TEST METHOD FOR TENSILE PROPERTIES OF CONTINUOUS FIBER REINFORCING MATERIALS (JSCE-E 531-1995)

1. SCOPE

This specifications specifies mainly the test method for tensile properties 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) Test section: The part of a test piece subject to testing between the anchoring sections of the test piece
(2) Anchoring section: The end part of a test piece where an anchorage is fitted to transmit loads from the testing machine to the test section
(3) Gauge length: The distance between two gauge points on the test section providing a reference length for strain measurements
(4) Anchorage: Device fitted to the anchoring section of a test piece to transmit loads from the testing machine to the test piece
(5) Tensile capacity: The tensile load at the time of failure of the test piece
(6) Guaranteed tensile capacity: Guaranteed value for the tensile capacity; if none is specified, the manufacturer's guaranteed tensile capacity shall be adopted
(7) Ultimate strain: Strain corresponding to the tensile capacity

3. TEST PIECES

3.1 Preparation of test pieces

Test pieces shall as a rule not be subjected to any processing. For mesh-type CFRM, linear test pieces may be prepared by cutting away extraneous parts in such a way as not to affect the performance of the part to be tested. However, processing will be permissible for anchoring sections to be provided in the test piece.

3.2 Handling of test pieces

During the sampling and preparation of test pieces, all deformation, heating, outdoor exposure to ultraviolet light etc. causing changes to the material properties of the test section of the test piece must be avoided.

3.3 Length of test pieces

The length of the test piece shall be the length of the test section added to the length of the anchoring

section. The length of the test section shall be not less than 100mm, and not less than 40 times the nominal diameter of the CFRM. For CFRM in strand form, as an additional condition, the length shall be more than 2 times the strand pitch.

3.4 Number of test pieces

The number of test pieces shall not be less than five. 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 to be used in tensile testing shall conform to JIS B 7721 (Tensile Testing Machines). The testing machine shall have a loading capacity in excess of the tensile capacity of the test piece, and shall be capable of applying loading at the required loading rate.

4.2 Anchorage

The anchorage shall be suited to the geometry of the test piece, and shall have the capacity to transmit loads capable to cause the test piece to fail at the test section. The anchorage shall constructed so as to transmit loads reliably from the testing machine to the test section, transmitting axial loads only to the test piece, without transmitting either torsion or flexural force.

4.3 Extensometer and strain gauge

The extensometer and strain gauge shall be capable of recording all variations in gauge length or elongation during testing, with an accuracy of not less than 10×10^{-6}.

5. TEST TEMPERATURE

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

6. TEST METHOD

6.1 Mounting of test piece

When mounting the test piece on the testing machine, care must be taken to ensure that the longer axis of the test piece coincides with the imaginary line joining the two anchorages fitted to the testing machine.

6.2 Mounting of extensometer and strain gauge

In order to determine the Young's modulus and ultimate strain of the test piece, an extensometer or strain gauges shall be mounted in the center of the test section at a distance of at least 8 times the nominal diameter of the CFRM from the anchorages, correctly in the direction of tensioning. The gauge length when using an extensometer shall not be less than 8 times the nominal diameter of the CFRM. The gauge length for stranded CFRM shall not be less than 8 times the nominal diameter of the CFRM,

and not less than the length of the stranding pitch.

6.3 Loading rate

The specifications rate of loading the test piece shall be between 100~500 N/mm^2 per minute. If a strain control type of testing machine is used, loading shall be applied to the test piece at a fixed strain rate corresponding to 100~500 N/ mm^2 per minute.

6.4 Scope of test

The loading shall be completed until tensile failure, and the measurements shall be recorded until the strain reaches at least 60% of the tensile capacity or the guaranteed tensile capacity.

7. CALCULATION AND EXPRESSION OF TEST RESULTS

7.1 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 five.

7.2 Load-displacement curve

A load (stress) ~ displacement (strain) curve shall be derived from load or stress and strain measurements recorded.

7.3 Tensile strength

Tensile strength shall be calculated according to Eq. (1), rounded off to three significant digits.

$$f_u = F_u / A \qquad (1)$$

where

f_u = tensile strength (N/mm^2)
F_u = tensile capacity (N)
A = nominal cross sectional area of a test piece (mm^2)

7.4 Tensile rigidity and Young's modulus

Tensile rigidity and Young's modulus shall be calculated from the load difference between 20% and 60% of tensile capacity according to the load-strain curve obtained from extensometer or strain gauge readings according to Eq. (2) and (3), rounded off to three significant digits. For materials where a guaranteed tensile capacity is set, the values at 20% and 60% of the guaranteed tensile capacity may be used.

$$EA = \Delta F / \Delta e \qquad (2)$$

$$E = \frac{\Delta F}{\Delta e \cdot A} \qquad (3)$$

where

EA = tensile rigidity (N)

E = Young's modulus(N/mm^2)

ΔF = difference between loads at 20% and 60% of tensile failure capacity or guaranteed tensile capacity

Δe = strain difference between the above two points

7.5 Ultimate strain

Ultimate strain shall be the strain corresponding to the tensile failure capacity when strain gauge measurements of the test piece are available up to failure. If extensometer etc. measurements could not be made until failure, ultimate strain shall be calculated from the tensile capacity and Young's modulus according to Eq. (4), rounded off to three significant digits.

$$e_u = \frac{F_u}{EA} \qquad (4)$$

where

e_u = ultimate strain

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, nominal cross sectional area

(5) Date of test, test temperature, loading rate

(6) Tensile capacity for each test piece, averages and specifications deviations for tensile capacity and tensile strength

(7) Tensile rigidity and Young's modulus for each test piece, and averages

(8) Ultimate strain for each test piece, and averages

(9) Stress-strain curve for each test piece