# SEISMIC RESPONSE OF RC BUILDING WITH DIFFERENT PLAN ASPECT RATIO

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**Abstract:** The irregular frames will be introduced with the common real life construction feature known as vertical structural irregularities specifically soft story frame cases. The location of irregularity will vary in three locations in the vertical plane viz. bottom, middle and top.
The objective of the investigation is to estimate the seismic demand for each slenderness and plan aspect geometric ratio. The variation in geometric ratios involve five slenderness ratios as 0.5,1, 1.5, 2 with different heights 10, 20 and 30 stories. Response spectrum and time history analysis is undertaken for the seismic response interpretation using ETABS software.
The results indicate that the increase of regular frame slenderness leads to slight increase in shear response but higher displacements and drift. The increase in plan aspect ratio increases the frames shear response significantly with almost convergent displacements..

**Keywords**: ***: ETABS, Aspect ratio, Storey displacement, Time period***

## 1. INTRODUCTION

### 1.1 General

Constructions tremble and wobble whenever their momentum forces are engaged during an earthquake. These forces finally deliver to the soil through the base after passing through different structural components along numerous "load routes.". The overall structure of the structure, which comprises the following: (a) plans form; (b) lateral aspect ratio; and (c) deformation, has a significant impact on t he generation of stresses based on fundamental vibrating and the ultimate transmission of power through foundation. A tower's ductility ratio is calculated by subtracting its height by its lowest base diameter, while its aperture is determined by dividing its length by its width (both in plan). As a building's length rises, the stresses on a floor that serves as a lateral redistribution diffuser in the that area increase. A lengthier structure necessitates more labour at a level that results in a horizontally spread resembling a dam. The lateral stress carried on by an earthquake may not be sufficiently transferred by the ground's rigidity.

## 2. OBJECTIVES

The main objective is to study the structural responses of different aspect ratio buildings having fixed length with different height. To attain the above said objectives the following tasks have been carried out.

- Static analysis and Dynamic analysis were performed upon all the buildings G+30, G+20, G+10, storeys each and different aspect ratios 0.5,1,1.5,2,2.5 with the seismic zone being considered in Zone II.
- All the values of their respective Displacements and Drifts were obtained, plotted and reviewed.
- Time history and response spectrum analysis were performed, and the outcomes• were recorded

## 3. LITERATURE REVIEW

**3.1 Ashish Singh, Sasankasekhar Mandal (2022)**

The author studied Changes in the along both across winds ESWL for various plan aspect ratios (0.5 to 2) and elevation aspect ratios (4 to 9), with the height being constant at 300m in all cases. For structures with plan aspect ratios of 1 to 2, the acrosswind forces are greater than the in at the same forces at heights over 175 metres, according to the plotted of designed forces vs storey characteristics.For plan proportions of 1 and 2, respectively, the magnitude of the across-wind forces was greater than equivalent along-wind forces by around 18% to 9% at the tip of the structures. Concluded that the between load diminishes as the building's breadth, or the side perpendicular to the flow, grows. The along-wind load eventually outweighs the between stress for plan aspects ratios up to 0.75.

**3.2 Suliman A. Alwatban, Mohammed Arif et.al (2020)** The seismic demand was examined for each geometric ratio of plan aspect and slenderness. Five slenderness ratios (1, 1.5, 2, 2.5, and 3) and five plan aspect ratios (1.2, 2.4, 3.6, 4.8, and 6) were among the different geometric ratios. Utilizing STAAD Pro software and the finite element method, response spectrum analysis was carried out for the seismic behaviour interpretations. The findings show that when regular frame slenderness increases, shear response only little increases, while displacements and drift are larger. With virtually convergence displacements, the increase in plan aspect ratio considerably improves the frame's shearing response.Determined that for different configurations of slenderness ratio and plan aspect ratio, the shear demands are lower on frames with bottom soft stories. Frames with lesser reinforcement ratio, in particular, display diverging tendency, whilst frames with bigger slenderness ratios, demonstrate converging trend. On bigger plan aspect ratios, the shorter plan aspect ratio frames exhibit convergence and divergence.

**3.3 T. B. Sajed & M. R. Mukhlis (2020)** Author reviewed the seismic reactions of three structures in both X and Y directions with three distinct plan aspect ratios (length to width ratios) had the same area and height, the author looked into nonlinear time history analysis. After being compared to the design response spectrum of the Bangladesh National Building Code, the chosen ground motion history is utilised in the study (BNBC). In terms of displacements and story drifts, the impacts of plan aspect ratio on the seismic responses of the structures was investigated.[4] The height of the structure displacements in the X direction have increased by 35 and 50 percent, respectively, due to an increase in aspect ratio from the basic square shape of the design by 1.5 and 2 times, respectively. However, due to an increase in aspect ratio of 1.5 and 2 times, respectively, there are 55 percent and 95 percent more maximum narrative displacements in the Y direction. However, the maximum tale drifts in the X direction have increased by 35 and 50 percent, respectively, as a result of the 1.5 and 2 times increases in aspect ratio. Similar to this, due to an increase in aspect ratio of 1.5 and 2 times, respectively, there was a 65 percent and 100 percent rise in the maximum tale drifts in the Y direction.

**3.4 Md. Mohiuddin Ahmed, SumsunnaherTonny (2019)** Author investigated seven building models with various vertical aspect ratios, including 1.875, 3, 3.75, 4.5, 5.625, 6.75, and 7.5 of 5, 8, 10, 12, 15, and 20 storeys. Their influence on the behaviour of the RCC multistorey buildings was demonstrated using the design parameters set forth in the BNBC-1993 for the seismic zone-2. The full analytical process was conducted using the ETABS programme. Other engineers and researchers was able to better grasp the impact of vertical aspect ratio on building performance according to the results of this study.Conclusion: As building heights rise, base shear gradually rises. With a5 storey structure (aspect ratio: 1.875), the base shear is achieved lower; with a 20 storey building, it is obtained higher (aspect ratio 7.5) The story overturning moment steadily rises with the height of the building. The value is lowest for buildings with five stories or less, and the greatest for those with twenty stories or more.

**3.5 Sanjay Kumar Sadh, Dr. Umesh Pendharkar . (2016)** The author looked at the impact of both the longitudinal or plan aspect ratio (L/B ratio) and the vertical aspect ratio (H/B ratio, also known as the slenderness ratio), where H had been the total height of the building frame, B was the base size, and L was really the length of the framed structure's various people to set..[1] On the basis of the aforementioned seismic criteria, it was determined that the square design, that has a aspect ratio of 1 (both horizontally and vertically), performs seismically among the best, would be the best option for plan configuration. It can be shown that 2-bay (12x12m) building frames up to 4-story (12m) buildings have lower critical seismic parameteric values than equivalent 8-bay (48x12m), 12-bay (72x12m), and 16-bay (96x12m) building frames. Therefore, lower construction heights are suitable for two bay (12x12m) structures.

## 4. METHODOLOGY & MODEL DESCRIPTION

The present work aims to investigate earthquake reactions, including storey displacements and storey drift. Basic time period and base shear) impact of plan aspect ratio (building length is set and situated in a separate seismic zone II in accordance with IS 1893- 2016). different plan aspect ratio buildings is modelled in ETABS and their responses for different seismic zones are noted down and compared to evaluate the results and conclusion. Dynamic Analysis is carried out using time history method to evaluate the seismic responses.

The present study was carried out to check parameters like

- Time period
- Frequency
- Stiffness
- Displacement,
- Drift to realize the ideal position and

| Title | Specifications |
|---|---|
| Plan Size | 20m ×20m |
| Floor height | 3 m |
| Beam sizes | 300 × 300 mm |
| Column sizes | 750× 750 mm |
| Slab thickness | 150 mm |
| Live load | 3 kN/m² |
| Floor finish | 1.5 kN/m² |
| Concrete Grade | M25, M30 |
| Poisson ratio | 0.17 |
| Compressive strength | 20000 kN/m² |
| Steel | Fe 500 |

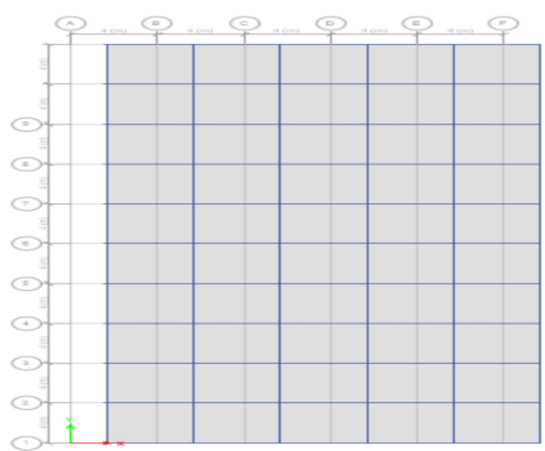

**Fig 4.1:** Plan of model with aspect ratio 0.5

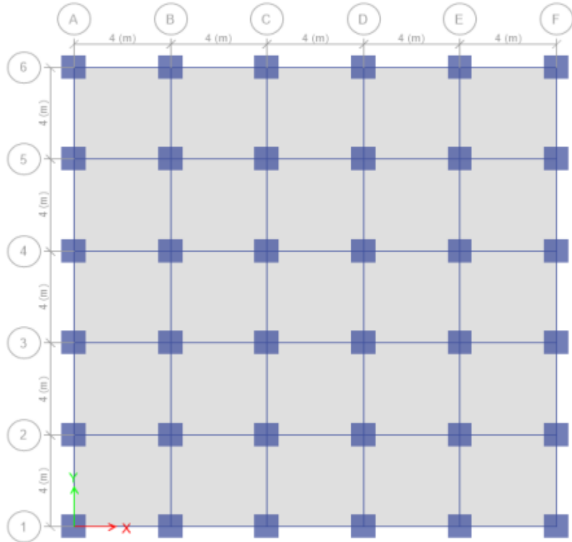


**Fig 4.2:** Plan of model with aspect ratio 1

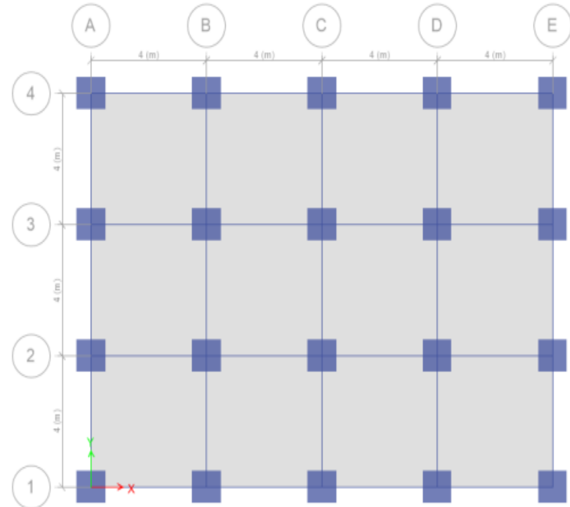


**Fig 4.4:** Plan of model with aspect ratio 2

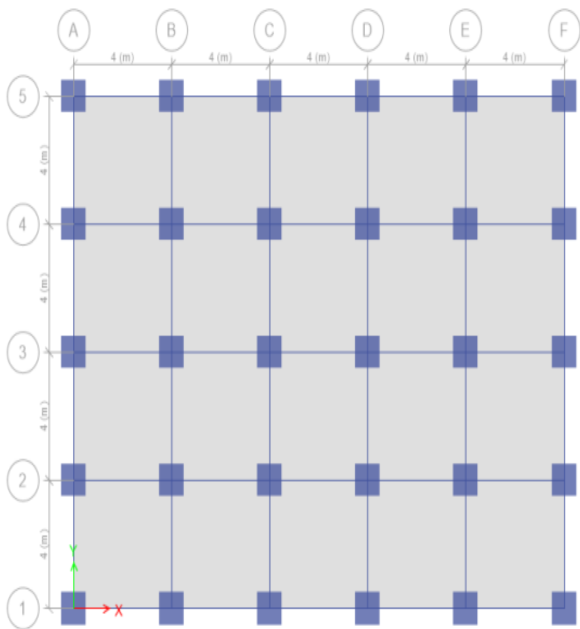


**Fig 4.3:** Plan of model with aspect ratio 1.5

## 5. RESULT&DISCUSSIONS

The results and discussions provided are thoroughly examined, with references to the necessary tables and figures.

### 5.1.1 Displacement

**Table 5.1: Max. Displacement values for different models (Response spectrum analysis in X direction)**

| Storey height | Maximum displacement in "mm" for different aspect ratio models | | | |
|---|---|---|---|---|
| | 0.5 | 1 | 1.5 | 2 |
| 10 | 14.792 | 14.12 | 14.047 | 14.146 |
| 20 | 35.374 | 29.874 | 29.823 | 30.098 |
| 30 | 79.19 | 78.288 | 77.89 | 80.477 |

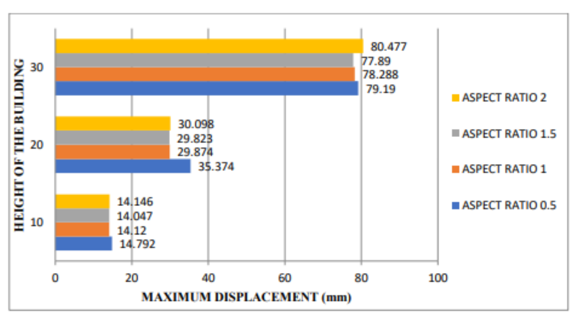


**Fig 5.1 Maximum Storey Displacement for different aspect ratio and different height models**

**Table 5.2: Max. Displacement values for different models (Response spectrum analysis analysis in Y direction)**

| Storey height | Maximum displacement in "mm" for different aspect ratio models | | | |
|---|---|---|---|---|
| | 0.5 | 1 | 1.5 | 2 |
| 10 | 14.447 | 14.12 | 14.193 | 14.372 |
| 20 | 29.064 | 29.874 | 30.242 | 30.751 |
| 30 | 72.124 | 78.288 | 81.431 | 86.748 |

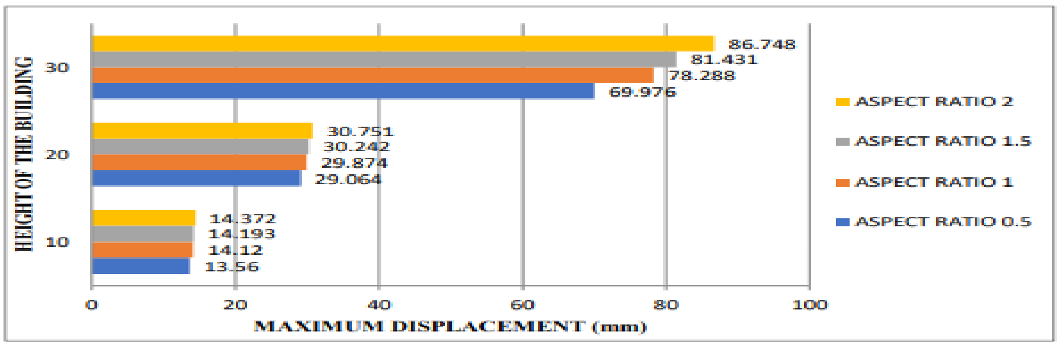


**Fig 5.2 Maximum Storey Displacement for different aspect ratio and different height models**

The maximum storey displacement along Y direction in the different models with different aspect ratio is listed in Table 5.2 and the variation of those values has been shown in Fig 5.2. It is seen that displacement increases as the height of the building increases. For all considered height, as aspect ratio increases displacement values for building along Y direction increases.

The maximum storey displacement along X direction in the different models with different aspect ratio is listed in Table 5.3 and the variation of those values has been shown in Fig 5.3. it is seen that displacement increases as the height of the building increases. For all considered height, aspect ratio 1.5 gives less displacement results.

**Table 5.3: Max. Displacement values for different models (Time history analysis in X direction)**

| Storey height | Maximum displacement in "mm" for different aspect ratio models | | | |
|---|---|---|---|---|
| | 0.5 | 1 | 1.5 | 2 |
| 10 | 12.979 | 12.213 | 11.545 | 11.675 |
| 20 | 39.036 | 38.677 | 38.55 | 39.378 |
| 30 | 112.624 | 111.837 | 111.331 | 114.964 |

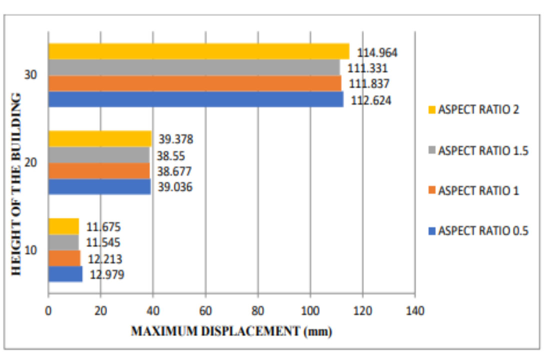


**Fig 5.3 Maximum Storey Displacement for different aspect ratio and different height models**

**Table 5.4: Max. Displacement values for different models (Time history analysis in Y direction)**

| Storey height | Maximum displacement in "mm" for different aspect ratio models | | | |
|---|---|---|---|---|
| | 0.5 | 1 | 1.5 | 2 |
| 10 | 12.291 | 12.213 | 11.945 | 12.328 |
| 20 | 36.504 | 38.677 | 39.811 | 41.398 |
| 30 | 101.396 | 111.837 | 116.257 | 122.621 |

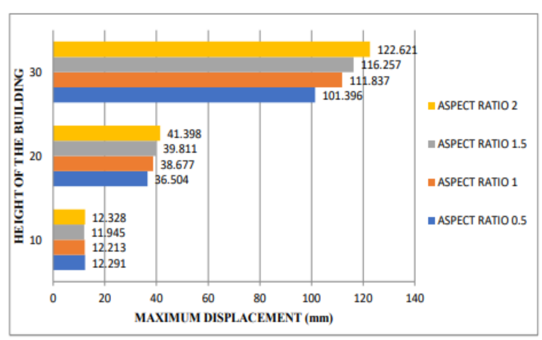


**Fig 5.4 Maximum Storey Displacement for different aspect ratio and different height models**

The maximum storey displacement along Y direction in the different models with different aspect ratio is listed in Table 5.4 and the variation of those values has been shown in Fig 5.4.

it is seen that displacement increases as the height of the building increases. For all considered height, aspect ratio 1.5 gives less displacement results.

Table 5.9: Max. base shear values for different models (in X direction)

| Storey height | Maximum Base Shear (kN) for different aspect ratio models | | | |
|---|---|---|---|---|
| | 0.5 | 1 | 1.5 | 2 |
| 10 | 1631.03 | 883.316 | 741.32 | 487.54 |
| 20 | 1367.52 | 743.922 | 619.2 | 404.266 |
| 30 | 1878.64 | 1015.286 | 842.61 | 555.18 |

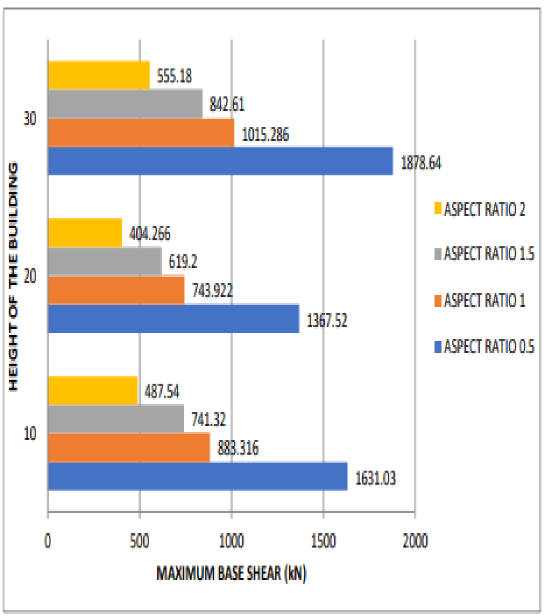


Fig 5.9 Maximum Base shear for different aspect ratio and different height models

The maximum Base shear along X direction in the different models with different aspect ratio is listed in Table 5.9 and the variation of those values has been shown in Fig 5.9.

It is seen that base shear values increases as the height of the building increases. For all considered height, aspect ratio 1.5 gives less drift results.

**Time period**

**Table 5.11 Max. Time Period in (Seconds) for different aspect ratio models**

| Storey height | Maximum Time Period in (Seconds) for different aspect ratio models | | | |
|---|---|---|---|---|
| | 0.5 | 1 | 1.5 | 2 |
| 10 | 1.461 | 1.48 | 1.46 | 1.473 |
| 20 | 3.619 | 3.59 | 3.646 | 3.71 |
| 30 | 5.92 | 5.89 | 6.002 | 6.518 |

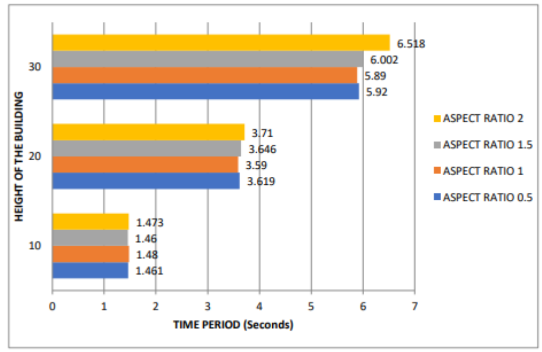


**Fig 5.11 Maximum Time Period in (Seconds)for different aspect ratio models**

The time period of the different models with different aspect ratio is listed in Table 5.10 and the variation of those values has been shown in Fig 5.10. It is seen that base shear values increases as the height of the building increases. For all considered height, aspect ratio 1.5 gives less drift results.

## 6. CONCLUSION

By considering the models with different aspect ratio and their behaviour in dynamic earthquake loading.

- It is shown that for response spectrum and time history analysis, the model with aspect ratio 1.5 will get the best results.
- In comparison to a model with aspect ratio, it tends to shorten the time period and significantly reduce the lateral displacement and storey drift in both the X and Y directions.
- As height of the structure increases base shear value decreases.
- Base shear is decreases with increasing in aspect ratio.

- Drift and displacement both increase with structural height.
- The best building to sustain extreme earthquake is model with aspect ratio 1.5.
- The tall building should have small aspect ratio i.e. sides of the building should be nearly equal in size, which will make it less critical.
- The building should square in shape as far as design is a concern.

The building with a plan aspect ratio of 1.5 exhibits the least base shear in both directions, and when the plan aspect ratio rises, base shear also rises noticeably.

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