Effect of Column Dimensions on Seismic Behavior of Multi-Storey Buildings

Diyar Yousif Ali

***Abstract*: This study aims at considering the effect of columns size on the seismic performance of reinforced concrete structures, in this article, three RC frames with different columns sizes have been analyzed. The five-storey building is analyzed for seismic force by Choosing three different type column cross-sections of the structural mechanism. i.e. (60x45) cm, (550x45) cm and (50x40). To assess the behavior of multi-storey building under seismic action Nonlinear static analyses for lateral loads were performed by using standard package SAP2000 software. The comparison of these frames for various earthquake response parameters like stiffness and base shear with roof displacement was executed. It is observed that the seismic efficiency in frame 1 of column dimensions(60x45) cm was significantly large with small displacements and The results are well-illustrated in this article.**

Keywords: SAP2000, columns, RC frame, pushover analyses.

I. INTRODUCTION

Under the action of earthquake activities, reinforced concrete columns (for example, middle columns of underground structures and bridge piers) would withstand not only the lateral and vertical loads but also the influence of torsion [1]. The main members of structures are the columns that dominate the Structure response throughout earthquakes. Almost all (RC) building collapses in earlier earthquakes were due to Column's poor performance [2]. Hence, it is necessary to control lateral displacement in structure to avoid generating large displacements (especially vertical load elements) [3].

As a common practice in the Analyze and design processes, and for economic purposes, columns are classified based on the load transferred to them. In a multi-storey building, the columns on the first level undergo a massive load [4]. The pattern of damage observed during past earthquakes suggests that columns are the most critical elements that sustain damage and lead the potential building failure. Hence, understanding their response to applied seismic loads is vital for the overall assessment of the performance of a structure [5]. Lateral Displacement of a cantilever column under horizontal loads usually consists of two portions: the shear deformation and the bending deformation. as shown in Figure 1 [6].

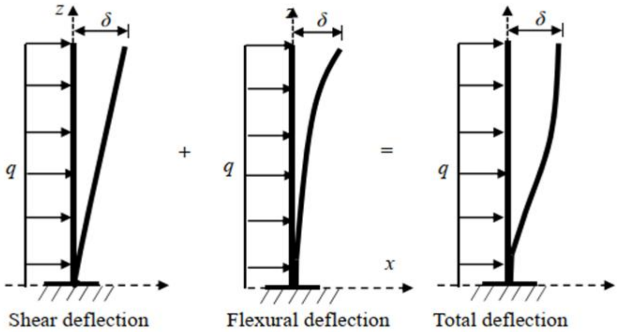

Fig. 1.lateral deflection of frame building [6].

Once a typical fixed ended reinforced concrete column is exposed to the horizontal loads at its ends, it subjects total lateral distortion that is mostly contained of three components because of reinforcement slip, shear and flexure mechanisms (Sezen & Moehle, 2004; Sezen &Setzler, 2008) as shown in Figure 2 [5].

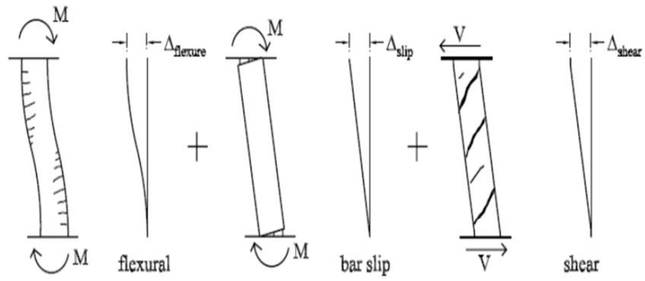

Fig. 2. Overall Horizontal Deformation Components in Fixed Ended Columns [5].

Pushover analysis (SAP2000) or Nonlinear Static processes are usually used for the performance assessment of the design of new structures and existing structures. A nonlinear static method is implemented to determine lateral load-displacement relationship under increasing static horizontal load or displacement of structures. The horizontal forces or displacements are increased steadily till the structure collapses or the structure achieves the displacement or target force [6].

II. CASE STUDY

The structures in this paper are designed as a two-dimensional model. The height of the floors is 3.2 m and the span of the columns is 5.5 m. For the nonlinear analysis of structures, SAP200 Version 17 was used. In recent years, Computer using technologies in engineering applications has become an unchangeable direction.

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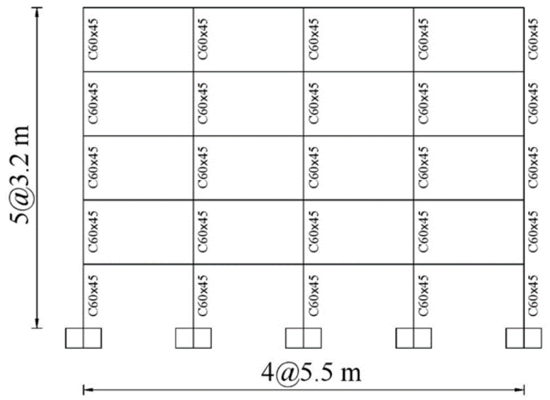
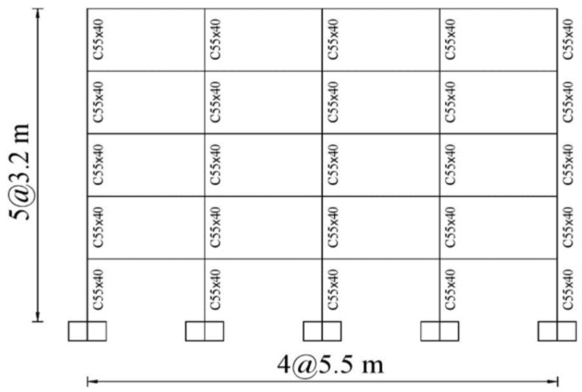
This is attained through the utility of a computer as a method for analysis and modeling design. Hence the example frame model established in this paper using SAP2000 is a four-bay five-storey 2-D frame. All columns are supposed to have fixed supports at the base of the building, the three frames of the five-storey building are presented in Figure 3. To keep the analysis general, the material properties of the components keep consistent within the whol building. For gravity loads, a dead load of 14 kN/m2 and the live load is taken as 2 kN/m2 for the roof and 4 kN/m2 for the floors,

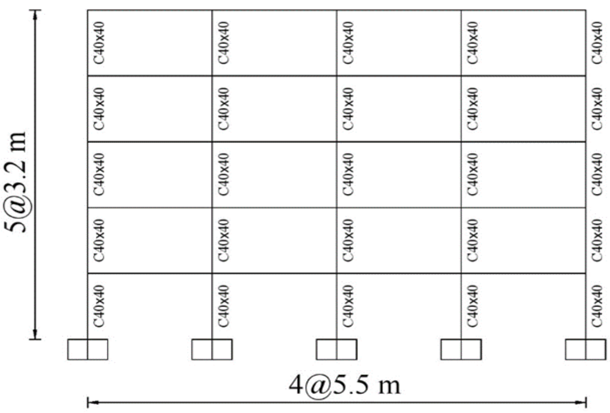
- Cross-section of beam: 50 cm by 40 cm.
- Bay widths: 5.5 m, Constant storey height: 3.2 m
- compressive strength of concrete (fc'=21 Mpa)
- yield strength of steel (fy =345 Mpa).



Frame 1



Frame 2



Frame 3

Fig. 3. RC structure with three frames.

Two load cases are considered, namely, gravity and horizontal loads. For each type, the three model buildings were analyzed for different scenarios of columns used. The scenarios represent different column dimensions. This variation of the dimensions of the column is important to investigate the effect of the Column stiffness on the deflection of the building. More details of structure members are provided in table I, followed by the results of the analysis and discussion.

Table- I: Dimensions in (cm) of structure members for the current study

Floor	Frame 1		Frame 2	
	Beams	Columns	Beams	Columns
1	50 x 40	60 x 45	50 x 40	55 x 40
2	50 x 40	60 x 45	50 x 40	55 x 40
3	50 x 40	60 x 45	50 x 40	55 x 40
4	50 x 40	60 x 45	50 x 40	55 x 40
5	50 x 40	60 x 45	50 x 40	55 x 40

Floor	Frame 3	
	Beams	Columns
1	50 x 40	40 x 40
2	50 x 40	40 x 40
3	50 x 40	40 x 40
4	50 x 40	40 x 40
5	50 x 40	40 x 40

III. RESULTS AND DISCUSSION

Increasing in section dimensions decreases the damage index for all reinforcement ratios. When section dimensions are enlarged from 30x30 cm to 60x60 cm, the probability of severe damage and collapse condition decrease from 34.5% to 7.5% for all earthquakes. The same probability changes from 66.7 % to 15 % for near-fault earthquakes and from 4.3 % to 0 % for far fault earthquakes. It is recommended to use 60x60 cm sectional dimensions having 2 % longitudinal reinforcement ratio if a minor damage is intended in design [7]. The base shears force versus displacement graphs of three models is presented in Fig.4. Figure 4 compares the roof displacements of three RC frames of different column dimensions calculated by the SAP2000 pushover analysis. Displacement beyond yielding or other material nonlinearity is called inelastic displacement. In this research, P-Δ effect was not involved in the analysis. As seen in Fig. 4, the maximum applied load on model frame 1 (with a column of 60 cm x 45 cm) is only 802 kN at a displacement of 38 cm, whereas in model frames 2 and 3, the maximum values of base shear reaches about 731 kN and 645 kN, respectively. Furthermore, the corresponding displacements at maximum applied loads reach approximately 49 cm and 58cm for frames 2 and 3, respectively. Therefore, based on model types 1 and 3, the maximum displacements decrease about 20 cm with an increase in the dimensions of a column from (40 cm x 40 cm) to (60 cm x 45 cm).

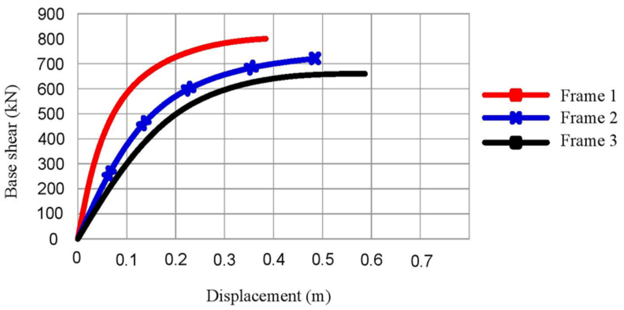


Fig. 4. Base shears force versus displacement.

From the load-displacement values derived from SAP2000, the stiffness at the last step of the pushover case was calculated for all three frames. The stiffness of the Reinforced Concrete frames with different column dimensions was calculated and presented in Fig. 5. For Reinforced Concrete frame1 (with a column of 60 cm x 45 cm), the initial stiffness value is 1586 kN/m, for frame 2 it was reduced to 1392 kN/m, similarly for a frame with (with a column of 40 cm x 40 cm), the initial stiffness was 1186 kN/m. Analysis of the frame stiffness for Three Frames with different column dimensions showed that the frame stiffness was shifted upward as the column dimensions increased. In Figure 5, the maximum stiffness difference between frame 3 and frame 1 is approximately 25%.

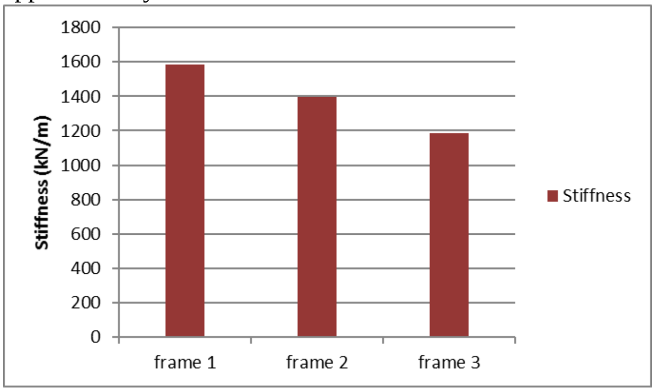


Fig.5. Lateral stiffness of the three frames.

IV. CONCLUSIONS

The effect of the size of the columns on the lateral performance of RC Frames was studied using three frames of different column cross-section sizes. The following conclusions can be summarized,

1-The shear force of the frame 3 is less than that of the frame 2 and frame 1.

2-The frame stiffness calculated based on frame 3 gave a lesser value than the other frames. It was observed that frame 1 is nearly 25% greater compared to frame 3.

3-It is noticed that the value of storey shear increases with an increase in column sections.

4-The paper illustrates that the storey displacement increases with the decreased column dimension; Meaning that, frame 3 produced the largest displacement compared to frame 1.

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