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**Standard for test methods of long-term performance and
durability of ordinary concrete**

普通混凝土长期性能和耐久性能试验方法标准

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Standard for test methods of long-term performance and durability of ordinary concrete

1 General provisions

1.0.1 This standard is formulated in order to standardize and unify the long-term performance and durability test methods of concrete and improve the concrete test and detection level.

1.0.2 This standard is applicable to long-term performance and durability testing of ordinary concrete during engineering construction activities.

1.0.3 This standard specifies the basic technical requirements for long-term performance and durability testing of ordinary concrete. When this standard conflicts with the provisions of national laws and administrative regulations, the provisions of national laws and administrative regulations shall be implemented.

1.0.4 In addition to complying with the provisions of this standard, the long-term performance and durability tests of ordinary concrete shall also comply with the provisions of the current national standards.

2 Terms

2.0.1 Ordinary concrete

Cement concrete, which has a dry apparent density of $(2000 \sim 2800) \text{ kg/m}^3$.

2.0.2 Resistance grade to freezing-thawing of concrete

The freezing resistance class of concrete, which is divided by the maximum number of freeze-thaw cycles, as measured by the slow freezing method.

2.0.3 Resistance class to freezing-thawing of concrete

The freezing resistance class of concrete, which is divided by the maximum number of freeze-thaw cycles, as measured by the quick freezing method.

2.0.4 Test method for coulomb electric flux

A test method, that uses the electric flux passing through a concrete specimen to reflect the resistance of concrete to chloride ion penetration.

exceed the side length or 0.0005 of diameter of the specimen.

3.3.2 Except for the water penetration resistant specimen, the angle between adjacent faces of all other specimens shall be 90°; the tolerance shall not exceed 0.5°.

3.3.3 Except for the dimensional tolerances of specially specified specimens, the tolerance of each side length, diameter or height of all specimens shall not exceed 1 mm.

3.4 Preparation and curing of specimen

3.4.1 The preparation and curing of specimens shall comply with the provisions of the current national standard "Standard for test method of mechanical properties on ordinary concrete" GB/T 50081.

3.4.2 When preparing specimens for long-term performance and durability tests of concrete, hydrophobic release agents shall not be used.

3.4.3 When preparing specimens for long-term performance and durability tests of concrete, it should simultaneously prepare specimens for concrete cube compressive strength corresponding to the durability performance test age.

3.4.4 When preparing specimens for long-term performance and durability tests of concrete, the vibration table and mixer used shall comply with the current industry standards "Vibrating table for concrete test" JG/T 245 and "Mixers for concrete test" JG 244, respectively.

3.5 Test report

3.5.1 The content provided by the entrusting organization shall include the following items:

- 1 Name of the entrusting organization and witnessing organization.
- 2 Project name and construction location.
- 3 Name of the item required to be tested.
- 4 Other things to note.

3.5.2 The content provided by the specimen preparation organization shall include the following items:

- 1 Specimen number.
- 2 Date of specimen preparation.

- 3 Concrete strength grade.
- 4 Shape and size of specimen.
- 5 Types, specifications, origin of raw materials, as well as concrete mix proportions.
- 6 Curing conditions.
- 7 Test ages.
- 8 Other things to note.

3.5.3 The content provided by the testing or inspection organization shall include the following items:

- 1 Date the specimen is received.
- 2 The shape and size of the specimen.
- 3 Test number.
- 4 Test date.
- 5 Name, model, serial number of the instrument and equipment.
- 6 Test chamber temperature (humidity).
- 7 Curing conditions and test age.
- 8 Actual strength of concrete.
- 9 Test results.
- 10 Other things to note.

4 Test methods for resistance of concrete to freezing and thawing

4.1 Test method for slow freezing and thawing

4.1.1 This method is suitable for determining the frost resistance of concrete specimens, which is expressed in terms of the number of freeze-thaw cycles they have endured, under air-freezing and water-thawing conditions.

4.1.2 The specimens used in the freezing resistance test, by slow freezing method, shall meet the following requirements:

20 ~ 20) °C; the measurement accuracy shall be ± 0.5 °C.

4.1.4 The slow freezing test shall be carried out according to the following steps:

- 1** The specimens of the freeze-thaw test, which are cured in the standard curing chamber or under the same conditions, shall be taken out from the curing location in advance, when the curing age is 24 days. Then the specimens shall be soaked in (20 ± 2) °C water. The water level shall be (20 ~ 30) mm higher than the top surface of the specimen, during immersion. The immersion time in water shall be 4 days. The freeze-thaw test shall be started, when the specimen reaches 28-day age. For freeze-thaw specimens that are always cured in water, when the curing age of the specimen reaches 28 days, subsequent tests can be directly conducted. This situation shall be explained in the test report.
- 2** When the curing age of the specimen reaches 28 days, it shall take out the specimen for the freeze-thaw test in time; use a damp cloth to wipe off the surface moisture, to measure the appearance dimensions. The appearance dimensions of the specimen shall meet the requirements of Clause 3.3 of this standard. They shall be numbered and weighed respectively, then placed into the specimen rack according to the number. The contact area between the specimen rack and the specimen should not exceed 1/5 of the bottom surface of the specimen. There shall be a gap of at least 20 mm between the specimen and the inner wall of the box. A gap of at least 30 mm shall be maintained between each specimen in the specimen rack.
- 3** The freezing time shall be calculated, when the temperature in the freeze-thaw box drops to -18 °C. The time required from the time the specimen is installed until the temperature drops to -18 °C shall be within (1.5 ~ 2.0) h. The temperature inside the freeze-thaw box shall be maintained at (-20 ~ -18) °C during freezing.
- 4** The freezing time of the specimen in each freeze-thaw cycle shall not be less than 4 hours.
- 5** After freezing, it shall add water at a temperature of (18 ~ 20) °C immediately, to transfer the specimen to a thawing state. The time for adding water shall not exceed 10 minutes. The control system shall ensure that the water temperature is not lower than 10 °C within 30 minutes, meanwhile the water temperature can be maintained at (18 ~ 20) °C after 30 minutes. The water level in the freeze-thaw box shall be at least 20 mm higher than the surface of the specimen. The thawing time shall not be less than 4 h. The completion of thawing is considered as the end of the freeze-thaw cycle; then it can enter the next freeze-thaw cycle.
- 6** It should perform a visual inspection on the freeze-thaw specimen once every 25 cycles. When serious damage occurs, weighing shall be carried out immediately. When the average mass loss rate of a group of specimens exceeds 5%, it may stop the freeze-thaw cycle test.

7 After the specimen reaches the number of freeze-thaw cycles specified in Table 4.1.2 of this standard, the specimen shall be weighed and visually inspected; it shall carefully record the surface damage, cracks, corner defects of the specimen in detail. When the surface of the specimen is seriously damaged, it shall be leveled with high-strength gypsum first; then the compressive strength test shall be carried out. The compressive strength test shall comply with the relevant provisions of the current national standard "Standard for test method of mechanical properties on ordinary concrete" GB/T 50081.

8 When the freeze-thaw cycle is interrupted for some reason and the specimen is in a frozen state, the specimen shall continue to remain frozen, until the freeze-thaw test is resumed. The cause of the failure and the suspension time shall be noted in the test results. When the specimen is interrupted for any reason while it is in a thawing state, the interruption time shall not exceed the time of two freeze-thaw cycles. During the entire test, the number of interruption failures which have a duration exceeding two freeze-thaw cycles shall not exceed two.

9 When some specimens are taken out due to failure or discontinuation of testing, blank specimens shall be used to fill the gaps.

10 The control specimens shall continue to maintain the original curing conditions, until the freeze-thaw cycle is completed. The compressive strength test shall be conducted at the same time as the freeze-thaw specimens.

4.1.5 When one of the following three conditions occurs during the freeze-thaw cycle, it may stop the test:

- 1** The specified number of cycles that has been reached;
- 2** The compressive strength loss rate has reached 25%;
- 3** The mass loss rate has reached 5%.

4.1.6 The calculation and processing of test results shall comply with the following provisions:

- 1** The strength loss rate shall be calculated according to the following formula:

$$\Delta f_c = \frac{f_{c0} - f_{cn}}{f_{c0}} \times 100 \quad (4.1.6-1)$$

Where:

Δf_c - Compressive strength loss rate of concrete (%) after N freeze-thaw cycles, accurate to 0.1;

operation, the temperature difference of each point of the antifreeze liquid in the freeze-thaw box shall not exceed 2 °C.

- 3 The maximum range of the weighing equipment shall be 20 kg. The sensitivity shall not exceed 5 g.
- 4 The measuring instrument for concrete dynamic elastic modulus shall comply with the provisions of Chapter 5 of this standard.
- 5 Temperature sensors (including thermocouples, potentiometers, etc.) shall measure the center temperature of the specimen within the range of (-20 ~ 20) °C; the measurement accuracy shall be ± 0.5 °C.

4.2.3 The specimens used in the anti-freeze test by quick-freezing method shall meet the following requirements:

- 1 The freezing resistance test of the quick freezing method shall use prism specimens, which have dimensions of 100 mm × 100 mm × 400 mm. Each group of specimens shall consist of 3 pieces.
- 2 When molding specimens, hydrophobic release agents shall not be used.
- 3 In addition to making the specimens for the freeze-thaw test, a temperature measurement specimen of the same shape and size shall be made, which has a temperature sensor buried in the center. The temperature measurement specimen shall use antifreeze as the freezing-thawing medium. The freezing resistance of the concrete, which is used in the temperature measurement specimens, shall be higher than that of the freeze-thaw specimens. The temperature sensor of the temperature measurement specimen shall be buried in the center of the specimen. Temperature sensors shall not be buried by drilling and then inserting.

4.2.4 The quick freezing test shall be carried out according to the following steps:

- 1 Specimens for freezing-thawing test, which is cured in a standard curing chamber or under the same conditions, shall be taken out from the curing location, before the curing age reaches 24 days. Then the frozen-thaw specimens shall be soaked in (20 ± 2) °C water. The water level shall be (20 ~ 30) mm higher than the top surface of the specimen during immersion. The immersion time in water shall be 4 days. The freeze-thaw test shall be started when the specimen reaches 28-day age. For specimens that are always cured in water, when the curing age of the specimen reaches 28 days, subsequent tests can be conducted directly. This situation shall be stated in the test report.
- 2 When the curing age of the specimen reaches 28 days, it shall take out the specimen in time. Use a damp cloth, to wipe off the surface moisture, before measuring the appearance size. The appearance size of the specimen shall meet the requirements of Clause 3.3 of this standard. It shall number and weigh the initial mass W_{0i} of the

specimen. Then it shall measure the initial value f_{0i} of its transverse fundamental frequency, according to the provisions of Chapter 5 of this standard.

3 Place the specimen into the specimen box. The specimen shall be located in the center of the specimen box. Then place the specimen box into the specimen rack in the freeze-thaw box. Pour clean water into the specimen box. During the entire test process, the water level in the box shall always be kept at least 5 mm higher than the top surface of the specimen.

4 The temperature measurement specimen box shall be placed in the center of the freezing-thawing box.

5 The freeze-thaw cycle process shall comply with the following requirements:

1) Each freeze-thaw cycle shall be completed within (2 ~ 4) hours; the time used for thawing shall not be less than 1/4 of the entire freeze-thaw cycle time;

2) During the freezing-thawing processes, the minimum and maximum temperatures in the center of the specimen shall be controlled within $(-18 \pm 2) ^\circ\text{C}$ and $(5 \pm 2) ^\circ\text{C}$, respectively. At any time, the center temperature of the specimen shall not be higher than $7 ^\circ\text{C}$ and shall not be lower than $-20 ^\circ\text{C}$;

3) The time it takes for each specimen to drop from $3 ^\circ\text{C}$ to $-16 ^\circ\text{C}$ shall not be less than 1/2 of the freezing time; the time it takes for each specimen to rise from $-16 ^\circ\text{C}$ to $3 ^\circ\text{C}$ shall not be less than 1/2 of the entire thawing time. The temperature difference between the inside and outside of the specimen should not exceed $28 ^\circ\text{C}$;

4) The transition time between freezing and thawing should not exceed 10 minutes.

6 It should measure the transverse fundamental frequency f_{ni} of the specimen, once every 25 freeze-thaw cycles. Before measurement, it shall clean the scum on the surface of the specimen and wipe dry the surface moisture. Then it shall check the external damage; weigh the specimen mass W_{ni} . It shall measure the transverse fundamental frequency, according to the method specified in Chapter 5 of this standard. After the test is completed, the specimen shall be quickly turned around and reinstalled into the specimen box and water shall be added to continue the test. The measurement, weighing, visual inspection of the specimen shall be carried out quickly. The specimen to be tested shall be covered with a damp cloth.

7 When a specimen is taken out after stopping the test, it shall use other specimens to fill the empty space. When the specimen is interrupted for any reason while in the frozen state, the specimen shall remain in the frozen state, until the freeze-thaw test is resumed; the cause of the failure and the suspension time shall be noted in the test results. The time for failure of the specimen in the non-frozen state should

steps:

- 1 The specimens that have reached the specified curing age shall be dried to 28 days, in a laboratory at a temperature of $(20 \pm 2) ^\circ\text{C}$ and a relative humidity of $(65 \pm 5)\%$. When drying, the specimens shall be placed on their sides and spaced 50 mm apart from each other.
- 2 At $(2 \sim 4)$ days before the specimen is dried to 28 days of age, except the test surface and the top surface which is parallel to the test surface, other sides shall be sealed with epoxy resin or other sealing materials that meet the requirements of Article 4.3.3 of this standard. The sides of the specimen shall be cleaned before sealing. During the sealing process, the specimen shall be kept clean and dry. It shall measure and record the mass w_0 and w_1 of the specimen before and after sealing, accurate to 0.1 g.
- 3 The sealed specimen shall be placed in the specimen box, which has the test surface downwards touched the pad. The gap between the specimen and the side wall of the specimen box shall be (30 ± 2) mm. Add test liquid to the specimen box and do not splash the top surface of the specimen. The liquid level height of the test liquid shall be adjusted to (10 ± 1) mm, by the liquid level adjustment device. After adding the test liquid, it shall close the lid of the specimen box; record the time of adding the test liquid. The pre-water absorption time of the specimen shall last for 7 days; the test temperature shall be maintained at $(20 \pm 2) ^\circ\text{C}$. During the pre-absorption period, it shall check the test liquid level regularly; the test liquid height shall always be maintained to meet the requirements of (10 ± 1) mm. During the pre-absorption process of the specimen, it shall measure the mass of the specimen once every $(2 \sim 3)$ d, accurate to 0.1 g.
- 4 After the pre-absorption of water on the specimen is completed, an ultrasonic tester shall be used to measure the initial value of the ultrasonic propagation time t_0 of the specimen, accurate to 0.1 μs . The ultrasonic testing instrument shall be calibrated, before each specimen test begins. The measurement of the initial value of ultrasonic propagation time shall comply with the following requirements:
 - 1) First, quickly take out the specimen from the specimen box. Place the specimen on the stainless steel plate with the test surface facing downward. Then place the specimen together with the stainless steel plate into the ultrasonic propagation time measurement device (Figure 4.3.3-6). The distance between the probe center of the ultrasonic sensor and the test surface of the specimen shall be 35 mm. The test solution shall be added as coupling agent to the ultrasonic transit time measurement device; the liquid level shall be 10 mm higher than the ultrasonic sensor probe; however, it shall not exceed the upper surface of the specimen.
 - 2) The ultrasonic propagation time of each specimen shall be obtained, by measuring two mutually perpendicular propagation axes 35 mm away from the

test surface. The final measurement position of the specimen can be determined by finely adjusting the position of the specimen, to minimize the measurement propagation time. These positions shall be marked for use in subsequent tests.

- 3) During the test, the temperature of the specimen and coupling agent shall always be kept at $(20 \pm 2) ^\circ\text{C}$, to prevent the upper surface of the specimen from getting wet. Eliminate air bubbles on the surface of the ultrasonic sensor and both sides of the specimen; protect the sealing material of the specimen from damage.
- 5 Reinstall the specimen, that has completed the initial value measurement of ultrasonic propagation time, into the specimen box, according to the requirements of Article 4.3.3 of this standard. The height of the test solution shall be (10 ± 1) mm. During the entire test process, it shall check the liquid level in the specimen box at any time; adjust the liquid level in time. Place the test box containing the specimens on the bracket of the single-sided freeze-thaw test chamber. After all the specimen boxes are placed in the single-sided freeze-thaw test chamber, ensure that the specimen box is immersed in the freezing liquid to the depth of (15 ± 2) mm, meanwhile the position of the specimen box in the single-sided freeze-thaw test chamber complies with the requirements of Figure 4.3.5. Before the freeze-thaw cycle test, the ultrasonic bath method shall be used to remove loose particles and substances on the surface of the specimen; the removed materials shall be treated as waste.
- 6 When performing a single-sided freeze-thaw test, the cover of the specimen box shall be removed. The freeze-thaw cycle process should be carried out continuously. When the freeze-thaw cycle is interrupted, the specimen shall be kept in the specimen box; the height of the test liquid shall be maintained.
- 7 The peeling material, water absorption rate, ultrasonic relative propagation time, relative dynamic elastic modulus of ultrasonic wave of the specimen shall be measured, once every 4 freeze-thaw cycles. The above parameter measurements shall be carried out, in a constant temperature room at $(20 \pm 2) ^\circ\text{C}$. When the measurement process is interrupted, the specimen shall be kept in a test container containing the test liquid.
- 8 The measurement of peeling matter, water absorption, ultrasonic relative propagation time, relative dynamic elastic modulus of ultrasonic wave of the specimen shall be carried out according to the following steps:

- 2 After the specimen is removed from the formwork, the cement slurry film on both ends shall be brushed away using a wire brush; the specimen shall be immediately sent to the standard curing chamber for curing.
- 3 The age of the water penetration resistance test should be 28 days. The specimen shall be taken out from the curing chamber and wiped clean, one day before reaching the test age. After the surface of the specimen is dry, the specimen shall be sealed according to the following methods:
 - 1) When sealing with paraffin, it shall wrap a layer of melted paraffin, to which a small amount of rosin is added, on the side of the specimen. Then use a screw press, to press the specimen into the test mold, that has been preheated in an oven or electric furnace, so that the specimen is flush with the bottom of the test mold; the pressure shall be released after the test mold becomes cold. The preheating temperature of the test mold shall be based on when the paraffin contacts the test mold, that is, it melts slowly but does not flow.
 - 2) When sealing with cement and butter, the mass ratio shall be (2.5 ~ 3):1. Use a triangular knife to evenly apply the sealing material on the side of the specimen; the thickness shall be (1 ~ 2) mm. The test mold shall be put on and the specimen shall be pressed in, so that the specimen is flush with the bottom of the test mold.
 - 3) Other more reliable sealing methods can also be used to seal the specimen.
- 4 After the specimen is ready, start the impermeability meter and open the valves under the 6 test positions, to allow water to seep out from the 6 holes. The water shall fill the test position pit. After closing the valves under the 6 test positions, install the sealed specimen on the impermeability meter.
- 5 After the specimen is installed, the valves under the 6 test positions shall be opened immediately, to control the water pressure at (1.2 ± 0.05) MPa within 24 hours; the pressurization process shall not exceed 5 minutes, taking the time to achieve stable pressure as the start time of test recording (accurate to 1 min). Observe the water seepage on the end face of the specimen at any time during the voltage stabilization process. When water seepage occurs on the end face of a certain specimen, it shall stop the test of this specimen and record the time; take the height of the specimen as the water seepage height of the specimen. If there is no water seepage on the end face of the specimen, it shall stop the test after 24 hours of testing and take out the specimen in time. During the test, when water is found to seep out from the periphery of the specimen, it shall be sealed again, according to the provisions of Article 6.1.3 of this standard.
- 6 Place the specimen, which is taken out from the impermeability meter, on the press. Place a steel pad, which has a diameter of 6 mm, each at the center of the upper and lower end faces of the specimen, along the diameter direction; ensure that they

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