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A Comparative Study on Analysis of Symmetric and Asymmetric Building Structure

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ABSTRACT

In recent years, due to the demand in aesthetical view and architectural designs, people want uniqueness in the building so the buildings are designed with irregularities, Irregularities such as change or discontinuity in the horizontal plan or any changes or discontinuity vertically with respect to the subsequent stories above. This irregularities causes danger during the earth quakes, so it is important for a structural engineer to study and give necessary design for such irregularities.

In present study a comparison is done between symmetric and asymmetric RC structure. Four models are made, 2 models are six storied in which 1 model is symmetric and other is asymmetric and another 2 models are nine storied in which 1 model is symmetric and other is asymmetric and various parameters are studied.

ETABS software is used for modelling and studying the various parameters such as Story drift, displacement, time period and story shear. R.S Method is used for analysing of models.

Keywords: drift, displacement, time period, symmetrical building, Asymmetrical building, Etabs.

1. Introduction

1.1 Symmetrical Building

Building is said to be symmetrical if it is regular or symmetric in plan and also symmetrical vertically. It means the building in which the horizontal plan remains same in every direction and remains same vertically on the subsequent above stories.

Advantages

1. Easy to design
2. Easy to construct
3. Chances of error will be less
4. It will be less effected during earthquake compare to unsymmetrical or irregular building

Disadvantages

1. Doesn’t meets the client’s requirement.

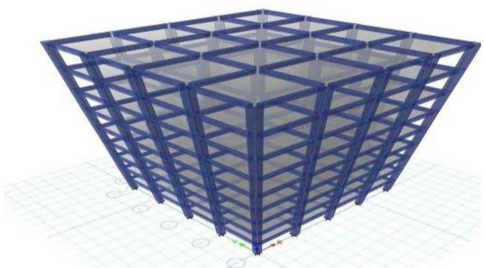

Fig .1 Symmetrical building

1.2 Asymmetrical Building

The building is said to be asymmetrical when it is irregular in plan or irregular vertically. It means the building in which there is change or discontinuity in the horizontal plan or any changes or discontinuity vertically with respect to the subsequent stories above.

Advantages

1. Looks modern and trendy
2. Looks good from architectural point of view

Disadvantages

1. Difficult to design
2. Difficult to construct
3. It attracts more forces and torsion
4. It will be more affected during the earthquakes

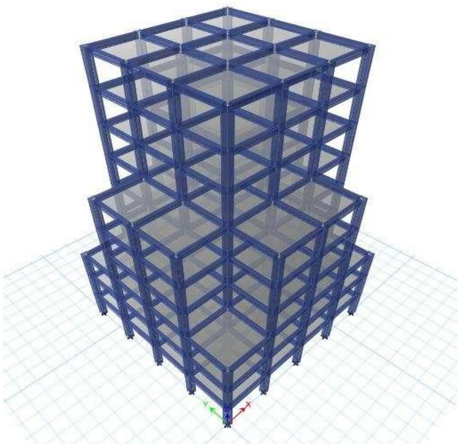

Fig .2 Asymmetrical building

2.Related work

[1] Sumit Desai, AkshayMahajan (2018) Presents a study on the comparison of asymmetric and symmetric building structure using ETABS Software, He created 6 Models of various heights and did the comparison between symmetric and asymmetric building, He considered vertical irregularity. He concluded that performance of regular building is better, asymmetric building should be designed for torsion, displacement and drift are higher in irregular building and also they are effected in seismic zones.

[2] Md. Malik Burhanuddin, N Punith (2017) Presents a study on comparison of plan symmetric and asymmetric building using ETABS Software, He created two G+4 Models that are box Shaped which is symmetric and L Shaped which is asymmetric and comparison was done. He concluded that during seismic activity asymmetric building is very much effected, so it is very important to study its performance. Displacement and drifts values are more in asymmetric building when compared to symmetric building.

[3] S.Laxmi Ganesh, G.Sabarish (2019) Presents a study on comparison of Symmetric and asymmetric multi storey building. He created models of L shape, T shape and Square shape and of two different heights that is G+4 and G+10 and they compared the parameters. They concluded that asymmetric building suffers more during seismic activities. During earthquakes damage will be more as the height of building increases.

[4] ShruthiIndaragi, M.B.Mogali (2019) Presents a study about the comparing symmetric and asymmetric building ,they created 3 models , A regular model of G+15 and 2 irregular model of G+12 and G+15 .they studied effect of plan irregularity in zone 3 and 4 .They concluded that displacement increases with increase in height of building in both directions. Displacement is more in asymmetrical build. Storey shear is maximum in all irregular model compare to regular model .moment is maximum in asymmetric models.

[5] Pardeshisameer, Prof. N. G. Gore (2016) Presents a study about the comparison of Symmetric and asymmetric building, they created 4 models of G+15 height. The models regular shape, plus shape, T shape and L Shape. They used RS method for dynamic analysis. They concluded that Displacement was more in T shape model, Storey drift and Shear is more in case of T shape model, displacement was also greater in case of T shape model

3.Objectives

1. Modelling of Symmetrical and asymmetric building and perform earthquake analysis by dynamic analysis method such as response spectrum.

2. To compare the seismic performance of symmetric and asymmetric building.

3. To analyse and compare the various such as storey drift, displacement, shear, time period.

4. Performing all the above activities for 2 different heights of stories of model.

4. Methodology

4.1 ***General Information About Building Model***

Table 1 General information about building

Nos. of storey	6 storey and 9 storey
Storey height	3 metre
Concrete strength	M25 (slabs) M35 (beams & columns)
Steel grade	Fe500
Column dimension	400 x 400 mm, 450 x 450 mm
Beam dimension	230 x 450 mm
Slab thickness	125 mm
Bays dimension (distance between 2 columns)	4 metre

Table 2 Seismic Parameters

Zone	II
Response reduction factor	05
Imp. factor (I)	1.0
Type of soil	II
Zone factor (Z)	0.1

4.2 ***Models***

Four models are made, 2 models are six storied in which 1 model is symmetric and other is asymmetric and another 2 models are nine storied in which 1 model is symmetric and other is asymmetric.

MODEL 1: Symmetric Model (6 Storeys)

A model is created which is 6 Storey (G+5) and consists of 4 bays in both the direction and each bay is of 4 metres.

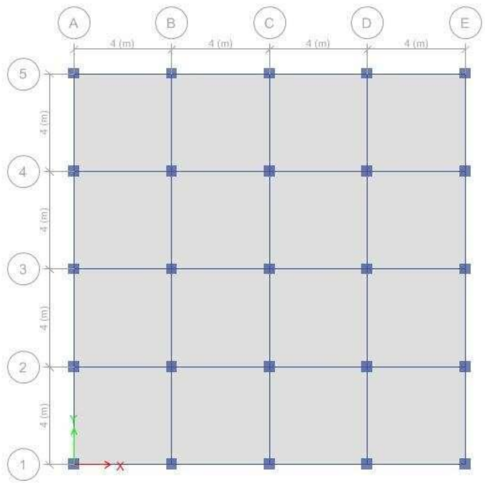

Fig.3 Plan of Model 1

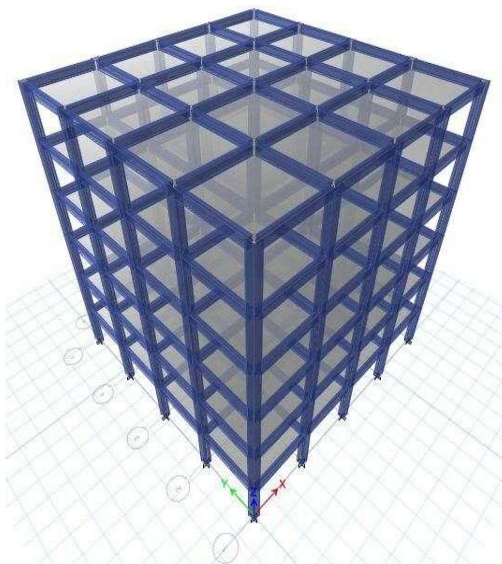

Fig. 4 3D View of Model 1

MODEL 2: ASYMMETRIC MODEL (6 STOREYS)

Another 6 Storey (G+5) model is created which is asymmetrical vertically and plan changes at every 2 storeys.

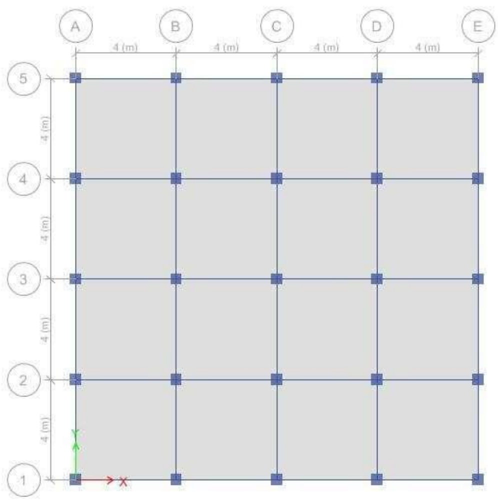

Fig. 5 Plan of Model 2 (1-2 Storeys)

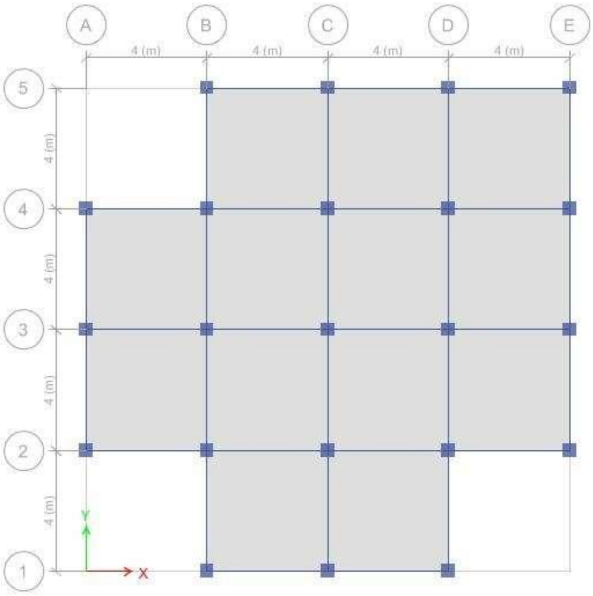

Fig.6 Plan of Model 2 (3-4 Storeys)

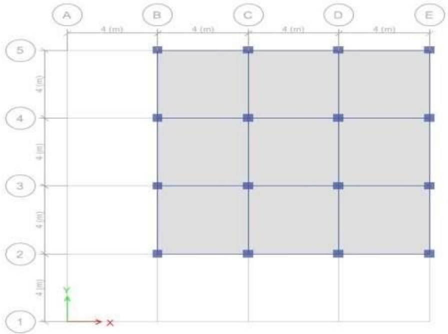

Fig.7 Plan of Model 2 (5-6 Storeys)

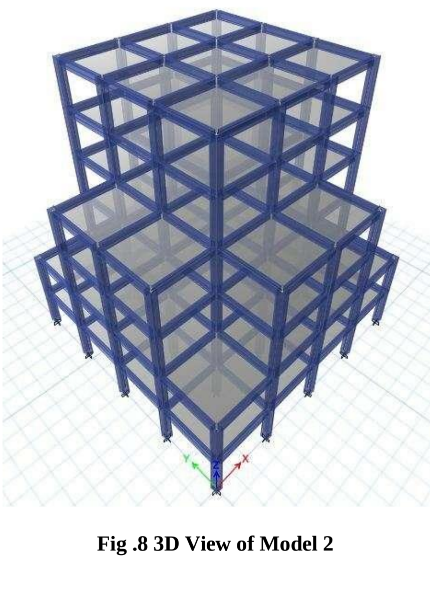

Fig .8 3D View of Model 2

MODEL 3: SYMMETRIC MODEL (9 STOREYS)

A model is created which is 9 Storey (G+8) and consists of 4 bays in both the direction and each bay is of 4 metres.

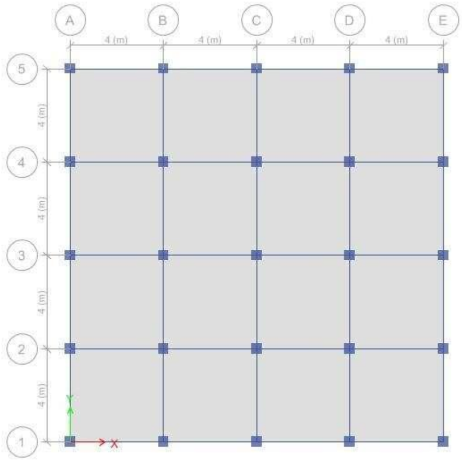

Fig 9 Plan of Model 3

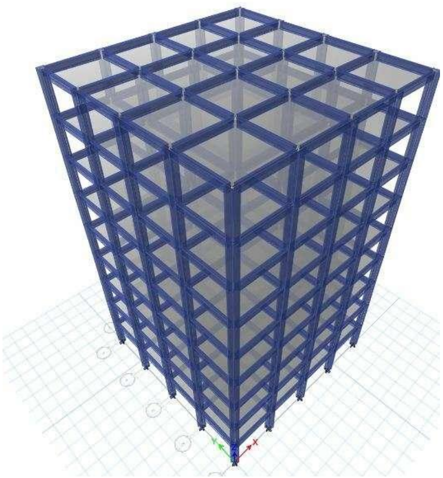

Fig 10 3D View of Model 3

MODEL 4: ASYMMETRIC MODEL (9 STOREYS)

Another 9 Storey (G+8) model is created which is asymmetrical vertically and plan changes at every 3 storeys.

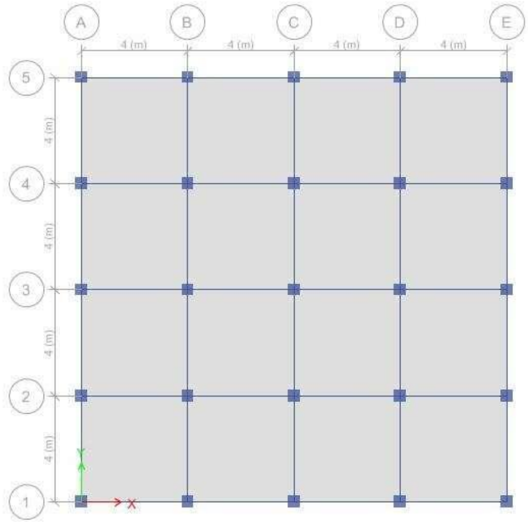

Fig 11 Plan of Model 4 (1-3 Storeys)

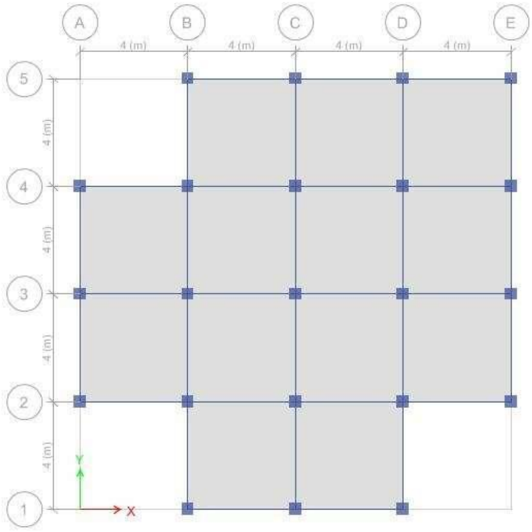

Fig 12 Plan of Model 4 (4-6 Storeys)

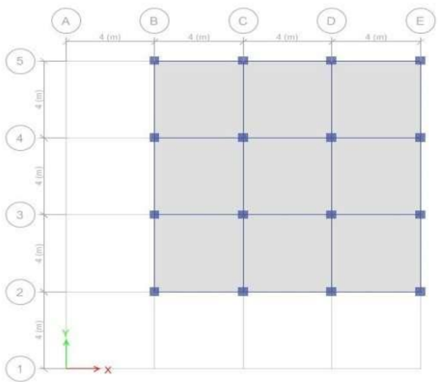

Fig 13 Plan of Model 4 (7-9 Storeys)

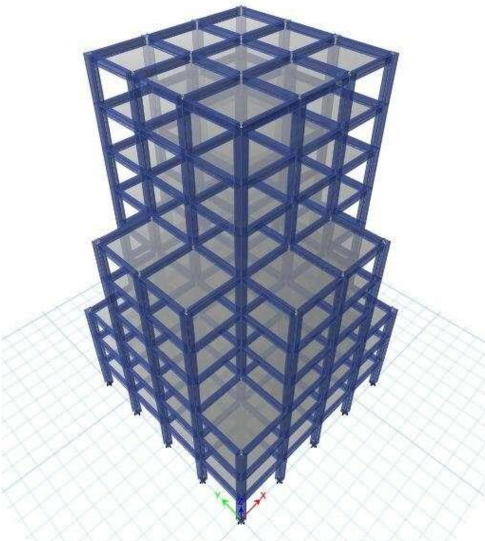

Fig 14 3D View of Model 4

4.3 MODELING & ANALYSING USING ETABS SOFTWARE

The following steps are involved in modelling and analysing the models in ETABS software.

1. Inputting units and grid system
2. Define material & sectional properties
3. Define structural components
4. Define load patterns
5. Define cases & combination of loads
6. Application of various loads
7. Dynamic analysis data
8. Check for error
9. Analysing the models
10. Results output

4.3.1 Inputting units and grid system

After starting ETAB software, Units for the model is selected and required design codes are also selected and after that grid data is inputted for both the directions and story data is entered.

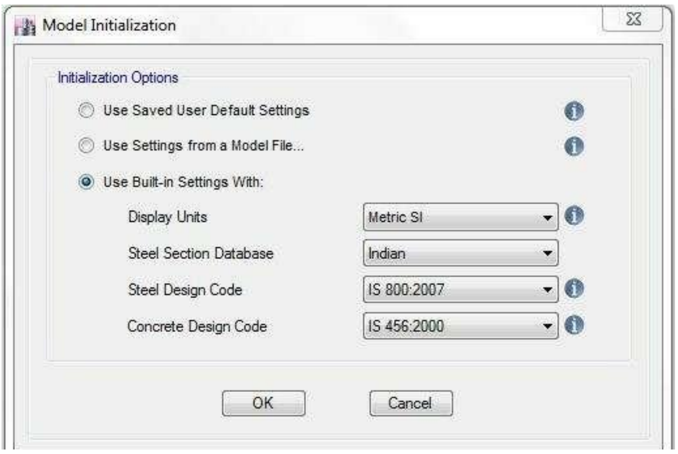

Fig 15 Units

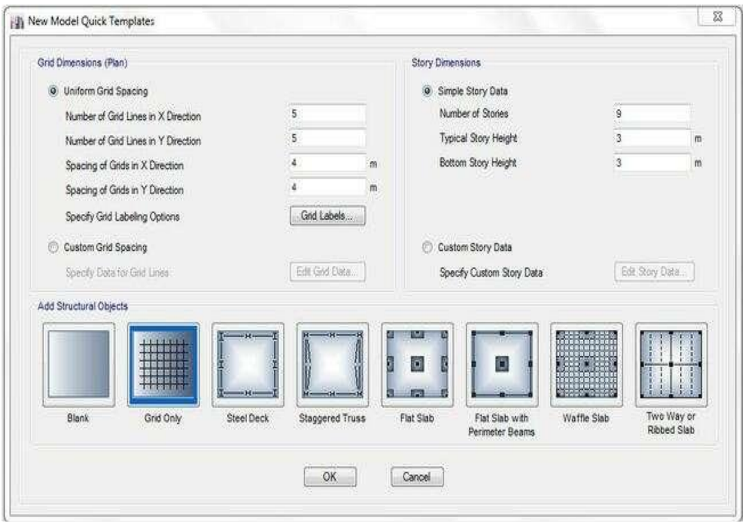

Fig 16 Grid system

4.3.2 Define material & sectional properties

Material properties are defined for concrete such as M25, M35. And for steel such as HYSD500. Sectional properties are also defined for various structural members like column, beam, slab etc. and its dimension, materials and reinforcements are also defined.

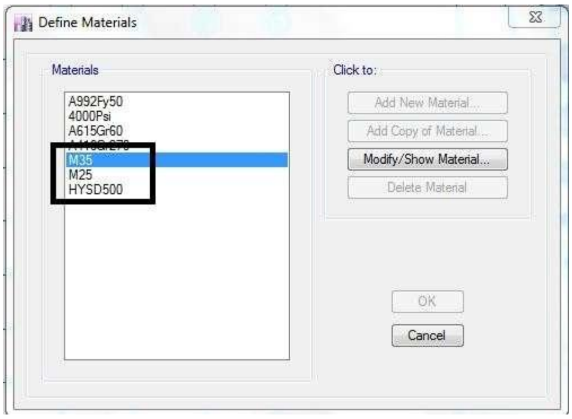

Fig 17 Material property

Fig 18 Sectional properties

4.3.3 Define structural components

The structural members like slabs, beams, column that are defined are drawn on the grid and modelling process is done.

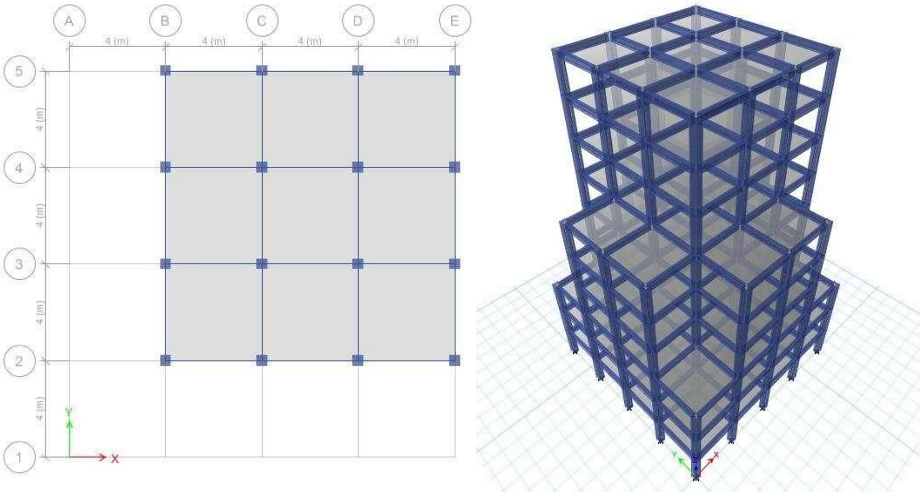

Fig 19 Modelling

4.3.4 Define load patterns

Load patterns such as dead load, seismic loads and live loads are defined. And data is inputted as per design codes.

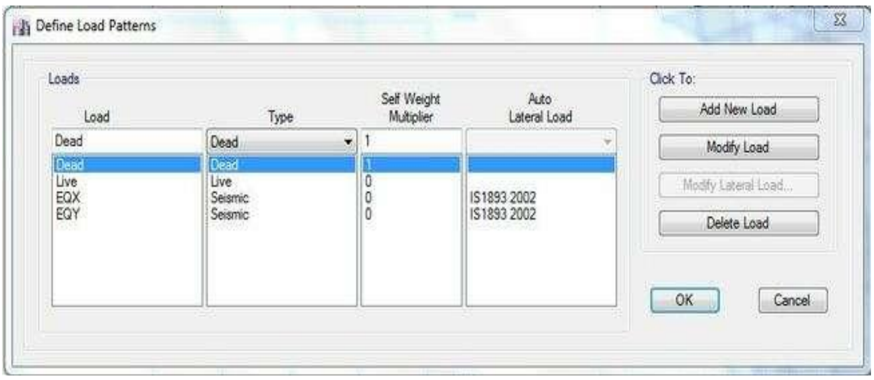

Fig 20 load pattern

4.3.5 Define cases & combination of loads

Load combination and cases are selected as per design codes.

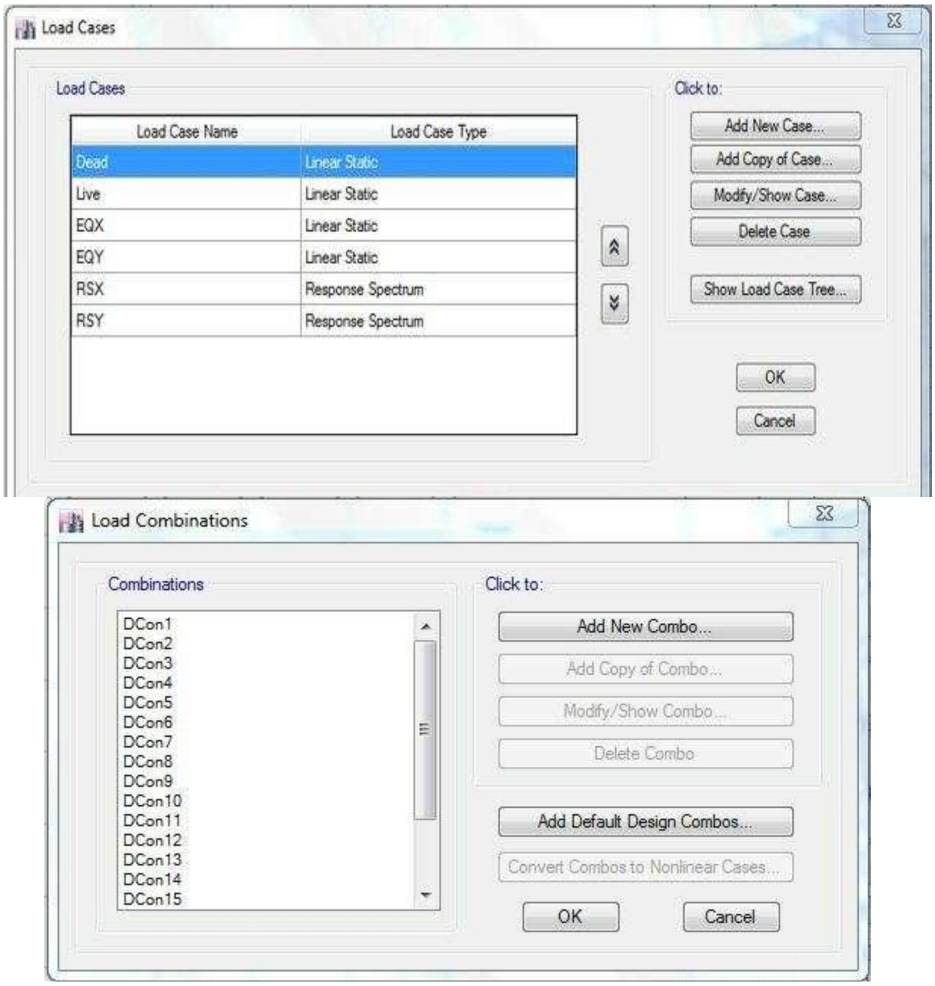

Fig 21 load cases and combination

4.3.6 Application of various loads

After defining the loads it is assigned on the respective members.

Fig 22 Load assignment

4.3.7 Dynamic analysis data

Dynamic analysis is done by selecting the required method such as RSA which stands for response spectrum method of analysis. Dynamic analysis data is entered, parameters like seismic zones, its factor, type of soil, reduction factor and importance factor is inputted. And procedure is followed as shown in the figure.

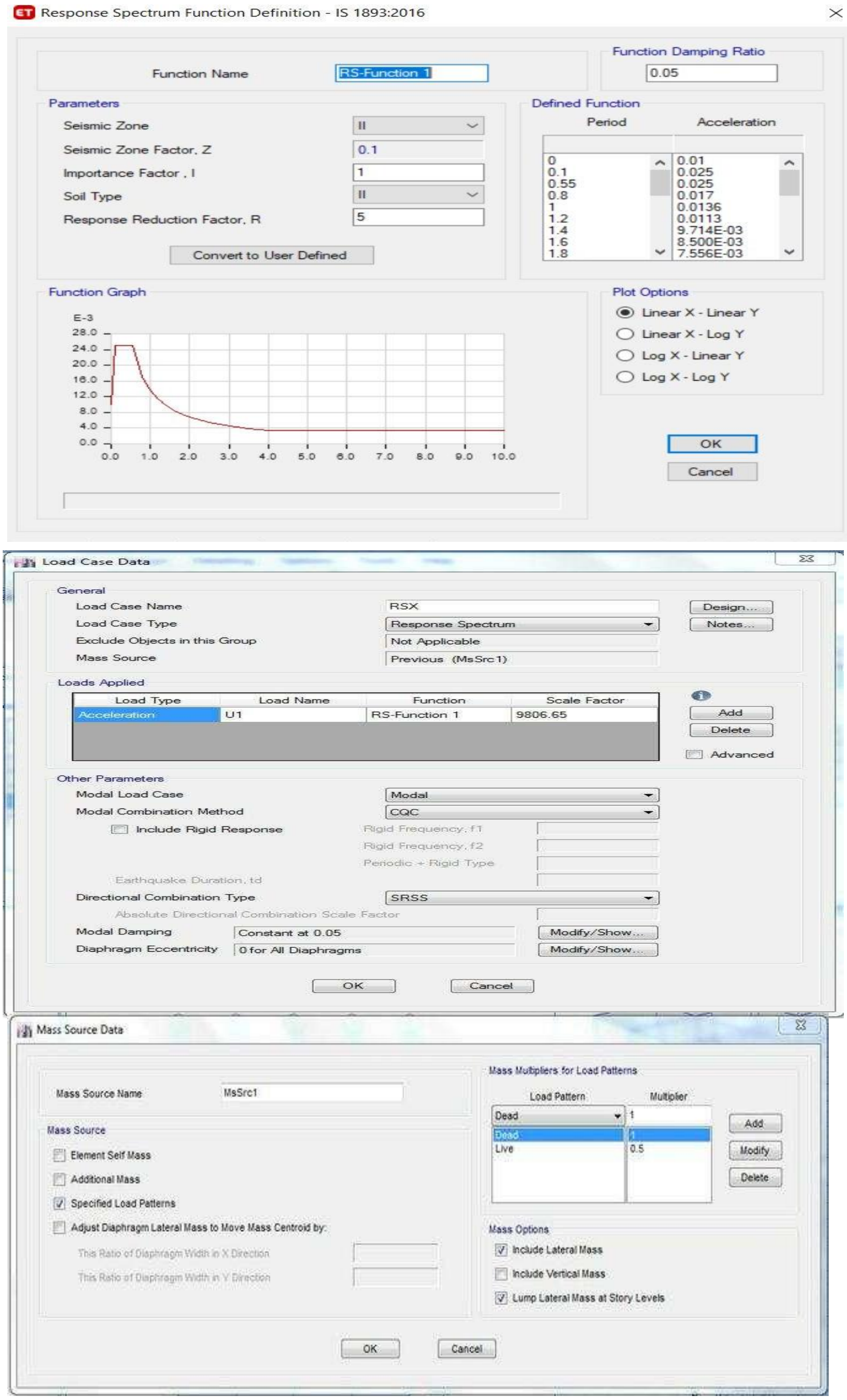

Fig 23 Dynamic analysis procedure

4.3.8 Check for error

After defining the material and section data, defining the loads, assigning the loads and modelling process is done. Checking of errors is done for the model. If any mistakes are seen it will be corrected and after that model is analysed

Fig 24 Checking for error

4.3.9 Analysing the models

After all process is done, the model is analysed. Etabs performs computations and results are generated.

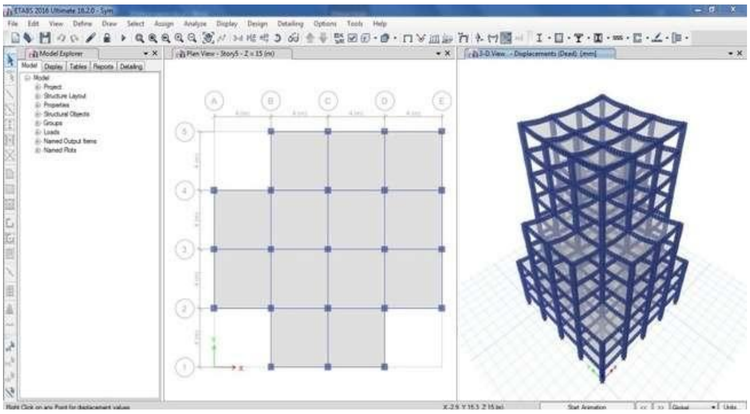

Fig 25 Analysis

5. Results

Table 3:- Storey drift (for 6 storey model)

STOREY	Model.M1	Model.M2
Base	0	0
StoryS1	0.002117	0.002048
StoryS2	0.003103	0.00297
StoryS3	0.002908	0.002963
StoryS4	0.002411	0.002513
StoryS5	0.001749	0.001934
StoryS6	0.001	0.001146

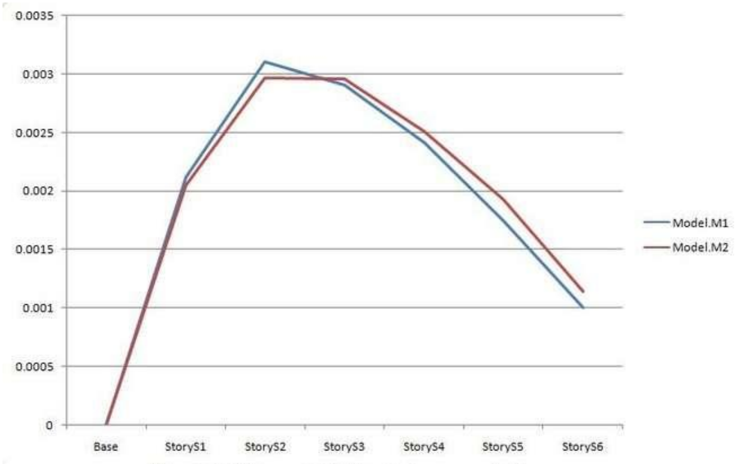

Fig 26 Storey drift (for 6 storey model)

Table 4:- Storey drift (for 9 storey model)

STOREY	ModelM-3	ModelM-4
Base	0	0
StoreyS-1	0.001785	0.001799
StoreyS-2	0.00293	0.00294
StoreyS-3	0.003007	0.002993
StoreyS-4	0.002825	0.002992
StoreyS-5	0.002542	0.00277
StoreyS-6	0.002191	0.002373
StoreyS-7	0.001774	0.002037
StoreyS-8	0.001293	0.001539
StoreyS-9	0.000787	0.000933

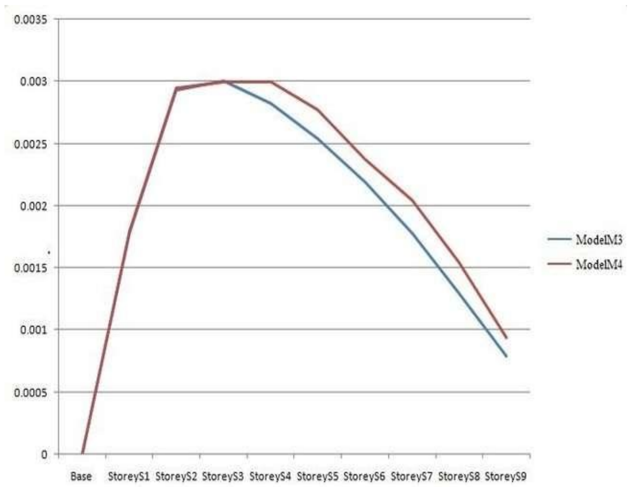

Fig 27 Storey drift (for 9 storey model)

Table 5:- Storey displacement (for 6 storey model)

STOREY	Model.M1	Model.M2
Base	0	0
StoryS1	6.352	6.143
StoryS2	15.65	15.026
StoryS3	24.336	23.843
StoryS4	31.481	31.282
StoryS5	36.596	36.942
StoryS6	39.471	40.251

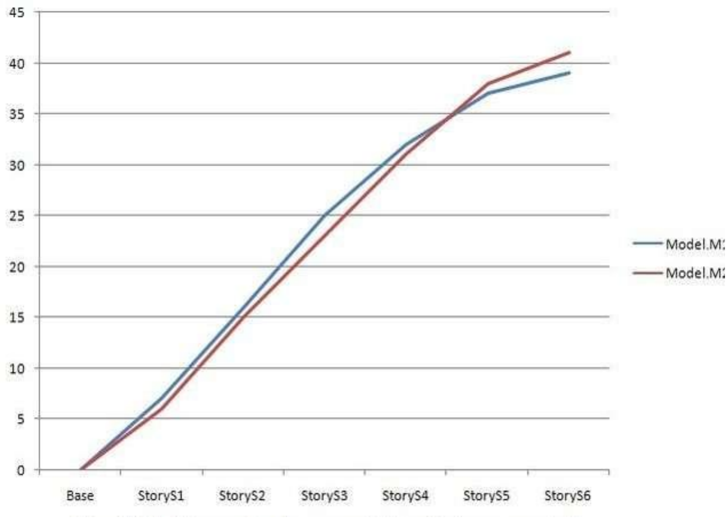

Fig 28 Storey displacement (for 6 storey model)

Table 6:- Storey displacement (for 9 storey model)

STOREY	ModelM-3	ModelM-4
Base	0	0
StoreyS-1	5.355	5.398
StoreyS-2	14.136	14.202
StoreyS-3	23.13	23.129
StoreyS-4	31.53	31.992
StoreyS-5	39.015	40.141
StoreyS-6	45.375	47.049

StoreyS-7	50.433	52.881
StoreyS-8	54.044	57.212
StoreyS-9	56.21	59.799

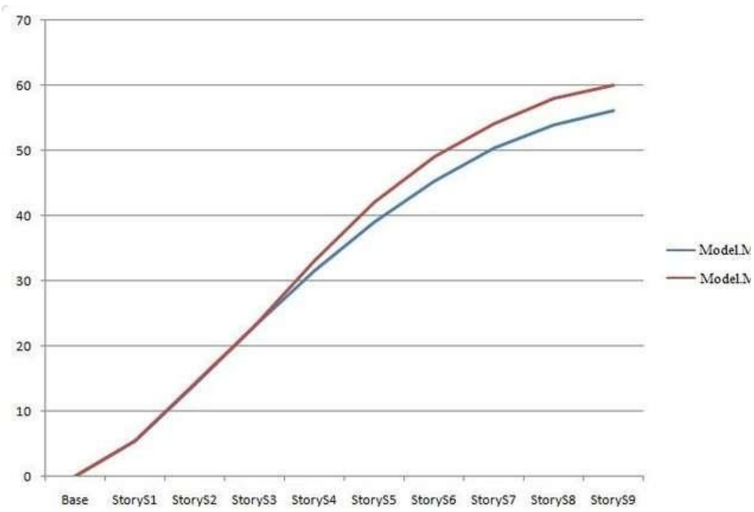

Fig 29 Storey displacement (for 9 storey model)

Table 7:- Storey Shear (for 6 storey model)

STOREY	Model.M1	Model.M2
Base	0	0
StoryS1	2252.7913	1740.3442
StoryS2	2143.4512	1627.1443
StoryS3	1906.5037	1392.3704
StoryS4	1559.9959	1099.2403
StoryS5	1116.8404	730.2368
StoryS6	583.5644	387.0228

Table 8:- Storey Shear (for 9 storey model)

STOREY	ModelM-3	ModelM-4
Base	0	0
StoreyS-1	2442.9769	1994.0281
StoreyS-2	2384.0808	1929.2874
StoreyS-3	2254.2453	1789.3492
StoreyS-4	2071.8336	1599.4375

StoreyS-5	1844.0755	1395.9501
StoreyS-6	1575.9964	1152.0124
StoreyS-7	1261.1855	875.1928
StoreyS-8	895.1041	629.2655
StoreyS-9	462.8304	326.8516

Table 9:- Time period (for 6 storey model)

Mode	ModelM-1	ModelM-2
Mode 1	0.735	0.657
Mode 2	0.208	0.208
Mode 3	0.081	0.077

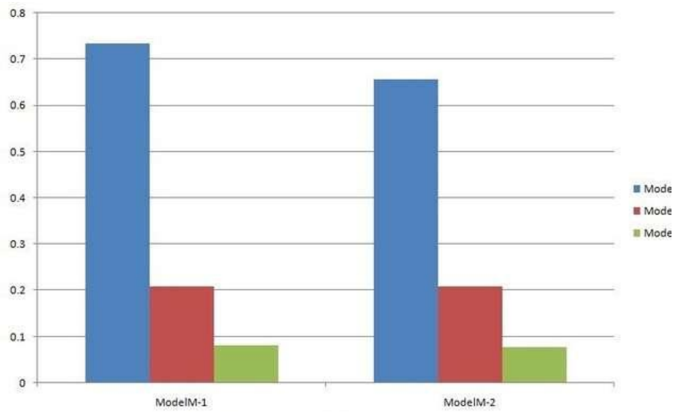

Fig 30 Time period (for 6 storey model)

Table 10:- Time period (for 9 storey model)

Mode	ModelM-1	ModelM-2
Mode 1	1.043	0.932
Mode 2	0.295	0.291
Mode 3	0.113	0.108

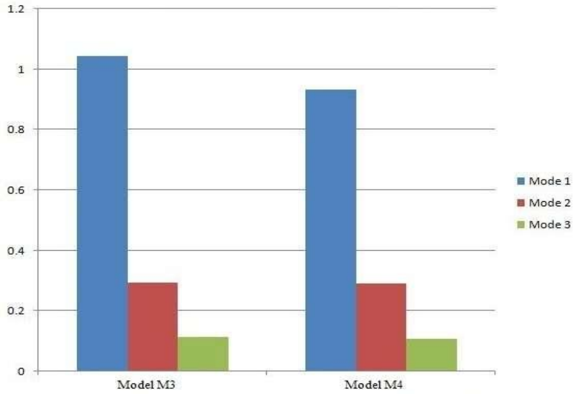

Fig 31 Time period (for 9 storey model)

6. Conclusion

1. Storey drift increases in starting, reaches maximum at the Storey 3 than it starts decreasing.
2. Storey drift is greater at starting stories in case of symmetrical building, but it becomes less and the drift in asymmetrical building overtakes.
3. Storey displacement increases exponentially as height of the building model increases.
4. Storey displacement remains almost same in starting stories of both the models, then displacement of asymmetrical building increases more than symmetrical building.
5. Storey shear increases exponentially from top stories to bottom stories.
6. Storey shear is more in symmetric model compared to asymmetric model.
7. Time period is almost same in both the cases but slightly more in symmetric models
8. Asymmetrical buildings are affected more during the seismic activities.

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