

TEST METHOD FOR CREEP FAILURE OF CONTINUOUS FIBER REINFORCING MATERIALS (JSCE-E 533-1995)

1. SCOPE

This specifications specifies mainly the test method for creep failure of CFRM used in place of steel reinforcement or prestressing tendon in concrete.

2. DEFINITIONS

The following terms are defined for general use in this Specifications, in addition to the terms used in the "Recommendation for Design and Construction for Concrete Structures using Continuous Fiber Reinforcing Materials" and the "Quality Specifications for Continuous Fiber Reinforcing Materials":

- (1) **Creep**: Time-dependent deformation when CFRM is subjected to a sustained constant load at a constant temperature
- (2) **Creep strain**: Strain occurring in a test piece due to creep
- (3) **Creep failure**: Failure occurring in a test piece due a sustained load
- (4) **Creep failure time**: Time between start of a sustained load, and failure of the test piece
- (5) **Creep failure capacity**: Load causing failure after a specified period of time from the start of a sustained load. In particular, the load causing failure after 1 million hours is referred to as the million hour creep failure capacity.
- (6) **Creep failure strength**: Stress causing failure after a specified period of time from the start of a sustained load. In particular, the stress causing failure after 1 million hours is referred to as the million hour creep failure strength.
- (7) **Load ratio**: Ratio of a constant sustained load applied to a test piece, and the tensile failure load

3. TEST PIECES

3.1 Preparation, handling and dimensions of test pieces

Test pieces shall be prepared and handled in accordance with the "Test Method for Tensile Properties of Continuous Fiber Reinforcing Materials".

3.2 Number of test pieces

The number of test pieces for each test condition shall not be less than three. If the test piece is found clearly to have failed at the anchoring section, or to have slipped out of the anchoring section, an additional test shall be performed on a separate test piece taken from the same lot.

4. TESTING MACHINE AND DEVICES

4.1 Testing machine

The testing machine must be capable of maintaining constant, sustained loading even during deformation of the test piece.

4.2 Anchorage

The anchorage must be in accordance with the "Test Method for Tensile Properties of Continuous Fiber Reinforcing Materials".

4.3 Extensometer and strain gauge

The extensometer and strain gauge must be in accordance with the "Test Method for Tensile Properties of Continuous Fiber Reinforcing Materials".

4.4 Hour meter

The hour meter for measuring the passage of time must be accurate to within 1% of the elapsed time .

5. TEST TEMPERATURE

The test temperature shall normally be within the range $20\pm 2^{\circ}\text{C}$, except in special circumstances.

6. TENSILE CAPACITY

The tensile capacity shall be calculated in accordance with the "Test Method for Tensile Properties of Continuous Fiber Reinforcing Materials".

7. TEST METHOD

7.1 Mounting of test piece, and gauge distance

Mounting of test pieces and gauge length shall be in accordance with the "Test Method for Tensile Properties of Continuous Fiber Reinforcing Materials".

7.2 Loading

- (1) Care must be taken during loading to prevent the test piece from being subjected to any shock or vibration.
- (2) Creep test measurement is considered to start at the moment when of the prescribed load to the test piece has been completed.

7.3 Selection of sustained loads to be applied

- (1) Creep tests must be conducted for not less than five sets of load ratio conditions, selected on the basis of the tensile capacity.
- (2) One set of load ratio conditions must be such that three test pieces must not fail after 1000 hours of loading.

7.4 Measurement of creep strain

Creep strain shall be recorded automatically by a recorder attached to the testing machine. If no recorder

is attached to the testing machine, creep strain shall be measured and recorded after the following times have elapsed:

1, 3, 6, 9, 15, 30, 45 minutes; 1, 1.5, 2, 4, 10, 24, 48, 72, 96, 120 hours; and in general every 24 hours subsequently, with a minimum of one measurement in every 120 hours.

8. CALCULATION AND EXPRESSION OF TEST RESULTS

8.1 Handling of data

The material properties of CFRM shall be assessed on the basis only of test pieces undergoing failure in the test section. In cases where tensile failure or slippage has clearly taken place at the anchoring section, the data shall be disregarded and additional tests shall be performed until the number of test pieces failing in the test section is not less than three.

Data for test pieces breaking at the start of loading shall be disregarded. In such cases, the applied load and the creep failure time only shall be recorded but excluded from the data, although no additional tests need be performed.

8.2 Load ratio - creep failure time curve

For each test piece subjected to creep test, the load ratio - creep failure time curve shall be plotted on a semi-logarithmic graph where the load ratio is represented on an arithmetic scale on the vertical axis, and creep failure time in hours is represented on a logarithmic scale on the horizontal axis.

8.3 Creep failure line chart

A creep failure line chart shall be prepared, calculating an approximation line from the graph data by the least-squares method according to Eq. (1).

$$Y = a - b \log T \quad (1)$$

where

Y = load ratio

a, b = empirical constants

T = time (h)

8.4 Creep failure capacity and creep failure strength

The load ratio at 1 million hours (approximately 114 years) determined from the calculated approximation line shall be the creep failure load ratio; the load and stress corresponding to this creep failure load ratio shall be the million hour creep failure capacity and the million hour creep failure strength respectively.

The million hour creep failure strength shall be calculated according to Eq. (2), rounded off to three significant figures

$$f_r = F_r / A \quad (2)$$

where

f_r = million hour creep failure strength (N/ mm²)

F_r = million hour creep failure capacity (N)

A = nominal cross sectional area of test piece (mm²)

9. TEST REPORT

The test report shall include the following items:

- (1) Name of CFRM
- (2) Type of fiber and fiber binding material, volume ratio of fiber
- (3) Numbers or identification marks of test pieces
- (4) Designation, nominal diameter, maximum cross sectional area
- (5) Date of test, test temperature
- (6) Type and name of test machine
- (7) Type and name of anchorage
- (8) Tensile capacity, and average tensile capacity and tensile strength for each test piece
- (9) Load ratios and creep failure time curve for each test piece
- (10) Formula for derivation of approximation line
- (11) Creep failure load ratio, million hour creep failure capacity and million hour creep failure strength