Study on Seismic Analysis of Multistorey RCC Building with Structural Irregularities

Fousiya Zaker
B Tech Department of Civil Engineering Mangalam College of EngineeringKerala, India

Jesmi Thaha
B. Tech Department of Civil Engineering Mangalam College of Engineering
Kerala, India

Sharon Teressa Biju
Department of Civil Engineering Mangalam College of Engineering
Kerala, India

Dony Stanly,
B. Tech Department of Civil Engineering Mangalam College of Engineering
Kerala, India

***Abstract*—Design of buildings with seismic resistance is gaining much importance due to increased safety and structural performance concerns. Seismic analysis can be performed by linear static analysis, nonlinear static analysis, linear dynamic analysis and nonlinear dynamic analysis. The present study, the response spectrum is adopted to evaluate the modal response of multi-storeyed RCC framed building with plan and vertical irregularity. The structure is been modelled and analysed utilizing ETABS V18 and various seismic responses of the building are calculated and the building is redesigned for seismic resistance. In this paper**

Keywords—Dynamic analysis; earthquake; tall buildings; response spectrum

1. INTRODUCTION

Earthquakes have the potential for causing the great damages. Earthquake forces are random and unpredictable. Earthquake disaster risk index report published in 2019 presents that about 60% of the land area of our country is susceptible to damaging levels of seismic hazard. Safe building construction practices can certainly reduce the magnitude of damage and loss. The behaviour of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building.

1.1 Structural Irregularities in Buildings

IS 1893(Part1), 2016 describes plan and vertical irregularities in building to be considered for seismic analysis. For each irregularity, certain limits are defined in the code as well as further action is detailed out whenever the irregularity exceeds the defined limits. Following are the types of plan and vertical irregularities in buildings.

Plan irregularities:

- Torsional irregularity
- Re-entrant corners
- Floor slabs having excessive cut-outs or opening
- Out-of-plane offsets in vertical elements
- Non-parallel lateral force system

*Vertical irregularities***:**

1. Stiffness irregularity (Soft storey)
2. Mass irregularity
3. Vertical geometric irregularity
4. In-plane discontinuity in Vertical elements resistinglateral force
5. Strength irregularity (Weak storey)
6. Floating or stub columns
7. Irregular modes of oscillation in two principal plandirections

TABLE 1

TYPE OF IRREGULARITY	CLASSIFICATION	LIMITS
Mass (M)	Vertical Irregularity	Mi<1.5ma
Stiffness (S)	Vertical Irregularity	Si<Sad
Vertical Geometry (VG)	Vertical Irregularity	Vg<1.25vga
Reentrant Corner(R)	Horizontal Irregularity	Ri<15%
Torsion (T)	Horizontal Irregularity	D Max<=1.5 D Avg

1.2 Type of seismic analysis

EQUIVALENT STATIC ANALYSIS: The equivalent static analysis procedure is essentially an elastic design technique. It is, however, simple to apply than the multi-model response method, with the absolute simplifying assumptions being arguably more consistent with other assumptions absolute elsewhere in the design procedure.

RESPONSE SPECTRUM ANALYSIS: This approach permitsthe multiple modes of response of a building to be taken into

account. This is required in many building codes for all except for very simple or very complex structures. The structural response can be defined as a combination of many modes. Computer analysis can be used to determine these modes for a structure. For each mode, a response is obtained from the design spectrum, corresponding to the modal frequency and the modal mass, and then they are combined to estimate the total response of the structure. In this the magnitude of forces in all directions is calculated and then effects on the building is observed

TIME HISTORY ANALYSIS: Time history analysis techniques involve the stepwise solution in the time domain of the multi degree-of-freedom equations of motion which represent the actual response of a building. It is the most sophisticated analysis method available to a structural engineer. Its solution is a direct function of the earthquake ground motion selected as an input parameter for a specific building. This analysis technique is usually limited to checking the suitability of assumptions made during the design of important structures rather than a method of assigning lateral forces themselves.

2. AIM AND OBJECTIVES

1.To analyse structures using ETABS software for static load
2. To investigate the behaviour of building under dynamic loading.
3. To study the effect of irregularity on seismic analysis
4. To study building responses such as displacement drift, base shear & time period of irregular buildings
5. To validate the method to analyse a RC structure.
6. Performing response spectrum methods to analyse typical irregular RC structure

3. METHODOLOGY AND VALIDATION

Geometry of building

It is important to understand the area, where the structure is being built. The model is of a G+7 multistorey RCC building with infill walls and soft storey. In the present study seismic zone-V of IS 1893 is taken as study area with soil type of II. For the initial study and validation of the methodology an RC framed structure with following details is selected. The structure is 30m in x-direction & 20m in y-direction, with columns spaced at 5m and 6m respectively. The storey height between two floors is 3.0m with beam size 300*650 and column size 350*600m, and also the slab thickness is taken as 0. 15m.Shape of the building for all the cases is shown in figure.1 and figure 2.

Table 2 DETAILS OF BUILDING

Elements	Dimensions
Zone	V
Soil Type	II
Importance Factor	1
Building Occupancy Type	A
Damping Ratio of Building	0.05
Height	24.5m
Plan Area	600m^2

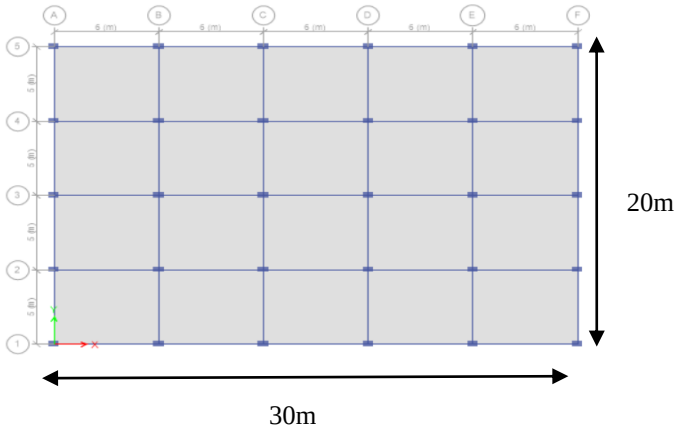

Figure 1 PLAN OF BUILDING

FE Model

The popular software package (ETABS v 9.7.4) has been used as finite element modelling software. The building components are modeled using frame elements for beams and columns and shell elements for edge supported slabs respectively. In the present project, the foundations included in the FE model have not been applied beneath the shallow footing. For simplicity fixed supports are used in all directions.

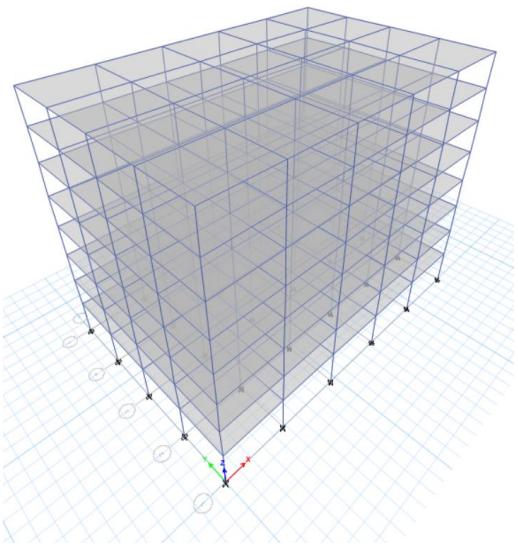

Figure 2 3-D MODEL OF BUILDING

Loads

Loads are applied as per IS 875. The outer and walls are masonry of 230 mm thickness and inner walls are masonry of 115mm thickness. The slab is 150 mm thick with a self-weight of 25Kn/m3. The dead loads and live loads are applied as per the following Table 3

TABLE 3 LOADS APPLIED

Load Type	Magnitude
Dead Load due to outer walls	6.45 kN/m
Dead Load due to inner walls	4.75 kN/m
Dead load due to parapet	2.25 kN/m
Live load on all stories except roof	2 kN/m2
Live load on roof	1.5 kN/m2

Analysis

For the present study linear analysis is only considered. For buildings with height less than 40 m seismic analysis is mainly done using response spectrum analysis (IS 1893)

4.RESULTS AND DISCUSSIONS

The present model is compared with the original model in terms of maximum storey displacements, time period and the results are as follows

FIG. 3 MAXIMUM STOREY DISPLACEMENT IN X DIRECTION

TABLE 4 COMPARISON OF MAXIMUM STORY DISPLACEMENT

Results Obtained from present study (in mm)	Results from Reference model (in mm)
66	57
63	55
59	52
52	48
43	42
33	35
22	26
11	16
0	0

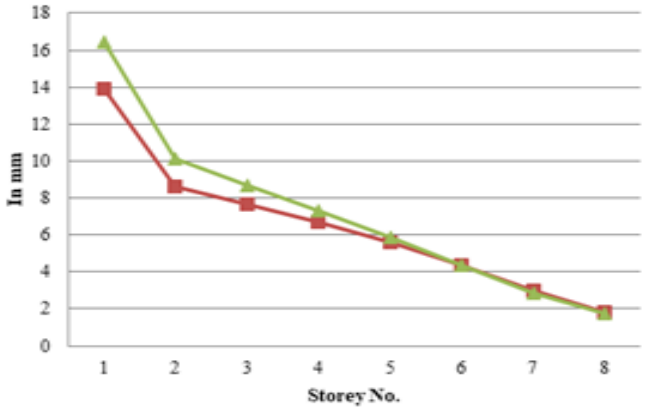

Figure 4 COMPARISON OF MAXIMUM STOREY DRIFT IN X DIRECTION

5. CONCLUSIONS

The seismic performance of the reinforced concrete G+7 multi-storeyed building for Frame with infill walls and soft storey is studied. The seismic performances were estimated through the comparison between different response like storey displacements, story drift etc. by Response Spectrum method of analysis.

(i) The increase in the displacement along the height in X dir. decreases as the height increases with the maximum increase in displacement for ground story.

(ii) The increase in drift is maximum for ground floor and reduces with height.

REFERENCES

[1] Soundarya R., Reddy K.G., Harshitha, Prathima, and Guruprasad, (2014). "Seismic Analysis of Symmetric RC Frame Using Response Spectrum Method and Time History Method." International Journal Of Scientific Research And Education, 2(3), 483-499

[2] Bansal H., 2014. "Seismic Analysis and Design of Vertically Irregular RC Building Frames." International Journal of Science and Research (IJSR), 3(8), 207-215

[3] Chopra A. K, Dynamics of structures theory and applications to earthquake engineering, PrenticeHall, Englewood Cliffs, N.J. 1995.

[4] Dubey S.K, SangamnerkaPrakash, AgrawalAnkit, 2015 "Dynamic analysis of structures subjected to earthquake load", International Journal of Advance Engineering and Research Development, vol.-02, issue-09, ISSN:2348-4470, Sep

[5] Patil A.S, Kumbhar P.D, 2013, "Time history analysis of multistoried RRC building for different seismic intensities", International Journal of Structural and Civil Engineering Research, vol.-02, issue-03, Aug.