2. TEST METHOD FOR OVERLAP SPLICE STRENGTH OF CONTINUOUS FIBER SHEETS (JSCE-E 542-2000)

1. Scope

This specification describes the test method for the overlap splice strength of 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
JIS K 7100	Plastics-standard atmospheres for conditioning and testing
JIS B 7721	Verification of the force measuring system of the tensile testing machine
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 and JSCE-E 541.

a) Overlap splice portion

The center of the test portion where the continuous fiber sheets are overlapped and spliced

4. Test specimens

4.1 Types and dimensions

The shape and dimensions of the overlap splice test specimen are shown in Figure 1 and Table 1, respectively. The method of preparing test specimens conforms to Section 4.2 "Preparation" in JSCE-E 541.

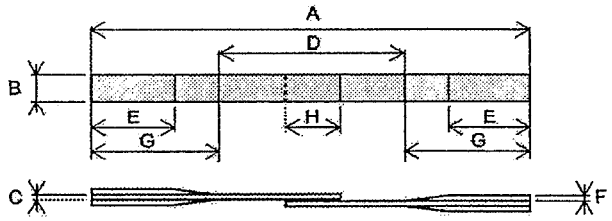

Figure 1 Shape of test specimens (Type A and Type B)

Table 1 Dimensions of test specimens (unit: mm)

Type of test specimen	Type A	Type B
A Total length	200 min.	
B Width at both ends	12.5 ±0.5	10-15
C Thickness	2.5 max.	
D Gauge length	Length of overlap splice + 100 min.	
E Anchoring portion length	35 min.	
F Anchorage thickness	1-2	
G Anchorage length	50 min.	
H Length of overlap splice portion	Necessary length	

4.2 Preparation

As a rule, test specimens shall be prepared using the same materials as those in the actual work and under constant temperature conditions. Sufficient care must be taken to ensure that fibers are not dispersed or bent in the overlap splice portion.

4.2.1 Type A test specimen

Type A test specimens are prepared by the following method.

a) Prepare a continuous fiber sheet cut to a sufficient length for the dimensions of the test specimen to be fabricated.

b) Apply the bottom coat of impregnation resin to the separation film and attach the aforementioned sheet, fastening it so that that the fiber axis of the sheet is in a straight line.
c) Overlap two sheets so that the prescribed overlap splice portion length is secured.
d) Apply the top coat of impregnation resin. Smooth the surface. Then thickness of the impregnation resin layer is even for a plate. Covering with separation film would be best.
e) Cure the plate for the prescribed period of time, then cut in widths of 12.5 mm as shown in Figure 2. The cut length should be at least 200 mm. Use a diamond cutter.
f) Attach the anchorage to the anchorage portion to form the test specimen.
g) Before performing the test, condition the test specimen as prescribed.

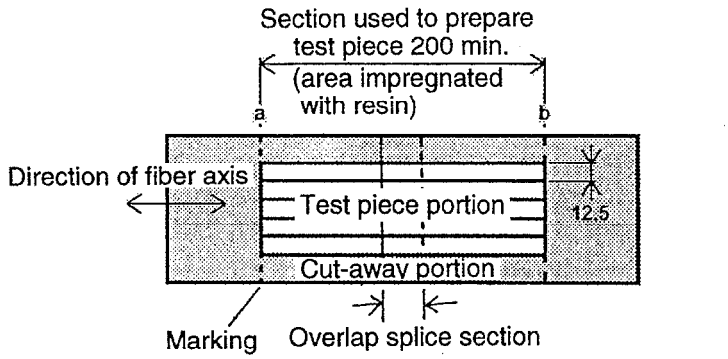

Figure 2 Dimensions of plate used to make Type A test specimens (unit: mm)

4.2.2 Type B test specimens

Type B test specimens are prepared by the following method.

a) Prepare a continuous fiber sheet cut to a sufficient length for the test specimen to be fabricated. Fasten the sheet so that the fiber axis is in a straight line.
b) In the center of the fastened sheet, mark two straight lines (a and b in Figure 3) perpendicular to the fiber axis that define a length of at least 200 mm. Mark two other straight lines (c and d in Figure 3) approximately 100 mm on either side of the area defined by lines a and b.
c) Along the fiber axis between lines c and d, remove 1-3 fiber bundles from each side of the portions so that the width measures 10-15 mm. When preparing several test specimens from the same continuous fiber sheet, the portions to be

used as test specimens should be separated by intervals of at least 50 mm in the direction perpendicular to the fiber axis. In such cases, cut along the marking on one side.

d) Apply the bottom coat of impregnation resin to the separation film and attach the aforementioned sheet to the film. The fiber bundles should be aligned in the fiber axis direction.

e) Apply impregnation resin to the top of the sheet and the overlap portion of the sheet. Then, checking the markings and making sure that the top and bottom sheets are positioned correctly, attach the sheets so that an overlap splice portion of the prescribed length is secured. The fiber bundles should be arranged in the fiber axis direction.

f) Apply the top coat of impregnation resin. Then smooth the surface so that the thickness of the impregnation resin layer is even, to form a plate. Covering with separation film would be best.

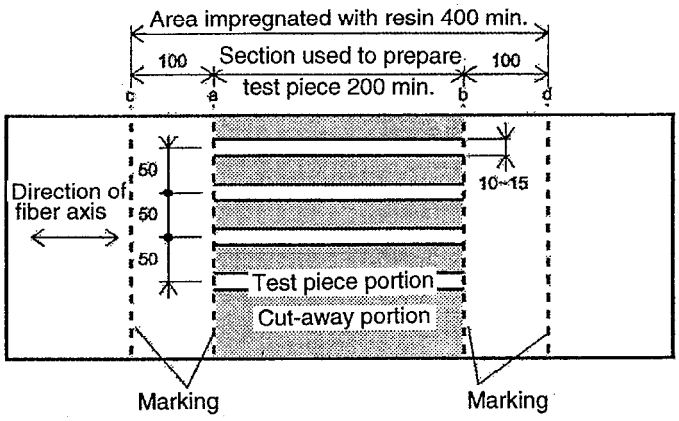

Figure 3 Dimensions of plate used to make Type B test specimens (unit: mm)

g) Cure the plate for the prescribed period of time, then cut the fiber bundle portion at widths of 10-15 mm. The cut length should be at least equivalent to 1.5 times the overlap splice length plus the anchorage length.

h) Attach the anchorage to the anchorage portion to form the test specimen.

i) Before performing the test, condition the test specimen as prescribed.

4.3 Curing the test specimen

A curing period for the test specimen to have the desired strength shall be established and the test specimen shall be cured.[1]

4.4 Anchorage portion of test specimen

The anchorage portion of the test specimen shall be of a shape that does not cause the test specimen to twist or bend. An anchorage made of fiber-reinforced plastic or aluminum shall be attached to the anchorage portion using resin or adhesive at a suitable pressure so that the thickness of the adhesive layer is constant. The adhesive or resin must ensure that the adhesive layer does not experience shear fracture before the test specimen breaks.

4.5 Conditioning of test specimen

As a rule, test specimens shall be conditioned for at least 48 hours before testing in a Class 2 standard atmosphere (temperature 23 ±2°C and humidity 50 ±10%) as described in JIS K 7100.

4.6 Number of test specimens

A number of test specimens suitable for objective of test shall be determined. However, there shall be no fewer than five test specimens for each case.

5. Testing Machine

The testing machine shall conform to JIS B 7721 (Verification of the force measuring system of the tensile testing machine). The testing machine shall have a loading capacity in excess of the tensile capacity of the test specimen and shall be capable of applying loading at the required loading rate.

---

[1] The curing period shall generally be about one week.

6. Test Method

6.1 Dimensions of test specimens

The width and thickness of the test portion of the test specimens shall be measured as follows at four locations other than the overlap splice portion and two locations within the overlap splice portion.

Type A test specimens shall be measured to 0.01 mm.
Type B test specimens shall be measured to 0.1 mm.

6.2 Mounting the test specimen

The test specimen shall be mounted so that the longer axis of the test specimen coincides with the center line between the two chucks.

6.3 Loading rate

The standard loading rate shall be a fixed strain rate equivalent to 1-3% strain per minute.

6.4 Test temperature

The test temperature shall be 20 ±5°C. However, if the test specimen is not sensitive to changes in temperature, the test may be conducted at a temperature of 5-35°C. When the sheet is to be applied under special work conditions or in special environments, these shall be taken into consideration in determining the test temperature.

6.5 Scope of test

The loading test shall be performed until tensile failure, and measurements of load shall be made and recorded continuously or at regular intervals until the tensile capacity is reached.

7. Calculation and Expression of Test Results

7.1 Handling of data

The test data shall be assessed on the basis only of test specimens undergoing failure in the test portion. In cases where tensile failure or slippage has clearly taken place at the anchorage portion, the data shall be disregarded and additional tests shall be performed using test specimens from the same lot until the number of test specimens failing in the test portion is not less than the prescribed number.

7.2 Failure categories

Table 2 shows the types of overlap splice failure. Shear fracture of the impregnation resin within the overlap splice portion is called "overlap splice failure." Failure of the continuous fiber sheet in parts of the test portion other than the overlap splice portion is called "base material failure."

Table 2 Categories of overlap splice failure

Code	Type of failure
JF	Overlap splice failure
SF	Base material failure

7.3 Overlap splice strength

The overlap splice strength f_{fus} shall be calculated using Eq. (1) and rounded off to three significant digits in accordance with JIS Z 8401.

$$f_{fus} = \frac{F_u}{A} \quad \text{..... (1)}$$

where

f_{fus} : Overlap splice strength (N/mm^2)

F_u : Tensile capacity (N)

A : Nominal cross-sectional area of a test specimen (mm^2)

The cross-sectional area A of the test specimen shall be calculated using Eq. (2).

$$A = \begin{cases} \dfrac{w}{\rho} \cdot b_t \text{ (for Type A test piece)} \\ \dfrac{w}{\rho} \cdot \dfrac{N_t}{n_u} \text{ (for Type B test piece)} \end{cases} \quad \text{..... (2)}$$

where

w : Fiber mass per unit area of continuous fiber sheet (g/mm^2)

ρ : Density of continuous fiber sheet (g/mm^3)

b_t : Minimum width of test portion of test specimen (mm)

N_t : Number of fiber bundles in test specimen

n_u : Number of fiber bundles per unit area of the continuous fiber sheet (strands / mm)

8. Report

The report shall include the following items:

a) Name of continuous fiber sheet
b) Type of continuous fiber sheet and impregnation resin
c) Fiber mass per unit area and density of continuous fiber sheet
d) Fabrication date, fabrication method and curing period for test specimens
e) Temperature, humidity and duration of test specimen conditioning
f) Test date, test temperature and loading rate
g) Shape and dimensions of each test specimen and calculated cross-sectional area
h) Length of overlap splice for each test specimen
i) Tensile capacity of each test specimen and average and standard deviation for these values
j) Tensile strength of each test specimen and average and standard deviation for these values
k) Failure type for each test specimen

COMMENTARY ON THE TEST METHOD FOR OVERLAP SPLICE STRENGTH OF CONTINUOUS FIBER SHEETS

Introduction

The test method for the overlap splice strength of continuous fiber sheets has been prepared based on JSCE-E 541 "Test method for tensile properties of continuous fiber sheets" and after reference to the test methods specified in the "Guidelines for Seismic Retrofit Design and Construction of Railway Viaduct Pier Using Carbon Fiber Sheets" of the Railway Technical Research Institute and the activities of ACI 440 K.

This draft has been prepared based on existing test results and covers carbon fiber sheets and aramid fiber sheets as test specimens, but it can be applied to other continuous fiber sheets as well.

1. Scope

As in the "Test method for tensile properties of continuous fiber sheets," the test specimens defined in the "Test method for overlap splice strength of continuous fiber sheets" are continuous fiber sheets in which the continuous fiber used to upgrade concrete members and the adhesive (impregnation resin) exhibit a monolithic mechanical behavior, and in which a single layer is used.

The test method is established mainly for carbon fiber or aramid fiber sheets, but this method may be applied to other materials if they are used in the same manner.

2. Normative Reference

3. Definitions

Only the terms unique to overlap splice tests are established. Since many of the terms used in overlap splice tests are the same as those used in tensile properties tests, JSCE-E 541 should be consulted for other vocabulary items.

4. Test specimens

4.1

With the exception of the overlap splice portion, the dimensions of Type A test specimens and Type B test specimens are the same as those of the Type A and B test specimens used in tensile strength tests.

4.2

With the exception of the overlap splice portion, the method of preparing test specimens is generally the same as that used to prepare Type A and Type B test specimens for tensile strength tests.

5. Testing Machine and Measuring Devices

6. Test Method

7. Calculation and Expression of Test Results

7.2

The type of failure of the overlap splice strength is divided into two categories. Failure in the overlap splice portion is assumed to be primarily the shear fracture of resin between the overlapping continuous fiber sheets. However, the fracture of continuous fiber sheets within the overlap splice portion is also included in this category.

7.3

The method of calculating the overlap splice strength is basically the same as that for the tensile strength. The cross-sectional area of the test specimen is calculated using the dimensions of the section other than the overlap splice area (in other words, using the dimensions of the base material section).

8. Report