

In Collaboration With



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Building Engineering Group (#12-00)

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Dear Sir/Madam

JOINT BCA / IES / ACES / GEOSS CIRCULAR 2016

REQUIREMENTS ON GROUND INVESTIGATION, LOAD TEST AND QUALITY CONTROL TEST FOR FOUNDATIONS OF:

(1) BUILDINGS OF 10-STOREYS OR MORE;

(2) BUILDINGS OF 5 TO 9 STOREYS WITH FOOTPRINT LARGER THAN 100M².

The Building Control Regulations require all buildings to be designed and constructed in compliance with the objective and performance requirements set out in the Fifth Schedule. The Approved Document issued by the Commissioner of Building Control sets out acceptable solutions on how the requirements in the 5th Schedule shall be met. The acceptable solutions comprise a list of tests relating to ground investigation, loading and quality control that must be carried out to ensure that the foundations of buildings are structurally safe.

2 The "BCA/IES/ACES Advisory Note 1/03" issued on 21st Aug 2003 lists out requirements on how the above mentioned tests should be carried out. To stay relevant with Eurocode, this joint BCA / IES / ACES / GeoSS circular 2016 is to update the industry on revised requirements on ground investigation, load test and quality control test for deep foundation. The revised requirements are described in Annex A.

3 The requirements in Annex A shall be complied with when making submissions of structural plans to the Commissioner of Building Control for approval in respect of building foundations for (1) buildings of 10-storeys or more; and (2) buildings of 5 to 9 storeys with footprint larger than 100m². For other types of building works not included in this circular, the requirements in the 5th Schedule of the Building Control Regulations shall be complied with and the submissions of structural plans for such building works will need to reflect how the requirements in the 5th schedule have been met.

4 This circular is for compliance by QPs, ACs, site supervisors, builders and developers with effect from 1 April 2017. The requirements will be applicable to projects where the first structural plans are submitted on or after 1 April 2017, and this circular will supersede Advisory Note 1/03.

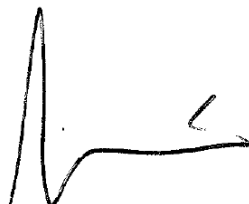
5 **Notwithstanding the requirements in this note, QPs must exercise their independent judgement and evaluation on whether more stringent requirements should be adopted especially where the ground conditions could be adverse or highly variable.**

6 BCA would appreciate it if you could disseminate the contents of this circular to your members. Please contact Dr Yet Nai Song or Er. Brian Phua at Tel 1800-3425222 or email brian_phua@bca.gov.sg if you need any clarification. Thank you.

Yours faithfully



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JOINT BCA / IES / ACES / GEOSSE CIRCULAR ON REQUIREMENTS ON GROUND INVESTIGATION, LOAD TEST AND QUALITY CONTROL TEST FOR FOUNDATIONS OF

(1) BUILDINGS OF 10 STOREYS OR MORE;

(2) BUILDINGS OF 5 TO 9 STOREYS WITH BUILDING FOOTPRINT LARGER THAN 100M²

1. Ground Investigation

For buildings of 10-storeys or more:

- (a) The minimum number of boreholes to be carried out should be 1 per 300 m² of the area of project site, 2 per block of building and not less than 3 per site. The borehole spacing should be between 10m to 30m apart.
- (b) For building supported by piles, the depth of the borehole should be the greater of (i) more than 5m into hard stratum with SPT blow count equal to or more than 100, (ii) more than 3 times the pile diameter beyond the intended pile toe termination.
- (c) For complex geological condition such as limestone, bouldery ground and underground cavities, a more comprehensive ground investigation is essential to establish the geo-hazards and to determine the bearing stratum of piles.

For buildings of 5 to 9-storeys with footprint larger than 100 m²:

The minimum number of borehole required should be 1 per block and not less than 2 per site. The borehole spacing should be between 15m to 40m apart.

- (a) The depth of the borehole should be similar to those for piles supporting buildings with 10-storeys or more.

2. Load Tests and Integrity Tests

2.1 For adequate assessment of the pile capacity and serviceability limit state, it is essential to conduct ultimate load test and working load test.

Table 1 below gives the minimum quantity and type of tests to be carried out on the foundation piles for buildings of 10-storeys or more.

Table 1: Pile test schedule for buildings of 10 storeys or more

Type of Tests	Pile Test Schedule
(a) Ultimate Load Test	1 number or 0.5% of the total number of working piles, whichever is greater
(b) Working Load Test	2 numbers or 1% of the total number of working piles or 1 for every 50 metres length of proposed building, whichever is greater.
(c) Non-Destructive Integrity Test (High-strain dynamic test or sonic logging test)	2 numbers or 2% of the total number of working piles, whichever is greater.

Table 2 below gives the minimum quantity and type of tests to be carried out on the foundation piles for buildings of 5 to 9 storeys with footprint larger than 100 m².

Table 2: Pile test schedule for buildings of 5 to 9 storeys with footprint larger than 100m²

Type of Tests	Pile Test Schedule
(a) Working Load Test	1 number or 0.5% of the total number of working piles, whichever is greater.

2.2 Eurocodes and Singapore National Annex are to take precedence if they impose more onerous requirement on pile testing than Table 1 or Table 2.

2.3 Pile load test should be carried out by maintained loads. For pile load test using maintained loads, pile load should be measured by both calibrated load gauge and calibrated pressure gauge.

2.4 Sonic Logging Test will require pre-installed tubes within the piles to be tested. Under such circumstance which may inevitably lead to the pre-selection of test piles, the Builder and the supervising QP shall ensure that the pre-selected test piles are constructed in the a manner that is representative of the other working piles on site. For sonic logging test, reference could be made to ASTM D6760-08 or other equivalent standards.

2.5 The industry is reminded that for every load test conducted, the Certificate of Supervision on Pile Load Test shall be submitted within 28 days upon completion. Load test report is to be incorporated with the certificate and submit to BCA for record.

2.6 The allowable settlement for pile working load test should be the same as SS CP4:2003. Working load test should be carried out to a minimum of 1.5 times or 2 times of the characteristic load acting on the piles, with the allowable maximum settlement at pile top generally not exceeding 15mm or 25mm respectively.

3. The Use of Rapid Load Test

3.1 If QP assessed that rapid load test is suitable for a project, QP can propose to use this alternative test method to verify the capacities of the working piles, provided that QP has full understanding of the limitations of the test method and have addressed them adequately. QP should ensure that competent personnel are involved in conducting the test and interpretation of the test results in accordance with BS EN ISO 22477-10 or other equivalent standards. QP should also ensure that due engineering allowance is made to account for time-dependent pile creep effect and loading rate effect which cannot be captured in rapid load test.

3.2 For foundation piles of buildings with 10-storeys or more, rapid load test should be calibrated against a static maintained load test to establish the reliability of its test results before it can be used to replace a maintained load test at site. This should be done on the same instrumented ultimate test pile and the rapid load test should be carried out first. For foundation piles of buildings with 10-storeys or more, the replacement with rapid load tests should be limited to not more than 50% of the number of pile working load tests.

4. Quality Control Tests on Bored Piles

With the implementation of Eurocodes, the allowable compressive stress of bored piles under working load condition are no longer restricted to 7.5MPa. Bored piles of the same diameter may be designed to take larger compressive stress as compared to SS CP4:2003.

Table 3 below gives the recommended quality control tests to be conducted on bored piles that are used to support buildings of 10-storeys or more.

Table 3: Quality control test on bored piles for foundations of buildings with 10-storeys or more

Type of Quality Control Test	Recommended Test Schedule
(a) Interface Coring Test at the pile base	5% of the total number of working piles, but may be reduced to 2% if base grouting is carried out. <i>Applicable for piles using characteristic unit end bearing resistance more than 10 MPa in design.</i>
(b) Concrete Core Test below pile cut-off level	5% of the total number of working piles <i>Applicable for piles designed using characteristic concrete cube strength, f_{cu}, greater than 40 MPa and concrete compressive stress under #working load condition greater than 7.5MPa.</i> <i>#Working load condition refer to pile subject to one (1) time of its characteristic load.</i> <i>*Refer to BS EN 12504-1:2009 "Testing concrete in structures" for taking and preparation of cored specimens, testing in compression.</i>
(c) Pile Profile Test (to assess verticality and shapes of pile bore prior to concreting)	100% of working piles with diameter bigger than 1.8m, which either have no steel casing going through soft or loose soil during construction or have no redundancy*. For pile diameter 1.8m or smaller, QP shall exercise their engineering judgement to determine the number of pile profile test needed to assess the verticality and shape of pile bore. <i>*Redundancy can be provided by having more than one pile to support a single column or having tie beams in 2 directions joining individual pilecaps together or having integrated pilecap with base slab.</i>

5. Design and Construction of Bored Piles

5.1 Supervising QP, site supervisors and builders are to ensure that the working piles are installed using the same method of construction as the ultimate test pile and with workmanship no less inferior. Ultimate test pile shall not be constructed under more favourable conditions than the working piles.

5.2 The characteristic shaft resistance of bored piles should not be less than 1.3 times of the characteristic load acting on them, unless method of enhancing the pile base resistance is employed at site with verification by testing.

5.3 Bored piles shall not be constructed without steel reinforcement. Bored piles should be designed for any lateral force acting on them both during construction stage and long term condition. Reinforcement of bored piles should go beyond any soft or loose soil layer. For the identification and classification of soil, refer to BS EN ISO 14688-2:2004.