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SEISMIC ANALYSIS OF VERTICAL IRREGULAR BUILDING

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Abstract:- Major structural collapses occur when a building is under the action of Dynamic Loads which includes both Earthquake and Wind loads. In these modern days, most of the structures are involved with architectural importance and it is highly impossible to plan with regular shapes. These irregularities are responsible for structural collapse of buildings under the action of dynamic loads. Hence, extensive research is required for achieving ultimate performance even with a poor configuration. In the present work, "Effect Of Vertical Irregularity In Multi-Storied Buildings Under Dynamic Loads Using Linear Static Analysis", considering four types of 20- Storied 3-D frames (i.e., a symmetrical elevation configuration throughout its height and three other frames with unsymmetrical vertical configuration starting from tenth floor, placed at corner, at the center and at edge of the plan respectively) it is focused to study their response using Linear Static Analysis.

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I INTRODUCTION

During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building. (Thowdoju et al. 2016)

The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated. There are two types of irregularities- (Thowdoju et al. 2016)

Vertical Irregularities.

Vertical Irregularities are mainly of five types-

a) Stiffness Irregularity — Soft Storey-A soft storey is one in which the lateral stiffness is less than 70 percent of the storey above or less than 80 percent of the average lateral stiffness of the three storey's above. (Thowdoju et al. 2016)

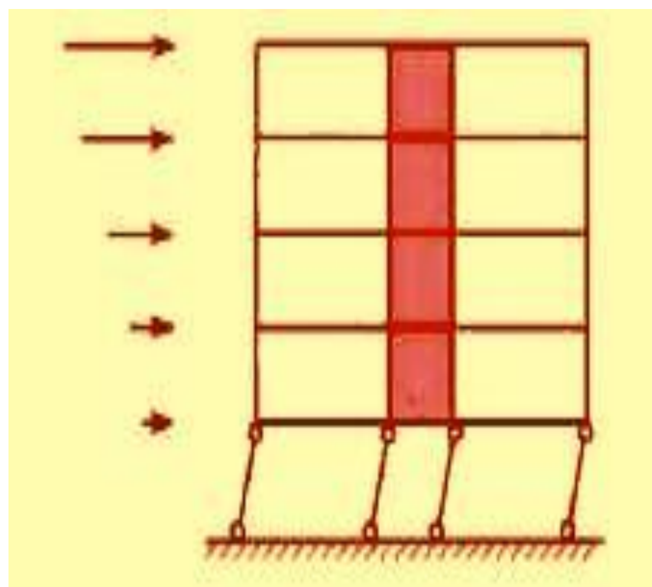


Figure 1.1 Stiffness Irregularities

b) Stiffness Irregularity — Extreme Soft Storey-An extreme soft storey is one in which the lateral stiffness is less than 60 percent of that in the storey above or less than 70 percent of the average stiffness of the three storey's above. (Thowdoju et al. 2016)

ii) Mass Irregularity-Mass irregularity shall be considered to exist where the seismic weight of any storey is more than

200 percent of that of its adjacent storey's. In case of roofs irregularity need not be considered. (Thowdoju et al. 2016)

iii) Vertical Geometric Irregularity- A structure is considered to be Vertical geometric irregular when the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey. (Thowdoju et al. 2016)

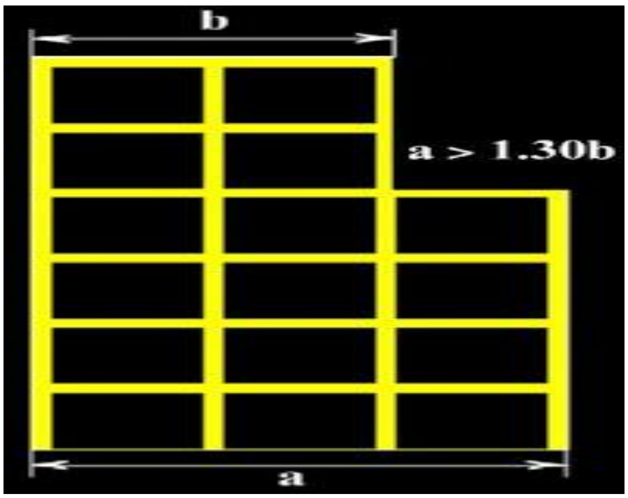


Figure 1.2 Vertical Geometric Irregulariities in Building

iv) In-Plane Discontinuity in Vertical Elements Resisting Lateral Force-An in-plane offset of the lateral force resisting elements greater than the length of those elements. (Thowdoju et al. 2016)

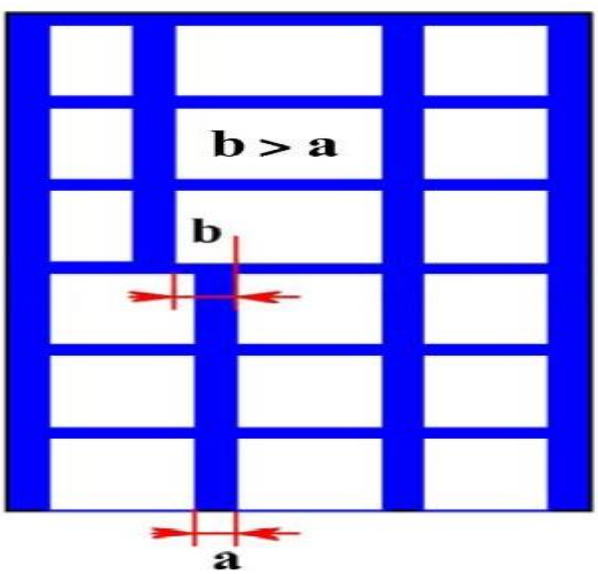


Figure 1.3 In-plane discontinuities in vertical lateral force-resisting element

v) Discontinuity in Capacity — Weak Storey-A weak storey is one in which the storey lateral strength is less than 80 percent of that in the storey above. (Thowdoju et al. 2016)

As per IS 1893, Part 1 Linear static analysis of structures can be used for regular structures of limited height as in this process lateral forces are calculated as per code based fundamental time period of the structure. Linear dynamic analysis are an improvement over linear static analysis, as this analysis produces the effect of the higher modes of vibration and the actual distribution of forces in the elastic range in a better way. (Ramayakrishna et al. 2017)

Buildings are designed as per Design based earthquake, but the actual forces acting on the structure is far more than that of DBE. So, in higher seismic zones Ductility based design approach is preferred as ductility of the structure narrows the gap. The primary objective in designing earthquake resistant structures is to ensure that the building has enough ductility to withstand the earthquake forces, which it will be subjected to during an earthquake. (Ramayakrishna et al. 2017)

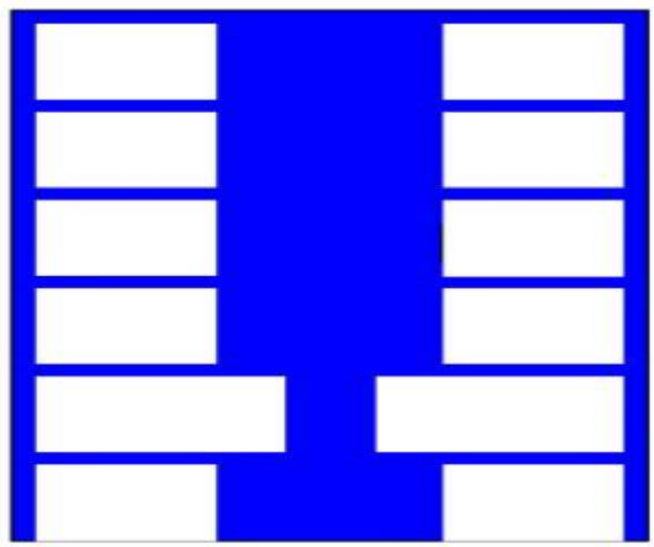


Figure 1.4 Discontinuity in capacity8

Criteria for vertical irregularities in building codes

In the earlier versions of IS 1893 (BIS, 1962, 1966, 1970, 1975, 1984), there was no mention of vertical irregularity in building frames. However, in the recent version of IS 1893 (Part 1)-2016 (BIS, 2016), irregular configuration of buildings has been defined explicitly. Five types of vertical irregularity have been listed as shown in Figure 1. They are: stiffness irregularity (soft story), mass irregularity, vertical geometric irregularity (set-back), in-plane discontinuity in lateral-force-resisting vertical elements, and discontinuity in capacity (weak story). NEHRP code (BSSC, 2003) has classifications of vertical irregularities similar to those described in IS 1893 (Part 1)-2016 (BIS, 2016). As per this code, a structure is defined to be irregular if the ratio of one of the quantities (such as mass, stiffness or strength) between adjacent stories exceeds a minimum prescribed value. These values (such as 70-80% for soft story, 80% for weak story, and 150% for set-back structures) and the criteria that define the irregularities have been assigned by judgment. Further, various building codes suggest dynamic analysis (which can be elastic time history analysis or elastic response spectrum analysis) to come up with design lateral force distribution for irregular structures rather than using equivalent lateral force (ELF) procedures.

OBJECTIVES OF THE STUDY

The main objectives of the present work is to study the effect of vertical irregularity in

Multi-Storied building

1) To calculate the design lateral forces on regular and irregular buildings using

Equivalent static method.

2) To validate the result, Calculate design lateral force of regular building using equivalent static frame method with using STADD-Pro.

3) To study two irregularities in structures namely mass and stiffness irregularities.

4) To study the structural response of the building models with respect to following aspects Fundamental time period of the building, Base shear, Storey displacement.

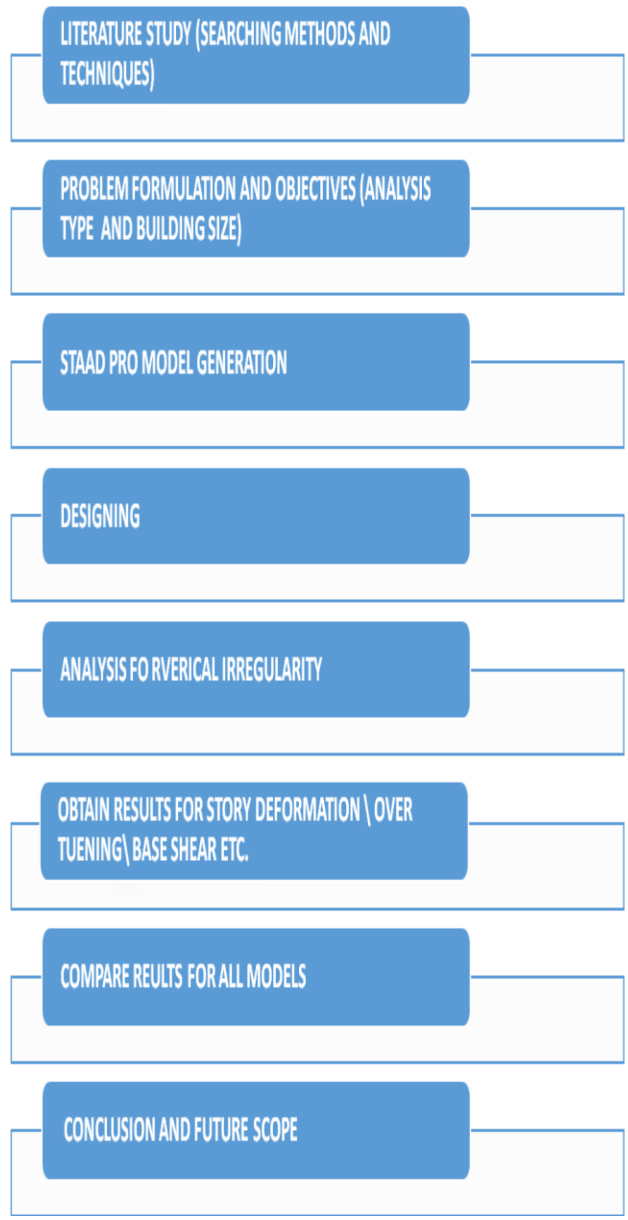
5) To determine the percentage variation of quantity of steel of various heights of Building.

6) To study the effect of wind on multistoried building with mass and stiffness irregularity.

II NEED FOR RESEARCH

Irregular buildings constitute a large portion of the modern urban infrastructure. Structures are never perfectly regular and hence the designers routinely need to evaluate the likely degree of irregularity and the effect of this irregularity on a structure during an earthquake. Need for research is required to get economical & efficient lateral stiffness system for high seismic prone areas. For optimization & design of high rise building with different structural. framing systems subjected to seismic loads. To improve the understanding of the seismic behavior of building structures with vertical irregularities.

III METHODOLOGY



The finite element analysis is a numerical technique. In this method all the complexities of the problems, like varying shape, boundary conditions and loads are maintained as they are but the solutions obtained are approximate. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in engineering. The fast improvements in computer hardware technology and slashing of cost of computers have boosted this method, since the computer is the basic need for the application of this method. A number of popular brand of finite element analysis packages are now available commercially. Some of the popular packages are STAAD-PRO, GT-STRUDEL, NASTRAN, NISA and ANSYS. Using these packages one can analyze several complex structures. The finite element analysis originated as a method of stress analysis in the design of aircrafts. It started as an extension of matrix method of structural analysis.

Civil engineers use this method extensively for the analysis of beams, space frames, plates, shells, folded plates, foundations, rock mechanics problems and seepage analysis of fluid through porous media. Both static and dynamic problems can be handled by finite element

analysis.

3.1 Description of Method

In engineering problems there are some basic unknowns. If they are found, the behaviour of the entire structure can be predicted In a continuum, these unknowns are infinite. The finite element procedure reduces such unknowns to a finite number by dividing the solution region into small parts called elements and by expressing the unknown field variables in terms of assumed approximating functions (Interpolating functions/Shape functions) within each element. The approximating functions are defined in terms of field variables of specified points called nodes or nodal points. Thus in the finite element analysis the unknowns are the field variables of the nodal points. After selecting elements and nodal unknowns next step in finite element analysis is to assemble element properties for each element. For example, in solid mechanics, we have to find the force-displacement i.e. stiffness characteristics of each individual element. Mathematically this relationship is of the form.

3.1.1 Finite Element Analysis

$$[k]e \ \{\delta\} \ e= \{F\} \ e$$

Where $[k]e$ is element stiffness matrix, $\{\delta\}$ eis nodal displacement vector of the element and $\{F\}$ $e$is nodal force vector. The element of stiffness matrix *kij* represent the force in coordinate direction '*i*' due to a unit displacement in coordinate direction '*j*'. Four methods are available for formulating these element properties viz. direct approach, Element properties are used to assemble global properties/structure properties to get system equations $[k]$ $\{\delta\}$ = $\{F\}$. Then the boundary conditions are imposed. The solution of these simultaneous equations give the nodal unknowns. Using these nodal values additional calculations are made to get the required values e.g. stresses, strains, moments, etc. in solid mechanics problems.

Thus the various steps involved in the finite element analysis are:

(i) Select suitable field variables and the elements.

(ii) Discretize the continua.

(iii) Select interpolation functions.

(iv) Find the element properties.

(v) Assemble element properties to get global properties.

(vi) Impose the boundary conditions.

(vii) Solve the system equations to get the nodal unknowns.

(viii) Make the additional calculations to get the required values

3.2.2 Equivalent static force analysis:3.2.3 Seismic Analysis using IS 1893 (Part1):2016

Table 2 Soil groups for calculations of seismic forces

Group	Soil Type
Group 1	Hard soil
Group 2	Medium soil
Group 3	Soft soil

3.3 Design Criteria

Following are the major steps in determining the seismic forces:

3.3.1 Determination of base shear:

For the determination of seismic forces, the country is classified in four seismic zones:

IV CONCLUSION

The main purpose of this study is to analyse plan irregular high rise building by STAAD Dynamic analysis has been carried out to know time period, natural frequency, deformations, displacements and floor responses by using +shaped model. The analysis include participation of 90% of the building mass for every principal horizontal direction of response as per IS 1893(Part-I)-2016 by complete Quadratic Combination (CQC).

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