International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 03 | March - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Seismic Behavior of RC Multistorey Building Frame Structure with Different Plan Configuration

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Abstract - The world today is facing some major problems caused by nature. One of the major natural disasters is earthquakes. We never know the Direction of the attack and magnitude of the Earthquake, so it will be the challenge the science and Technology. Past few years' research done on the various issues of Earthquake. Currently, people live in multiple buildings. In this case, when an earthquake knocks out the densely populated area, this causes a major damage. Therefore, the analysis of the earthquake is important for analysis of a safe structure for the collapse and structure design, which occurs during the duration of the structure, as it is safe for the earthquake. In this study, a G+11 structure with square plan configuration has been modelled in Staad Pro and the seismic analysis of the structure has been analyzed in a seismic city, Jabalpur, located in seismic zone III, with soft, hard and medium soils resulting in different seismic and structural parameters. The analysis has been carried out using STAAD Pro V8i software using linear static analysis and is compared with the analysis of a multi-storey reinforced concrete frame structure in terms of maximum bending moment and floor displacements.

Key Words: *Seismic zone, Soil type, Multistory RC Building, Staad Pro Software etc.*

1. INTRODUCTION

The Earth is spherical and made up of three layers: the crust, the mantle, and the core. Earthquakes only occur in the Earth's crust, which is divided into two parts: the lithosphere and the asthenosphere. The lithosphere is a rigid plate and is divided into seven major parts and several minor parts. The asthenosphere is the semi-rigid part and the lithosphere floats on top of the asthenosphere. Convection currents cause the movement of the lithospheric plates. When two plates collide, a large amount of energy is released in the form of waves. The waves are hit the earth surface in the form of vibrations that vibrations lead to earthquakes. Tremor vibrations are formed at the point of initiation of rupture to in all directions in the form of elastic waves, these waves are mainly divided into primary waves or p waves, secondary waves or s waves and surface waves. Earthquakes are usually caused by the rupture of plates, and the place where the rupture occurs, i.e. where the earthquake occurs, is called the epicentre. The location just above the Earth's surface is called the epicentre. The distance from the epicentre to the earthquake's source is called the focal depth. The size of an earthquake is determined by both its magnitude and its intensity. Magnitude refers to the amount of energy released during the rupture.

The structure is a complex structure with different considerations, and later in the planning stage, the designer and key professionals must work together to eliminate the negative aspects and choose a good layout for the structure. If we have an initially helpless design, each of these specialists can make, for example, a patch to improve the essentially helpless arrangement as best as possible. On the other hand, if we start from a correct plan and a reasonable surrounding structure, even a helpless architect cannot damage its final execution to the extreme. In any case, the arrangements can withstand different damages when subjected to seismic excitations, although for the same auxiliary facility, the area, the EQ damages in the frame are neither unilateral nor uniform. The desire to create an elegant and practically productive structure motivates engineers to consider amazing and creative structures. Sometimes the condition of the building captures the visitor's attention, sometimes the basic framework suggests, and sometimes both the shape and the supporting framework interact to make the structure extraordinary. Either way, these shape and structure choices have a major impact on the work's expression when subjected to a strong earthquake shock. Therefore, uniformity and regularity are generally recommended. How you respond during an earthquake is determined primarily by the earthquake's overall shape, size, and topography. A structure with sporadic geometry reacts clearly to seismic activity. The geometry of the plan is a border that selects presentations for various stacking conditions. The effect of divergence (plan and form) on the structure was carried out using STAAD Pro inspection assistant software. V8i. Ground motions generated by surface earthquakes can produce varying levels of seismic motion, leading to damage or destruction of buildings and public infrastructure. Buildings must be able to withstand moderate ground motions without secondary damage, but possibly with basic or non-structural damage. This state of rupture can be compared to the strength of the tremors, equivalent to the most anchored or the figure most based on the site.

1.1. Building Plan

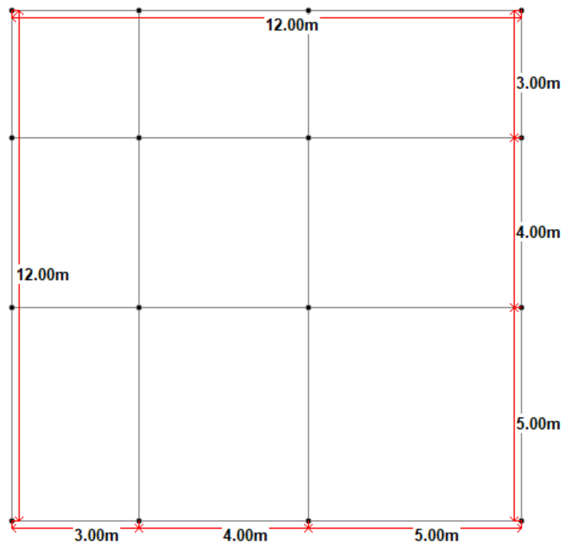

Fig. 1.1 Building Plan

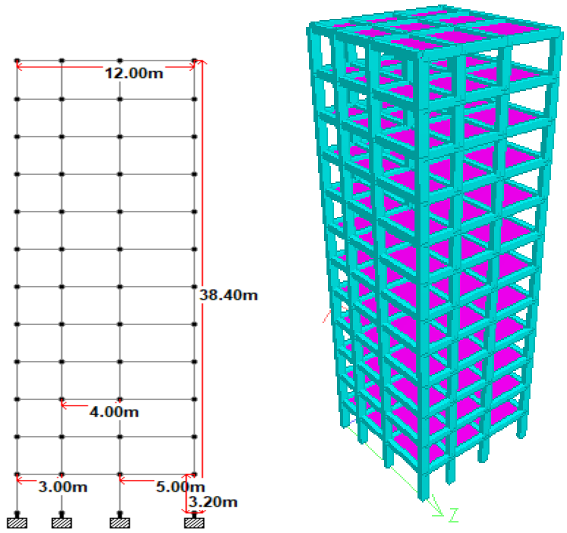

Fig. 1a- Elevation & 3D view

In this study, the structure of the construction plan was adopted as a rectangle of 3.5 m of 3.5 m.

1.2 Objective of Research

1. To know the seismic behaviors on RC building due to Earthquake Forces.

2. Comparative Seismic Analysis of Structure between different types of Soil.

3. To analyses the G+11 RC building by Linear Static Method by using Staad Pro.

2. LITRATURE REVIEW

1. Umer Bin Fayaz and Brahamjeet Singh (2023): - He analyzed 9m x 12m in a three -story RC G + 9 -story building using Auto Cad and Etabs software. They examined various parameters, including the area of E earthquake V, the burden of 1.5 kN / m2 earthquakes, and specific varieties. Earthquake analysis of all types of structures is an important aspect when working in high earthquake areas. With the help of an earthquake analysis, you can design and build structures to withstand the horizontal movement of the earthquake. They found that inappropriate elements were displayed and suitable sections were recommended by the software. By using this software, they could achieve a higher analysis accuracy and based on this analysis and design, they can conclude that the performance of the frame structure can be improved by introducing shear walls. **2. Sitesh Kumar Singh, Rajat Shrivastava: -** He analyzed and designed a multi-storey (G+9) frame structure for Seismic Zone II (Delhi) using Staad Pro. He conducted the seismic study of the RC structure using response spectrum method considering mass non-uniformity using structural software. He found that subtle differences in segments made under the slightest suspicion of twisting remain crucial for structures faced with enormous deformations that unravel their states of internal and external consistency. In graphs, essential structures are seen as deliberately developing regulating states of general system consistency. Two computational progressions are represented in the graphical examination. One is the direct path collection which is used to recover the Cartesian nodal expulsions from the relative nodal evacuation sand which explores a graph from the hub center point to the terminal centers. Another method is reverse progression, which is used to reconstruct the nodal controls in the relative reward system from the known nodal controls in the apparent driving force structure and traverses the final center to the base center points. **3. Amit Chakrawarty, Sourav Ray etc all [2016] –** It studied four distinct shapes (W-shape, L-shape, rectangular, square), ten known reinforced concrete building outlines were studied using ETABS v9.7.1 and SAP 2000 v14.0.0 for seismic zone 3 (Sylhet) in Bangladesh. A similar study of maximum removal of different structures formed due to static stacking and dynamic range of response was studied. The analysis showed that the static load study showed that the effect of seismic forces was almost the same for all models except model 1 (W-shape). It was found that the W-shape was generally not protected against earthquake shaking. Furthermore, the response range study revealed that the contour removal of the sporadically formed structures was greater than that of the standardly formed structures. The general execution of the normal structure is larger than the unpredictable structure. **4. Gauri G. Kakpure, Ashok R. Mundhada [2016] –** He tested four very unexpected shapes of R+15 floor structures: rectangular, L-shaped, H-shaped and C-shaped, which were used for correlation. All models were inspected using ETABS 9.7.1 renderings. For each of the four cases, a relative dynamic analysis was performed to assess the deformation of the structure. Working with an extreme anomaly result in more distortion than working with less inconsistency, especially in areas of high seismic activity. Moreover, the joint collapse of the history of the second changes inversely proportional to the growth of history. The shift of the basis of history for the normal structure is most elevated in comparison with sporadic molded structures. Authorized Story Float is 0.004 times the stature of history. A story floated with the increase with the increase in the height of history to the seventh story to the most extreme value and, thereafter, it begins to decrease. The most extreme story float allowed is 0.004 x tallness of story. The distinction of estimations of dislodging among static and dynamic investigation is immaterial for lower stories however the thing that matters is expanded in higher stories and static examination gives higher qualities than dynamic investigation. Static inspections are not suitable for high structures, and it is important to conduct dynamic research. The work using the re -equipment at the corner has increased the number of horizontal floats and basic shifts, which is in contrast to the normal structure. Compared to unpredictable designs, the value of storey float is higher in a typical setting. As the building height increases, so does the storey float. The sporadic structure of the form knows the coolest, and then needs to love the normal structure of the form. The results of proportional static tests are associated with unprofitable titles because travel evaluation is larger than dynamic research.

3. MATHEDOLOGY

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In this research, the work deals with the relative study of the behavior of earthquakes on the construction structures RC G + 11 of the different soil conditions and this structure of building frame of square form with three ground conditions for Jabalpur, Madhya Pradesh under the effect of the tremor) - 2016 Static analysis. A comparative analysis is carried out in the term of max. Bending moments and maximum floor displacements were respected. In this work included various steps**:**

Step-1 Modeling of building frame in structure wizard with different type of soils of G+11 in square shape**.**

Step-2 Creating 3D frame structure**.**

Step-3 Providing seismic zone and soil conditions as per IS-1893 (Part-I):2016

Step-4 Applied various type load and load combination.

Step-5 Analysis of building frames Structure, providing different seismic zones.

Step-6 After analysis the structure compared all the results of Max**.** B.M.**,** SF**.** Deflection, displacement, storey displacement etc**.**

4. MODELING AND PROBLEM FORMULATION

STAAD. Pro is a general-purpose program for doing the analysis the structure with different types soil condition and seismic region Jabalpur, Madhya Pradesh which is located in earthquake region III. The following three actions should be carried out to achieve this objective. (a) Generation of models using Stad.Pro. (b) Calculations to determine analytical results. (c) Verification of results is fully facilitated by the devices contained in the graphical environment of the system. Parameter Using: Building type: Reinforced concrete. Plan layout is square. Number of floors: G+11. Column size = 450mm x 700mm. Beam = 450mm x 600mm. Floor height = 3.2m. Slab thickness = 150mm. Stone wall thickness = 230mm. Density of reinforced concrete: 25 kN/m3. Density of masonry: 20.0 kN/m3. Seismic Parameter: As per IS 1893-2002: Seismic Zone – III, Soil Type – Soft, Medium, Stiff, Damping = 5% (as per Table 3, para 6.4.2), Zoning factor for Zone III, Z = 0.16) Importance factor I = 1.5 (as per Essential Structure Table 6) Reaction reduction factor for special moment resisting reinforced concrete frames R = 5 (Table 7) Sa/g = Average acceleration factor (depending on natural fundamental period) Dead Load: Wall load 12.65 kN/m, Parapet wall 4.6 kN/m, Slab 3.75 kN/m2, Finishing load 1 kN/m2, Total 4.75 kN/m2, Live Load: As per IS: 875 (Part 2) 1987: Live load on standard floor = 3.0 kN/m2, Earthquake calculated temporary load = 0.75 kN/m2.) Seismic Load: All frames are analyzed for Seismic Zone III. Calculation of earthquake loads will be done as per IS:1893(2016).

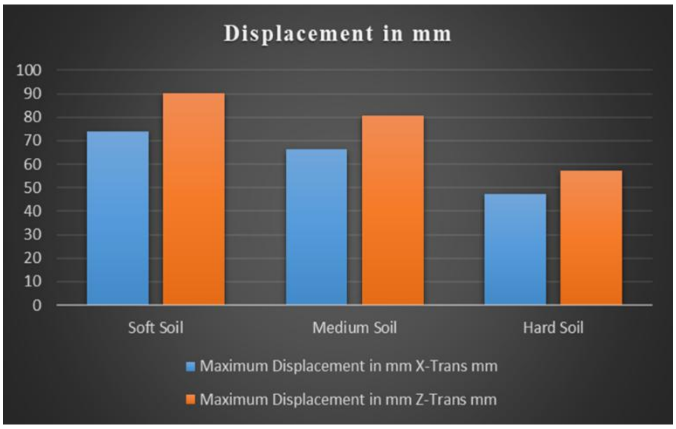
5. RESULTS AND ANALYSIS

5.1. RESULTS WITH GRAPHICAL ANALYSIS

5.1.1 Maximum Node Displacement (mm) in X and Z direction

Table 5.1.1: Displacement in X and Y direction

Soil Type	Maximum Displacement in mm	
	X-Trans mm	Z-Trans mm
Soft Soil	74.059	90.409
Medium Soil	66.242	80.661
Hard Soil	47.402	57.165



According to the analysis, the maximum displacement is 74.059 mm for soft soil and at least 47.402 mm in the soil condition of X direction X.

It can be seen that the maximum displacement of the soft soil 90.409 mm is at least 57.165 mm in the stiff ground in the Z direction Z. In percentage terms, the displacement along the X direction is 39.74% (medium) and 56.24% (soft) more compared to the hard ground. Similarly, the displacement is 41.10% (medium) and 58.15% (soft) more compared to the hard ground in the Z direction. In general, it was found that the maximum displacement in soft soil condition and the minimum displacement in stiff soil condition occur along the X and Z directions, which means that stiff soil condition is much better than soft soil condition, making soft ground suitable for high-rise structures.

5.1.2 Bending Moment (KN-m)

Table 5.1.2: Bending Moment (KN-m)

Soil Tpye	Maximum Bending Moment in KN-m	
	Moment About-Y	Moment About-Z
Soft Soil	355.063	396.852
Medium Soil	318.031	362.579
Hard Soil	229.187	285.248

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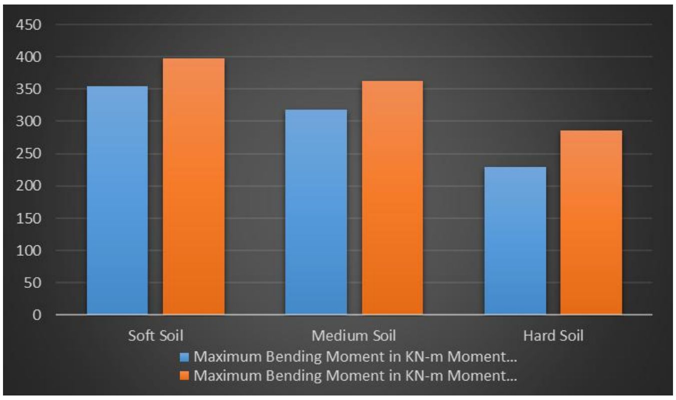

The maximum bending moment was 355.063 KN-M on the soft ground, and it was established that it was at least 229.187 kn m in narrow soil along the X direction.

On the soft ground, the maximum bending moment is 396.852 KN-M, and at least 285.248 kn m is observed in the closest state of the soil along the Z direction.

In terms of percentage, the bending moment is 38.76% (medium) and 54.92% (soft) more than the bending moment of stiff soil in X direction.

Similarly, the bending moment is 27.11% (medium) and 39.12% (soft) more than the bending moment of stiff soil along Z direction.

In general, the maximum bending moments under soft ground condition along the X and Z directions and the minimum bending moments under hard ground condition are found to be much better under hard ground condition than under soft ground condition for high-rise and multi-rise buildings and elevated structures.

6. CONCLUSIONS

6.1.1 NODE DISPLACEMENT

- As per analysis, found that the maximum displacement is 74.059 mm in soft soil and minimum 47.402 mm in hard soil condition along the X direction.

- It is seen that the maximum displacement 90.409 mm in soft soil and minimum 57.165 mm in hard soil condition along the Z direction.

- Compared to solid soils along the X X, comparing 39.74 % (environment) and 56.24 % (soft) displacement.

- Similarly, compared to solid soil along the direction of Z, 41.10 % (environment) and 58.15 % (soft) displacements are higher than in displacement.

- In general, we found that the maximum displacement under soft soil conditions and the minimum displacement under hard soil conditions occur in the X and Z directions.

- This means that hard soil conditions are much better than soft soil conditions for both high- and low-rise structures.

6.1.2 BENDING MOMENT

- It is observed that the maximum bending moment is 355.063 KN-m in soft soil and that it is minimum 229.187 KN-m in hard soil in the X direction.

- It is observed that the maximum bending moment is 396.852 KN-m in soft soil and that it is minimum 285.248 KN-m in hard soil in the Z direction.

- In terms of percentage, the bending moment is 38.76% (medium) and 54.92% (soft) higher than stiff soil along X direction.

- Similarly, the bending moment is 27.11% (medium) and 39.12% (soft) higher than stiff soil along Z direction.

- Generally, it was found that along X and Z directions, there is maximum bending moment under soft soil condition and minimum bending moment under hard soil condition, which means that hard soil condition is much better than soft soil condition for high rise and tall buildings.

- Increased bending moments can affect the structural integrity of the building, potentially leading to overloading or failure of structural members.

- This may involve strengthening existing structural members, redesigning members to better resist bending, or implementing other mitigation measures.

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