Study Of Dynamic Properties of Building with Varying Plan Area and Height

Neena Vedic[1], Aswathy Prakash[2]

[1]Sree Buddha College of Engineering For Women, Alappuzha/Pathanamthitta cluster of APJ Abdul Kalam Technological University, Ayathil, Elavumthitta P.O, Pathanamthitta-689625

[2]Assistant Professor Sree Buddha College of Engineering For Women, Alappuzha/Pathanamthitta cluster of APJ Abdul Kalam Technological University, Ayathil, Elavumthitta P.O, Pathanamthitta-689625

Abstract: ***In this topic Effect of height of building on time period natural frequency and mode shapes are evaluated by using ETABS software. For this purpose response spectrum method is taken into consideration and results are obtained in ETABS. The study includes the modelling of two buildings having plan areas 15 m x9 m and 25mx15m and the height is varied from G+3, G+6, G+9 and G+12 storey. The study is conducted by varying the geometrical properties of the structure but the seismic properties are kept constant. The buildings are located in zone III region. Spring mass model with the lateral forces are also plotted for the different buildings. Variation in bending moment and shear force are also evaluated.***

Keywords: Natural Frequency, Time Period, Mode Shape, Response Spectrum

1. Introduction

An earthquake (also known as a quake, tremor or temblor) is the perceptible shaking of the surface of the Earth, resulting from the sudden release of energy in the Earth's crust that creates seismic waves. Earthquakes can be violent enough to toss people around and destroy whole cities. The seismicity or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time.

When earthquakes occur, a buildings undergoes dynamic motion. This is because the building is subjected to inertia forces that act in opposite direction to the acceleration of earthquake excitations. These inertia forces, called seismic loads, are usually dealt with by assuming forces external to the building. Since earthquake motions vary with time and inertia forces vary with time and direction, seismic loads are not constant in terms of time and space. In designing buildings, the maximum story shear force is considered to be the most influential, therefore in this chapter seismic loads are the static loads to give the maximum story shear force for each story, i.e. equivalent static seismic loads. Time histories of earthquake motions are also used to analyze high-rise buildings, and their elements and contents for seismic design. The earthquake motions for dynamic design are called design earthquake motions. In the previous recommendations, only the equivalent static seismic loads were considered to be seismic loads. the equivalent static seismic loads are story shear forces in the building that can be calculated through response spectrum analysis. The analytical model is fundamentally the multi degree-of-freedom (MDOF) model (also called “lumped mass model”) that takes into account the soil-structure interaction considering sway and rocking motions. The maximum story shear force for each mode is calculated from the natural frequency and mode that can be calculated through eigen value analysis of the model, estimating the damping ratio for each mode. The seismic loads are the maximum story shear forces that can be calculated from the shear force of each mode. The fixed base model can be employed if the building is on a firm soil, so that soil-structure interaction may be neglected. Since the response spectra are affected by the characteristics of earthquake motions and buildings, they are expressed as functions of many parameters to represent input motions to buildings or soil structure systems. The response spectra defined for the engineering bedrock are used as inputs to the soil-structure system, or the response spectra that consider amplification effect (including nonlinear characteristics) of surface soil and soil-structure interaction are used as inputs to the building. The seismic loads that take into account the inelastic response of buildings during strong earthquake motions include the reduction factor related to ductility and response deformation that are defined the nonlinear characteristics of the building and its limit deformation.

2. Objectives

1) To find out the storey shear, storey drift, storey displacement and time period for buildings with varying plan area and height.
2) To find the mode shapes.
3) To compare the results.

3. Methodology

Methodology employed is response spectrum method

3.1 Modelling of Building

Here the study is carried out for the behaviour of G+3,G+6,G+9 andG+12 storied buildings with two plan areas of 15m x 9m and 25m x 15m. Floor height provided as 3m.And also properties are defined for the frame structure. Eight models including G+3,G+6,G+9 and G+12 building for two different plan areas are created. Properties are different for different models. The general software ETABS has been used for the modelling. It is more user friendly and versatile program that offers a wide scope of features like static and dynamic analysis, non- linear dynamic analysis and non-linear static pushover analysis, etc.

3.1.1 Building Plan And Dimension Details

The Following are the specification of buildings located in seismic zone III. The complete detail of the structure including modelling concepts is given below: To model any structure in ETABS the first step is to specify the nodal co-ordinate data followed by selection of elements from element library. For the present work beam elements are selected to model the structure. The element selected for modeling is then assigned the properties if the element is beam the cross section of beam is assigned. For plate elements thickness is assigned. After assigning the sectional property to the member it is important to assign it with member properties. Material properties include modulus of elasticity, poisson's ratio; weight density, thermal coefficient, damping ratio and shear modulus

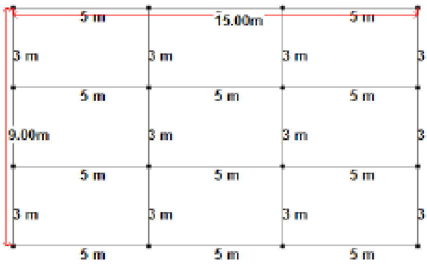

Figure 1: Plan 1 (15m × 9m)

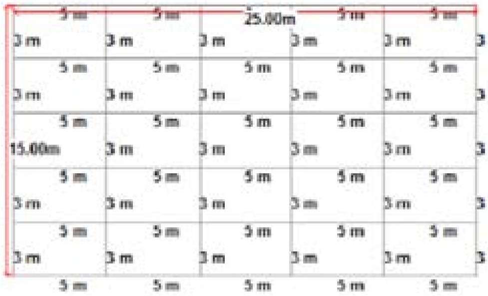

Figure 2: Plan 2 (25m × 15m)

Table 1: Details and dimension of the building models with plan 1

Plan Area	Structure	Member Properties	Size B x D (mm)
15m × 9m and 25m×15m	G+3	Beams parallel to	
		X axis	300 × 450
		Y axis	300 × 300
		Columns	450 × 450
		Slab	Thickness= 125 mm
	G+6	Beams parallel to	
		X axis	300 × 450
		Y axis	300 × 300
		Columns	550 × 550
		Slab	Thickness= 125 mm
	G+9	Beams parallel to	
		X axis	300 × 450
		Y axis	300 × 300
		Columns	650 × 650
		Slab	Thickness= 125 mm
	G+12	Beams parallel to	
		X axis	300 × 450
		Y axis	300 × 300
		Columns	750 ×750
		Slab	Thickness= 125 mm

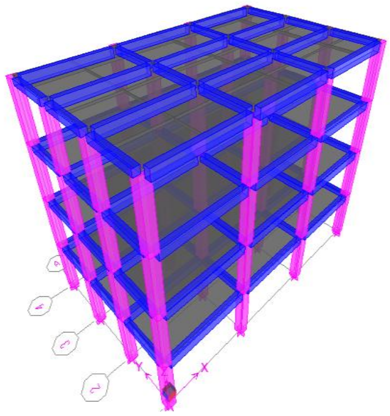

Figure 3: Three dimensional view of G+3 Building with plan area 15m × 9m

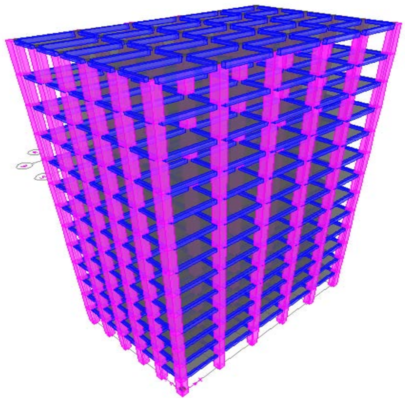

Figure 4: Three dimensional view of G+12 Building with plan area 25m×15m

3.2 Load Formulation

In the present project works following loads are considered for analysis. Dead Loads (IS- 875 PART 1) and Live Loads (IS 875 PART 2). In addition to the above mentioned loads, dynamic loads in form of Response Spectrum method are also be assigned.

➢ **Live Load**

Floor load:

Live Load Intensity specified (Public building) = 4kN/m^2
Live Load at roof level =1.5 kN/m

Wind Load

Design wind speed $V_z = V_b k_1 k_2 k_3 = 39×1×1.05×1 = 40.95$m/s
Design wind pressure $P_z = 0.6 V_z^2 = 0.6×40.95^2 = 1006.1415$N/$m^2$

3.3 Analysis

The three dimensional reinforced concrete structures were analyzed by Response Spectrum Analysis using ETABS software. It is a linear dynamic statistical analysis method to indicate the likely maximum seismic response of an elastic structure. A plot of the peak acceleration for the mixed vertical oscillators. A response spectrum is simply a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency that are forced into motion by the same base vibration or shock.The analysis results will show the performance levels, behaviour of the structures. It will also give the variations in bending moment and shear force

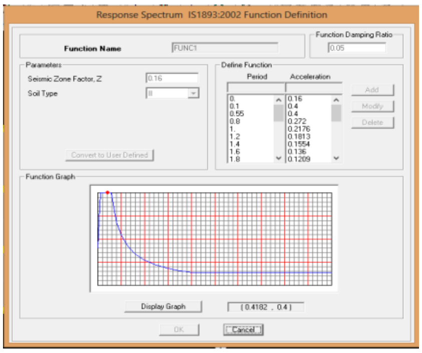

Figure 5: Response Spectrum IS 1893:2002 Function Definition

4. Comparison of Results

After analysing the results obtained then it will be compared and find the seismic performance of the building frames.

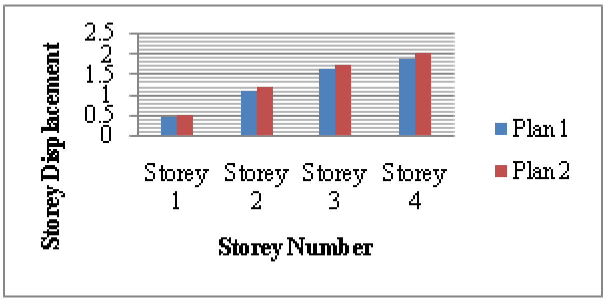

Figure 6: Storey Displacement of G+3 Buildings (mm)

From Fig 6 it is clear that storey displacement is higher in plan 2 in all stories. But the variation is very small.

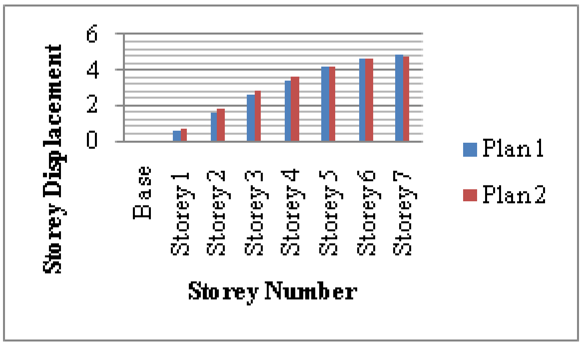

Figure 7: Storey Displacement of G+6 Buildings (mm)

From Fig 7 it is clear that the storey displacement is higher for plan 2 till 3rd storey. In 4th and 5th storey it is nearly equal and in 6th storey plan 1 have higher storey displacement.

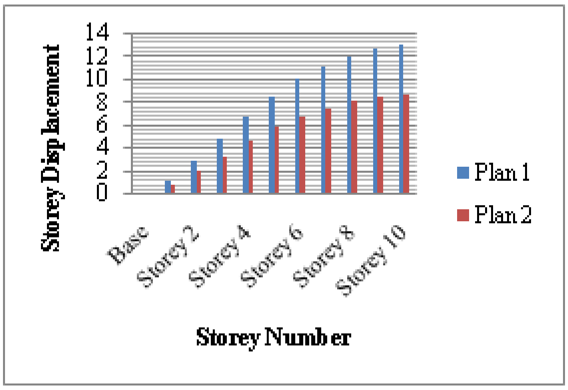

Figure 8: Storey Displacement of G+9 Buildings (mm)

Fig 8 shows the variations in storey displacement of plan 1 and plan 2 with G+9 stories. It can be seen that plan 1 have higher storey displacement.

Figure 9: Storey Displacement of G+12 Buildings (mm)

From Fig 9 it can conclude that for G+12 building, plan 1 have higher storey displacement. And the differences between the values are very high.

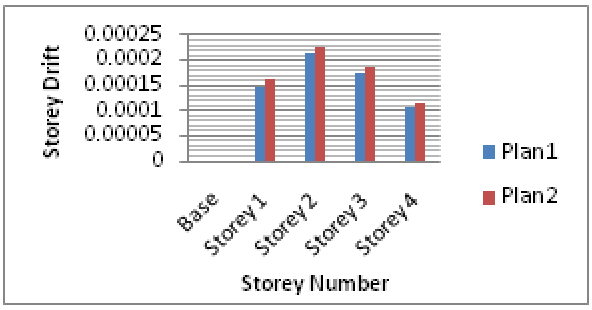

Figure 10: Storey Drift of G+3 Buildings

From Fig 10 it is clear that storey drift is higher for plan 2. Drift is maximum at first storey for both buildings.

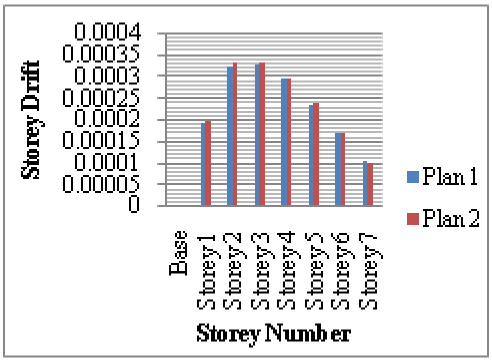

Figure 11: Storey Drift of G+6 Buildings

Fig 11 shows the variations of storey drift of G+6 buildings. From this it can conclude storey drift is higher for plan 2. And the maximum drift for both building occurs at storey 2.

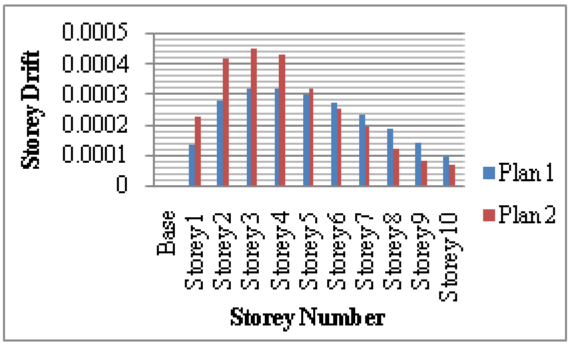

Figure 12: Storey Drift of G+9 Buildings

From Fig 12 it can conclude that till 4th storey, drift is higher for plan 2 and after that plan 1 have higher drift. Drift is maximum at storey 2 and 3 for both buildings.

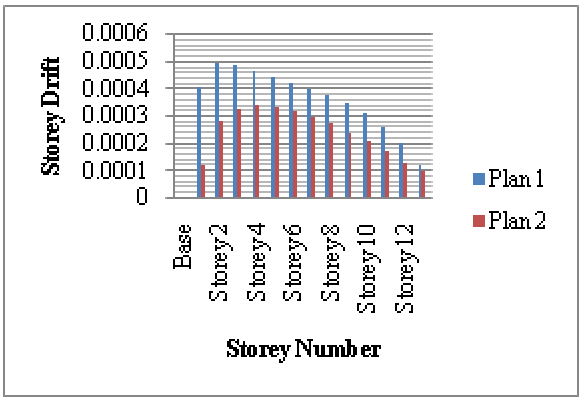

Figure 13: Storey Drift of G+12 Buildings

From Fig 13 it can be observed that storey drift is higher for plan 1. Drift is maximum at first storey.

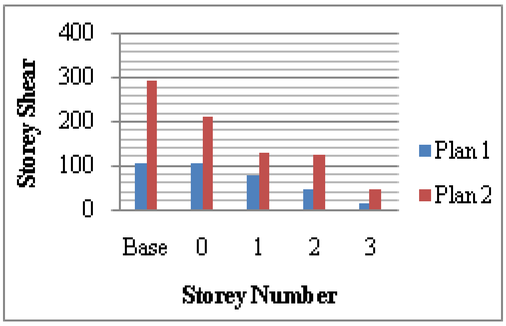

Figure 14: Storey Shear of G+3 Buildings (kN)

From Fig 14 it can be observed that Storey shear is higher for plan 2. And maximum shear is occurred at the base of buildings.

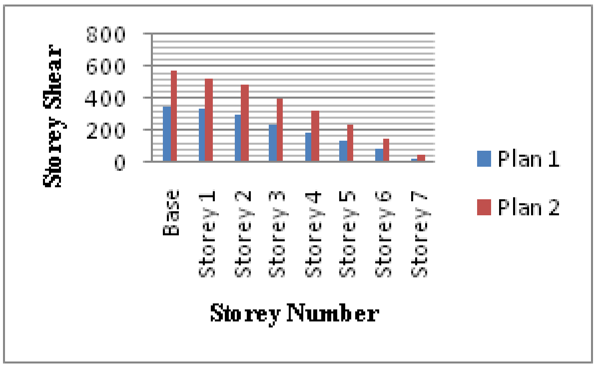

Figure 15: Storey Shear of G+6 Buildings (kN)

From Fig 15 it can be observed that storey shear is higher for plan 2 and maximum shear is at the base and minimum at the top storey.

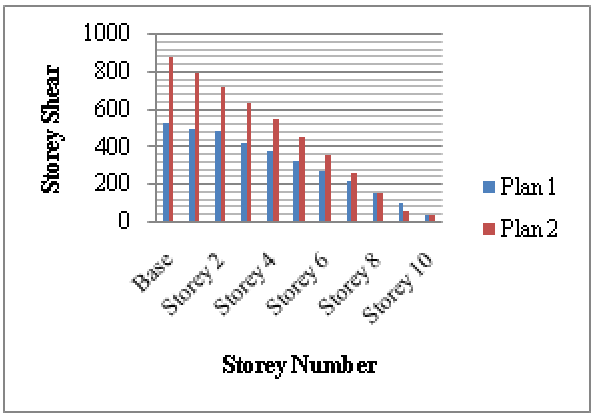

Figure 16: Storey Shear of G+9 Buildings (kN)

From Fig 16 it can be observed that Storey shear is higher for plan 2 and maximum at base. Beyond 6th storey the difference in shear between buildings is very small.

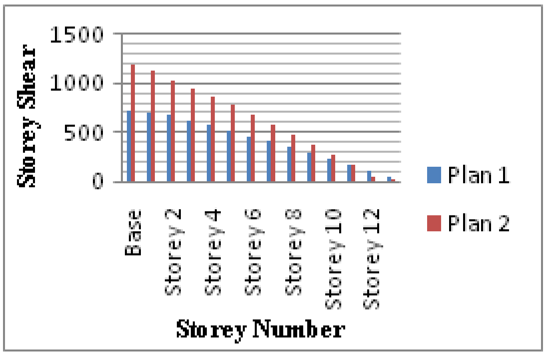

Figure 17: Storey Shear of G+12 Buildings (kN)

From Fig 17 it can be observed that storey shear is higher for plan 2. But at storey10 shears are almost same. At storey 11 and 12 plan 1 have greater shear.

5. Conclusions

In the present study, an attempt is made to compare the results obtained from Response Spectrum Method. Different models of G+3, G+6, G+9 and G+12 are modelled in ETABS. The seismic analysis is carried out taking into consideration that all the buildings are located in zone III i.e. Thiruvananthapuram region as per code. The Storey shears, storey displacement at each storey along with the storey drift are plotted and compared with each model. The major conclusions drawn from the present study are as follows:

- The mode shapes corresponding to each time period is obtained.
- For G+3, G+6, G+9 and G+12 buildings it can be observed that the average increase in storey shear is by 36%, 39.9%, 40% and 42 % respectively. Thus G+12 is the most critical one.
- Up to G+6 Building, plan 2 has 2.4% more storey drift compared to Plan 2. For G+9 Building up to storey 5, plans 2 have more storey drift. After that plan 1 have more storey drift. For G+9 Building. For G+12 Building storey drift of plan1 is 33% more than plan 2
- Storey drift is maximum at intermediate storey level.
- For G+3 Building storey displacement is more in plan 2 and the percentage increase by 6.4 %. For G+6, G+9 and G+12 Buildings it can be observed that storey displacement is more in plan 1and the increase by 3.2%, 33.91% and 88.23 %.

6. Future Scope

Further study can be carried out by keeping the height constant and varying the plan area.

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