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Comparative Study of Tall Building with & Without Earthquake Loading

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Abstract:
Tall buildings are the need of the present civilization in urban area due to increase in population & migration from village to urban area. In the times to come with the mounting pressure of population, the need would perhaps be to go up for tall buildings. The land of urban area limited and to accommodate large urban population in limited space, construction of tall building is a must. Present project structure was modeled with "Three dimensional analysis of building system" computer program. Seven storied residential tall building has been designed with and without earthquake consideration and comparison has been made. Analysis revealed that compressive forces, bending moment and shear force is more in the case of earthquake loading as compared to without earthquake loading. Same cross section of beam leads to M25 grade of concrete for without earthquake case whereas M30 grade of concrete is required in the case of earthquake loading for safe design. Design of the column also revealed that for safe design M30 grade of concrete is required in place of M25 grade of concrete which shows unsafe section. Safe design of column required larger cross section with higher grade of concrete in the case of earthquake loading.

Keywords: Structure, Seismic Analysis, Loading Consideration, Numerical Analysis

I. INTRODUCTION

A multi-story building is a building that has multiple floors above ground in the building. They are usually constructed for the offices, residential flats, hotels, hospitals, schools, social centers etc. These are becoming increasingly popular because of crowding of population and available land being scarce for the more development. After becoming a new state Chhattisgarh and Raipur being a capital, huge population pressure developed in the city due to increase in various activities such as residential, commercial, industrial, educational and political.

Therefore it is extremely necessary to adopt tall buildings to fulfill the housing and commercial requirements. It is very difficult to cope up the tall building in earthquake prone area. The Jabalpur earth quake (1997) was first moderate earthquake (magnitude 6.0) to have occurred close to a major Indian city which opened our eyes to things for ductile designing and detailing of structure considering in soft earthquake zone also.

In this paper, a multi storey residential building i.e. (G+6) is designed and compared the earthquake and without earthquake loading. The building is rectangular in shape. The ground floor is left as a parking i.e. stilt floor parking space for Vehicles. Every floor has 2 flats, each 3 BHK. Plans of all the floors are identical. Orientation of building is in such a way that the front is facing towards north. The building has been designed as a RCC framed structure and the type of wall is a brick wall.

II. ANALYSIS OF STRUCTURE

General cases of loading in the dynamic of structure:

Forces considered for the analysis are static forces, dead load, live load and dynamic forces –Wind load, Earthquake load, Air blast. Following consideration has been made while seismic analysis:

- Seismic loads are the inertial forces acting on a house due to earthquake induced ground motion.
- This force generally act horizontally on each element of the structure.
- All components of a frame feel the effect of seismic loads.
- Earthquake is a sudden undulation of a portion of the earth's surface.
- The ground surface moves both horizontal and vertical direction during an earthquake.
- It is a horizontal component of ground motion that causes structure damage & that must be considered in design.
- Vertical component of ground motion is usually small & doesn't have significant impact on most structure.

Following load consideration has been made during loading:

- Wind load and Earthquake load is considered separately in calculations because they are different kinds of forces and require different kinds of structural resistance.
- For example, wind loads push against the entire face of a building. Therefore a heavy building will resist wind loads better than a light one.
- But an earthquake shakes the building from the bottom. In a tall building, the bottom shifts quickly and becomes out of alignment with the top. As the building straightens itself out, a lot of momentum is generated. Therefore lighter buildings do better against earthquake forces because they generate less momentum. They have less weight swinging back and forth.
- Basically, weight is good against wind forces and flexibility is good against earthquake forces. (Some flexibility is good against wind too but not to the extreme needed to resist earthquakes).
- The building needs to be checked against expected values of both of these forces for the area it's located in.

Numerical analysis:
The numerical analysis is performed in the following step:

- Estimation of gravity load forces in girders and columns by approximate method.
- Preliminary estimate of member size based on gravity load force with arbitrary increase in the sizes to allow for horizontal loading.
- Approximate allocation of horizontal loading to bents and preliminary analysis of member forces in bents.
- Check on drift and adjustments of member sizes if necessary.
- Check on strength of members for worst combination of gravity and horizontal loading, and adjustment of member sizes if necessary.
- Computer analysis of total structure for more accurate check on member strength and a drift, with further adjustment of sizes where required.

III. DESIGN CONSIDERATIONS

Structural design of the structure has been done as per IS 456:2000, IS 875(1987) and IS 1893(Part 1). Material properties considered for the design with and without earthquake are tabulated in Table 2 and Table 1 respectively.

Table.1. Material properties without earthquake consideration

Material Properties		
Soil Properties	Soil type Unit weight SBC of soil Soil surcharge	Drained 22.000 KN/m^3 210.000 KN/m^2 10.000 KN/m^2
Sliding and Overturning	Coefficient of friction Factor of safety against sliding Factor of safety against overturning	0.500 1.500 1.500
Footing Material Properties	Grade of concrete Grade of steel Unit weight of concrete	M20 Fe415 25.000 KN/m^3
Material Properties		
Column Material Properties	Grade of concrete Main steel grade Grade of steel stirrups	M25 Fe415 Fe415
Beam Material Properties	Grade of concrete Main steel grade Grade of steel stirrups	M25 Fe415 Fe415
Slab Material Properties	Grade of concrete Main steel grade Distribution steel grade	M20 Fe415 Fe415

Table.2. Material properties with earthquake consideration

Material Properties		
Soil Properties	Soil type Unit weight SBC of soil Soil surcharge	Drained 22.000 KN/m^3 210.000 KN/m^2 10.000 KN/m^2
Sliding and Overturning	Coefficient of friction Factor of safety against sliding Factor of safety against overturning	0.500 1.500 1.500
Footing Material Properties	Grade of concrete Grade of steel Unit weight of concrete	M30 Fe415 25.000 KN/m^3
Column Material Properties	Grade of concrete Main steel grade Grade of steel stirrups	M30 Fe415 Fe415
Beam Material Properties	Grade of concrete Main steel grade Grade of Steel Stirrups	M30 Fe415 Fe415
Slab Material Properties	Grade of concrete Main steel grade Distribution steel grade	M20 Fe415 Fe415

IV. RESULT AND CONCLUSIONS

Result of analysis and design of the structure is presented in the following section by various cases:

Case 1: Column Design Comparison 1 -
In this case, a column member has been designed by taking the cross section 600mm x 350mm and by using Grade of steel and Grade of concrete Fe415 & M25 respectively. The section is found not adequate and in this case reinforcement requirement of section exceeds the maximum limit. In the same column member if cross section is increased by 700mm x 400mm and Grade of concrete and steel is taken M30 and Fe415 respectively, then result of the design of column get passed. Hence, Using the cross section size 700mm x 400mm & Grade of concrete M30 is suitable and economic design.

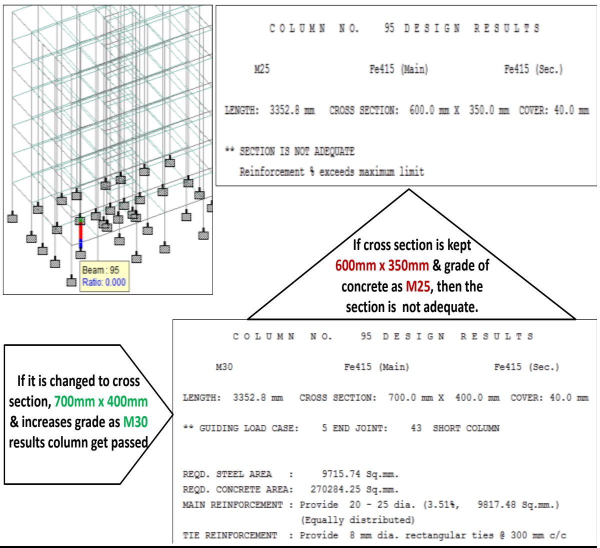

Figure.1. Comparison of column design results 1

Case 2: Column Design Comparison 2 –
In this case, a column member has been designed by taking the cross section 650mm x 350mm and by using Grade of steel and Grade of concrete Fe415 & M25 respectively. The section is found not adequate and in this case reinforcement requirement of section exceeds the maximum limit. In the same column member if the cross section remains same Grade of concrete is increased by M30 and Grade of steel is Fe415, then result of the design of column get passed. Hence, Using the cross section size 650mm x 350mm & Grade of concrete M30 is suitable and economic design.

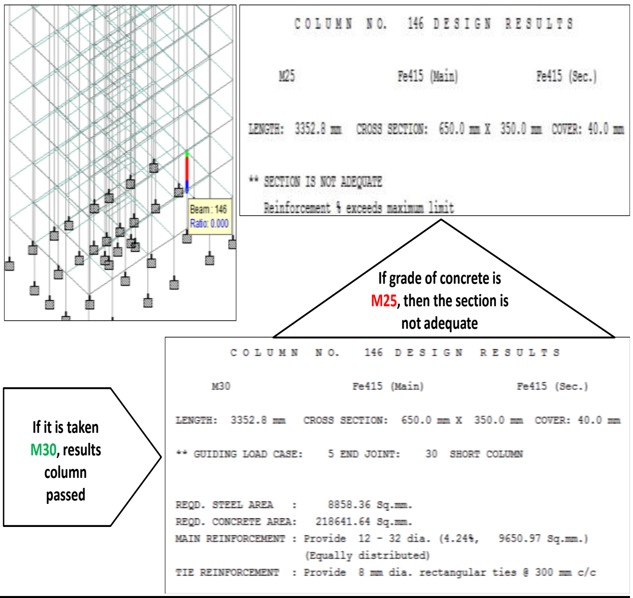

Figure.2. Comparison of column design results 2

Case3: Beam design without earthquake consideration-In this case, a beam member has been designed for without earthquake consideration by taking the cross section 350mm x 300mm and by using Grade of steel and Grade of concrete Fe415 & M25 respectively, then result of the design of beam is adequate..

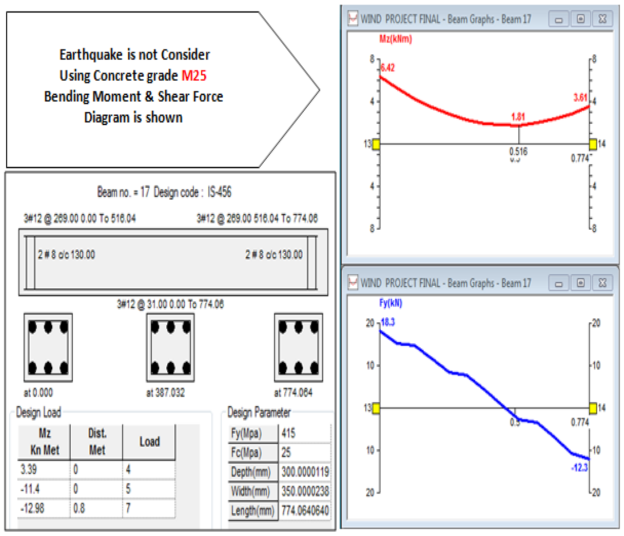

Figure.3.Beam design result without earthquake consideration

Case 4: Beam design with earthquake consideration-
In this case, a beam member has been designed for earthquake consideration by taking the cross section 350mm x 300mm and by using Grade of steel and Grade of concrete Fe415 & M30 respectively, then result of the design of beam is adequate.

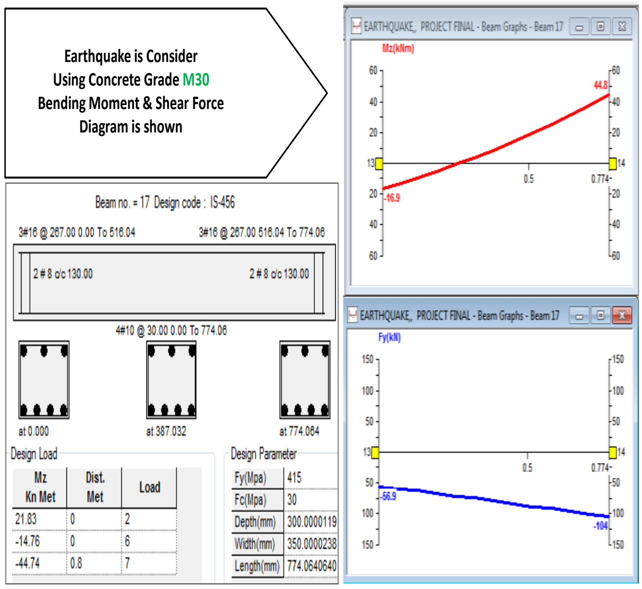

Figure.4.Beam design result with earthquake consideration

Same cross section of beam leads to M25 grade of concrete for without earthquake case whereas M30 grade of concrete is required in the case of earthquake loadings for safe design.

V. CONCLUSION

Seven storied residential tall building has been designed for with and without earthquake consideration. Analysis revealed that compressive forces, bending moment and shear force is more in the case of earthquake loading as compared to without earthquake loading. Sections were designed based on the bending moment obtained from the analysis. Following are salient features of design of the sections.

(i) Same cross section of beam leads to M25 grade of concrete for without earthquake case whereas M30 grade of concrete is required in the case of earthquake loadings for safe design.

(ii) Design of the column also revealed that for safe design M30 grade of concrete is required in place of M25 grade of concrete which shows unsafe section.

(iii) Safe design of column required larger cross section with higher grade of concrete in the case of earthquake loading.

It is seen that small changes in cross section, grade of concrete, steel reinforcement structure can be designed safely in earthquake affected zone. The extra investment is no matter to save the valuable human and property loss during the earthquake hazard which may come during life of the structures ones upon a time.

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