Effect of Lateral Load in High Rise Structure with Plan Irregularity

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Abstract- This paper is concerned with the comparison of seismic behavior of RC buildings having plan irregularity. The objective of the project is to carry out Static Analysis (Equivalent Lateral Force Method) and Dynamic Analysis (Response Spectrum Method) of plan irregular RC building frames according to IS 1893:2016 (Part 1) code. In this study, 3D analytical model of G+30 storied buildings have been generated for symmetric and asymmetric building models and analyzed. ETABS (version 2017) software is used to perform the modelling. G+30 storey building is considered for the analysis in the seismic zone III as per IS 1893:2016 (Part 1) code. Results of this analysis are discussed in terms of base shear, lateral displacement, storey drift, storey stiffness, modal periods, eccentricity, modes shapes and modal frequencies**.**

Keywords: Asymmetric Structure, Response-spectrum Analysis, Storey Deflection, Storey Shear, Base Shear, Eccentricity.

1.1 INTRODUCTION

Earthquakes are among the most unpredictable natural hazards. At whatever point rocks or arrangements inside the earth are out of nowhere get disturbed, a lot of energy is released, this energy would have created over drawn out intervals as a result of structural exercises inside the earth. The ensuing vibrations result from the release of this energy spread out all over from the source where unsettling influence happened. A Quake is the section of these vibrations. Quakes occur with no notice. Seismic tremors may prompt death toll and structure destruction.

1.2 Tall Structures

The word 'tall' is relative and tall structures can't be portrayed as far as story numbers or tallness. As it relies upon individual's or network's acknowledgment it may not be conceivable to give general definition for tall structures. As indicated by structural designer's point of view, a tall structure might be characterized as one that because of its stature is influenced by lateral forces, for example, wind and earthquake to a degree that they become critical part in the design of structures.

1.3 RESPONSE SPECTRUM ANALYSIS

This strategy allows thought to be given to the different strategies for structure response. This is needed for with or without of simple or extraordinarily complex frameworks in various development laws. The auxiliary reaction could be represented as a mixture of different modes. An evaluation of ETABS programming can be used to pick certain modes for a system. A response is obtained for each mode from the arrangement run, identifying with the particular recurrence and the secluded area, and sometime later they are united to check the structure's overall response. In this the magnitude of the forces is overcome all over and the consequences on the system are presented a while later.

1.4 CONCEPT OF SYMMETRICAL AND ASYMMETRICAL CONFIGURATION

To achieve fine in a tremors, structure ought to have four principle properties in particular basic and standard setup and sufficient horizontal Strength, solidness and flexibility. Current quakes codes describe assistant structure as either standard or unpredictable to the extent degree measurement and state of the structure, plan of the basic and unimportant parts inside the building, scattering of mass in the structure, etc. A structure will be considered as flighty for the inspirations driving this ordinary, if in any occasion one of the circumstances is relevant as indicated by IS 1893(part1):2016

A. PLAN IRREGULARITY

Deviated buildings are those in which seismic response isn't simply translational yet also torsional, and is an eventual outcome of firmness just as mass capriciousness in the construction. Irregularity may in sureness occur in an apparently regular construction because of weakness in the assessment of focal point of mass and firmness, botch in the assessment of the segments of basic component.

B. VERTICAL IRREGULARITY

Perpendicular abnormality results from the potholed dissemination of mass, power along the height of a construction. Mass and Stiffness abnormality results from a sudden change in mass and firmness between adjoining floors exclusively.

1.5 OBJECTIVES

Main objective is to understand seismic response of both storey framed building structure in terms of displacements and drifts. The parameters considered are stiffness and eccentricity for building which is symmetrical in plan and asymmetrical in plan.
To attain the above said objectives the following tasks have been carried out

1. Modal analysis is carried out for the two buildings (G+30) RCC models by considering two types of structure plans viz Symmetrical, Asymmetrical and results of time periods and frequencies are tabulated, plotted and compared.
2. Modal masses for the modes considered are tabulated and also mode shapes are plotted for principal torsional modes.
3. By observing the seismic zone – III, the equivalent lateral force method (static analysis) and response spectrum analysis (dynamic analysis) for a 30-story structure is conducted.
4. Displacements and drifts results obtained from static analysis and dynamic analysis are tabulated, plotted and compared.
5. Every floor size of the columns is reduced by 10mm while going from base to 30th floor.

2.1 LITERATURE REVIEW

1.Pardeshi Sameer and Prof. N. G. Gore (2016)presented paper on "Study of seismic analysis and design of multi storey symmetrical and asymmetrical building"
In this study, ETABS software was used. G+15 storied symmetric and asymmetric building models were constructed. Response spectrum analysis (RSA), Time history

Analysis (THA) and the ductility based design using IS 13920 was done. Analysis results of irregular structures was compared with regular structure. From all the outcomes acquired it was inferred that the configurations of the building plan had a significant effect on the building's seismic response in terms of displacement, storey drift and storey shear. Standard structural frames and symmetrical building undergo a smaller base shear than irregular mass building frames. Time history analysis values of base shear and top storey displacement were lower than an examination of the response spectrum.

2. B.Rajesh et al. (2015) presented paper on "Static and Dynamic analysis of reinforced concrete building with plan irregularity". ETABS software was used. 4 models of G+15 storey building was generated. 1 was regular and 3 were irregular in plan. Authors concluded that a maximum displacement value was less for dynamic analysis. The base shear and storey drift values was increased gradually while going higher from bottom storey to top storey in both static and dynamic analysis. Base shear esteems got by manual examination were marginally higher than programmed investigation. Dynamic examination was required for tall building structure. Regular building had less lateral drift, more storey drift and baser shear capacity compared to irregular building. The lower base shear came into the building in L form and the higher base shear came into the building in Rectangular shape, zone 5 and that in soft soil resulting in uneven structure. The asymmetric shape building undergoes more deformation and earthquake impact and hence normal shape building should be favoured.

3.1 METHODOLOGY

Here the study is carried out for the behavior of G+10 Storied Buildings, Floor height provided as 3.5m and also properties are defined for the building structure. The model of buildings is created in Staad.pro software. The seismic zone considered is zone V and soil type is medium. Six models of buildings are prepared. Two types geometry are adopted in this analysis- regular and H shaped plan irregular building. Three different vertical irregular building such as stepped, inverted T, U shaped are modeled in both regular and irregular(H shape) building. The modeling of building is done for Indian Seismic Zone V, IS 1893-2002. Applied loads include live load, earthquake load and dead load and they are according to IS 875 part I, part II and IS:1893-2002 respectively. Analysis is carried out by Response Spectrum Analysis using Staad.Pro Software. The analysis is carried out to determine maximum node displacement and base shear. After analysis, results are obtained in the form of graphs which are in turn observed to form conclusions.

Table 3.1 Details of the Building model

Model Description	
Geometric Properties	
Plan dimensions	24m x 24m
No. of stories	30
Height of ground storey	3.5m
Height of each storey	3m
Height of building	90.5m (G+30)
Beam size	300mm x 750mm
Slab thickness	150mm
Material Properties	
For columns	M50
For beams	M40
For Slabs	M40
Grade of Steel	
Longitudinal reinforcement	Fe500
Confinement reinforcement (Stirrups/Ties)	Fe500
Loading Details	
Live load	3 kN/m^2
Roof Live Load	1.5 kN/m^2
Floor finish	1.5 kN/m^2

Earthquake Load Details	
(I)	1.0
(R)	5
Soil type	Medium soil (Type - II)
Seismic zone	III

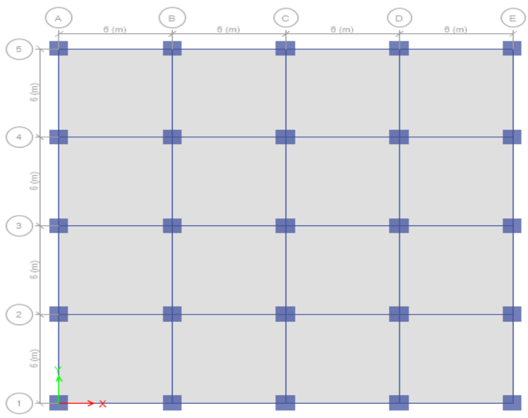

Fig 3.1 Plan of Symmetrical Model

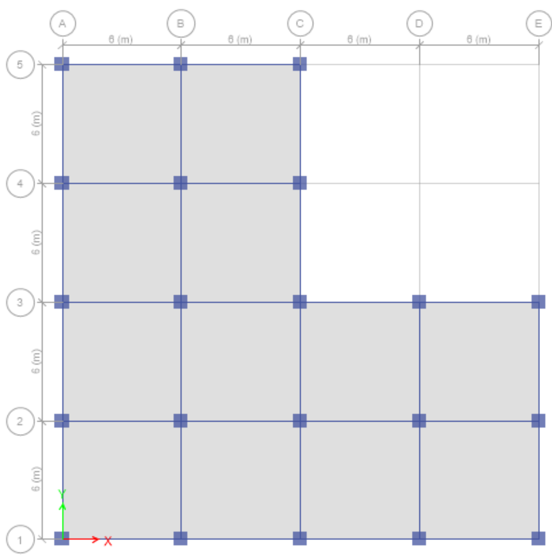

Fig 3.2 Plan of Asymmetrical Model

4.1 ANALYSIS & RESULTS

Table 4.1 Eccentricity

Static Analysis		
Load Case: EQ-X & EQ-Y		
STOREY	**SYMMETRICAL MODEL**	**ASYMMETRICAL MODEL**
	m	**m**
30	**0**	**0.7073**
29	**0**	**0.7013**
28	**0**	**0.6773**
27	**0**	**0.6537**
26	**0**	**0.6308**
25	**0**	**0.6085**
24	**0**	**0.587**
23	**0**	**0.566**
22	**0**	**0.5457**
21	**0**	**0.526**
20	**0**	**0.5111**
19	**0**	**0.4888**
18	**0**	**0.4698**
17	**0**	**0.452**
16	**0**	**0.4337**
15	**0**	**0.4163**
14	**0**	**0.4006**
13	**0**	**0.384**
12	**0**	**0.3673**
11	**0**	**0.3502**
10	**0**	**0.3326**
9	**0**	**0.3139**
8	**0**	**0.2933**
7	**0**	**0.27**
6	**0**	**0.2424**
5	**0**	**0.2086**
4	**0**	**0.1658**
3	**0**	**0.1104**
2	**0**	**0.0372**
1	**0**	**-0.0629**

Table 4.2 Storey Shear		
Static Analysis		
Load Case: EQ-X & EQ-Y		
STOREY	SYMMETRICAL MODEL	ASYMMETRICAL MODEL
	kN	kN
1	1374.326366	1068.266313
2	1374.158854	1068.134847
3	1373.493	1067.612495
4	1372.00416	1066.445014
5	1369.373744	1064.383227
6	1365.289077	1061.182913
7	1359.443268	1056.604689
8	1351.535071	1050.4139
9	1341.274034	1042.380508
10	1328.371708	1032.278975
11	1312.538531	1019.888153
12	1293.494725	1004.991169
13	1270.965468	987.3753161
14	1244.680768	966.8319353
15	1214.360206	943.1563069
16	1179.745331	916.1517928
17	1140.588369	885.6166795
18	1096.633365	851.3536724
19	1047.636273	813.1766578
20	993.3530576	770.8989115
21	933.4614064	724.2553535
22	867.8892548	673.2289015
23	796.3216628	617.560658
24	718.5293375	557.0762645
25	634.2863332	491.6041714
26	543.3699163	420.9755257
27	445.5604301	345.024058
28	340.6411597	263.5859693
29	228.3981966	176.4998186
30	108.9544257	83.88520571

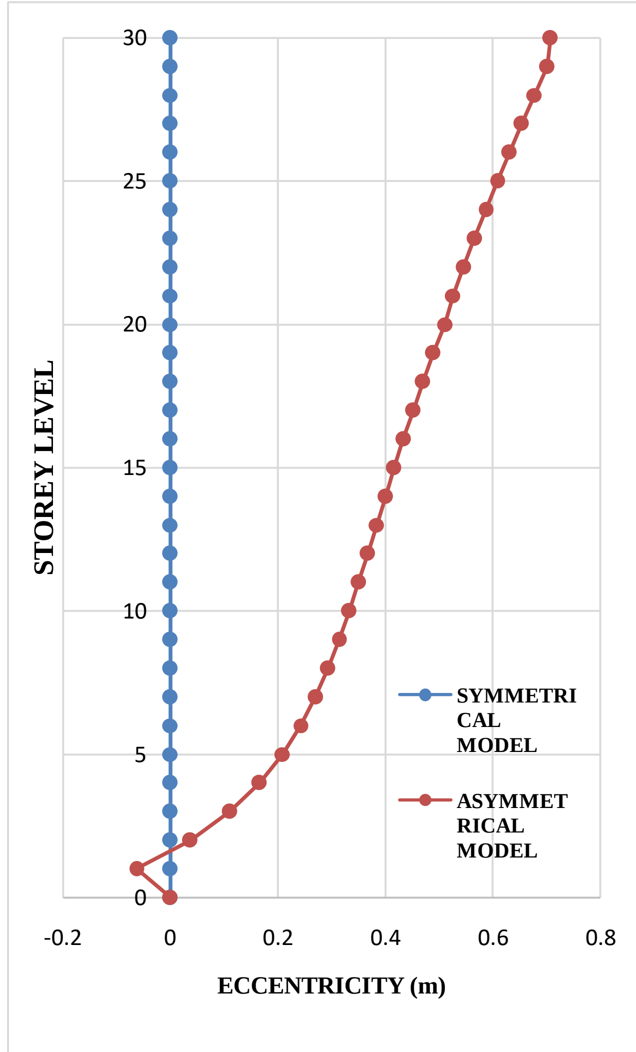

Fig 4.1 Eccentricity variation

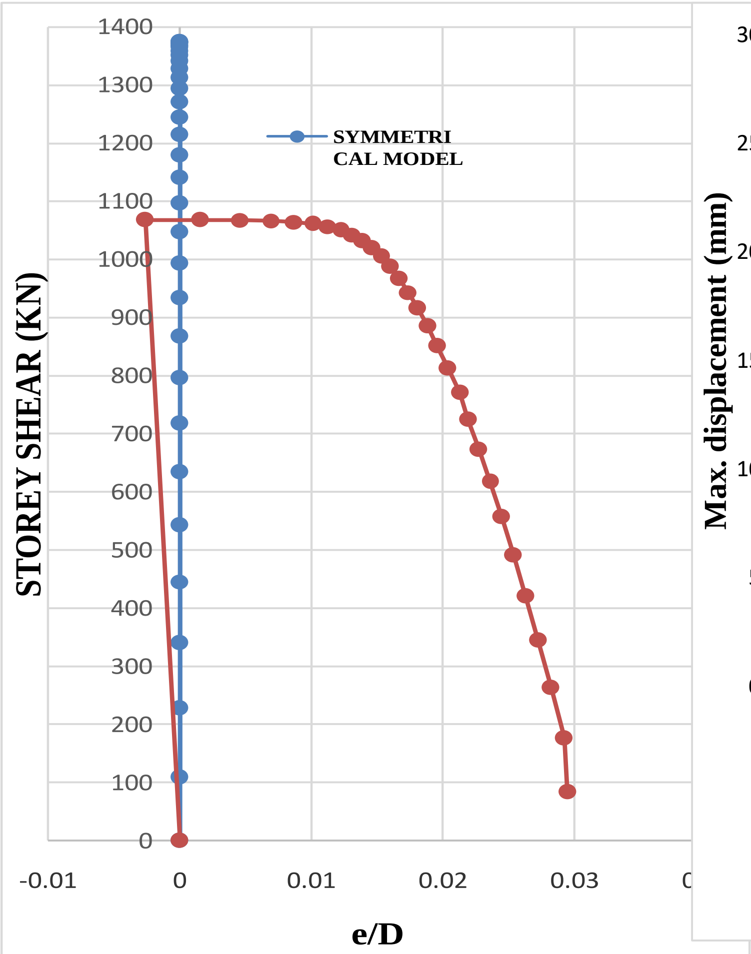

Fig 4.2 Storey Shear v/s Eccentricity/Lateral Dimension

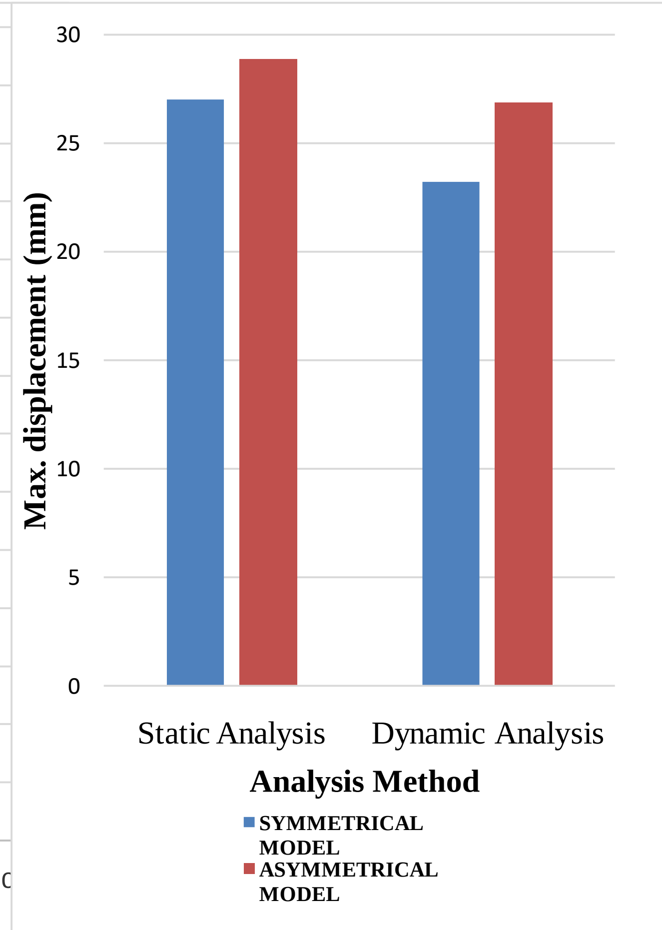

Fig 4.3 Comparison of Max. Displacement

Table 4.3 Comparison of Max. Displacement

Max. Displacement (mm)		
Method of Analysis	**SYMMETRICAL MODEL**	**ASYMMETRICAL MODEL**
Static Analysis	**27.01816304**	**28.85797112**
Dynamic Analysis	**23.2283803**	**26.87115394**

Table 4.4 Comparison of Max. Drift

Max. Displacement (mm)		
Method of Analysis	**SYMMETRICAL MODEL**	**ASYMMETRICAL MODEL**
Static Analysis	**0.000378635**	**0.000398547**
Dynamic Analysis	**0.000354463**	**0.000400126**

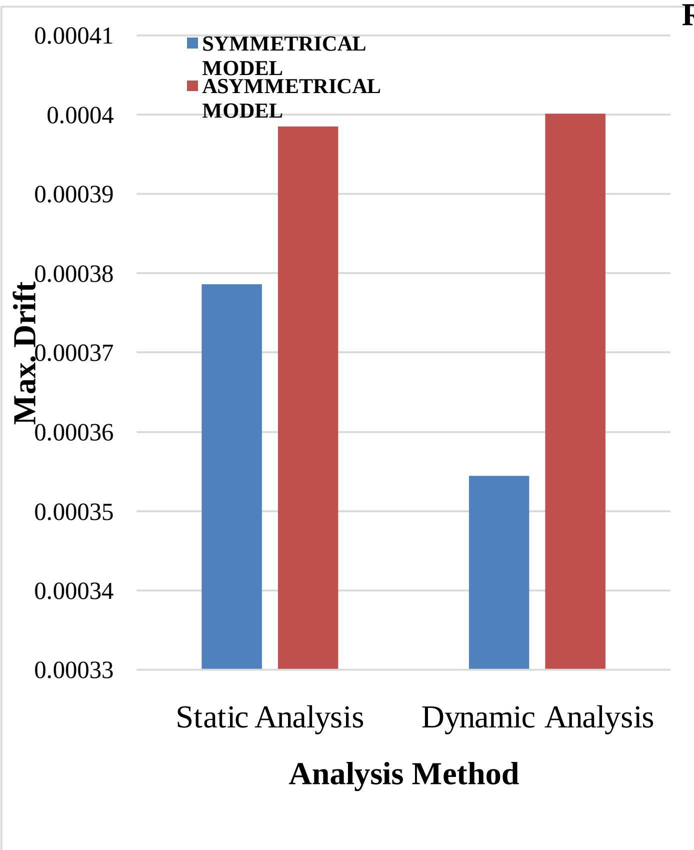

Fig 4.4 Max. Drift comparison

5.1 CONCLUSIONS

1. In Asymmetrical model structural parameters such as storey drift, lateral displacement, time period is higher as compare to Symmetrical model.
2. Asymmetrical model base shear is less as compare to Symmetrical model.
3. Mode shape 3 is the Principal torsional mode for both Asymmetrical and Symmetrical models and therefore they are in compliance with IS 1893:2016.

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