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**Standard for test methods of concrete physical and
mechanical properties**

混凝土物理力学性能试验方法标准

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Standard for test methods of concrete physical and mechanical properties

1 General

1.0.1 In order to standardize and unify the test methods of concrete physical and mechanical properties, to improve the level of concrete test technology, this standard is hereby formulated.

1.0.2 This standard is applicable to the test of physical and mechanical properties of concrete in construction projects. This standard does not apply to fully graded concrete and roller-compacted concrete in water conservancy and hydropower projects.

1.0.3 In addition to the provisions of this standard, the test methods of concrete physical and mechanical properties shall also comply with the provisions of the current relevant national standards.

2 Terms and symbols

2.1 Terms

2.1.1 Concrete

The engineering materials, which are produced through such processes as blending, forming, curing, AND have strength after hardening, through the use of cement, aggregate, water as the main raw materials, by adding mineral admixtures and additives as required, according to a certain ratio.

2.1.2 Compressive strength

The maximum pressure, that the cube specimen can withstand per unit area.

2.1.3 Axial compressive strength

The maximum pressure, that the prism specimen can withstand per unit area, in the axial direction.

2.1.4 Elastic modulus under static compressive stress

The stress required for producing unit deformation, when a prism specimen or

0.25 kg ~ 0.50 kg.

4.1.5 For dry hard concrete, a forming cover mold, weight steel plate, weight block or other pressure device shall be provided. The inner contour size of the cover mold shall be the same as the inner contour size of the specimen mold; the height should be 50 mm; it is not easy to deform AND can be fixed on the specimen mold. The side length or diameter of the weight steel plate shall be smaller than the inner contour size of the specimen mold. The difference between the two should be 5 mm.

4.2 Sampling and preparation of specimen

4.2.1 For the concrete sampling and specimen preparation, it shall comply with the relevant provisions of the current national standard "Standard for test method of performance on ordinary fresh concrete" GB/T 50080.

4.2.2 The mixture used for each set of specimens shall be sampled from the same pan of concrete OR the same truck of concrete.

4.2.3 The concrete sampled or mixed in the laboratory shall be formed as soon as possible.

4.2.4 When preparing concrete specimens, it shall take labor protection measures.

4.3 Preparation of specimen

4.3.1 Before the specimen is formed, the size of the specimen mold shall be checked, which shall comply with the relevant provisions in article 4.1.1 of this standard. The specimen mold shall be wiped clean; a thin layer of mineral oil OR release agent, which does not react with concrete, shall be evenly painted on the inner wall. The release agent on the inner wall of the specimen mold shall be evenly distributed; there shall be no obvious deposits.

4.3.2 The homogeneity of the concrete mixture shall be ensured, before it is pouring into mold.

4.3.3 It should determine the appropriate forming method, according to the consistency of the concrete mixture or the purpose of the test. The concrete shall be sufficiently dense, to avoid delamination and segregation.

1 The preparation of specimens, through vibrating, by a vibrating table shall be carried out as follows:

1) Load the concrete mixture into the specimen mold at one time. When

be 20 s. The vibrating rod shall be pulled out slowly; no holes shall be left after pulling out.

- 4 For self-compacting concrete, the concrete mixture shall be loaded into the specimen mold in two times. The thickness of each layer should be the same. The interval between two loadings is 10 s. The concrete shall be higher than the opening of specimen mold. It shall not be formed through the vibrating table, manual inserting & tamping, or vibrating rod method.
- 5 For dry hard concrete, the specimen can be formed according to the following method:
 - 1) After the concrete is mixed, it shall be poured on a non-absorbent bottom plate. Use the quartering method to take sample AND load it into the specimen mold of cast iron or cast steel.
 - 2) Use the quartering method to load the uniformly mixed dry hard concrete material into the specimen mold, to about half the height of the specimen mold. Use the tamping rod to perform even inserting and tamping. After compacting it, before continuing to load, it shall add a sleeve to the specimen mold. The second loading shall be slightly higher than the top surface of the specimen mold. Then perform even inserting and tamping. The top surface of the concrete shall be slightly higher than the top surface of the specimen mold.
 - 3) Inserting and tamping shall be carried out evenly, from the edge to the center, along the spiral direction. When inserting & tamping the bottom layer of concrete, the vibrating rod shall reach the bottom of the specimen mold. When inserting & tamping the upper layer, the tamping rod shall penetrate the upper layer AND then inserting 10 mm ~ 20 mm into the lower layer. When inserting & tamping, the tamping rod shall be vertical and not inclined. After inserting & tamping of each layer, it shall use the spatula to insert the mixture along the inner wall of specimen mold.
 - 4) The number of inserting & tamping of each layer shall be no less than 12, within a cross-sectional area of 10000 mm²;
 - 5) After loading, inserting and tamping, attach or fix the specimen mold on the vibration table. Place a weight steel plate and weight block OR other pressure device. It shall, according to the consistency of the concrete mixture, adjust the mass of the weight block OR the pressure which is applied by the pressurizing device. Start to vibrate. The vibrating time should not be less than the Viber consistency of the concrete, AND until the surface produces slurry.

L - Measurement gauge length (mm);

Δn - The average value of the deformation, on both sides of the specimen, when the load is applied from F_0 to F_a the last time (mm);

ε_a - The average value of deformation, on both sides of the specimen, at F_a (mm);

ε_0 - The average value of the deformation, on both sides of the specimen, at F_0 (mm).

- 2 It shall use the arithmetic average of the measured values of the 3 specimens, as the elastic modulus value of the group of specimens, which shall be accurate to 100 MPa. After measuring the elastic modulus, when there is a specimen, whose axial compressive strength value differs from the axial compressive strength value, which is used to determine the test control load, by more than 20% of the latter, THEN, the elastic modulus value shall be calculated based on the arithmetic average of the measured values of two specimens. After measuring the elastic modulus, when there are two specimens, whose axial compressive strength values differ from the axial compressive strength value, which is used to determine the test control load, by more than 20% of the latter, THEN, the test is invalid.

8 Test of Poisson's ratio

8.0.1 For the specimens, which are used for the test of Poisson's ratio of concrete, the size and quantity shall meet the following requirements:

- 1 The specimen shall be a prism specimen, which has a side length of 150 mm x 150 mm x 300 mm;
- 2 For each test, it shall prepare 6 specimens, of which 3 specimens are used to determine the axial compressive strength, whilst the other 3 are used to determine the Poisson's ratio.

8.0.2 The test instrument and equipment shall meet the following requirements:

- 1 The pressure testing machine shall comply with the provisions of item 1 in article 5.0.3 of this standard.
- 2 The instrument used for micro-deformation measurement shall meet the following requirements:
 - 1) The vertical micro-deformation measuring instrument of the specimen may be a dial gauge, resistance strain gauge, laser length gauge, extensometer or displacement sensor, etc. The instrument used for

When the resistance strain gauge is used to measure the vertical deformation, the vertical measurement gauge distance shall be 150 mm. For the resistance strain gauge that measures the lateral deformation, the measurement gauge distance shall be 100 mm. After the specimen is taken out of the curing room, it shall process the surface defects of the specimen, in the area where the strain gauge is attached. It may use hair dryer to blow dry the surface of the specimen. Meanwhile, at the middle of both sides of the specimen, use the 502 glue to paste the strain gauge.

- 4 Before the specimen is placed in the testing machine, it shall wipe clean the surface of the specimen AND the upper and lower pressure plates.
- 5 Place the specimen upright, on the lower pressure plate or steel backing plate of the testing machine. The axis of the specimen shall be aligned with the center of the lower pressure plate.
- 6 Turn on the testing machine. The surface of the specimen shall be in uniform contact with the upper and lower pressure plates OR steel backing plates.
- 7 It shall be loaded to the initial load value F_0 , which has a reference stress of 0.5 MPa. Keep the constant load for 60 s. In the subsequent 30 s, record the deformation reading ε_0 and ε_{t0} of each measuring point. The load shall be applied continuously and uniformly, until reaching the load value F_a , which has a stress of 1/3 of the axial compressive strength f_{cp} . Keep the constant load for 60 s. In the subsequent 30 s, record the deformation reading ε_a and ε_{ta} of each measuring point. The loading speed used shall comply with the provisions of item 5 in article 6.0.4 of this standard.
- 8 When the ratio of the difference between the longitudinal or lateral deformation values, on the left and right sides, TO their average value, is greater than 20%, the specimen shall be re-aligned and the steps of item 7 of this article shall be repeated. When it cannot be reduced to less than 20%, this test is invalid.
- 9 After confirming that the alignment of the specimen meets the requirements of item 8 of this article, at the same speed as the loading speed, unload to the reference stress 0.5 MPa (F_0); keep the constant load for 60 s. It shall, at the same loading and unloading speed, as well as keeping the constant load (F_0 and F_a) for 60 s, carry out repeated preloading, for at least two times. After the last preloading is completed, the load shall be held at the reference stress of 0.5 MPa (F_0) for 60 s; in the subsequent 30 s, record the deformation reading ε_0 and ε_{t0} of each measuring point. Then, at the same loading speed, apply load, until reaching to F_a ; hold this load for 60 s; in the subsequent 30 s, record the deformation reading ε_a and ε_{ta} of each measuring point (Figure 8.0.3).

shall be accurate to 0.01 MPa;

F - The failure load of the specimen (N);

A - The area of the splitting plane of the specimen (mm²).

2 The determination of the splitting tensile strength of concrete shall meet the following requirements:

1) It shall use the arithmetic average of the measured values of 3 specimens, as the split tensile strength value of the group of specimens, which shall be accurate to 0.01 MPa;

2) When the difference BETWEEN the maximum or minimum of the three measured values AND the median value, exceeds 15% of the median value, the maximum and minimum values shall be discarded together; THEN, take the median value as the splitting tensile strength value of this group of specimens;

3) When the difference BETWEEN the maximum value and the minimum value AND the median value, exceeds 15% of the median value, the test results of this group of specimens are invalid.

3 For the splitting tensile strength value, which is obtained by the use of a 100 mm × 100 mm × 100 mm non-standard specimen, it shall be multiplied by a size conversion factor 0.85. When the concrete strength grade is not less than C60, it shall use standard specimen.

10 Test of flexural tensile strength

10.0.1 This method is suitable for determining the flexural tensile strength of concrete, also known as bending tensile strength.

10.0.2 For the specimens, which are used in the test for determining the concrete's flexural tensile strength, the size, quantity and surface quality shall meet the following requirements:

1 The standard specimen shall be a prism specimen, which has a side length of 150 mm × 150 mm × 600 mm or 150 mm × 150 mm × 550 mm;

2 Prism specimens, which have a side length of 100 mm × 100 mm × 400 mm, are non-standard specimens;

3 On the inner surface of the middle 1/3 section, in the long direction, of the specimen, there shall be no holes, which have a diameter of more than 5 mm and a depth of more than 2 mm;

which shall be accurate to 0.1 MPa;

- 2) When the difference BETWEEN the maximum or minimum of the three measured values AND the median value, exceeds 15% of the median value, the maximum and minimum values shall be discarded together; then, take the median value as the flexural tensile strength of this group of specimens;
- 3) When the difference BETWEEN the maximum value and the minimum value AND the median value, exceeds 15% of the median value, the test results of this group of specimens are invalid.

3 When one of the 3 specimens has a fracture surface, which is outside the two concentrated loads, the flexural tensile strength of concrete shall be calculated, based on the test results of the other two specimens. When the difference between these two measured values, is not more than 15% of the smaller value of these two measured values, THEN, for the flexural tensile strength value of the group of specimens, it shall be calculated, based on the average of these two measured values; otherwise, the test results of this group of specimens are invalid. When the fracture position of the lower edge of two specimens is outside the two action lines of concentrated load, the tests of this group of specimens are invalid.

4 When the specimen is 100 mm × 100 mm × 400 mm non-standard specimen, it shall be multiplied by the size conversion factor 0.85. When the concrete strength grade is not less than C60, it should use standard specimen. When the non-standard specimen is used, the size conversion factor shall be determined by test.

11 Test of axial tensile

11.0.1 This method is suitable for determining the axial tensile strength, ultimate tensile value, tensile elastic modulus of concrete.

11.0.2 The size of the middle cross-section of the axially stretched specimen, which is formed indoors, shall be 100 mm × 100 mm (Figure 11.0.2a, Figure 11.0.2b, Figure 11.0.2c). The core-drilled specimen shall use a cylinder, which has a diameter of 100 mm (Figure 11.0.2d). Each group of specimens shall include 4 pieces.

11.0.3 The performance of the test equipment shall meet the following requirements.

1 Tensile testing machine:

- 1) The failure load of the specimen should be greater than 20% of the full

range of the tensile testing machine AND should be less than 80% of the full range of the tensile testing machine;

- 2) The relative error of the indication shall be $\pm 1\%$;
- 3) It shall have a loading speed indicating device or a loading speed control device; it shall be able to load uniformly and continuously;
- 4) Other requirements shall comply with the relevant requirements of the current national standard "Hydraulic universal testing machines" GB/T 3159 and "General requirements for testing machines" GB/T 2611.

12.0.3 The test of bond strength between concrete and steel bars shall be carried out according to the following steps:

- 1** For the ribbed steel bar HRB400 used for the test, the performance shall meet the requirements of the current national standard "Steel for the reinforcement of concrete - Part 2: Hot rolled ribbed bars" GB/T 1499.2; its nominal diameter is 20 mm. The steel bars shall have enough length, for the universal machine to hold and install the gauge. The length should be 500 mm. The size and shape of the steel bars used in the test shall be the same. Before forming, the steel bars shall be cleaned by a steel wire brush; wiped by acetone or ethanol. There shall be no rust and oil stains. The top surface of the free end of the steel bar shall be smooth and flat; it shall be consistent with the reserved holes of the specimen mold. It may also use HPB300 hot-rolled plain bars, which has a nominal diameter of 20 mm, in accordance with the current national standard "Steel for the reinforcement of concrete - Part 1: Hot rolled plain bars" GB/T 1499.1, OR other steel bars actually used in the project. The requirements and the treatment method are the same as the ribbed steel bar.
- 2** The specimens shall be prepared according to the relevant requirements in article 4.3 of this standard. It shall use 6 specimens as a group. The maximum particle size of concrete aggregate shall not exceed 31.5 mm. When installing the steel bar, the free end of the steel bar is embedded in the mold wall. For the hole on the mold wall, through which the steel bar passes, it shall fill rubber rings and fixing rings to fix the steel bar; there is no leakage of grout or water. The steel bar and the specimen mold shall be at right angles; the allowable tolerance is 0.5° .
- 3** After the specimen is formed until the test age, especially when the mold is removed, the steel bar shall not be touched. The mold removal time should be 2 d. When removing the mold, it shall first remove the rubber fixing ring; then carefully remove the specimen mold, which is sleeved around the steel bar.

- 4 When the test age is reached, it shall take the specimen out of the curing room; wipe it clean; check its appearance. The specimen shall not have obvious defects or loose or skewed steel bars; the test shall be carried out as soon as possible.
 - 5 It shall put the specimen on the backing plate, which has a hole in the center. Put it into the test fixture, which had been installed on the tensile testing machine. Use the lower chuck of the tensile testing machine to clamp the steel bar of the specimen firmly.
 - 6 Install the gauge holder and the dial indicator on the specimen. The rod end of the dial gauge shall be vertically downward AND in contact with the top surface of the steel bar, which is slightly protruding from the surface of the specimen.
 - 7 Before loading, it shall check whether the dial gauge's measuring rod is in good contact with the top surface of the steel bar; whether the dial gauge is flexible; meanwhile it shall make appropriate adjustments.
 - 8 After taking the initial reading of the dial gauge, turn on the tensile testing machine. Pull the steel bar at a loading speed not exceeding 400 N/s. In the load range of 1000 N ~ 5000 N, record the corresponding reading of dial gauge for each application of certain load.
 - 9 The loading shall be stopped, when any of the following conditions is reached:
 - 1) The steel bar reaches the yield point;
 - 2) The concrete fractures;
 - 3) The sliding deformation of the steel bar exceeds 0.1 mm.
- 12.0.4** For the test results of the bond strength between concrete and steel bars, the calculation and determination shall be carried out according to the following methods:
- 1 Subtract the initial reading from the reading of dial gauge, under various loads, to obtain the sliding deformation under this load.
 - 2 When ribbed steel bars are used, use the arithmetic mean value of the sliding deformation of 6 specimens, under various loads, as the abscissa; AND use the load as the ordinate, to draw a load-sliding deformation relationship curve. Take the sliding deformation of 0.01 mm, 0.05 mm, 0.10 mm. Find out the corresponding load from the curve.

The bond strength between concrete and steel bars shall be calculated

14 Test of abrasion resistance

14.1 Test of abrasion loss

14.1.1 This method is suitable for determining the abrasion resistance per unit area on the wear surface of a concrete specimen.

14.1.2 For the test of abrasion loss method of concrete, it shall use 150 mm × 150 mm × 150 mm cube specimens, with 3 specimens in each group.

14.1.3 The test instrument and equipment shall meet the following requirements:

1 The abrasion testing machine of concrete is composed of a main vertical shaft, a horizontal turntable, a transmission mechanism, a control system. The main shaft and the turntable are not on the same axis. The main shaft and the turntable shall rotate in opposite directions at the same time. The lower end of the main shaft is equipped with a grinding head connection device, which can load and unload the grinding head. At the same time, it shall meet the following technical requirements:

- 1) The perpendicularity of the main shaft and the horizontal turntable: the deviation shall not be greater than 0.04 mm when the measured length is 80 mm.
- 2) The rotating speed of the horizontal turntable shall be 17.5 r/min ± 0.5 r/min; the speed ratio of the main shaft to the turntable shall be 35:1.
- 3) The center distance between the main shaft and the turntable shall be 40 mm ± 0.2 mm.
- 4) The load can be divided into three stages: 200 N, 300 N, 400 N; the error shall not be greater than ±1%.
- 5) The rise-fall stroke of the main shaft shall not be less than 80 mm. The distance BETWEEN the lowest point of the grinding head AND the working surface of the horizontal turntable shall not be greater than 25 mm.
- 6) The horizontal turntable shall be equipped with a fixture, which can clamp the specimen. The one-way stroke of the chuck shall be $150\text{mm}^{+4}_{-1}\text{mm}$. The width of the clamp shall not be less than 50 mm, which shall be able to hold a 150 mm × 150 mm × 150 mm cube specimen. After clamping the specimen, it shall be ensured that the specimen does not float or tilt.

specimen mold at a depth of 200 mm, at the center of the specimen, as a reserved hole for measuring the center temperature of the specimen.

- 3 The range of the thermometer shall be 0 °C ~ 100 °C. The accuracy shall be 0.1 °C. When using a mercury thermometer, the distance between the mercury ball and the starting point of the scale shall be greater than 250 mm. In addition, it shall be equipped with a clock, asbestos thread, tape, transformer oil, etc.

15.0.2 The thermal diffusivity test of concrete shall be carried out according to the following steps:

- 1 Prepare the concrete mixture according to the indoor mixing method. The maximum particle size of aggregate in concrete shall not exceed 37.5 mm.
- 2 The mixed concrete shall be loaded into the specimen mold in three layers, which can be vibrated by a vibrating table or tamped by a tamping rod. When the tamping rod is used for insertion tamping, each layer shall be tamped 40 times by the tamping rod. After the first layer of concrete is loaded, install the bracket. Insert the iron rod into the specimen mold. Fix it in the center. Then, pour and tamp the second and third layers. The test shall take 2 specimens as a group.
- 3 After forming, perform plastering within 1 h ~ 2 h. After about 4 h, rotate the buried iron rod slightly, BUT do not move up and down, to avoid bonding with the concrete. After 1 d ~ 2 d, pull out the iron rod and remove the mold; number it. Put the specimen in the standard curing room for curing at least 7 d. The curing age can also be determined according to the actual needs. It can be used for testing after reaching to the curing age.
- 4 One day before the test, it shall take out the specimen. Roughen the top surface near the center hole. Use a wet cloth to wipe it clean. Inject transformer oil into the hole. Put in the temperature measuring element. Make the probe immersed in the oil. Use asbestos thread to plug the hole tightly. Use tape to fix it. Use plain cement paste to seal the hole tightly.
- 5 During the test, the specimen shall be placed on the specimen rack. Put it together with the rack into the heating barrel. Add water to submerge the top surface of the specimen, for more than 5 mm. Cover the lid. Turn on the heater and agitator, to heat the water in the barrel to 60 °C ~ 70 °C. When the temperature at the center of specimen is completely same as the water temperature, stop heating and stirring. When the thermal diffusivities of different temperatures are to be measured, they can be heated to the required temperature, respectively.
- 6 Fill the cooling water barrel with water. Make it flow continuously. The water

temperature shall be uniform.

- 7 Put the heated specimen at uniform temperature, together with the specimen rack, into the cooling water barrel. The water level in the barrel shall be more than 50 mm above the top surface of the specimen. Immediately, quickly and accurately measure the center temperature of specimen AND the temperature of cooling water. Start timekeeping. Measure and read every 5 minutes, until the difference BETWEEN the center temperature of the specimen AND the temperature of cooling water is $3^{\circ}\text{C} \sim 6^{\circ}\text{C}$; the time is about 1 h.

15.0.3 The calculation and determination of test results shall be carried out according to the following methods:

- 1 Calculate the initial temperature difference θ_0 , BETWEEN the center temperature of the specimen AND the cooling water temperature, as well as the temperature difference θ between the two, at any time, based on the records.
- 2 Calculate the ratio of θ/θ_0 at the corresponding time; the calculation result shall be accurate to the fifth decimal place.
- 3 According to the ratio of θ/θ_0 at each time, check the Table F.0.1 in Appendix F of this standard, to get the corresponding value $\alpha t/D^2$, where t is the cooling time, in h; D is the diameter of the specimen, in m. From this value, it may calculate the thermal diffusivity α at the corresponding time.
- 4 Take the average of the measured values within 30 min to 1 h after the specimen starts to cool, as the thermal diffusivity of the specimen.
- 5 When the absolute value of the difference between the test results of the two specimens is not greater than 10% of the average value, it shall take the average of the measured values of the two specimens, as the thermal diffusivity value of the group of specimens; the calculation result shall be accurate to the fourth decimal place. When the difference between the two test results exceeds the allowable range, the test shall be repeated.
- 6 The thermal diffusivity can also be calculated, according to the following steps, based on the initial temperature difference θ_0 , which is calculated by the record AND the temperature difference θ , at any time:
 - 1) Use the cooling time t as the abscissa AND the $\ln\theta$ as the ordinate, to draw a curve of $\ln\theta = f(t)$ on a semi-logarithmic paper.
 - 2) In the straight-line segment of the $\ln\theta = f(t)$ curve, select two points, set the temperature as θ_a , θ_b , AND the corresponding time as t_a , t_b . The

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