The Effect of the Distance between Core and Steel Casing on the Behavior of Concrete Frame Reinforced with Buckling-Restrained eccentrically Braces

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1-Introduction

Studying previous earthquakes indicates that most concrete buildings are not earthquake resistant. Changing the use, changing the regulation criteria, and building development are among the reasons that make retrofitting mandatory. Among the retrofitting methods, most attention is paid to the use of steel braces due to ease and high speed of construction, and lower cost of repair or replacement of damaged bracing system after earthquakes. At the same time, steel bracing system is also of some shortcomings among which the main problems are related to weak post-buckling behavior, and stiffness and strength losses in the performance of compressive members in conventional steel braces. The buckling-restrained bracing system is a new type of bracing system along with energy dissipation that the brace behavior in pressure is the same as its behavior in tension and as a result, it is of a much better ductility and energy dissipation compared to conventional braces.

In this research, the reinforcement of concrete frames using buckling restrained eccentrically braces has been analyzed and by changing the distance between core and casing, the effect of this parameter on the brace behavior has been investigated.

2-Experimental Prototype

In order to validate the model, the experimental studies performed by Khampanit et al. (2014) have been used. The experimental investigation includes a buckling-restrained concrete bracing frame. The concrete frame characteristics are related to the building of a school in Thailand. The manufactured model has a scale of 0.5 relative to the main frame. The frame height is 1.6m, the frame span is 4m, columns have dimensions of 0.15×0.15 m, the beam dimensions are 0.15×0.3 m. The used bracing system is of fully-steel buckling-restrained type. Using hydraulic jacks, the samples have been subjected to pseudo-static lateral loading, having the time history presented in Figure 1. Additionally, a constant gravity force of 150 kN has been applied to the columns.

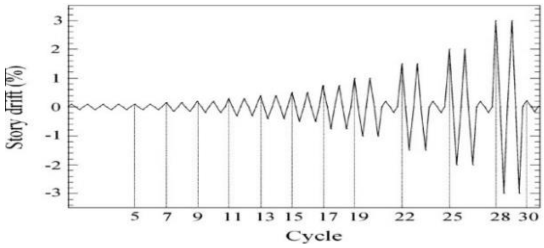

Fig 1. Cyclic loading pattern

3-Finite Element modeling of the Sample

In this section, the experimental sample is modeled by using finite element method (FEM) and by the help of ABAQUS software, and the results are considered for validation.

Regarding the three-dimensional (3D) model of the frame and brace, damaged concrete plasticity model and 3D 8-node element C3D8R have been used for modeling of concrete, and bilinear stress-strain behavior and 3D 2-node truss element T3D2 has also been used for modeling of steel.

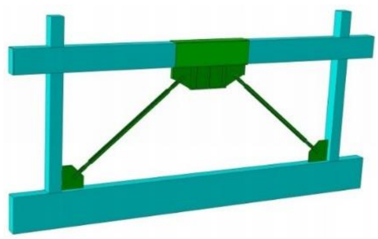

Fig 2. Finite element model of the reinforced concrete frame

After the analysis of the finite element models, their hysteretic envelope curves were drawn and the obtained results were compared with the results from experimental samples.

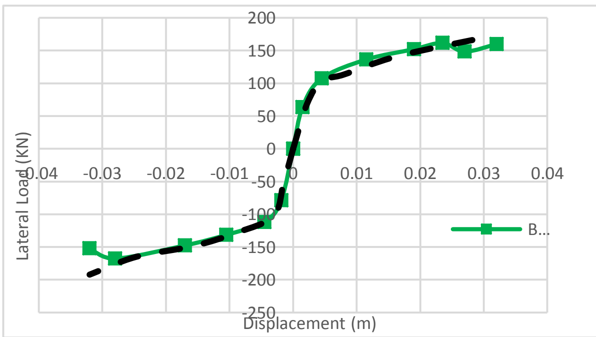

Fig 3. Envelope curves of concrete frames reinforced with buckling-restrained brace in two experimental and finite element cases

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4- The Effect of the Distance between Core and Casing on the Behavior of Concrete Frame Reinforced with Buckling Restrained Brace

In order to investigate the effects of changing of the parameter of the distance between core and steel casing on the behavior of concrete frame reinforced with buckling-restrained brace, models having the distance parameters of 1, 2, 3, and 4 mm and model without distance have been prepared and analyzed for which the obtained results are presented. For examining the behavior of the finite element models, nonlinear static analysis under increasing lateral load has been used. The loading is gradually applied to the structure, starting from zero, and it increases to an extent until the structure reaches the stage of collapsing. The analysis results are shown in Figure 4.

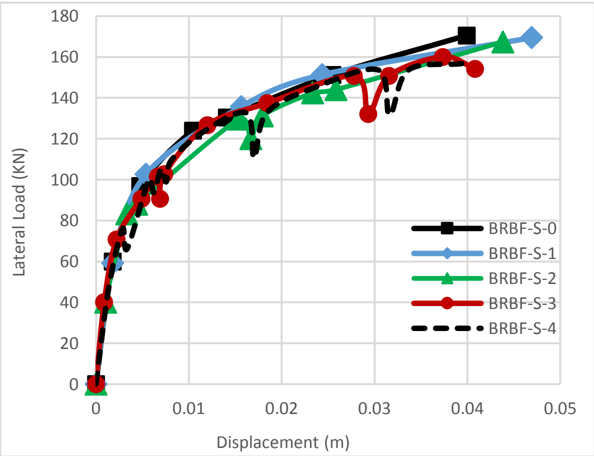

Fig 4. Load-displacement curve of frame models reinforced by buckling-restrained brace having distance between core and casing

Table 1. Analysis results of models having distance between core and casing

Model Name	Distance between core and casing	Pu (KN)	δu (m)	E (KN.m)
BRBF-S-0	0	170	0.04	5.43
BRBF-S-1	1	171	0.044	6.06
BRBF-S-2	2	167	0.043	5/5
BRBF-S-3	3	154	0.041	5/2
BRBF - S-4	4	157	0.04	4/65

Table 1 represents the amount of deformation, strength, and energy dissipation of models with different distances between core and casing.

5- Conclusion

The amount of energy dissipation by the structure has a direct relation with the number of buckling half waves and consequently, the number of core-to-casing contacts. Thus, the more the number of contacts, the greater is the amount of energy absorption by the structure.

The less the distance between core and casing, the more the core-to-casing number of contacts. However, greater displacements are required for the formation of half-waves as the distance between core and casing increases. Therefore, because of the lack of contacting of core to the casing in some displacements, the structure energy dissipation drops down and remains until contacting of the core with the casing.

In the case of no space between core and casing (S=0), it is reduced from the structure lateral deformation.

At the distances of 1 to 2 mm between core and steel casing, the core is of the best behavior in terms of ductility and it has the maximum number of buckling half-waves, which lead to more energy absorption, itself. Moreover, by increasing the distance between core and casing, the number of vibrations is reduced and it is reduced from energy absorption by the brace.