Application of Ultra Strength Fiber Reinforced Concrete to Bridge Piers

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Summary

In this study, the experimental specimens composed by the extra-high tensile strength concrete called as ESCON and the high yield strength steels called as USD685 were prepared to clarify the seismic performance of the ultra high strength fiber RC columns under cyclic bending loading. Compared to the experimental results of normal strength RC columns, the yielding capacity and the maximum capacity of the high strength one were improved. In addition, the crack distributions and the failure modes were different by the polyvinyl alcohol fiber contained in ESCON. Moreover, the trace analyses using the Finite Element Method (FEM) of these experiments of RC columns were conducted. As a result, it was identified that the experimental hysteresis curves could be traced by FEA. Lastly, it was calculated that how much cross section with equivalent strength of the normal strength specimen by using ESCON and USD685 could be reduced. The calculations showed that the cross section of area of RC columns using these high strength materials could be reduced by about 40% of normal one.

Keywords: RC column; high strength fiber concrete; high strength rebars; cyclic loading; FEA.

1. Cyclic bending loading experiments

Photo 1 shows the experimental specimen and setup, The RC columns with 400mm×400mm cross-section and 1600mm length were used. In this study, 3 experimental specimens were prepared as shown in Table 1. No.1 uses the normal strength concrete and SD345 main rebars. The target compressive strength of the concrete was 30N/mm^2. No.2 and No.3 use the high strength fiber concrete using ESCON and USD685 main rebars. The target compressive strength of ESCON was 150N/mm^2. The axial forces were 160kN in all cases because the axial stresses were set to be 1.0N/mm^2.

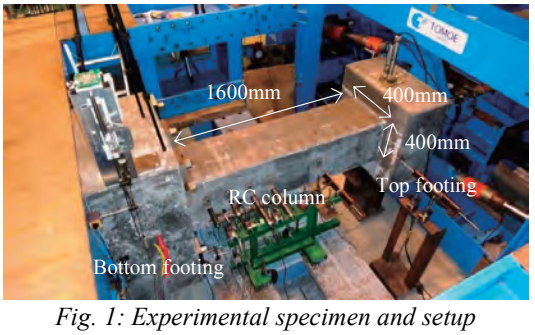


Fig. 1: Experimental specimen and setup

Table 1: Experimental cases

Parameters	No.1	No.2	No.3
Kind of Concrete	normal concrete	ESCON	ESCON
Kind of Main Rebars	SD345	USD685	USD685
Arrangement of Main Rebars	D19×16	D16×16	D19×16
Kind of Hoop Ties	SD345		
Arrangement of Hoop Ties	D13@100		

2. Experimental Results under Cyclic Bending Loading

In this paper, the cyclic bending loading experiments were conducted for three specimens varied the target compressive strength of the concrete, the yield strength of main rebars and the amounts of the main rebars. Fig. 2 shows the experimental results of hysteresis loops of lateral load and lateral displacement in No.3. According to the cyclic bending loading experiments, it was clarified that high strength concrete and steels can improve the horizontal capacities of RC column. The core concrete and the main rebars were constrained by the cover concrete with hoop ties, and high strength materials improved deformation capacity at yielding of hoop ties. However, ruptures of main rebars were only confirmed in No.2 and No.3. It was because that high strength steels showed more brittle failure than normal steels. As a result, the ultimate displacements were almost same. More number of cracks was observed in No.2 and No.3 than in No.1. It was assumed that the fiber contained in ESCON prevented the expansion of crack width and generated new cracks on sound concretes among cracks.

3. Trace Analyses Results Using Finite Element Method

In addition, the trace analyses for the experiments were conducted. Fig. 3 shows the analytical model and Fig. 4 shows the comparison of hysteresis loops in No.3. According to the trace analyses, it was clarified that we could estimate the capacities at the yielding of main rebars and the maximum capacities by using FEA.

4. Design for Experimental Specimen with Reduced Section

Moreover, the parametric analyses varied the width of the column were conducted. Fig. 5 shows the comparison of parametric analyses results. According to the parametric analyses, it was clarified that the cross-section area of RC columns using these high strength materials could be reduced until about 40% of normal one.

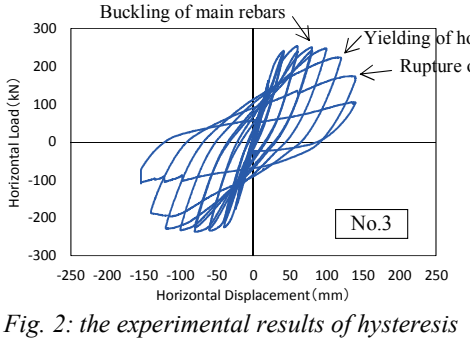
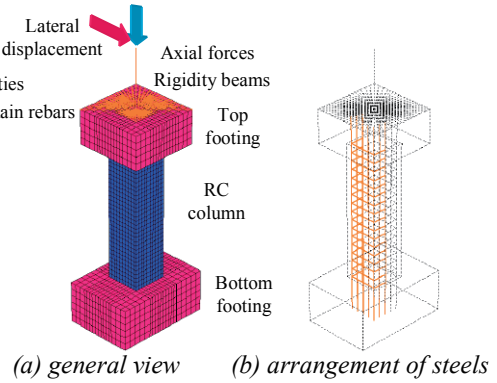


Fig. 2: the experimental results of hysteresis loops of lateral load and lateral displacement



(a) general view (b) arrangement of steels

Fig. 3: Analytical models

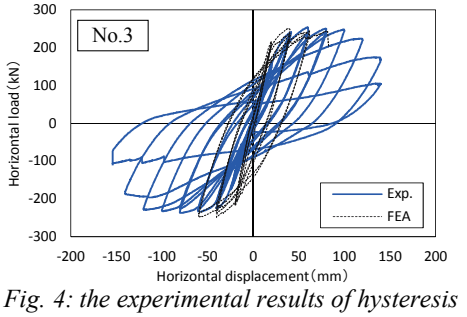


Fig. 4: the experimental results of hysteresis loops of lateral load and lateral displacement

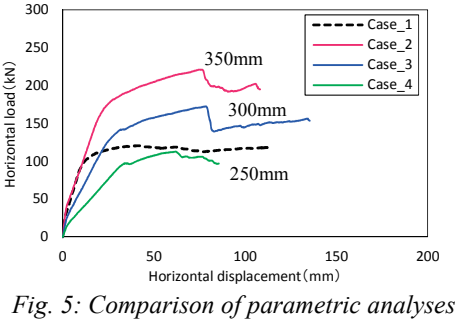


Fig. 5: Comparison of parametric analyses results