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ANALYSIS AND DESIGN OF G+11 STOREY RESIDENTIAL BUILDING WITH AND WITHOUT FLOATING COLUMN

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Abstract

In the current era, there is a growing trend of constructing structurally complex buildings with features like floating columns at different floors and spaces. However, buildings with floating columns can pose significant risks, particularly in earthquake-prone regions. This study aims to analyze and compare buildings with and without floating columns, focusing on their structural performance. Floating columns refer to columns that are directly supported by a beam without a rigid base. In India, several buildings have been constructed using this design, often necessitated by the need for larger spacing between columns to accommodate parking or reception lobbies. The present project focuses on the analysis of a multi-storey residential building with a ground floor and 11 upper floors, comprising six apartments on each floor. Various loads, including dead load, live load, earthquake load, and wind load, are applied to the structure and analyzed using STAAD software. The comparison of results is based on three key parameters: storey displacement, storey drift, and base shear. The findings reveal that the building with floating columns exhibits higher storey displacement and storey drift values compared to the building without floating columns, with an increase of approximately 9% to 10%. This indicates that the presence of floating columns contributes to increased lateral movement and deformation of the structure.

Interestingly, the building with floating columns shows a reduction in base shear. This is because the provision of floating columns reduces the overall weight of the structure. However, it is important to note that the building with floating columns also results in an increase in steel consumption, approximately 8.52% higher compared to the building without floating columns. These results highlight the trade-offs associated with incorporating floating columns in building design. While the use of floating columns may reduce base shear, it comes at the expense of increased storey displacement, storey drift, and steel consumption. It is essential to carefully evaluate the structural implications and seismic risks associated with floating columns, particularly in earthquake-prone regions. By conducting thorough analyses and comparisons, engineers and designers can make informed decisions about the inclusion of floating columns in building projects, considering factors such as safety, structural integrity, and overall performance in the face of dynamic loads like earthquakes and wind.

Keywords: STAAD software, Storey displacement, Storey drift, Storey shear.

I. Introduction

Building construction is the engineering deals with the construction of building such as residential houses. In a simple building can be define as an enclose space by walls with roof, food, cloth and the basic needs of human beings. In the early ancient times humans lived in caves, over trees or under trees, to protect themselves from wild animals, rain, sun, etc. as the times passed as humans being started living in huts made of timber branches. The shelters of those old have been developed nowadays into beautiful houses. Rich people live in sophisticated condition houses.

Buildings are the important indicator of social progress of the county. Every human has desire to own comfortable homes on an average generally one spends his two-third life times in the houses. The security civic sense of the responsibility. These are the few reasons which are responsible that the person do most effort and spend hard earned saving in owning houses [1-2]. Nowadays the house building is major work of the social progress of the county. Daily new techniques are being developed for the construction of houses economically, quickly and fulfilling the requirements of the community engineers and architects do the design work, planning and layout, etc. of the buildings. Draughtsman is responsible for doing the drawing works of building as for the direction of engineers and architects. A building frame consists of number of bays and storey [3-5]. A multi-storey, multi-paneled frame is a complicated statically intermediate structure. A design of R.C building of G+11 storey frame work is taken up. The building in plan (30.75*17.21) consists of columns built monolithically forming a network. The numbers of columns are 52. It is residential complex.

The design is made using software on structural analysis design (Staad-pro). The building subjected to both the vertical loads as well as horizontal loads. The vertical load consists of dead load of structural components such as beams, columns, slabs etc. and live loads. The horizontal load consists of the wind forces & earthquake forces thus building is designed for dead load, live load and wind load & earthquake load as per IS 875 & IS 1893. The building is designed as two dimensional vertical

II. FLOATING COLUMN

In the present-day construction of buildings in urban India the main problem arises in the accommodation of parking areas, reception lobbies etc [6-7]. To overcome this problem floating columns came into existence and now it has become an unavoidable feature in most of the multistoried buildings [8]. The floating column shows undesirable results during earthquake [9]. Excitation and the base shear induced is dependent on the natural period and shape of the building [10]. As the height of the building is increased, the earthquake load acting at different floors of the building varies and these should be carried down in the shortest distance [11]. If the load travelling has any discontinuity in its path, it will cause the reduction in the performance of the building [12]. Due to discontinuity in the load transfer path, many buildings in Gujarat have been collapsed in Bhuj 2001 and the buildings with the vertical setbacks caused a sudden jump [13]. The floating column are safe for the vertical loading but the lateral loads acting on the building causes overturning of the building and load travel path is also disturbed which results in the damage of the columns by buckling. This is because the strength of the lower floor is less due to removal of the columns. This project mainly focuses on the comparison of the building with and without floating columns. A column is supposed to be a vertical member which starts from the foundation level and transfers the load safely to the ground from the building. Floating column is a vertical member in which the lower end rests on the beam and load is transferred to the nearby column through the beam.

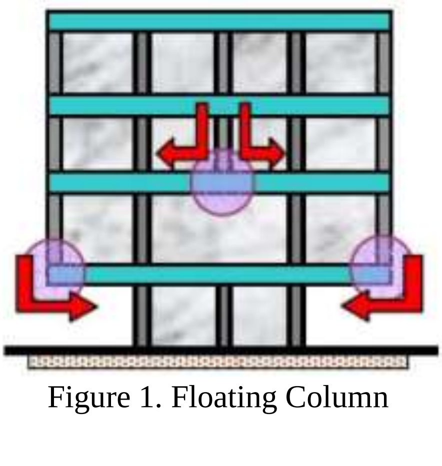

Figure 1. Floating Column

III. STUDY AREA

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In this paper MAHESH SOCIETY project were constructed in Pune. This project layout having 2 buildings of G+11 storey structure and a club house. The layout is as shown in figure 2. Fig 3. Illustrate the Architectural Plan of building.

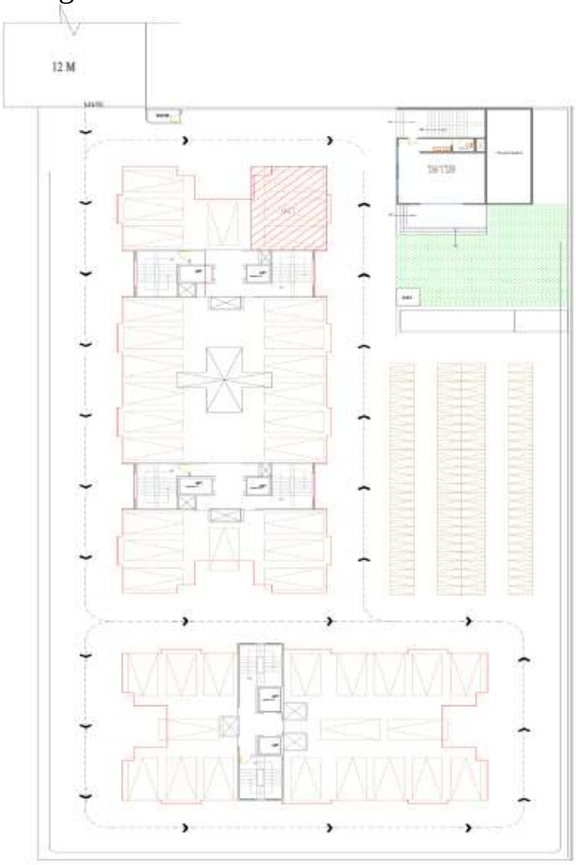

Figure 2. Layout plan of site

Statement of salient feature of building:
Utility of building: Residential complex
No of stories: G+11
Shape of the building: 6 Apartments
No of staircases: 2
No. of flats: 66
No of lifts: 2
Area of building at first floor: 510 m^2
Type of construction: R.C.C framed structure
Types of walls: Siporex
Geometric details:
Ground floor: 3m
Floor to floor height: 3m.
Depth of foundation: 1.5 m
Building location: Pune.
Earthquake Zone: III
Wind speed: 39 m/s
Concrete grade: M30
All steel grades: Fe500 grade
Bearing capacity of soil: 350 KN/m^2

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Figure 3. Architectural Plan of building.

Column position:

Depending upon the architectural requirements and loads to be supported, R.C columns may be cast in various shapes i.e., square rectangle, and hexagonal, octagonal, circular. Columns of L shaped or T shaped are also sometimes used in multistoried buildings.

Some of the guiding principles which help the positioning of the columns are as follows: -

1. Columns should be preferably located at or near the corners of the building and at the intersection of the wall, but for the columns on the property line as the following requirements some area beyond the column, the column can be shifted inside along a cross wall to provide the required area for the footing with in the property line. Alternatively, a combined or a strap footing may be provided.
2. The spacing between the column is governed by the lamination on spans of supported beams, as the spanning of the column decides the span of the beam. As the span of the of the beam increases, the depth of the beam, and the self-weight of beam also increases software-based modeling.

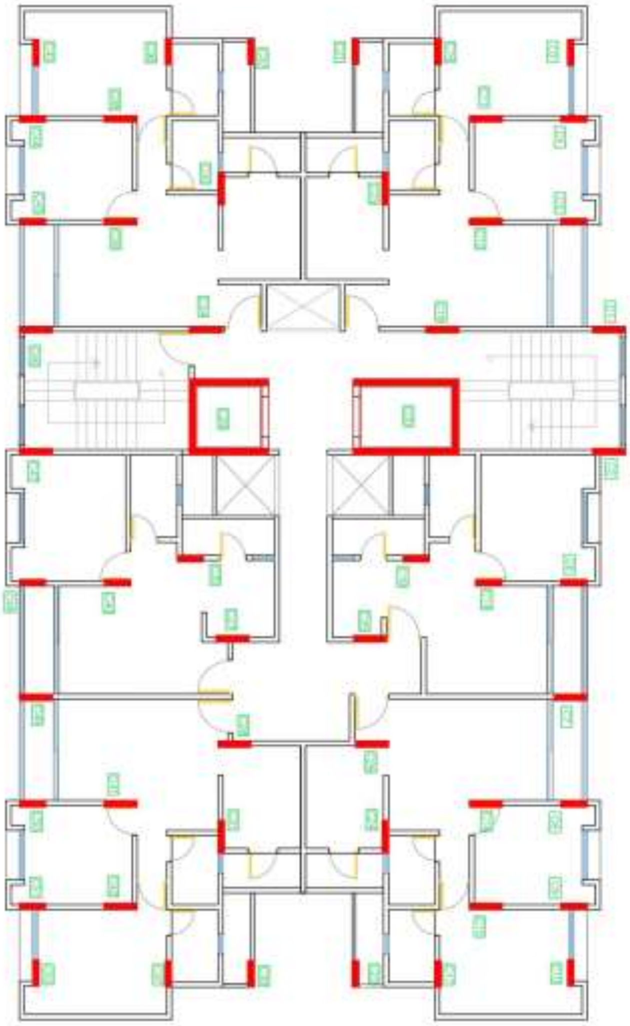

Figure 4. Column position of building without floating column.

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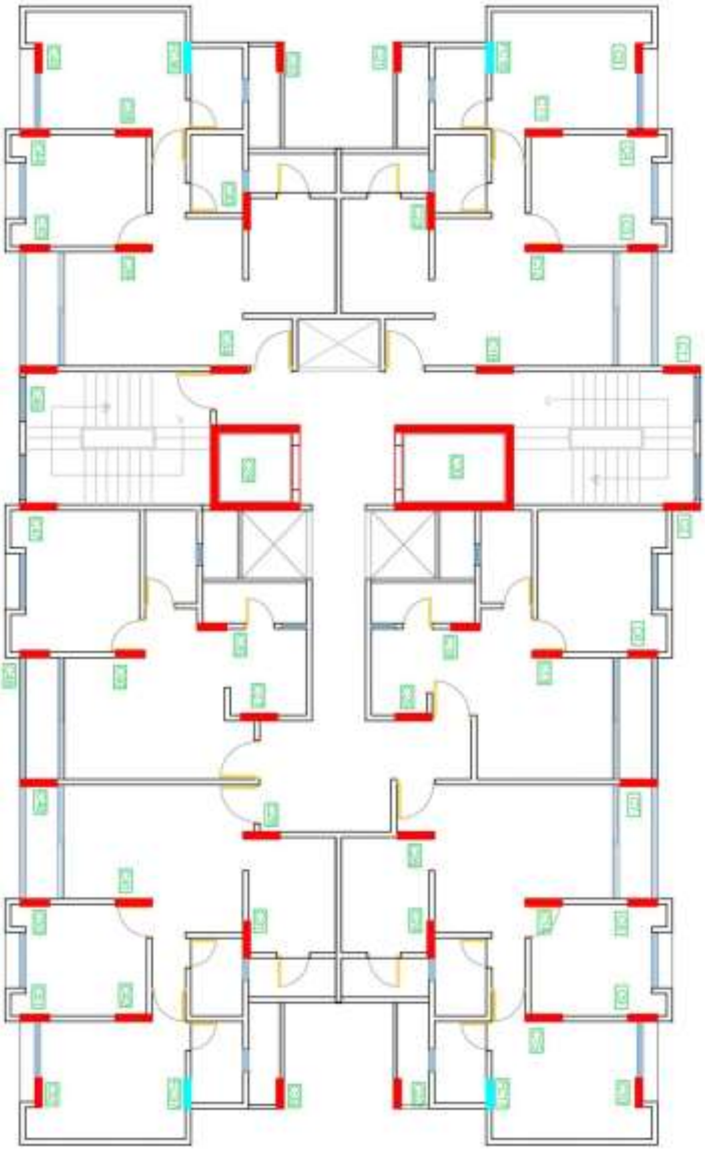

Figure 5. Column position of building with floating column

LOADINGS

The concepts presented in this section provide an overview of building loads and their effect on the structural response of typical wood-framed homes. As shown in Table, building loads can be divided into types based on the orientation of the structural action or forces that they induce: vertical and horizontal (i.e., lateral) loads. Classification of loads is described in the following sections.

Building Loads Categorized by Orientation:

Types of loads on a hypothetical building are as follows.

Vertical Loads

Dead (gravity)

Live (gravity)

Floor finish (gravity)

Horizontal loads

- Wind
- Seismic (horizontal ground motion)

1. Dead Loads:

Dead loads consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, including claddings, finishes and fixed equipment. Dead load is the total load of all of the components of the components of the building that generally do not change over time, such as the steel columns, concrete floors, bricks, roofing material etc. In STAAD pro assignment of dead load is automatically done by giving the property of the member. In load case we have option called self-weight which automatically calculates weights using the properties of material i.e., density and after assignment of dead load the skeletal structure looks red in color as shown in the figure.

Dead load of slab: 25x0.125= 3.125kN/m^2

Dead load of beam: 0.2 x 0.6 x 25= 3 kN/m

Dead load of wall: 0.15 x 6.3 x 3= 2.9 kN/m

Floor finish: 1kN/m^2.

2. Live Loads:

Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform area loads, concentrated loads, and uniform line loads. The uniform and concentrated live loads should not be applied simultaneously a structural evaluation. Concentrated loads should be applied to a small area or surface consistent with the application and should be located or directed to give the maximum load effect possible in endues conditions. Live load on residential building: 2 kN/m^2

Load combinations:

All the load cases are tested by taking load factors and analyzing the building in different load combination as per IS456 and analyzed the building for all the load combinations and results are taken and maximum load combination is selected for the design Load factors as per IS 456-2000. When the building is designed for both wind and seismic loads maximum of both is taken. Because wind and seismic do not come at same time as per Code. In RCC structure seismic load is predominant than wind load that's why it is not necessary to take load cases for wind load in seismic load itself building will design safely.

1.5 (DL+LL)
1.5 (DL+EQX)
1.5 (DL+EQZ)
1.2(DL+LL+EQX)
1.2(DL+LL+EQZ)
0.9DL+1.5EQX
0.9DL+1.5EQZ
1.5(DL+WLX)
1.5(DL+WLZ)
1.2(DL+LL+WLX)
1.2(DL+LL+WLZ)
0.9DL+1.5WLX
0.9DL+1.5WLZ

III. RESULTS AND DISCUSSION

Center line plan:

The above figure represents the center line diagram of our building in STAAD pro. Each support represents the location of different columns in the structure. This structure is used in generating the entire structure using a tool called transitional repeat and link steps. After using the tool, the structure that is created can be analyzed in STAAD pro under various loading cases. Below figure represents

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the skeletal structure of the building which is used to carry out the analysis of our building. All the loadings are acted on this skeletal structure to carry out the analysis of our building. This is not the actual structure but just represents the outline of the building in STAAD pro. A mesh is automatically created for the analysis of these building.

A comparative study and analysis is performed between a normal column building that is the building with all regular columns and other structural and non-structural members in it and on the other hand a floating column building as per the specifications in IS- 1893(2002) part 1. A detail study is carried out on the floating column building to find out the variations in the structural response of the building, observed from the parameters like maximum displacements in the building at each floor, Storey drifts and the results obtained are beyond the deformation limits. Then such a floating column building tend to fail in extreme earthquake zones, thus some recommendations are performed to analyses the building response in that case. In the present research paper, the effect of floating columns as per floor wise on various structural response quantities of the building using static analysis is carried out. The results are compared in tabular form and graphically for the analysis of the building without floating columns and with floating columns. From model 1 and model 2 the floating column is present at the defined location of the frame is modeled and analyzed. The results obtained are by considering the parameters like maximum Storey displacements and Storey drifts, Base shear, bending moment, Shear force of the structure modeled, and the results obtained are discussed as below.

Storey Displacement: Storey displacement is the deflection of a single Storey relative to the base or ground level of the structure. Intuitively, we can expect higher total displacement values as we move up the structure. So, a graph showing the Storey displacement vs. the height of the structure looks exactly like the deflected shape.

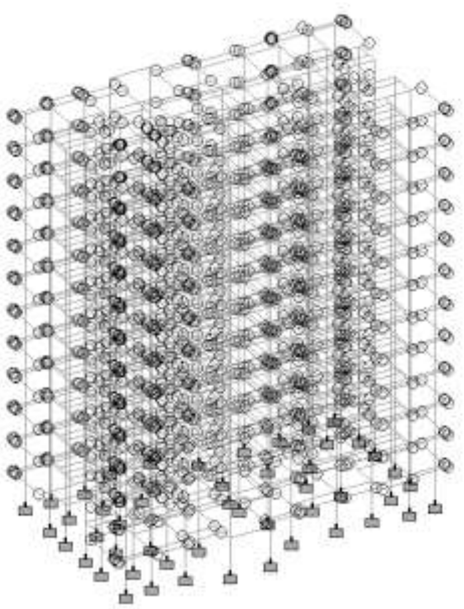

Fig. 6. Skeletal structure of the building without floating column

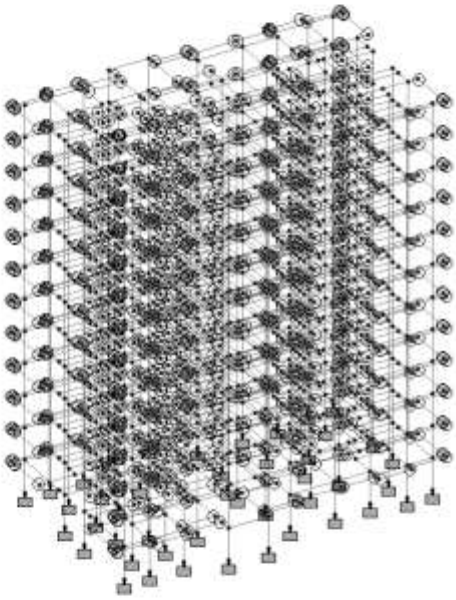

Figure 7. Skeletal structure of the building with floating column

Table 1. Maximum Storey Displacement in X-Direction

Storey	Height(M)	Max. Displacement in X-Direction (in mm)	
		Model without Floating Column	Model with Floating Column
Base	0	0	0
Storey 1	3	0.146	1.820
Storey 2	6	0.372	4.630
Storey 3	9	0.654	8.234
Storey 4	12	0.976	12.042
Storey 5	15	1.324	15.621
Storey 6	18	1.684	19.032
Storey 7	21	2.044	22.357
Storey 8	24	2.394	25.754
Storey 9	27	2.726	29.009
Storey 10	30	3.031	32.109
Storey 11	33	3.3010	35.068
Roof Slab	36	3.556	37.968

Table 2: Maximum Storey Displacement in Z-Direction

Storey	Height(M)	**Max. Displacement in Z-Direction (mm**	
		Model without Floating Column	Model with Floating Column
Base	0	0	0
Storey 1	3	0.115	2.449
Storey 2	6	0.279	3.773
Storey 3	9	0.484	5.759
Storey 4	12	0.721	8.174
Storey 5	15	0.984	10.890

Storey 6	18	1.264	13.806
Storey 7	21	1.554	16.842
Storey 8	24	1.848	19.921
Storey 9	27	2.139	22.977
Storey 10	30	2.422	25.952
Storey 11	33	2.694	28.801
Roof Slab	36	2.951	31.498

Storey Drift:
Storey drift is the lateral displacement of a floor relative to the floor below, and the storey drift ratio is the storey drift divided by the storey height.

Table 3. Maximum Storey Drift in X-Direction

Storey	Height(M)	Max. Drift in X-Direction (mm)	
		Model without Floating Column	Model with Floating Column
Base	0	0	0
Storey 1	3	0.146	1.820
Storey 2	6	0.226	2.81
Storey 3	9	0.282	3.604
Storey 4	12	0.322	3.808
Storey 5	15	0.348	3.579
Storey 6	18	0.36	3.411
Storey 7	21	0.35	3.325
Storey 8	24	0.332	3.397
Storey 9	27	0.305	3.255
Storey 10	30	0.27	3.1
Storey 11	33	0.225	2.959
Roof Slab	36	0.255	2.959

Maximum Storey Drift in Z direction:

Table 4. Maximum Storey Drift in Z-Direction

Storey	Height(M)	Max. Drift in Z-Direction (mm	
		Model without Floating Column	Model with Floating Column
Base	0	0	0
Storey 1	3	0.115	2.124
Storey 2	6	0.146	2.224
Storey 3	9	0.205	2.386
Storey 4	12	0.237	2.415
Storey 5	15	0.263	2.716
Storey 6	18	0.280	2.916
Storey 7	21	0.290	3.036
Storey 8	24	0.294	3.079
Storey 9	27	0.291	3.056
Storey 10	30	0.283	2.975
Storey 11	33	0.272	2.849
Roof Slab	36	0.257	2.697

IV. CONCLUSION:

The study presented in this project aims to provide a comprehensive comparison between a building without floating columns and a building with floating columns. The analysis focuses on assessing the impact of floating columns on various structural aspects, including storey displacement, storey drift, and base shear. By evaluating these parameters, the study seeks to understand the advantages and disadvantages associated with incorporating floating columns in building design, particularly in earthquake-prone regions. By conducting a thorough comparison between buildings with and without floating columns, this study provides valuable insights into the impact of floating columns on different structural aspects. This knowledge can guide architects and engineers in making informed decisions regarding the use of floating columns in construction projects, taking into account the specific requirements, challenges, and seismic risks of the intended location.

The findings of this study can help inform architectural and engineering decisions and provide valuable insights for future construction projects. The following conclusions were drawn based on the investigation:

1. The building with floating column having more storey displacement and storey drift value as compare to building without floating column, it is about 9 to 10 % increases.
2. The building with floating column reduces the base shear of the building because provision of floating column reduces the overall weight of the structure.
3. The building with floating column having 8.52 % more consumption of steel than without floating column building.
4. As the bending moment and shear force are increases in column in case of floating column building.
5. The floating column building, will lead to the increase in dimensions of the members in the structure to increase the stiffness and for the earthquake resistant design of the building.
6. As the building with floating column is more efficient to carry the vertical load than the lateral loads.
7. The final conclusion is that do not prefer to construct floating column in buildings unless there is a proper purpose and functional requirement for those.

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