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Seismic Performance of Hollow RC Columns in High Rise Buildings

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ABSTRACT

The seismic behaviour is the response of the structure during the excitation of earthquake force. Neglecting this force in the design of building will cause serious damages during earthquakes. Since mass and stiffness of the structure influences in the seismic response of the structure. The present study focuses on the analysis of multi-storey R.C building using hollow columns using finite element tool, E-TABS. Hollow RC columns are the type of columns having hollow core. Removal of concrete in this hollow section/core reduces the total weight of building, thereby reducing the base shear of the structure and also provision of hollow columns enhances the stiffness of the building. In the present study, solid RC columns are replaced by hollow RC columns and response of the building is analyzed. Buildings with symmetric, asymmetric, axis-symmetric plan and mass irregular axis-symmetric plans having different heights are analytically studied using ETABS. Seismic parameters like base shear, lateral displacement and time periods are evaluated for different models. Models with hollow RC columns shows better responses when compared with the models having solid RC columns.

I.INTRODUCTION

Hollow columns have lighter weight when compared to that of conventional solid columns. Reduction in the quantity of materials in the center hollow region decreases the seismic weight of the structure. Material deduction makes construction economical. Abhay [1] proposed that by replacement of solid RC columns by hollow RC columns 22.67% weight decreased. It is mentioned that axial force of Hollow RC columns is less than that of RC solid Columns.

This study deals with the analysis of structure having Solid and Hollow columns and compare the behavior of both in seismic loads. Analysis is done by using ETAB software. Different models are used in the analysis varying with different plans, different heights and with different number of stories with hollow columns. Symmetric, asymmetric and axisymmetric plans are done in model. 5m x 5m bays are used in all the models. Height of each storey is taken as 3 meters. Respective IS codes are considered while assigning material properties, section properties and different loads. Bujj earthquake data is taken in time history analysis. Base shear, max storey displacement, and modal time period variation is obtained after the analysis. Obtained results are compared between structure having full solid RC columns and structure having hollow RC columns.

II.MODELING

A. Types of Models

Models are classified into several types based on different parameter, i.e., based on plan of model, based on the number of stories and based on the number of stories having Solid columns

i. Base on plan of model

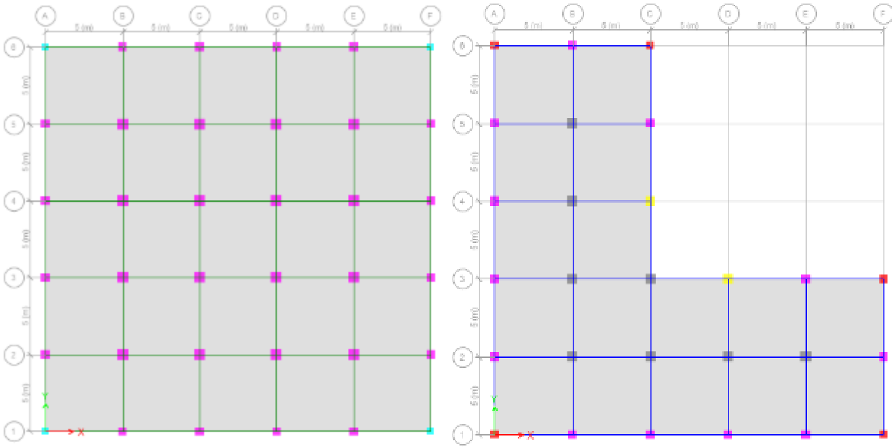


Fig. 1 Plan of symmetric (Square shape) shape and asymmetric Plan (L- Shape)

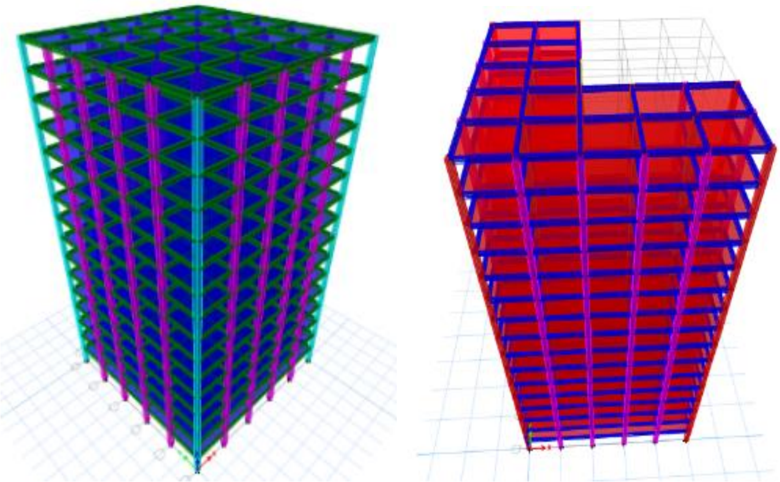


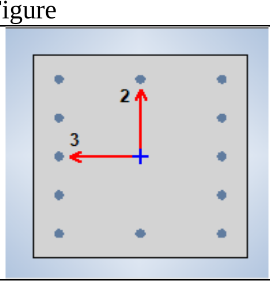
Fig. 2 Elevation of symmetric (Square shape) shape and asymmetric Plan (L- Shape)

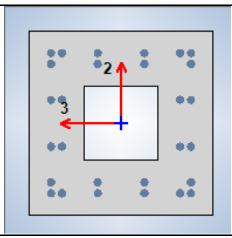
ii. Models based number of stories
   a) 15 Storey's
   b) 20 Storey's
   c) 25 Storey's
   d) 30 Storey's

iii. Models based on number of stories having Solid columns
   a) Building of solid columns
   b) Bottom 10 Storey's with solid columns followed by hollow columns of 15, 20, 25 and 30 storey building.
   c) Bottom 5 Story's with solid columns followed by hollow columns 15, 20, 25 and 30 storey building.
   d) Bottom 2 Story's with solid columns followed by hollow columns 15, 20, 25 and 30 storey building

B. Column Description

Table 2: Column Details

Type of Column	Figure	Size
Solid Column		• Varies for different models depending upon the axial load coming to the column

Hollow Column		• Varies for different models depending upon the axial load coming to the column • Thickness of concrete ring=150mm.

C. Load Data

- Dead load (IS 875-part I)
- Super imposed dead load on beam from wall = 10.2kN/m (IS 875-part I)
- Live load on the slab = 2kN/m^2(IS 875-part II)
- Seismic Loads-Time History analysis (Bhuj Earthquake)

III. RESULTS

From the analysis, base shear and maximum storey displacement of the structure with solid, with hollow columns and combination of both are found out.

A. Base Shear

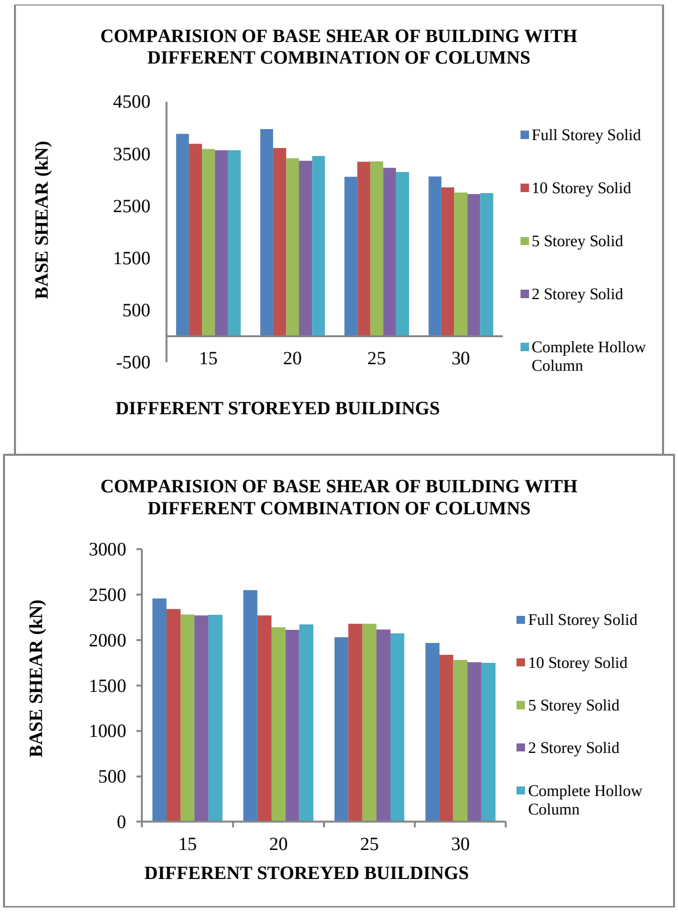


Fig. 3 Base Shear of Symmetric Planed Building (Square Shape) and Asymmetric Planed Building (L-Shape)

Fig. 3 show that base shear decreases with the increase in number of hollow columns. In 15, 20 and 30 storey buildings with both symmetric and asymmetric planned structure with only solid columns has higher base shear. The range of reduction in base shear is 4-8%, 10-18% and 6-11% for 10, 5 and 2 storeyed with solid columns in 15, 20 and 30 storey building respectively, whereas the 25 storey building has lesser base shear relatively 3-7%. In 15, 25 and 30 storey buildings with symmetric and asymmetric plan structures with only solid columns has higher base shear compared to complete hollow columned structure of relatively 5-8%, whereas the 20 storey building has lesser base shear of 0.5%.

B. Storey Displacement

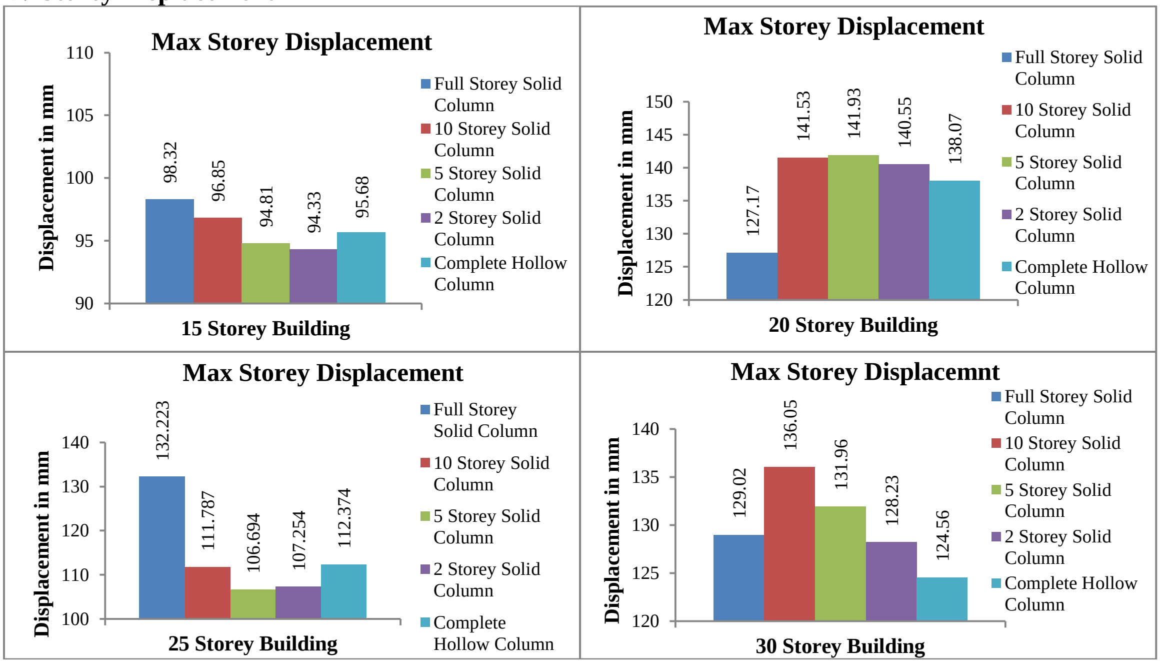


Fig.4 Max Storey Displacement of 15, 20, 25 and 30Storey Symmetric Planed Building (Square Shape)

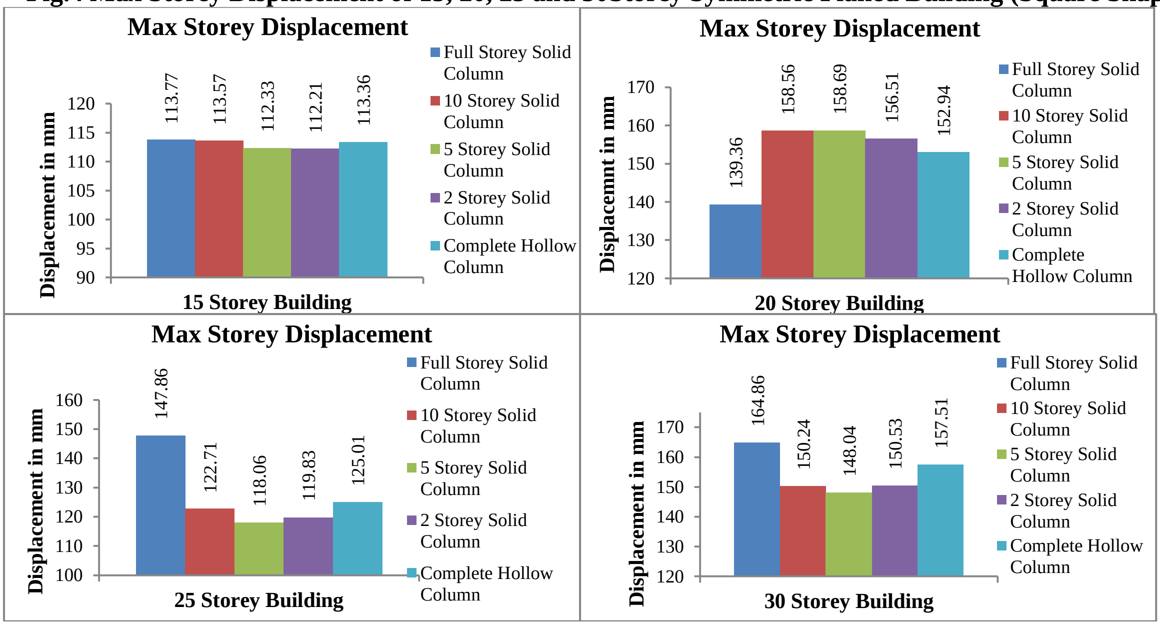


Fig.5 Max Storey Displacement of 15, 20, 25 and 30Storey Asymmetric Planed Building (L-Shape)

Storey displacement decreases with increase in number of hollow columns. Maximum storey displacement is higher in the structure with only solid columns, but the displacement decreases with decrease in the number of storeys with solid columns replacing those columns by hollow RC columns.

By increase in number hollow columns the stiffness of the structure increases which reduces the Storey displacement. This behaviour is same for symmetrical and asymmetrical planed structures.

IV.CONCLUSIONS

1. Seismic weight of the structure depends upon the weight of the structure, i.e., directly proportional to the base shear.
2. In 15, 20 and 30 storey buildings with symmetric plan (Square shape) structure with only solid columns has higher base shear. The range of reduction in base shear is 5-8%, 9-16% and 6-11% for 10, 5 and 2 storeyedwith solid columns in 15, 20 and 30 storey building respectively, whereas the 25 storey building has lesser base shear relatively 5-9%.
3. In 15, 20 and 30 storey buildings with asymmetric plan (L-Shape) structure with only solid columns has higher base shear. The range of reduction in base shear is 4-8%, 10-18% and 6-11% for 10, 5 and 2 storeyed with solid columns in 15, 20 and 30 storey building respectively, whereas the 25 storey building has lesser base shear relatively 3-7%.
4. In 15, 25 and 30 storey buildings with symmetric, asymmetric and axis-symmetric plan structures with only solid columns has higher base shear compared to hollow columns of relatively 5-8%, whereas the 20 storey building has lesser base shear of 0.5%
5. The 30 storey buildings are more efficient for base shear irrespective of the plan i.e., symmetric, asymmetric, axis-symmetric plan and mass irregular axis-symmetric and type of column sections (Complete Solid, partially solid and complete hollow).
6. Storey displacement decreases with increase in number of hollow columns. Maximum storey displacement is higher in the structure with only solid columns, but the displacement decreases with decrease in the number of storeys with solid columns i.e., by replacing those columns by hollow RC columns.
7. In 15 storey building with symmetric, asymmetric, axis-symmetric plan and mass irregular axis-symmetric plan the displacement is more in only solid column building followed by 10 storey solid column, 5 storey solid column and 2 Storey solid column. where as in only hollow column building the displacement is less than only solid column building but more than other three combinations of columned buildings.
8. In 20 storey building with symmetric, asymmetric, axis-symmetric plan, axis-symmetric plan and mass irregular axis-symmetric plan the displacement is less in only solid column building compared to 10 storey solid column, 5 storey solid column, 2 Storey solid column and for hollow column building.
9. In 25 and 30 storey building for with symmetric, asymmetric and mass irregular axis-symmetric plan structures storey displacement is more for solid column building, whereas the displacement reduces depending on the combination of columns in rest of the buildings.
10. As per plan irregularity the displacement of regular plan building is more efficient compared to others and building with bottom 2 storey solid columns is better compared to other type of column combinations.

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