TEST METHOD FOR TENSILE FATIGUE OF CONTINUOUS FIBER REINFORCING MATERIALS (JSCE-E 535-1995)

1. SCOPE

This specifications specifies mainly the test method for tensile fatigue under constant tensile loading for 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", the "Quality Specifications for Continuous Fiber Reinforcing Materials", and the "Test Method for Tensile Properties of Continuous Fiber Reinforcing Materials":

(1) Repeated load (stress): Load (stress) alternating simply and cyclically between fixed maximum and minimum values
(2) Maximum repeated load (stress): Maximum load (stress) during repeated loading (stressing)
(3) Minimum repeated load (stress): Minimum load (stress) during repeated loading (stressing)
(4) Load (stress) range: Difference between maximum and minimum repeated load (stress)
(5) Load (stress) amplitude: One-half of the load (stress) range
(6) Average load (stress): Average of the maximum and minimum repeated load (stress)
(7) Number of cycles: Number of times the repeated load (stress) is applied to the test piece
(8) *S-N* curve: Curve plotted in a graph with repeated stress on the vertical axis and the number of cycles to fatigue failure on the horizontal axis
(9) Fatigue strength: Maximum repeated stress at which the test piece does not fail at the prescribed number of cycles
(10) Frequency: Number of loading (stressing) cycles in one second during the test

3. TEST PIECES

3.1 Preparation, handling and dimensions of test pieces

Preparation, handling and dimensions of test pieces shall be 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 should be at least three, for each of at least three levels of loading (stress). 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 shall be capable of maintaining a constant load (stress) amplitude, maximum and minimum repeated load (stress), and frequency. The testing machine shall be fitted with a counter capable of recording the number of cycles to failure of the test piece.

The accuracy of the load shall be within 1% of the load range.

4.2 Anchorage

The anchorage must be in accordance with the "Test Method for Tensile Properties of Continuous Fiber Reinforcing Materials". Ideally the same type of anchorage should be used for all in a given series of tests.

4.3 Strain measurements

If strain measurements are required as part of the fatigue tests, an extensometer and strain gauge capable of maintaining an accuracy of ±1% of the indicated value during the test shall be used.

5. TEST TEMPERATURE

The test temperature shall generally be within the range 5~35°C. The specifications test temperature for test pieces sensitive to temperature variations shall be 20±2°C.

6. TEST METHOD

6.1 Mounting of test pieces

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

6.2 Load setting

Load may be set in two ways: either fixing the average load and varying the load amplitude, or fixing the minimum repeated load by partial pulsation and varying the maximum repeated load. The method adopted shall be determined according to the purpose of the test. In either case, at least three load levels shall be set within the range of number of cycles to failure 10^3 to 2×10^6.

6.3 Frequency

The frequency shall normally be within the range 1~10 Hz.

6.4 Start of test

After static loading up to the average load, repeated loading shall be commenced. The prescribed load shall be introduced rapidly and without any shock. The maximum and minimum repeated loads shall remain constant for the duration of the test. Counting of the number of cycles shall normally commence when the load on the test piece has reached the prescribed load.

6.5 End of test

Complete separation (breaking) of the test piece shall be deemed to constitute failure, and the number of cycles to failure shall be recorded. If the test piece doesn't fail after 2×10^6 cycles, the test may be discontinued. Test pieces that did not fail must not be reused.

6.6 Interruption of test

Tests shall normally be conducted without interruption for each test piece from the start of the test to the end of the test. When a test is interrupted, the number of cycles up to the time of interruption, and the period of the interruption shall be recorded.

7. CALCULATION AND EXPRESSION OF TEST RESULTS

7.1 Handing of data

Data for test pieces that slipped from the anchoring section shall be disregarded in assessing the material properties of the CFRM. 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.

7.2 *S-N* curve

The *S-N* curve shall be plotted with the maximum repeated stress, stress range or stress amplitude represented on an arithmetic scale on the vertical axis, and the number of cycles represented on a logarithmic scale on the horizontal axis. Where measurement points coincide, the number of coinciding points shall be noted. Right-facing arrows shall be added to indicate points representing test results for test pieces remaining that did not fail.

7.3 Fatigue strength

The fatigue strength after 2×10^6 cycles shall be derived from the *S-N* curve. The fatigue strength shall be rounded off to three significant digits.

8. 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 and humidity (from start to end of test)
(6) Maximum load (stress), minimum load (stress), load (stress range), number of cycles to failure, and frequency rate for each test piece
(7) Record of observed failure mode for each test piece
(8) *S-N* curve