Analysis of G+6 Earthquake Resistant Building using Staad Pro

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Abstract:- Earthquakes are one of the Earth's most destructive forces — "The seismic waves throughout the ground can destroy buildings, take lives, and cost tremendous amounts of money for loss and repair."
In this paper a G+6 existing RCC framed structure has been analysed and designed using STAAD Pro V8i. The building is designed as per IS 1893(Part 1):2002 for earthquake forces in different seismic zones. The dead load & live loads are applied and the design for beams, columns, footing is obtained. The main purpose of the project is to compare and analyze the variation of maximum shear force, maximum bending moment, and maximum deflection in different seismic zones.

Keywords: *RCC framed structure, earthquake analysis, base shear, equivalent static analysis*

1. INTRODUCTION

Throughout history, we've built impressive structures and cities only for them to encounter the forces of nature. When an earthquake occurs, it sends shockwaves throughout the ground in short rapid intervals in all different directions.
While buildings are generally equipped to handle vertical forces from their weight and gravity, they cannot handle side-to-side forces emitted by quakes. This horizontal load vibrates walls, floors, columns, beams and the connectors that hold them together.
According to building codes, earthquake-resistant structures are 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 preventing collapse of the buildings for rare earthquakes while the loss functionality should be limited for more frequent ones.
The latest version of the seismic zoning map of India given in the earthquake resistant design code of India [IS 1893 (Part 1) 2002] assigns four levels of seismicity for India in terms of zone factors. In other words, the earthquake-zoning map of India divides India into 4 seismic zones (Zone 2, 3, 4 and 5) unlike its previous version, which consisted of five or six zones for the country. According to the present zoning map, Zone 5 expects the highest level of seismicity whereas Zone 2 is associated with the lowest level of seismicity.
We have designed and analyzed the example of a six storey building which is taken from the report of IIT Kanpur research paper on the topic "Design example of a six storey building" presented by Dr. H.J.Shah & Dr. Sudhir K Jain.
We have studied the seismic analysis and design of a six storey building for a commercial complex. The building is located in seismic zone III on a site with medium soil. Building is designed for seismic loads as per IS 1893 (part 1) : 2002.

A building frame consists of a number of bays and storeys. A multi-storey, multi-paneled frame is a complicated statically intermediate structure. A design of R.C building of G+6 storey frame work is taken up. The design is made using software on structural analysis design (Staad-pro). The building is subjected to both the vertical loads as well as horizontal loads. The vertical load consists of dead loads of structural components such as beams, columns, slabs etc and live loads. The horizontal load consists of the wind forces thus the building is designed for dead load, live load and wind load as per IS 875. The building is designed as a two dimensional vertical frame and analyzed for the maximum and minimum bending moments and shear forces by trial and error methods as per IS 456-2000.

2. METHODOLOGY

Earthquakes cause the ground to shake. A building resting on it experiences movement at the bottom.

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When the ground is under the influence of shaking in horizontal direction, the movements generated are horizontal inertia forces in the structure. These horizontal inertial forces are shifted by the floor slab to the walls or columns, to the footing, and at length to the soil system below the building. So, each of these architectural elements (floor slabs, walls, columns, and foundations) and the relations connecting them must be plotted to safely transfer these forces through them.
Hence in order to avoid all destruction due to calamities we have come to a conclusion of earthquake resistant building. The engineers do not try to make earthquake proof buildings that will not collapse even during the infrequent earthquake of strong magnitude. These buildings will be very strong and high priced as well. As an alternative, the engineering purpose is to make buildings earthquake resistant. These structures hold out against the effects of earth shaking, although they may get damaged severely but they won't collapse during the earthquake of high magnitude. In that way, safety of people and contents are made in earthquake-resistant buildings, and thereby calamities are avoided. This is a major objective of codes in seismic design.
This method has been widely used throughout the world for years. In our project we have tried to come to a solution of earthquake resistant buildings. The building frame represented in the project consists of a number of bays and storeys. The design of RC building of six storey for a commercial complex has been taken up from IITK-GSDMA Project on Building codes. It is based on earthquake building. Total floors are G.F. + 5 upper floors. The building is designed as a two dimensional vertical frame and analyzed for maximum and minimum bending moments and shear forces. The help is taken from the numerical, earthquake tips and the software that has computations of loads, moments and shear forces obtained from the software.

2.1 METHODS OF FINDING THE EARTHQUAKE FORCES

1. Equivalent Lateral Force (Static Force) Procedure
2. Dynamic Analysis (considers of 2 methods)
   - Response Spectrum Method
   - Time History Analysis

We have used an equivalent static method. It is a simplification method to design earthquake loads that must be calculated in the structural design. The static method is applied for regular structures under 73 m in height or irregular structures at least 20 m in height. This method is practical and easy to apply, but only appropriate for low structures with high rigidity. We have referred to Is Codes to design the building.
The design is made using software on structural analysis design (Staad pro) and the building is subjected to both vertical and horizontal loads.

2.2 PROBLEM STATEMENT

An example of seismic analysis and design of a six-storey building is considered ,given from IIT Kanpur. In which a detailed numerical on earthquake (seismic analysis) resistance of G+6 building is given. The problem statement of the numerical is "A six storey building for a commercial complex has plan dimensions as shown in Figure 1. The building is located in seismic zone III on a site with medium soil. Design the building for seismic loads as per IS 1893 (Part 1): 2002." The designing and modeling of this numerical is done by us on Staad pro.
Staad pro. V8i SS6 & connect edition of Bentley is used. The design data shall be as follows:

- Live load : 4.0 KN/m2 at typical floor : 1.5 KN/m2 on terrace
- Floor finish : 1.0 KN/m2
- Water proofing : 2.0 KN/m2
- Terrace finish : 1.0 KN/m2
- Location : Vadodara city
- Wind load: As per IS: 875-Not designed for wind load, since earthquake loads exceed the wind loads.
- Earthquake load : As per IS-1893 (Part 1) - 2002 Depth of foundation below ground : 2.5 m
- Type of soil : Type II, Medium as per IS:1893
- Allowable bearing pressure : 200 kN/m2
- Average thickness of footing : 0.9 m, assume isolated footings
- Storey height : Typical floor: 5 m, GF: 3.4 m
- Floors: G.F. + 5 upper floors.
- Ground beams: To be provided at 100 mm below G.L.
- Plinth level: 0.6 m
- Walls : 230 mm thick brick masonry walls only at periphery.

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2.2.1 Material Properties

- **Concrete**: All components unless specified in design: M25 grade all
- EC= 5 000 ck f N/mm2 = 5 000 ck f MN/m2 = 25 000 N/mm2 = 25 000 MN/m2.
- For central columns up to plinth, ground floor and first floor: M30 grade
- EC = 5 000 ck f N/mm2 = 5 000 ck f MN/m2 = 27 386 N/mm2 = 27 386 MN/m2 .
- **Steel:** HYSD reinforcement of grade Fe 415 confirming to IS: 1786 is used throughout

Step 1: Creating structure of G+6 building on staad pro.

The plan shows the details of dimensions of each and every floor, its height. Every floor has a height of 5m and ground floor has a height of 4m neglecting the height of the beam which is 0.6m the height of ground floor is 3.4m. The height of the terrace and plinth makes the total height of the building 31.5m.

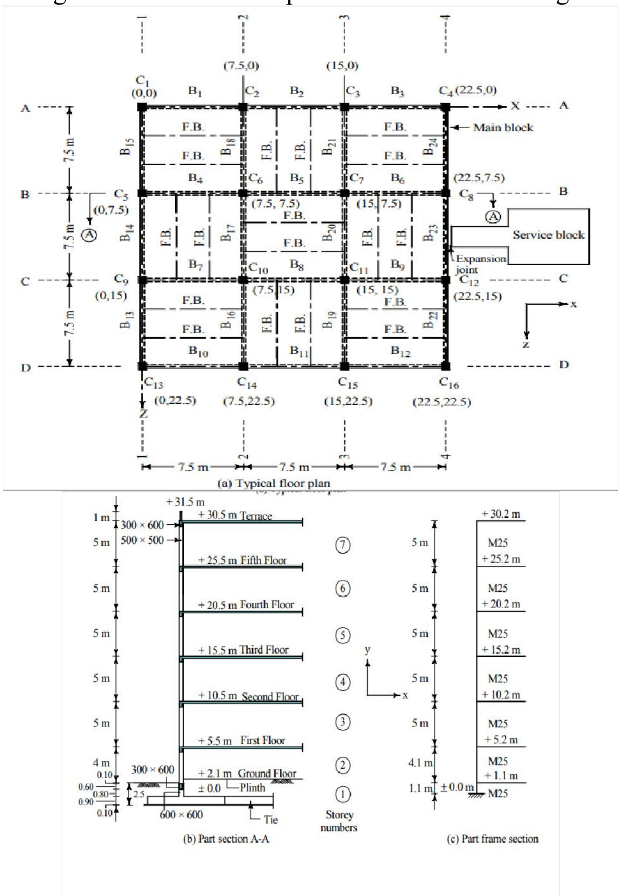

Figure 1 General lay-out of the Building.

In staad we use structural wizard and translation and repeat to create the structure. Then went to specification, created a new support, clicked on fixed support and then added, use cursor to assign option to assign the fixed supports by selecting the nodes of plinth and assigning the fixed supports to them.

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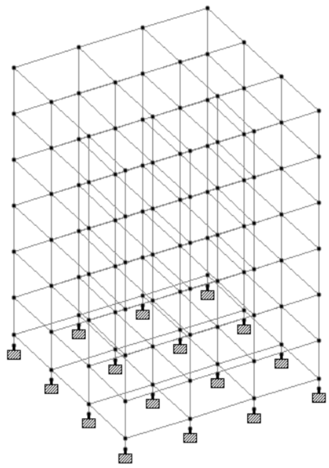
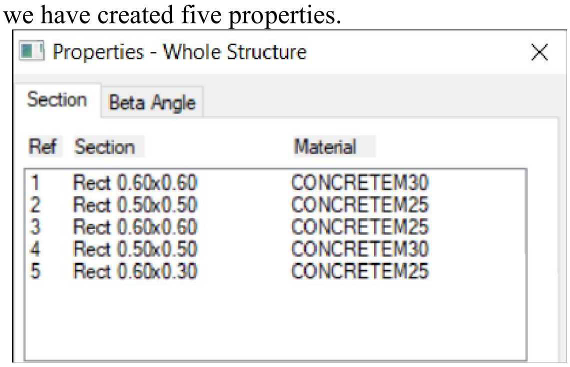


Step 2: Specifications – Properties

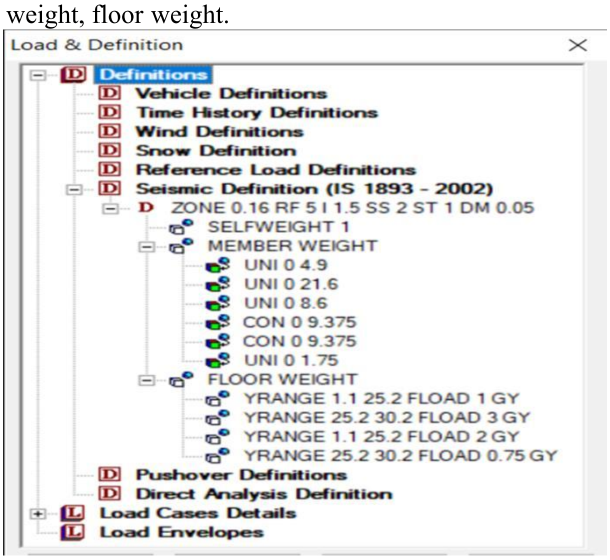
In this we have to assign the properties of beam and column sections. In specification a dialog box of properties is open in which we can create and assign the properties of beam and column sections. Firstly we need to define the properties then select the rectangle; material and enter the value YD and ZD then add and close. In this way we have created five properties.



After creating we need to assign the properties to the beam and columns of respective sections.

Step 3: Load cases

After specification of properties we add loading to the structure. Firstly we will define the load in definition i.e., Seismic definition (IS 1893- 2002) in that zone 0.16 RF 5 1.5 SS 2ST 1 DM 0.05 in it there is self-weight 1, member weight, floor weight.

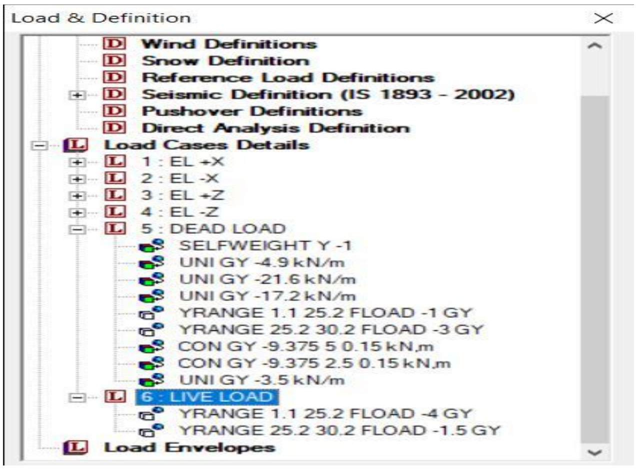


Next is Load cases details, in it there are 6 cases:

- EL + X

- EL - X
- EL + Z
- EL – Z
- Dead Load
- Live Load

Furthermore bifurcations are there in dead load and live load as shown in below



After creating and adding the load cases and definition we need to assign it to the structure respectively.

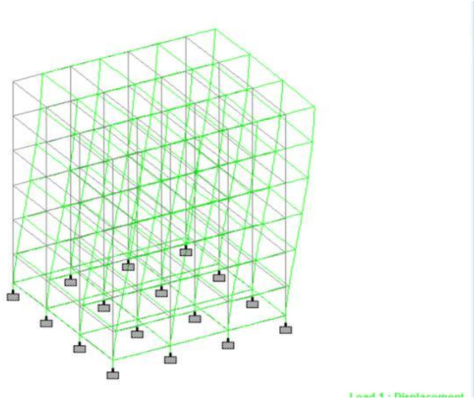
Step 4: Analysis and Design

Firstly we need to add concrete design and then select our Indian IS code IS456. Secondly in the analysis and design part there is a dialog box of analysis in which we need to define commands; perform analysis; add and close. Then we run the analysis and go for post processing mode.

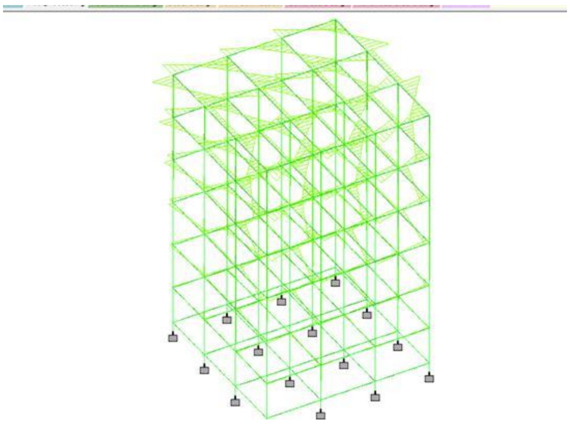
Step 5: Result and Analysis

In result part we can see the displacement, bending moment along y axis and z axis, shear force along y axis, reaction force, axial force, torsion about the building all this results of the building are shown in below:

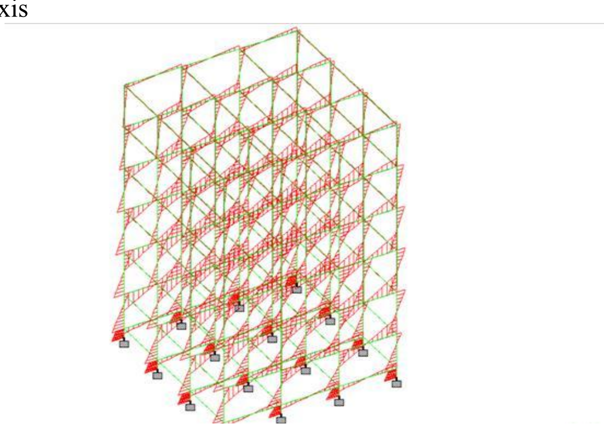
- Displacement



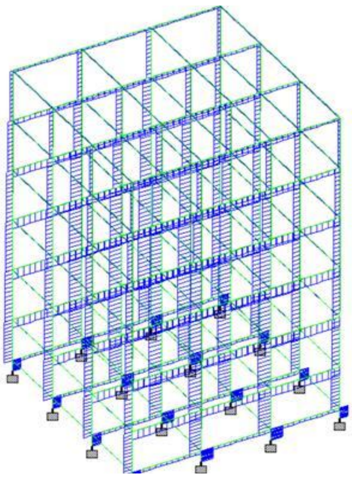
- Bending moment along Y axis



Bending moment along z axis



- Shear Force Y



3. RESULT AND ANALYSIS

The Staad analysis and design is performed for G+6 building. In order to carry out the design, parameters must be stated with geometry, properties etc. The results shown in Staad are loading, deflection, axial forces along different directions, bending movements, beam stress along each beam and column and layouts.

Time period for X 1893 Loading= 0.96620 sec which is equivalent to the data provided in earthquake numerical from IIT Kanpur.

Sa/g as per IS 1893= 1.408

Load Factor = 1

VB as per IS 1893 = 0.0338 X 31685.59 = 1070.40 KN

Seismic weight = 31685.59

Total volume of concrete used in building = 122.7 cubic meter

Total weight of steel in building = 242974 Newton

4. CONCLUSION

From the study of earthquake resistant building, the model of G+6 storeyed building is developed in Staad and analysis and design is carried out for earthquake loading. The design of a six storey building which was done manually from the IITK report gives much accurate and perfect results when it is designed on STAAD PRO V8i. The % variation in results of BM, SF, deflection and base shear is very less and the software can be widely used for performing analysis and design of multi storeyed building with good accuracy.

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