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

Ali Kheir-aldin[1]   Mohammad Mollaie[2]

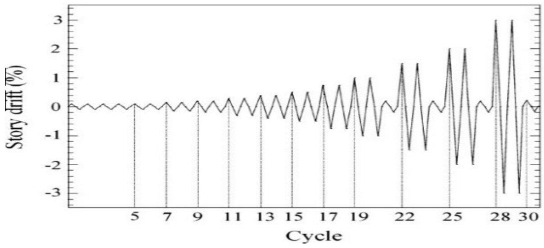

Fig 1. Cyclic loading pattern

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.

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.

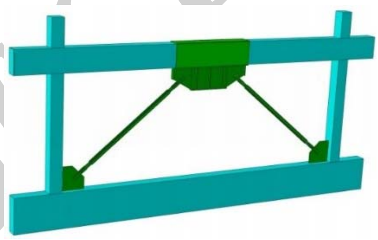

Fig 2. Finite element model of the reinforced concrete frame

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.

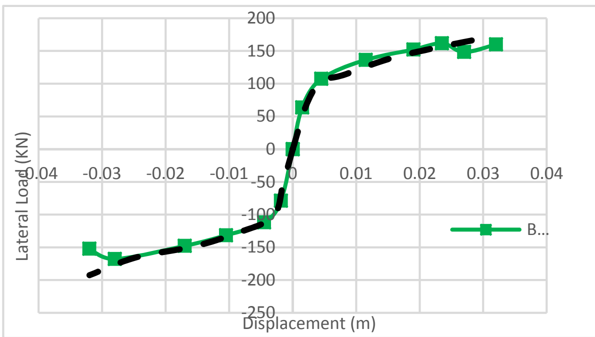

Fig 3. Envelope curves of concrete frames reinforced with buckling-restrained brace in two experimental and finite element cases

[1] Corresponding Author, Professor, Faculty of Civil Engineering, Semnan University
E-mail: kheyroddin@semnan.ac.ir
[2] M.Sc. in Structural Engineering, Semnan University

Table. 3. Summary of the experiments

Fr	H(cm)	de	d	α(deg)	Le
0.2	*	*	*	*	*
0.2	3	4H	H	10	16H
0.2	3	4H	H	20	16H
0.2	3	4H	H	30	16H
0.2	3	4H	H	40	16H

In the above Table, Fr is Froude number, H is the height of vanes, Le is the lengthy distance of vanes, α is the insertion angle in degrees, d is the insertion depth of the vanes and de is the distance from the outer bank of the vane. After conducting each experiment, the bed topography was measured using a laser meter and finally using the Tecplot software, the bed topography of the physical model was constructed.

3-Results

Based on the experiments and analyzing them, the results are as follows:

1. In the control experiment and without inserting the immersed vanes, the erosional hole with a maximum depth of 50 mm exited from the 130-degree position near the outer beach and was continued to the end of the data sampling scope.
2. Immersed vane's structure caused fundamental changes in the pattern of erosion and sedimentation in rivers arc.
3. The maximum depth of the erosion hole in two mounting angles of 20 and 40 degrees, is equal to 20 mm whereas compared to the control test (the maximum erosion hole depth of 49 mm) it has 60% reduction.
4. In the mounting angle of 20 degrees, the erosion holes utterly attached to the outer banks, but the erosion hole installed at 40 degrees angle got away from the outer beach.
5. The best installation angle of immersed vanes is 40 degrees. Also, the results of this study is compatible with the results of Avodgard (2008).
6. At the insertion angle of 40 degrees, the length of the erosion hole was 44 cm where compared to the control experiment (160 cm) it has 73% reduction. Hence, by installing immersed vanes at this angle, the minimum possible length of the outer beach with face with erosion is obtained.