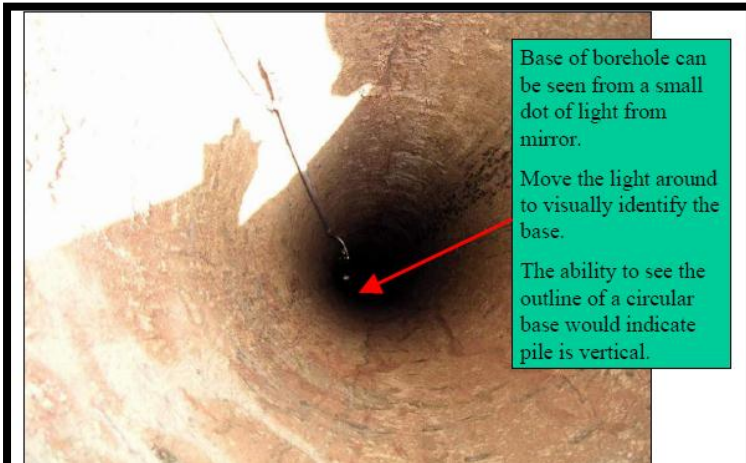


Figure 2.5.1.3H

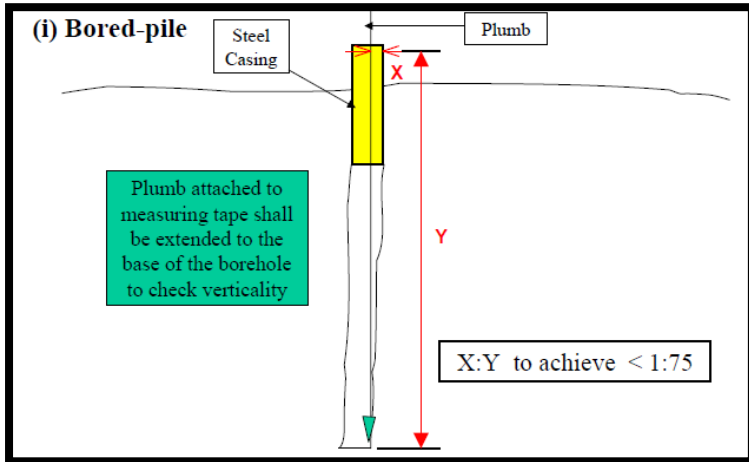


Figure 2.5.1.3i





Figure 2.5.1.3L

Checking of pile toe level

2.5.1.4 Soil strata and final pile depth penetration



Soil sample for every layer of soil strata shall be extracted for each borehole during the boring operation

- Samples shall be labelled clearly indicating date, pile reference, pile diameter, strata depth and pile location
- QSS shall compare actual soil strata profile to bore log soil profile from the site investigation report to determine final penetration depth under the QP's direction

2.5.1.5 Steel reinforcement



- A. Check steel reinforcement length provided above and below cut-off-level
 - B. Check lap length provided for lapping of steel reinforcement
 - C. Check spacers are provided to achieve concrete cover (eg.80mm)
 - D. Check that the size of steel reinforcement size is provided is in accordance to drawings
- Slight lowering of steel cage in wet concrete after release could occur

- Steel cage shall be secured to prevent sinking of whole cage into the borehole
- Adjustments can be made to raise the steel cage such that the protrusion lengths above and below cut-off-level are adequate



Figure 2.5.1.5E



Figure 2.5.1.5F



Figure 2.5.1.5G

Lowering of steel cage and preparation for concreting

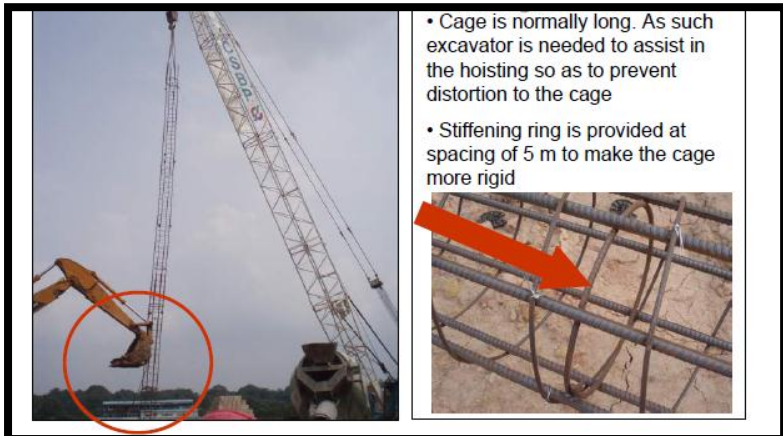


Figure 2.5.1.5H

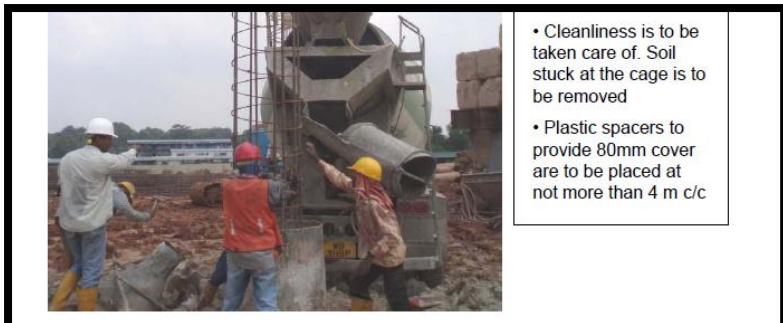


Figure 2.5.1.5i



Figure 2.5.1.5J

2.5.1.6 Concreting



Figure 2.5.1.6A



Figure 2.5.1.6B



Figure 2.5.1.6C

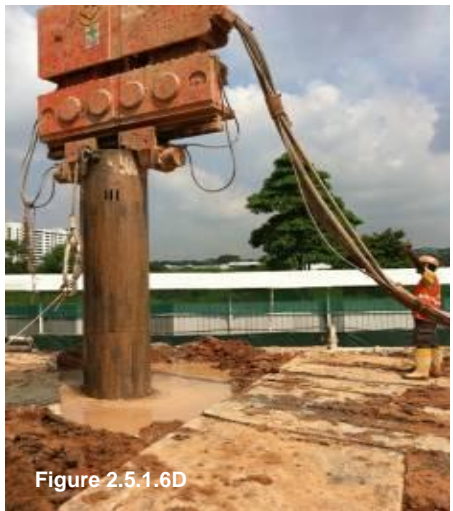


Figure 2.5.1.6D



Concreting works and Extraction of casing

- Concrete should be composed (i.e. properly batched in accordance to the required mix design) to minimize segregation during placing
- A dense and watertight material shall be formed when set
- Concrete shall comply with the requirements related to strength and durability in the hardened state as well as with the requirements related to consistency in the fresh state
- Aggregates shall not be gap graded (i.e. gradation that contains only a small percentage of aggregate particles in mid-size range) and round aggregates are preferred, to prevent segregation
- Maximum size of the aggregate shall not exceed 32 mm or $\frac{1}{4}$ of the clear space between the longitudinal bars, whichever is the smaller
- QP shall specify other requirements such as fines and cement content, water/cement ratio, etc
- Design mix shall be approved by the project QP
- Concrete mix design may varies for dry concreting and tremie pipe concreting

Dry/Wet method: Usually Grade 35 (concrete grade for construction to refer to construction drawing)

QSS to check the concrete slump

- Dry method (100 to 150mm)
- Tremie method (170 to 225mm)

New

- 4 cubes shall be taken for every 10 m³ of concrete for 7 days and 28 days compressive strength testing. 2 cubes shall be tested at 7 days and the remaining 2 cubes shall be tested at 28 days.

Grade of concrete	Compressive Strength (N/mm ²)	
	7 Days	28 Days
Grade 35	28	38

- QSS to ensure that concrete test cubes are properly stored, locked in curing tank room






Table 2.5.1.6A

Slump Test Requirement and Cube Compression Strength

The above table shows a sample of the slump test requirement and cube compressive strength required. QSS is to check with specifications by the QP on specific project requirements.

- Concreting of any one pile is to be carried out in one continuous operation upon completion of full boring, without stoppages
- Skin resistance of a freshly bored hole (dry hole) is reduced over time when it is exposed to ground water ingress or rainwater
- Interval between completion of boring and commencement of concrete placement is required to be kept as short as possible
- Same RMC supplier, using the same mix design, should supply the concrete
- Concrete is usually cast well above the cut off level (at least 500mm) so that weak concrete and laitance at the top can be removed during the hacking of the pile head to cut-off level

2.5.1.7 Usage of support fluids

- Pile that fails to reach the required depth shall not be concreted without the Builder and site supervisor first consulting the QP
- Builder shall propose the support fluids (i.e. water, bentonite or polymers) to the Project QP
- Builder should demonstrate either by calibration certificate or dimensional calculation on the method of water measurement prior to commencement of mixing if water is chosen as the support fluid
- Details of support fluids proposals, not limited to manufacturer's certificates and mix proportions, shall be submitted to the QP for approval
- Compliance test shall be performed by the Builder
- Type of construction activities and the timing of the works that may be carried out adjacent to an already concreted pile shall be approved by the QP

2.5.1.8 Inspection forms

- QSS should ensure that all inspection forms for all working piles are properly signed off by all project parties and a copy is to be kept on site at all times

2.5.2 Noise nuisance

- Builder shall make reference to the Environmental Pollution Control (Control of Noise at Construction Sites) Regulations
- Noise and vibration shall be monitored in accordance with the provision of SS CP 49
- A copy of SS CP 49 shall be kept on site at all times

2.5.3 Damage to Adjacent Structures

- Vibration monitoring plan shall be prepared by the Builder and submitted by the QP and to the relevant Authority before piling commences
- If the Builder believes additional existing structures are also at risk, he shall bring them to the attention of the QP. Builder shall provide pre-construction survey of the surrounding buildings and structures already identified.
- Protection proposals shall be submitted to the QP in respect of these structures and utilities

2.5.4 Damage to piles

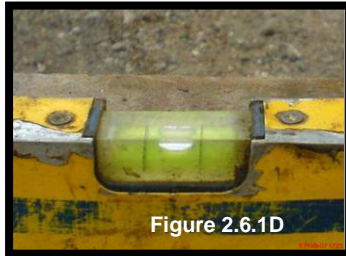
- Damage to completed piles can arise from a number of other factors including adjacent excavations, vehicle impact and the effects of hydraulic breakers and cutters during pile trimming
- Common cause of cracking in piles is the use of machine-mounted hydraulic breakers to trim piles, particularly where the direction of impact is at an angle to the pile axis and especially with small diameter piles which have less resistance to bending and eccentric loading
- Handheld tools should be used when in doubt
- Builder shall take all precautions to prevent the damage to piles

2.6 Displacement Piles (See Appendix 1 for checklist)

- Piles and production facilities shall be made available for inspection at any time
- QP should request any relevant information pertaining to the system to verify the design, since a number of proprietary systems are available
- QP shall consider practical matters such as pile drivability and noise emissions, and the Builder shall be aware of performance criteria such as acceptable ground movements and pile deflections
- Builder shall provide sets calculation for the acceptance of the QP

- Sets obtained by driving formula may give very misleading criteria and hence wherever possible, pile depth should be based on a static design
- Penetration into the founding strata shall be determined by taking into account variations in strength or relative density indicated by the Site Investigation Report and confirmed by the driving resistance achieved
- Builder shall consult the QP on any restrictions on methods to assist driving of piles (by water jetting for instance)
- Pile shall be checked by the site supervisor and Builder for verticality or for its correct inclination before driving commences
- Further checks for verticality and rake shall be made as the driving process is continued
- This is particularly important during the early stages of driving so that early corrective action may be taken
- Positional tolerance (typically 75 mm) may also be checked
- Builder shall submit records of mill certificates (for steel piles) and test certificates to the QP
- As a minimum requirement, a complete driving record or blow count for the first pile on the site or section of site shall be logged, including time of installation, time to join elements and change of packing
- Driving records shall be taken at such intervals as required by the site supervisor and QP basing on site conditions and variability
- QSS could also refer to Appendix 2 as a reference for pile installation record

2.6.1 Quality Control and Site Installation Works



- Steel I-beam is often used for the placing of the piling frame
- Check that the beams are level and stable and before the putting on the frame



- Placing the piling frame on CHS and stabilizing the frame



- Checking of the correct pile size (physical dimensions) is used by measuring tape
- Check marking of pile at every meter to show pile depth



- Check the setting out position and setting up of first pile
- Check pile verticality in each of the two orthogonal directions for every segment of pile



Figure 2.6.1J




Figure 2.6.1K

- Check that every connection are fully welded
- T16 rebar could be used as an aid for connecting to the next pile section to the one driven into the ground
- Verticality should be checked before and after the welding of the connection



Figure 2.6.1L

 福海建築工程私人有限公司 HOCK HAI CIVIL ENGINEERING & BUILDING PTE LTD 8A THONG SOON AVENUE SINGAPORE 787436 TEL: 456-1923 FAX: 456-1923			
FILE NO.	MH2/14	DATE	17/1/07
LENGTH	6+6=12	PILE SIZE	RC150MM
LAGGING	-0.2	SET	
PENETRATION	11.8	T.C.	

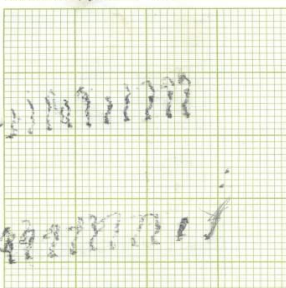


Figure 2.6.1M

- Check the set of the pile based on last ten blows meeting a set criteria specified by the QP (usually determined by Hiley's formula or other approved driving formula)
- Check that the temporary compression is within the value specified by QP



Figure 2.6.1N

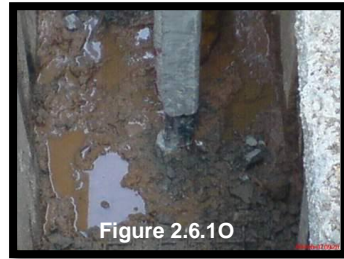


Figure 2.6.1O

Hacking off unwanted piles to cut-off level

- RC driven piles may sometimes cause excessive vibrations to the surrounding
- QSS is to ensure vibrations are measured and are within the allowable limits specified by the QP
- QP may consider using jack-in RC piles in place of driven RC piles in specific site environments
- Non-prestressed RC jack-in or driven piles in soft marine clay areas may give rise to problems involving heave or reverse tensile stress at the toe of the pile
- In such instances, the QP's advice should be sought on possible mitigating measures to be employed on site

2.7 Testing of Piles

2.7.1 Integrity Testing of piles

- Method of integrity testing methods shall be specified by the QP
- It should be noted that these methods do not directly measure the condition of the pile, which is inferred in most cases from acoustic properties
- High Strain Pile Dynamic Analyzer (or PDA) and the Low Strain Pile Integrity Test (PIT) are the more commonly adopted tests
- QSS should ensure the testing works are in accordance to the approved method statements by the design QP
- Proper site test record signed by the site supervisor (from the Builder), the QSS, the piling contractor's representative as well as the specialist carrying out the testing works (where applicable) shall be documented for reference after completion of the test
- Test report shall then be submitted directly to the QP



Figure 2.7.1A



Figure 2.7.1B

Photos of PIT in progress



Figure 2.7.1C



Figure 2.7.1D



Figure 2.7.1E



Figure 2.7.1F



Figure 2.7.1G

Examples of Pile Defects

2.7.2 Static Load Testing of piles (See Appendix 4 and 5)

- Requirement of the static load testing shall be specified by the QP
- 2 types of static tests are commonly adopted locally, namely the Ultimate Load Test (ULT) and the Working Load Test (WLT)
- ULT is normally carried out prior to the installation of the working piles which is normally instrumented as it serves the purpose of verifying the design assumptions used in designing the deep foundation
- WLT is carried out on working piles as a means of quality assurance and checking on the installed deep foundation member
- Test report shall be submitted to the QP
- Builder or the specialist contractor carrying out the testing shall also make reference to other guides published by the relevant authorities in recommending good practices for pile load test
- QSS are also advised to ensure that the pile testing is carried out strictly in accordance to recommended guidelines

stipulated in the Workplace Safety and Health (Construction) Regulation 2007, in particular Clause 132



Objectives of ULT & WLT

- To check and verify that the settlement does not exceed allowable limit
- To verify design parameters used in design (usually instrumented for ULT)
- To estimate the ultimate loading capacity

Test Load	Max. Settlement
2WL	<u>25mm or failure to reach 2WL</u>
3WL	<u>10% pile diameter or failure to reach 3WL</u>

Table 2.7.2A Typical Passing Criteria (ULT & WLT) for bored-piles

Loading		Unloading	
Applied Load (% of Working Load)	Time to Sustain Load	Applied Load (% of Working Load)	Time to Sustain Load
0	-	275	15 min
25	15 min	250	15 min
50	15 min	225	15 min
75	15 min	200	15 min
100	24 hrs	175	15 min
125	15 min	150	15 min
150	15 min	125	15 min
175	15 min	100	15 min
200	24 hrs	75	15 min
225	15 min	50	15 min
250	15 min	25	15 min
275	15 min	0	24 hrs
300	72 hrs		

Table 2.7.2B Typical Loading Sequence (ULT)

Loading		Unloading	
Applied Load (% of Working Load)	Time to Sustain Load	Applied Load (% of Working Load)	Time to Sustain Load
0	-	175	15 min
25	15 min	150	15 min
50	15 min	125	15 min
75	15 min	100	15 min
100	24 hrs	75	15 min
125	15 min	50	15 min
150	15 min	25	15 min
175	15 min	0	24 hrs
200	72 hrs		

Table 2.7.2C Typical Loading Sequence (WLT)

ULT & WLT procedure

There are 2 main systems of static load tests commonly adopted locally; the Kentledge System and the Anchored (or Tension) Pile Reaction System.

- Pile top levels should be measured and recorded immediately after pile build up and before load test
- This is to prevent accidental and undetected loading to the pile
- Before placing the concrete blocks (for the Kentledge System), the ground around the test pile should be levelled and compacted
- The structural integrity of the reaction system shall be properly designed by a PE
- PE should also assess the existing bearing capacity and adequacy of the supporting ground and where necessary, steel plates are placed to ensure stability and safety during loading of the concrete blocks
- For the Anchor (or Tension) Pile Reaction System, the reaction piles (normally prestressed ground anchors or driven steel sections) shall be designed by the piling PE to ensure adequate pull out capacity



Figure 2.7.2B

Preparation of site for static load test set-up

General Sequence of work for setting up of a static load test



Figure 2.7.2C



- Tension or reaction piles (where applicable) are to be driven or installed to designed depth specified by the piling PE
- Weld steel plate onto the pile head prior to the placing of the jack, and provide cement mortar on top surface of pile head if necessary to level the surface and ensure snug contact
- Check that the pile head and the surface of the steel plate are even





Figure 2.7.2G

- Lift and place the jack onto the pile head
- Place the center universal beam across the jack
- Align the jack to the center of the beam
- Place the secondary universal beams
- Place the steel platform
- Place the concrete test blocks in layers (where applicable)
- The tonnage required for a test is the equivalent of the testing load of the test pile plus 10% (or to the piling PE design)



Figure 2.7.2H



Completed set-up of pile load test

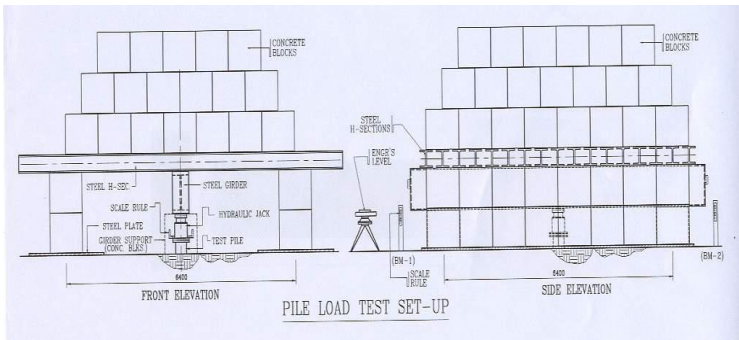


Figure 2.7.2J

Set Up Theodolite and Benchmarks

- Set up the theodolite and two benchmarks on immovable structure or on a pile and it shall not be affected by any movement of the ground due to the test loading or any other causes

- Record the first readings taken from the two benchmarks
- Use tapes to secure the rulers of the benchmark to prevent unauthorized adjustment



Set Up Hydraulic Jack

- The hydraulic hoses are connected to the jack from the hydraulic pump prior to the start of the load test
- The release valve must be properly secured to prevent any tampering of the test
- A general worker needs to guard the test pile if the loading is required to be maintained overnight
- The jack meter needs to be regularly calibrated at an approved laboratory

- Hydraulic pump for the jack shall, when required, be encased in a steel or wooden box under lock and key

Settlement Taking

- Pile level readings are taken with the help of two L-shaped steel bars, welded to the sides of the test pile
- The rulers must be properly secured
- The L-shaped steel bars must be vertical





Pile Testing in progress



高利測量儀器服務私人有限公司
KODI ENGINEERING SERVICES PTE LTD

Co. Reg. No. 199209221P

No. 8, Kallang Road #01-01
Kodi Engineering Services
91114, Singapore 319112
Tel: 6245 9651 (ext. 100)
Fax: 6247 8102
E-mail: kodi@kodieng.com.sg

SOKKIA

CERTIFICATE OF CALIBRATION

Handwritten: 4626A
S-21-3
Chew
10/1/05

Customer Name : P4 ENGINEERING PTE LTD
 Attention To : MS ADELINE / MR THOMAS / MR JAHANGIR
 Project/Site/Office : JALAN MEMBINA
 Brand/Instrument : Sokkia Level
 Model/Serial No. : E24/ 308367
 Report No. : W3191B(A)/ 2004
 Date of Calibration : 3 NOVEMBER 2004
 Next Calibration Due : 2 MAY 2005
 Calibration Warranty Period : 6 MONTHS FROM DATE OF CALIBRATION

This certifies that the accuracy of the above mentioned instrument is acceptable according to SOKKIA instrument's specification. The instrument was checked, calibrated and calibrated with applicable SOKKIA factory procedures (Certificate No. SSC00-02) & traceable to JIS B 7505. The standards used are certified by JQA (No. JQA-6567) in accordance with ISO 9001:2000 / JIS Q 9001:2000.

The testing equipment currently used has been calibrated at the National Measurement of SPRING (SPRING Calibration Report No. E1-002934). These working standards are traceable to national reference standards maintained at SPRING.

Accuracy of Instrument:

	Spec	Error Before Calibrate	After Calibrate (%)		Spec	Error Before Calibrate	After Calibrate (%)
Magnification	24x	Checked	Checked	Compensator Range Perpendicularity of Pressure	± 15'	18'	15'
Circular Bubble	± 0.2 mm	0.2 mm	0.2 mm		± 5 sec	5"	5"
18W Double Run	± 2.0 mm	3.0 mm	2.0 mm				

* Note: Calibrated as according to minimum reading of instrument specified.

Calibration & Checked By



Lawrence Chong
Approval Officer



Approved By



Huang Xiaoxian
Inspector

**MW Group Pte. Ltd.**

196 Pandan Loop - #02-21 Pandech Industrial Complex Singapore 128184
Tel: 65 - 6872 - 0811 - Fax: 65 - 6872 - 1811
E-mail: sales@mwgroup.com.sg
Website: www.mwgroup.com.sg

CALIBRATION REPORT

CLIENT	: P4 PILING PTE LTD	DATE	: 08/09/2006
		PAGE	: 1 OF 4
		CERTIFICATE NO	: 2639
INSTRUMENT	: COMPRESSION CELL	MANUFACTURER	: GEOKON
RANGE	: 0 to 1000 mTou	DATE CALIBRATED	: 08/09/2006
SERIAL NO	: S203/1782	MANUFACTURER RECOMMENDED DUE DATE	: 08/09/2007

The calibration was performed at a constant ambient temperature of $30^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and a relative humidity of 60% \pm 10% R.H.

Reference Standard Used

Equipment : Digital Calibrator
Manufacture : Druck
Serial No : 61014306
Traceability Ref : J6316-S-P

CALIBRATION TRACEABLE TO NATIONAL STANDARDS**Calibration Method**

The unit under test was calibrated against a Digital Calibrator using effective area of 173.263 in². The unit under test was exercised three times to the maximum force and was allowed to settle for 30 seconds before the readings were taken. The readings were recorded in an ascending order from zero to the maximum value.

Calibration Results

Please refer to Page 2

The site environmental conditions were obtained using a Digital Thermohygrometer Serial # C061183.

No adjustments were performed.

The user should determine the suitability for the instrument for its intended use.

The calibration certificate shall not be reproduced in part except in full without the written approval of MW Group Pte Ltd.

Note : This cover page does not form part of the calibration results, part or whole of the work may be subcontracted under International Standard ISO/IEC 17025 Section 4.5.1.





Typical Pressure gauge and Load Cell Calibration Certificates

2.7.3 Pile Instrumentation

- QP shall either specify the instrumentation required or approve the Builder's proposal
- Instrumentation shall not compromise the constructability of the works since this may result in construction defects and invalidate the data obtained
- Selected instruments (for example extensometers, inclinometers, load cells or strain gauges) shall therefore be carefully located and well protected
- Site supervisor shall check the instrumentation according to the approved plans
- Typical spacing of strain gauge = 3m c/c or change in soil strata (and to QP's approval)



Section Three - Shallow Foundations Works

This section provides guidance on the supervision of the construction of shallow foundation such as footings, rafts, mats or other types of compensated foundations.

3.1 Safety of Excavation

- Builder shall comply with the Workplace Safety and Health Act, in particular to the Workplace Safety and Health (Construction) Regulations 2007
- When required under the Regulation or at the direction of the QP, the builder shall engage his own Professional Engineer (PE) to design and supervise temporary works to maintain safety and stability of any excavation
- All temporary works shall be subjected to the approval of the QP and shall be submitted to the relevant Authority when necessary
- Builder and his PE shall regularly inspect the excavation to ensure its safety and stability
- Builder and his PE shall attend promptly to any directions given by the QP and site supervisor on matters relating to safety and stability of the excavation

3.2 Trial Pits

- QP shall decide if trial pits are required before work is carried out
- Location, size and depth of trial pits shall be decided by the QP

3.3 Inspection of Founding Soil Layer

- Builder and site supervisor shall promptly inform the QP of any variation in soil properties encountered during the course of the work
- QP shall inspect the excavated soil and confirm its suitability for the foundation design



Figure 3.3A
Basement raft construction in progress



Figure 3.3B
Footing construction in progress

3.4 Soil Bearing Pressure Tests

- Plate loading tests, if required, shall be specified by the QP and performed at locations selected by the QP
- Builder shall submit method statement of the test for approval by the QP
- Objectives of soil bearing pressure test are used to assure that the in-situ soil strength falls within the design limits and that there shall be no excessive settlement that will give rise to undesirable serviceability issues
- Reference could also be made to CP4:2003 on the recommended bearing capacity for different types of soil or to QP's design and specifications
- Load and settlement readings shall be recorded jointly by the builder and the site supervisor for assessment by the QP

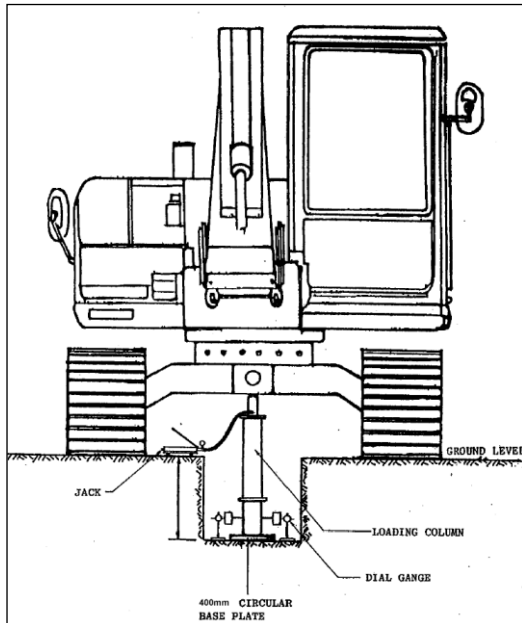


Figure 3.4A

Schematic set-up of plate load test (using excavator as counter-weight)

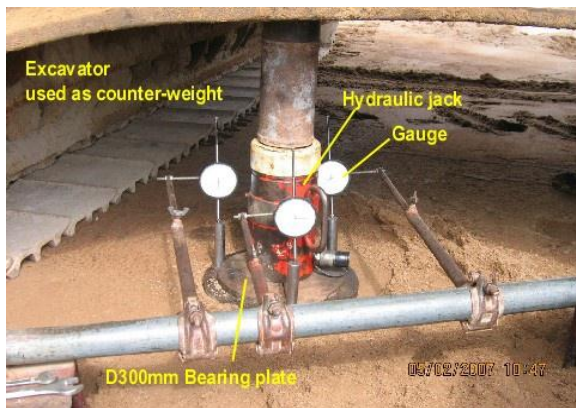


Figure 3.4B

Instruments set-up for plate load test

3.5 Existing Structures and Services

- Care shall be taken to avoid damage to existing structures and services when the new foundation is constructed near to them
- Trial pits shall be carried out to determine the location and extent of existing foundation and services in relation to the new works
- Builder and site supervisor shall promptly inform the QP of any conflict between existing foundation/services and the new foundation
- Excavation that may undermine any existing foundation shall not be carried out without protective measures approved by the QP
- No new foundation shall be constructed over existing foundation and services without the approval of the QP
- Builder and his PE shall carry out stability check and necessary protective and strengthening measures as directed by the Project QP for excavation works near to existing embankments and retaining walls

3.6 Over Excavation

- In cases where the builder has over excavated beyond the intended level of the foundation, the builder shall make good with measures approved by the QP

3.7 Dewatering

- Builder shall keep the excavation dry during the course of construction works by appropriate means
- When dewatering is likely to cause ground settlement and movement of the surrounding areas, the builder and his PE shall carry out necessary measures to avoid such ground settlement and movement

3.8 Excavated Materials

- Builder shall not store or heap excavated materials in a manner likely to endanger the excavated or surrounding areas.
- Builder shall remove such excavated materials immediately when directed by the QP to do so

3.9 Standard Checklist for Shallow Foundation

The standard checklist for shallow foundation covers:

- (a) Soil condition encountered;
- (b) Depth and level;
- (c) Cleanliness of excavation;
- (d) Lean concrete;
- (e) Size and alignment;
- (f) Formwork, rebar and concreting;
- (g) Backfilling; and
- (h) Others.

The above serves as a guide; the QSS should follow project specified requirements and to the satisfaction of the QP.

3.10 Backfilling

- Backfilling shall be in accordance to project specification
- Backfilling shall not cause any damages to existing services and structure

APPENDICES

APPENDIX 1
CHECKLIST FOR DISPLACEMENT PILE

Project: _____ Location: _____
 Pile ref. no: _____ Date: _____
 Drawing ref. no : _____

Description	Compliance		Remarks
	Yes	No	
General:			
Site condition			
Access road condition			
Lighting condition			
Setting-out:			
Pile size			
Pile position			
Offset pegs			
Pile cut-off level			
Existing ground R.L.			
Driving test:			
Drop height			
Driving equipment			
Site condition agree with design assumptions			
Driving pile:			
Working procedures followed			
Any anomaly?			
Splicing of piles:			
Working procedures followed			
Any anomaly?			
Final sets:			
Value			
Proof test:			
Selected for proof test?			
Result			
Reference record			

Submitted by
 Builder's Representative: _____ Date: _____
 Name & signature

Checked by Site
 Supervisor: _____ Date: _____
 Name & signature

Approved by
 Project PE _____ Date: _____
 Name & signature

APPENDIX 4
CHECKLIST FOR STATIC PILE LOAD TEST USING KENTLEDGE STACK

Project: _____
Load test identification: _____

Item	Description	Not satisfactory	Satisfactory	Notes
Safety				
1	Edge of test pile to Kentledge stack support			<ul style="list-style-type: none"> The distance from the edge of the test pile to the nearest part of the crib supporting the kentledge stack in contact with the ground should not be less than 1.5m.
2	Warning signboards provision			<ul style="list-style-type: none"> Adequate warning signboards shall be provided.
3	Safety barricade provision			<ul style="list-style-type: none"> The test pile shall be barricaded to prevent unauthorised entry.
4	Crane age			<ul style="list-style-type: none"> The age of crane shall be less than 15 years old.
Test equipment				
<i>Calibration certificates for:</i>				
5	Pressure gauge			<ul style="list-style-type: none"> Equipment used for the measurement of load and pile movement shall be calibrated by an accredited laboratory. The pressure gauge and hydraulic gauge shall be calibrated together and not separately.
6	Dial gauge			<ul style="list-style-type: none"> For Constant Rate of Penetration (CRP) or Constant Rate of Uplift (CRU) tests, the dial gauge shall be graduated in divisions of 0.02 mm or less, otherwise, the dial gauge shall enable readings to be made to within an accuracy of up to 0.1 mm.
7	Load cell			
8	Hydraulic jack			

APPENDIX 4 (CONTD)
CHECKLIST FOR STATIC PILE LOAD TEST USING KENTLEDGE STACK

Item	Description	Not satisfactory	Satisfactory	Notes
9	Survey levelling instrument			<ul style="list-style-type: none"> Where a level and a staff are used, the level and scale of the staff shall be chosen to enable readings to be made to within an accuracy of 0.5 mm.
	<i>Protection of:</i>			
10	Benchmark			<ul style="list-style-type: none"> The benchmark or independent reference frame shall be protected from weather and tampering.
11	Test equipment			<ul style="list-style-type: none"> All equipment for measuring load and movement shall be protected from the weather and tampering.
	<i>Arrangement and setup of:</i>			
12	Test equipment			<ul style="list-style-type: none"> To ensure that when the hydraulic jack and load measuring device are mounted on the pile head, the whole system will be stable up to the maximum load to be applied, means should be provided to allow the dial gauges to be read from a position clear of the kentledge stack. Test frames containing cables should be fixed in any part of the system will not constitute a hazard to personnel. The equipment used for applying load should consist of one or more hydraulic rams or jacks. The total capacity of the jacks shall be at least equal to the required maximum load. The jack or jacks shall be arranged in conjunction with the reaction system to deliver an axial load to the test pile. The complete system shall be capable of transferring the maximum load required for the test. The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding the maximum working test pressure without leaking. The maximum test load or test pressure expressed as a reading on the gauge or hose shall be displayed and all operators shall be made aware of this limit.

APPENDIX 4 (CONT'D)

Static pile load test using kentledge stack

Item	Description	Not satisfactory	Satisfactory	Notes
Loading				
13	P.E. checks on foundation for Kentledge			<ul style="list-style-type: none"> P.E. endorsed check on the bearing capacity/ foundation calculation for the kentledge base.
14	P.E. checks on adequacy of reaction load			<ul style="list-style-type: none"> P.E. endorsed check on the adequacy of the reaction load for the kentledge test.
15	Acceptance of loading arrangement			<ul style="list-style-type: none"> Plan of test arrangements showing position and distances of kentledge supports. The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing.
16	Acceptance of proposed loading sequence			<ul style="list-style-type: none"> Proposed loading sequence or loading cycle as per specifications.
Concrete strength and pile head				
17	Test cube results			<ul style="list-style-type: none"> Test cubes shall be made from the concrete used in each of the preliminary test piles. The pile test shall not be started until the sample cubes have acquired strength. This requirement shall apply to both pile and pile cap.
18	Pile head construction			<ul style="list-style-type: none"> The pile head or cap shall be formed to prevent damage from the concentrated application of load from the loading equipment. Sufficient clear space shall be made under any part of the cap projecting beyond the section of the pile so that, at the maximum exposed settlement, load is not transmitted to the ground except through the pile.

Submitted by: _____ Name & signature of Builder's Representative _____ Approved by: _____ Name & signature of Project PE _____
 Date: _____ Date: _____

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Singapore 289758

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