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Approval & Reception Procedure

DMC – Departamento de Materiais de Construção		
PHC Pile Sections	Document no.	**ARP/DMC/017**
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1 Reference standard

The Reference standards are GB 13476-99, JIS A5337-95, BS EN 12504-1:2009, JC/T 947-2005, Certification Rules for Prestressed High-Strength Concrete Piles.

2 Approval procedures

2.1 Definitions

- PHC Pile sections : Cylindrical prestressed hollow pile elemental component, of precast high strength concrete, using spinning process, with a specified concrete strength of 80 MPa, and including end steel plates, to enable weld connections between elements.
- Bending strength test : Including cracking moment and ultimate moment.
- Pile section model : Pile sections of the same type, with the same diameter and thickness, regardless of their length.
- Pile section type : Classification of pile sections according to the specified limit value of cracking moment and ultimate moment for bending.
- Inspection lot : Quantity of pile sections, of the same manufacturers, models, types, delivered to site and submitted for reception.
- Inspection unit : The number of piles per inspection lot of ten with a production interval not exceeding three months.

2.2 Approval of the manufacturer

2.2.1 Manufacturers certified by LECM

Manufacturers with the factory Production Control System certified by LECM may be considered approval for supply of pile sections to Macau when the follow conditions are satisfied. The LECM's web site gives permanent information on current status of all certified manufactures.

a) Concrete mix composition, origin of constituent materials, valid certification, pile section bending strength test results for each pile section models, types to be used in the project, not older than six months, performed by a recognized testing laboratory.

b) Manufacturers should have arranged for LECM to conduct a factory inspection within the preceding three months and submit raw material sampling test reports covering the physical and

chemical properties of aggregates, spiral wire and prestressing strands. Only if the test results comply with the requirements will their supply qualification be approved.

2.2.2 Manufacturers not certified by LECM

Manufacturers wishing to supply to Macau the pile section models, types to be used in a project, must follow the procedure for approval presented below:

2.2.2.1 The following information concerning the pile section models, types shall be submitted for verification.

a) Pile section catalogue of the proposed factory.

b) Information regarding the factory Production Control System, namely about the following items:
   - quality manual and the related quality documentation;
   - technical information about the sources of raw materials and the related recent test results;
   - product test results and testing plans;
   - testing laboratory facilities, relevant test procedures, as well as calibration of all testing equipment.

c) Statistical summary of:
   - concrete compressive strength test results and
   - Spiral wire and prestressing strands tensile strength test results,

   for the last six months, including, at least, the testing frequency and the average, standard deviation, maximum and minimum values of the test results. Conformity with the product standard requirements shall be demonstrated.

d) Pile section bending strength test results for each pile section model, type to be used in the project, not older than three months, performed by a recognized testing laboratory. Results of tests performed at the factory, under the supervision of a recognized institute, may also be accepted if accompanied by:
   - test procedure;
   - list of testing equipment used and copy of the calibration certificates;
   - test report prepared by the institute responsible for test execution or supervision;
   - qualification of the institute responsible for test execution or supervision.

e) Test results of:
- alkali content of cement;
- potential reactivity of aggregates with cement alkalis and
- chloride content of river sand

not older than one month, as supplementary information for assessment of the quality of the raw material used in the PHC pile section. These tests shall be performed by a recognized testing laboratory and their results shall comply with the Macau Standard for Concrete.

2.2.2.2 After submission of the documentation, a visit of LECM to the factory must be arranged, in order to verify the implementation of the factory Production Control System, technical and quality competence for the regulation. During the inspection, concrete compressive strength and bending strength test of each pile model, type must be tested, aggregates, spiral wire and prestressing strands must be sampled for physical and chemical property test. The supply can only be approved after the test results meet the requirements.

3 Reception procedure

After approval of the manufacturer, reception tests must be carried out in the pile sections to be used in the project.

3.1 Reception test

3.1.1 Reception tests can be categorised into three aspects, as described below:
- Bending strength test: following the Chinese standard GB 13476-99 or the Japanese standard JIS A5337-95, performed on one sample of two pile sections.
- Concrete compressive strength test and verification of spiral wire and prestressing strands diameter: following BS EN 12504-1:2009, performed on 3 sets of 2 cores (total 6 number) for each sample pile section, taken normal to the length of the pile section from 3 transverse sections; the core diameter is 70 mm for pile section thickness lower than 125 mm and 100 mm for pile section thickness higher than or equal to 125 mm.

  After the completion of concrete compressive strength test, one of the six cores will be broken in order to obtain the spiral wire and prestressing strands for further verification of diameter.
- Dimensional and visual inspection:

Item	Followed Standard / Specification
Dimension and appearance of PHC pile sections	Chinese Standard GB13476-99 or Japanese standard JIS A5337-95
Appearance of steel joint plate	Chinese Standard JC/T947-2005
Dimension and appearance of pile shoes	Model, type of PHC pile section manufacturer's specification

3.1.2 For the manufacturer certified by LECM, before delivery, bending strength tests should be submitted, not older than six months, performed by a recognized testing laboratory.
For the manufacturer not certified by LECM, bending strength tests must be performed, as reception tests, by an independent, recognized testing laboratory or at the factory under the supervision of a recognized institute, in the same conditions as referred in 2.2.2.1 d). The testing frequency mainly depends on the pile section model, type, as defined in the Chinese and in the Japanese standards mentioned above. For each inspection lot, 1 sample of 2 pile sections shall be tested for each pile section model, type.

3.1.3 All pile sections delivered to site shall be accompanied by a delivery list issued by the factory indicating the pile section model, the pile section identification, the casting date and the visual inspection record.

The pile sections delivered on site shall be divided into inspection lots for concrete compressive strength tests, verification of spiral wire and prestressing strands diameter, and dimensional and visual inspection. The composition of each inspection lot, including also the quantity of pile shoes, shall be submitted before the performance of reception test. For the pile shoes not fabricated by the manufacturer of pile sections, mill certificate of constituent material shall be submitted together. All tests must be performed by an independent, recognized testing laboratory.
The lot size and the sampling frequency are presented in Table A for manufacturers that are certified by LECM and in Table B for manufacturers that are not certified by LECM.

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Table A – Lot size and sampling frequency
for manufacturers certified by LECM

Total length of each pile section model used in the project (m)	Lot size (each inspection lot)	Concrete compressive strength test	Dimensional and visual inspection
< 500	All pile sections	- -	10 pile sections and 10% of pile shoes with a minimum of 1 pile shoes
≥ 500	≤ 200 pile sections	0.5% of the pile sections	10% of the pile sections and pile shoes with a minimum of 10 pile sections and 1 pile shoes

Table B – Lot size and sampling frequency
for manufacturers not certified by LECM

Total length of each pile section model used in the project (m)	Lot size (each inspection lot)	Concrete compressive strength test	Dimensional and visual inspection
< 20,000	≤ 200 pile sections	1.5% of the pile sections	10% of the pile sections and pile shoes with a minimum of 10 pile sections and 1 pile shoes
≥ 20,000	≤ 200 pile sections	1.5% of the pile sections for the first 20,000 m and 0.5% for the remaining	10% of the pile sections and pile shoes with a minimum of 10 pile sections and 1 pile shoes

3.1.4 For the manufacturer certified by LECM, all pile sections delivered to the site must be accompanied by a mechanical and durability performance test report for each inspection unit. This includes tests for chloride content of hardened concrete, alkalis-aggregate reactivity, tensile test for prestressing strands and proof of origin for aggregates used in the inspection unit.

3.1.5 For the manufacturer not certified by LECM, all pile sections delivered to the site must be accompanied by a mechanical and durability performance test report for each inspection lot. This includes tests for chloride content of hardened concrete, alkalis-aggregate reactivity, tensile test for prestressing strands and proof of origin for aggregates used in the inspection unit.

3.1.6 Random inspections of pile section and raw materials can be conducted during the supply period if required by the project or if concerns are raised by relevant parties.

3.1.7 Pile sections or pile shoes belonging to each inspection lot cannot be used before acceptance of the reception tests

4 Acceptance criteria

4.1 As regards the pile section cracking moment reception test and only for manufacturer not certified by LECM, from the production of each pile section model, type to be delivered to a particular project, samples will be chosen for testing according to the frequency defined in 3.1.2. Any tested pile sections shall display no sign of cracking when the specified cracking moment is reached. In case both pile sections fail to meet the test requirement, the whole production of this pile section model shall be rejected. In case one of the pile sections fails to meet the test requirement, four additional pile sections from the same production and model, type will be tested. If any one of these four pile sections fails, the whole production of this pile section model, type shall be rejected.

4.2 As regards the concrete compressive strength and the diameter of spiral wire and prestressing strands, all conditions below shall be verified for each inspection lot:

- The average value of six estimated in-situ cube strength results (calculated as indicated in 4.4) should not be less than the specified strength (80 MPa);
- The estimated in-situ cube strength result of any individual core (calculated as indicated in 4.4) should not be less than 85% of the specified strength (68 MPa);

- For pile sections which outer diameter ≦ 450 mm, the diameter of spiral wires shall not be less than 4 mm, diameter of prestressing strands should compliance with the LECM Certification Rules for Prestressed High-Strength Concrete Piles;
  For pile sections which outer diameter 500 mm ~ 600 mm, the diameter of spiral wires shall not be less than 5 mm, diameter of prestressing strands should compliance with the LECM Certification Rules for Prestressed High-Strength Concrete Piles;
  For pile sections which outer diameter 800 mm ~ 1000 mm, the diameter of spiral wires shall not be less than 6 mm, diameter of prestressing strands should compliance with the LECM Certification Rules for Prestressed High-Strength Concrete Piles;

In case of failure to meet all above requirements, all the pile sections of the same model, type and casting date will be deemed to be unacceptable for the project and shall be rejected. Two additional pile sections from the same inspection lot, but from different casting dates, shall be used for further verification. If any one of these two tests fails to comply with all above requirements, all the pile sections of the inspection lot shall be rejected and all the pile sections of the same model, type and casting date will be deemed to be unacceptable for the project and shall be rejected.

After non-compliance of two consecutive inspection lots with the above requirements, all pile sections of the same model, type will be deemed to be unacceptable for the project and shall be rejected.

4.3 As regards dimensional and visual inspection, all inspected pile sections must meet the following criteria. Each pile section that fails to comply with this requirement must be rejected. Two additional pile sections shall be inspected for each non-conforming pile section.

Item	Followed Standard / Specification
Dimension and appearance of PHC pile sections	Chinese Standard GB13476-99 or Japanese standard JIS A5337-95
Appearance of steel joint plate	Chinese Standard JC/T947-2005
Dimension and appearance of pile shoes	PHC pile section manufacturer's specification

4.4 The compressive strength of the cores shall be adjusted for length / diameter ratio and converted to estimated in-situ cube strength in accordance with BS EN 12504-1:2009.

4.4.1 Estimated in-situ cube strength

4.4.1.1 For cores free of reinforcement: Calculate the estimated in-situ cube strength to the nearest 0.5 N/mm2 from the equation

$$\text{Estimated in-situ cube strength} = \frac{D}{1.5 + \frac{1}{\lambda}} \; x \; \text{Measured compressive strength of core}$$

where

D is 2.5 for cores drilled horizontally (for precast units perpendicular to height when cast);

λ is the length (after end preparation) / diameter ratio.

NOTE: It should be noted that in-situ strengths estimated from the above formula cannot be equated to standard cube strengths.

4.4.1.2 For cores with reinforcement perpendicular to the core axes: Calculate the estimated in-situ cube strength by multiplying the strength obtained from the formula in 4.4.1.1 by the following factors:

- for cores containing a single bar:

$$1.0+1.5\ \frac{\phi_r \cdot d}{\phi_c \cdot \ell}$$

- for specimens containing two bars no further apart than the diameter of the larger bar, only the bar corresponding to the higher value of $\phi_r \cdot d$ need be considered. If the bars are further apart, their combined effect should be assessed by using the factor:

$$1.0+1.5\ \frac{\sum \phi_r \cdot d}{\phi_c \cdot \ell}$$

where

ϕ_r is the diameter of the reinforcement;

ϕ_c is the diameter of specimen;

d is the distance of axis of bar from nearer end of specimen;

ℓ is the length of the specimen after end preparation by grinding or capping.

4.5 For raw materials, compliance with the LECM Certification Rules for Prestressed High-Strength Concrete Piles and the standards listed in the reference standards is required.