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Seismic analysis of five and eight storeys concrete and steel building frame at different zones of earthquake

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ABSTRACT

Earthquake is the major impact on everyday life. It causes huge damages to structure especially building a structure. In this circumferential, we need accuracy in the design so the assessment of the design and execution will be correct. The main focus in this paper to check the adequacy of the material used in the building and conclude that either steel and concrete which one is more suitable for two different sized frames five storeys and eight storeys frame structure. The amount of deformations in the frame has been calculated and compared with the deformations of different zones. The three different zones are taken here for the comparison in deformation (Zone III, IV, and V). Five and eight storeys framed structure were subjected to seismic analysis of different magnitude. The seismic analysis was performed in ANSYS using time acceleration histogram for different zones. It was observed that structures performed well in areas which were less prone to earthquakes. Stability of five framed structure was more than that of eight storeys framed structure.

Keywords*: Earthquake, Material, Histogram, ANSYS*

1. INTRODUCTION

Frame structures are those structure which has a combination of elements like beam, column, and slabs in proper order with adequate stability. These structures are majorly supported all kind of vertical loads or gravity loads which acts perpendicular to the horizontal face of the frame or we can say parallel to the direction of gravity. There is another type of loads which also acts as the frame but from the direction called lateral direction. Wind loads and Earthquake Loads are the two types of lateral loads. These loads are not only working axially although they work eccentrically as well so it also cased torsion in the frame of the structure. These structures are usually used to overcome the large moments developing due to the applied loading. The biggest advantage of the frame structure is that it's simple to construct. Construction of frame structure is rapid. As an architecture, a person just creates the things on paper and tell to execute that but a structural engineer has to choose the ways of execution. Frame structures have economical designs. In frames structures, span lengths are usually restricted to 40 ft when normal reinforced concrete. Otherwise spans greater than that, can cause lateral deflections.

Indians are affected by a large number of the earthquake in last two decades. In the last two decades, we saw huge damages like Bhuj (2001), Tsunami (2004), Sikkim (2011) and Nepal (2015). In fact, Statics of geography shows that 54% area of the country is a prone area which is considered as prone damaging by the earthquake. According to the report of World Bank and United Nations, they estimated that 200 million city dwellers of India will expose to earthquake and cyclone by 2050. The major reason for this high intensity and frequency of earthquake that Indian plate is driving into the Eurasian plate at the rate of 47 mm per year. The northeastern part of India is coming under the high magnitude zones because this zone's past geology is created by the plate tectonics. The five seismic zones I, II, III, IV, and V in the Indian seismic code (IS:1893-1984) correspond to areas that have potential for shaking intensity on the MMI scale of V or less, VI, VII, VIII, and IX or more, respectively. The varying geology at different locations in the country implies that the likelihood of damaging earthquakes taking place at different locations is different. Thus, a seismic zone map is required to identify these regions.

Based on the levels of intensities sustained during damaging past earthquakes, the 1970 version of the zone map subdivided India into five zones – I, II, III, IV, and V (Figure 1). The maximum Modified Mercalli (MM) intensity of seismic shaking expected in these zones was V or less, VI, VII, VIII, and IX and higher, respectively. Parts of the Himalayan boundary in the north and northeast and the Kachchh area in the west were classified as zone V.

When the ground accelerates, seismic waves generated inertia forces at its floor levels. This force is traveling through the various columns and beams to the foundation and the ground. Building component must be ductile to prevent a collapse in an earthquake.

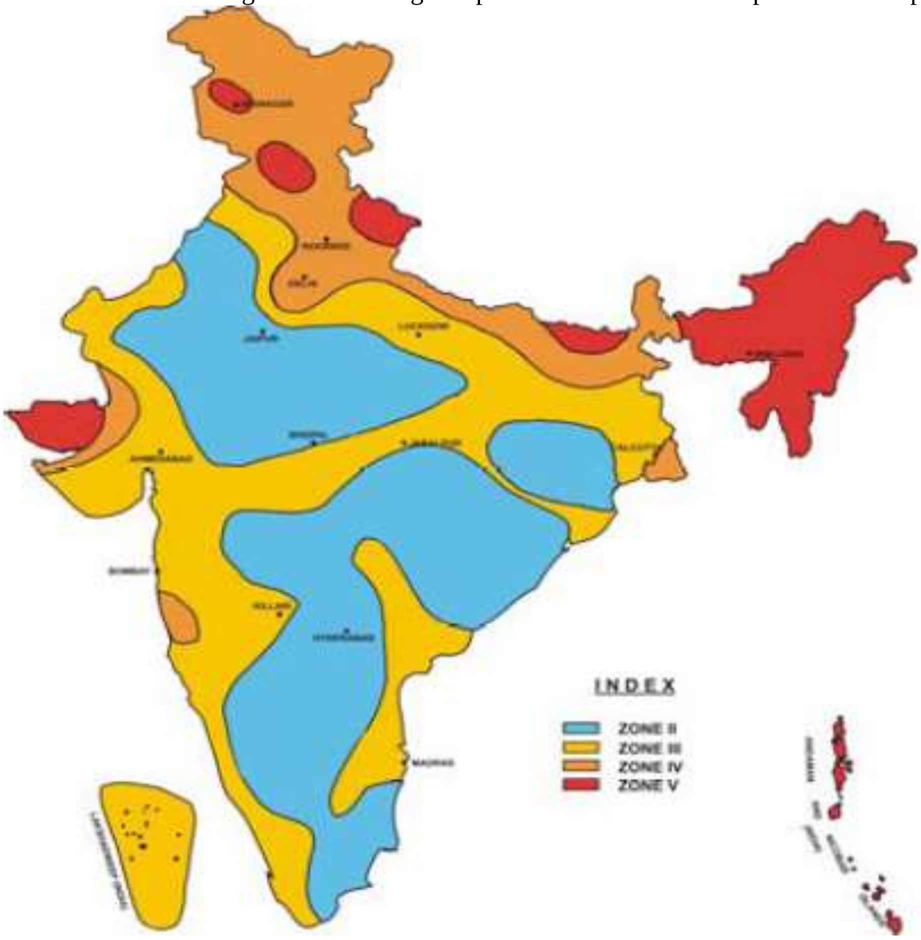

Fig. 1: Different Seismic zones of India from IS 1893-2002

The efficiency of buildings against the action of seismic loads has always been a major problem. Due to lack of interpretation and knowledge of parameters affecting the performance of building structures under seismic loading, the design of the building under earthquake is hampered. Development of a numerical model becomes very essential which can illustrate the phenomenon of earthquake properly and with less cost it makes building react approximately to same conditions it has to undergo at a practical level. Dynamic analysis although is a tedious and time taking effort but closeness to practicality becomes important for a structure to perform and evaluate it at its prime. To develop a numerical model of five and eight storey building utilizing both concrete and steel frame respectively under seismic loads.

2. METHODOLOGY

2.1 Design

In this phase, a five and eight storey building models were developed in both two dimension and three dimensions. Five storey frame and eight storey frame was developed in a commercial modeling software named SOLIDEDGE. SOLIDEDGE is a three-dimension modeling software in order to attain proper geometric dimension and structural integrity SOLIDEDGE was used for creating building frame in three dimensions. Frames were mostly composed of four columns at four corner supporting different beams in between.

Column = 150 mm * 150 mm* 3000 mm
Beam/Slab = 3000 mm* 1000 mm* 50 mm

Slab thickness = 50 mm

Height of column = 3000 mm each

Height of building = 15000 mm and 24000 mm for five storey and eight storey respectively.

The material used was structural steel with a Young modulus of elasticity as 210 GPa and Poisson's ratio as 0.3.

Concrete was also taken as material for some simulations with Poisson's ratio 0.3 and Young modulus of elasticity as 25 GPa.

Element type as 2 nodded beam elements for 2D analysis while solid (quad) element. Tetrahedron or triangular element has to be avoided in order to attain proper results.

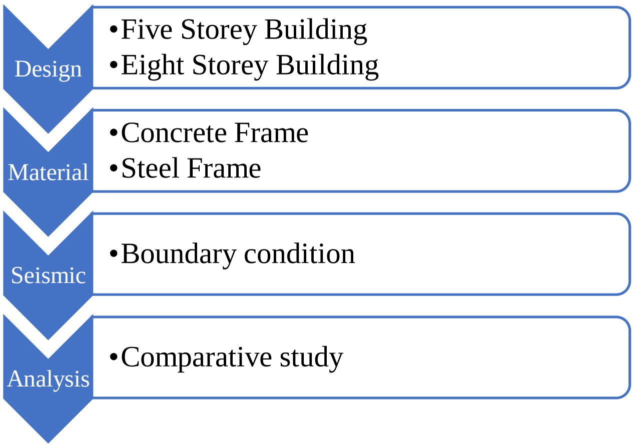

Fig. 2: Design Methodology

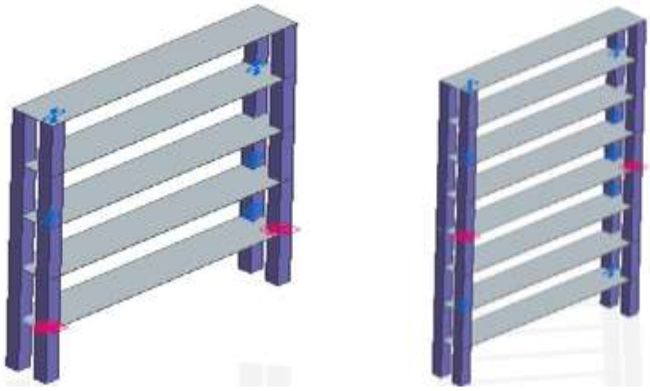

Fig. 3: Five storey and eight storey frame

2.2 Meshing

All the components were first assigned material either concrete or steel depending on the material to be provided. After assigning material components of the building frame meshed with elements. An optimum element size was obtained using convergence technique. Optimization of mesh element number is an important aspect as it prevents computational time wastage and computational cost that occurs in the process. The solid element was considered for the meshing of three dimensional solid bodies. Utter care has been taken while meshing to provide optimum and proper mesh elements.

2.3 Boundary conditions

One of the most important methods during pre-processing of a simulation work is to provide the boundary conditions. In the boundary conditions for a frame system bottom faces of the column was considered to be fixed. Bonded contacts were provided between all the faces of columns of the frame which are connected to each other. No separation was allowed between the joints of the structure o that the loads can be transferred to the whole structure perfectly. Gravity load was given to the structure to consider the effects of inertia and gravitational force of the building while seismic analysis. The seismic analysis was performed as an explicit dynamic analysis. Loads to the building frame were provided in the form of time- acceleration history plot for different earthquake zones.

2.4 Analysis

Five and eight storey building frame was subjected to seismic loads using FEM. In this analysis, different modes of deformation were analyzed using both 3D and 2D modeling techniques. 2D modeling technique was used as it provides a better view of modes with comparatively less computational time.

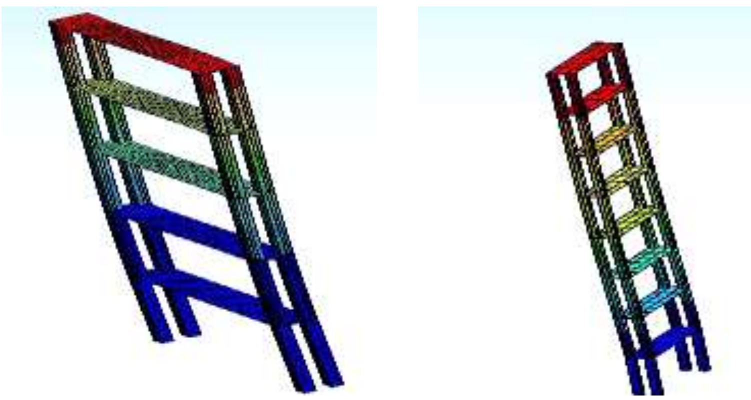

Fig. 4: Five storeys frame and eight storeys frame after analysis

3. RESULTS

The major focus in this analysis is the effect of material and calculation of stresses in the material. Structures were subjected to seismic loading with the help of time acceleration history. Here both types of frame structures were subjected to time acceleration histogram of zone III (earthquake category of India). It was clearly visible that deflection and stresses incurred in the concrete frame is much more than that of the steel frame. Even weight of the concrete frame is much more than that of a steel frame which results in an increase in inertia and finally when subjected to dynamic loads inertial effects plays a significant role.

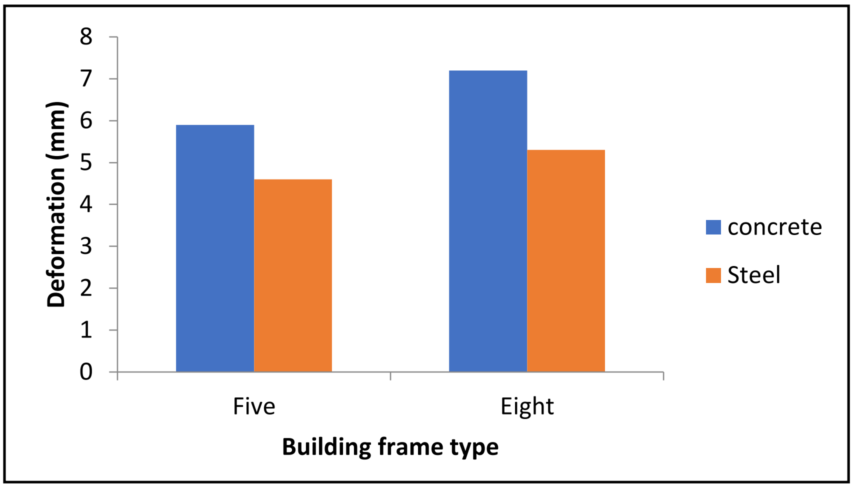

Fig. 5: Deflection of Frames subjected to Zone III

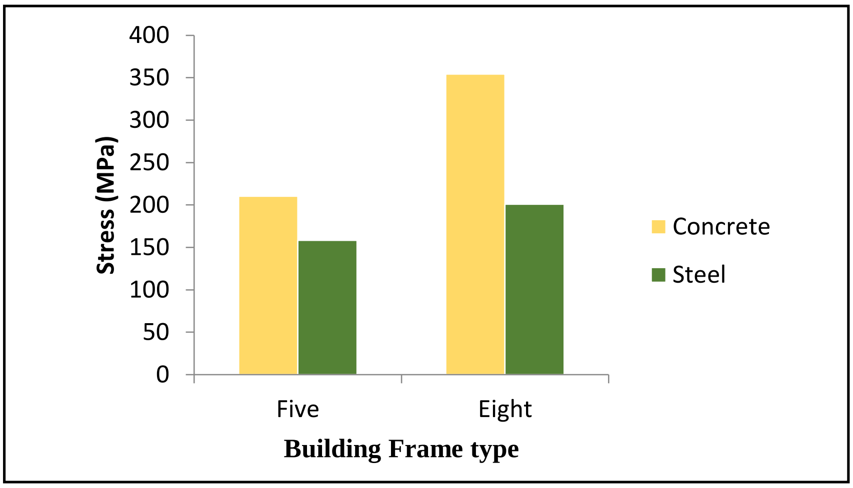

Fig. 6: Stresses of Frames subjected to Zone III

Structures were subjected to seismic loading with the help of time acceleration history. Here both types of frame structures were subjected to time acceleration histogram of zone III (earthquake category of India). It was clearly visible that deflection and stresses incurred in the concrete frame are much more than that of the steel frame. Even weight of the concrete frame is much more than that of a steel frame which results in an increase in inertia and finally when subjected to dynamic loads inertial effects plays a significant role.

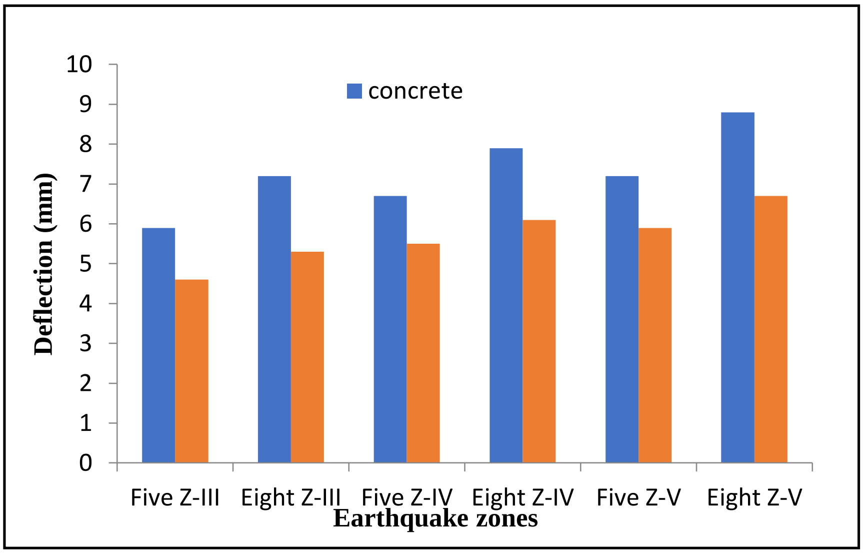

Fig. 7: Deflection of building frames in different zones

3.1 Modes of deformation

Most of the structure (framed) subjected to seismic loads acts as a structure under high vibratory loads. Thus different modes of deformation were obtained throughout the full analysis of the structure under seismic loads. Seismic loads are the very high vibratory (shock) loads appearing in a structure for a very small period of time. The seismic analysis in practical conditions is the dynamic analysis. Modes of deformation for both five and eight-storey building were found to be similar under all types of earthquake zone loading.

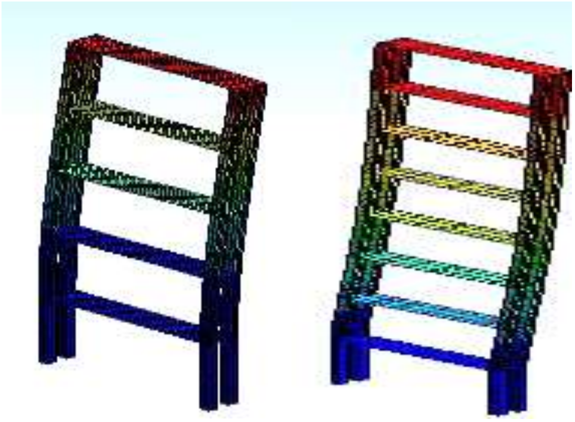

Fig. 8: Modes of deformation

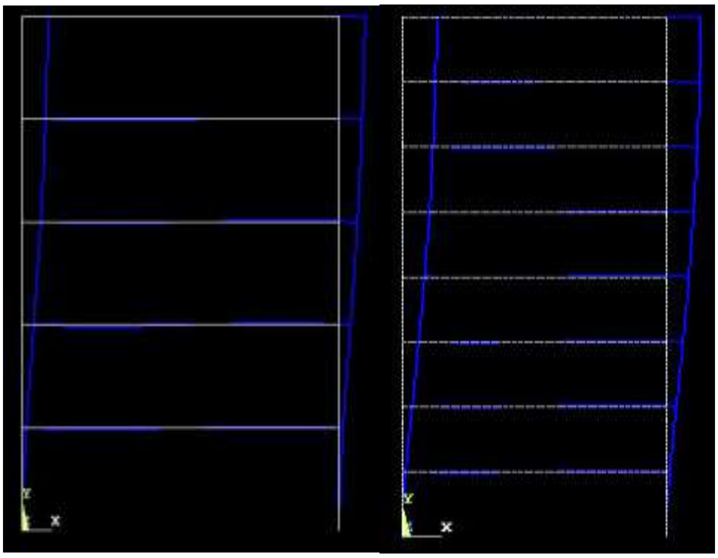

Fig. 9: Modes of deformation in 2D

4. CONCLUSIONS

- The steel framed structure was found to be performing better than a concrete framed structure for both five and eight story buildings.
- The steel frame was lighter and stronger than the concrete frame.
- Steel frame needs to be protected from fire.
- Five storey frame has lesser deflection than eight-storey building frame in all the earthquake zones
- Five storey frame has lesser stresses than eight-storey building frame in all the earthquake zones
- Five storey building frame was more stable than eight-storey building frame.

5. REFERENCES

[1] A. Kadid and A. Boumrkik, "Pushover analysis of reinforced concrete frame structures", Asian journal of civil engineering (building and housing) Vol. 9, No.1, pp. 75-83, 2008.

[2] A.Ghaffar, A.Javed, H.Rehman, K.Ahmed and M hyas, "Development of shear capacity equations for rectangular reinforced beams", Park J Eng. & appl.Sci.Vol.6, pp.

[3] ACI 318, Building Code Requirements for Reinforced Concrete, American Concrete Institute, Detroit, Michigan, 2002.

[4] Alexander Placas and Paul E. Regan and A.L.L Baker, "Shear failure of reinforced concrete beams," ACI journal, title No.68-67, pp.763-773, October 1971.

[5] Applied Technology Council (ATC-40), "Seismic evaluation and retrofit of concrete buildings", Vol.1& 2, California, 1996.

[6] ASCE-ACI Task Committee 426, "The Shear Strength of Reinforced Concrete Members," ASCE Journal of Structural Div., Vol. 99, pp. 1091-1187, June 1973.

[7] Bazant Z P and Kazemi M T, "Size effect on diagonal shear failure of beams without stirrups", ACI Structural Journal, 88(3), pp.268–276, 1991.

[8] Bazant Z P and Sun H H, "Size effect in diagonal shear failure: influence of aggregate size and stirrups", ACI Materials Journal, 84(4) pp. 259–272, 1987.