GB

NATIONAL STANDARD OF THE

PEOPLE'S REPUBLIC OF CHINA

ICS 91.100.10

CCS Q 11

GB/T 41060-2021

Test method for determining frost resistance of cement mortar

水泥胶砂抗冻性试验方法

Issued on: December 31, 2021 **Implemented on: July 01, 2022**

Issued by: State Administration for Market Regulation;
Standardization Administration of the People's Republic of China.

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1 Scope

This document specifies the method summary, instruments and equipment, materials, laboratory conditions, specimen molding, specimen maintenance, test of frost resistance properties, processing of test results, calculation of parameters of frost resistance properties and test method allowable deviation for the test method for frost resistance of cement mortar.

This document is applicable to the test of the frost resistance of general Portland cement under the conditions of water freezing and thawing.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB 175, *Common Portland cement*

GB/T 17671, *Test method of cement mortar strength (ISO method)*

GB/T 50082, *Standard for test methods of long-term performance and durability of ordinary concrete*

JC/T 243, *Concrete frost resistance test equipment*

JC/T 681, *Mixer for mixing mortars*

JC/T 682, *Jolting table for compacting mortars specimen*

JC/T 723, *Cement mortar vibration compaction equipment*

JC/T 726, *Mould for cement mortars*

JC/T 960, *Automatic compression machine for testing cement strength*

3 Terms and definitions

For the purposes of this document, the terms and definitions defined in GB/T 50082 as

well as the followings apply.

3.1 dynamic modulus of elasticity

The proportionality factor between stress and strain during the elastic deformation phase of a material under dynamic loading conditions.

3.2 relative dynamic modulus of elasticity

The ratio of the dynamic elastic modulus of the specimen before and after freezing and thawing calculated by the resonance method. It is usually expressed as a percentage of the square of the fundamental frequency of the vibration frequency of the test piece.

4 Method summary

Two groups of 40mm×40mm×160mm cement mortar specimens are formed in parallel according to the method of GB/T 17671. After curing to a certain age under standard conditions, test the strength loss rate, mass loss rate and relative dynamic modulus of elasticity of the specimen before and after freeze-thaw cycles, to characterize the frost resistance of cement.

5 Instruments and equipment

5.1 Cement mortar mixer

It shall comply with the provisions of JC/T 681.

5.2 Jolting table

It shall comply with the provisions of JC/T 682.

5.3 Vibration compaction equipment

It shall comply with the provisions of JC/T 723.

5.4 Test mould

It shall comply with the provisions of JC/T 726.

5.5 Balance

It shall comply with the provisions of GB/T 17671.

5.6 Pressure testing machine

It shall comply with the provisions of JC/T 960.

6 Materials

Standard sand and test water shall comply with the provisions of GB/T 17671.

7 Laboratory conditions

The temperature and humidity requirements of the laboratory shall comply with the provisions of GB/T 17671.

8 Specimen molding

The mass ratio of cement mortar shall be in accordance with the provisions of GB/T 17671. Three specimens are formed in each pot of mortar, and 2 groups are formed in parallel, with 6 pieces in each group. The water-cement ratio of ordinary Portland cement, pozzolanic Portland cement, fly ash Portland cement and composite Portland cement mixed with pozzolanic mixing materials is 0.50. The fluidity of the mortar shall not be less than 180mm. When the fluidity is less than 180mm, it shall be adjusted according to the relevant provisions in GB 175.

9 Specimen maintenance

Cement specimen maintenance shall be carried out in accordance with the relevant provisions of GB/T 17671. The maintenance period is 28d. For cement with high content of admixture (≥50%), the maintenance period can be up to 90d after consultation with the customer. It shall be noted in the test report.

10 Test of frost resistance properties

10.1 A reference specimen shall be prepared before freezing and thawing. That is, prepare cement mortar specimens of the same specification as required in Chapters 7 and 8 of this document. Bury the temperature sensor in the center of the specimen. The frost resistance ability of the reference specimen is higher than that of the freeze-thawed specimen to be tested. There is no obvious damage to the specimen after 25 freeze-thaw cycles. The freezing and thawing medium of the reference specimen shall be drinking water.

10.2 After the specimen is maintained to the specified period according to the requirements of Chapter 8, take a group of specimens to test the strength (e_0) of cement mortar before freezing and thawing according to the relevant requirements of GB/T 17671. Take another group of specimens for the freeze-thaw test.

10.3 Wipe off the surface moisture of the specimen before the freeze-thaw test begins. Accurately weigh the mass of the specimen (m_0) to one decimal place. At the same time, according to the relevant provisions of the method in GB/T 50082, test the initial value (f_0) of the lateral fundamental frequency vibration frequency of the specimen. Record the appearance of the specimen.

10.4 Put the cement mortar specimen into the specimen box. Inject the drinking water. The water shall not exceed the top surface of the specimen by 3mm~5mm. Then, put it into the specimen rack of the freeze-thaw testing machine for the freeze-thaw test. Each freeze-thaw cycle shall be completed within 2h~4h. The thawing and freezing time shall not be less than 1h. When freezing and thawing, control the central temperature of the specimen at -18°C ± 2°C and 5°C ± 2°C, respectively. During each freezing and thawing process, the time taken for the specimen to drop from 3°C to -16°C shall not be less than 1/2 of the freezing time. The time taken for the specimen to rise from -16°C to 3°C shall not be less than 1/2 of the entire thawing time. The number of freeze-thaw cycles shall be 25 times. The number of freezing and thawing can also be appropriately increased as needed, but it shall be indicated in the test report. In each freeze-thaw test, the number of freeze-thaw test stops due to external reasons shall not exceed 1.

10.5 After the freeze-thaw test is completed, take out the specimen and wipe off the surface moisture. Test the mass of the specimen after freezing and thawing (m_i) as well as the transverse fundamental vibration frequency of the specimen (f_i). Record the appearance of the specimen. Test the strength (e_i) of cement mortar after freezing and thawing according to GB/T 17671. The specimen shall be prevented from losing water during the testing process. The test specimen needs to be covered with a damp cloth.

10.6 Calculate the relative dynamic modulus of elasticity, strength loss rate and mass loss rate of the specimen before and after freezing and thawing according to formula (1) to formula (3), so as to characterize the frost resistance of cement.

11 Processing of test results

11.1 Fundamental vibration frequency

The fundamental vibration frequency of each specimen shall be tested twice in parallel. The two test results shall not exceed 0.5% of the average value. Take the average value of the two results as the fundamental vibration frequency of the specimen.

11.2 Compressive strength

For the compressive strength, take the average value of 6 test values of 3 specimens in each group as the test result. The elimination and processing of the test value shall be carried out according to the relevant provisions of GB/T 17671.

12 Calculation of parameters of frost resistance properties

12.1 Relative dynamic modulus of elasticity

The relative dynamic modulus of elasticity of the cement specimen is calculated according to formula (1). The calculation result is accurate to one decimal place:

$$P = \frac{f_i^2}{f_0^2} \times 100\% \qquad \cdots\cdots (1)$$

Where,

P - The relative dynamic modulus of elasticity of cement specimen after i cycles of freezing and thawing, %;

f_0 - The initial value of the lateral fundamental vibration frequency of the specimen before the freeze-thaw cycle, in Hertz (Hz);

f_i - The lateral fundamental vibration frequency of the specimen after i cycles of freezing and thawing, in Hertz (Hz).

Take the relative dynamic modulus of elasticity of cement specimens as the final test result as the average of the test values of 3 specimens in each group. When the difference BETWEEN the maximum or minimum value of the relative dynamic modulus of elasticity of the 3 specimens AND the average value exceeds the average value by 15%, the average value of the remaining test values shall be used as the test result after removing it. When the difference BETWEEN the maximum value and the minimum value AND the average value exceeds the average value by 15%, the median value is used as the test result.

12.2 Strength loss rate

The strength loss rate of the cement specimen is calculated according to formula (2). The calculation result is accurate to one decimal place:

$$S = \frac{e_0 - e_i}{e_0} \times 100\% \qquad \cdots\cdots (2)$$

Where,

S - The strength loss rate of cement specimen after i cycles of freezing and thawing, %;

e_0 - The compressive strength of cement specimen before freeze-thaw cycles, in megapascals (MPa);

e_i - The compressive strength of cement specimen after i cycles of freezing and thawing,

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