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Seismic Evaluation of Un-reinforced Masonry Structures

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A B S T R A C T

It is commonly known that earthquakes cause severe damage to masonry structures, resulting in significant loss of life. In India, the bulk of tenements is unreinforced masonry (URM) structures, which are weak and dangerous even in minor earthquakes. For simple structures analysis and design of structure can be done easily but in the case of multi-storey structures, it is cumbersome to calculate the various loads manually. A quick scan of the literature on earthquake-resistant structures, on the other hand, indicates that RC structures are the focus of much of the study. Further research is needed to better understand masonry structures subjected to earthquake-induced dynamic stresses.Any structure should be designed in such a way that damages to the structure should be reduced during an earthquake which makes the building a little uneconomical; because an earthquake may or may not occur in a fixed period it is a rare phenomenon. This paper is the work for the analysis and design of the G+6 building in India for various seismic zones with the help of STAAD Pro software.

Keywords:Un-reinforced masonry: Seismic evaluation: Base shear: framed structure: STAAD Pro

1. Introduction

According to the scenario, the population is increasing day by day which causes an industrial revolution in cities so people living in the village area tend to move to the city area for employment. If people are moving from village to city so it is necessary to construct a residential building for their living and also for office purpose. If multi-storied buildings are not designed according to IS code for consideration of lateral forces it causes complete collapse of the structure. To provide safety to the building which is constructed in the seismic zone it is required to analyze the earthquake forces for constructing a building that resists earthquake forces. To design an earthquake resistance building it is necessary to have a sound understanding of the ground motion. Ground motion can be recorded in terms of ground acceleration, displacement, and velocity. The design requires collecting the various data required for the analysis purpose which involves the calculation part also. Engineers and architects are in charge of the building's design, planning, and layout, among other things. Draughtsman is in charge of constructing drawings under the guidance of engineers and architects. Many academics have researched various stresses operating on high-rise structures in an attempt to improve their performance. Soft stories, floating columns, mass irregularities, poor quality of building materials, bad construction procedures, soil, and foundation have all been identified as major causes of failure. Due to increasing urbanization and population, there is a significant demand for high-rise building development all over the world, and these loads have the potential to cause the most damage to high-rise structures. Because these forces are unpredictable, engineering methods must be practiced to thoroughly analyze structures under their influence.

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2. Literature Review

A research based on investigation of some factors which help us to understand the behavior of soft storey building was performed (**Setia and Sharma 2012)**. For this study they use STAAD Pro 2006 for modeling of whole structure. They use five different models for the whole analysis process. Using STAAD Pro they done study on displacement, storey shear etc.**Bansal and Gagandeep (2012)** performed seismic analysis and design of vertically irregular RC building frames. In this study it was found that the storey shear force is highest at lower floors and decreases with increases in floor i.e. lower at top floor. Also, found that mass irregular structure experiences more base shear as compared to similar regular building.**Veerababu and Kumar (2016)** worked on spectra method for analysis of multi storey building in zone V (arunachal Pradesh and Meghalaya). They also plotted spectra to break some structure using STAAD Pro software. After completing the work they found that there is major impact of properties of soil in soil profundity and its range. They also obtained reaction range physical properties and information of time history tremor that means North East seismic tremor in 10 September 1986 is considered with greatness factor of 5.2.

Kumar and Rao (2013) worked on seismic behavior of structure due to change in % reinforcement of steel and cement concrete volume for various reinforced cement concrete framed building structures. They also considered different factors which affect the building like: gravity load, seismic forces or any other factor. According to their research they find that for zone II - zone V: a) In case of exterior column support reaction varies from 11.5% to 41.7%, b) In case of edge column support reaction varies from 11.7% to 63.6%, and c)In case of exterior column support reaction is very less. The variation in percentage of steel for external beam varies from 0.53% to 1.22% and for internal beam it is varies from 0.77 to 1.4%. There is no necessity to change the bottom reinforcement for seismic and non-seismic design. The behavior of structure under the action of percentage variation and variation in quantities in different seismic zones was done and analyse the effect on the cost of construction (**Karunakar 2014**). Based on his work he conclude that with the increase in vertical reaction there is an increase in variation in quantity of external and corner column and for interior column footings variations are very small.

Inchara and Ashwini (2016) worked on the performance of structure under varying percentage of steel and quantities of concrete in different seismic zones of India. They also compare the quantities of concrete and steel reinforcement percentage designed by two different IS codes (i.e. IS 456:2000 for gravity load and IS1893:2002 for earthquake forces). In this work the researcher prepare total five numbers of models. Out of these five models four models are designed and analyzed for earthquake forces and one for gravity loads for different seismic zones of India using computer software ETAB. The outcome of the result was the support reactions are tends to increase from Zone II to V which causes increase in concrete volume and weight of reinforcement. Analytical study for finding some alternate sources for seismic analysis (**Arora 2015)** which reduces the destructions occurred during an earthquake. The researcher uses computer software ETAB for modeling of the whole structure. In this analysis the researcher provides RCC in two different manners: a) to increase the stiffness of the column uses stiff column and b) to increase the load carrying strength by providing infill wall paneling frame.

Sadh and Pendharkar (2016) studied the effect of horizontal and vertical aspect ratio of building using method of static analysis. Horizontal aspect ratio is nothing but length to breadth ratio of building whereas, height to breadth ratio i.e. slenderness ratio is also known as vertical aspect ratio. In this work the researcher consider four models of building with both type of aspect ratio. **Prashanth et al., (2012)** compare the results obtained by STAAD Pro and ETABS software separately for design of regular and plan irregular building. Comparison is done on the basis of manual calculation for beam and column which is designed according to IS 456. After analysis it is found that by using ETABS requirement of area for steel is less as compared to STAAD Pro. Analysis of wind load and seismic load of 30 storey high rise building is performed by using STAAD Pro 2008 (**kulkarni et al., 2016)**. The findings of analysing ten examples of distinct wind zones in terms of shear force, bending moment, axial force, storey drift, and displacement are gathered. The study is done with STAAD Pro software, and the findings are gathered in terms of axial force, shear force, moment, storey-wise drift, and displacement, which are then critically assessed to quantify the impacts of different structural heights.

3.Methodology

From the standpoint of seismic evaluation, the primary goal of these evaluations is to determine the demand-to-capacity ratios of the building components and, as a result, code compliance. For the analysis and designing of the structure, structural analysis software STAAD Pro is used.

Before the analysis by software some required parameters are collected as per the codal provision for seismic and wind load given in IS 1893 (2002) and IS 875 (Part III) respectively. These parameters may vary for the different zone or different site. Here the (G+6) structure is taken for the Bhopal city in the state of Madhya Pradesh. After the manual calculation of the wind and seismic parameter these data is entered to the software and according to the values of the parameters results are obtained by the software.

The software STAAD Pro uses the design method as per limit state for the purpose of design of concrete structure. The software consists of IS 456:2000 which is used for the designing of concrete structures. For the designing of the structure concrete design option is selected after the geometrical modeling and application of load and load combinations. Compressive strength of concrete and yield strength of reinforcement bar are selected than beam, column and slab is selected for the design. Ultimately the design result can be obtained from the post processing. In this paper work an attempt is also made to understand the response or behavior of the framed structure during the wind force and seismic force. Study is performed on the behavior of different shape and size of the structure under the effect of wind load and seismic load.

3.1. Calculation of wind load

The velocity of the wind and the height of the structure are the two most important parameters in calculating the wind load. The wind load calculation is detailed in section III of IS-875. Basic wind speed 'Vb' that is required for the calculation of wind load is given in zoning map of India for different wind zone. As per the location of structure in this zoning map designermay adopt basic wind speed value.Below equation can be used to measure velocity of wind at any height (z):

$\mathbf{V_z = V_b \times k_1 x k_2 \times k_3}$

Where k_1 denotes probability factor or risk coefficient, k_2 is a coefficient that depends on size of the structure, height, and terrain and k_3 denotes topography factor

The pressure due to wind at height (z) can be measured using equation: $\mathbf{p_z = 0.6\ V^2_z}$

For height of 10 m: V_z = 1*1*1* 39 = 39 m/sec; $P_z = 0.6 * 39^2 = 912.600$ N/m^2
For height of 15 m: V_z = 1*1.05*1* 39 = 40.95 m/sec; $P_z = 0.6 * 40.95^2 = 1006.141$ N/m^2
For height of 18 m: V_z = 1*1.06*1* 39 = 41.34 m/sec; $P_z = 0.6 * 41.34^2 = 1025.397$ N/m^2

Table 1 - Basic wind velocity, wind velocity at different depth and wind pressure at different depth of a building

Sr. No.	Height (m)	V_b (m/sec.)	K_1	K_2	K_3	V_z (m/sec)	$P_z = 0.6\ V_z^2$ (N/m^2)
1	10	39	1	1	1	39	912
2	15	39	1	1.05	1	40.95	1006
3	18	39	1	1.06	1	41.34	1025

3.1.1 Calculation for the seismic load analysis as per IS-1893 (2002)

To analyze the seismic behavior of the structure required seismic parameter is gathered from the IS-1893:2002 such as: damping ratio, zone factor, importance factor, rock/soil type, response reduction factor, etc.

Design Seismic Base Shear (V_b)

It is also known as lateral force (design) that can be measured in any mutual perpendicular direction and may determine using equation:

$$\mathbf{V_b = W \times A_h}$$

Where,

A_h is the acceleration in horizontal direction, and W is the total weight of all the storeys due to seismic loading.

Calculation for the fundamental natural period T_a

$$T_a = 0.09h/\sqrt{d}$$

Considering the dimension of structure in x- direction d = 30 m, height of the building h = 18 m
Fundamental natural period in x- direction $T_a = 0.09*18/\sqrt{30} = 0.295$ second

Considering the dimension of structure in z- direction d = 20 m, height of the building h = 18 m
Fundamental natural period in z- direction $T_a = 0.09*18/\sqrt{20} = 0.362$ second

3.1.2 Design of concrete

After locating the building at different zones the design of all the components of building made of RCC is designed and analysed with the help of STAAD Pro. IS 456 (2000) is used for this purpose. The grade of steel and concrete used in this work are Fe 415 and M 25 respectively.

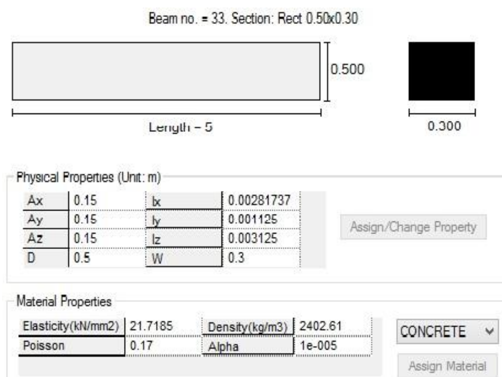

Fig. 1 - Property of beam used for analysis

Table 2 - Property of various component of building considered in the project

Sr. No.	Building component	Size of building component
1	Beam	500 mm x 300 mm
2	Column	450 mm x 450 mm
3	Slab	115 mm

4. Result and Discussion

While analyzing and designing of the multi-storied (G+6) framed structure some manual calculation is carried out for the feeding of data to the STAAD Pro software. As per the Indian standard code of practice data is taken for calculation and result is obtained. After the calculation of wind intensity and seismic parameter these values are entered for the analysis purpose. Predefined size of beams and columns for which results are obtained in term of deflection, shear bending and design of elements. Most of the results are obtained using the software. In this section results obtained and discussion on the result is carried out. The results obtained by analysis and design of (G+6) structure are shown below.

Table 3 - Volume of concrete used in building for different zone

Sr. No.	Type of Zone	Volume of concrete (cum)
1	II	488
2	III	504
3	IV	732
4	V	830

Table 4 - Quantity of material used

Sr. No.	Material Used	Grade of material	Quantity
1	Concrete	M25	777.2 cum
2	Reinforcement	Fe-415	79576.9 kg

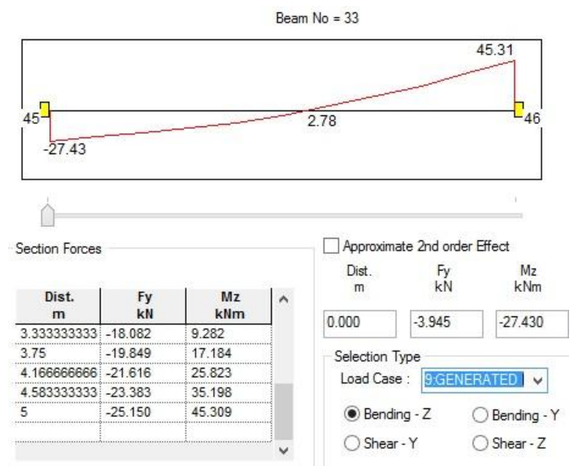

Fig. 2 - Shear and bending value obtained for the beam

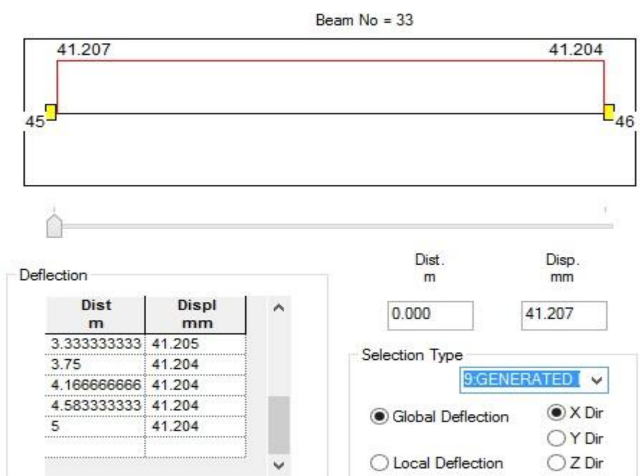

Fig. 3 - Deflection value obtained for the beam

5.Conclusion

After analyzing and designing the G + 6 building with the help of STAAD Pro thesethree conclusions were drawn:

- The recommended dimensions of the beams and columns are safe for use in the building
- The building is safe against shear, bending, and deflection
- Wind and seismic loads do not have a dangerous effect on the building at zone II

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