Nonlinear Response of a RC Frame Retrofitted by External Confinement and Steel Cross Braces with Super High Tension Bolts

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Summary

A novel seismic retrofitting method for RC frame is proposed in this paper. The results of cyclic lateral load test show that, the retrofitted specimen exhibits excellent seismic performance in term of strength while the non-retrofitted one failed in shear. Numerical studies on the non-retrofitted and retrofitted specimens are carried out using OpenSees. The results from numerical models agree well with the experimental results.

Keywords: seismic retrofit; high-strength external hoop; active confinement technique; super high tension bolt; steel cross brace; numerical study; OpenSees.

1. Specimens

Two RC frame specimens with insufficient transverse reinforcement ratio are investigated in this study; 10-F is a non-retrofitted specimen and 11-FXB is a specimen retrofitted by steel plates, high-strength external hoops and steel cross braces. The details of 11-FXB are illustrated in Fig. 1. The reinforcing details of each column and dimensions are also shown in the figure. Each column has sectional dimension of 200 mm × 200 mm. In this study, cyclic lateral displacements are applied to each specimen without applying axial load.

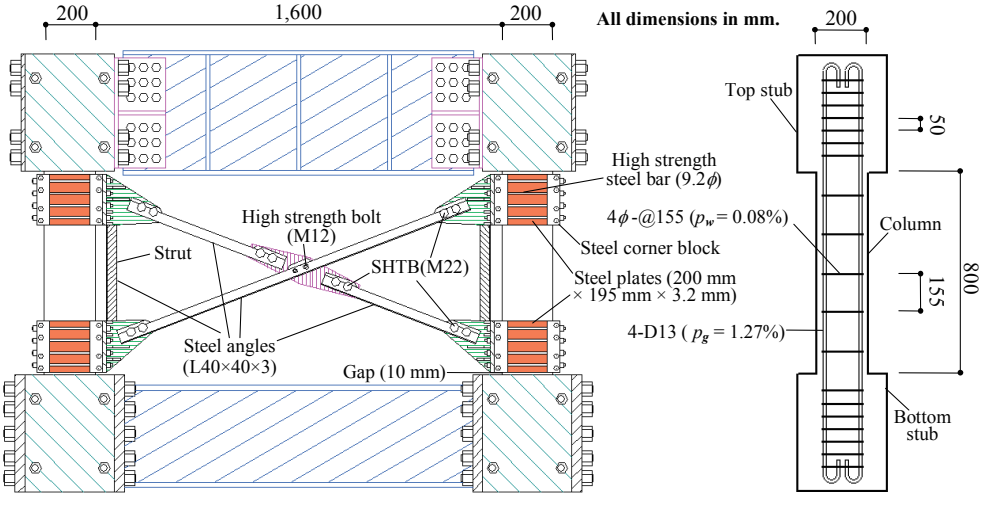

Fig. 1: Details of retrofitted specimen 11-FXB

2. Numerical Modelling Using OpenSees

Fig. 2 illustrates the numerical elements of the specimens in OpenSees. Two-dimensional frame elements are used to model the two specimens. Static cyclic analyses are carried out based on the displacement history applied to the specimens. The comparisons of experimental results and numerical analysis results are shown in Fig. 3. In 10-F, shear failure is detected at story drift angle, R, of 1.3%. The detection of shear failure is related to modelling the shear springs and shear limit curves. In 11-FXB, the initial lateral stiffness of numerical response matches the experimental one so well. Moreover, buckling behavior of the steel braces is simulated at the peak point.

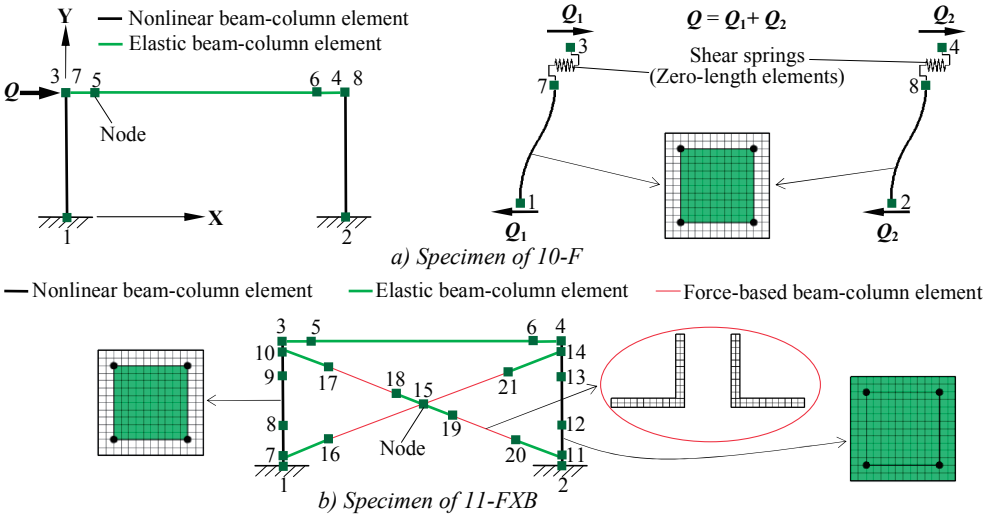

Fig. 2: OpenSees model

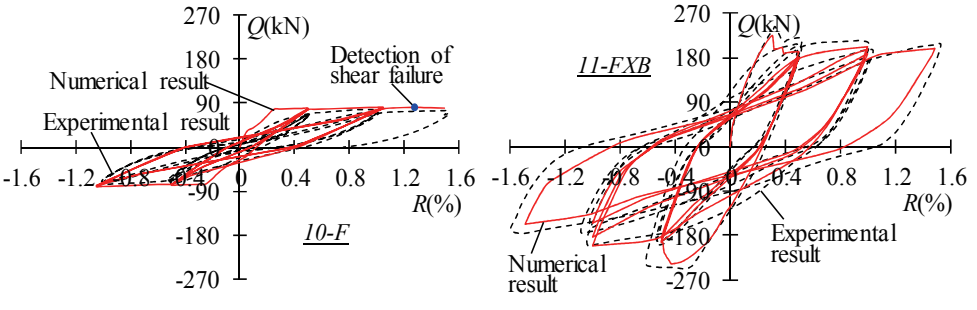

Fig. 3: Comparisons of experimental results and numerical results

3. Conclusions

A RC frame without retrofit and the other one retrofitted by external confinement and steel cross braces with super high tension bolts, were tested under the reversed cyclic lateral force. The cyclic analyses of the specimens are carried out using OpenSees. The experimental and numerical results lead to the following conclusions:

(1) The retrofitted one exhibited excellent seismic performance.

(2) For 10-F, the shear failure can be detected in numerical study.

(3) For 11-FXB, the initial lateral stiffness of numerical response matches the experimental one so well, and buckling behavior of the steel braces can be simulated in numerical analysis.