Study of Different Variation of Height of Symmetric and Asymmetric Building by Linear Static and Dynamic Analysis Using STAAD Pro

Pratibha Nargatti and Abhija Patil

Abstract--- *The paper aim towards the analysis of Symmetric and Asymmetric building using a software STAAD.PRO. The two buildings are considered in the study, one is rectangular in shape and other is 'L' in shape and both are been analyzed by linear Static method and Response Spectrum method. The two plans are studied for different variation of height i.e., G+5, G+10, G+15 and G+20 and seismic properties are kept similar for both the buildings. The parameter evaluated are Base Shear, Story displacement, Story shear, Story drift and Time period. The manual calculation of Base shear is obtained and compared with the STAAD result as per code IS 1893:2002. The each parameter is studied for different height and checked the difference between Symmetric and Asymmetric building. The paper also includes what will be the effect, if the height of building increases due to a seismic analysis.*

Keywords--- *Base Shear, Response Spectrum Method, STAAD.PRO, Static Analysis, Time Period*

I. INTRODUCTION

AN Earthquake is defined as rock formation are suddenly disturbed, a large amount of elastic energy released by a sudden slip on a fault and resulting vibration spread out in all direction from the source of disturbance. The Earthquake have been expected most disastrous thing. The cause of Earthquake is due to the geological faults, volcanic activity, nuclear test, landslides and mine blast. The building which don't meet the current seismic requirement and seismic design, which may suffer a damage during earthquake and may also suffer an extensive collapse if the ground is shaken by a severe motion. The Reinforced concrete frame building which are been used in many developed countries and in the Industrial countries and are popular in many hilly areas. In developed countries and in hilly areas reinforced concrete construction is more in use due to low initial cost compared to steel and composite. The paces which are situated in a Zone IV like which are in the junction of Alps-Himalaya and Circum Pacific are subjected to frequent Earthquake. The areas in Zone IV are often subjected to frequent Earthquake; Earthquake consists of horizontal and vertical movement of the Earth's surface. So it is necessary to consider structural design of building for seismic load, the seismic load is concerned with structural safety during major ground motion.

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DOI:10.9756/BIJMMI.8185

II. MODELING IN STAAD

A. Structural Modeling

Symmetric and Asymmetric building is analyzed by Static and Dynamic Analysis using a software STAAD.PRO V8i. The result obtained after analyzing using STAAD.PRO is represented by a graphically using MS office Excel.

B. Data Analysis of RCC Structure

Table 1: Data Analysis of RCC Structure

PLAN DIMENSION Symmetric area Asymmetric area	 1080m^2 810m^2
Foundation depth	2.5m
Height of each floor	3.15m
Parapet Height	1.0m
Live load	4.0kN/m^2
Zone factor	IV
Importance factor	1.5
Soil Condition	Hard
Damping ratio	5%
Floor finish	1.0kN/m^2
Density of concrete	25kN/m^3
Density of masonry	20kN/m^3

C. Section Properties

Plan area	*Structure*	*Member Properties*	*Size (B x D) mm*
Symmetry	G+5	Beams Column Slab	300 x 600 450 x 450 150
	G+10	Beam Column Slab	300 x 600 600 x 600 150
	G+15, G+20	Beam Column Slab	300 x 600 900 x 900 150

Plan area	*Structure*	*Member Properties*	*Size (B x D) mm*
Asymmetry	G+5	Beams Column Slab	300 x 600 450 x 450 150
	G+10	Beam Column Slab	300 x 600 600 x 600 150
	G+15, G+20	Beam Column Slab	300 x 600 900 x 900 150

D. Plan of Symmetric and Asymmetric Building

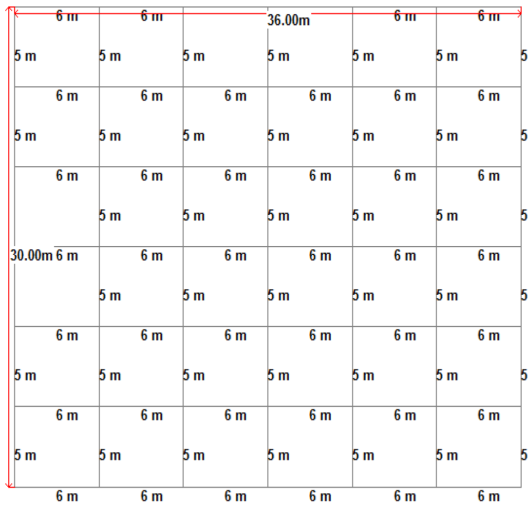

Figure 1: Plan of Symmetric Building

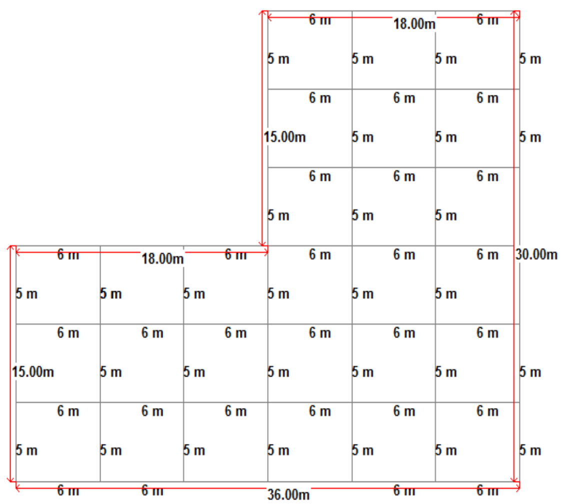

Figure 2: Plan of Symmetric Building

E. Load Considered in Analysis

1. Dead Load

- Wall Load = Thickness of wall x (Height of floor-depth of beam) x Density of masonry = 0.23 x (3.15-0.6) x 20 = 11.73Kn/m
- Parapet wall = Thickness of wall x Height of parapet x Density of masonry = 0.23 x 1.0 x 20 = 4.6kN/m
- Floor Load = (Thickness of slab x Density of concrete) + Floor finish = (0.15 x 25) +1 =4.75kN/m^2

2. Live Load

- Floor Load for public building = 4kN/m^2
- Floor load at roof = 1.5kN/m^2
- As per IS 1893:2002 Clause no. 7.3.1, Table no.8, the live load considered for seismic weight is 50%.
- Hence,
- Floor load for public building = 4 x 0.5 = 2kN/m^2
- Floor load on roof = 1.5 x .5 = 0.75kN/m^2

Type	*Load Combination*	*Name*
Primary	1	DL
Primary	2	LL
Primary	3	EQX
Primary	4	EQZ
Combination	5	1.5DL
Combination	6	1.5(DL+LL)
Combination	7	1.5(DL+EQX+)
Combination	8	1.5(DL+EQX-)
Combination	9	1.5(DL+EQZ+)
Combination	10	1.5(DL+EQZ-)
Combination	11	1.2(DL+LL)
Combination	12	1.2(DL+LL+EQX+)
Combination	13	1.2(DL+LL+EQX-)
Combination	14	1.2(DL+LL+EQZ+)
Combination	15	1.2(DL+LL+EQZ-)
Combination	16	0.9DL+1.5EQX+
Combination	17	0.9DL+1.5EQX-
Combination	18	0.9DL+1.5EQZ+
Combination	19	0.9DL+EQZ-

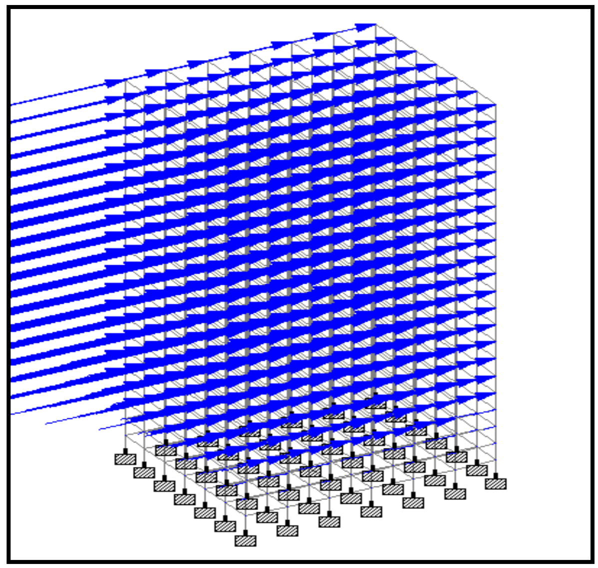

Figure 3: Earthquake Loading on Symmetric Building

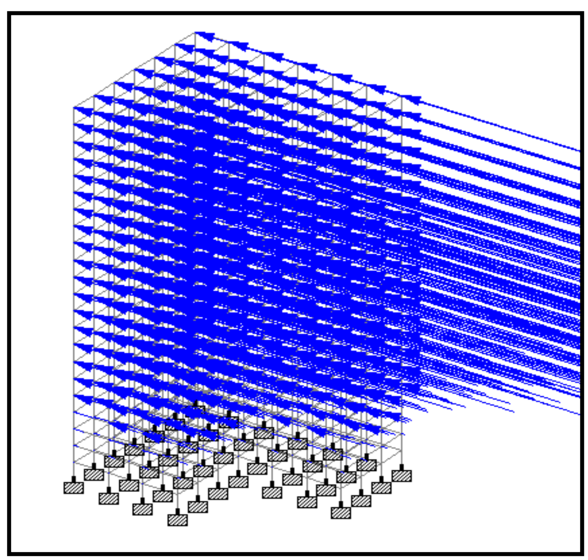

Figure 4: Earthquake Loading on Asymmetric Building

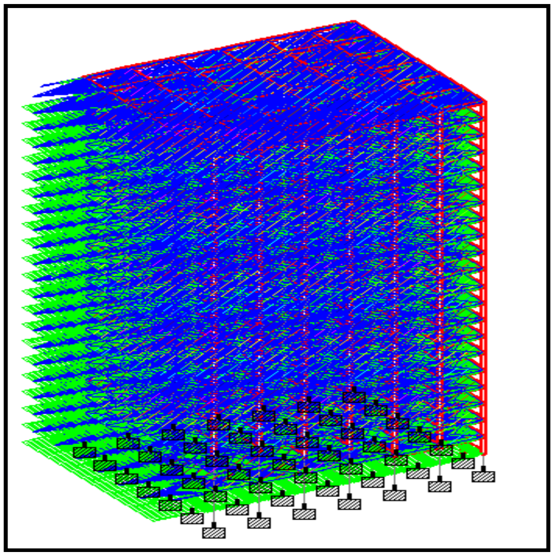

Figure 5: RSX Loading on Symmetric Building

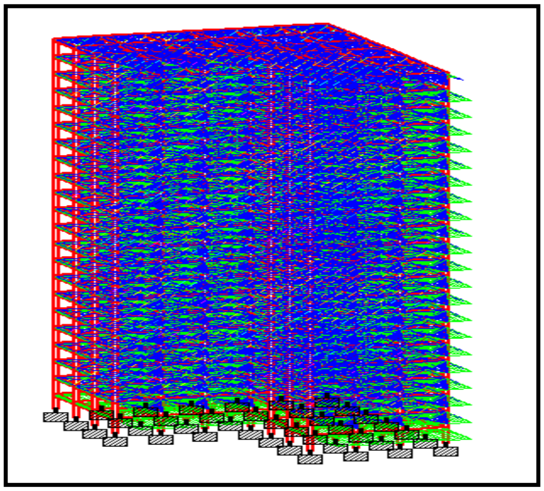

Figure 6: RSX Loading on Asymmetric Building

III. Results and Discussion

A. Base Shear

Base shear is the force that occur at the base of the building due to an earthquake and it depends on the seismic zone, height and shape of building.

Manual Calculation of Base Shear

1. *Calculation of Seismic Weight of Symmetric and Asymmetric Building*

G+5 storey symmetric building

Roof Calculation

Slab load = (36 x 30 x 4.75) = 5130 KN

Live load = (36 x 30 x 0.75) = 810 KN

Beam = (0.3 x 0.6 x 6 x 25) x 42 + (0.3 x 0.6 x 5 x 25) x 42 = 2079 KN

Column = (0.45 x 0.45 x 1 x 25 x 24) = 121.5 KN

Wall = (0.23 x 1 x 6 x 20 x 12) + (0.23 x 1 x 5 x 20 x 12) =607.2 KN

Total = 8140.5 KN

Storey Calculation

Slab load = (36 x 30 x 4.75) = 5130 KN

Live load = (36 x 30 x 2) = 2160 KN

Beam = (0.3 x 0.6 x 6 x 25) x 42 + (0.3 x 0.6 x 5 x 25) x 42 = 2079 KN

Column = (0.45 x 0.45 x 3.15 x 25 x 49) =781.4 KN

Wall = (0.23 x 2.55 x 6 x 20 x 42) + (0.23 x 2.55 x 5 x 20 x 42) = 5419.26 KN

Total = 15569.65 KN

Total 5 Storey calculation = 15569.65 x 5 = 77848.25 KN

Ground Level

Beam = (0.3 x 0.6 x 6 x 25) x 42 + (0.3 x 0.6 x 5 x 25) x 42 = 2079 KN

Column = (0.45 x 0.45 x 3.15 x 25 x 49) =781.4 KN

Wall = (0.23 x 2.55 x 6 x 20 x 42) + (0.23 x 2.55 x 5 x 20 x 42) = 5419.26KN

Total = 8279.65 KN

Total Seismic Weight = 94268.4 KN

G+5 storey Asymmetric building

Area of the Building = (36 x 30) – (18 x 15) = 810mm^2

Roof Calculation

Slab load = (810 x 4.75) = 3847.5 KN

Live load = (810 x 0.75) = 607.5 KN

Beam = (0.3 x 0.6 x 6 x 25) x 33 + (0.3 x 0.6 x 5 x 25) x 33 = 1633.5 KN

Column = (0.45 x 0.45 x 1 x 25 x 24) = 121.5 KN

Wall = (0.23 x 1 x 6 x 20 x 12) + (0.23 x 1 x 5 x 20 x 12) =607.2 KN

Total = 6817.2 KN

Storey Calculation

Slab load = (810 x 4.75) = 3847.5 KN

Live load = (810 x 2) = 1620 KN

Beam = (0.3 x 0.6 x 6 x 25) x 33 + (0.3 x 0.6 x 5 x 25) x 33 = 1633.5 KN

Column = (0.45 x 0.45 x 3.15 x 25 x 40) =637.8 KN

Wall = (0.23 x 2.55 x 6 x 20 x 33) + (0.23 x 2.55 x 5 x 20 x 4 x 33) = 4257.99 KN

Total = 11996.86 KN

Total 5 Storey calculation = 11996.86 x 5 = 59984.3 KN

Ground Level

Beam = (0.3 x 0.6 x 6 x 25) x 33 + (0.3 x 0.6 x 5 x 25) x 33 = 1633.5 KN

Column = (0.45 x 0.45 x 3.15 x 25 x 40) =637.8 KN

Wall = (0.23 x 2.55 x 6 x 20 x 33) + (0.23 x 2.55 x 5 x 20 x 33) = 4257.99 KN

Total = 6529.36 KN

Total Seismic Weight = 73330.86 KN

2. *Design of Seismic Base Shear*

The design seismic base shear as per IS code 1893:2002,

$$V_b = A_h \text{ x } w$$

A_h = Design horizontal acceleration

w = Seismic weight of building

$$A_h = (Z/2) \text{ x } (I/R) \text{ x } (S_a/g)$$

Z = 0.24

For important structure, I = 1.5

R = 5, S_a/g = Average response acceleration coefficient

Time period is required to calculate for average response acceleration coefficient. Stiffness of masonry infill is neglected in time period

$$T = 0.075xh^{0.75}$$

For G+5 storey building

Height of building for 5 storey = 18.9m

Time period for symmetric and asymmetric structure is,

$$T = 0.075x\ (18.9)^{0.75} = 0.679sec$$

From IS 1893:2002 page no.16

$$S_a/g = 1.47$$

$$A_h = (0.24/2) \text{ x } (1.5/5) \text{ x } (1.47) = 0.529$$

Table 2: Comparison of Base Shear of Manual and STAAD Result of a Symmetric Building

Structure	*Manual Result of Base Shear(KN)*	*STAAD Result of Base Shear(KN)*
G+5	4996.22	5169.74
G+10	6042.10	6089.43
G+15	7326.46	7330.57
G+20	7824.86	7797.22

Table 3: Comparison of Base Shear of Manual and STAAD Result of an Asymmetric Building

Structure	*Manual Result of Base Shear(KN)*	*STAAD Result of Base Shear(KN)*
G+5	3886.53	3976.61
G+10	4665.9	4699.82
G+15	5696.77	5686.08
G+20	6082.38	6051.19

B. *Time Period*

The height of building and the behavior of different shapes of building is influenced by the Natural period. The Natural period is known by a response spectrum method and hence it is a convenient method for evaluation of a response of the structure. The Time period obtained by a Symmetric and Asymmetric building for different height is shown in below tables and graphs.

Table 4: Comparison of Time period G+5 Building

Mode	*Symmetric*	*Asymmetric*
	sec	*sec*
1	1.38	1.34

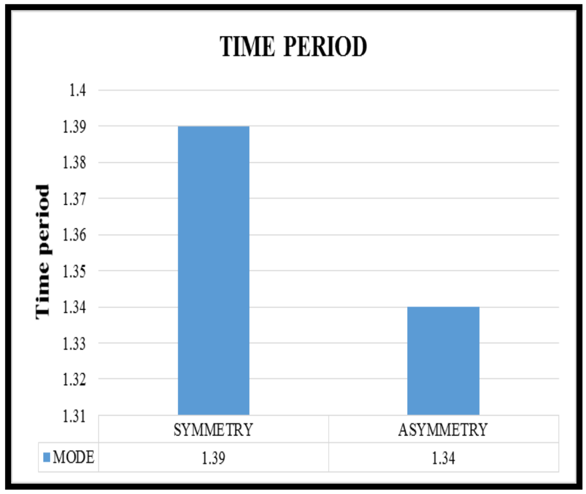

Figure 7: Graph of time Period of G+5 Storey

Table 5: Comparison of Time Period G+10 Building

Mode	*Symmetric*	*Asymmetric*
	sec	*sec*
1	2.06	2.04

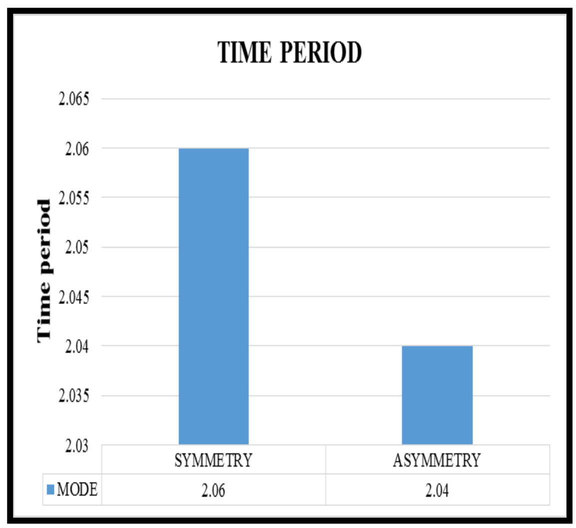

Figure 8: Graph of Time Period of G+10 Storey

Table 6: Comparison of Time period G+15 Building

Mode	*Symmetric*	*Asymmetric*
	sec	*sec*
1	2.74	2.72

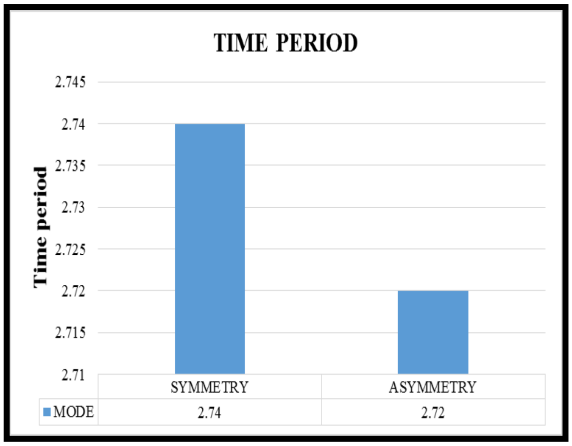

Figure 9: Graph of Time Period of G+15 Storey

Table 7: Comparison of Time Period G+20 Building

Mode	*Symmetric*	*Asymmetric*
	sec	*sec*
1	3.66	3.65

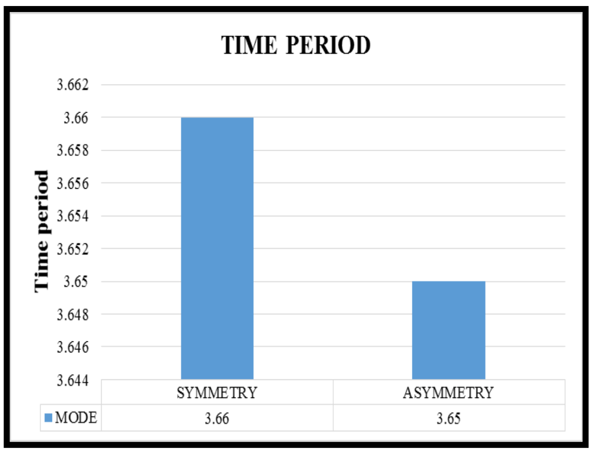

Figure 10: Graph of Time Period of G+20 Storey

Fom graphs and tables of Time period it is observed that, Fig 5.1 shows the time period of Symmetric building G+5 increases by 0.04sec compared to Asymmetric Building G+5. Fig 5.2 and Fig 5.3 The time period of Symmetric Building G+10 and G+15 increases by 0.02 sec compared to Asymmetric building G+10 and G+15. Fig 5.4 The time period of Symmetric building G+20 increases by 0.01 sec compared to Asymmetric building G+20. The increase of Time period is due to damping of structure and lateral interia force decreases due to increase in time period.

IV. Conclusion

1. The Base Shear value obtained by manual analysis is less compare to the Software analysis.
2. The Base Shear value of Symmetric building is more compared to the Asymmetric building.
3. In Symmetric building the time period is more compare to Asymmetric building. The time period of Symmetric and Asymmetric building tries to match with each other when the height of building is increased.
4. The regular building is preferred more compared to irregular building as the irregular building undergoes more deformation.

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