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# "COMPARATIVE STUDY OF MULTISTORIED BUILDING WITH VARIOUS CONFIGURATIONS OF COLUMNS AND SHEAR WALL"

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**ABSTRACT:**

In modern times floating columns are typical building feature in multistorey buildings. Floating columns are used to fulfill various aesthetic and functional requirements. This study has been undertaken to investigate the Comparative analysis between the buildings with and without floating columns for single column building. To analyze the models Staad.Pro V8i software is used. For performing the seismic analysis Equivalent Static Analysis method is considered. The study is made with four different cases classified on the basis of system provided. To compare the results, different structural parameters like shear force, story displacements, bending moment, axial force are taken under consideration.

**KEY WORDS: single column building, STAAD Pro, floating columns, earth quake load, wind load etc.**

## 1. INTRODUCTION

### 1.1 INTRODUCTION

Structure supported on a single column provides better architectural view compared to structure supported on many columns. They save ground space as requires less area for providing foundation and provides more space for parking. They are also unique. Single column structure can be made either by using RCC or Steel. RCC structures are more common now a days in India. Reinforced concrete as a structural material is widely used in many types of structures. It is competitive with steel if economically designed and executed. It has a relatively high compressive strength and better fire resistance than steel. It has long service life with low maintenance cost. It can be cast into any required shape.

Reinforced concrete is a composite material in which concrete is having relatively low tensile strength and ductility, which are counteracted by the inclusion of reinforcement having higher tensile strength and ductility. The modeling and analysis of structure supported on a single column is done by using STAAD Pro software. STAAD Pro is a structural analysis and design computer program originally developed by Research Engineers International in Yorba Linda.

Many urban multistorey buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storey

The term floating column is a vertical member which ends at its lower-level rests on a beam which is a horizontal member. The beams in turns transfer the load to other column below it. In present scenario buildings with floating column is a typical feature in the modern multistory construction in India. In present paper effort has been taken to review the behavior of building with floating column.

## 1.2 FLOATING COLUMN

A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground. The term floating column is also a vertical element which (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams in turn transfer the load to other columns below it.

There are many projects in which floating columns are adopted, especially above the ground floor, where transfer girders are employed, so that more open space is available in the ground floor. These open spaces may be required for assembly hall or parking purpose. The transfer girders have to be designed and detailed properly, especially in earth quake zones. The column is a concentrated load on the beam which supports it. As far as analysis is concerned, the column is often assumed pinned at the base and is therefore taken as a point load on the transfer beam. STAAD Pro, ETABS and SAP2000 can be used to do the analysis of this type of structure. Floating columns are competent enough to carry gravity loading but transfer girder must be of adequate dimensions (Stiffness) with very minimal deflection.

Looking ahead, of course, one will continue to make buildings interesting rather than monotonous. However, this need not be done at the cost of poor behavior and earthquake safety of buildings. Architectural features that are detrimental to earthquake response of buildings should be avoided. If not, they must be minimized. When irregular features are included in buildings, a considerably higher.

level of engineering effort is required in the structural design and yet the building may not be as good as one with simple architectural features. Hence, the structures already made with these kinds of discontinuous members are endangered in seismic regions. But those structures cannot be demolished, rather study can be done to strengthen the structure or some remedial features can be suggested. The columns of the first storey can be made stronger, the stiffness of these columns can be increased by retrofitting or these may be provided with bracing to decrease the lateral deformation.

The floating column is a vertical member which rest on a beam and doesn't have a foundation. The floating column act as a point load on the beam i.e., Transfer Beam and this beam transfers the load to the columns below it. But such column cannot be implemented easily to construct practically since the true columns below the termination level are not constructed with care and hence finally cause to failure. Most of the time, architect demands for the aesthetic view of the building, in such cases also many of the columns are terminated at certain floors and floating columns are introduced. But Provision of floating columns resting at the tip of taper overhanging beams increases the vulnerability of the lateral load resisting system due to vertical discontinuity. This type of construction does not create any problem under vertical loading conditions. But during an earthquake a clear load path is not available for transferring the lateral forces to the foundation.

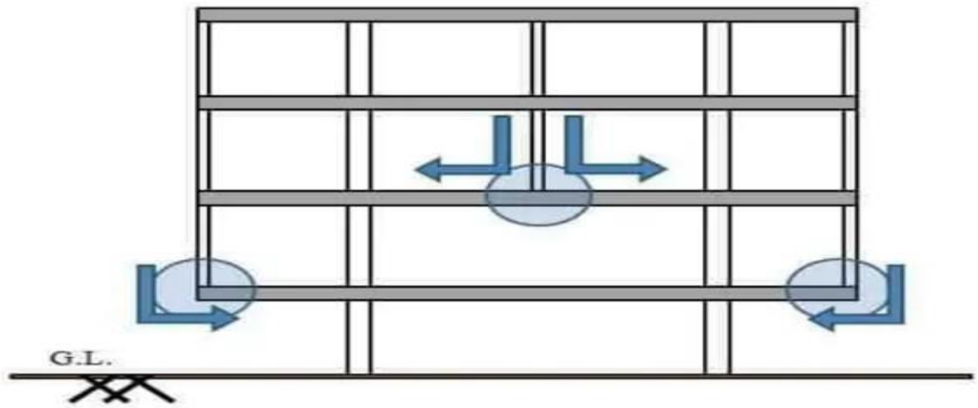



Fig 1.1: Floating Column

**1.3 Shear Wall**

Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. Shear walls are usually provided along both length and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation. When walls are situated in advantageous positions in a building. They can be very efficient in resisting lateral loads originating from wind or earthquakes. Because a large portion of the lateral load on a building, if not the whole amount, and the horizontal shear force resulting from the load, are often assigned to such structural elements, they have been called shear wall.


Fig.1.2 Shear Wall

**1.4 NEED OF STUDY**

Recently, innovative architectural design merged with the advanced and powerful structural numerical analysis stimulated a new generation of super-structures and mega- tall buildings. Furthermore, discontinued vertical elements (columns and shear walls) within high-rise buildings are no longer considered as a design mistake. Consequently, the architectural demands for high-rise buildings in which columns may have different arrangement between levels become familiar. The immense change in building at transfer floor from shear wall system to column girder system may create a soft (or weak) storey.

Structure supported on a single column provides better architectural view compared to structure supported on many columns. They save ground space as requires less area for providing foundation and provides more space for parking. They are also unique. Single column structure can be made either by using RCC or Steel.

## LITERATURE REVIEW

### 2.1 GENERAL

A significant amount of research work on single column high rise building has been published by many investigators. The main objective of this literature is to explore related studies of analysis used in this dissertation of analysis of high rise building with single column. Some of them are briefed below,

### 2.2 REVIEW OF TECHNICAL PAPERS

**Vivek Soni, M. P. Verma.2020**. G+7 buildings were chosen for analysis in this study. E-TABs 2018 designed the building models. The research is being carried out on a structure with floating columns. The building's floor plan is represented in Figure.

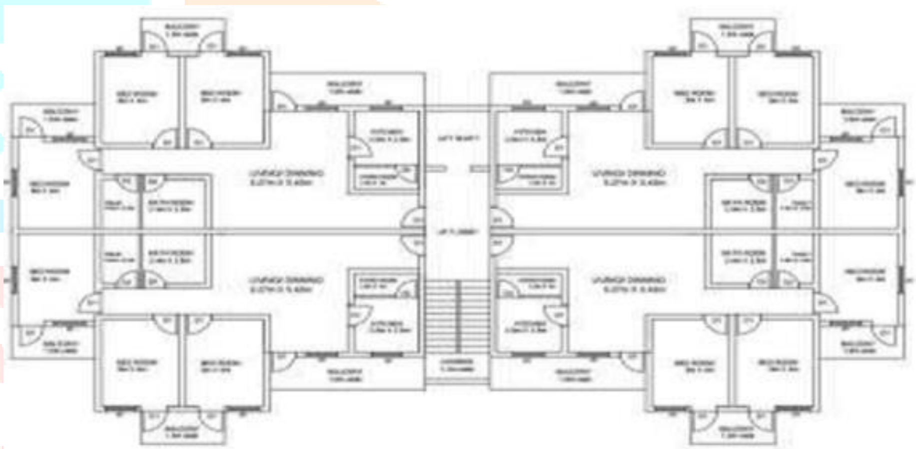


Fig.2.1 Typical architectural plan

The structure is categorized as a G+7 residential structure. The height of each storey is maintained at the same level as the rest of the data. Based on the results of the analysis, it has been determined that the best location for a floating column is on the first floor.

**N. Elakkiyarajan, G. Iyappan and A Naveen3.2018.** The behavior of structures with and without columns was investigated in this work. The structure was first examined without a floating column and then with a floating column, and it was discovered that the structure's strength was reduced as a result of the addition of the floating column. When compared to a model with a floating column, the model with no floating column has a far lower bending moment. The bottom storey experiences a quick rise in shear force and bending moment as a result of the floating column, but the other levels experience a gradual change. The behavior of various structural materials, such as concrete, steel, and composite materials, was also studied. When it comes to deflection criterion, concrete outperforms steel because the value of deflection in concrete grows rapidly as the seismic force increases. When compared to concrete, the values of deflection for steel and composite sections increase gradually as the seismic zone increases. Steel constructions outperform concrete and composite structures in terms of shear performance. The author of the study concludes that, in terms of ductility, steel and composite sections outperform concrete since steel has a lower stiffness than concrete.

**Chandan Kumar, G. Ragul, V. Jayakumar, Prasidh E Prakash. 2018**. Static analysis was used to investigate the behaviour of a G+10 storey building in this study. Exterior, interior, and core columns were grouped for comparison, and characteristics such as storey drifts, displacement, and base shear were evaluated and compared. After evaluating the structure, it was discovered that the usage of floating columns has no effect on the building's stiffness as long as the floating column and beam column joint is planned correctly and ductile detailing is done in accordance with IS 13920:1993. From the bottom to the top, the structure's drift grows steadily. Although there was an increase in drift in structures with floating columns, the value of drift still satisfied the serviceability criterion. For all three groups, shear force and axial load values increased in structures with floating columns. Both structures behave similarly in terms of displacement, with the floating column experiencing an increase in displacement. The author of the study concludes that the construction of a structure with a floating column is feasible if serviceability and economic conditions are met.

**Kandukuri Sunitha, Mr. Kiran Kumar Reddy.2017.** For external lateral stresses, the author analyzed G+4, G+9, and G+14 buildings with and without floating columns in this paper. The building is located in Zone III, and forces are applied in accordance with IS1893:Part 1:2002. In this study, seven models were investigated: one with a conventional building and the other six with a floating column, shear wall, and bracing. The maximum displacement and stoey drift values for floating columns rise in static analysis, according to the study. The height of the building has a substantial impact on deflections and storey drifts, which both change dramatically as the height of the building rises. Axial loads on other columns increase as a result of the load being transferred from floating columns to conventional columns. Buildings with shear walls perform well in all instances, but buildings with bracing systems perform well for buildings of lower height. The bending moment varies depending on the story; it is greatest in the top stories and lowest in the bottom stories.

**Badgire Udhav S., Shaikh A.N., Maske Ravi G.2015.** The primary goal of this research is to analyze a structure with a floating column. The G+10 building was chosen for study, and the software STAAD Pro V8i was used. The G+10 was chosen because it has a floating column with a moment resistant frame in orthogonal directions. The structure is assumed to be in zone III, and the analysis is carried out in accordance with IS1893:2002. Lateral loads in the X and Z directions were applied to the structure, which was then studied for various load combinations, displacement, and base shear for each storey. Shear values are observed to change dramatically depending on the position and orientation of the column.

**Ankit kumar and Durgesh nandan verma.2018.** A building model was created in STAAD Pro V8i to analyze properties such as Storey drift, Storey displacement, and Max. Displacement with and without floating column. This property was compared to various load combinations in IS code 1893 in order to determine whether a floating column is safe to use in a seismic zone. By altering the location of the floating column in the static analysis design spectrum, a total of four models were analyzed. The position of the floating column in both the horizontal and vertical directions affect the values of Displacement and storey drift. When a floating column is used at the base, the value of displacement and storey drift is higher than when it is used at the first and second storeys. Also, Storey drift increases rapidly until the third level, then begins to decrease while displacement continues to rise. According to the findings of the study, floating columns create high Storey drift and displacement, making them unsafe to use in strong seismic zones.

**Trupanshu patel, Jasmin Gadhiya, Aditya bhatt.2017**. The work behavior of a G+3 building with a floating column is investigated in this research in order to determine the infill walls and the effect of mass variation on the behavior of a floating column and a normal building. Using SAP 2000 version 18 and a floating column at the ground floor corner, different building models were analyzed with and without infill walls. The maximum horizontal and vertical displacement of a typical floor for each example was obtained by applying various load combinations. Various models were compared based on the position of the floating column, with and without increments in the live load, and with and without the influence of infills. The author of the study concludes that a floating column with corner provision is a significant example. The displacement value decreases as one moves from the corner to the Centre of a standard floor. When compared to horizontal displacement, vertical displacement shows a greater decrease. Without infills, a dramatic increase in the value of displacement happens when compared to infill, reducing seismic response and making the structure more cost-effective.

**Chimanna chaitali R, Mohite Prakash M, Mohite kiran K.2017.** this paper, the seismic response of a G+13 multistory structure with floating column resting on RCC Transfer girder and post tensioning transfer girder is compared. The reaction of the building, such as storey displacement, storey shear, and storey drift, was evaluated using ETABS Software. This model has 22 columns, each of which supports a 1 m thick transfer slab, which in turn supports 64 floating columns. This column comes to an end at the first level. The authors of the study conclude that a structure with a floating column resting on RCC transfer girder has a longer time period, displacement, and drift storey than a building with a floating column resting on P.T transfer girder. However, the base shear of a building with a floating column supported by a P.T transfer girder is greater than that of a building supported by an RCC transfer girder.

**CONCLUDING REMARK**

Based on the above literature review it is found that,

 Design of structure with floating column can be possible by satisfying serviceability and economic criteria.

 Building with shear wall behaves well for high rise building.

Structure with floating column having higher maximum bending moment and maximum support reaction than that structures without floating column and also zone IV are more affected by earthquake than zone III

**OBJECTIVES**

1. Analysis and design of multi column building.

2.Analysis and design of single column multistoried building with floating columns.

3. Study of results obtained for multicolumn building and single column multi storied building with floating columns.

4. Analysis and design of single column multi storied building without floating columns.

5.Analysis and design of single column multi storied building for various locations of shear wall.

6.Comparison of results for above cases.

**METHODOLOGY**

Taking into the consideration the need and objectives of dissertation,

**Case 1:** Analysis and design of multi-column building using structural analysis software.

**Case 2:** Analysis and design single column multi-storied building with floating columns.

**Case 3:** Analysis and design single column multi-storied building without floating columns.

**Case 4:** Analysis and design of single column multi-storied for various locations of shear wall.

**Case 5:** Comparison of results for above.

Considering earthquake loads as loading for the structure according to Indian standards, IS 1893:2016 by using structural analysis software.

## THEORETICAL FORMULATION

### GENERAL

This study based on comparative study of single column multistoried building with various configurations of columns and shear wall. The work presented in this report is seismic analysis of high rise building with single column building. The analysis is carried out by considering earthquake loads according to Indian standard, IS 1893:2016. Computational model for validation case taken from reference and building is modeled as per IS 456:2000 and IS 1893:2016 in structural analysis software.

Mainly, four case studies have been chosen for the seismic analysis of high rise building with single column using structural analysis software are given below,

**Case 1:** Analysis and design of multi-column building.

**Case 2:** Analysis and design single column multi-storied building with floating columns.

**Case 3:** Analysis and design single column multi-storied building without floating columns.

**Case 4:** Analysis and design of single column multi-storied for various locations of shear wall.

**Case 5:** Comparison of results for above.

### METHODOLOGY FOR ANALYSIS OF BUILDING.

Various steps to be followed, to achieve the objectives are given below,

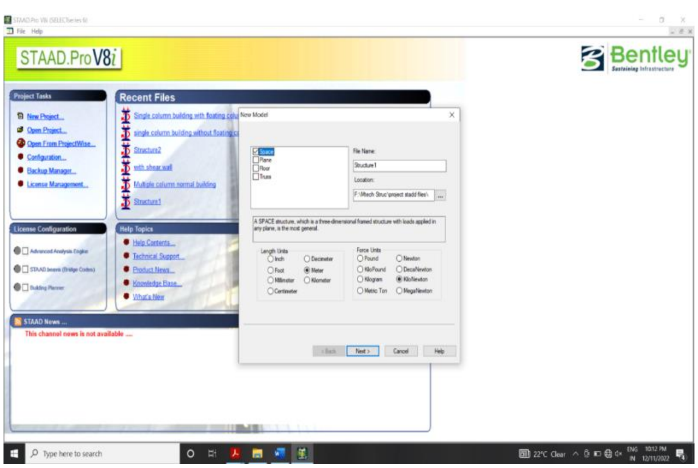
Step 1: **Inputting the job Information.**

1. Select the new project "click new project."

2. Enter file name and select the storage location of file.

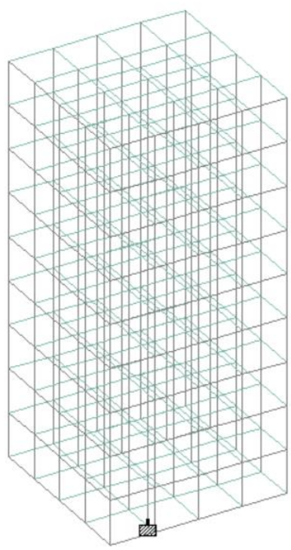
3. Select length and force units "Click on meter and kilonewton."

4. Click next, Select add beam and click on finish.



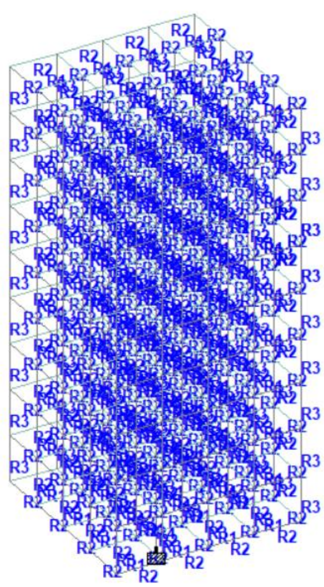
Step 2: **Generating the 3d model geometry:**

1. Select the “Geometry” Menu.
2. In geometry menu select “Run structure wizard”
3. Click on “frame model and select bay frame.”
4. Select parameters and click on apply and then ok.



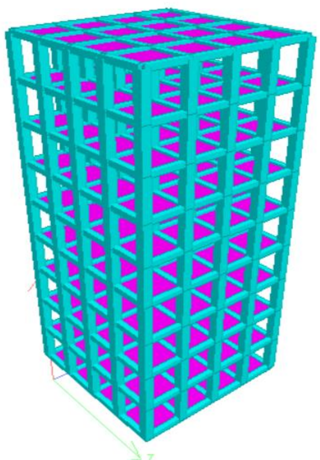
Step 3: **Assigning the material:**

1. Select the General Menu.
2. In general menu select section propertise
4. Then provide required general data click on Add and then close.



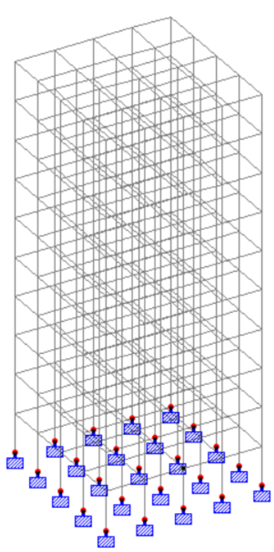
Step 4: **Specifying member properties**.

1. Select the General Menu.
2. In general menu select define.
3. The dialog box has a tab properties, click on same and define properties of slab such as thickness of slab, material of slab and press ok



Step 5. **Specifying material constants:**
As we assigned the concrete material so by default, we have the constants of concrete and we don't need to use this command separately. Or if we need to change the constants we can do so by this command.

Step 6: **Specifying Supports:**
1. Select the support menu.
2. Then click create option and select add and press OK.
3.Select nodes by node cursor.
4. Assign to selected nodes Add and press ok.



Step 7: **Printing member information:** As if we would like to get a report consisting of information about all the members including start and end joint numbers, members length in STAAD output file then we use this command as by going to Commands Pre-Analysis Print Member information from top menu bar.

Step 8: **Specifying Loads:** This is done in following steps:

**a.** Firstly creating all the load cases.

**b.** Then assigning them to respective members and nodes**.**

The STAAD program can produce all types of loads and can assign them to the structure. It also has the capability to apply the dead load on the structure. There are some definitions of loads which are firstly created according to IS codes before creating specific load cases (As Seismic or wind load). Here below are some types of loads as we have assigned.

**c.** Load Combinations.

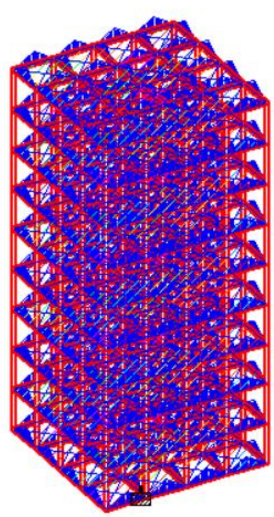
The load combinations have been created with the command of auto load combinations. By selecting the Indian code we can generate loads according to that and then adding these loads. These combinations do not require to be assigned on members.

Hence all the loads are assigned on the structure we will move towards forward step.

Step 9: **LOADS ACTING ON THE STRUCTURE**

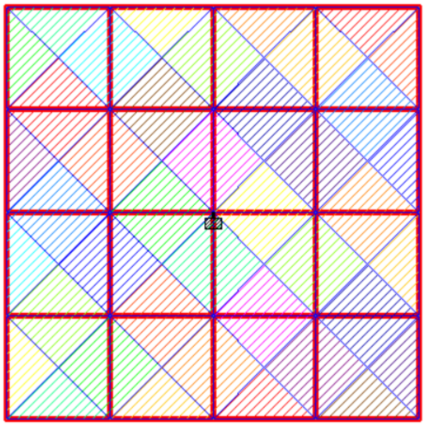
**Dead load:**

1. Select Load and Definition option.
2. In Load and Definition option select Load case details.
3. Select loading type click on Add and then press close.



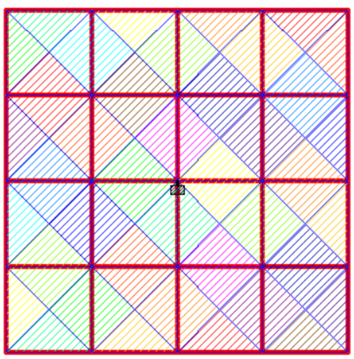
Step 10: **Live load:**

1. Select Load and Definition option.
2. In Load and Definition option select Load case details.
3. Select loading type click on Add and then press close.



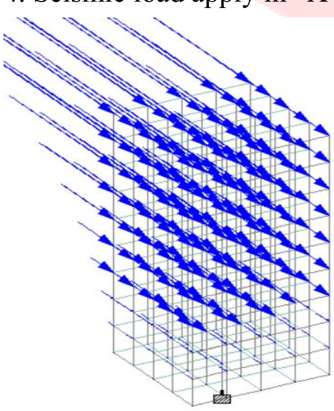
Step 11: **Floor load**

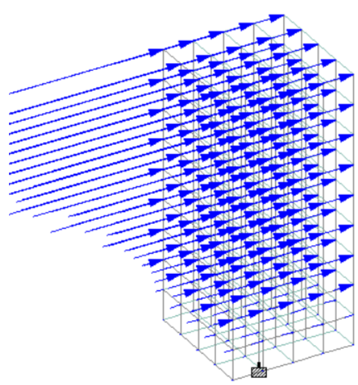
1. Select the Live Load.
2. In Live Load, select Add.
3. Click on floor load provide load application range, click on add and then close.



Step 12: **SESMIC LOAD**

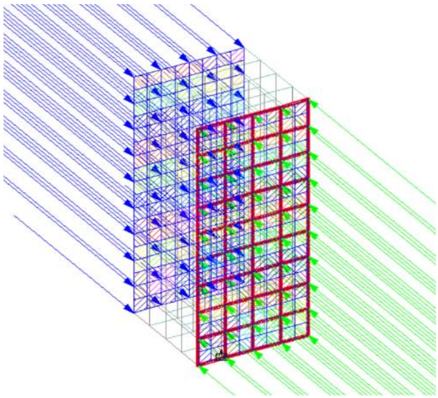
1. Select Load and Definition option.
2. In Load and Definition option select Load case details.
3. Select loading type click on Add and then press close.
4. Seismic load apply in "X" direction and then In "Z" direction.

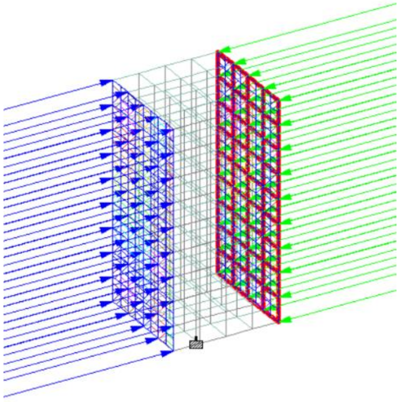




Step 13: **WIND LOAD**

1. Select Load and Definition option.
2. In Load and Definition option select Load case details.
3. Select loading type click on Add and then press close.
4. Wind Load apply in "X" direction And in "-X" Direction.
5. After this Wind Load applied in "Z" direction And "-Z" Direction.





Step 11: Define Load combinations

1. Select Auto Load Combination option.

2. Press Add and then close.

**Load Combinations:**

1) EQ X

2)EQ Z

3)Wind X

4)Wind Z

5)DL

6)LL

7) 1.5(DL+LL)

8) 1.2(DL+LL+ Wind X)

9)1.2(DL+LL+ Wind X)

10)1.2(DL+LL) x (-1.2 x Wind X)

11)1.2(DL+LL) x (-1.2 x Wind Z)

12)1.2(DL+LL+EQ X)

13)1.2(DL+LL+EQ Z)

14)1.2(DL+LL)(-1.2EQ X)

15)1.2(DL+LL)(-1.2EQ Z)

16)1.5(DL+ Wind X)

17)1.5(DL+ Wind Z)

18)1.5DL + (-1.5Wind X)

19)1.5DL+(-1.5 Wind Z)

20)1.5(DL+ EQ X)

21)1.5(DL+EQ Z)

22)1.5DL+(-1.5EQ X)

23)1.5DL +(-1.5 EQ Z)

24)0.9DL+1.5EQX

25)0.9DL+1.5EQ Z

26)0.9DL+(-1.5EQ X)

27)0.9DL+(-1.5EQ Z)

Step 16: Run analysis

1. Select the Analyze,menu

2. In analyze menu, select Run analysis

3. Finally, we get the results.

**CONCLUDING REMARK :**

This chapter presents the concept of response spectrum analysis, the structural software needed for analysis of building. The modeling steps needed for the present analysis are explained in this chapter.

In this study nomenclatures used for all models types of analysis, IS recomdation for selection of type of analysis have been discussed. The seismic parameters consider for study are included in this chapter. This chapter also deals with basic modeling steps and static earthquake load analysis in structural analysis software.

**PARAMETRIC INVESTIGATION:**

Taking into the consideration the need and objectives of dissertation, a 10 storey building is taken into account and the analysis is carried out by using various configurations of columns and shear wall considering earthquake loads as loading for the structure according to Indian standards, IS 1893:2016 by using structural analysis software. The analysis results are performed for building such as axial force, shear force, and bending moments. The analysis and design comparison of building with above mentioned parameters are studied to investigate the behavior of high rise building with single column.

Following cases are considered for the analysis of G+9 buildings.

**Case A:** Multi column normal building.

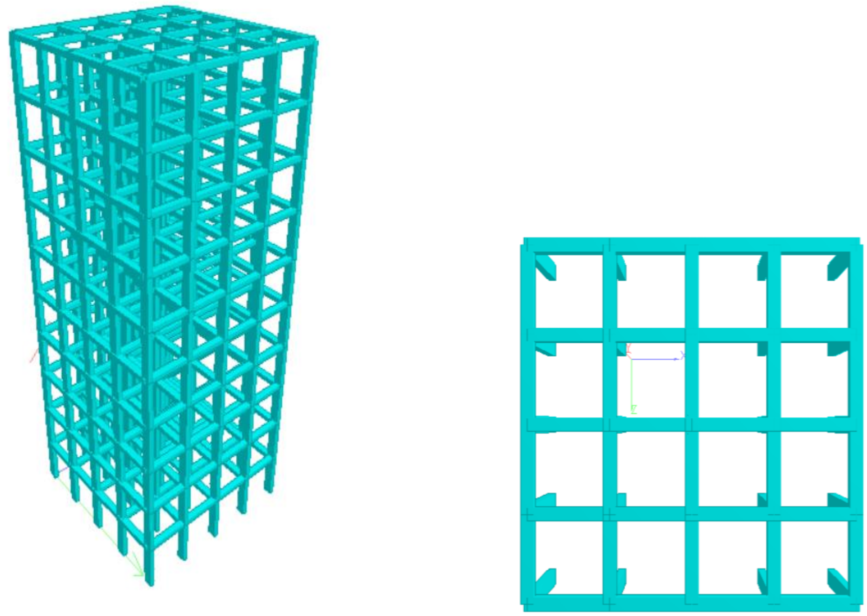


Fig. Multi column normal building

**Case B: S**ingle column building with floating columns.

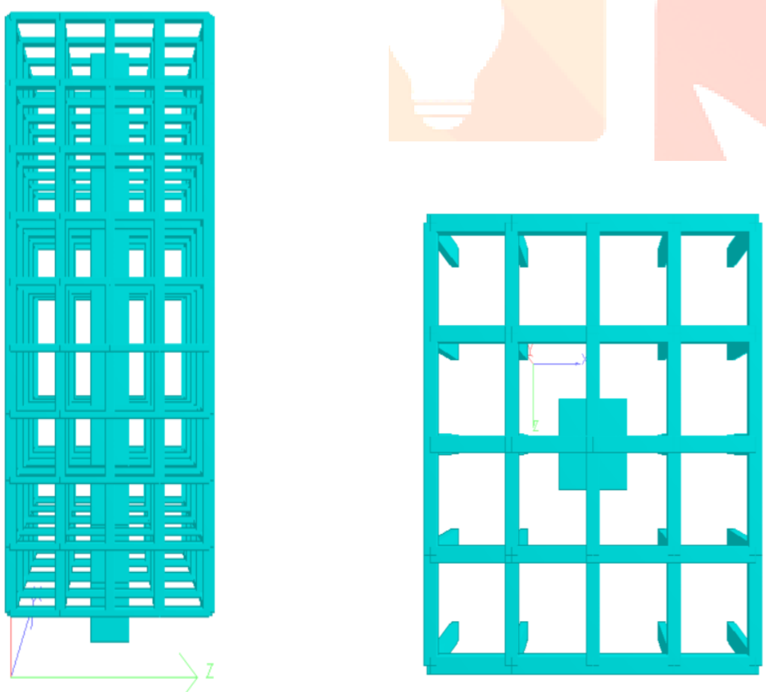


Fig. **S**ingle column building with floating columns

**Case C:** Single column building without floating columns.

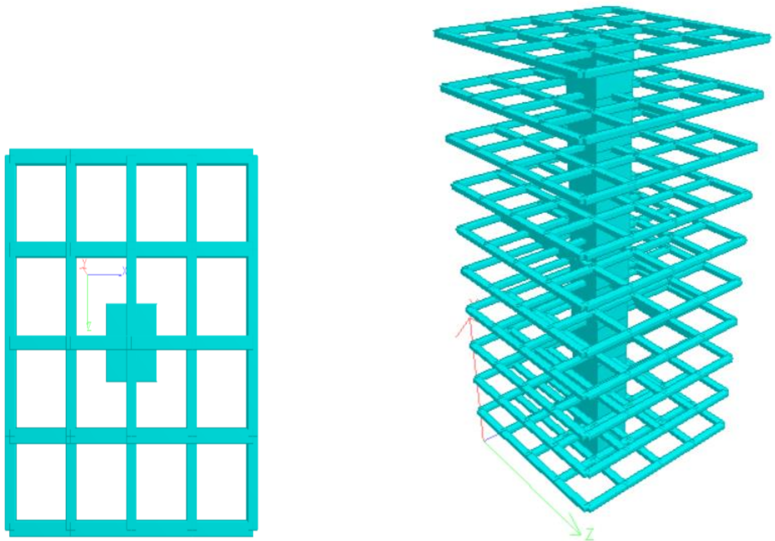


Fig. Single column building without floating columns.

**Case D:** Single column building With Shear Wall.

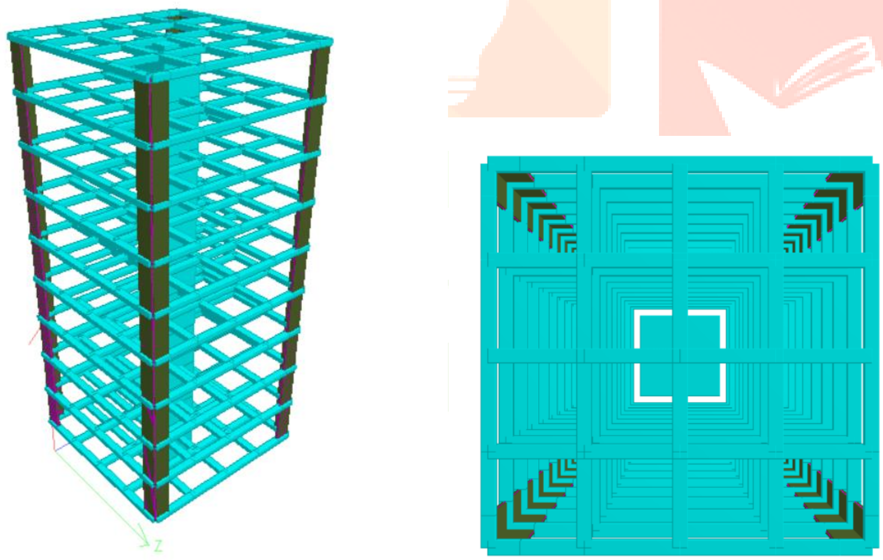


Fig. Single column building With Shear Wall.

**. Specifications:** The following specifications are adopted for study.

Table 4.2: Specification of Modeling

| | |
|---|---|
| Live Load | 2kN/m$^2$ |
| Density of RCC Considered | 25kN/m$^3$ |
| Steel | HYSD 500 |
| Thickness of slab | 150 mm |
| Depth of beam | 450 mm |
| Width of beam | 300 mm |

| | |
|---|---|
| Dimension of column | 300x600 mm |
| Height of each floor | 3m |
| Earthquake Zone | Zone III |
| Damping Ratio | 5% |
| Importance Factor | 1.5 |
| Type of Soil | Hard soil |
| Type of structure | Special moment resisting frame |
| Response reduction factor | 5 |
| Type of diaphragms | Rigid |
| Direction of lateral force | X direction and Y direction |
| Load combinations | All load combination as per IS 1893-2016 |
| Type of support at base | Fixed |

**Analysis Results of 10 Storey Building**

**A) Multi Column Normal Building**

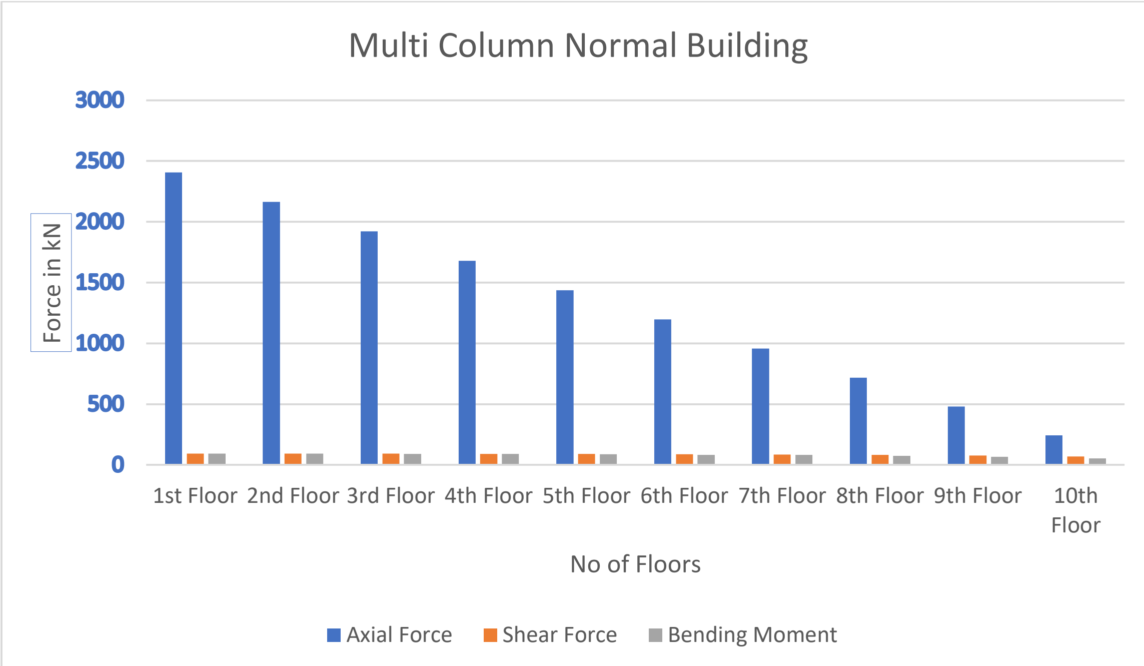
Table 4.3 Multi Column Normal building

| Floors | Axial force (kN) | Load Combinations | Shear force (kN) | Load Combinations | Bending moment (kNm) | Load Combinations |
|---|---|---|---|---|---|---|
| 1st | 2406.597 | 1.5(DL+LL) | 93.115 | 1.5(DL+EQ X) | 92.725 | 1.5(EQ X +DL) |
| 2nd | 2163.379 | 1.5(DL+LL) | 92.492 | 1.5(DL+EQ X) | 92.683 | 1.5(EQ X +DL) |
| 3rd | 1920.567 | 1.5(DL+LL) | 92.457 | 1.5(DL+EQ X) | 91.600 | 1.5(EQ X +DL) |
| 4th | 1678.697 | 1.5(DL+LL) | 91.186 | 1.5(DL+EQ Z) | 90.781 | 1.5(EQ X +DL) |
| 5th | 1437.636 | 1.5(DL+LL) | 90.504 | 1.5(DL+EQ Z) | 88.550 | 1.5(EQ X +DL) |
| 6th | 1197.374 | 1.5(DL+LL) | 87.076 | 1.5(DL+EQ Z) | 83.310 | 1.5(DL+EQ Z) |
| 7th | 957.828 | 1.5(DL+LL) | 85.59 | 1.5(DL+EQ Z) | 81.701 | 1.5(DL+EQ Z) |
| 8th | 718.873 | 1.5(DL+LL) | 82.208 | 1.5(DL+EQ Z) | 75.868 | 1.5(DL+EQ Z) |
| 9th | 480.448 | 1.5(DL+LL) | 76.502 | 1.5(DL+EQ Z) | 67.230 | 1.5(DL+EQ Z) |
| 10th | 242.359 | 1.5(DL+LL) | 70.241 | 1.5(DL+LL) | 52.701 | 1.5(DL+EQ Z) |

**Design results:**

Total Volume of Concrete = 297.0 $m^3$

Total Volume of Steel = 234160 Kg




**Observations:**

1) Maximum Value of axial force is obtained for 1.5(DL+LL) load combination, for shear force 1.5(DL+EQ X) is critical load combination and 1.5(DL+ EQ X) load combination having greater bending moments in normal building.
2) The values of Axial Force, Shear Force And Bending Moments are highest at ground floor.
3) The values of Axial Force, Shear Force and Bending Moments goes on increasing from top story to bottom story.

**B) Single Column with Floating Columns**

Table 4.4 Single column with floating columns

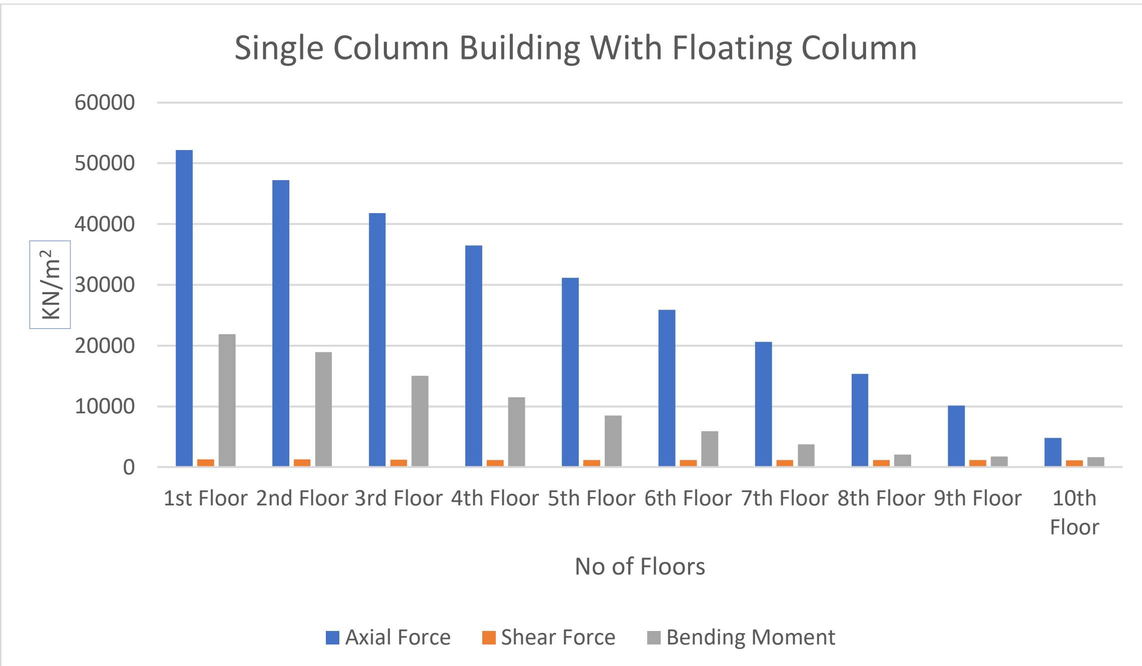
| Floors | Axial force (kN) | Load Combinations | Shear force (kN) | Load Combinations | Bending moment (kNm) | Load Combinations |
|---|---|---|---|---|---|---|
| 1st | 52204.51 | 1.5(DL+LL) | 1293.82 | 1.5(DL+LL) | 21902.56 | 1.5(DL+EQ X) |
| 2nd | 47212.94 | 1.5(DL+LL) | 1274.72 | 1.5(DL+LL) | 18947.84 | 1.5(DL+EQ X) |
| 3rd | 41797.33 | 1.5(DL+LL) | 1204.65 | 1.5(DL+LL) | 15030.46 | 1.5(DL+EQ X) |
| 4th | 36470.78 | 1.5(DL+LL) | 1199.81 | 1.5(DL+LL) | 11524.60 | 1.5(DL+EQ X) |
| 5th | 31162.24 | 1.5(DL+LL) | 1193.92 | 1.5(DL+LL) | 8477.07 | 1.5(DL+EQ X) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6th | 25876.38 | 1.5(DL+LL) | 1189.18 | 1.5(DL+LL) | 5900.63 | 1.5(DL+EQ X) |
| 7th | 20608.74 | 1.5(DL+LL) | 1185.53 | 1.5(DL+LL) | 3776.18 | 1.5(DL+EQ X) |
| 8th | 15355.02 | 1.5(DL+LL) | 1180.82 | 1.5(DL+LL) | 2099.15 | 1.5(DL+LL) |
| 9th | 10119.99 | 1.5(DL+LL) | 1191.96 | 1.5(DL+LL) | 1764.62 | 1.5(DL+LL) |
| 10th | 4835.42 | 1.5(DL+LL) | 1098.61 | 1.5(DL+LL) | 1671.72 | 1.5(DL+LL) |

**Design results:**

Total Volume of Concrete = 359.2 $m^3$

Total Volume of Steel = 318686 Kg.




**Observations:**

1) For single column building with floating columns have highest axial force at 1.5(DL+ EQ X) load combination, 1.5(EQ X+ DL) load combination have shear values and bending moments are higher at 1.5(EQ X+ DL) load combination.

2) The values of axial force, SF and bending moments are highest at ground level and lowest at top level.

3) The values in single column building with floating columns are get increased from last floor to ground floor.

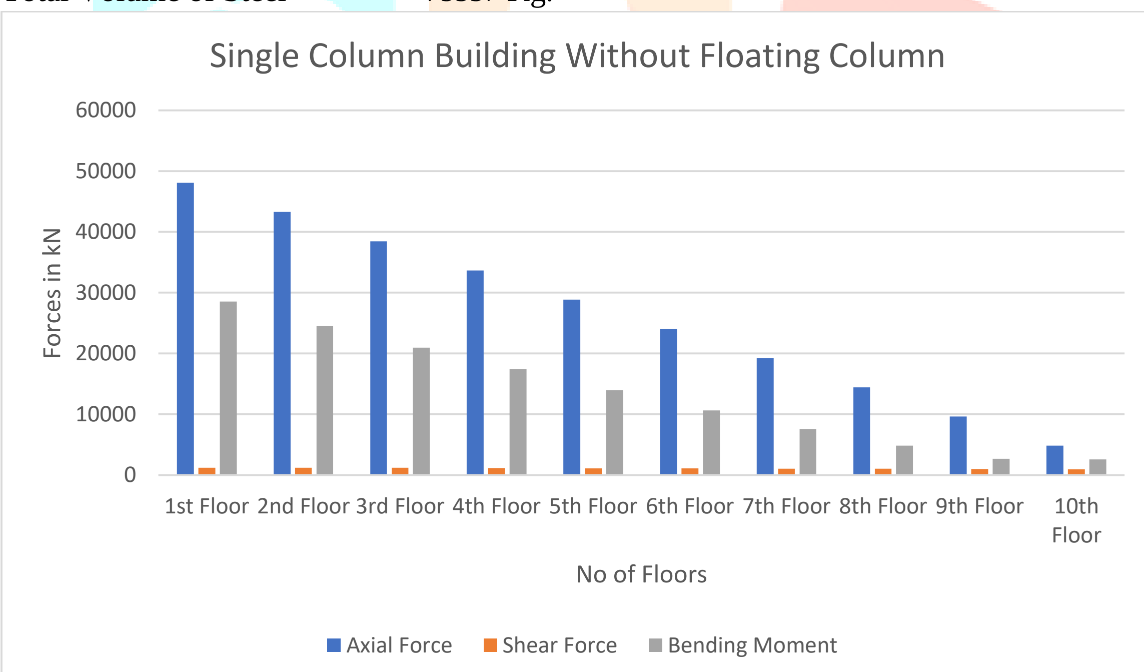
**C) Single column without floating columns**

Table 4.5 single column without floating column.

| Floors | Axial force (kN) | Load Combinations | Shear force (kN) | Load Combinations | Bending moment (kNm) | Load Combinations |
|---|---|---|---|---|---|---|
| 1st | 48082.17 | 1.5(DL+LL) | 1200 | 1.5(DL+EQ X) | 28512.36 | 1.5(DL+EQ X) |
| 2nd | 43273.95 | 1.5(DL+LL) | 1197.3 | 1.5(DL+EQ X) | 24551.44 | 1.5(DL+EQ X) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3rd | 38465.73 | 1.5(DL+LL) | 1184.43 | 1.5(DL+EQ X)) | 20960.03 | 1.5(DL+EQ X) |
| 4th | 33657.52 | 1.5(DL+LL) | 1155.86 | 1.5(DL+EQ X) | 17406.72 | 1.5(DL+EQ X) |
| 5th | 28849.30 | 1.5(DL+LL) | 1105.07 | 1.5(DL+EQ X) | 13939.13 | 1.5(DL+EQ X) |
| 6th | 24041.08 | 1.5(DL+LL) | 1096.38 | 1.5(DL+LL) | 10623.90 | 1.5(DL+EQ X) |
| 7th | 19232.4 | 1.5(DL+LL) | 1046.36 | 1.5(DL+LL) | 7546.77 | 1.5(DL+EQ X) |
| 8th | 14424.65 | 1.5(DL+LL) | 1036.38 | 1.5(DL+LL) | 4812.48 | 1.5(DL+EQ X) |
| 9th | 9616.43 | 1.5(DL+LL) | 990.6 | 1.5(DL+LL) | 2658.19 | 1.5(DL+LL) |
| 10th | 4808.21 | 1.5(DL+LL) | 936.38 | 1.5(DL+LL) | 2563.3 | 1.5(DL+LL) |

**Design results:**
Total Volume of Concrete = 203.7 $m^3$
Total Volume of Steel = 75557 Kg.




**Observations**
1) At load combination 1.5(DL+LL) the axial force is maximum, shear force is also maximum for 1.5 (DL+LL) load combinations, But bending moments are maximum for 1.5 (DL+EQ X) load combination.
2)The higher values of axial force and bending moments at bottom story of single column building without floating columns.
3) The shear force remain stable in whole single column building without floating columns.
4) the values of axial force and bending moments goes decrease at top story from ground story.

**D) Single column with shear wall**

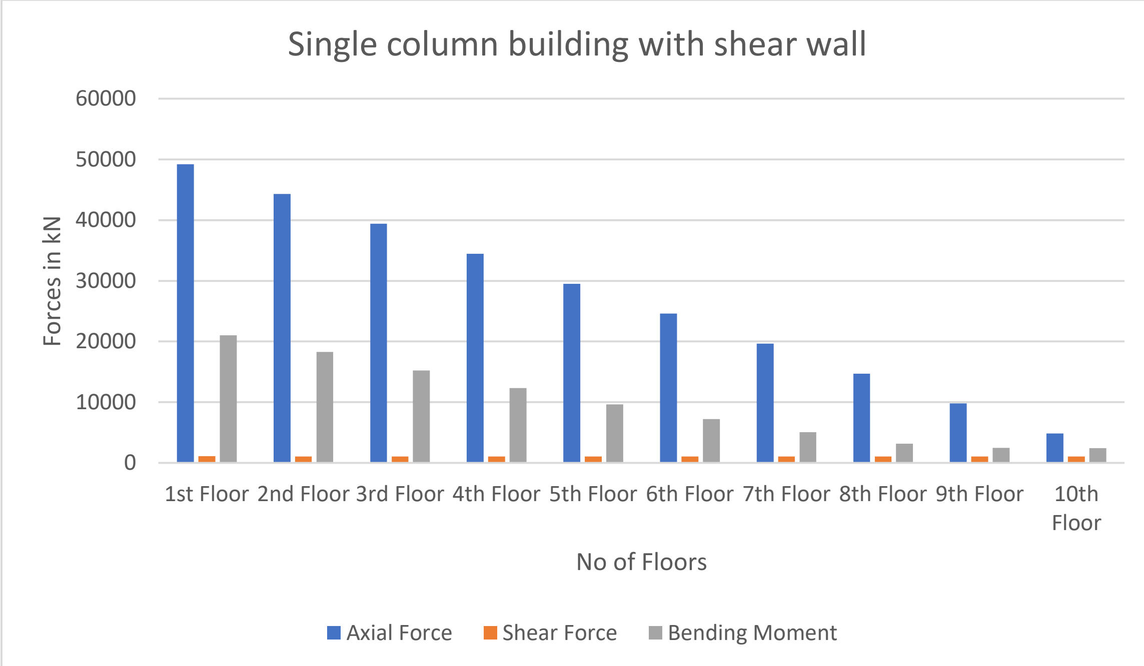
Table 4.6 Single column building with shear wall.

| Floors | Axial force (KN) | Load Combinations | Shear force (KN) | Load Combinations | Bending moment (KN/m) | Load Combinations |
|---|---|---|---|---|---|---|
| 1st | 49227.26 | 1.5(DL+LL) | 1084.05 | 1.5(DL+EQ X) | 21024.5 | 1.5(DL+LL) |
| 2nd | 44328.37 | 1.5(DL+LL) | 1071.15 | 1.5(DL+EQ X) | 18264.22 | 1.5(DL+LL) |
| 3rd | 39401.07 | 1.5(DL+LL) | 1069.3 | 1.5(DL+EQ X) | 15248.595 | 1.5(DL+LL) |
| 4th | 34460.86 | 1.5(DL+LL) | 1068.5 | 1.5(DL+EQ X) | 12344.68 | 0.9DL+1.5EQ X |
| 5th | 29523.85 | 1.5(DL+LL) | 1067.3 | 1.5(DL+EQ X) | 9666.93 | 0.9DL+1.5EQ X |
| 6th | 24589.13 | 1.5(DL+LL) | 1066.4 | 1.5(DL+EQ X) | 7236.39 | 0.9DL+1.5EQ X |
| 7th | 19656.38 | 1.5(DL+LL) | 1055.1 | 1.5(DL+EQ X) | 5064.18 | 0.9DL+1.5EQ X |
| 8th | 14725.33 | 1.5(DL+LL) | 1054.7 | 1.5(DL+LL) | 3184.43 | 0.9DL+1.5EQ X |
| 9th | 9795.03 | 1.5(DL+LL) | 1051.3 | 1.5(DL+LL) | 2478.07 | 1.5(DL+LL) |
| 10th | 4861.67 | 1.5(DL+LL) | 1049.7 | 1.5(DL+LL) | 2444.21 | 1.5(DL+LL) |

**Design results:**

Total Volume of Concrete = 239.7 $m^3$

Total Volume of Steel = 93649 Kg.




**Observations:**

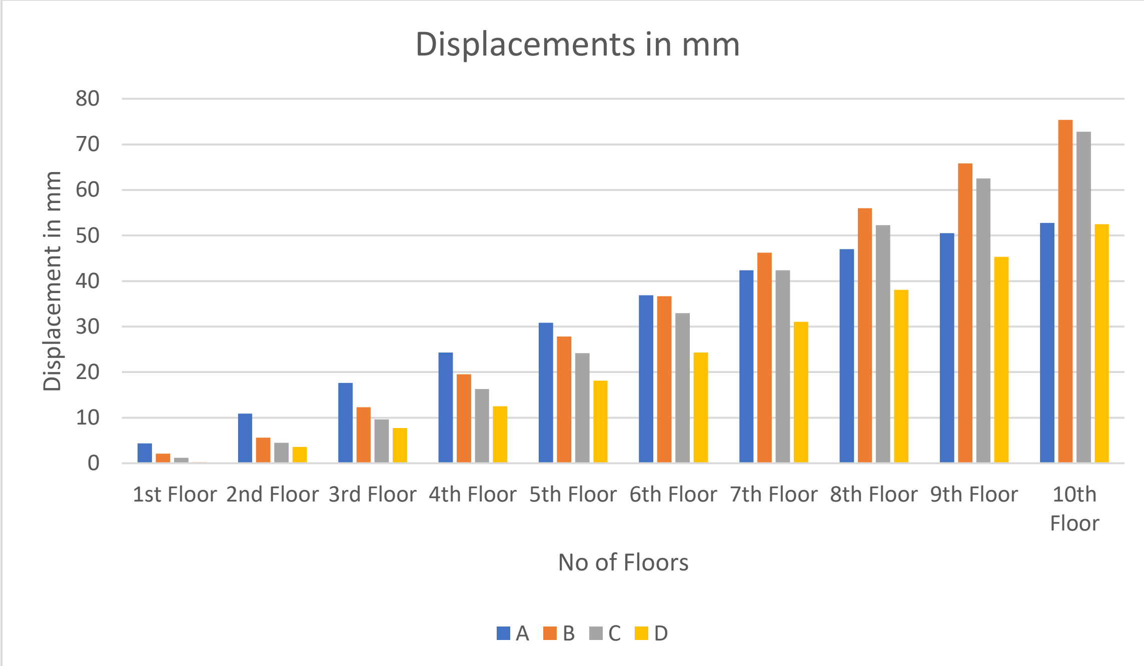
1) The bending moments and shear force values are maximum for load combination 1.5(EQ X + DL) and axial force is maximum at 1.5 (DL+LL) load combination.

2)The values of axial force, shear force and bending moments at bottom story are maximum and minimum at top story.

3) The values of Axial Force, Shear Force and Bending Moment goes on decreasing from bottom story to top story.

**Displacement Results of All Above Cases**

| Floors | Displacements (in mm) | | | | |
|---|---|---|---|---|---|
| | A | Load Combinations | B | C | D |
| $1^{st}$ | 4.36 | 1.5(DL+EQ X) | 2.08 | 1.2 | 0.2 |
| $2^{nd}$ | 10.87 | 1.5(DL+EQ X) | 5.6 | 4.5 | 3.6 |
| $3^{rd}$ | 17.64 | 1.5(DL+EQ X) | 12.3 | 9.6 | 7.7 |
| $4^{th}$ | 24.34 | 1.5(DL+EQ X) | 19.5 | 16.3 | 12.5 |
| $5^{th}$ | 30.81 | 1.5(DL+EQ X) | 27.8 | 24.18 | 18.1 |
| $6^{th}$ | 36.89 | 1.5(DL+EQ X) | 36.7 | 32.98 | 24.32 |
| $7^{th}$ | 42.36 | 1.5(DL+EQ X) | 46.2 | 42.4 | 31.06 |
| $8^{th}$ | 46.98 | 1.5(DL+EQ X) | 56.03 | 52.3 | 38.116 |
| $9^{th}$ | 50.51 | 1.5(DL+EQ X) | 65.8 | 62.5 | 45.30 |
| $10^{th}$ | 52.75 | 1.5(DL+EQ X) | 75.4 | 72.8 | 52.47 |




**Observations:**

A) The displacement in all above cases is maximum at top story and minimum at bottom story.

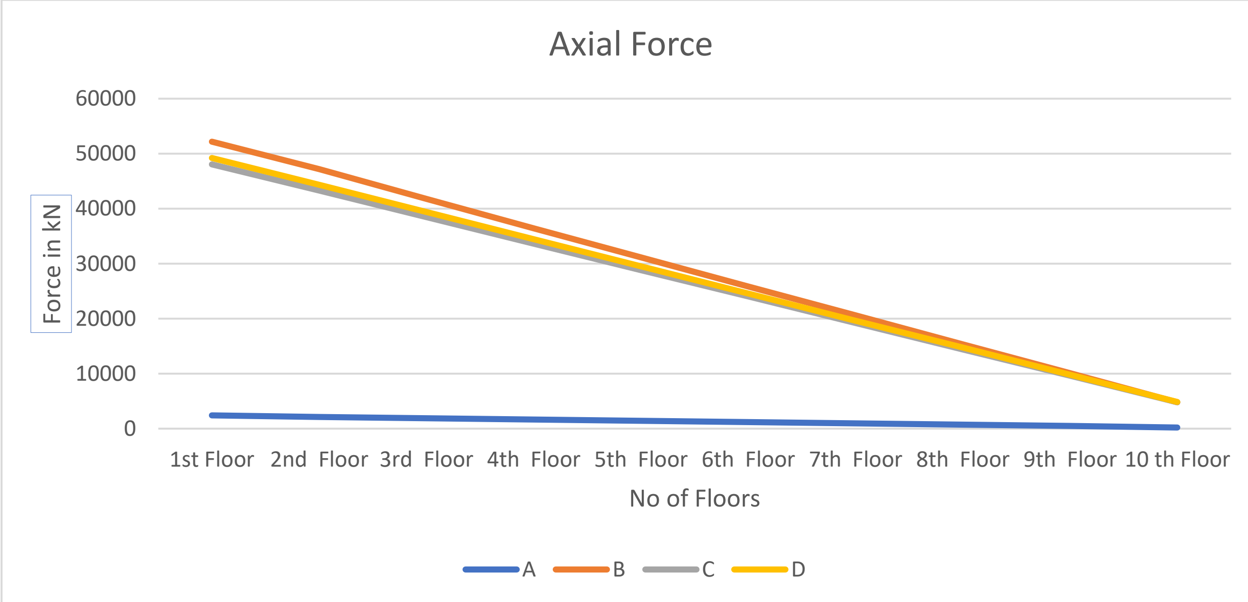
B) Values of Single Column Building with Floating Column are higher as compare to other cases of single column building.

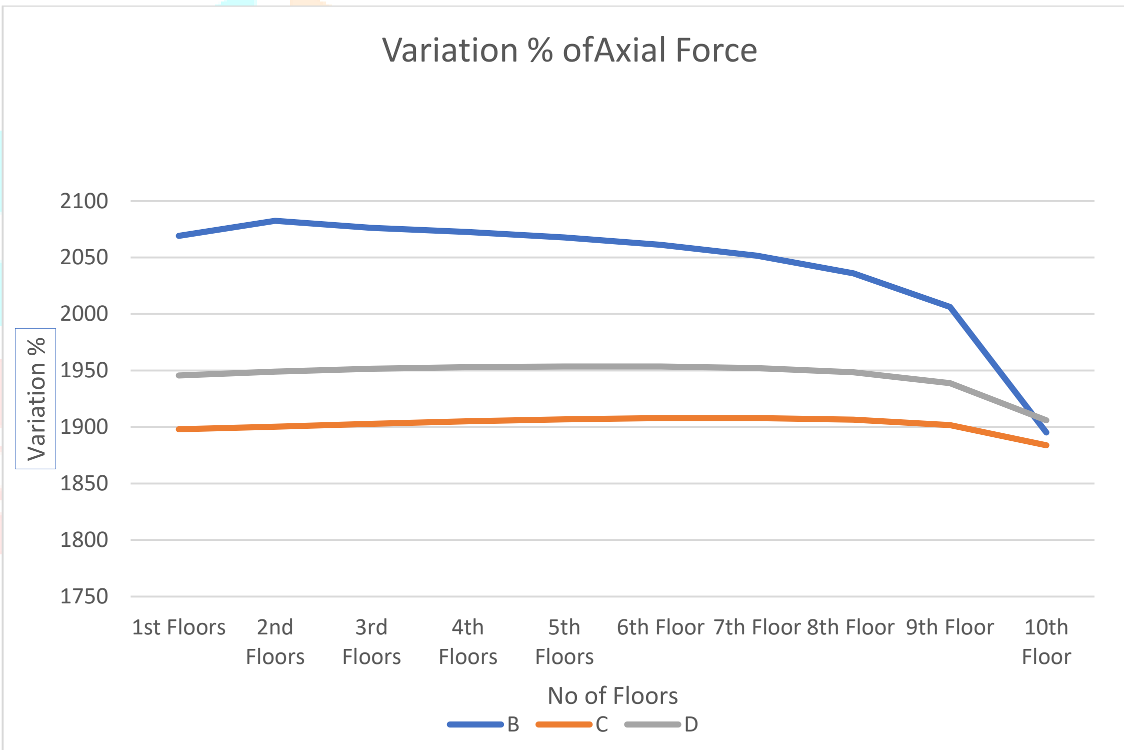
C) The displacement in single column building with shear wall minimum than conventional multi column normal building.

**Comparison of Axial Forces for above cases**

Table 4.7 Percentage of increment of Axial Forces

| Stories | Axial Forces | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | % variation | C | % variation | D | % variation |
| 1St | 2406.597 | 52204.51 | 2069.23 | 48082.17 | 1897.93 | 49227.26 | 1945.51 |
| 2nd | 2163.379 | 47212.94 | 2082.37 | 43273.95 | 1900.29 | 44328.37 | 1949.03 |
| 3rd | 1920.567 | 41797.33 | 2076.3 | 38465.73 | 1902.83 | 39401.07 | 1951.53 |
| 4th | 1678.697 | 36470.78 | 2072.56 | 33657.52 | 1904.98 | 34460.86 | 1952.83 |
| 5th | 1437.636 | 31162.24 | 2067.6 | 28849.30 | 1906.72 | 29523.85 | 1953.64 |
| 6th | 1197.374 | 25876.38 | 2061.09 | 24041.08 | 1907.82 | 24589.13 | 1953.59 |
| 7th | 957.828 | 20608.74 | 2051.61 | 19232.4 | 1907.92 | 19656.38 | 1952.18 |
| 8th | 718.873 | 15355.02 | 2035.99 | 14424.65 | 1906.56 | 14725.33 | 1948.39 |
| 9th | 480.448 | 10119.99 | 2006.37 | 9616.43 | 1901.55 | 9795.03 | 1938.73 |
| 10th | 242.359 | 4835.42 | 1895.15 | 4808.21 | 1883.92 | 4861.67 | 1905.98 |



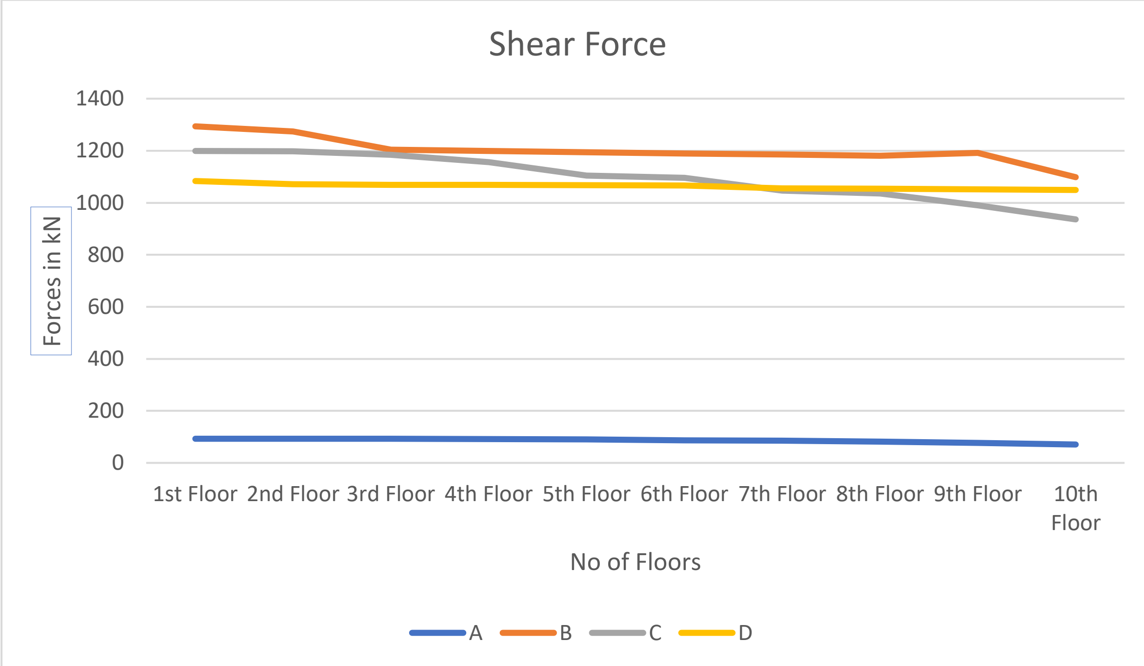

**Observations**:

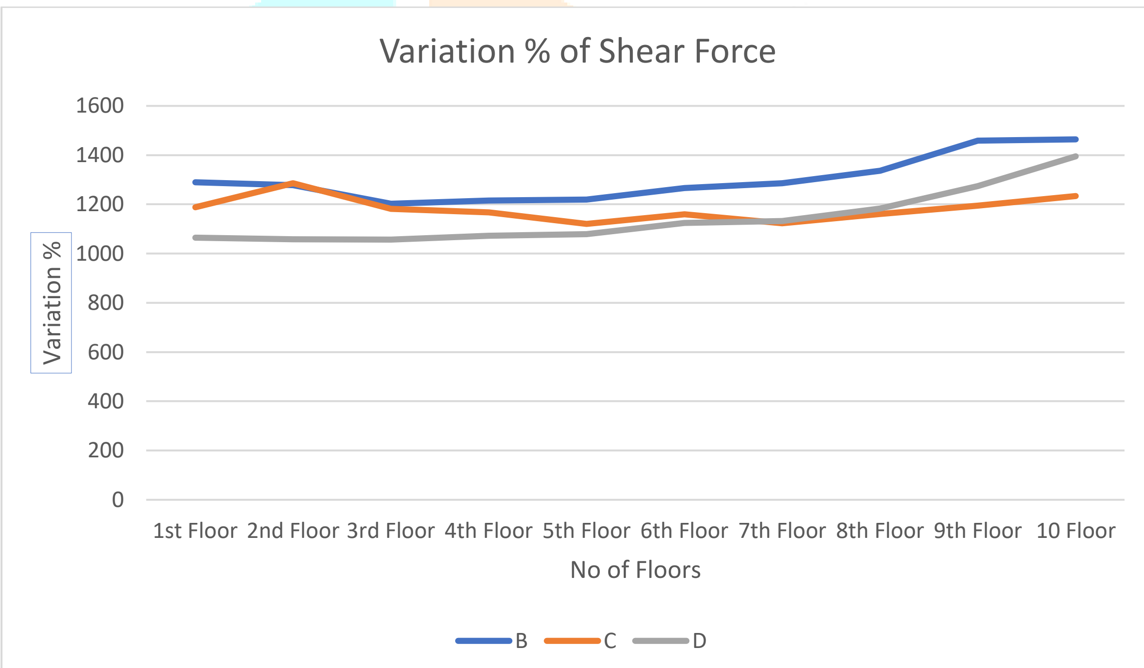
1) From the above table and graph, It is observed that values of Axial force are linearly varying.
2) Axial forces are maximum for Single column building with floating column and minimum for Conventional multi column normal building.
3) Comparing all above cases Single column building without floating column is more effective than other two cases of single column building.

**Comparison of Shear Forces for above cases**

Table 4.8 Percentage of increment of Shear Force.

| Stories | Shear Force | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | % variation | C | % variation | D | % variation |
| 1St | 93.115 | 1293.82 | 1289.49 | 1200 | 1188.73 | 1084.05 | 1064.21 |
| 2nd | 92.492 | 1274.72 | 1278.19 | 1198.13 | 1286.2 | 1071.15 | 1058.1 |
| 3rd | 92.457 | 1204.65 | 1202.93 | 1184.43 | 1181.06 | 1069.3 | 1056.54 |
| 4th | 91.186 | 1199.81 | 1215.78 | 1155.86 | 1167.58 | 1068.5 | 1071.78 |
| 5th | 90.504 | 1193.92 | 1219.19 | 1105.07 | 1121.02 | 1067.3 | 1079.28 |
| 6th | 87.076 | 1189.18 | 1265.68 | 1096.38 | 1159.11 | 1066.4 | 1124.68 |
| 7th | 85.59 | 1185.53 | 1285.13 | 1046.36 | 1122.53 | 1055.1 | 1132.74 |
| 8th | 82.208 | 1180.82 | 1336.38 | 1036.38 | 1160.68 | 1054.7 | 1182.97 |
| 9th | 76.502 | 1191.96 | 1458.08 | 990.6 | 1194.87 | 1051.3 | 1274.21 |
| 10th | 70.241 | 1098.61 | 1464.06 | 936.3 | 1233.1 | 1049.7 | 1394.43 |




**Observations:**

1) From above table and graph, It is observed that values of shear force are linearly varying from bottom story to top story except.

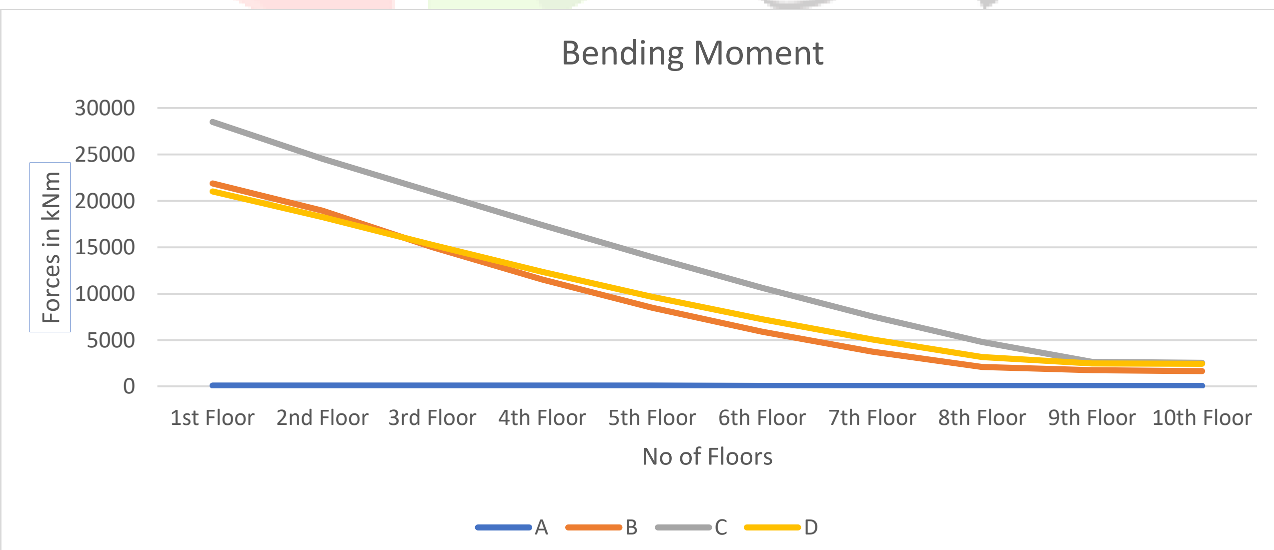
2) The values of shear force are maximum Single column with floating column and minimum for single column building with shear wall.

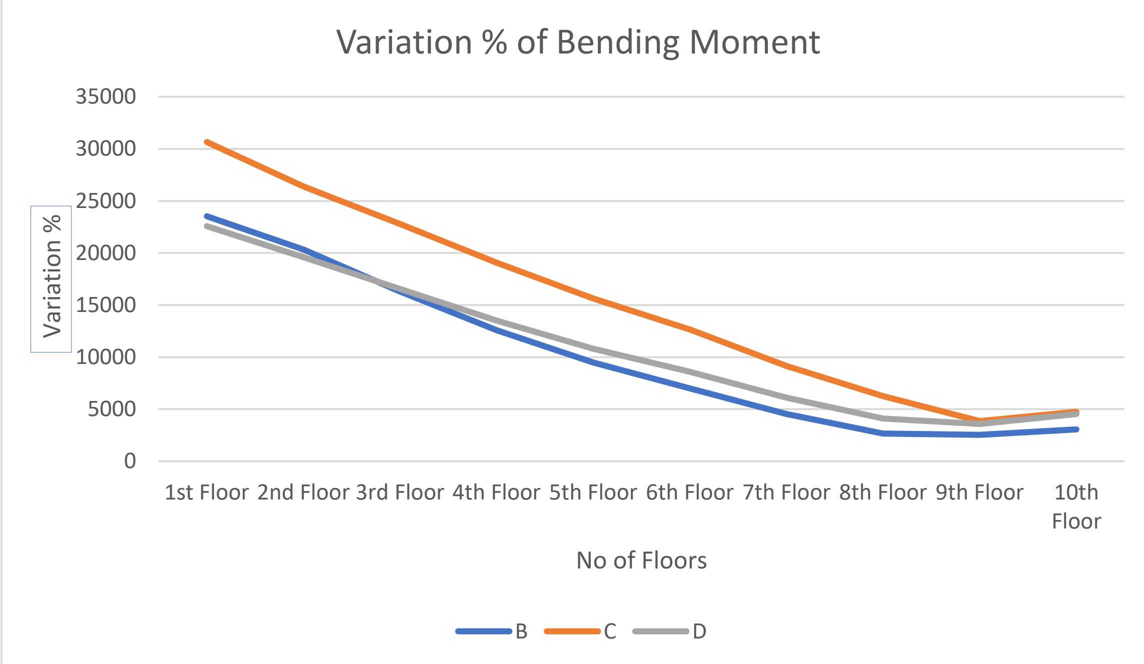
3) Comparing all above cases, Single column building with shear wall is more effective than other two cases of single column building.

**Comparison of Bending Moments for above cases**

Table 4.9 Percentage of increment of Bending Moment

| Stories | Bending Moment | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | % variation | C | % variation | D | % variation |
| 1St | 92.725 | 21902.56 | 23521 | 28512.36 | 30649.4 | 21024.5 | 22574 |
| 2nd | 92.683 | 18947.84 | 20343.7 | 24551.44 | 26389.7 | 18264.22 | 19606.1 |
| 3rd | 91.600 | 15030.46 | 16308.8 | 20960.03 | 22782.1 | 15248.595 | 16546.9 |
| 4th | 90.781 | 11524.60 | 12594.9 | 17406.72 | 19074.4 | 12344.68 | 13498.3 |
| 5th | 88.550 | 8477.07 | 9473.2 | 13939.13 | 15641.5 | 9666.93 | 10816.9 |
| 6th | 83.310 | 5900.63 | 6982.74 | 10623.90 | 12652.3 | 7236.39 | 8586.1 |
| 7th | 81.701 | 3776.18 | 4521.95 | 7546.77 | 9137.06 | 5064.18 | 6098.43 |
| 8th | 75.868 | 2099.15 | 2666.85 | 4812.48 | 6243.23 | 3184.43 | 4097.33 |
| 9th | 67.230 | 1764.62 | 2524.75 | 2658.19 | 3853.87 | 2478.07 | 3585.96 |
| 10th | 52.701 | 1671.72 | 3072.08 | 2563.3 | 4763.85 | 2444.21 | 4537.88 |






**Observations:**

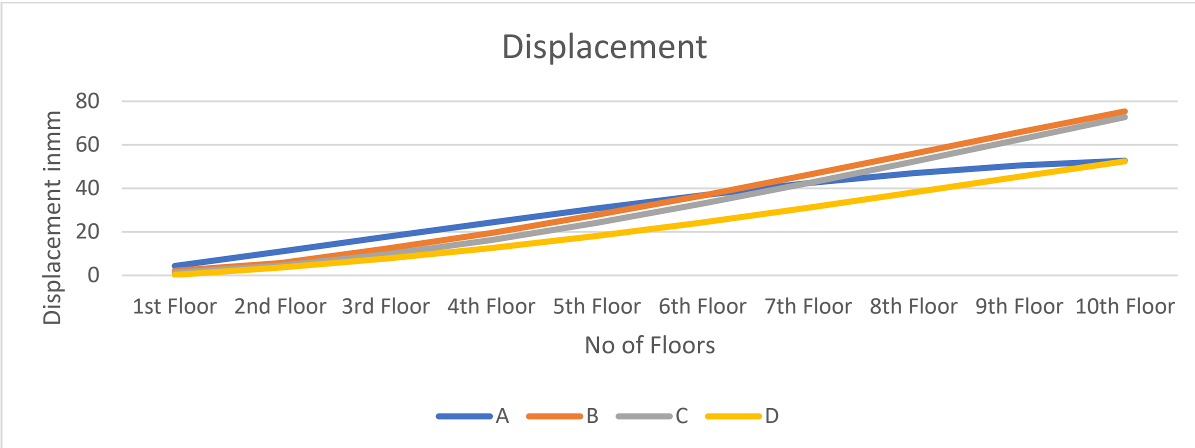
1) The values in above table and graph shows that Bending moment is linearly varying.
2) Bending moments are higher for single column building without floating columns and minimum in single column building with floating columns.

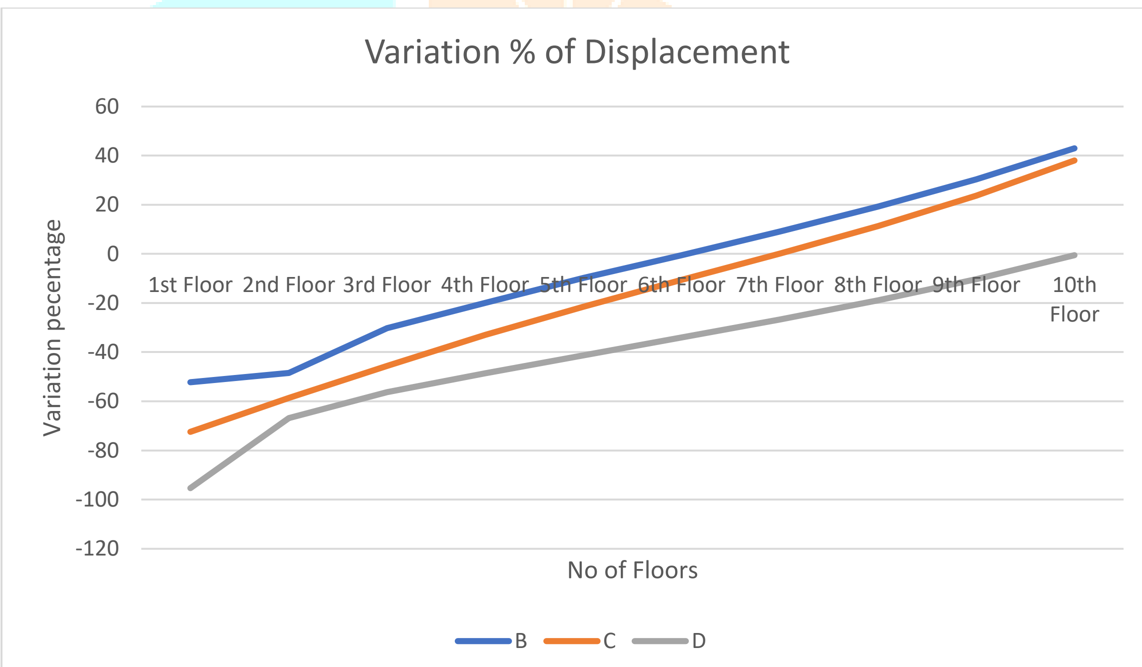
**Comparison of Displacements for above cases**

Table 4.10 Percentage of increment of Bending Moment

| Floors | Displacements (in mm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | % variation | C | % variation | D | % variation |
| 1st | 4.36 | 2.08 | -52.294 | 1.2 | -72.477 | 0.2 | -95.413 |
| 2nd | 10.87 | 5.6 | -48.482 | 4.5 | -58.602 | 3.6 | -66.881 |
| 3rd | 17.64 | 12.3 | -30.272 | 9.6 | -45.578 | 7.7 | -56.349 |
| 4th | 24.34 | 19.5 | -19.885 | 16.3 | -33.032 | 12.5 | -48.644 |
| 5th | 30.81 | 27.8 | -9.7696 | 24.18 | -21.519 | 18.1 | -41.253 |
| 6th | 36.89 | 36.7 | -0.515 | 32.98 | -10.599 | 24.32 | -34.074 |
| 7th | 42.36 | 46.2 | 9.06516 | 42.4 | 0.09443 | 31.06 | -26.676 |
| 8th | 46.98 | 56.03 | 19.2635 | 52.3 | 11.324 | 38.116 | -18.868 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9th | 50.51 | 65.8 | 30.2712 | 62.5 | 23.7379 | 45.30 | -10.315 |
| 10th | 52.75 | 75.4 | 42.9384 | 72.8 | 38.0095 | 52.47 | -0.5308 |




**Observations:**

1) From above table and graph, It is observed that values of displacement are linearly varying.
2) Displacement is maximum for single column building with floating columns and minimum for single column building with shear wall .
3) Comparing all above cases it is observed that single column building with shear wall is more effective than other other two cases of single column building.

**Design Results for Concrete and Steel:**

| Building | Concrete Qty. | % variation | Steel Qty. | % variation |
|---|---|---|---|---|
| A | 297.0 | | 234160 | |
| B | 359.2 | 20.94 | 318686 | 36.09 |
| C | 203.7 | -31.64 | 75557 | -67.7 |
| D | 239.7 | -19.29 | 93649 | -60 |

**Observations:**

1) Normal Building required 297 $m^3$ concrete for construction.
2) Single column building with floating columns required 359.2 $m^3$ concrete and that is maximum need of concrete quantity among all buildings.
3) Single column building with shear wall requires concrete i.e. 239.7 $m^3$
4) Conventional building require 234160 kg steel for construction.
5) Single column building with floating column requires max steel i.e. 318686 kg.
6) Single column building without floating column requires 67.7% less steel i.e. 75557kg than conventional building.

## CONCLUSIONS

### 5.1 GENERAL

An analytical study is conducted to investigate the single column high-rise buildings with various configurations. A number of building models are analyzed using single column using structural analysis software. The comparative analytical study of single column with and without floating columns and shear wall is presented. From the study following conclusions are made,

### 5.2 General Conclusions

- Single column structure provides better architectural view and free ground space even though it costs bit more than multi column structure.
- Maximum space utilization is considered while planning and designing and it assure that it will serve its maximum serviceability.

### 5.3 Specific Conclusions

- Single column building with shear wall perform best in above cases for axial force, shear force and bending moment.
- Deflection in single column building is minimum as compare to other buildings.
- single column building without floating column requires 33.12% less steel than normal building but it is very weak in displacements.
- Single column building with floating columns required 480.8 $m^3$ concrete and that is maximum need of concrete quantity among all buildings in this project.
- Comparing all above cases it is observed that single column building with shear wall is more effective than other other two cases of single column building.
- The values of shear force are Maximum Single column with floating column and minimum for single column building with shear wall.
- The values of axial force, SF and bending moments are highest at ground level and lowest at top level.
- Single column structure provides better architectural view and free ground space even though it costs bit more than multi column structure.
- Maximum space utilization is considered while planning and designing and it assure that it will serve its maximum serviceability.
- Design of structure with floating column can be possible by satisfying serviceability and economic criteria.
- Structure with floating column having higher maximum bending moment and maximum support reaction than that structures without floating column.
- By comparing all the analyzed results, we can say that the Case 4 model is more suitable model for constructing for safety precautions.
- The probabilities of failure of without floating column are less as compared to with floating column.
- This increased probability of failure when floating column is used can be minimized effectively by introducing the shear wall to the structure.
- Building with floating column and shear wall and building with floating columns performed way better than building with floating column without any lateral load resisting system considering all the structural parameters.

From the above results it is concluded that floating column building should not be prefer in seismic prone areas without any lateral load resisting system. If there is need of floating column in higher seismic zones then suitable lateral load resisting system should be used along with it for safety purpose.

### 5.4 Future Scope

1) The data presented in the current study tackled high-rise buildings for single column with various alterations of columns and shear wall. In few buildings the Architect may require inclined columns; it is expected that this will change the building results compared to buildings with analyzed herein.

2)Seismic analysis of high rise building for single column building with various alterations of columns and shear wall can be carried out in different zones mentioned in IS Code.

3) Unsymmetric Single column building can be analyzed in future with the alterations in columns and shear wall.

4)For the seismic analysis of single column buildings other methods can be used rather than response spectrum.

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