Dynamic Behavior of High Rise RC Building with A Vertical Irregularities

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***Abstract*— Earthquake damages are caused due to deficiency in few aspects such as, the building with irregularities, soft storey, insufficient lateral strength, structural behavior between the building and the ground. In Modern Urban Infrastructure, irregular structure constitutes a larger portion. Also, it is the major characteristics which affect the structure during earthquake. Irregular Structures are those which have discontinuity in geometry, distribution of mass, stiffness. This project deals with an analytical study of a Stiffness irregularity i.e., soft storey behavior of a simple high-rise building under the dynamic loads. The analysis is carried out with response spectrum. Tall building is considered having stiffness irregularity, i.e., making different floors as a soft storey and masonry wall is used for stiffening the other floors. The main parameters are focused on time period, storey drifts, storey displacement, storey stiffness. The bare frame possesses high displacement and the risk of deflection during earthquake is high. Hence providing the lateral load resisting unit is important to minimize the risk of failure. Infill walls with openings have weak performance compared to the walls without openings. Anyhow, some portion of openings can be provided which will be less effective to earthquake forces. Since stiffness is directly proportional to the modulus of elasticity of the infill walls, material property and quality of this infill will vary the seismic responses of the structure. Displacement resistance and controlling the drift can be achieved by the addition of infill walls in turn, improves the stiffness of the structure.**

Keywords—Tall building, Soft Storey, Storey drift, Storey Displacement etc.

I. INTRODUCTION

Due An Earthquake is the most natural disaster in which shaking of the earth's surface takes place. Ground rupture and ground shaking are the most vulnerable effects creates by earthquakes, resulting in less or more severe destruction to building and other rigid infrastructure. Though many studies and experiments are done about earthquake, it is difficult to avoid the structure undergoing damage or failure during this distinctive shaking. Earthquake damages is caused due to deficiency in few aspects such as, the building with irregularities, soft storey, insufficient lateral strength, structural behavior between the building and the ground (type of foundation used).

IRREGULAR STRUCTURES

In Modern Urban Infrastructure, irregular structure constitutes a larger portion. Also, it is the major characteristics which affect the structure during earthquake. Irregular Structures are those which have discontinuity in geometry, distribution of mass, stiffness. As per IS Code 1893 (Part 1):2002, irregularities are classified as Plan Irregularities and Vertical Irregularities.

Soft storey is one of the reasons for the failure of the structure during earth shaking. It is also the Stiffness defect which comes under vertical Irregularities. The recent trend is to construct the high rise building with an open ground floor which is used as a parking area or for any other utilities. These structures are usually designed as framed structure, having a masonry wall at the upper floors. This wall makes the upper floors to be stiffer against the lateral loads in compared to ground floor and the building is performed as a soft storey. According to IS 1893:2002 (part 1), Soft storey is in which the lateral stiffness will be less than 70% of the stiffness in the above storey or it will be less than 80% of the average lateral stiffness of other above 3 story's.

The code suggests following considerations for a building with soft storey. (Page 27)

➢ Special arrangements are done to make the lateral strength and stiffness of the soft storey more.

➢ Members are designed according to the analysis carried out, i.e., dynamic analysis.

➢ after the analysis is over, the beams and columns should be designed to satisfy more than 2.5 times of the obtained moments and shear.

➢ Apart from the above column design, shear wall should be placed symmetrically on both sides of the building.

➢ These walls to be designed for 1.5 times the lateral storey shear force.

II. OBJECTIVES

This paper deals with an analytical study of a Stiffness irregularity *of the building structure i.e.* soft storey behavior of a simple high-rise building under the dynamic loads. Tall building is considered having stiffness irregularity, i.e., making different floors as a soft storey and masonry wall is used for stiffening the other floors. The building will be modeled and designed using ETAB V18 software and dynamic analysis are carried out.

The main parameters are focused on time period, storey drifts, storey displacement, and storey stiffness.

III. ANALYSIS AND PROBLEM DESCRIPTION

An RCC building of 50mX30m is considered having a special moment resisting frame of 35 storeys. ETABS V15.2 is the software used for analyzing the frame. Inputs are mentioned below.

TABLE I. DETAILS OF THE MODEL

Sl. No	*Description*	*Details*
1	Storey height	Base- 4.5m
		Typical- 3m
2	Materials	Steel, Concrete and masonry
3	Codes	IS 456:2000.
		IS 875-1987 (Part II) - Live Loads/ Design Loads,
		IS 875 (Part III): 1987 - For Wind Loads
		IS 1893 (Part 1): 2002 – For Earthquake Designing

TABLE II. LIVE LOAD DETAILS

SL. No.	*Type of Loads*	*Floor*	*Details*
1	Live Load	Typical floor Terrace Floor	2kN/m² 1.5kN/m²
2	Super Dead Load (SDL)	Typical floor Terrace Floor	1kN/m²

Case 1: Bare Frame Model (BFM)
Case 2: Building with Infill walls and soft storey effect at different floors

Model 1: Soft storey at 1st/ Ground Floor and other floors having infill walls. (M1)

Model 2: 10th floor having soft storey effect with others as infill walls. (M2)

Model 3: Building with soft storey effect at 20th floor and remaining floor are infill walls. (M3)

Model 4: 30th storey is without infill walls and rest are having infill walls (M4)

Model 5: 35th/Terrace floor are soft storey and all others with infill walls. (M5)

Case 3: Buildings having infill walls with the openings for above all the 5models. (OM1, OM2,OM3, OM4, OM5)

A. Bare frame Model

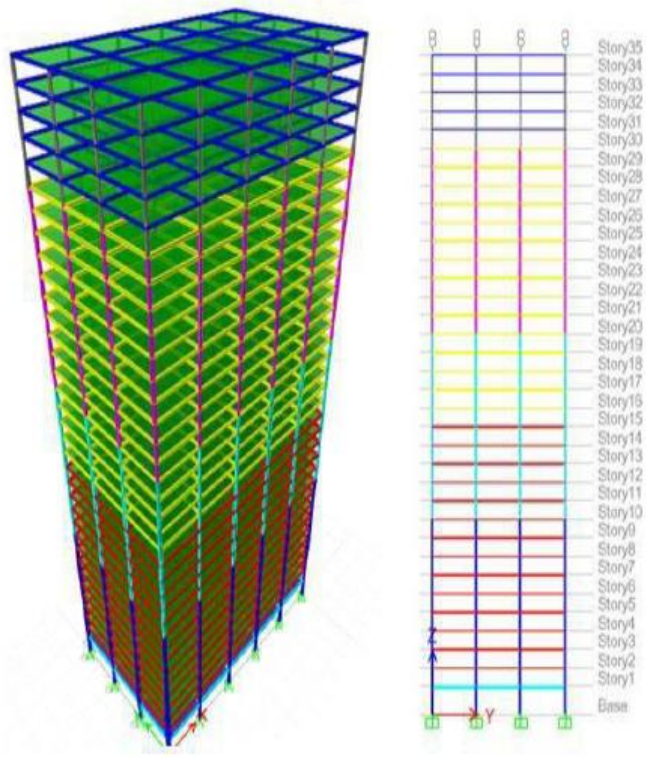

Fig 6.1. 3D View of the Bare Frame (BFM)

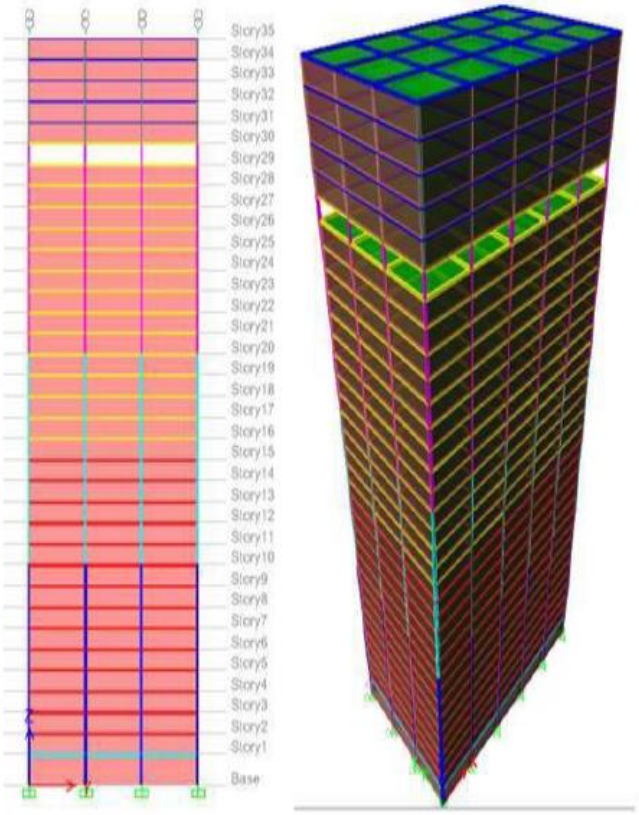

Fig 6.17. Elevation and 3D model of the soft storey at 30th floor (M4)

B. Results

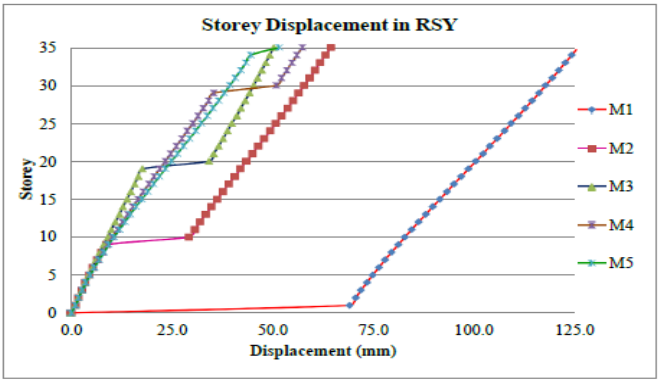

Fig 7.3. Displacement for different Soft Storey levels in Y-Direction

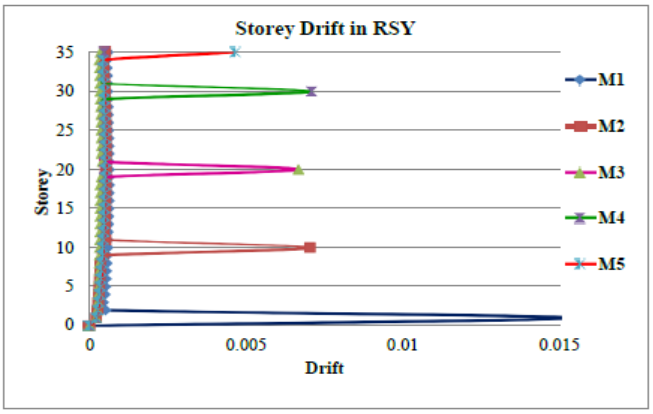

Fig 7.7. Drift for different Soft Storey levels in Y-Direction

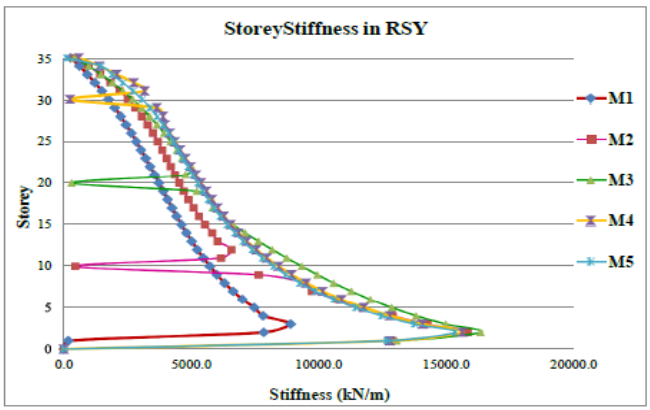

Fig 7.11. Stiffness for different Soft Storey levels in Y-Direction

IV. CONCLUSION

The bare frame possesses high displacement and the risk of deflection during earthquake is high. Hence providing the lateral load resisting unit is important to minimize the risk of failure.

➢ Open ground floor (M1) is having more displacement value compared to other models with different soft storey levels. The failure of the structure with open ground floor will be more during earth's shaking. Hence, soft storey effect at ground floor is not preferable.

➢ Due to soft storey, sudden increase in the drift can be seen in that floor. Stiffness will be more for the storey having infill walls and bare frame is weak in stiffness.

➢ Infill walls with openings have weak performance compared to the walls without openings. Anyhow, some portion of openings can be provided which will be less effective to earthquake forces.

➢ The approach of conventional design -in which assumption is made that loads are carried by frame and infill walls act like divider, may not be suitable for structure present in the high seismic zone consisting of the open ground floor which possess soft storey effect.

➢ Soft storey should be checked carefully and then the structure should comprises of sufficient stiff by means of shear wall or braces.

➢ Lateral strength can be increased by two ways, by providing stiffer columns or by constructing infill walls at particular floor where there is a deficiency in stiffness.

➢ Arrangement and placing of the infill walls are most important to minimize the soft storey effect.

➢ Since, stiffness is directly proportional to the modulus of elasticity of the infill walls, material property and quality of these infill will vary the seismic responses of the structure.

➢ Displacement resistance and controlling the drift can be achieved by the addition of infill walls in turn, improves the stiffness of the structure.

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