

1. Title

SR-CF System (Seismic Retrofit by Carbon Fiber sheet)

2. Outline

The SR-CF system ¹⁾ is a seismic retrofitting technology for existing reinforced concrete buildings by gluing carbon fiber sheets with epoxy resin on the concrete surfaces. This system can improve the structural properties of independent columns, columns with wing-walls ²⁾, beams ³⁾, and walls ⁴⁾ by using special devices called CF-anchors, while conventional seismic strengthening by carbon fiber sheets has been considered to be effective only to independent columns. The use of the CF-anchor is the most characteristic in this system.

3. Specifications for materials

PAN type unidirectional carbon fiber sheets and carbon fiber strands are used in the SR-CF system. Carbon fiber strands are used as materials of the CF anchors. Sizing level of the carbon fiber strand is regulated smaller in order that the epoxy resin can easily emerge into the strand. Table 1 lists their design specification values.

Table 1 Specifications of the carbon fiber sheets

Fiber areal weight (g/m ²)	200	300
Thickness (mm)	0.111	0.167
Tensile strength (MPa)	3400	3400
Young's modulus (GPa)	230	230

Table 2 Specifications of the carbon fiber strands

Type	12K	24K
Cross section (mm ²)	0.435	0.870
Tensile strength (MPa)	4500 for strands 3400 for CF-anchor	4500 for strands 3400 for CF-anchor
Young's modulus (GPa)	230	230

4. Typical construction details

Figure 1 shows an outline of the SR-CF system. The innovative technique called CF-anchor is used in this system. The CF-anchor is a bundle of carbon fiber strands which are strings of 2 to 3 mm in diameter consisting of 24,000 or 12,000 filaments. The CF-anchor may be classified into two categories by the usage. One is penetrating type, and another the fixing type.

The penetrating anchors are used for the shear strengthening of columns with wing walls. A bundle of carbon fiber strands is passed through a hole drilled at the wing wall. The ends of the bundle are spread like a fan and glued to the carbon fiber sheet pasted on the column. The bundle joins the both ends of the carbon fiber sheet, which was separated by the side wall. Consequently, it is made possible to envelop the column by the carbon fiber without demolishing a part of wing walls. Beams with slabs can be strengthened by the similar method.

The fixing-type CF-anchors are used for the shear strengthening of walls. The carbon

fiber sheet is glued on the wall surface diagonally. An end of the CF-anchor is spread like a fan and glued to the carbon fiber sheet. The other end is inserted into a hole drilled on the peripheral reinforced concrete frame and is fixed with injected epoxy resin. The CF-anchors fix the edges of the carbon fiber sheets on the wall to the peripheral columns and beams.

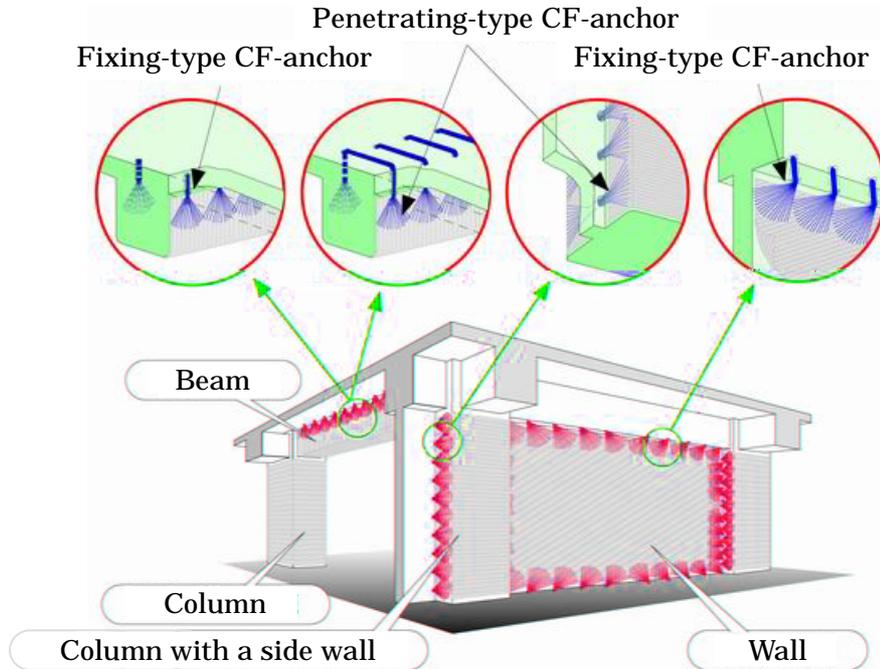


Figure 1 Outline of the SR-CF System

5. Research for verification

A number of specimens were tested to evaluate the effect of strengthening for each type of structural members, such as independent columns, columns with side-walls, beams with slabs, and walls. Photo 1 shows specimens of columns with side-walls after the tests. (a) is a specimen without strengthening and (b) is a specimen strengthened by the SR-CF system. The specimen without strengthening failed in shear at small drift angle. On the other hand, the column of the strengthened specimen was not so much damaged even at 3.0% of drift angle while the wing walls were considerably damaged. Figure 2 shows the test results of the wall specimens. It shows that the shear strength of the strengthened walls increase in proportion to the amount of the carbon fiber sheets glued on the wall surfaces.

6. Examples of Application

Photo 3 shows the execution of CF-anchors to the column with spandrel walls and windows. The CF-anchors are penetrated through the walls at the narrow space between the column and the window frame (a). As a result, the strengthening was completed without temporarily removing the windows (b). Photo 4 shows a strengthening of a beam and Photo 5 shows a strengthening of a wall.



(a) Specimen not strengthened



(b) Specimen strengthened by SR-CF system

Photo 1 Failures of column with wing-walls specimens after tests



Photo 2 Beam specimens after tests

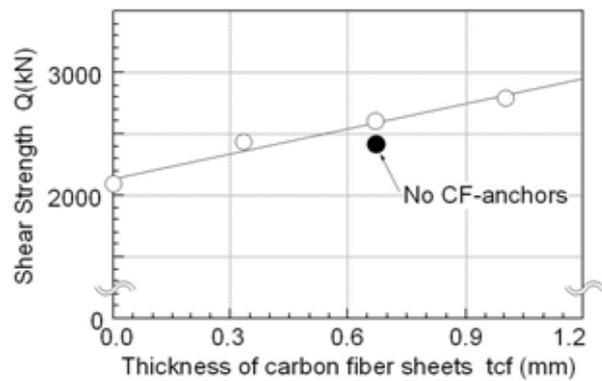


Figure 2 Test results of wall specimens



(a) The CF-anchor under installation



(b) Strengthening completed

Photo 3 Application to the column with wing walls



Photo 4 Application to the beam with slabs



Photo 5 Application to the wall

7. References

- 1) SR-CF System Research Association : Design Guidelines for SR-CF System, Feb. 2002 (in Japanese)
- 2) K.Masuo, S.Morita, Y.Jinno, H.Watanabe : Advanced Wrapping System with CF-anchor -Seismic Strengthening of RC Columns with Wing Walls-, FRPRCS-5, Vol.1, pp.299-308 , May 2001
- 3) Y.Jinno, H.Tsukagoshi : Seismic Strengthening of Reinforced Concrete Beams with Slabs by Carbon Fiber Sheet and CF-anchor, Proceedings of Structural Engineers World Congress 2002, Session T8-3-a-1, pp.1-8, Oct.2002
- 4) Y.Jinno, H.Tsukagoshi : Seismic Strengthening of Reinforced Concrete Walls by SR-CF System, Proceedings of the first fib congress 2002, Session 6, pp.109-118, Oct.2002

8. Ownership organization

SR-CF System Research Association, Tokyo, Japan

Tel: +81-3-5623-5558

Fax: +81-3-5623-5551

E-mail:nick-info@nick.co.jp

9. Certification

DPBA Certification No.1399

Patent No.: US 6330776 B1(USA), 10-2000-7002781(Korea) , 121278(Taiwan)

Patent Application No.(Published): 10-206983(Japan) etc.