

8. TEST METHOD FOR FREEZE-THAW RESISTANCE OF CONTINUOUS FIBER SHEETS (JSCE-E 548-2000)

1. Scope

This specification describes the method used to test the freeze-thaw resistance of the continuous fiber sheets used for upgrading of concrete members.

2. Normative Reference

The following standards, by being referenced herein, form a portion of these specifications. The most recent version of each standard should be used.

- JSCE-E 541 Test method for tensile properties of continuous fiber sheets
- JSCE-E 542 Test method for overlap splice strength of continuous fiber sheets
- JIS A 1435 Test methods for frost resistance of exterior wall materials of buildings (freezing and thawing method)
- JIS Z 8401 Guide to the significant digits

3. Definitions

The following are the definitions of the major terms used in this specification in addition to the terms used in the “Recommendations for Upgrading of Concrete Structures with Use of Continuous Fiber Sheets” published by the Japan Society of Civil Engineers, JSCE-E 541 and JSCE-E 542.

a) Tensile strength retention

The ratio of the tensile strength after freezing-thawing divided by the tensile strength before freezing-thawing, expressed as a percentage of one hundred (%)

b) Overlap splice strength retention

The ratio of the overlap splice strength after freezing-thawing divided by the overlap splice strength before freezing-thawing, expressed as a percentage of one hundred (%)

4. Test specimens

4.1 Types and dimensions

There shall be two types of test specimens as described below.

- a) Type A or Type B test specimen in accordance with JSCE-E 541
- b) Type A or Type B test specimen in accordance with JSCE-E 542

4.2 Number of test specimens

A number of test specimens suitable for the test objective shall be determined. However, there shall be no fewer than five test specimens for the tensile strength test and overlap splice strength test before and after freezing-thawing.

5. Testing Machine and Measuring Devices

5.1 Freeze-thaw testing machine

The testing machine used for the freeze-thaw resistance test shall consist of the heating and cooling unit needed to subject the test specimen to the prescribed freezing and thawing cycles, a testing tank, a spray unit, a temperature measurement unit and a control unit. The temperature measurement unit shall be capable of measuring the surface temperature of the control test specimen in the testing tank to an accuracy of within 1.0°C and shall be equipped with a recording unit, in accordance with the specification in JIS A 1435.

5.2 Tensile testing machine

The tensile testing machine shall be the machine specified in JSCE-E 541.

6. Test Method

6.1 Freezing and thawing method

The test method shall conform to the air freezing and thawing method specified in JIS A 1435, as follows.

- a) Before the freeze-thaw resistance test, soak the test specimen in water for 24 hours.
- b) The conditions for the freeze-thaw resistance test shall be as follows: the surface temperature of the test specimen shall be $-20 \pm 2^\circ\text{C}$ during freezing and $30 \pm 2^\circ\text{C}$ during thawing (spraying). The temperature begins from room temperature for one cycle immediately after the start or the restart after interruption.
- c) The period for each freeze-thaw cycle shall be 100 minutes, an 80-minute cooling period and a 20-minute thawing period. The test specimen shall reach the prescribed temperature within each of these time periods.
- d) As a rule, the test shall consist of 300 freeze-thaw cycles.

6.2 Control of freezing and thawing temperatures

The freezing and thawing temperatures shall be controlled through measurement of the surface temperature of the continuous fiber sheet.

6.3 Tensile strength test and overlap splice strength test

The tensile strength, modulus of elasticity and ultimate strain shall be obtained before and after the freeze-thaw resistance test in accordance with JSCE-E 541. The overlap splice strength shall be measured before and after the freeze-thaw resistance test in accordance with JSCE-E 542.

7. Calculation and Expression of Test Results

7.1 Tensile strength retention

The tensile strength retention shall be calculated using Eq. (1) and rounded off to three significant digits in accordance with JIS Z 8401.

$$R_{ett} = \frac{\bar{f}_{fu1}}{\bar{f}_{fu0}} \times 100 \dots\dots\dots (1)$$

where

R_{ett} : Tensile strength retention (%)

\bar{f}_{fu0} : Average value for tensile strength before freezing and thawing (N/mm²)

\bar{f}_{fu1} : Average value for tensile strength after freezing and thawing (N/mm²)

7.2 Overlap splice strength retention

The overlap splice strength retention shall be calculated using Eq. (2) and rounded off to three significant digits in accordance with JIS Z 8401.

$$R_{ets} = \frac{\bar{f}_{fus1}}{\bar{f}_{fus0}} \times 100 \dots\dots\dots (2)$$

where

R_{ets} : Overlap splice strength retention (%)

\bar{f}_{fus0} : Average value for overlap splice strength before freezing and thawing (N/mm²)

\bar{f}_{fus1} : Average value for overlap splice strength after freezing and thawing (N/mm²)

8. Report

The report shall include the following items:

- a) Common items
 - (1) Name of continuous fiber sheet
 - (2) Type of continuous fiber sheet and impregnation resin
 - (3) Fiber mass per unit area and density of continuous fiber sheet
 - (4) Identification of test specimen
- b) Items relating to freeze-thaw resistance test
 - (1) Type and model of testing machine and test conditions
 - (2) Date that freeze-thaw resistance test starts and ends
- c) Items relating to tensile strength test
 - (1) Fabrication date, fabrication method and curing period for test specimens
 - (2) Temperature, humidity and duration of test specimen conditioning
 - (3) Test date, test temperature and loading rate
 - (4) Shape, dimensions and calculated cross-sectional area for each test specimen
 - (5) Tensile capacity of each test specimen and average for these values

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- (6) Maximum tensile strength of each test specimen and average for these values
 - (7) Young's modulus of each test specimen and average for these values
 - (8) Ultimate strain of each test specimen and average for these values
 - (9) Load-strain curve for each test specimen
 - (10) Tensile strength retention
- d) Items relating to overlap splice strength test
- (1) Fabrication date, fabrication method and curing period for test specimens
 - (2) Temperature, humidity and duration of test specimen conditioning
 - (3) Test date, test temperature and loading rate
 - (4) Shape, dimensions and calculated cross-sectional area for each test specimen
 - (5) Tensile capacity of each test specimen and average for these values
 - (6) Maximum tensile strength of each test specimen and average for these values
 - (7) Mode of failure for each test specimen
 - (8) Overlap splice strength retention

COMMENTARY ON TEST METHOD FOR FREEZE-THAW RESISTANCE OF CONTINUOUS FIBER SHEETS

Introduction

To determine the resistance of continuous fiber sheets to the effects of freezing and thawing, it is necessary to establish a proper test method. The method must evaluate the durability of continuous fiber sheets after they have experienced the range from low temperatures to high temperatures anticipated under the environmental conditions in which they are used. As a means of accomplishing this, the test specimens are subjected to repeated hot-cold temperature cycles between approximately -20°C - 30°C , after which the tensile strength and overlap splice strength of the continuous fiber sheets are measured to determine changes in their mechanical properties. The following standards are referenced in the preparation of this test method:

- JIS A 1435 Test methods for frost resistance of exterior wall materials of buildings (freezing and thawing method)
- JIS A 6204 Chemical admixtures for concrete (Supplement 2: Test method for concrete freeze-thaw resistance)
- JIS A 5209 Ceramic tiles

Of these specifications, the freeze-thaw resistance test method noted in the supplement of JIS A 6204 can be applied to bond tests using concrete test specimens in water, performed by rapidly alternating between freezing and thawing. However, a large-scale equipment is needed to evaluate the properties for individual continuous fiber sheets with concrete blocks, so this method is not necessarily applicable. Accordingly, a freeze-thaw resistance test method for continuous fiber sheets is established different from the ordinary freeze-thaw resistance test method for concrete.

The freeze-thaw resistance test method for continuous fiber sheets takes the test temperature range of -20°C and $+30^{\circ}\text{C}$ which is used for exterior wall construction materials, since this is a normal external environment for fiber sheets. The method conforming to the air freezing and thawing method is also taken into consideration

because the continuous fiber sheets have a comparatively low water absorption coefficient.

1. Scope

2. Normative Reference

3. Definitions

4. Test specimens

4.1

For durability evaluation it is necessary to determine frost resistance with regard to the mechanical properties of continuous fiber sheets and their bond properties to concrete.

In general, the damage due to frost depends on the temperatures and duration of repeated freezing and thawing, the velocity gradient, and without or without water.

The types of test in this specification are categorized according to test specimen. The tensile strength test and overlap splice strength test of continuous fiber sheets conform to the air freezing and thawing method, one of the methods in JIS A 1435.

As a rule, the determination of frost resistance of materials combined with concrete should be done using the test methods for concrete and is outside the scope of this specification.

5. Testing Machine

5.1

The testing machine specified in JIS A 1435 houses the test specimen inside a testing tank. The machine should be capable of controlling the temperature in the tank from a humid state of 30°C to -20°C within 50 minutes and holding it there for a set period of time. As for the heating systems, rapid spraying with warm water having a temperature of 30°C, or a combination of spray and heater, must be equipped to

increase the temperature to +30°C within 10 minutes. As a rule, the cooling capability of the testing machine must exceed 1°C/minute under load conditions.

During the thawing process, the nozzles to spray 30°C over the entire surface of the test specimen evenly must be provided on the top or side or both of the inside of the tank.

6. Test Method

6.1

- a) In test methods for freeze-thaw resistance, the initial water content of test specimens affects the test results. Materials with a low coefficient of water absorption come to an almost completely saturated state after immersion in water for 24 hours. Therefore, continuous fiber sheets should be immersed in water for 24 hours prior to the start of the test.
- b) and c) The air freezing and thawing method applied to this specification has generally been studied for use in evaluating the frost resistance of tile, a material with a low coefficient of water absorption. Through comparison with the frost resistance test in JIS A 5209, the number of freeze-thaw repetitions is more important than the freezing period or thawing period. Thus, in this test method, the period for each cycle is made as short as possible.
- d) The number of freeze-thaw cycles should be 300 in accordance with the test method for the freeze-thaw resistance of concrete.

7. Calculation and Expression of Test Results

8. Report