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**CỌC – PHƯƠNG PHÁP THÍ NGHIỆM BẰNG TẢI TRỌNG TĨNH ÉP DỌC TRỰC
PILES – STANDARD TEST METHOD FOR PILES UNDER AXIAL COMPRESSIVE LOAD**

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1st edition**Cọc - Phương pháp thí nghiệm
bằng tải trọng tĩnh ép dọc trục*****Piles – Standard Test Method for Piles Under Axial Compressive Load*****1. Scope of application**

- 1.1 This standard shall replace the section “Standard test method for Piles under axial compressive load” of the Standard 20 TCN 82-88 “Piles – Field test method”.
- 1.2 Standard defining the field-test method by Axial Compressive Load shall apply for vertical single piles, slanting single piles, does not depend on the dimension and construction method (driving, compression, guiding drill, boring, etc) in construction works. This standard is not applied for bamboo pile, sand pile and loose materials.

2. General provisions

- 2.1 Standard Test method for Piles under Axial Compressive Load (hereinafter referred to as Pile static compression test) can be implemented at phases: investigation for design and project quality checking.
- 2.2 Static compression test at investigation for design phase (hereinafter referred to as Investigation test) shall be implemented before execution of pile in order to determine the necessary data in terms of strength, deformation and relations of loading and displacement of pile for the basis of design or correction of design documents, selection of suitable equipments and technology for construction of pile.
- Note: In case the subgrade soil conditions are known and with experience of pile design for neighbouring area, the investigation test is not necessary.*
- 2.3 Static compression test at project quality checking phase (hereinafter referred to as Check test) shall be implemented during the construction or after completion of pile execution in order to verify the pile capacity according to design and quality of pile execution.
- 2.4 Piles for Investigation test are usually executed separately outside the scope of foundation. Piles for Check test shall be selected into the piles of project foundation.

Notes:

- 1) *The piles of foundation can also be selected for Investigation test with condition that these piles must have excessive strength to sustain the maximum estimated testing load and the displacement of piles must*

7.2 Test shall be implemented according to loading and unloading process of each step, calculated by (%) of designed load. New loading step is increased or decreased when displacement (depression) or recovery of pile head satisfy the conventional stability or adequate defined time.

7.3 The standard loading process shall be implemented as follows:

- a) Loading in steps to maximum test load as estimated, each loading step must not be more than 25% of designed load...The maximum loading step is remained until the depression of pile head reach the convetional stability or in 24 hours, which is longer.
- b) When completion of loading, if pile is not failed, unloading to 0, each unloading step is equal to 2 times of loading step and load maintaining time of each step is 30 minutes, particularly loading step 0 can be longer, but not more than 6 hours.

Notes:

- 1) *Value of each loading step can be taken by 10%, 15% or 20% of designed load;*
- 2) *Load maintaining time of 100% designed load can be lengthen to 6 hours to monitor the estimated displacement;*
- 3) *When availability of conformance, testing according to other special process can be applied (see Appendix 1).*

7.4 If cycled test is required, loading process is implemented as follows:

- a) 1st cycle: loading to defined load (normally to 100% of designed load), then unloading to 0. Value of each loading and unloading steps and load maintaining time is similar to standard loading process (article 7.3).
- b) 2nd cycle: reloading to last step of 1st cycle, load maintaining time of each step is 30 minutes, contineously loading to last step of 2nd cycle, then unloading to 0 as step (a).
- c) Loading next cycles is repeated as (b) to failure load or maximum load as anticipated, according to principle of last loading step of next cycle that is bigger than previous one.

Notes:

- 1) *Number of testing cycles shall be determined by Design consultant basing on testing purpose;*
- 2) *Loading step can be doubled or loading once to last step of previous cycle when reloading of next cycle.*

7.5 Not depending on testing purpose, the values in terms of time, load and settlement of pile head must be measured and recorded after increasing or decreasing of load according to defined time period at table 7.1. The

horizontal movement of pile head, movement of reaction system or of standard beam can be measured when required.

Table 7.1. Time for monitoring of settlement and recording data

Loading step	Monitoring and reading period
Loading step	Not exceeding 10 minutes once for first 30 minutes Not exceeding 15 minutes once for next 30 minutes Not exceeding 30 minutes once for next 1 hour Not exceeding 1 hour once for next 10 hours Not exceeding 2 hours once for > last 12 hours
Reloading and unloading steps	Not exceeding 10 minutes once for first 30 minutes Not exceeding 15 minutes once for next 30 minutes Not exceeding 1 hour once for > 1 hour

7.6 Displacement speed is considered to reach the conventional stability if reach following values:

- a) Not exceeding 0.25mm/h for piles into soil clay with big clod, sandy or clay from plastic to hard.
- b) Not exceeding 0.5 mm/h for friction pile in soft plastic to loose plastic.

7.7 Maxium test pile sh.all be stipulated by design, normally taken as follows:

- a) For probe test pile: by failure load or 250 to 300% of designed load;
- b) For checking test pile: 150-200% of designed load.

7.8 Monitoring and treatment of some cases can be occurred during loading process:

- a) Numeric value of loading step can be increased at first step if pile settlement is unremarkable or decreased when loading nearly to failure load to detemine accurately the failure load.
- b) In case pile is failed under maximum loading step as anticipated, it can be decreased back to previous loading step and maintained as regulated.
- c) In case at estimated maximum loading step, pile is not failed, if required by Design consultant to determine the failure load and allowable loading condition, loading can be continued and taken as 10% of designed load at each loading step, loading period between steps is 5 minutes to determine failure load.

7.9 To draw the diagram of relations between load - displacement and displacement – time of each loading step to monitor the development of testing process.

7.10 During test time, the observation and monitoring must regularly be made for state of test piles, elasticity of land anchor bar or connecting bar of anchor pile with load bearing beam system, movement of loading truss, etc...to timely have treatment methods.

7.11 Probe test pile is considered failure if:

- a) Total settlement of pile head exceeds 10% of diameter or width of pile section including elastic deformation of pile when necessary.
- b) Materials of failure pile.

7.12 Test pile is considered unaccepted if:

- a) Pile is failed in accordance with regulations at article 7.11;
- b) Total settlement of pile head under maximum test load and excessive deformation of pile exceed regulations in draft.

7.13 Test is considered completed if:

- a) Achieve testing purpose according to draft.
- b) Test pile is failed.

7.14 Test must be paused if following phenonmenons are discovered:

- a) The bench marks are placed at incorrect place, unstably or failed;
- b) Jack or monitoring devices are not operated or incorrect;
- c) Reaction system is unstable.

Testing can be continued after processing and recovering.

7.15 Test shall be cancelled if discover:

- a) Pile is compressed before loading;
- b) States mentioned at article 7.11 can not be recovered.

8. Processing and reporting test result

8.1 Test data are analysed, processed and tabulated as regulations at Appendix C, including:

- a) Test data table
- b) Summary of test result

8.2 From test data, relation diagrams are established as follows:

- a) diagram of load – displacement
- b) diagram of displacement – time of loading step
- c) diagram of load – time
- d) diagram of displacement – load – time.

Note: For sample of diagrams, refer to Appendix B. Scale of diagram between load (S) – displacement (P) is taken as $S / P = 1110 - 1120$ (the bigger P_{max} , the smaller scale).

8.3 From test result, limit load capacity of single pile can be determined by following method:

a) Graph method basing on curve form of relations between load – displacement:

- In case the curve rapidly changes, implying this point at slope dramatically changed (hereinafter referred to as bending point), limit load capacity is equal to load and equivalent to beginning variation point of curved line.
- If curved line changes slowly, the bending is difficultly or impossibly determined, basing on loading method and testing process to select determination method of limit load capacity (refer to Appendix B).

Note: Value of limit load capacity determined by various methods can be different.

b) Limit displacement equivalent to limit load capacity

Limit load capacity by load equivalent to displacement of 10% of diameter or width of pile.

Note: Elastic deformation of pile is calculated by $PLIEA$, where P is imposed load, E is elastic module of pile material, sL is pile length, A is pile section area.

c) With consideration to actual testing and test pile:

- Limit load capacity by maximum load when stopping the test (In case the test must be stopped earlier than foreseen because of limit loading condition).
- Limit load capacity by ...

8.4 Allowable load capacity of single vertical pile is determined by limit load capacity deviding safety coefficient.

8.5 Basing on the importance level of project, subgrade soil condition, testing method and determination method of limit load capacity, Design consultant shall decide to apply suitable safety coefficient for specific case (refer to Appendix E).

9. Testing result report

9.1 General

- a) Characteristic of project;
- b) Characteristic of testing site;

- c) Geotechnical conditions (test result at field and in room, diagram of investigation points, cylinder of boring hole nearest the testing pile, etc.)

9.2 Characteristic of testing pile

- a) Number and place of pile;
- b) Equipments and construction method of pile;
- c) Pile type;
- d) Pile material;
- e) Pile dimension (length, diameter);
- f) Level of pile head, pile toe;
- g) Characteristic of reinforcement;
- h) Testing result of concrete sample strength;
- i) Type of testing pile (probe, checking);
- j) Designed load of pile;
- k) Test load and maximum displacement as anticipated.

9.3 Testing diagram and equipments

- a) Date of testing;
- b) Type of testing;
- c) Number of testing pile;
- d) Basic description of test equipments;
- e) Diagram of test piles and test equipment system;
- f) Diagram of monitoring system;
- g) Verification certificates of test equipments

9.4 Testing process

- a) Testing cycle;
- b) Loading and unloading process;
- c) Table for monitoring and recording testing data at field.

9.5 Expression of testing result.

9.6 Conclusion, suggestion on testing result.

10. Safety work

Beside the regulations on labour safety in construction, following regulations must also be observed in testing:

10.1 People with no responsibility are not allowed to enter testing area.

10.2 Waste, broken brick, pasty mud, grease and oil, etc. on testing field must be cleared.

- 10.3 The measures for testing equipments, machine protected against rain and wind, sunny.
- 10.4 Jack, pump and hydraulic piping, valve systems, connection head must be periodically checked and cleared. The damaged parts must be timely replaced.
- 10.5 The installation and dismounting of counterbalance must be implemented with suitable safety methods.
- 10.6 Dismantlement of supporting, anchor, etc. and clearance of testing area to ensure the safety for construction plan.
- 10.7 After completion of test, the whole test equipments must be dismantled, transported out of the field and carefully maintained.

Appendix A

(regulation)

DIAGRAM OF TESTING EQUIPMENTS

FIGURE A1

Figure A1 – Loading by hydraulic jack, kentledge and counterbalance are used as reaction

FIGURE A2

**Figure A2 – Loading by hydraulic jack, anchor piles
Are used as reaction**

FIGURE A3

**Figure A3 – Loading by hydraulic jack, kentledge and counterbalance
combined with compression piles are used as reaction**

FIGURE A4

Figure A4 – Loading by hydraulic jack,

Appendix B

(Regulation)

DIAGRAM OF RELATIONS

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Figure B1 – Diagram of load – displacement relations

Figure B2 – Diagram of displacement – time relations

Figure B3 – Diagram of load – displacement time relations

Figure B4 – Diagram of load – time relations

Appendix C

(regulation)

SAMPLE OF RECORDING TEST DATA

Name of project:					Pile number:									
Location:					Pile dimension:									
Date of testing:					Pile length:									
Tester:					Max load test:									
Checked by:					Loading method:									
Date of testing	Test time	Monitoring time	Test load		Displacement meter				Settlement of pile head (mm)					Remark
			% designed load	Test load (ton)	Meter No.1	Meter No.2	Meter No.3	Meter No.4	Settlement S1	Settlement S2	Settlement S3	Settlement S4	Average settlement	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)

Note:

- (1) Date, month of testing
- (2) Testing time
- (3) Reading time
- (4) % designed load (unit: %)
- (5) Test load (ton)
- (6) (7) (8) (9) Settlement
- (10) (11) (12) (13)
- (14) Settlement of pile head
- (15)

SUMMARY OF TEST RESULT

Test cycle	Test load (ton)	Load maintaining time (hour,minute)	Settlement of pile head	Remarks

Appendix D

(reference)

SOME SPECIAL TESTING PROCESS

The loading processes mentioned hereinafter are mainly applied for single pile. Requirements on test equipments and preparation works are similar to regulations in the Standard.

D1. Constant Time Interval Loading

D.1.1 Loading process

Loading and unloading are placed in steps, each step is by 20% of designed load, load maintaining time is 1 hour (or any fixed time).

D.1.2 Recording data

Monitoring and recording data according to loading process with low speed.

Note: This method is recommended for use in standard ASTM 1143-81.

D2. Quick Load test for Individual Piles

D.2.1 Loading process

- a) Loading to maximum load, each step is 10% - 15% of designed load, load maintaining time is 2.5 minutes.
- b) After 5 minutes, keeping at maximum load, unloading up to 0.

D.2.2 Recording data

- a) Recording data before and after loading of each step.
- b) At each maximum loading step, recording data when stopping loading and after at every 2.5 minutes and 5 minutes.
- c) Recording data after unloading up to 0 and after at every 2.5 minutes and 5 minutes.

Note: *This method is recommended for use by New York Traffic Department, Federal high speed management Department and Standard ASTM 1143 81.*

D3. Constant Settlement Increment Loading Method

D.3.1 Loading process

- a) Load is regulated during loading with constant settlement (by 1% of pile diameter or width).
- b) No loading in 1 hour, changing rate of load is smaller than 1% of total load.

- c) Continue loading until the settlement of pile reaching 10% of pile diameter or width (or loading ability of jack is over).
- l) After maintaining the last settlement increment, unloading up to 0 through 4 steps. New loading step is not decreased if in 1 hour, recovery of previous loading step is smaller than 0.3% of pile diameter and width.

D.2.2 Recording data

- h) Recording data at suitable time to determine the alternative rate of load to maintain the constant settlement increment and recovery speed.
- b) After unloading up to 0, recording the last data after 12 hours.

Note: *This method is recommended in Standard ASTM 1143-81.*

D4. Constant Rate of Penetration Method – CRP

D.4.1 Testing equipments

Testing equipments are similar as regulated in the Standard. Particularly hydraulic pump must be with flow control valve to regulate the loading speed.

D.4.2 Loading process

- a) Load is regulated during loading period so that the settlement speed of pile varies from 0.01 to 0.05 in. (0.25 to 1.25 mm/minute) for cohesive soil or 0.03 to 0.10 in. (0.75 to 2.5 mm/minute) for loose soil or otherwise specified.
- b) Continue loading until no need for loading but pile still keeps the settlement with defined speed.
- c) Maintain the loading with specified settlement speed until the total settlement at least by 10% of pile diameter or width.
- d) Unloading when pile stops its settlement at maximum loading step.

D.4.3 Recording data

- a) Recording data at least every 30 seconds or according to suitable time to determine the settlement speed of pile.
- b) When pile reach the specified speed, continue recording the data during loading time and determine the maximum load.
- c) Recording the unloading data, at unloading step of 0, recording the last data after 1 hour.

Note: *This method is recommended by Sweden Committee on pile foundation, New York Transport Department and Standard ASTM 1143-81.*

D5. Swedish Cyclic Load Method

D.5.1 Loading process

- a) Loading up to 1/3 of designed load.
- b) Unloading up to 1/6 of designed load.
- c) Repeat loading, unloading as above for 20 times.
- d) Loading to step more than 50% previous loading step (a), after that repeat to step (a) and (b).
- e) Continue as above to failure load.

D.5.2 Recording data

- a) Recording data before and after loading of each step.
- b) At maximum loading step, recording data when stopping loading and after at every 2.5 minutes and 5 minutes.
- c) Recording data after unloading up to 0 and after at every 2.5 minutes and 5 minutes.

Note: *This method is recommended by Sweden committee on pile foundation.*