Analysis of Vertically Irregular Building under Seismic Condition in Different Aspect Ratios

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Abstract- *Seismic analysis of building is an inquisitive research topic as of now. It is because earthquake triggers lots of damage to structure, loss to valuable life, loss of finance and structure loses its integrity. Building Frame may have a solitary irregularity or a combination of irregularity; hence both of the conditions should be taken in account for a precise seismic analysis. Therefore this paper analyses the effect of various vertical irregularity in seismic zone and various aspect ratio. A 10 storey regular building frame is modified and incorporated with various vertical irregularities in elevation resulting in formation of 5 frameworks with singular irregularity and 1 with combination of irregularity. The frameworks have also been tested numerically in the presence of shear wall. All structures are stimulated by seismic loading and results are presented numerically. The analysis is carried out by Response spectrum method using STAAD PRO V8i in the embodiment of maximum nodal displacements, base shear reactions, mode shapes and storey drifts.*

Key Words: **Vertical irregularity, Mass and Setback Irregularities, Shear wall, Base shear, Maximum Displacement, Storey drift.**

1. INTRODUCTION

Earthquake is considered the most dangerous event that typically creates large destruction in building frameworks. It is reported that two sources of errors which will seriously endanger structures tend to be in relation to the ways an earthquake affects structures and construction substandard. As earthquake hits structures, it creates inertia forces which could be greatly destructive causing deformations in horizontal and shaking in vertical direction. When a structure is subjected to dynamic burden, it starts trembling, generating displacement of the building framework. Seismic zones IV & V are extreme zones.

The failure of the structure begins at the point of fragility. This weakness causes wear and tear of the building, this results in structural break down.

This occurs due to the presence of irregularities in the building framework .The behavior of any building depends on the placement of structural substances existing in it. Eccentricity of the irregular structure increases the torsional effects on the building. Location and size of structural component have appreciable effect on torsional coupling which is the main cause of damage during earthquake.

1.1 Objectives

1. To analyze building framework with different sorts of vertical irregularities in different aspect ratio.
2. Modeling and analyzing effect of various singular irregularity and combination of irregularities and shear wall on a building.
3. To analyze a 10(g+9) story building framework using STAAD PRO V8I as per IS 1893(part 1) 2002.
4. Study of different analytical information as story drift, storey shear and displacement of the building framework.

2. METHODOLOGY

A 10-storey building frame is considered with four different irregularities as stiffness, setback, mass and strength irregularities thus, we have seven building frames including the regular building frame. These frames have been analyzed using Response Spectrum method while assuming seismic zone V, importance factor 1 and response reduction factor 5.

Regular framework

This is regular structure with zero irregularity having 10 storeys' of storey height 3m and a plan of 12x12 with bay width of 3m.

Model-1 Stiffness Irregularity at 1st storey

This is a modified regular structure in which the 1st storey has been made less stiff than the rest of the storeys.

Model-2 Strength irregularity

This is also a modified regular structure in which column size of the bottom five storey's is kept same as that of the regular structure but the column size of top five storey's are changed to 350mm x 350mm.

Model-3 Setback Irregularity at 8th storey

In this framework the numbers of bays are discontinued at 8th storey of the building.

Model-4 Setback Irregularity at 5th storey

In this framework the numbers of bays are discontinued at 5th storey of the building.

Model-5 Mass irregularity

This is a variation of regular structure in which a swimming pool is introduced at the topmost floor of the building framework to create mass irregularity in the building.

Model-6 Combination structure

In this the regular structure has been incorporated with 3 different type of irregularity (setback, stiffness and strength).

3. MODELLING

The building framework consists of a plan of 12x12(m) with a bay width of 3m and the height of the framework is 30m with storey height of 3m. A total of 7 models are prepared using STAAD PRO V8I software which includes a regular structure, 5 irregular structures with single irregularity and 1 structure with combination of various vertical irregularities. Below figures represents the plan, elevation and 3-d view of the regular structure.

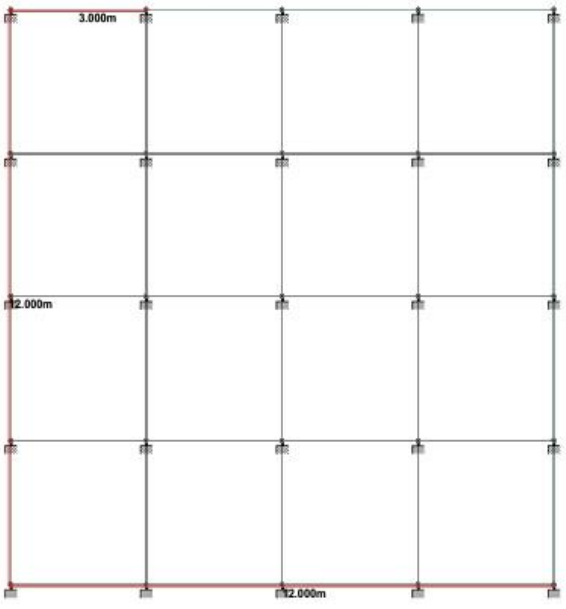


Fig -1: Plan of the building

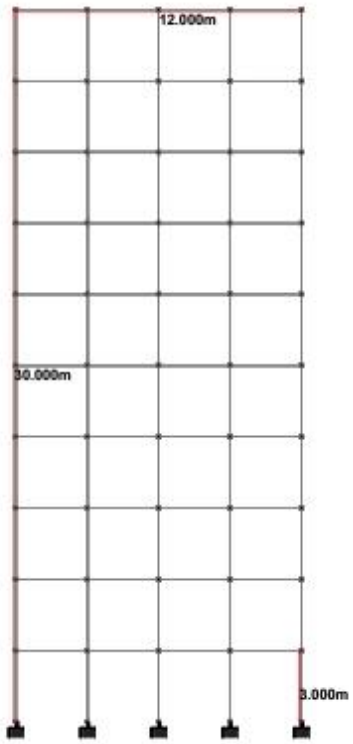


Fig -2: Elevation of the building

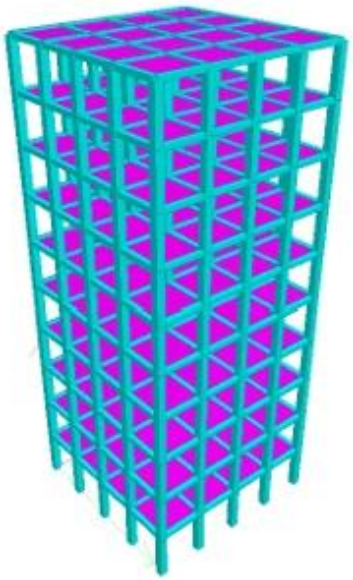


Fig -3: 3-d rendering view of the building

In this study response spectrum analysis is used to analyze all the models. The seismic parameters are as per IS 1893:2002 considering seismic zone V and response reduction factor as 5. Below are the geometric and seismic properties of the building.

a) Dimensions of structural elements

Beam size: 300mm x 300mm

Column size: 450mm x 450mm

Slab thickness: 125mm

Shear wall thickness: 120mm

b) Seismic definitions

Zone: V

Importance factor: 1

Response reduction factor: 5

Soil type: medium

Type of structure: special moment resisting frame

c) Loads on structure

Self weight of member: 2.25 KN per m^2

Element weight: 3.125 KN per m^2

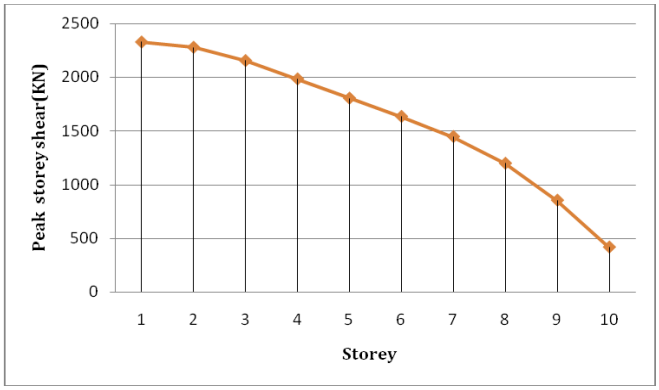
Table -1: Modal geometry as per different aspect ratio

Aspect ratio	Vertical		
	3 storey	7 storey	11storey
Horizontal			
4 bays	12x12x12	12x12x24	12x12x36
8 bays	24x12x12	24x12x24	24x12x36
12 bays	36x12x12	36x12x24	36x12x36

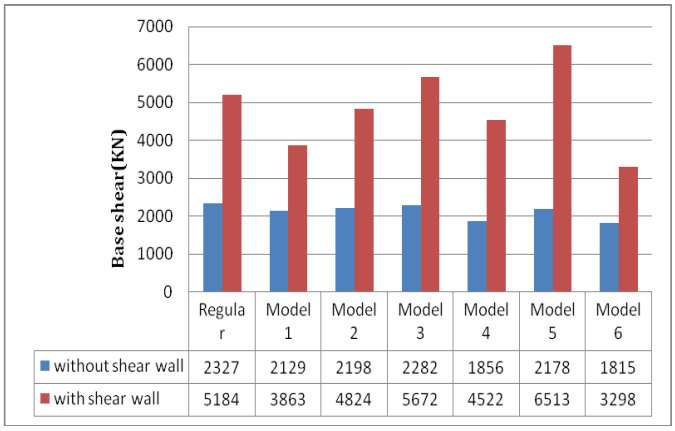
4. Results and discussion

There are a total of 7 models compared on the basis of maximum nodal displacement, Base shear and Maximum bending moment. The first three comparison of regular structure v/s structures of irregularity comprises of above parameters with and without shear wall, followed by the last three comparison on above parameters in different aspect ratio for a vertically irregular building (stiffness irregularity) with and without shear wall. Below is the storey wise base shear and drift of the regular structure.

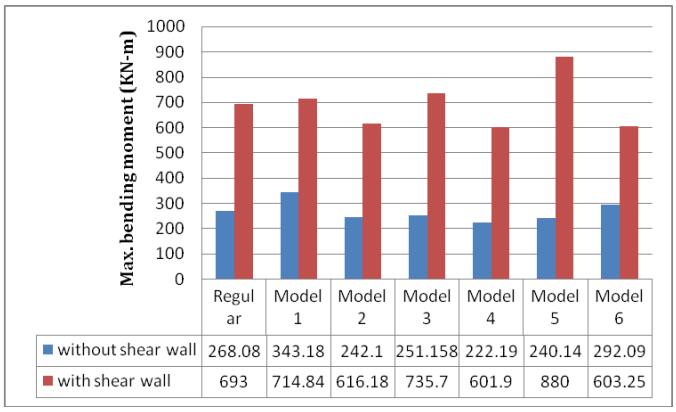
Graph-1: Graph between storey and storey drift of regular structure



Graph-2: Graph between storey and peak storey shear of regular structure

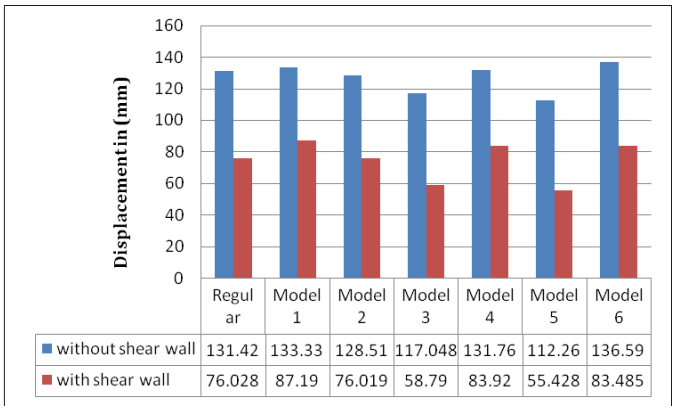


Graph-3: Comparative graph on base shear between different models with and without shear wall



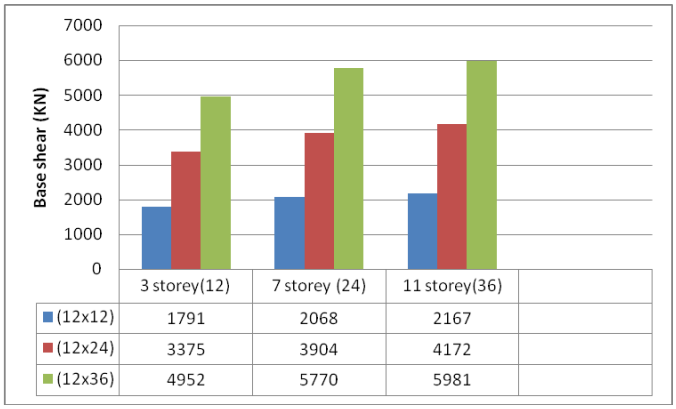
	Regular	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
without shear wall	268.08	343.18	242.1	251.158	222.19	240.14	292.09
with shear wall	693	714.84	616.18	735.7	601.9	880	603.25

Graph-4: Comparative graph on maximum bending moment between different models with and without shear wall



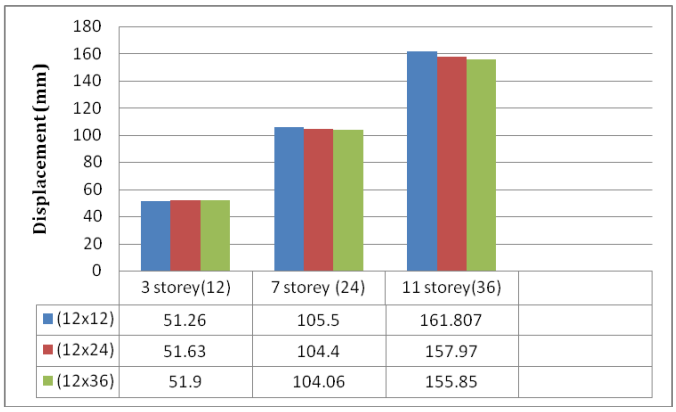
	Regular	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
without shear wall	131.42	133.33	128.51	117.048	131.76	112.26	136.59
with shear wall	76.028	87.19	76.019	58.79	83.92	55.428	83.485

Graph-5: Comparative graph on displacement between different models with and without shear wall



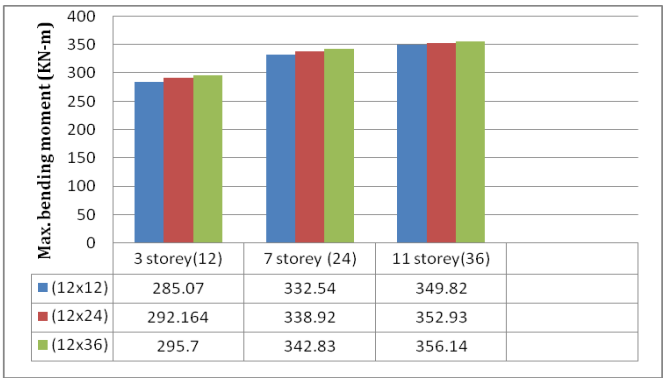
	3 storey(12)	7 storey (24)	11 storey(36)
(12x12)	1791	2068	2167
(12x24)	3375	3904	4172
(12x36)	4952	5770	5981

Graph-6: Comparative graph on base shear of vertically irregular building (stiffness irregularity) in different horizontal and vertical aspect ratio



	3 storey(12)	7 storey (24)	11 storey(36)
(12x12)	51.26	105.5	161.807
(12x24)	51.63	104.4	157.97
(12x36)	51.9	104.06	155.85

Graph-7: Comparative graph on displacement of vertically irregular building (stiffness irregularity) in different horizontal and vertical aspect ratio



	3 storey(12)	7 storey (24)	11 storey(36)
(12x12)	285.07	332.54	349.82
(12x24)	292.164	338.92	352.93
(12x36)	295.7	342.83	356.14

Graph-8: Comparative graph on maximum bending moment of vertically irregular building (stiffness irregularity) in different horizontal and vertical aspect ratio

5. CONCLUSIONS

In the above study proper analysis of regular and irregular structure is performed using response spectrum analysis in STAAD pro v8i software. The regular structure of (g+9) having a plan of 12*12 has been analyzed along with 5 structure of same properties having singular irregularity and 1 structure with combination of different vertical irregularities. The storeys shear and drift values of the regular structure decreases with the increase in height. It has been observed that base shear was somewhat similar in the cases when the shear wall hasn't been introduced whereas with shear wall the base shear had staggering increment in all the cases with a maximum in model 5 and least in model 6, similar results were observed for maximum bending moment, while a substantial decrement in displacement has been observed with the introduction of shear wall in all the cases. When it comes to result analysis of irregular structure in different aspect ratio, it is found that the higher the number of bays, higher are the values of seismic parameters. In comparison to different configurations the model with less aspect ratio performed better than that of with greater aspect ratio.

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