ANALYSIS OF SEISMIC DESIGN AND EARTHQUAKE RESISTANT BUILDINGS

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***Abstract*: Earthquake resistant buildings are the need of the hour because of India's extreme vulnerability to extensive seismic activities. This paper provides a survey study on the seismic design and analysis of an earthquake resistant (G+4) storey R.C. Framed structure with a stilt floor, a residential building, under various load combinations. Also, this work includes seismic load calculations following IS 1893: 2002. The supports at the base of the structure are also specified as pinned. The codes of practice for the design are also specified along with other important details. The residential buildings taken into consideration to check for all the loading and its different floor load in various sections of the plan is shown in the paper.**

***Keywords*: Earthquake resistant buildings, seismic design, residential building.**

Introduction

Structures like residential buildings are considered as critical infrastructure due to their important role in the aftereffects of any natural or man-made disaster. Seismic analysis and design of a residential building in Zone-III earthquake region consists of the planning of the residential building, to the framing of the structure, to the appropriate application of suitable loads that would be applied on the structure, to the analysis and finally completion of the design of the residential building structure and evaluation of the design consequences using STAAD PRO V8i software .

Seismic Zones In India

The country has been split into various zones demonstrating the power of damage or regularity of seismic activity events. These zoning maps show comprehensively coefficient that could be received for design of structures in various parts of the country. These drawings depend on subjective evaluations of intensity from accessible data on earthquake event, geography and tectonic plates of the country.

The zone maps are revised at regular intervals to incorporate the data accumulated over the period of time on earthquakes, the seismic-tectonics and the seismic movement in India. Seismic zone map in the protruding region has been reworked subsequently. Chennai has been brought under the zone 3. The 2002 zone map is a continuing document on seismic hazard of the country, constantly undergoing modification as more and more data becomes available.

Considering the previous earthquakes of the country, seismologists have characterized 59% of the area of India as inclined to tremors of numerous magnitudes – 11 percent in high risk zone 5, 18 percent in elevated hazard zone 4 and 30 percent moderate risk zone 3. The urban areas of capitals Guwahati and Srinagar lie in the seismic zone 5 while national capital of Delhi is located in zone 4 and the super urban communities of Mumbai, Kolkata and Chennai are located in zone 3. 38 urban communities with population of a 5,00,000 or more each and a joined population of a 10,00,000 are situated in these 3 regions.

Effect of Seismic Forces On Building

Earthquake causes arbitrary vibrations on the ground and a building erect on it wi1l undergo random motions through the base. The vibratory wave experience by the base is transferred to the roof of the building via walls, columns and the floors of these structure. The movement of the roof starts from its rest point (inertia) and hence, in the beginning, its movement is different than the movement of the base of the structure due to the earthquake. In buildings, the seismic load or energy produced at the base of the structure is dispersed throughout the structure with the aid of walls or columns.

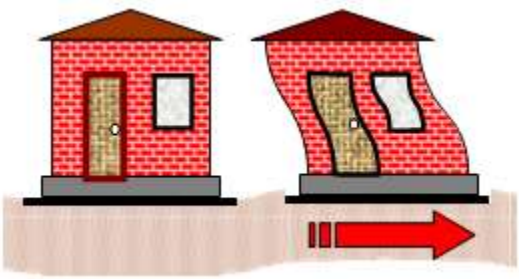

Figure : Effect of Inertia on Building

Ruminate a building with the roof held on columns. When the ground moves due to a seismic incident, the entire building is flung backwards and starts moving from the default position. The roof of the building also undergoes an equivalent sudden force due to its inertia. Consider that the roof has a mass *M* and it moves with the resulting acceleration *a*, then the inertial force on the roof be calculated by multiplying tis mass to the resulting acceleration of the movement in the direction opposite to that of the acceleration. Evidently, higher mass of the structure generates higher inertia force. Therefore, it be concluded that the lighter structures experience lower the earthquake loads.

Effect Of Deformation On Structures

These inertial forces on the roof is transferred to the base of the structure through the pillars. These forces present in the columns be further explained the following way. However, if we imagine a free boundary condition for the co1umns, they would snap back to their original vertical position and resist the deformations. However, due to the attached structure, these columns undergo bending deformation and internal forces are developed. The greater is the comparative parallel displacement of top and bottom ends of the columns, the bigger will be the resulting internal forces in columns. Stiffness present in the columns restricts the movement of the column ends which is results in higher internal forces for the columns. Thus, the larger is the size of the columns (higher stiffness), the larger will the internal force (stiffness force) experienced by the column. Therefore, the stiffness of the columns is affected by its size, length and relative movement between its ends.

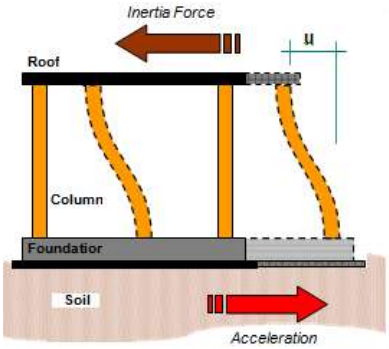

Figure: Effects of Seismic Inertial Force on the Relative Motion of the Structure

Flow of Inertial Forces to Foundation

Beneath the horizontal vibrational movement of the surface, the building experiences horizontal inertial forces (usually the seismic forces are focused at the floor altitudes). These crosswise forces are move from end to end of the structure with the help of floor slabs to the walls and the supporting columns to the nitty-gritties and then to the soil. Thus, individually of the physical components (f1oor slabs, walls, columns, and foundations) and the influences among them should be premeditated to safeguard distribution of the inertial forces in the interior the structure.

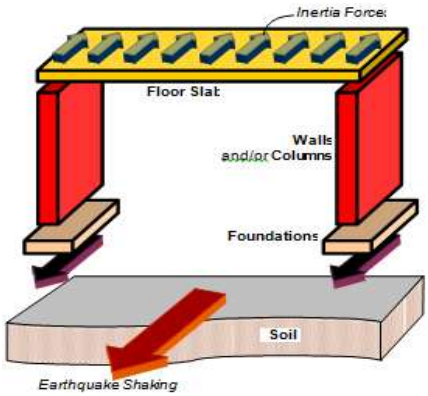

Figure: Final transfer of seismic inertial forces to the structural components

Seismic design

There are two most important factors which factors to the seismic response of the buildings: (i) Mass of the building (ii) Stiffness of the building. To reduce the effects of the seismic loading, engineers choose to design elastically deforming structures which may deform throughout the earthquake without any extreme brittle failure. However, introducing elasticity in the structure comes at the cost of reduced project economy.

HOW IS 1893: 2002 DIFFERENT FROM IS 456: 2000

IS 1893: 2000 (Part 1) pacts with calculation of seismic loads present on numerous buildings and tremor resilient strategy of structures, its rudimentary requirements apply to the structures, raised structures, engineering and heap like structures, connexions, tangible brickwork and earth blocks, etc.It contains the materials, workmanship, inspection and testing requirements of concrete as well as the general design consideration and structural design procedure of R.C. members by Limit State Method of Design.

IS 1893: 2002 prescribes the value of various factors responsible for calculation of seismic loads such as seismic weight of the structure, Zone factor, Design Base Shear, etc. as stated in the further sections of the report. The code also encompasses all the design terms related to earthquake, the assumptions made while designing an earthquake resisting structure and zone factors for various cities in India.

Methodology

The methodology adopted for the completion of the project is seven fold. The successful undertaking of these seven steps would result in the complete design and analysis of a seismically resistant structure. The steps to be undertake are:

- Selection of site and building details.
- Drawing and preparation of the residential building plans.
- Property and support conditions.
- Framing of the structure.
- Load Application
- Analysis of structure
- Design of structure

These seven steps would be further discussed in details in the following section.

Selection Of Site and Building Details

The site conditions and building details are as follows:

- Medium soil conditions.
- Water table has no effect on the foundation
- Moderate environmental conditions
- Building is in Zone III. Therefore, the Zone Factor of the building = 0.16

- Importance Factor of the building = 1.
- Reinforced concrete framed structure with brick infill panel
- Response Reduction Factor of the building is take as 5, as we are going to use a SMRF i.e. Specially Moment Resisting Frame abiding by the IS 13920.
- The residential building would consist of a G+4 storey R.C.C. framed structure, with stilt floor provided.
- The floor to floor height would be 3 m for all the floors.
- Support conditions of the structure at the base are pinned.

Drawing and Preparation Of Residential Building Plan

The size of the residential building is 320m^2. Thus for this, the building size is planned to be 16 m X 20 m. The residential building plans are:

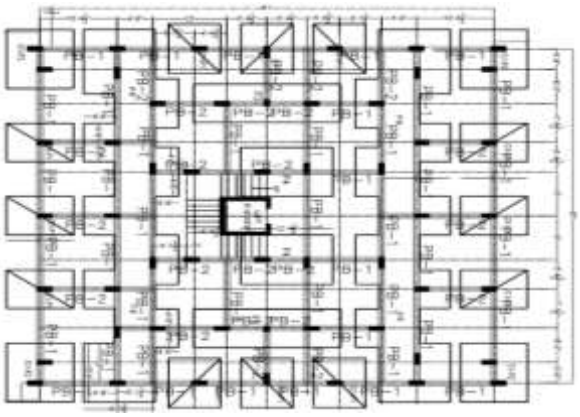

Figure Stilt Floor Plan

Framing of the structure

The residential building is framed in a 4 X 5 grid. The exterior bays of the structure are kept all in frame, whereas some of the interior bays are symmetrically chose along both X and Z direction whose beam moments are released, so as ot to transfer the beam moments to the column, thereby accommodating for the decrease in size of the columns supporting the selected beam.

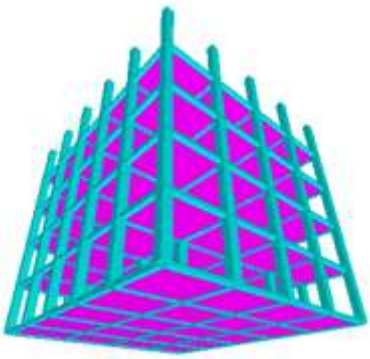

Figure View of Building: Framed 3D

Results

The results as obtained from the software STAAD PRO V8i for the required reinforcement area in beams and columns along with the appropriate member sizes are given below in the tables. IS 13920 has been followed for

the designing of beams and columns of the structure. The beam results provided at distance 0 mm from the left end, thus we would find the reinforcement at the top being higher or equal to the reinforcement at the bottom because of the increased negative moment that there is at the ends.

Beam Results:

The beam results we have inputted from STAAD PRO V8i are at a distance of 0 mm from the left end, thus we would find the reinforcement at the top being higher than or equal to the reinforcement at the bottom because of the negative moment at the ends.

Conclusions

Earthquake resistant buildings are the need of the hour because of India's extreme vulnerability to extensive seismic activities. We worked on the seismic design and analysis of an earthquake resistant (G+4) storey R.C. framed structure with a stilt floor, a residential building, under various load combinations. Seismic load calculations were done following IS 1893: 2002. The supports at the base of the structure were also specified as pinned. The codes of practice for the design were also specified along with other important details. The Residential Building was well planned (architecturally) taking into consideration all the loading a Residential Building and its different floor loads in various sections of the plan as shown in the report. In consequence, we have done the hand calculation of selected beams to verify the design obtained in STAAD Pro V8i which was the most efficient and easy procedure for analysing and designing structures. In the near future, use of mass tuned dampers and base isolation system as well as research will greatly help in the development and construction of earthquake resistant structures in India.

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