Performance of RCTall Buildings under Different Seismic Zones
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Abstract:
When earthquakes occur, a building undergoes dynamic motion. This is because the building is subjected to inertia forces that act in opposite direction to the acceleration of earthquake excitations. These inertia forces, called seismic loads, are usually dealt with by assuming forces external to the building. Since earthquake motions vary with time and inertia forces vary with time and direction, seismic loads are not constant in terms of time and space. In this study Rectangular and L-shape plan building models is considered for all zones of earthquake. The models are subjected to a series of dynamic loads and analysed. The common method of Dynamic Analysis is Response Spectrum method based on IS 1893 Part 1 2002 is done using ETABS 2016 software.

Keywords: Seismic zones, Response spectrum,

I. INTRODUCTION
Earthquake-resistant structures are structures designed to withstand earthquakes. While no structure can be entirely immune to damage from earthquakes, the goal of earthquake-resistant construction is to erect structures that fare better during seismic activity than their conventional counterparts. According to building codes, earthquake-resistant structures are intended to withstand the largest earthquake of a certain probability that is likely to occur at their location. This means the loss of life should be minimized by preventing collapse of the buildings for rare earthquakes while the loss of the functionality should be limited for more frequent ones. There are four aspects of buildings that architects and design engineers work with to create the earthquake-resistant design of a building, namely seismic structural configuration, lateral stiffness, lateral strength and ductility, in addition to other aspects like form, aesthetics, functionality and comfort of building. Lateral stiffness, lateral strength and ductility of buildings can be ensured by strictly following most seismic design codes. But, good seismic structural configuration can be ensured by following coherent architectural features that result in good structural behaviour.

II. SIGNIFICANCE OF SEISMIC ZONATION
Seismic Zonation may be termed as the geographic delineation of areas having different potentials for hazardous effects from future earthquakes. Seismic zonation can be done at any scale, national, regional, local, or site. The term Zoning implies that the parameter or parameters that characterize the hazard have a constant value in each zone. If, for example, for practical reasons, the number of zones is reduced (from five as is the case in large majority of national codes), we obtain a rather simplified representation of the hazard, which in reality has continuous variation. A seismic zone is a region in which the rate of seismic activity remains fairly consistent. This may mean that seismic activity is incredibly rare, or that it is extremely common. Some people often use the term “seismic zone” to talk about an area with an increased risk of seismic activity, while others prefer to talk about “seismic hazard zones” when discussing areas where seismic activity is more frequent.

Figure 1. Seismic zonation in India
Many nations have government agencies concerned with seismic activity. These agencies use the data they collect about seismic activity to divide the nation into various seismic zones. A number of different zoning systems are used, from numerical zones to colored zones, with each number or color representing a different level of seismic activity.

ZONE 5 - Covers the areas with the highest risks zone that suffers earthquakes of intensity MSK IX or greater. The IS code assigns zone factor of 0.36 for Zone 5.
ZONE 4 - This zone is called the High Damage Risk Zone and covers areas liable to MSK VIII. The IS code assigns zone factor of 0.24 for Zone 4.

ZONE 3 - This zone is classified as Moderate Damage Risk Zone which is liable to MSK VII. The IS code assigns zone factor of 0.16 for Zone 3.

ZONE 2 - This region is classified as the Low Damage Risk Zone. The IS code assigns zone factor of 0.10 for Zone 2.

ZONE 1 - Since the current division of India into earthquake hazard zones does not use Zone 1, no area of India is classed as Zone 1.

III. SEISMIC EFFECTS ON STRUCTURES

Earthquake causes shaking of the ground. So a building resting on it will experience motion at its base. From Newton’s First Law of Motion, even though the base of the building moves with the ground, the roof has a tendency to stay in its original position. But since the walls and columns are connected to it, they drag the roof along with them. This is much like the situation that you are faced with when the bus you are standing in suddenly starts; your feet move with the bus, but your upper body tends to stay back making you fall backwards!! This tendency to continue to remain in the previous position is known as inertia. In the building, since the walls or columns are flexible, the motion of the roof is different from that of the ground.

Under horizontal shaking of the ground, horizontal inertia forces are generated at level of the mass of the structure (usually situated at the floor levels). These lateral inertia forces are transferred by the floor slab to the walls or columns, to the foundations, and finally to the soil system underneath (Figure- 3). So, each of these structural elements (floor slabs, walls, columns, and foundations) and the connections between them must be designed to safely transfer these inertia forces through them.

Figure 2. Collapse of reinforced concrete building during 2001 Bhuj (India) earthquake.

IV. PRINCIPLES CONSIDERED DURING SEISMIC ANALYSIS

The analysis of a building for seismic forces is carried out generally by application of the following principles:

Direction of earthquake forces –

In the analysis, the horizontal component of earthquake force only is considered. The vertical component is disregarded, normally. If particular consideration of the vertical force component is necessary, it requires special application. The horizontal force is assured to act separately in the longitudinal and transverse directions. Consideration of the simultaneous action of the two force components is not necessary usually. Each case requires a check as to the validity of this assumption.

Action of earthquake force – The earthquake force is assumed to act at the floor slab level. If the framing and mass...
distribution is such that a large amount of force is reactive at the mid-height of any one story, the local stress due to this force must be considered.

**Displacement of the floor slabs –**

The assumption is made that the floor structures are rigid in the horizontal direction. Accordingly, all resisting framing elements in any one story are assumed to have the same relative horizontal displacement, when eccentricity exists between the centre of shear and the centre of rigidity, the resulting torsion must be taken into account. When the floor structure is not considered to be rigid sufficiently to validate this assumption, as in the case of a prefabricated floor slab or if the distance between adjacent seismic walls is large, special consideration is necessary.

**Plastic deformation –**

The shear distribution and the stress analysis of the resisting framing elements is to be made according to the elastic theory. For portions of the structure where the accumulation of stress is overly large, such as the adjacent and boundary framing of a wall, the stress can be decreased due to localized plastic deformation.

**Condition of the foundation –**

In the normal building, it is unusual for the foundation to neither settle, displace laterally nor rotate. The normal building does not have sufficient foundation rigidity to prevent these occurrences. It is recommended, where necessary that allowances be made for such occurrences, in the method presented in this paper, the foundation rotation incurred by the large foundation reaction under seismic walls is considered.

**V. PROBLEM DEFINITION**

The main purpose of seismic analysis of buildings/structures is to study the effect of dynamic loads on the buildings. Dynamic loads are those loads which vary with time like Wind load and Earthquake loads. The structures are subjected to a series of dynamic loads and analysed. The common method of Dynamic Analysis is Response Spectrum method based on IS 1893 Part 1 2002. It is done using ETABS 2016 software. Following are the objectives:

- To model a rectangular plan building for all zones, and to analyse and compare the results.
- To model a L-shape plan building for all zones, and to analyse and compare the results.
- To study various parameters such as displacement,
- Storey drift, storey shear, base shear for all the models different zones.

**VI. MODEL SPECIFICATION**

In this study two different shapes of plan like Rectangular shaped and L – shaped models are considered with 15 storey reinforced concrete structure. Dynamic analysis is carried out by response spectrum method using FEM package ETAB v 2016.
Table 4. Model Details

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Details</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Storey height</td>
<td>Base- 5 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Typical floor- 3m</td>
</tr>
<tr>
<td>2</td>
<td>Materials</td>
<td>Rebar, Concrete</td>
</tr>
<tr>
<td>3</td>
<td>Grade of concrete</td>
<td>M30 (Column), M25 (Beam), M20 (Slab)</td>
</tr>
<tr>
<td>4</td>
<td>Grade of rebar</td>
<td>Fe550 &amp; Fe 415 (Modulus of Elasticity of rebar = 200 kN/mm²)</td>
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<tr>
<td>5</td>
<td>Codes</td>
<td>IS 456:2000</td>
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<td></td>
<td></td>
<td>IS 875-1987 (Part II) - Live Loads/ Design Loads,</td>
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<td>IS 1893 (Part 1): 2002 – For Earthquake parameters</td>
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VII. RESULT DISCUSSIONS & CONCLUSIONS

Figure 5. Comparison of storey displacement values - RSX case

Figure 6. Comparison of storey displacement values - RSY case

Figure 7. Comparison of storey drift values - RSX case
Figure 8. Comparison of storey drift values - RSY case

Figure 9. Comparison of storey shear values - RSX case

Figure 10. Comparison of storey shear values - RSY case

Figure 11. Comparison of base shear values in X-direction.

Figure 12. Comparison of base shear values in Y-direction.

L-shape plan model results:

Figure 13. Comparison of storey displacement values - RSX case

Figure 14. Comparison of storey displacement values - RSY case

Figure 15. Comparison of storey drift values - RSX case
From above results following observations are made during study:

- With respect to displacement parameter it is observed that the maximum displacement value found is 101.469 mm for model RMZ5 with least value is 28.186 mm for model RMZ2 at top floor. This indicates displacement increased more than 3 times from zone II to zone V.

- The displacement values are less in Y-direction compared to X-direction since structure is stiffer in Y-direction.

- The maximum drift value found is 0.003617 for model RMZ5 with least value is 0.001005 for model RMZ2 at 11th floor. This indicates drift increased more than 3 times from zone II to zone V.

- From above Figure it indicates that drift values is maximum at intermediate floor and least at top and bottom floors of the structure.

- The maximum storey shear value found is 1084.9386 kN for model RMZ5 with least value is 301.3718 kN for model RMZ2 at 1st floor. This indicates shear value increased more than 3 times from zone II to zone V.

- The storey shear values are more or less same in Y-direction and X-direction since structure is symmetric, the values are 613.6096 kN & 170.4471 kN for zone V & zone II models respectively.

- From above Figure it indicates that storey shear value is maximum at bottom floors floor and least at top floors of the structure.

- Base shear values found more in zone V & least values in zone II models.

- Base shear values plays important parameter for design of any structure specially structures located in seismic areas.

- The maximum displacement value found is 59.066 mm for model LMZ5 with least value is 16.407 mm for model LMZ2 at top floor. This indicates displacement increased more than 3 times from zone II to zone V.

- The maximum drift value found is 0.002068 for model LMZ5 with least value is 0.000574 for model LMZ2 at 11th floor. This indicates drift increased more than 3 times from zone II to zone V.

- The maximum storey shear value found is 564.1124 kN for model LMZ5 with least value is 156.6979 kN for model LMZ2 at 1st floor. This indicates shear value increased more than 3 times from zone II to zone V.

- The storey shear values are more or less same in Y-direction and X-direction since structure is symmetric, the values are 613.6096 kN & 170.4471 kN for zone V & zone II models respectively.

Following are the conclusions:

- In this study, it is observed that the models are more vulnerable to higher lateral load due to earthquake
when structures are located in high seismic zone compared to low seismic zone.

- The minimum values of parameters studied (Storey displacement, Storey drift, Storey shear, Base shear) for both rectangular and L shape model occurred for zone 2 and maximum values occurred for zone 5.

- It was observed that all the parameters for models in zone 5 increased by 28% compared to zone 2 values.

- Important structures like public buildings, school etc. which are located in high seismic zone need to be analysed by response spectrum method before construction.

- The structure should be provided with sufficient lateral strength by providing shear wall, bracings, infill walls etc.

VIII. REFERENCES


[4]. IS-875 (Part-1)-1987 code of practice for design loads (other than earthquake loads) for buildings and structures: part-1 for dead loads.
