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Design of Earthquake Resistance on Residential Building by using STAADPRO

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Abstract: *In India, multi-storied buildings are usually constructed due to high cost and scarcity of land. In order to utilize maximum land area, builders and architects generally propose asymmetrical plan configurations. These asymmetrical plan buildings, which are constructed in seismic prone areas, are likely to be damaged during earthquake. Earthquake is a natural phenomenon which can generate the most destructive forces on structures. Buildings should be made safe for lives by proper design and detailing of structural members in order to have a ductile form of failure. The concept of earthquake resistant design is that the building should be designed to resist the forces, which arises due to Design Basis Earthquake, with only minor damages and the forces, which arises due to Maximum Considered Earthquake, with some accepted structural damages but no collapse. This project report comprises of seismic analysis and design of an eight-storied R.C. building with asymmetrical plan. The building is modelled as a 3D space frame with six degrees of freedom at each node using the software STAAD PRO V8I v 14.2.4. Building is analyzed using Response Spectrum method. The Response Spectra as per IS 1893 (Part 1): 2002 for rocky or hard soil is used.*

Keywords: Earthquake

I. INTRODUCTION

Earthquake is known to be one of the most destructive phenomenon experienced on earth. It is caused due to a sudden release of energy in the earth's crust which results in seismic waves. When the seismic waves reach the foundation level of the structure, it experiences horizontal and vertical motion at ground surface level. Due to this, earthquake is responsiblefor the damage to various man-made structures like buildings, bridges, roads, dams, etc. it also causes landslides, liquefaction, slope-instability and overall loss of life and property. The complete protection against earthquakes of all sizes is not economically
feasible for structures. The seismic design should be such that it prevents loss of life and minimize the damage to the property.

The concept of earthquake resistant design is that the building should be designed to resist the forces which arises due to Design Basis Earthquake, with only minor damages and the forces, which arises due to Maximum Considered Earthquake with some accepted structural damages but no collapse. The design philosophy was established considering the following aspects:

The structure should withstand the moderate earthquakes, which may be expected to occur during the service life of structure with damage within acceptable limits. Such earthquakes are characterized as Design Basis Earthquakes (DBE).

The structure should not collapse when subjected to severe ground motion that could possibly occur at the site. Such earthquake is characterized as Maximum Considered Earthquakes (MCE).

II. OBJECTIVE OF WORK

This project report comprises of seismic analysis and design of a five storied R.C. building with asymmetrical plan. The building is modelled as a 3D space frame with six degrees of freedom at each node using the software STAAD PRO V8i. Building is analyzed using Response Spectrum method. The Response Spectra as per IS 1893 (Part 1): 2002 for rocky or hard soil is used. Adequate modes of vibrations of the building to contribute more than 90% mass are considered for the analysis. Analysis is performed for various load cases and combinations and the worst case is considered for the design of beams and columns. Reinforced concrete design is carried out as Per IS 456: 2000 and ductile detailing is done as per IS 13920: 1993. Various static checks are applied on the results. Finally the designobtained from the software is compared by manual design of typical ground story beams and columns. We are doing seismic Ares's zone 4 in India.

III. METHODOLOGY

3.1 Graphical Environment

The manual contains a detailed description of the GUI of STAAD Pro. The topics covered include mode generation, structural analysis and design, result verification and report generation.

3.2 Technical Reference

This manually deals with the theory behind engg calculations made by STAAD engine. It also includes an explanation of commands available is a STAAD command file. Construction of the building is done in at least two steps. Which are following:

- Sub Structure
- Super Structure.

A. Sub Structure

Foundation is a part of the sub structure. Sub structure is constructed according to soil quality at that site. If soil have good bearing capacity than we use shallow foundation in construction. And if the bearing capacity of the soil is not good or suitable than we use deep foundation at that site. Sub structure is a load bearing structure and it is designed for load bearing.

i. Foundation

foundation is the element of any structure which connects it to the ground, and transfers loads from the structure to the ground. Foundations are generally considered either shallow or deep. The low artificially built part of a structure which transmits the load of the structure to the ground is called foundation. Foundation is a load bearing structure which bears all loads coming on the building or any structure. Foundation is generally of two types:

1. Shallow Foundation.
2. Deep Foundation.

B. Super Structure

Super-structure is a part of structure that is above plinth level (P.L). Generally, columns and walls are constructed in super structure. Following are the important parts of super-structure.

1. Floor
2. Roof
3. Lintel
4. Parapet
5. Sun Shade
6. Doors & Windows

3.3 Floor

Floor is that part of a building on which furniture, household, Residential, industrial or another type of items are stored. Floor is used for walking around .Floor separates the different levels of a building. Building is also named with reference to floor. Like Ground floor, first floor, or a floor that is below ground level like basement floor.

3.4 Roof

Roof is made to cover room from upper face. Different types of roofs are used in building depending on the location and weather. Sloping roofs are generally considered better in mountain areas. While, in plan areas flat roofs are preferred.

3.5 Lintel

Lintel is constructed above doors, windows etc. to support load of wall on openings. Lintel beam is generally made as reinforced cement concrete member. While, in residential houses sometime lintel is made by using concrete and bricks. Breadth of lintel is generally equals to the breadth of wall. In case of metric unit, it is normally equals to 10cm, 15cm, 20cm etc. While, in case of FPS system it is consider as 6",9", 12" etc. Thickness of lintel should not be less than 10cm (4.5") and maximum thickness of lintel should not be more than its breadth.

3.6 Sun Shade

Sun shade is a slab that is cast on the top of doors and windows. Sun shade protects doors and windows from sun and rain. Sun shade is cast monolithically with the lintel.

3.7 Doors and Windows

A door is a moving structure used to block off, and allow access to, an entrance to or within an enclosed space, such as a building or vehicle. Doors normally consist of a panel that swings on hinges on the edge, but there are also doors that slide or spin inside of a space. A window is an opening in a wall, door, roof or vehicle that allows the passage of light and, if not closed or sealed, air and sound.

3.8 Beams

A beam is a structural element that is capable of withstanding load primarily by resisting bending. The bending force induced into the material of the beam as a result of the external loads, own weight, span and external reactions to these loads is called a bending moment. Beams are traditionally descriptions of a building or civil engineering structural elements, but smaller structures such as a truck or automobile frames, machine frames, and other mechanical or structural systems contain beam structures that are designed and analyzed similarly.

A. Types of Beams

- **Simply supported:** a beam supported on the ends which are free to rotate and have no moment resistance.
- **Fixed:** a beam supported on both ends and restrained from rotation.
- **Over hanging:** a simple beam extending beyond its support on one end.
- **Continuous:** a beam extending over more than two supports.
- **Cantilever:** a projecting beam fixed only at one end.
- **Trussed:** a beam strengthened by adding a cable or rod to form a truss

B. Analysis of Beam

Structural beams are an integral part of most structural projects. They are used for floors, columns, structural frames, and pretty much any part of a structure that needs added strength and stability to resist failure. Beams can be made of concrete, steel, wood, or other materials depending on the project. To assure that the beams meet the specifics needed to resist failure, a structural analysis of the beam is completed. The structural analysis of a beam examines what stresses occur in a beam when it is exposed to loading. In a real case these load effects can come from environmental effects such as snow, wind, and earthquakes, as well as the structures self-weight and stresses induced from its use. There are three types of stress resultants that can occur in a beam; axial forces, shear forces, and bending moments which can occur on the internal of the beam or the external at the supports. It is very important to understand how all these forces effect the beam so analysis must be completed and a shear and bending moment diagram can be drawn for that beam.

This article will describe how to calculation these three stress forces and draw the shear and bending moment diagram for a beam from these forces.

- Stress Forces
- Axial or Normal
- Shear
- Moment

Types of Reaction Supports

- Fixed
- Pinned
- Roller
- Hinge

Loading Cases

- Point load
- Moment point load
- Uniformly distributed load
- Linearly varying distributed load

3.9 Column

A column or pillar in architecture and structural engineering is a structural element that transmits, through compression, the weight of the structure above to other structural elements below. In other words, a column is a compression member. The term column applies especially to a large round support (the *shaft* of the column) with a capital and a *base* or pedestal which is made of stone, or appearing to be so. A small wooden or metal support is typically called a post, and supports with a rectangular or other non-round section are usually called piers. For the purpose of wind or earthquake engineering, columns may be designed to resist lateral forces. Other compression members are often termed "columns" because of the similar stress conditions. Columns are frequently used to support beams or arches on which the upper parts of walls or ceilings rest. In architecture, "column" refers to such a structural element that also has certain proportional and decorative features. A column might also be a decorative element not needed for structural purposes; many columns are "engaged", that is to say form part of a wall.

IV. EXPERIMENTAL ARRANGEMENT

This project is mostly based on software and it is essential to know the details about these Software's. List of software's used

1. Staad pro (v8i)
2. Staad foundations (v8i)
3. Auto cad

V. STAAD

1. Staad is powerful design software licensed by Bentley .Staad stands for structural analysis and design
2. Any object which is stable under a given loading can be considered as structure. So first find the outline of the structure, whereas analysis is the estimation of what are the type of loads that acts on the beam and calculation of shear force and bending moment comes under analysis stage.
3. Design phase is designing the type of materials and its dimensions to resist the load. This we do after the analysis.
4. To calculate s.f.d and b.m.d of a complex loading beam it takes about an hour. So when it comes into the building with several members it will take a week. Staad pro is a very powerful tool which does this job in just

an hour's staad is a best alternative for high rise buildings. Now a days most of the high rise buildings are designed by staad which makes

5. a compulsion for a civil engineer to know about this software.
6. These software can be used to carry rcc, steel, bridge, truss etc. according to various country codes.

5.1 Alternatives for STAAD

Struts, robot, sap, adds pro which gives details very clearly regarding reinforcement and manual calculations. But these software's are restricted to some designs only whereas staad can deal with several types of structure.

5.2 STAAD Editor

Staad has very great advantage to other software's i.e., staad editor. Staad editor is the programming. For the structure we created and loads we taken all details are presented in programming formation staad editor. This program can be used to analyze another structuresalso by just making some modifications, but this require some programming skills. So load cases

created for a structure can be used for another structure using staad editor.

5.3 Limitations of Staad pro:

1. Huge output data
2. Even analysis of a small beam creates large output.
3. Unable to show plinth beams.

5.4 Staad Foundation

Staad foundation is a powerful tool used to calculate different types of foundations. It is also licensed by Bentley software's. All Bentley software's cost about 10 lakhs and so all engineers can't use it due to heavy cost. Analysis and design carried in Staad and post processing in staad gives the load at various supports. These supports are to be imported into these software to calculate the footing details i.e., regarding the geometry and reinforcement details

VI. CONCLUSION

The earthquake resistant RESIDENTIAL building in India is the topic of our project. We took this topic for our project because earthquake destroy the buildings, money as well as life too. The main motive is to design the earthquake resistant building to save the peoples life as well as wealth. As we know the last earthquake took in Nepal, by which several lives was harm and lots of money destroyed. We designed the earthquake RESIDENTIAL building so the people can feel safe and the money saves as well.Our building is safe and will not harm if the earthquake take place. We used many techniques by fighting with earthquake waves.

VII. FUTURE SCOPE

The Provisions and the building codes and consensus standards based on its recommendations are technical documents used primarily by the professionals who design and construct buildings and other structures. Understanding the basis for the seismic regulations in the nation's codes and standards is nevertheless important to others outside the technical community including elected officials, decision-makers in the insurance and financial communities, and individual building or business owners and other concerned citizens. This document is intended to provide these interested individuals with a readily understandable explanation of the intent and requirements of seismic design in general and the Provisions in particular. We wishes to express its deepest gratitude for the significant efforts of the over 200 volunteer experts. Americans unfortunate enough to experience the earthquakes that will inevitably occur in the future will owe much, perhaps even their lives, to the contributions and dedication of these individuals. Without the expertise and efforts of these men and women, this document and all it represents with respect to earthquake risk mitigation would not have been possible. As we know the seismic area is large enough that is why it effects will be large. Only the earthquake safety will save the lives from seismin waves. The scope of seismic design buildings will be increased.

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VIII. SUMMARY

In the present project report seismic analysis and design of a five-storied asymmetrical Plan building has been done. The building is modelled as a 3D frame using STAAD PRO V8I.The building is analyzed by Response Spectrum method. The following conclusions have been drawn from the seismic analysis and design of the building

- The fundamental time period of the building, as per IS 1893 (Part 1): 2002, is 0.25sec in longitudinal direction and 0.334 sec in transverse direction.
- The modal mass participation percentage are 0.63% and .006465% along X and Y directions of the building, respectively. This is because of low torsional rigidity of the building.
- Maximum modal mass participation is in mode no.10 is 91% in the longitudinal direction and 90% in transverse direction.
- From the manual design of a typical beam and column, it has been found that the required flexure and shear reinforcement as obtained from STAAD PRO V8I is in reasonable agreement with manual calculations
- Special confining reinforcement in potential plastic hinge zone has to be provided because STAAD PRO V8I does not provide any such special confining reinforcement.
- In a typical beam, shear force obtained from applied loads is 271.46kN for member ID-533.
- Out of the different load combinations the governing load cases consist of different combinations with earthquake load
- The period of vibration as calculated from the empirical formula of IS: 1893(Part1)-2002 comes out to be 0.25 sec in the longitudinal direction and 0.334 sec in the transverse direction. The period of the structure as obtained from the software is 0.6099 sec and 0.60991sec in longitudinal and transverse directions, respectively. So correction for base shear (ṼB/VB) is considered for the capping on time period prescribed by IS: 1893 -2002.
- ṼB/VB)X Direction 0.7523 sec is applied and in Y direction 0.7116sec base shear correction are applied

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