Seismic Performance of Reinforced Concrete Column using Vinylon Fiber as Tie Hoop

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Abstract: This research paper deals with seismic performance of reinforced concrete column using vinylon fiber as tie hoop. Vinylon fiber is soft and has high strength. When vinylon fiber tape is used instead of the steel tie hoop, constructing term can be shortened. Therefore, loading tests of reinforced concrete column with usual steel tie hoop and columns with vinylon fiber tie hoop were carried out under reversed cyclic loading in order to investigate the seismic performance of reinforced concrete column using vinylon fiber as tie hoop.

Keywords: vinylon fiber; tie hoop; seismic performance; reinforced concrete column; grid pattern vinylon tape; string vinylon tape; shear failure.

1. Research Objective

In recent years, structural designs have been revised from the experience of the Great Hanshin Earthquake to improve a seismic performance of the structure. Therefore, concrete construction needed many tie hoops because there was a strong demand for high tenacity. Overcrowding lateral reinforcing bars should be fixed in the predesignated position as accurately and quickly as possible. But it needs technical skills, and longer constructing term is required. Veteran engineers depopulated due to aging population combined with the diminishing number of children or construction laborers depopulation. Therefore, laborsaving construction methods or laborsaving construction materials are requested.

Vinylon fiber is soft and has high strength. Vinylon fiber is covered with coating material (EVA) and it is bundled by coating material as shown in photo 1. Vinylon fiber and coating material as a whole is named vinylon fiber tape. If a grid pattern of vinylon fiber tape as shown in photo 2 is used instead of the steel tie hoop, constructing term can be shortened. However, reports on this type of research have apparently not been published yet. It is needed to confirm whether performance of reinforced concrete column using the vinylon fiber tape. Therefore, loading tests of reinforced concrete column with usual steel tie hoop and column with vinylon fiber tie hoop were carried out under reversed cyclic loading.

Photo 1 Coating material and vinylon fiber

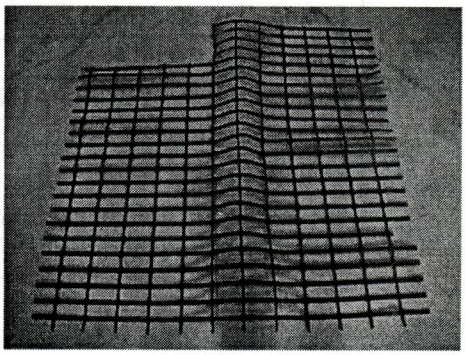


Photo 2 Grid pattern vinylon tape

2. Experiment Description

2.1 Experiment designing

Reinforcing bars as the main reinforcement were used for all kinds of examination specimen and examination specimen condition were the same as basis RC excluding tie hoop. Experiment Designation is shown in Table 1 and Design table is shown in Table 2.

2.2 Experiment Manufacture Method

B1 was processed like the loop at both ends of grid pattern vinylon tape. Reinforcing bar (D10) was into the loop as an anchoring material.

2.3 Load pattern

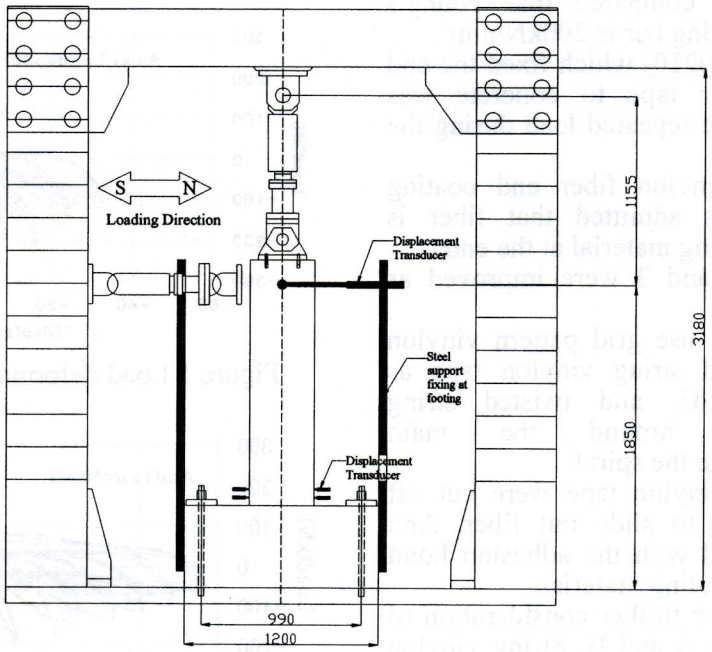
Before the yield of longitudinal reinforcement, the load was applied by load control at step of 100kN. The load was applied one cycle at each strain interval. After yield of longitudinal reinforcement, the displacement control was performed with three cycles at each loading step. The applied constant axial load was 500kN for all examination bodies. The yield displacement was 8mm, and the yield displacement was 1δy. Position of displacement transducer installation is shown in Figure 1. Load pattern is shown in Figure 2.

Table 1 Experiment designation

Experiment Designation	Tie foop condition
RC	Steel reinforcing bar (D6)
B1	Grid pattern vinylon tape
B2	String vinylon tape (once space winding)
B3	String vinylon tape (twice space winding)

Table 2 Design values of specimen

	RC	B1	B2	B3
Height of cross section (mm)	400	400	400	400
Width of cross section (mm)	400	400	400	400
A protection cover (mm)	30	30	30	30
Main reinforcement diameter(mm)	19.1	19.1	19.1	19.1
Number of main reinforcement	16	16	16	16
Steel tie hoop diameter (mm)	6.35			
Strand diameter (mm)		0.443	0.443	0.443
Number of strand		55	55	55
Yield strength of tie hoop (N/mm^2)	342	1273	1347	1347
Young modulus of tie hoop (kN/mm^2)	200	26.4	26.4	26.4
Distance of tie hoop (mm)	50	50	53	53
Cross-section area of tie hoop (mm^2)	63.3	16.9	16.9	33.8
Tie hoop ratio (%)	0.32	0.08	0.08	0.16
Shear capacity	135.7	135.2	135.0	270.4



Front View

Figure 1 Position of displacement transducer installation

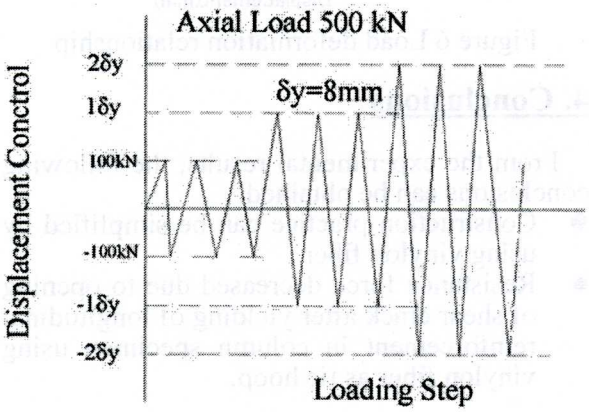


Figure 2 Load pattern

3. Experimental Results

RC resulted in causing the flexural failure when yield displacement is 5δy of 40mm. The result of RC load deformation relationship is shown in Figure 3.

B1 resulted in causing the shear failure when displacement is 2δy of 14mm, load is 216kN. And after the shear failure B1 did not hold axial load. The result of B1 load deformation relationship is shown in Figure 4.

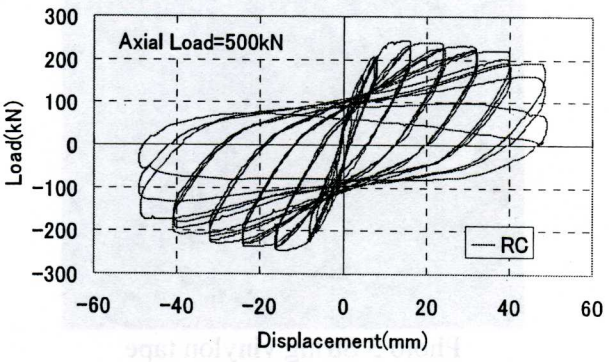


Figure 3 Load deformation relationship

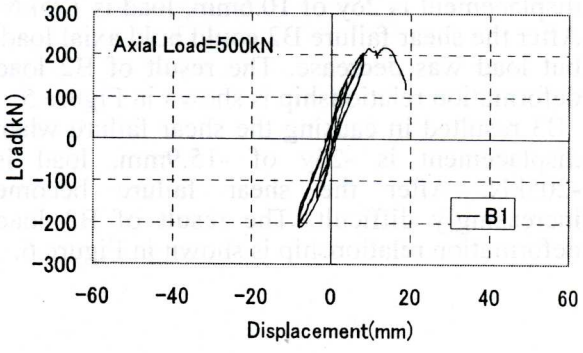


Figure 4 Load deformation relationship

The following three points are considered as the reason of shear failure

1. Rigidity of the vinylon fiber is small. Young's modulus vinylon fiber is

26.4kN/mm^2 as compared that Young's modulus reinforcing bar is 200kN/mm^2.

2. Reinforcing bar (D10) which fixed the end of vinylon fiber tape to concrete was moved due to the repeated load during the experiment.
3. Slip between vinylon fiber and coating material. It was admitted that fiber is slipped into coating material at the ends.

Therefore, above 2 and 3 were improved as follows

A. Tie hoop did not use grid pattern vinylon tape but it used string vinylon tape as shown in Photo3, and twisted string vinylon tape around the main reinforcement like the spiral.
B. Ends of string vinylon tape were cut off coating material to slide out fiber. And fibers were fixed with the adhesion bond for to slip into coating material.

And so, B3 was for further consideration of the influence of case A and B. String vinylon tape was twice twisted around the main reinforcement like the spiral.

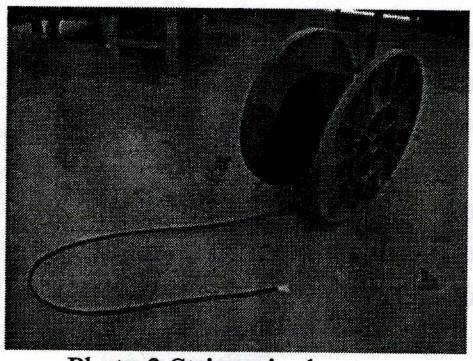


Photo 3 String vinylon tape

B2 resulted in causing the shear failure when displacement is 2δy of 10.6mm, load is 175kN. After the shear failure B2 could hold axial load, but load was decrease. The result of B2 load deformation relationship is shown in Figure 5.

B3 resulted in causing the shear failure when displacement is -2δy of -15.9mm, load is -205kN. After the shear failure become increasingly difficult. The result of B3 load deformation relationship is shown in Figure 6.

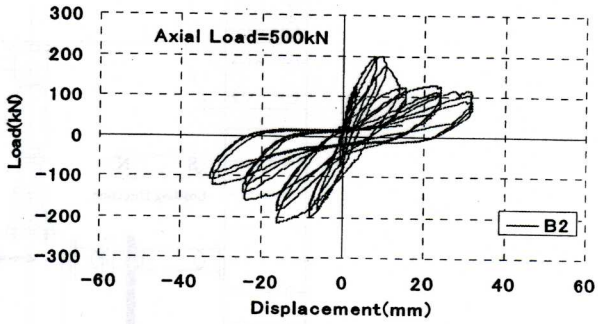


Figure 5 Load deformation relationship

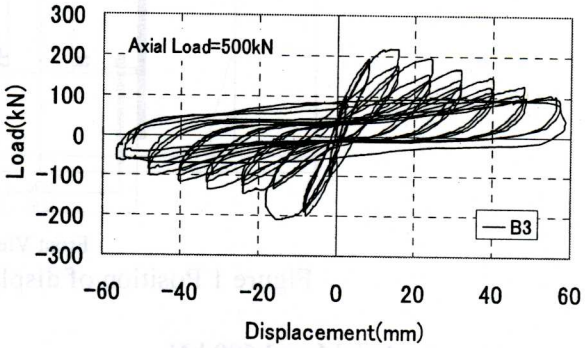


Figure 6 Load deformation relationship

4. Conclusions

From the experimental results, the following conclusions can be obtained.

- Construction practice can be simplified by using vinylon fiber.
- Resistance force decreased due to opening of shear crack after yielding of longitudinal reinforcement in column specimen using vinylon fiber as tie hoop.

REFERENCES

Japan Society of Civil Engineers; "Recommendation for Design and Construction of Concrete Structures Using Continuous Fiber Reinforcing Materials", Concrete Engineering Series, No.23, October, 1997, pp7-90