EXPERIMENTAL INVESTIGATION ON THE SEISMIC BEHAVIOUR OF AN L SHAPED REINFORCED CONCRETE COLUMN

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Abstract: *This paper presents an experimental investigation on the behaviour of an L shaped reinforced concrete column under seismic action. The specimen was one-quarter of typical columns of a prototype medium-rise building tested to failure using shaking table. The loading procedure was successively increasing peak ground acceleration until the test structure collapsed. The seismic response characteristics of specimen such as displacement at the top, failure mechanisms are evaluated and discussed in detail.*

Key words: *L shaped column, seismic, reinforced concrete, shaking table.*

I. INTRODUCTION

L shaped columns can be effectively used at the corner of high-rise building structures. Reinforced concrete (RC) frame structures with L shape column offer advantages of open space and increase the overall flexural stiffness of building structures, reducing lateral displacements due to horizontal loadings such as earthquake or wind. However, the seismic behaviour of such configuration is not well known nowadays and there was rarely investigating available in literature. Ramamurthy and Khan [1] proposed two methods of designs for such columns including the “failure surface” and the “equivalent” rectangular column, while Hsu [2] reported experimental study on L-shaped column under biaxial bending action. Pham and Li [3] tested ten short tied L-shaped reinforced concrete columns under the combination of constant axial and cyclic lateral loads to investigate the seismic performance of such irregularly shaped columns. Aman et al. [4] conducted a quasi-static test on four reinforced concrete shear walls with L-shaped cross sections under the simultaneous action of axial and cyclic loads. An experimental study was investigated the seismic performance of solid steel reinforced concrete frames with special-shaped columns by Liu et al. [5]. In [6], Nguyen et al. presented an experimental program to investigate the effects of cross-sectional shape on the seismic performance of irregularly shaped RC columns. Most of these work carried out by the aforementioned researchers focused on static analysis of such columns. Consequently, in design practice, engineers generally assume that the L-shaped columns respond as two separate, perpendiculars, barbell walls.

With the objective of deepening the understanding of the behaviour of this type structure, an experimental study on the seismic performance of L shaped RC columns has been carried out at University of Transport and Communications of Vietnam. The specimen was dynamically tested to failure using the shaking table. The seismic response characteristics of specimen such as drift capacity, failure mechanisms are evaluated and discussed in detail.

II. EXPERIMENT PROGRAM

A nine-storey reinforced concrete building is selected as the prototype structure for the experimental investigation. The reinforced concrete frames in residential stories from the second to the top floor are infilled with masonry walls, while in the ground storey façade is made by glass (figure 1). During a seismic event, the ground columns, without strengthening effects of infilled masonry walls that are present in the stories above, are the most vulnerable and will be governed by shear-sliding mechanisms.

2.1. Test setup

Test setup is designed based on two assumptions. First, under seismic action reinforced concrete frame from the second to the top floor is strengthened by infilled masonry walls so that the seismic performance of the prototype building structure will solely be governed by the shear-sliding mechanism of the ground columns. Second, with the presence of the upper building structure strengthened by infilled masonry walls and the pile caps at the foundation level, the column is rotationally restrained at both top and bottom.

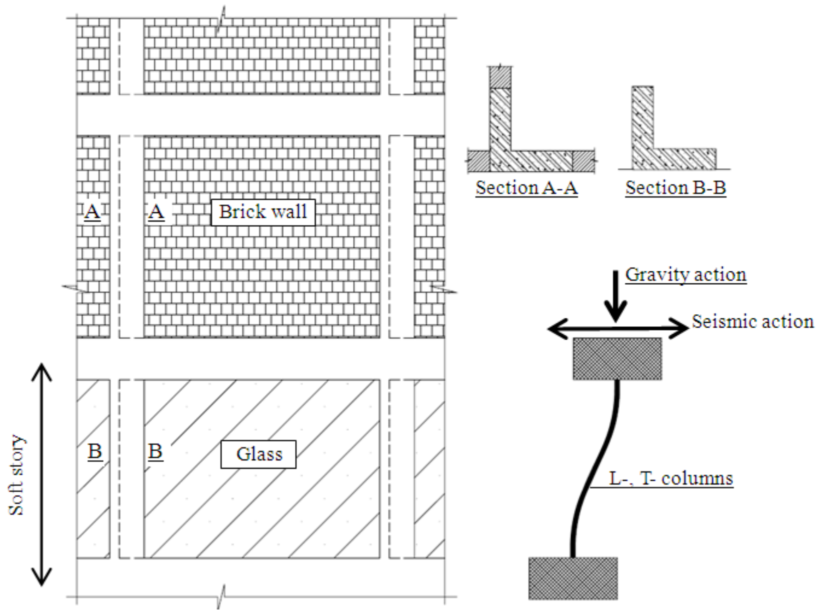

Figure 1. *Test assumptions*

The typical test setup is represented in figure 2. The specimen was anchored to the shaking table by eight high-strength 14mm bolts. Four steel bars (diameter of 22 mm) are used to create the shear-sliding mechanism in the test specimens. A concrete block (0.84mx0.7mx2.4m) was mounted on top of specimens using four high strength 18mm bolts.

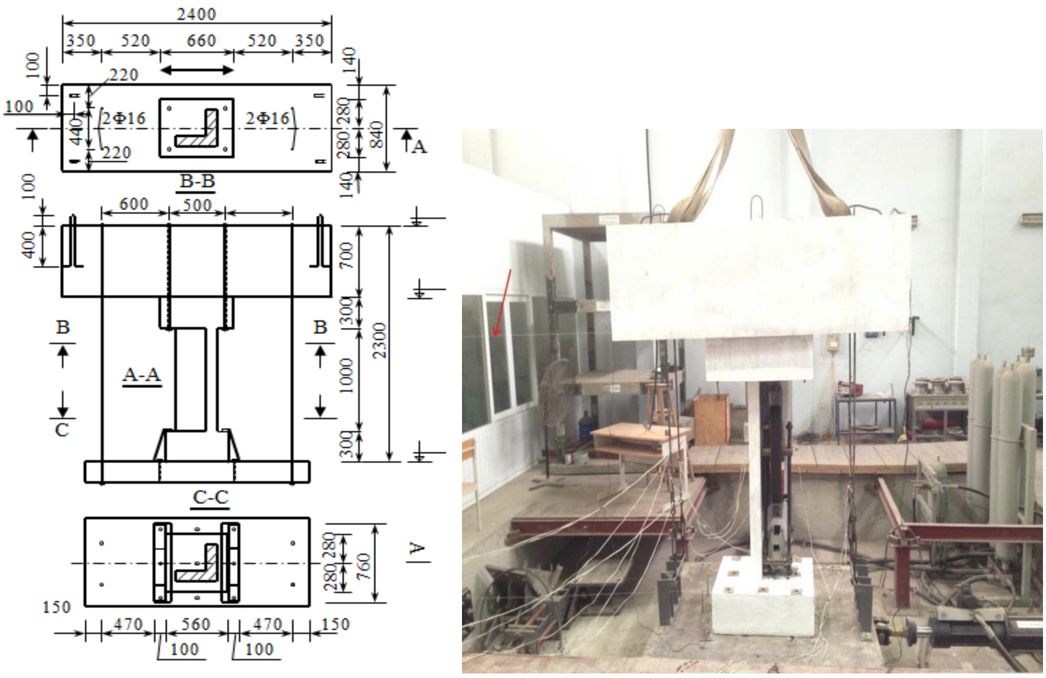

Figure 2. *Test setup*

2.2. Specimens detail

Due to the limited capacity of the shaking table, dimensions of test specimen were scaled down from the actual ones by ¼. The column body of 1000 mm length was cast monolithically with two concrete bases of 300 mm thickness at both ends that were used to connect to a concrete block (at the top) and the shaking table (at the bottom). At the testing time that was 40 days after the specimens were cast, the average cylinder strength of the concrete was 18 MPa and the secant modulus of elasticity of concrete is 24500 MPa. Average yield and ultimate strengths of the reinforcement were 390 MPa and 420 MPa. Figure 3 showed the section design of the test specimen.

Figure 3. *Section design of test specimen*

2.3. Testing procedure

In this experimental program, the specimen was tested to failure using the shaking table to investigate the seismic performance of the columns. Specimens were subject to a combination of gravity and seismic lateral loadings. Gravity axial load of 20 tons was applied at the top of specimen while seismic loading was simulated by the shaking table with the time history of the input base motion (accelerogram). The acceleration time history was applied uni-directionally to the specimen with the duration of 15 seconds with increasing scale of the peak acceleration from 1 m/s^2 until the test structure collapsed.

III. EXPERIMENTAL RESULTS & DISCUSSIONS

3.1. Test observations

Two types of cracks were observed in this experimental study, including: flexural horizontal cracks located at height of specimen and vertical cracks located at the base of specimen (see figure 4).

Figure 4. *Tested specimen*

The first cracks ever appeared were flexural ones in specimen at the peak acceleration of 4 m/s^2. The vertical cracks appeared much latter in at acceleration levels of 8 m/s^2. It is worth noting the shear diagonal crack that is reported in previous tests [6] has not been observed in the present specimen.

3.1. Displacement at the top

The figure 5 shows the maximum horizontal displacement at the top of the specimen in all the tests. As can be seen, the displacement changes gradually following the increase of ground acceleration. However, this value increases rapidly from the turning point after the peak acceleration of 4 m/s^2 where the first cracks appeared.

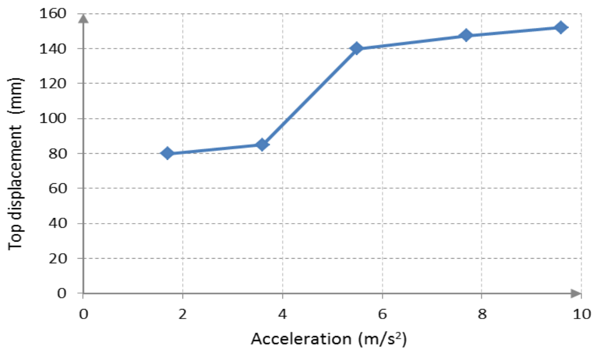

Figure 5. *Horizontal displacement at the top*

VI. CONCLUSIONS

In the experimental program presented herein, one L- shaped RC column has been tested to failure to examine the performance of this type of column. The test specimen that was 1/4 scaled from columns of the soft storey of a prototype building. The loading procedure was successively increasing peak ground acceleration. As can be observed, two types of cracks were observed: flexural horizontal cracks located at height of specimen and vertical cracks located at the base of specimen but the shear diagonal crack has not been appeared. Future study is suggested to investigate on different parameters surch as the axial load, aspect ratio, horizontal loading direction and arrangements reinforcement. Theses parameters propably influences to the failure mechanism of L-shaped RC column under seismic action.

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