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Seismic Assessment of Multi Storey Buildings for Different Lateral Resistance Elements

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Abstract: **The main objective of this project is to study different techniques for resisting lateral forces acting on structure. The method studied and analyzed are shear walls and bracing. The project also aims at finding the most suitable method along with the design of a G+25 structure using infill wall, shear wall and bracing. The analysis is carried out using analytical methods.**

Keywords – Seismic Assessment, Buildings, Lateral Resistance.

I. INTRODUCTION

The high rise building is mostly considered as the one which requires mechanical transportation for use. Technically speaking a high rise structure is the one in which the wind forces are more predominant than any other forces. As the height of building increases, the loads coming on the building also increase, which may affect the stability of the building, thus addition of some extra structural element is required for the safety from loads acting on the building.

To perform more in an earthquake, a building may have four main attributes, namely simple and regular configuration, large lateral stiffness, adequate ductility and adequate lateral strength. Buildings having simple regular geometry, uniformly distributed mass and stiffness in plan as well as elevation, suffer much less damage than the building with irregular configuration.

Structural response to earthquake is a dynamic phenomenon that depends on dynamic characteristic of structures and the intensities, duration and frequency of existing ground motion. Although the seismic action is dynamic in nature, building code often recommend equivalent static load analysis for design of earthquake resistant building due to its simplicity.

This is done by focusing on predominant first node response and developing with some empirical adjustments for higher effects. My project hence focuses on the use of these additional structural elements in G+15, G+20 and G+25 floor building. The structural elements used are shear wall, bracing. A comparative analysis of shear wall and bracing with respect to the stability of the structure has been carried out using software.

II. OBJECTIVE

The main objectives is to increase the resistance of structure against lateral forces/ground motion which is produced by earthquake. To avoid the damage of structural elements caused due to earthquake forces. To prevent the additional cost and operation of retrofitting of structure in future. To increase the accessibility time for users to escape out from structure during earthquake. To improve the sustainability and overall stability of structure during earthquake.

III. SCOPE OF PROJECT

The original scope of this project is to improve the safety of the high rise structure by provision of structural elements viz. Shear wall, bracing. Three buildings of respectively 15, 20 and 25 floors have been designed with infill wall (normal brick wall). Shear wall and bracing. Out of the three methods used the most suitable structure element is found out by the analysis of the results obtained.

IV. METHODOLOGY

The project report is presented in 4 chapters, each chapter bringing out important aspects in performing seismic assessment of RC frame structure. An introduction to all chapters is given in following paragraphs.

An introduction to purpose, different types of loads and their effects on structure, objectives and scope of project is given in chapter 1.

An overview of various investigations work carried out by researchers in the field of seismic assessment for different lateral resistance elements in multi storey structures is described in chapter 2.

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Chapter 3 includes information about various lateral resistance elements and methods for seismic analysis of building.

Chapter 4 includes detailed procedure of seismic assessment using Seismic coefficient method, results of present study.

Chapter 5 includes Conclusion of the present work and future scope of project.

V. LITERATURE REVIEW

The research studies mainly focus on the method to improve stability of building, comparative study of the different methods, standard and modification for seismic resistance etc. The above papers give detailed information about the Shear walls and Bracings. The construction of braced and shear wall structure can be understood. The types of bracings are studied. The location of shear wall and its overall impact on the structure is studied. The above literature review also gives information about the effect of earthquakes on multi storey buildings.

The review also tells about the methods of seismic assessment of multi storey building using different software. It tells about the various methods of analysis such as Response spectrum method, Time history analysis, Pushover analysis, etc. As seismic coefficient method is going to be used in the assessment, various factors related to it are studied in detail from these papers.

VI. THEORETICAL INVESTIGATION

A theoretical study has been done on shear wall and bracing system. In this study the areas highlighted are basic concepts of the methods, forces resisted, importance and advantages of shear wall and bracing respectively, different types of bracing along with their suitability. Also the different methods of analysis of structures have been stated in brief.

Shear wall

This section gives the information about the shear wall and how it resists forces coming due to earthquake and wind forces. This part also states the appropriate method of construction of shear wall, so that errors due to construction can be eliminated. Shear walls are vertical elements of a horizontal system. Shear wall should be located on each level of structure. For the formation of a good box structure, similar dimensions should be placed in symmetrical manner on all the external wall of the building. Sometimes shear walls should be added to the interior of buildings when the external shear walls cannot provide enough stability and resistance from seismic forces. Interior shear walls are necessary if the width of the building exceeds 75 feet and in case the stiffness of the external shear wall is inadequate.

Mainly shear walls resist shear forces and uplift forces. As the shear wall is continuous, the horizontal forces are transferred to the shear wall. This transfer creates shear forces throughout the shear wall connections .When the shear walls are strong enough, they transfer the seismic forces to the next element in the load path below them. These may be other shear walls, floors, slabs, footing, etc. The shear walls prevent floor and roof members from support movements.

The high rise building must be capable of resisting all types of loads coming on it for the safety of structures. If any high rise structure is designed without including shear walls, the structural elements like beams, columns have high depth and become quite heavy. This creates a lot of problems like difficulty during casting, increased dead load, congestion and heavy forces are induced in members. These disturb the economy and safety of structure. Thus shear wall become a good alternative for maintaining and controlling lateral deflection.

Most of the RCC structures with shear walls are also provided with columns, these columns carry vertical loads and self-weight of other elements .Shear walls gives strength and stiffness to the buildings which reduces the swaying in lateral direction minimizing damages to the structural elements. Since large over turning forces act on shear walls due to the lateral forces, the construction of foundation requires special care. Generally shear walls should be provided in both along length and width.

But if they are provided only in one direction a moment of resistant frame must be provided along other direction to reduce the effect of earthquake forces. Design checks should be taken for symmetrical design of opening. Shear walls should be placed symmetrical so that twisting forces are reduced. Shear walls are most effective when placed around the entire periphery of structure.

Bracing system

Seismic control using structural braces has been one of the most studied mechanisms. Systems of this type generally consist of set of braces connected to the structural elements like beams, columns, etc. Bracing frames provide lateral stability to entire structure. It has to resist all possible kinds of lateral loads due to external forces e.g. wind forces, earthquake forces and leaning forces. The wind or the equipment earthquake forces on the structure, whichever are greater, should be assessed and divided into number of members resisting the lateral forces in each direction.

In the single bracing frames, where a single diagonal brace is used, it must be capable of resisting both tensile and compressive axial forces caused by the alternate wind load. Hollow sections must be used for the diagonal braces as they are stronger in compression. In the design of diagonal braces, gravity forces may tend to dominate axial forces in the members and due considerations must be given to the design of such members.

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In the cross braced system, the brace members are usually designed to resist tension only. Consequently, light sections such as structural angles and channels, or tie rods can be used to provide very stiff bracing. The advantage of the cross braced system is that the beams are not subjected to significant axial force, as the lateral forces are mostly taken up by bracing members.

For K trusses, the diagonals do not participate extensively in taking load, and can thus be designed for winds forces without gravity axial forces being considered as major force. K-braced frame is more efficient in preventing side sway than cross-braced frame although equal steel areas of braced members are used. This type is preferred for long bay width because of the shorter length of braces. K-braced frame is found to be more efficient if the apexes of all the braces are pointing in the upward direction.

In case of eccentric braced load frame system, it mainly consists of flexure of beam between beam joint and column joint. Forces are by shear and buckling of beam segment.

SEISMIC FORCES

In general, the structures are usually built in having more regulations i.e. stiffness, diaphragm, mass and torsion irregularity. The damage due to earthquake at weak point in multi –storey building usually occurs. This weakness is wide due to strength and variation in stiffness, so if any structure is to resist earthquake forces means it should possess adequate strength, ductility, stiffness. Therefore this type of structure should be designed considering the earthquake loading according to the specified design philosophies so that they can sustain moderate to strong earthquakes. The structures are analyzed using equivalent static method of analysis and dynamic method of analysis.

METHODS OF ANALYSIS OF STRUCTURE

The seismic analysis is should be carried out for the building so that we have to know about various seismic forces. In seismic analysis the dynamic effect should be consider so that exact analysis will be complex. There are different methods to be adopted for seismic analysis procedure.

A. Seismic coefficient method

B. Response spectrum method

C. Time history method

D. Pushover method

A. Seismic coefficient method

This method follows dynamic nature of the load. This analysis is useful for determining the calculations of design base shear and its distribution to all storey by using the formula as given in IS code 1983:2002

B. Response spectrum method

This gives the representation of maximum response of idealized single degree freedom system, having certain period and damping during earthquake ground motion. This analysis is carried out by using the code IS 1893:2002. Here type of soil, seismic zone factor should be entered from IS1893:2002 (part I). The standard response spectrum for the type of soil considered is applied to building for the analysis in ETABs software.

C. Time history method

Dynamic response of the building will be calculated in this analysis at each time interval. This analysis is calculated by taking record data of ground motion. This analysis overcomes all disadvantages of response spectrum analysis. Hence this method requires greater effort in calculating response of building in seismic time intervals.

D. Pushover analysis

This is a performance based analysis and it is used for controlling the structural damage. In this analysis several built in hinge properties are included from FEMA356 for concrete members. This analysis will be determined by using nonlinear software ETABs. This analysis is very useful for determining displacement vs. base shear graph.

Seismic coefficient method

The seismic coefficient method is one of the static procedures for the resistant design of structure. Horizontal and vertical forces are calculated as product of seismic coefficients. The total weight of structure is applied to the structure. The seismic coefficient is determined by taking the importance level of the structure. By seismic coefficient method various parameters are determined by considering the fundamental mode of the structure.

Various factors are involved in the seismic analysis by seismic coefficient method. All the factors are taken from the IS1893:2002.

The factors are as;

1. Zone factor

2. Importance factor

3. Response reduction factor

4. Fundamental natural factor

VII. CONCLUSION

This paper focuses on improving the resistance and stability of high rise building against the different loads and forces (mainly seismic forces) it is subjected to during its life time.

The three most important factors responsible for the overall stability of any building are Time period, Base shear and Joint displacement. The results from analysis are summarized below.

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i. Time period much less when shear wall is used.

ii. Joint displacement is a minimum when shear wall is used.

iii. Base shear is a minimum when bracing is used.

For shear wall the time period is 60%-85% less than the infill wall and 65%-80% less than the bracing system. As the time period of a structure is increase than the deflection of the structure also increase so to make structure stiff large size members are required which increase the cost of the building. Shear wall having large member but they are stiffer than the conventional building, so it is economical for the multi storey building.

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