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EVALUATION OF SEISMIC PERFORMANCE OF MULTISTOREY BUILDING WITH FLOATING COLUMN

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Abstract

The current study deals with utilization of space such as basements, parking areas/recreational hall under building etc. as well as in terms of elevation of building; for this reason, a study of floating columns is necessary for earthquake safety. Finding the influence of floating columns given at various positions on seismic response and determining the optimum placement for floating columns where the structure can resist with the least likelihood of failure for RCC buildings. The primary goal of this research is to use the response spectrum approach to do seismic analysis on an RC building in order to better use the available space.

Keywords: Multi storey buildings; RCC buildings, Earthquake; Floating column; Response Spectrum Method.

1. INTRODUCTION

An open first floor is becoming an inescapable characteristic of many Indian urban multi-story structures. This is often used for the first floor's parking or reception areas. A building's whole base shear during an earthquake relies on its natural quantity, but the peak seismic force distribution is determined by its stiffness and mass distribution. During earthquakes, a building's general shape, scale, and geometry, as well as how the earthquake forces are transmitted to the ground, are key factors in its behaviour. Any variation or discontinuity in the load transfer route from the peak of a structure to the ground results in poor building performance. Vertical setbacks (such the hotel buildings with many floors

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wider than the rest) produce an abrupt increase in earthquake forces. When a building has fewer columns and walls on one floor or an abnormally tall storey, the damage or collapse is more likely to begin there. During the 2001 Bhuj earthquake in Gujarat, many buildings with an open ground floor designated for parking fell or were seriously damaged. Discontinuities in the weight transmission route may be seen in buildings with columns suspended from beams at an intermediary floor level that are not connected to the foundation. (Prasannan & Mathew, 2017)

1.1. RCC Frame

RCC is used extensively in the construction of high-rise buildings. Stress is first transported from a concrete slab to the beams, then to the lower columns, and finally to the foundation, which in turn distributes the load to the earth. Once the structure's frame is ready, the walls are constructed.(Maitra & Serker, 2018)

The compressive strength of cement concrete is high, but its tensile strength is low. Mild steel bars are often used in cement concrete to increase its strength. Cement concrete structures reinforced with steel bars provide a high degree of strength. Occasionally, steel bars are chafed or corrugated to enhance the concrete-steel connection. There should be no joints in steel bars used in RCC construction. Because of this, it's common for RCC steel to be lengthy in length. There should be a suitable overlap in the steel bar if it isn't given in full length. (Udaygowda & Karthik, 2018)

Steel must be kept out of the way when concrete is being poured. Planks or plates for walking should be supplied for steel rods that are not adequately bonded. A minimum of 20 days is required for the curing of all concrete.

A building's structural components are referred to as the following:

Slab: The flat ceiling of a story is called a ‘Slab’.

Columns: The vertical members supporting the beams are called ‘Columns’.

Beam: There are two types of beams: horizontal and vertical. 'Beams' are the horizontal components that hold the slab in place around the perimeter. It resists winding when it is subjected to a certain amount of stress. It is possible to make beams out of a wide range of materials such as metals and woods. RCC is the most used material for a beam.

Foundation: There are two types of reinforced cement concrete foundations: one is a position, and the other is a pedestal. For an RCC construction, "steel" is utilised as a kind of reinforcement in a variety of foundations. When a building is supported by a foundation, it securely conveys its weight to the ground. (Chaudhari & Talikoti, 2017)

1.2. Advantages

- The inclusion of a floating column aids in boosting the building's floor area index (FSI).
- In order to provide a large, unbroken space for people or vehicles to travel through, avoid placing columns in close proximity to each other on the bottom floor.
- The floor has a greater amount of open space.

- The floating column is used for architectural and site-related purposes.
- In addition, open spaces may be used for an assembly hall or parking.
- Cantilever Deflections may be controlled using floating columns.

1.3. Objectives of Study:

1. To perform a comparative study for floating column using “Square Shape Structure, L-Shaped Structure (Regular Columns Placed in L-Shape), Plus (+) Shaped Structure (Regular Columns Placed in Plus (+) Shape, T Shaped Structure (Regular Columns Placed in T-Shape)”.
2. To perform the seismic analysis in ZONE-III and ZONE-IV for comparing the performance of all the structures in both the zones.
3. To evaluate and compare the results for “Max. Support Reaction, Max. Bending Moment, Max. Base Shear, Max. Shear Force, Check for Story drift and Check for soft Story”. In addition with calculating the quantity of steel and concrete.

2. LITERATURE REVIEW

(Ashwini, 2017) recognised the unique impacts of a building's seismic load-induced structural irregularity caused by a discontinuity in a column. In this work, a multi-story structure with and without floating columns is subjected to static and dynamic analyses using a response variety system. Floating columns may be built in a variety of ways, including on the floor and within the floor. According to the time period, spectral acceleration, the base shear, storey drift and storey displacements of the building models are studied. STAAD Pro V8i software is used to distribute the results of the analysis.

(S.B et al., 2017) A static study of a multi-story structure with and without floating columns has been completed and is available for download. As the position of the floating columns is varied from floor to floor, a variety of architectural scenarios may be examined. Structural response to base shear and level displacements is studied. The software system sap2000v17 is exploited in the study. It has been shown that the base shear of a building with a floating column at the first floor is lower than that of a structure without a floating column. It was also discovered that the base shear would rise from the first storey. In comparison to non-floating column construction, the displacement of each level of floating column building is much greater.

(K & Rajeeva, 2017) A response spectrum analysis is performed on RC and steel-concrete composite structures with floating columns in the middle of the penultimate bay with and without shear walls, and the RC structure's storey displacement, storey drift, and storey shear are compared.

(Kumar, 2016) An examination of a building's structure is incomplete if it does not take into account the existence of a floating column. The irregularity caused by the floating columns has to be reduced by a variety of methods, including balancing the stiffness of the main level and the storey above it. FEM programmes for 2nd multi-story frames with and without floating columns are created to evaluate the structure's reaction to entirely distinct seismic excitations with varying frequency content while maintaining the PGA and time duration problem constant. All the frames with and without a floating column are analysed for their floor displacement, interstory drift, base shear, and overturning moment.

(Singla, 2015) studied the result of Floating columns that are adopted in soft story and mass irregular building in Zone5 are disclosed. to realize this objective six G+15stories RC clean frame structures that are having 3mt and 4mt column height regular structure are not taking an account within the style as a result of the buildings aren't often subjected to earthquakes, and additionally it takes base shear and displacement with the base shear and displacement of soppy story and additionally mass irregular structure using ETABS 9.7.4.Lateral displacement will increase with the peak of the building. Displacement is a lot of for the floating column buildings compared with the regular building.

(Banerjee & Patro, 2014) The shakiness of the ground may cause damage to floating column buildings because of the rigidity of the infill wall. The nonlinear analysis software IDARC-second is used for modelling and analysis. Damage indices for beams, columns, and levels are calculated using a modified Park model. Building damage indices due to ground tremor are compiled into one comprehensive report. Results are compared to those of standard moment-resisting frame buildings in terms of dynamic response characteristics including lateral floor displacement, level drift, time period, base shear. Analysis determines the formation of fractures, yield, and plastic hinges.

(Engineering & Behera, 2012) The necessity of specifically noting the existence of the floating column in the examination of a structure was examined. Shock-balancing of the basic structure, as well as the structure above, is proposed to mitigate the irregularity induced by the floating columns The PGA of each earthquake has been scaled to 0.2g, and the excitation period is continuous. The dynamic behaviour of a multi-story frame has been studied using a finite component model. The findings obtained using the current finite component algorithms for static and free vibrations are accurate. The column dimension is a variable in the dynamic analysis of the frame. Inter-structure drift values are decreasing as a result of the ground-floor column's rise in displacement; this has been confirmed. Changes in column size affect the base shear and the overturning moment of the structure.

3. METHODOLOGY

Seismic response is utilised to determine the overall position of the structure where it has the least likelihood of failure, and this research mostly includes standard columns set in square shapes, as well as T-shaped, L-shaped, plus-shaped floating columns. Staad Pro is used to generate all of the final findings. Prerna NautiyalA, 2014

Selection of Study Area: For research and investigation, the response spectrum of floating columns on multistory buildings was investigated.

Literature Review: Previous research in the subject of floating columns was investigated and information was gathered based on that study.

Selection of Seismic Zones and Parameters: for this study seismic zones; ZONE III and ZONE IV has been taken. (Banerjee & Patro, 2014)

4. RESULTS AND DISCUSSION

4.1. General

The results of the analyses of instances with square, L, Plus (+) and T-shape structures are presented in this chapter. For each scenario, the results are presented in terms of bending moment, torsional moment, base shearing, maximum shear force, check for storey drift, volume of concrete utilised, and amount of steel used with regard to zones III and IV, respectively.

4.2. Support Reaction

The table below shows the maximum support reaction for cases square shape, L-shape, Plus (+) shape and T-shape structures in Zone III and Zone IV.

Table 1: Max. Support Reaction

Structure Type	Zone III	ZONE IV
Square Shape Structure	2484 KN	2484KN
L-Shaped Structure (Regular Columns Placed in L-Shape)	5168 KN	5168 KN
Plus (+) Shaped Structure (Regular Columns Placed in Plus (+) Shape)	2609 KN	2609 KN
T Shaped Structure (Regular Columns Placed in T-Shape)	3421 KN	3421 KN

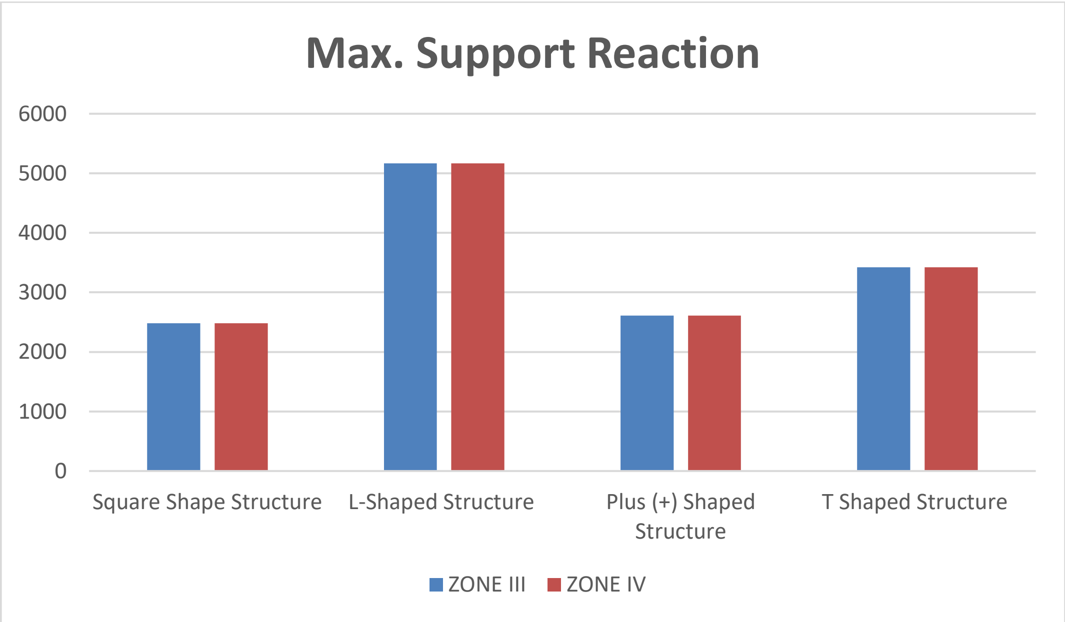

Figure 1: Max. Support Reaction for different structures in Zone III and Zone IV

4.3. Bending Moment

The table below shows the maximum bending moment for cases square shape, L-shape, Plus (+) shape and T-shape structures in Zone III and Zone IV.

Table 2: Max. Bending Moment

Structure Type	Zone III	ZONE IV
Square Shape Structure	238 KN/m	321 KN/m
L-Shaped Structure (Regular Columns Placed in L-Shape)	1288 KN/m	1366 KN/m
Plus (+) Shaped Structure (Regular Columns Placed in Plus (+) Shape)	447 KN/m	499 KN/m
T Shaped Structure (Regular Columns Placed in T-Shape)	702 KN/m	750 KN/m

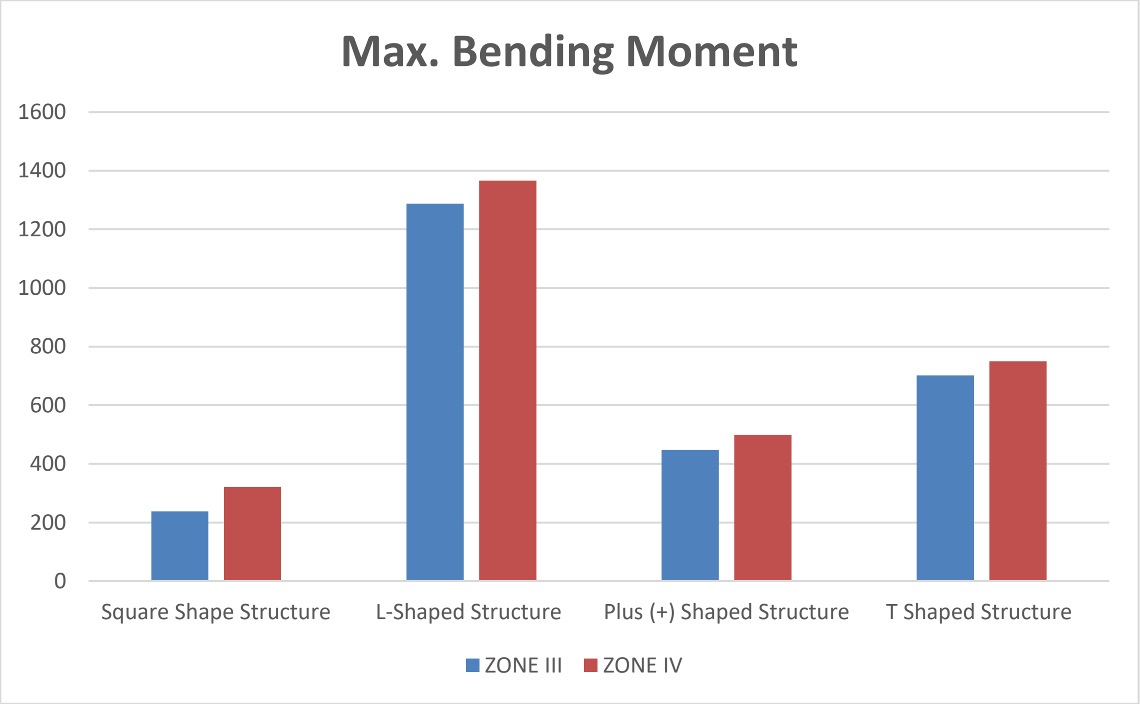

Figure 2: Max. Bending Moment for different structures in Zone III and Zone IV

4.4. Base Shear

The table below shows the maximum base shear for cases square shape, L-shape, Plus (+) shape and T-shape structures in Zone III and Zone IV.

Table 3: Max. Base Shear

Structure Type	Zone III	ZONE IV
Square Shape Structure	238 KN/m	321 KN/m
L-Shaped Structure (Regular Columns Placed in L-Shape)	1288 KN/m	1366 KN/m
Plus (+) Shaped Structure (Regular Columns Placed in Plus (+) Shape)	447 KN/m	499 KN/m
T Shaped Structure (Regular Columns Placed in T-Shape)	702 KN/m	750 KN/m

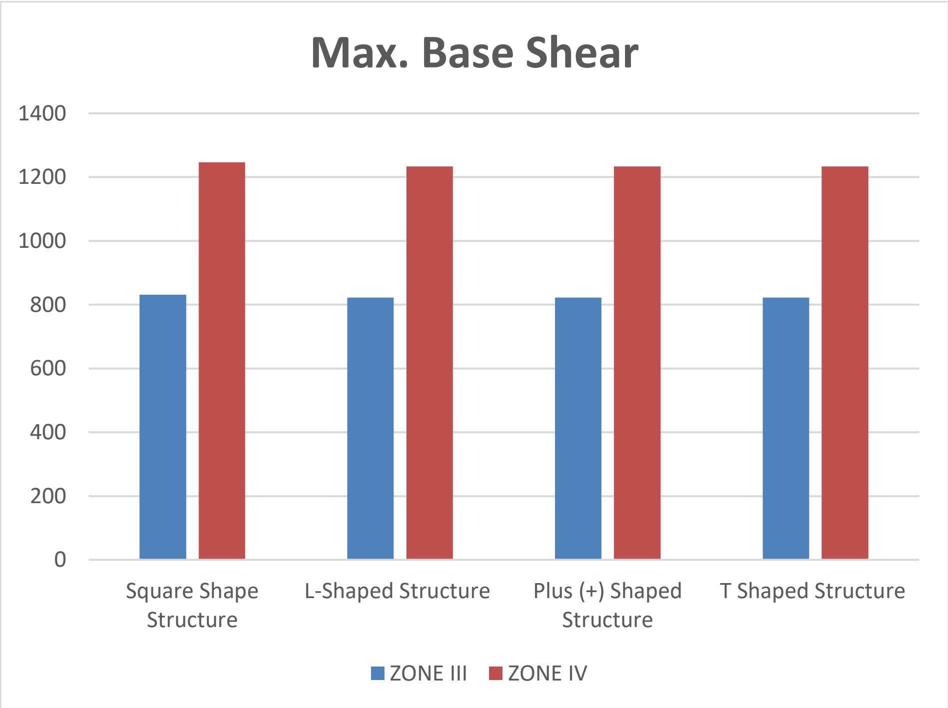

Figure 3: Max. Base Shear for different structures in Zone III and Zone IV

4.5. Shear Force

The table below shows the maximum shear force for cases square shape, L-shape, Plus (+) shape and T-shape structures in Zone III and Zone IV.

Table 4: Max. Shear Force

Structure Type	Zone III	ZONE IV
Square Shape Structure	171 KN	211 KN
L-Shaped Structure (Regular Columns Placed in L-Shape)	644 KN	679 KN
Plus (+) Shaped Structure (Regular Columns Placed in Plus (+) Shape)	268 KN	294 KN
T Shaped Structure (Regular Columns Placed in T-Shape)	394 KN	413 KN

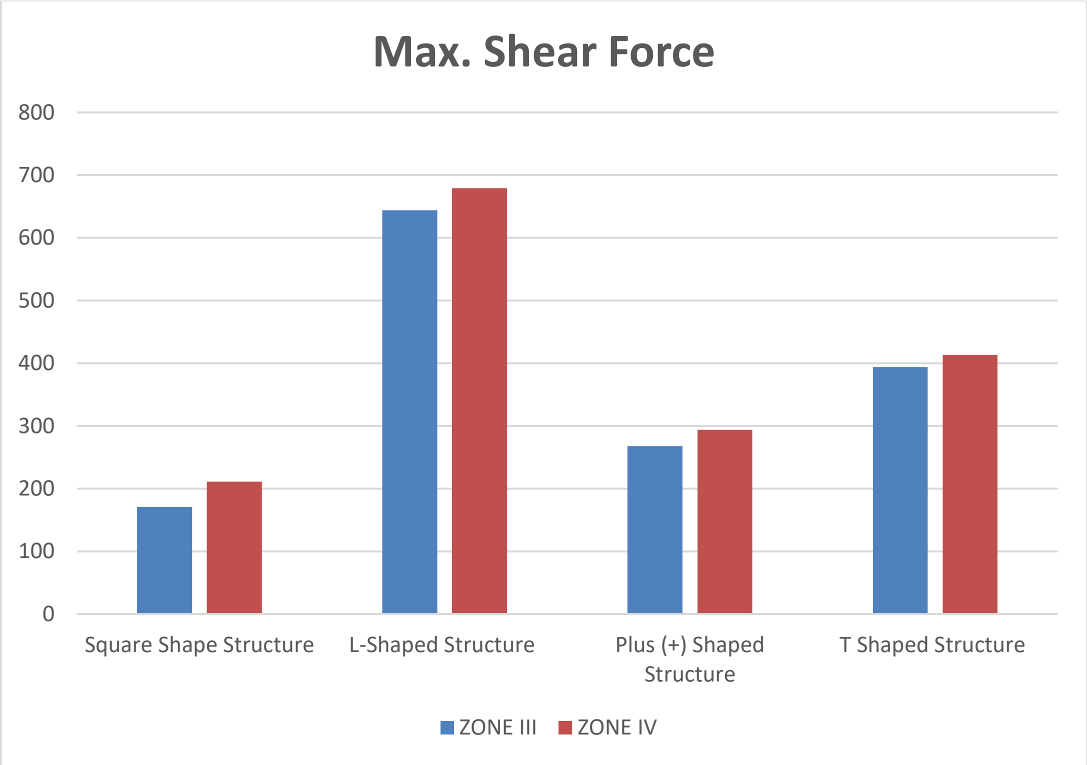

Figure 4: Max. Shear Force for different structures in Zone III and Zone IV

4.6. Volume of Concrete

The table below shows the volume of concrete required in Cum for cases square shape, L-shape, Plus (+) shape and T-shape structures in Zone III and Zone IV**.**

Table 5: Volume of concrete (Cum)

Structure Type	Zone III	ZONE IV
Square Shape Structure	309.02 Cum	309.02 Cum
L-Shaped Structure (Regular Columns Placed in L-Shape)	296.7 Cum	304.0 Cum
Plus (+) Shaped Structure (Regular Columns Placed in Plus (+) Shape)	304.0 Cum	304.0 Cum
T Shaped Structure (Regular Columns Placed in T-Shape)	304.0 Cum	304.0 Cum

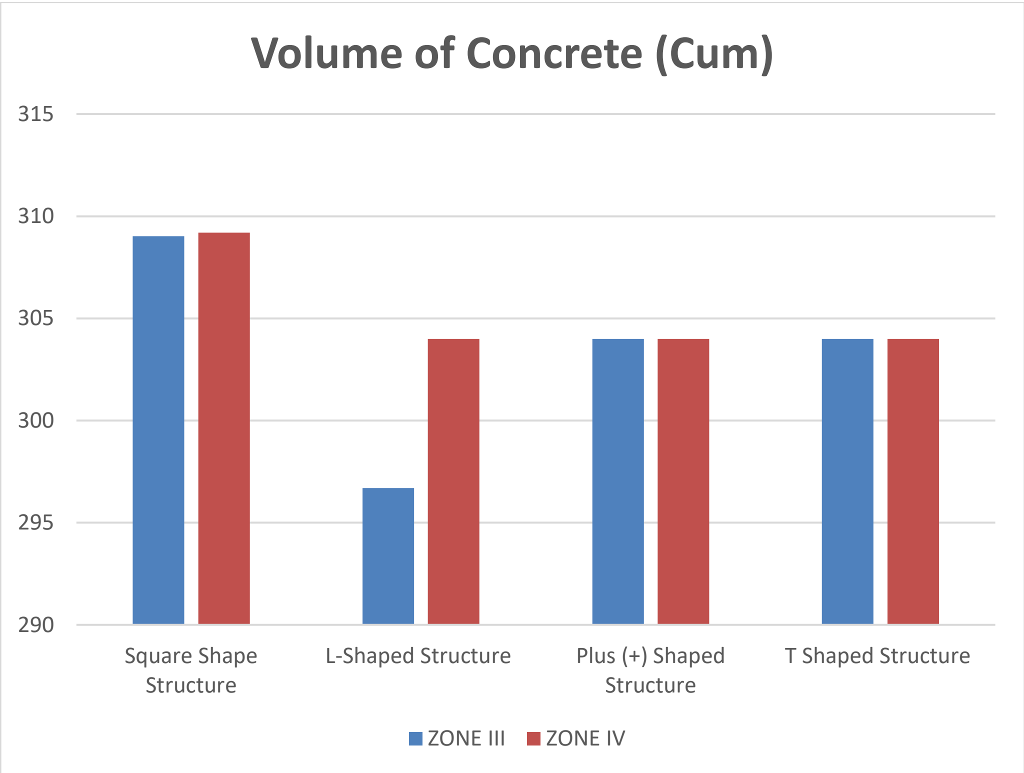

Figure 5: Max. Volume of Concrete for different structures in Zone III and Zone IV

5. CONCLUSION

From the above parameters analyzed in the work; the following set of conclusions are obtained:

1. For the cases discussed base shear is not much affected in Zone III and Zone IV and almost similar values are obtained in **Square Shape structure**, **L-Shaped Structure** (Regular Columns

Placed in L-Shape), **Plus (+) Shaped Structure** (Regular Columns Placed in Plus (+) Shape), **T Shaped Structure** (Regular Columns Placed in T-Shape). In Zone III Max. Support Reaction is obtained for **L-Shaped Structure** (Regular Columns Placed in L-Shape) and Minimum for **Square Shape structure**. In Zone IV Max. Support Reaction is obtained for **L-Shaped Structure** (Regular Columns Placed in L-Shape) and Minimum for **Square Shape structure**. The values of Max. Support Reaction is higher in Asymmetric structures and lower in symmetric structures.

2. The findings of above study discussed values of maximum bending moments in seismic ZONE IV are higher than in seismic ZONE III. Max. Bending stress for Zone III during seismic analysis is obtained for **L-Shaped Structure** (Regular Columns Placed in L-Shape) and Min. for **Square Shape Structure.** Max. Bending stress for Zone IV during seismic analysis is obtained for **L-Shaped Structure** (Regular Columns Placed in L-Shape) and Min. for **Square Shape Structure.** The values of maximum bending moments for the structures without floating columns are lesser than the structures with floating columns.
3. For G+6 Structure Max. Base Shear is obtained in square shape structure. The values of base shear in ZONE IV are approximately 30-40 % higher than in ZONE III. Base shear is not affected by orientation of floating columns weather they are in set in L Shape, Plus Shape or in T Shape.
4. For G+6 Structure Min. Base Shear is obtained in square shape structure. The values of base shear in ZONE IV are comparatively higher than in ZONE III. For G+6 Structure Max. Base Shear is obtained in **L-Shaped Structure** (Regular Columns Placed in L-Shape).
5. All the structures are found to be safe while the check for story drift.
6. All the structures are found with no Soft Story for all the cases and building is stiff in resisting lateral load.
7. The maximum volume of concrete is found in ZONE IV which is little more than ZONE III.
8. The maximum quantity of steel is found in ZONE III which is little more than ZONE IV.

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