Study of Seismic Response of Multi-Storied Vertical Irregular Building due to Stiffness Irregularity

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ABSTRACT

There are various types of irregularities in the buildings depending upon their location and scope, but mainly they are divided into two groups plan irregularities and vertical irregularities. Nowadays, as in the urban areas the space available is limited for the construction of buildings. So, in that limited space we have to construct such type of buildings which can be used for the multiple purposes such as parking, lobbies etc.

In This Project Study of Seismic Response of Multi-Storied Vertical Irregular Building due to Stiffness Irregularity was carried. Objective of this project was to study Seismic Response of Multi-Storied Vertical Irregular Building due to Stiffness Irregularity. To evaluate lateral load behavior of special moment resisting frame structure with vertical stiffness irregularities by studying the following parameters Storey Deflection, Storey Drift and Storey Shear under dynamic analysis by using response spectrum method. Comparison between building without stiffness irregularity and building with stiffness irregularity was observed. For the analysis and modeling of the structure Finite element based ETABS 2016 (V 16.0.2) software was used.

Keyword: - Stiffness, Storey Deflection, Storey Drift, Storey Shear, ETABS 2016 (V 16.0.2).

1. INTRODUCTION

Irregular buildings constitute a large portion of the modern urban infrastructure. The group of people involved in constructing the building facilities, including owner, architect, structural engineer, contractor and local authorities, contribute to the overall planning, selection of structural system, and to its configuration. This may lead to building structures with irregular distributions in their mass, stiffness and strength along the height of building. When such buildings are located in a high seismic zone, the structural engineer's role becomes more challenging. Therefore, the structural engineer needs to have a thorough understanding of the seismic response of irregular structures. 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 render the dynamic characteristics of these buildings different from the regular building.

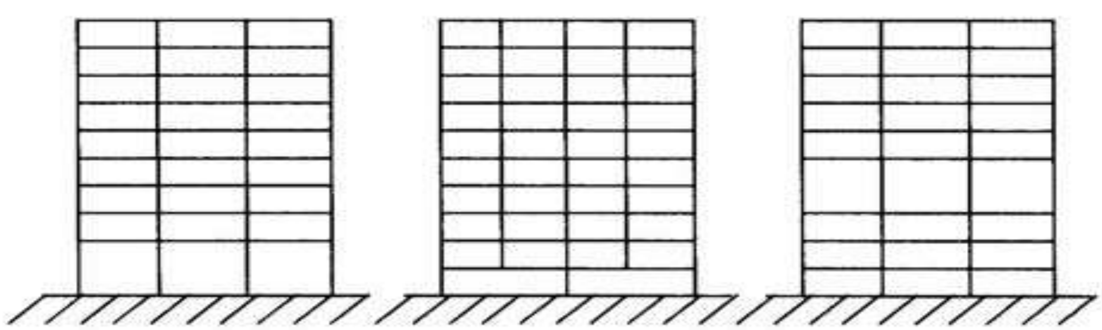

Fig.1 Stiffness irregularity

2. LITERATURE REVIEW

S. A. Rahman and A. U. Salik (2016) studied the proportional distribution of lateral forces evolved through seismic action in each storey level due to changes in mass and stiffness of frame on vertically irregular structures. They also studied effect of mass and stiffness irregularity of G+10 storeyed vertical geometric irregular building by using finite element method-based software. Two methods of analysis, namely linear static and linear dynamic analysis are used to evaluate response of the structure in the form of storey shear, storey displacement and storey drift. Responses are plotted and compared, and conclusions have been made from the results.

C. Dya and C. Oretaa (2015) found that one of the primary concerns in vertical irregularities is the localization of seismic demand. For soft story buildings, the concentration of seismic demand is where the soft story is located. In the study, it is assumed that the properties and number of structural members for each story is constant. Thus, soft stories may be defined by simply determining the height of the stories. The study is also limited to a single soft story at the first story. The severity of the soft story is varied by increasing the height of the soft story. A static pushover analysis is utilized to determine the performance of the building under different irregularity conditions. The output of the study may be used to improve existing seismic risk assessments. Due to the limitations of a static pushover analysis, the study only covers low-rise buildings as permitted by the NSCP (National Structural Code of the Philippines). Though it is recognized that a dynamic time history is more suitable, a pushover analysis is sufficient due to the preliminary assessment nature of the objective.

Hema Mukundan and S. Manivel (2015) investigated the effect of irregularity by creating openings in shear wall and varying the thickness of shear wall, along the storeys and they found that the provision of shear wall in building has been effective and economical. In this paper, a 10 storey building in zone IV is presented to reduce the effect of earthquake using reinforced concrete shear wall-framed structures in the building. The results were tabulated by performing response spectrum analysis using ETABS version 9.7.4 in the form of maximum storey displacements, base shear reactions, mode shapes and storey drifts.

3. OBJECTIVES

To evaluate lateral load behavior of Multi-Storey building and special moment resisting frame structure with vertical stiffness irregularities by studying the following parameters:-

- To study irregularity in structures mainly stiffness irregularity.
- To evaluate lateral load behavior of special moment resisting frame structure with vertical stiffness irregularities by studying the following parameters:-
  - Storey Deflection
  - Storey Drift
  - Base Shear
- To study these response parameters of structure under the dynamic analysis.

4. STRUCTURAL MODELLING

Frame 1 – Base Model

The basic model consists of (G+20) vertically geometric irregular structure with stilt at basement. It has 11 bays of 5 m in both X and Y directions. After each four consecutive stories, the size of model is reduced by 5 m in both X and Y directions. The typical storey height is 3.0 m, ground storey height is 3.5 m, and foundation height below the plinth level is 3.0 m.

Frame 2 – Base Model with stiffness irregularity at ground storey

Frame 3 – Base Model with stiffness irregularity at 10^{th} storey

Frame 4 – Base Model with stiffness irregularity at 20^{th} storey

Table-1:- Preliminary data for building

Length x Width	55 m x 55 m
No. of Storey's	21 (G+20) storey
Beam size	230 mm x 600 mm
Column size	300 mm x 600 mm 300 mm x 800 mm 300 mm x 1000 mm 300 mm x 1200 mm 300 mm x 1500 mm
Slab thickness	150 mm
Thickness of Wall	230 mm
Grade of Concrete and steel	M 30 & Fe 500
Length of each bay	5 m
Floor Finish	1 Kn/m^2
Live Load	2 Kn/m^2 for intermediate floor 1.5 Kn/m^2 for terrace floor
Waterproofing	3.5 Km/m^2
Seismic Zone	III
Zone Factor	0.16
Response Reduction Factor	5
Importance Factor	1
Soil Type	II

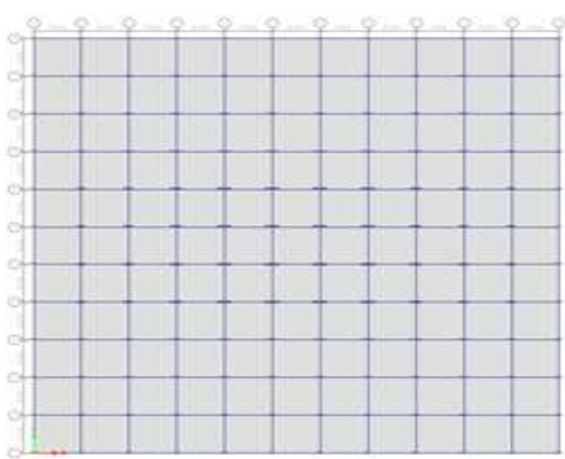

Fig.2 Plan of building in ETABS Software

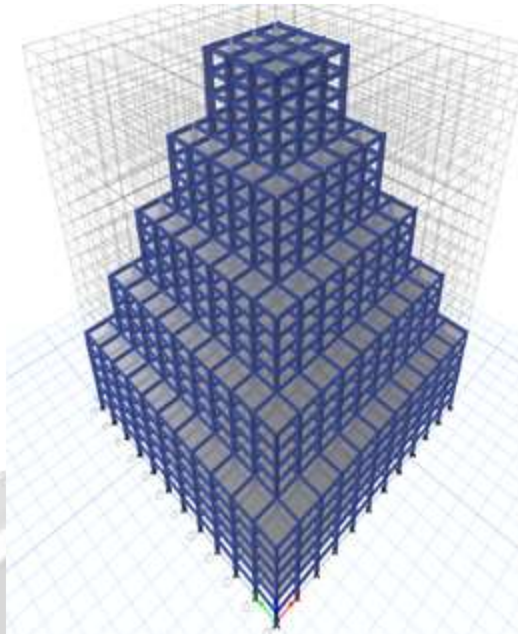

Fig.3 3-D view of building in ETABS Software

5. RESULTS AND DISCUSSION

Response structure analysis was performed on vertical irregular buildings using ETABS Ultimate 16.0.2. Four frames are analysed by using software. In this chapter results of dynamic analysis of g+20 building are represented. The structural results like storey shear, storey moments, storey drift, storey displacement of all four frames at each floor is calculated and are represented in tabular format. By using this tabular results graphs of particular result with storey are plotted, this chapter consist graphical representation of all the results. This chapter also consist comparative study of all results with graphical representation. So, variation in results of frames is clearly seen from graphs.

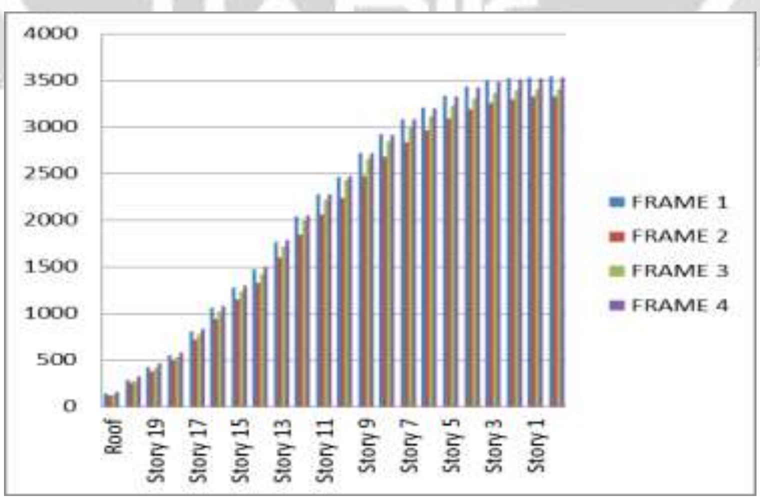

Fig.4 Story vs Storey Shear

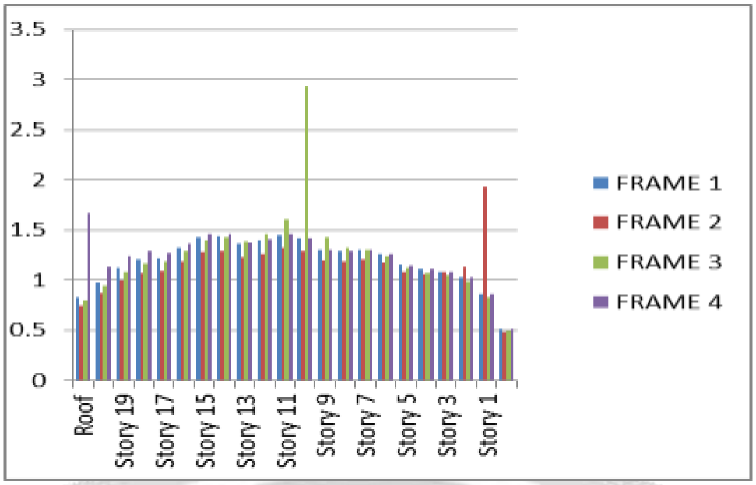

Fig.5 Story vs Storey Drift

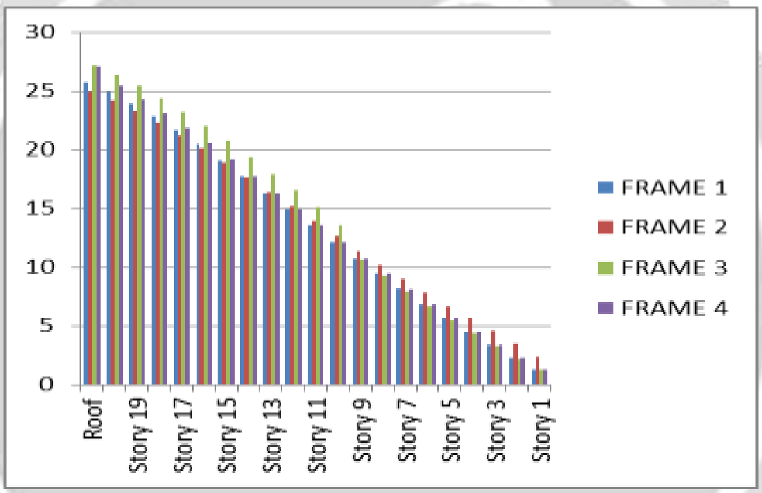

Fig.6 Story vs Storey Drift

6. CONCLUSION

After analyzed all the frames results in the form of storey displacement, storey drift and storey shear are evaluated and compared. The following conclusions are made from the obtained results.

- Vertical stiffness irregularity at a storey in a building causes increase in storey drift at that storey, while buildings without stiffness irregularity perform well for lateral loads.
- Sudden change in storey height causes change in structure results.
- Storey displacement in particular floor where stiffness irregularity introduced at that floor sudden change in displacement value.
- The analysis proves that irregularities are harmful for the structures and it is important to have simpler and regular shapes of frames as well as uniform load distribution around the building.

- Frame 4 i.e stiffness irregularity at uppermost floor performs better as compared to the frame 2 and frame 3.
- So, When there is stiffness irregularity in the model of a structure, it should not be provided at ground floor and for the intermediate floor. Stiffness irregularity may be provided in top floor levels.
- The analysis proves that vertically irregular structures are harmful and the effect of stiffness irregularity on the vertically irregular structure is also dangerous in seismic zone. Therefore, as far as possible irregularities in a building must be avoided. But, if irregularities have to be introduced for any reason, they must be designed properly following the conditions of IS 1893-part-1: 2002 and IS- 456: 2000, and joints should be made ductile as per IS 13920:1993.
- The open first storey is an important functional requirement of almost all the urban multi-storey buildings, and therefore it cannot be eliminated. Alternative measures need to be adopted for this specific situation. Increasing the stiffnesses of the first storey such that the first storey is at least 50% as stiff as the second storey, i.e., soft first storeys are to be avoided and providing adequate lateral strength in the first storey.

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