SEISMIC VULNERABILITY AND STRUCTURAL DESIGN OPTIMIZATION OF MULTI-STOREY BUILDINGS USING STAAD

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Abstract :

Multi storey building is defined as a building with more than one floor in the building. Multi-storey buildings seek to maximize the floor area of the building but not the area of the land and save money. Conventional methods deal with lot of complications and edacious calculations when analysing multi-storey building frames. Such analysis is a time consuming activity. Substitute frame methodology of analysis may prove useful in rough and fast analysis rather than bidding process. Designers have so far used this technique in vertical loading conditions. The given plan which is represented as the office use can be expanded with the minimal facilities. The bending moments in general may cause buildings to fail, the latter refers to shear forces exerted on building members. Remembering these failures, we developed beams, columns, footings under the consideration of maximum loads on members. To simplify the calculation time is saved by using substitute frame method to reduce complexity of loads calculation. It is important in urban regions in particular, we know that R.C structural system is most prevalent nowadays in the urban areas having multi-bay and multi-storeys, which makes its significance in the urban areas more than ever. A building frame comprises of number of bays and storey. A frame with many storeys and many panels is a complex statically intermediate frame. A G+15 storey frame work of R.C building is assumed. The plan (30m 20m) building includes columns constructed monolithically in a network form. The design is prepared by the use of a software on structural analysis design (staad-pro). The construction was exposed to the vertical forces as well as to the horizontal forces. Vertical load is made up of dead load of structural elements like beams, columns, slabs etc and live loads. Horizontal load is made up of the wind forces thereby constructing is made according to IS 875 dead load, live load, and wind load and seismic loads. The structure is the design used in the form of a vertical frame which is two-dimensional and trial and error analysis of the overall building according to the IS 456- 2000 to determine the maximum and the minimum bending moments and the shear forces of the building. The assistance is borrowed by the software in the institute and the calculations of loads, moments and shear force and through this software.

1. INTRODUCTION

It is not only important during a designing of a building which resist earthquake to resist the force acting on it but it is also to be ductile enough to transfer this force and dissipate this energy. And this capability is founded on the fineness of the structure in case it is finely detailed, it has a higher possibility of escaping earthquakes. Certain measures may be applied during a seismic resistant building in order to make the structure safe during a seismic event. The horizontal force on the slabs and the floor could be transferred to the vertical parts of the building including beams and walls by the floors and roof acting as a diaphragm.the transfer of forces to the bottom of the building or the foundation is one of the benefits of shear wall. The functions of the braced frames are nearly similar to those of shear wall which is to transfer the lateral loads to the building foundation. The building could have moment resisting frames which would absorb the energy contained within the earthquake waves, the columns and beams may be ductile to allow the energy to dissipate through the ductility of the steel that is contained between the columns and beams. As the solution to dissipate this energy lies in the movement and deformation of the structure, such movement will result in some damage unless regulated in such a way. Devices can be exploited to tame this deformation such devices resemble shock absorbers in a car, which controls and maintains the shaking of the building within a decent range.

Earthquake-proof design is the Design of buildings in a manner that the damage would not occur during the strong but infrequent earthquake. The engineers are not trying to produce earthquake proof buildings, which are not going to be destroyed even during the occasional but strong earthquake. These buildings will be overstrong and expensive as well. The goal of the design earthquake resistant is to ensure that structures will act as elastic and survive in the event of major earthquakes that may hit the structure during the duration of the structure. The structural members should be ductile so as to absorb and release energy through post-elastic deformation to prevent collapse in a major earthquake.

Many researchers have been conducted on this topic and still, it is continuing because more we try to learn more we can minimize the damages and save the lives. According to studies that have been made on the seismology about 90% earthquake happens due to tectonics. If we come to civil engineering an engineer's job is to provide maximum safety in the structures designed and maintain the economy. Prior to the analysis and design of any structure, necessary information regarding supporting soil has to be collected by means of geotechnical investigation. A geotechnical site investigation is a process of collecting information and evaluating the conditions of the site for the purpose of designing and constructing the foundation for a structure. Structural engineers are facing the challenges of striving for most efficient and economical design with accuracy in solution while ensuring that the final design of a building and the building must be serviceable for its intended function over its design lifetime. Now a day's various software packages are available in the market for analyzing and designing practically all types of structures viz. RISA, STAADPRO, ETABS, STRUDL, MIDAS, SAP and RAM, etc.

The latest version of the seismic zoning map of India given in the earthquake resistant design code of India [IS 1893 (Part1) 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.

Zone 5 covers the areas with the highest risks zone that suffers earthquakes of intensity MSK IX or greater. The IS code assigns zone factor of 0.36 for Zone 5. Structural designers use this factor for earthquake resistant design of structures in Zone 5. The zone factor of 0.36 is indicative of effective (zero periods) level earthquake in this zone. It is referred to as the Very High Damage Risk Zone. The region of Kashmir, the western and central Himalayas, North and Middle Bihar, the North-East Indian region and the Rann of Kutch fall in this zone.

Zone 4 is called the High Damage Risk Zone and covers areas liable to MSK VIII. The IS code assigns zone factor of 0.24 for Zone 4. The Indo-Gangetic basin and the capital ofthe country (Delhi), Jammu and Kashmir fall in Zone 4. In Maharashtra, the Patan area (Koyananager) is also in zone no 4. In Bihar, the northern part of the state like-Raksaul, near the border of India and Nepal, is also in zone no 4.

Zone 3, the Andaman and Nicobar Islands, parts of Kashmir, Western Himalayas fall under this zone. This zone is classified as Moderate Damage Risk Zone, which is liable to MSK VII. The IS code assigns zone factor of 0.16 for Zone 3.

Zone 2 is liable to MSK VI or less and is classified as the Low Damage Risk Zone. The IS code assigns zone factor of (maximum horizontal acceleration that can be experienced by a structure in this zone is 10% of gravitational acceleration) for Zone 2.

Importance of the Study: The importance of this study is to control and reduce the potential damage that the earthquake may cause, although it is hard and uneconomical to design a building for all types of earthquake forces, therefore, this paper tends to find a solution which is safe and economic to stand against maximum considered earthquake in the area. Building failures are frequently due to shortage or lack of suitable local materials. For example, when the design required a certain amount of steel and its reduced to lower the overall cost its critical for the safety condition of the buildings. In seismic resistant building its important that the building joints are strong enough because the earthquake produces tensile and torsional forces on structural elements so a strong joint throughout the building is required to resist the shear loading that acts on the building during an earthquake.

During normal conditions the building elements only have vertical loads acting on the building but during an earthquake besides the vertical loads lateral forces act on the building elements as well, thus leading to high amounts of stress on the buildings joints. So the importance of this study is to show how to make a building that is properly grounded and how well the building is connected to the foundation. Another important point is that the building should not be built on loose soil because this causes more unimportant stress on the building during earthquakes.

Objectives

To perform analysis and design of a building without any kind of failure as much as possible.

• To make a building that is easy to maintain after a seismic activity and survive with the least amount of damage.

• To get a better understanding of the basic principles of a seismic resistant building and prepare seismic resistant building by staadpro software program for a better analysis.

• To get a better understanding of the design from its columns, beams, slabs and seismic joints.

To make a building that is safe and has a better chance of being safe during a seismic activity.

.LITERATURE REVIEW

IS 456:2000 [22], this standard is basically used for the plain and reinforced structure. It deals with the design of building according to their requirements. In this code, it has been assumed that the design of plan and reinforced cement concrete work is entrusted to a qualified engineer and that the execution of cement concrete work is carried out under the direction of a qualified and experienced supervisor.

R.Ellingwood (2001) [7] studied the prospect and future improvement in earthquake resistant and design procedure based on the more rational probability-based treatment of uncertainty are examined. IS 1893(part1):2002 [21] this standard deals with assessment of seismic loads on various structures and earthquake resistant design of buildings, its basic provision are applicable for building; elevated structures; industrial and stack like structures; bridges; concrete masonry and earth dams; embankments and retaining walls and other structures.

S.K. Ahirwar, S.K.Jain and M.M.Pande(2008): Estimated earthquake loads on multi-story R.C. Framed buildings as per IS:1893-1984 and IS:1893-2002 recommendations. They considered three, five, seven and nine storey buildings and each was analyzed individually. For each building, a set of five individual sequences was decided in the process. The methods of analysis adopted were the Seismic Coefficient method, Response Spectrum method, and Modal Analysis method. Seismic responses viz. storey shear, base shear

Geotechnical Earthquake Engineering (Steven L. Kramer), (2013) deals with the basic concept of earthquake engineering, geotechnical engineering, seismology, and structural engineering. This book deals with the type of damage done by earthquake, measurement of ground motion, hazard analysis and methods for analyzing the ground response during an earthquake.

Anil K. Chopra (2015) [17] this book includes the theory of structural dynamics and application of this theory to earthquake analysis, response and design of structures. This book concerned with the earthquake response and design of the multi-story building with dynamic analysis.

1. METHODOLOGY

3.1 methodology

NATURE OF WIND IN ATMOSPHERE

In general, wind speed in the atmospheric boundary layer increases with height from zero at ground level to a maximum at a height called the gradient height. There is usually a slight change in direction (Ekman effect) but this is ignored in the Code. The variation with height depends primarily on the terrain conditions. However, the wind speed at any height never remains constant and it has been found convenient to resolve its instantaneous magnitude into an average or mean value and a fluctuating component around this average value. The average value depends on the averaging time employed in analyzing the meteorological data and this averaging time can be taken to be from a few seconds to several minutes. The magnitude of fluctuating component of the wind speed, which represents the gustiness of wind, depends on the averaging time. Smaller the averaging interval, greater is the magnitude of the wind speed.

TERRAIN AND HEIGHT FACTOR

The categorization of the terrain will be done considering the impact of the obstructions that form the roughness of the ground surface. The category of the terrain applied in designing a structure can differ according to the direction of the wind of interest. The direction of any building or construction can be also planned appropriately wherever there is adequate meteorological data regarding the direction of wind.

Terrain on which a particular structure exists will be evaluated as being under one of the following categories of terrain:

Category 1 - Open terrain that is either exposed or barely covered and where there are no or minimal obstructions, and the average height of any object surrounding the structure is under 1.5m. (Under this category there are open sea-coasts and plain treeless plains)

Category 2 - Open country with widely spaced obstructions of a mean height often 1.5 to 10 m.(This is the one on which the regional basic wind speeds are measured and it comprises of airfields, open parklands and undeveloped sparsely built up outskirts of towns and suburbs. Open land around sea coast can be also categorized as Category 2 because of roughness of large sea waves during high winds)

DESIGN WIND SPEED (VZ)

The basic wind speed (Vb) for any site shall be obtained and shall be modified to include then following effects to get design wind velocity at any height (Vz) for the chosen structure:

a) Risk level

b) Terrain roughness, height and size of structure

c) Local topography

.It can be mathematically expressed as follows:

where

Vz, = Vb k1k2k3

Vz = design wind speed at any height z in m/s;

k1 = probability factor (risk coefficient)

k2 = terrain, height and structure size factor.

K3 = topography factor

Design wind pressure

The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity:

Pz = 0.6Vz2

where

Pz= design wind pressure in N/ms at height z,

Vz - design wind velocity in m/s at height z.

Pressure coefficient

The pressure coefficients are always given for a particular surface or part of the surface of a building. The wind load acting normal to a surface is obtained by multiplying the area of that surface or its appropriate portion by the pressure coefficient (Cp) and the design wind pressure at the height of the surface from the ground. Average values of pressure coefficients are given for critical wind directions in one or more quadrants. In order to determine the maximum wind load on the building, the total load should be calculated for each of the critical directions shown from all quadrants. Where considerable variation of pressure occurs over a surface, it has been sub divided and mean pressure coefficients given for each of its several parts.

ANALYSIS DESIGN

Site selection has an important bearing on planning and designing of buildings. Generally, therefore an architect has either to make a choice of suitable site or to plan his building structure to suit the available site. Natural defects of a site will involve considerable expenditure on construction and maintenance of the building.

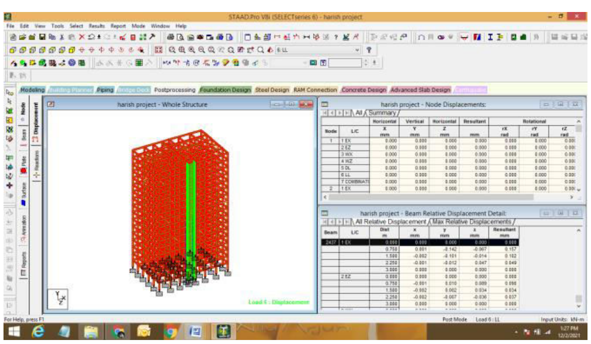
1. A site which comes within the limits of an area where the by-laws of the local authority enforce restrictions regarding proportions of plots to built up, vacant spaces to be left in front and sides, heights of buildings etc. should be preferred.

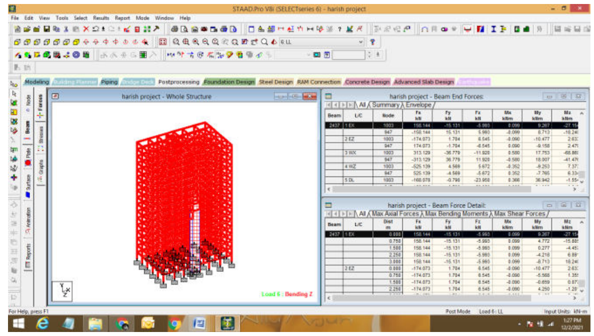
2. The site should be situated on an elevated place and also leveled on with uniform slopes from one end to the other so as to provide good and quick drainage of rain water.

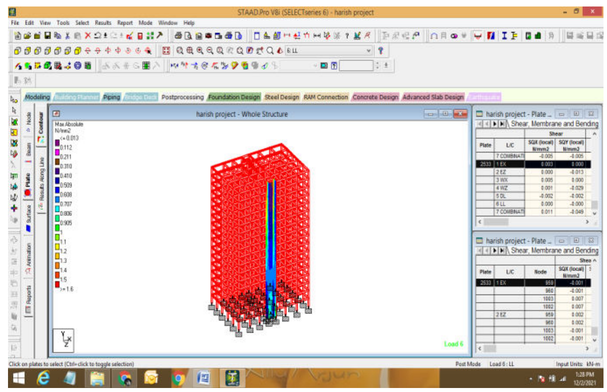
3. The soil surface of the site should be good enough to provide economical foundations for the intended building without causing any problem. Generally for most satisfactory instructions, the site should have rock, sand or firm soil below 60 to 120cm. layer of light or even black cotton soil.

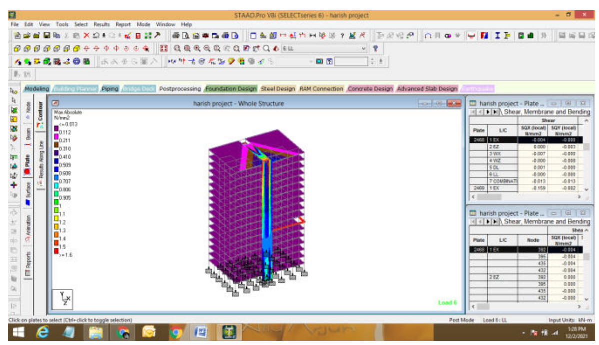
2. RESULTS

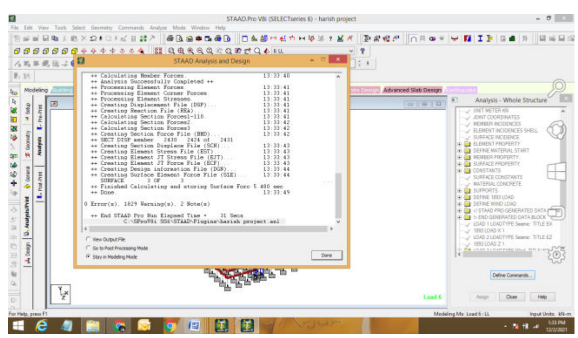
From the analysis procedure with STAAD.Pro, the design for concrete and steel reinforcement is shown below

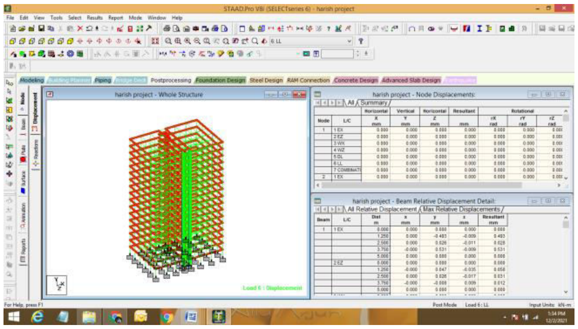


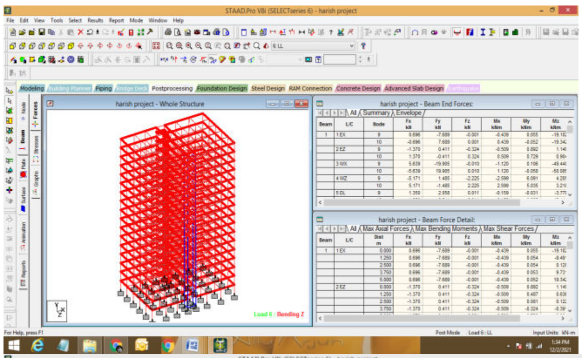


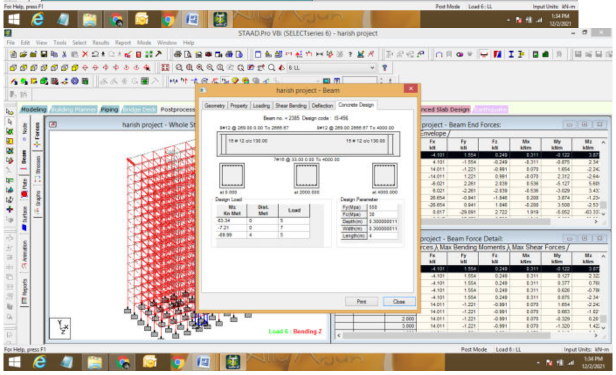


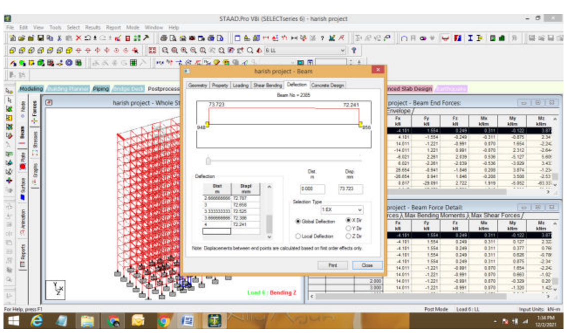


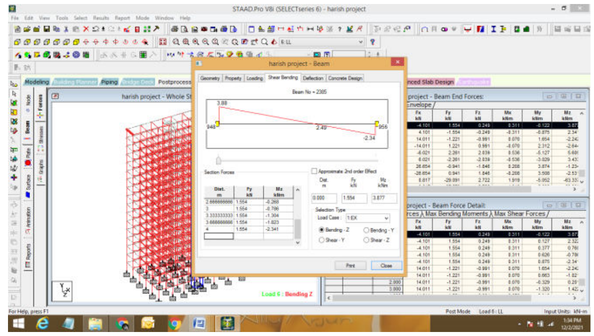












3. Conclusion

This analysis various studies carried out over planning, designing and analyzing a structure with the help of different software. All the studies considered above gives a suggestion of adopting STAAD.Pro over other software for analyzing a building structure. Due to its flexibility and its provision for economic sections both in terms of steel and concrete, STAAD.Pro is adopted for further analysis procedure. The analysis and design is done for hospital building and varioud results of bending moment ,shearforce ,torsion and stresses etc,. are discussed. The analysis and design were done according to standard specifications using STAAD.Pro for static and dynamic loads. The dimensions of structural members are specified and the loads such as dead load, live load and wind load are applied. Deflection and shear tests are checked for beams, columns and slabs. The tests proved to be safe. Both theoretical and practical work has been done. Hence, I conclude that we can gain more knowledge in practical work when compared to theoretical work

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