Seismic Analysis of Multi-Storey Structure Subjected To Different Ground Motions

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Abstract: Major Construction project in urban India is incorporated with Reinforced Concrete (RC) frames, which experience both static and dynamic forces during their lifetime. Static forces can easily be analysed whereas dynamic force analysis is very time consuming, but it can't be left unanalysed as the results may be catastrophic. Earthquake is an important dynamic force which a building may experience during its lifespan and is therefore its analysis becomes a critical step in design.

The present work in its utmost sense, aim at understanding the influence of different ground motions on the structure over its life span. This providing new parameters and information to help improve design work.

INTRODUCTION

During an earthquake, the structure undergoes dynamic motion due to reaction of the inertia forces built up in the direction against the acceleration of seismic forces. These inertia forces, also known as seismic forces, are considered by assuming pseudo external forces acting on the building. Excluding gravity loads, predominant structure experiences significant lateral forces of considerable magnitude during seismic action. Thus, before the designing of the structure is carried out, it becomes integral to identify and estimate the magnitude of lateral forces acting on the structure.

Reinforced concrete structures are routinely designed for higher strength parameters than the necessary service load constraints. In general, the members are designated with greater dimensions and higher material standards than the minimum strength requirements specified in the IS design codes. The design procedures for seismic loads also results with greater strength parameters. Furthermore, the redundancy of the structure under the account of division of stresses will also lead to increased overall strength. The current study understands the comparison of storey displacement, base shear, and storey drift of RC framed structure with in individual seismic regions of Indian sub-continent.

Keywords: Seismic Analysis, Multi- Storey Structure, Storey Displacement, RC Structure

1. Literature Review

Numerous studies have been accomplished for seismic analysis of multistorey structure due to different ground motions. Some of them were discussed below.

- Mr. Dr.B.Panduranga Rao, Mr. S.Mahesh, et al (2014). Taking into account the importance of a building to resist earthquake loads, the paper focuses on using ETABS to help analyse and design of multi-storied buildings in various regions and different soils in regular and irregular conFigureuration. Base shear and storey drift were identified as the main parameters and values obtained from both the software's were plotted for different regions and soil. Results are analysed and appropriate conclusion are drawn.

- Mohit Sharma and Dr. Savita Maru et al (2014). The paper focuses on the static and dynamic analysis of a G+30 storied regular building for regions-2 and region-3 using STAAD. Axial forces, torsion, moment, displacement were some of the parameters considered and values for static and dynamic analysis were compared and reported. The performance of RCC Framed Structure is analysed. For the same points and conditions, it was observed that values obtained in dynamic analysis were greater than those obtained in static analysis

- Anirudh Gottala, Kintali Sai Nanda et al (2015). The paper focuses on the study the seismic performance of ten storey building taking into account different setbacks and ductility classes. Inter storey drifts, performance of structural members, over strength factors and pushover curves are some of the parameters considered to compare and arrive at the results and draw appropriate conclusions

- Athanassiadou et al (2008) the effect of earthquake load on structures cannot be overlooked. Keeping this in mind, the following paper constitutes the analysis of a multi-storied framed structure (G+9) building under static and dynamic forces. Bending moment, Nodal Displacements, Mode shapes were the parameters used to draw the comparisons between static and dynamic analysis. From the values obtained, appropriate conclusions were arrived upon.

2..Methodology

The present study about the multi-storey seismic analysis will proceed in two stages-

i. Performance differentiation of a reinforced concrete structure for all present seismic regions in India i.e., II(Two), III(Three), IV(Four), and V(Five). For the desired structure, it will consist of the following steps-

- Modelling of the structure with all the mandatory parameters.
- Structure design adequate for the four seismic regions in India.

ii. Analysis of factors like base shear, storey drift and storey displacement of designed structure for various seismic sectors.

Type of Structure	Familial Building
Number of Stories	16
Typical Floor Height	3.2m
Size of Column	300mm X 500mm
Slab Thickness	150 mm
Masonry Wall's Thickness	230 mm
Live Load	2 kN/m^2
Miscellaneous Load	1 kN/ m^2
Soil Types Considered	Type II
Characteristic Compressive Strength of Concrete, F_{ck}	20 N/mm^2
Steel's Grade	500 N/mm^2
Concrete's Density	25 N/mm^2
Modulus Elasticity of Concrete	2000 N/mm^2
Poison's Ratio of Concrete(M)	0.3
Density of Brick Masonry(P)	19.2 kN/m^3
Modulus of Elasticity for The Brick Masonry	14000 N/mm^2
Poison's Ratio of Brick Masonry	0.2

A. Details of the structure and properties of the materials

Table 1: Structural details.

B. Seismic Parameters of respective regions

Characteristics	Region 2	Region 3	Region 4	Region 5
Number of stories	16	16	16	16
Typical storey height, m	3.2	3.2	3.2	3.2
Seismic region, Z	0.10	0.16	0.24	0.36
Response reduction factor, R	3	3	3	3
Importance factor, I	1	1	1	1
Soil type	II	II	II	II

Table 2: Seismic Attributes

C. Modelling Procedure in ETABS

1. Selection of new model template to create new model.

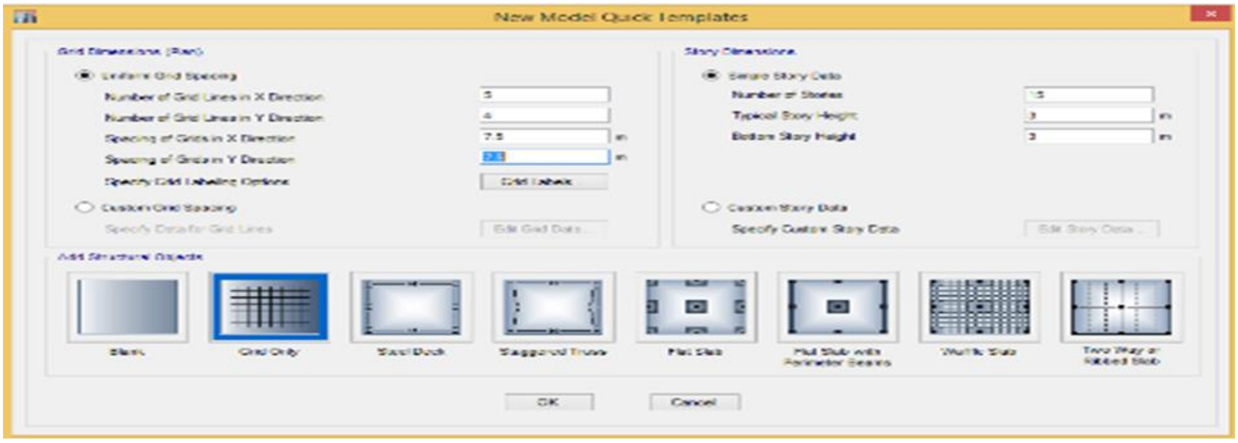

Figure.1 New Model Quick Templates

2. Define new materials.

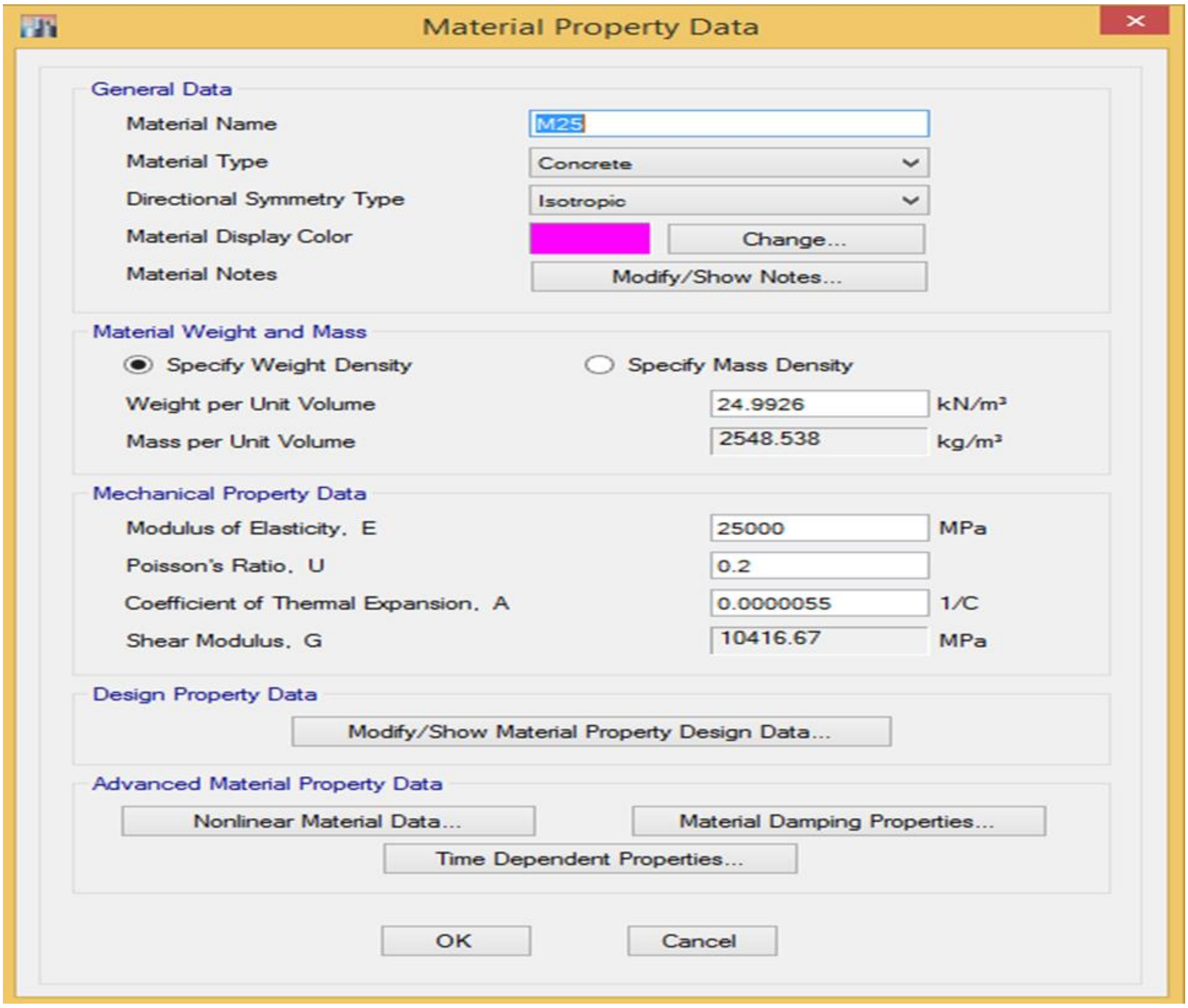

Figure. 2: Material Property Data

3. Defining M25 grade concrete as material.

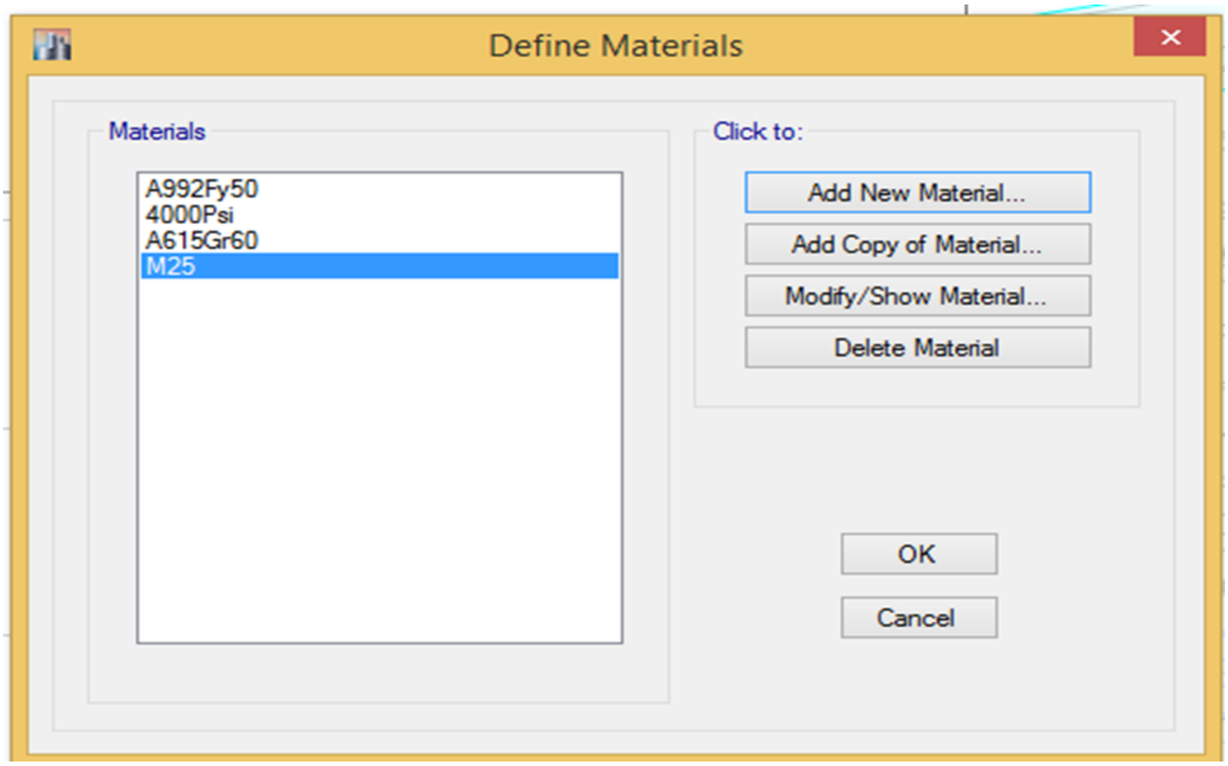

Figure.3: Define Materials

4. Define frame section.

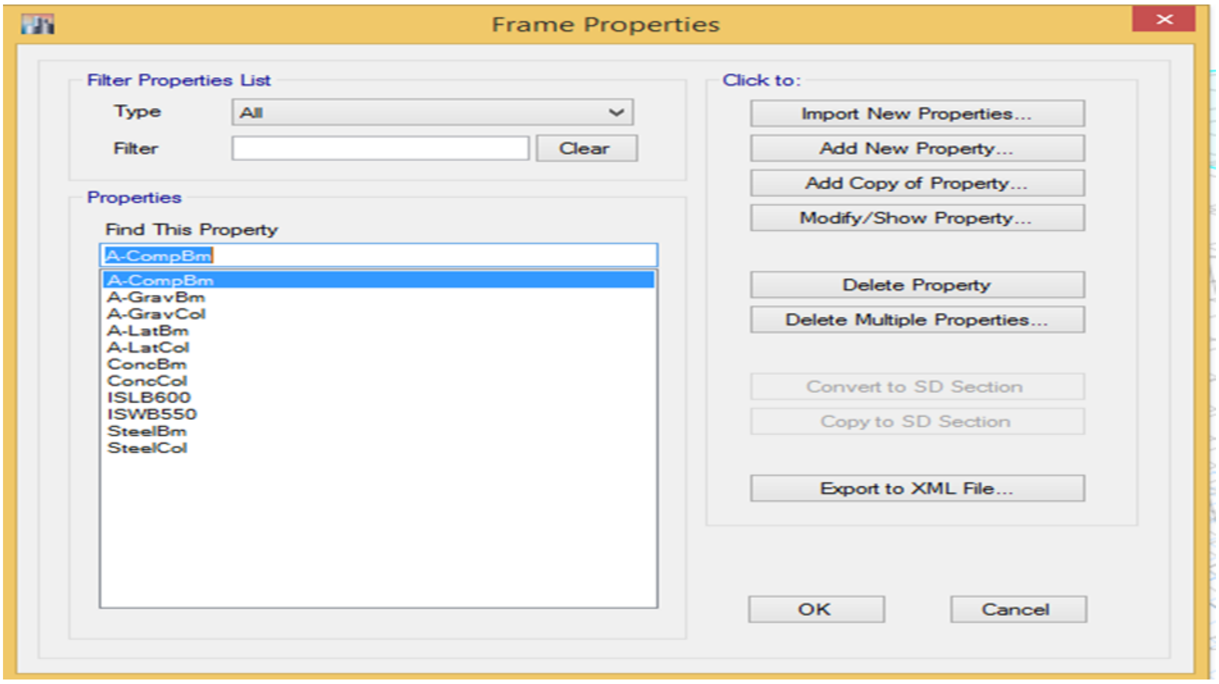

Figure. 4: Frame Properties

5. Define rectangular section.

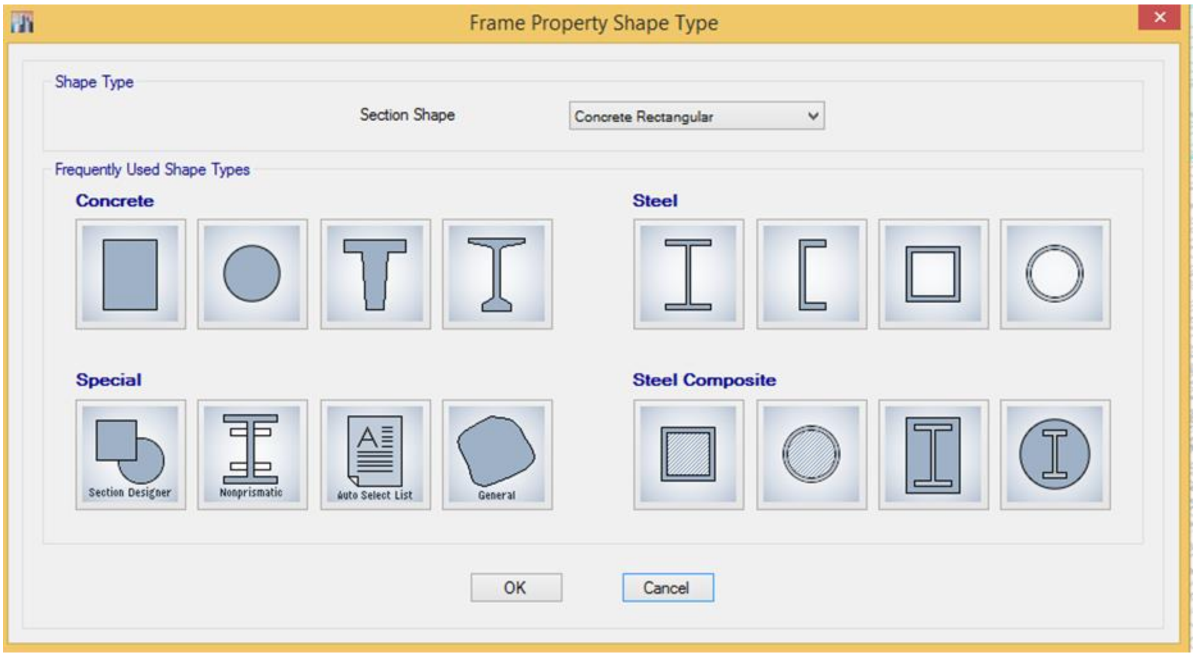

Figure.5: Frame Property Shape Type

6. Define rectangular beam section of 400x500mm.

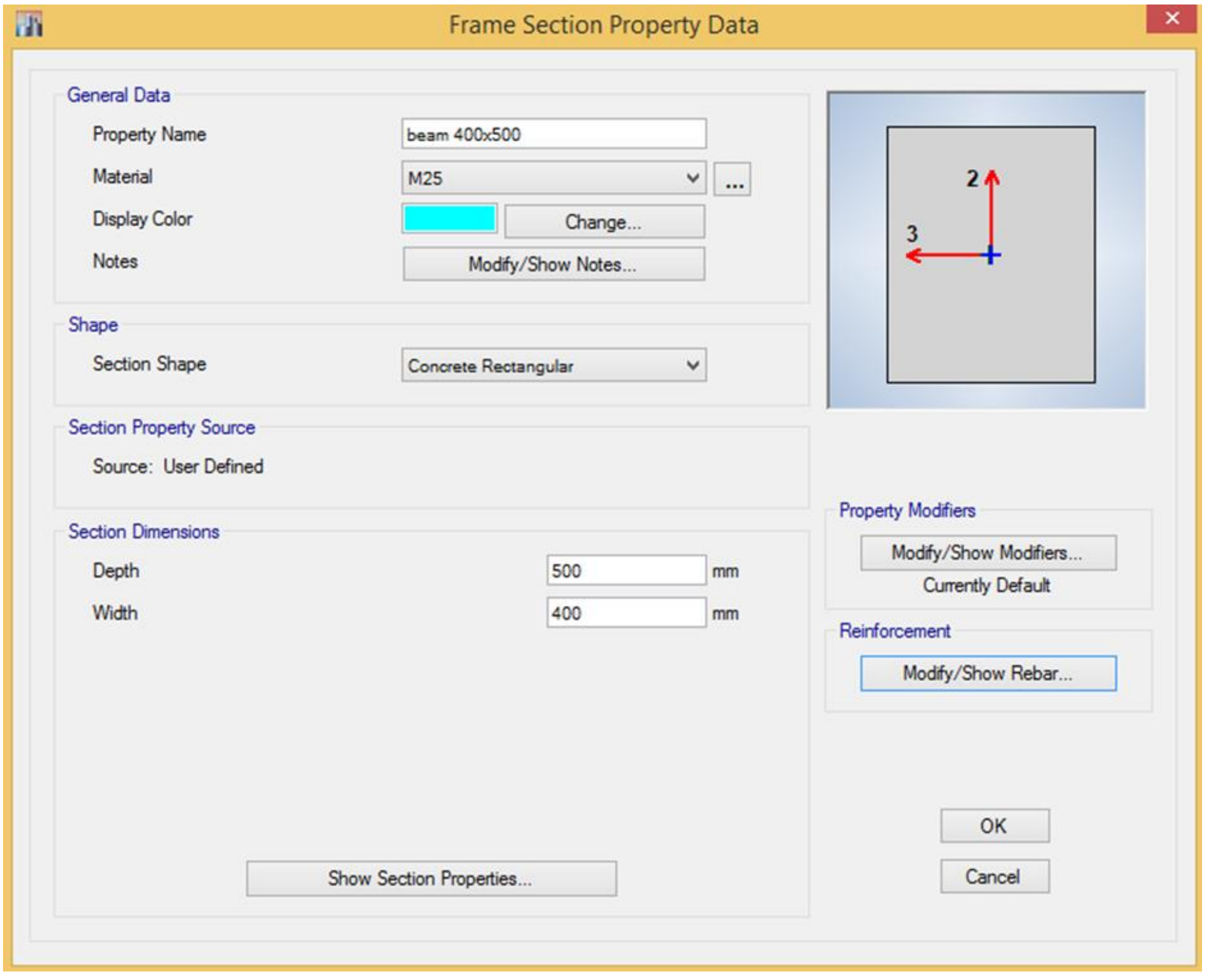

Figure. 6: Frame Section Property Data

7. Define rectangular column section of 600x600mm.

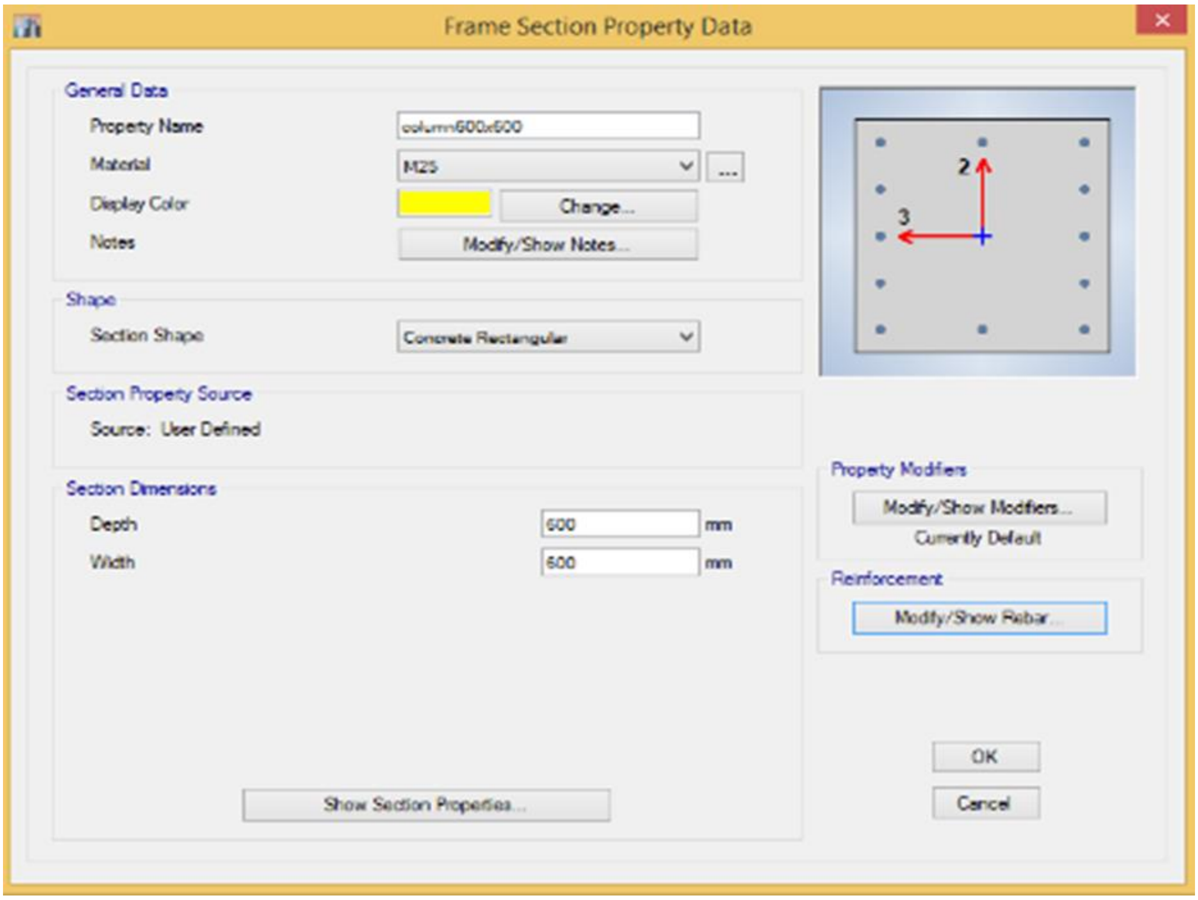

Figure. 7: Frame Section Property Data

8. Define slab section.

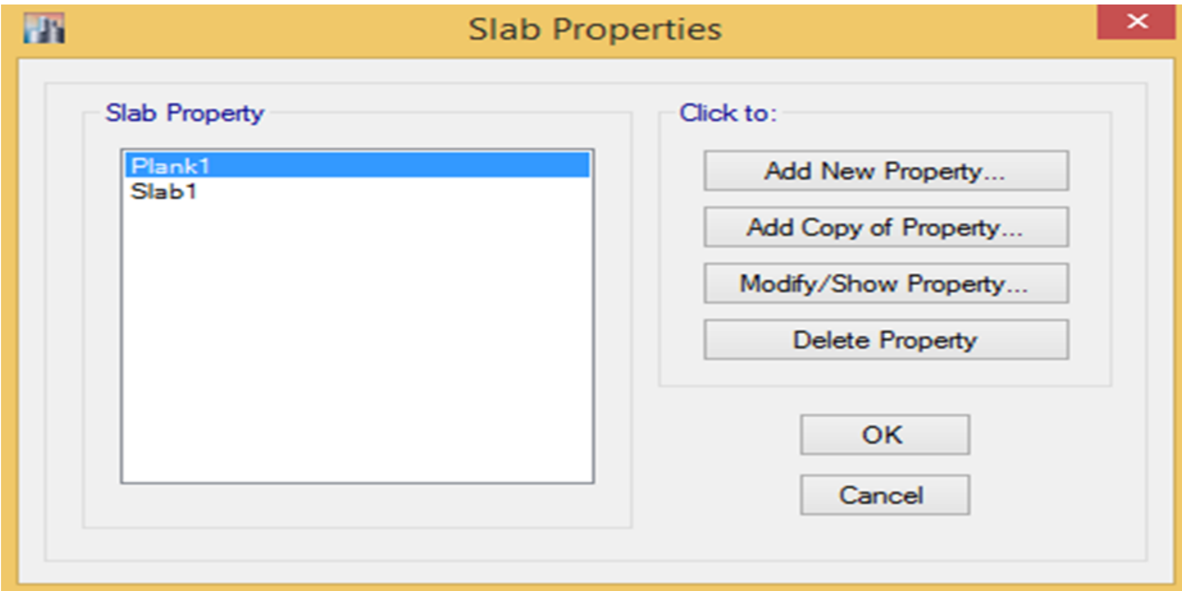

Figure. 8: Slab Properties

9. Create slab section of 150mm thick.

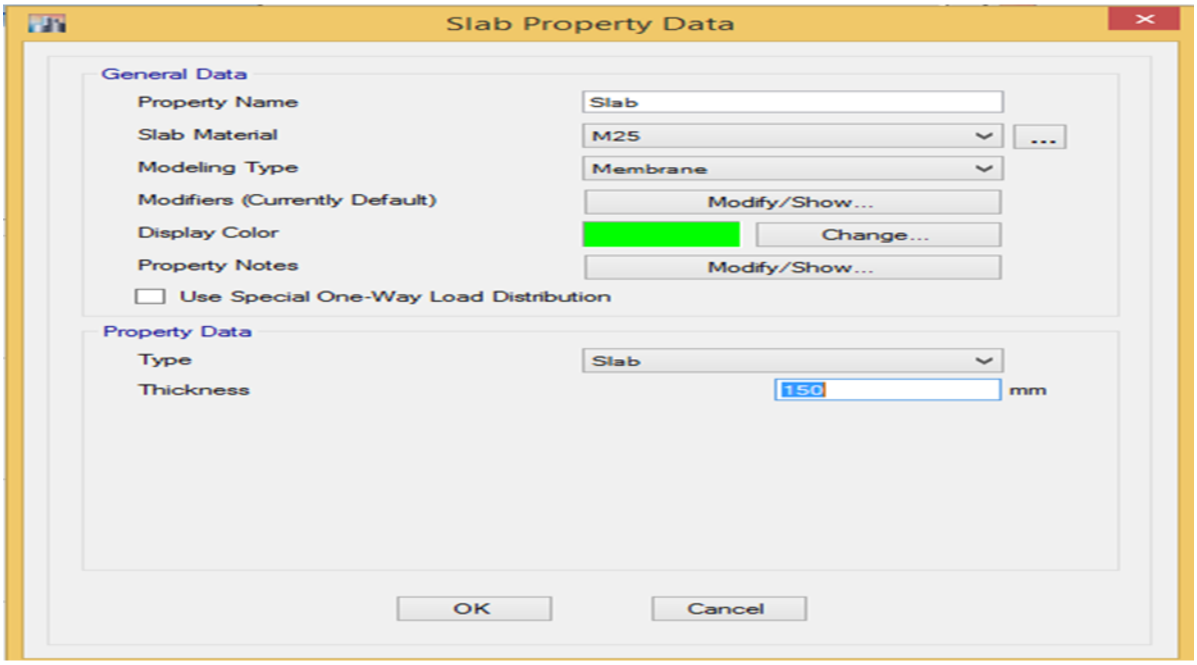

Figure. 9: Slab Property Data

10. Plan view of the building.

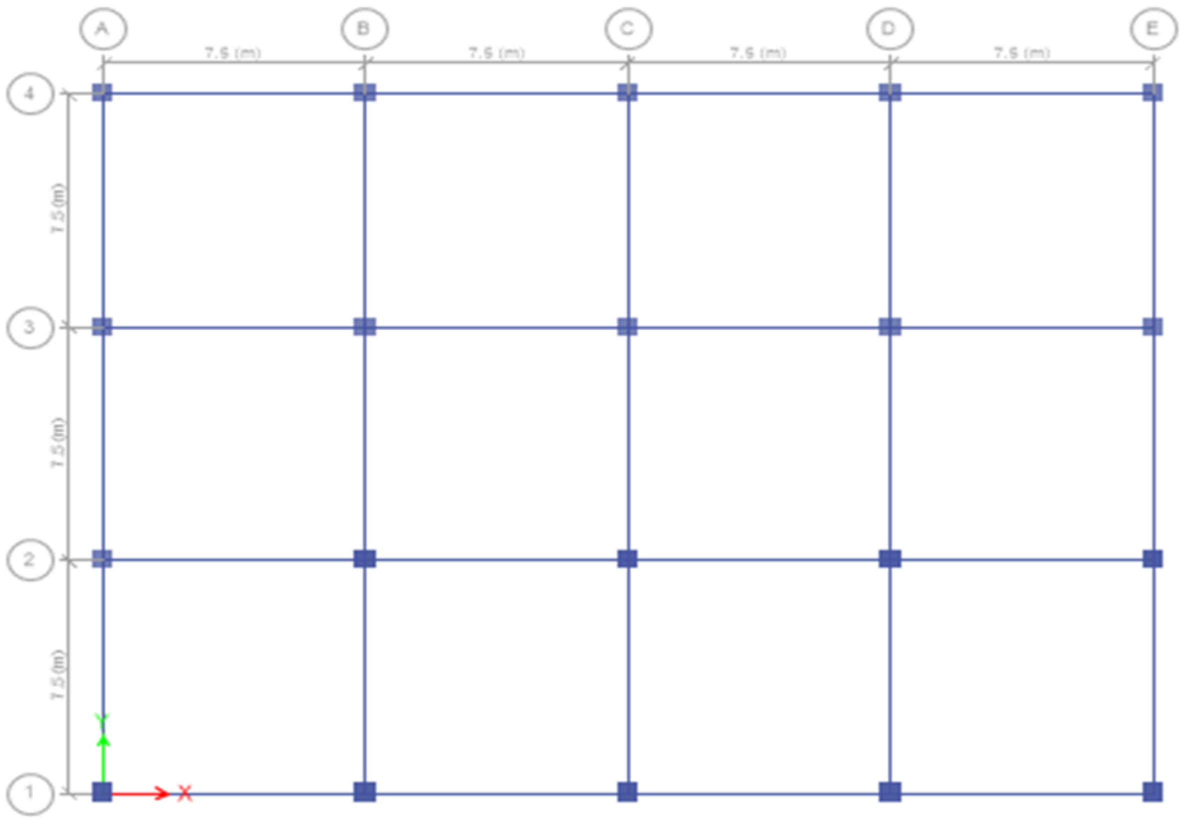

Figure. 10: Plan View

11. 3D Rendered view of building

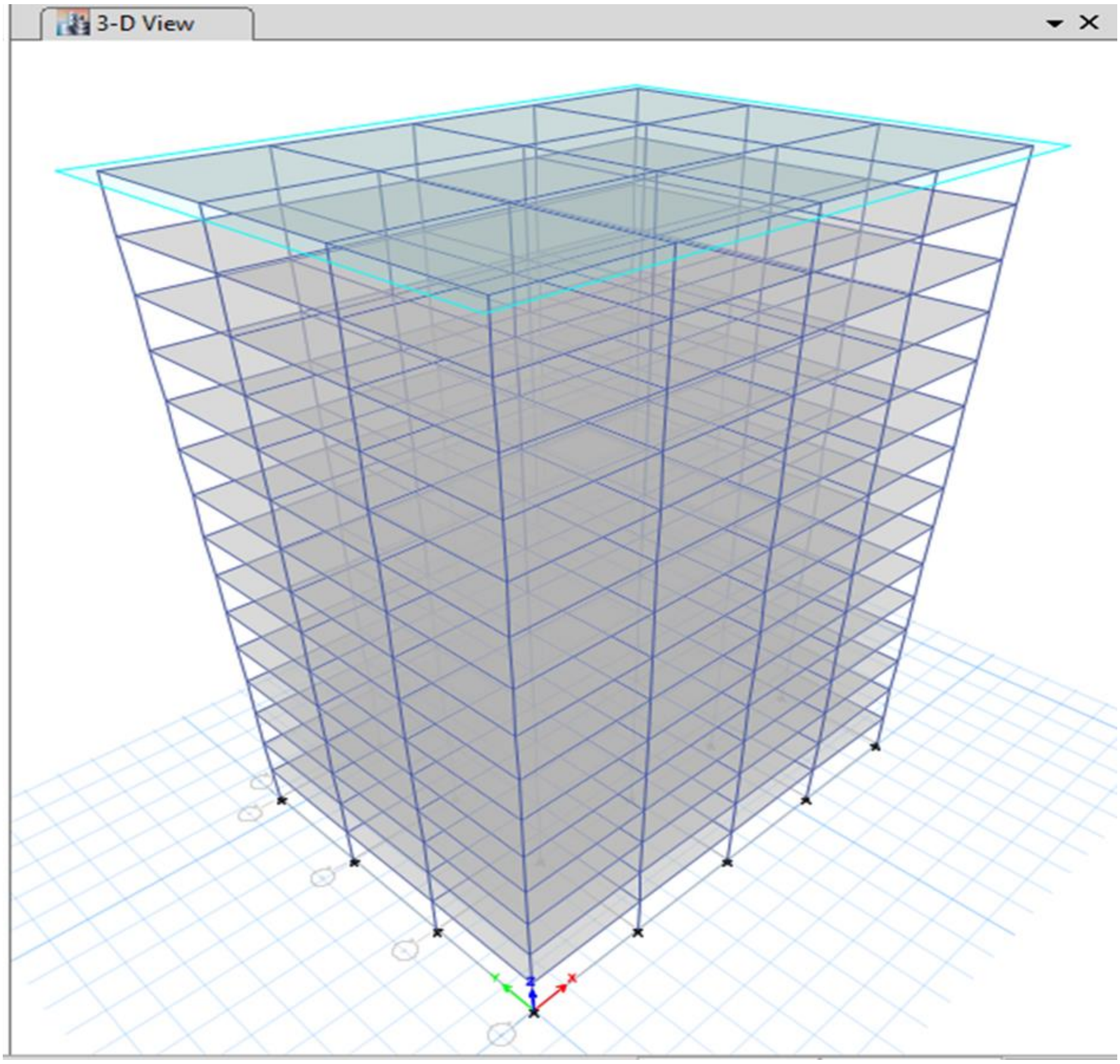

Figure. 11: 3D Rendered View

12. Define different load types.

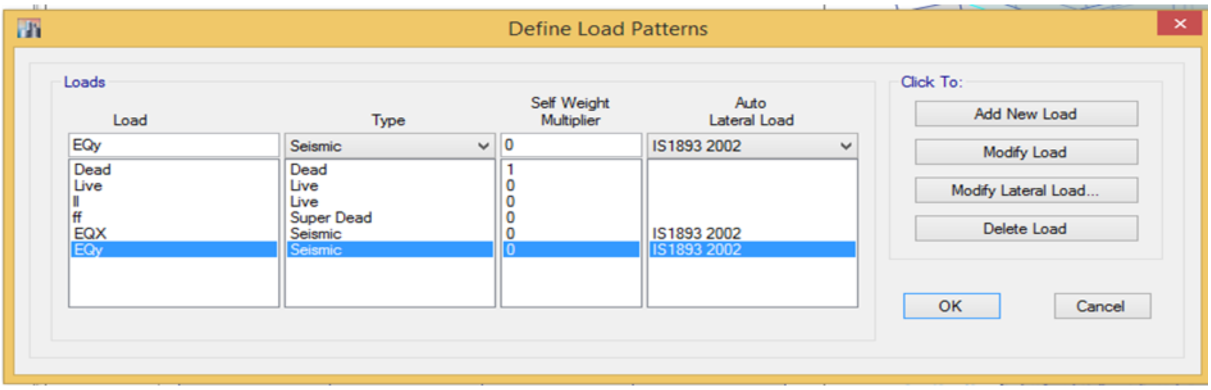

Figure. 12: Define Load Patterns

13. Elevation of typical 16 storey building.

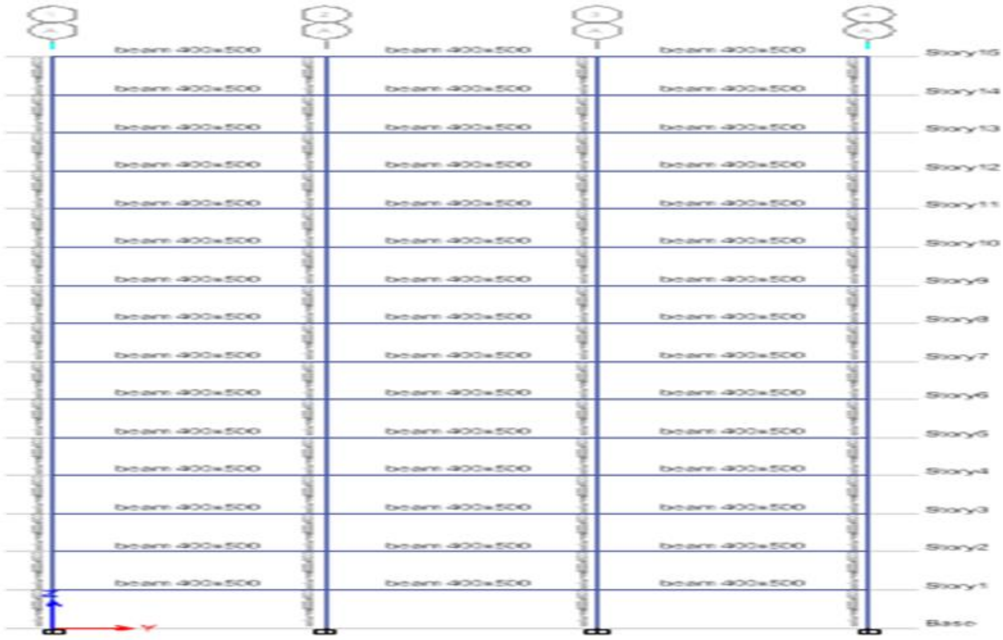

Figure. 13: Typical Elevation

14. Assigning different types of loads.

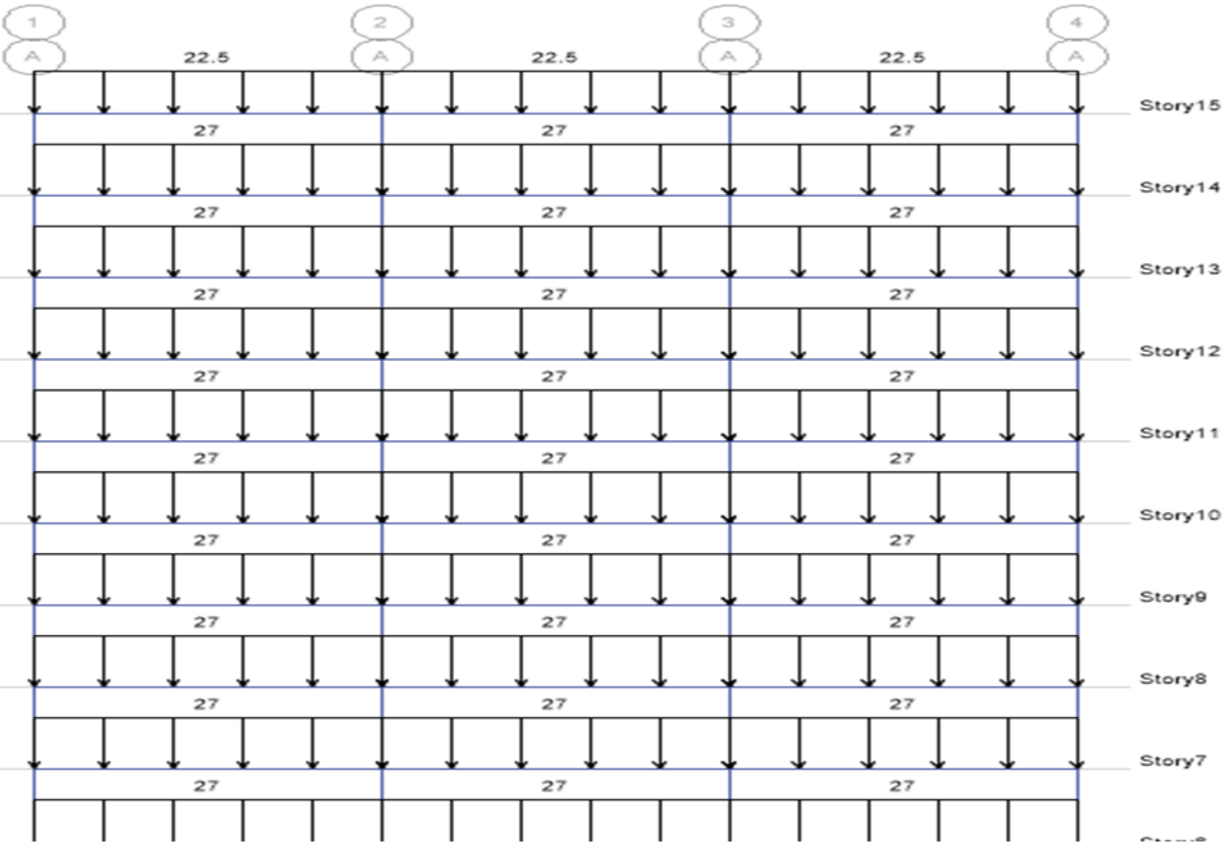

Figure. 14: Assigned Loads

15. Define typical mass source data.

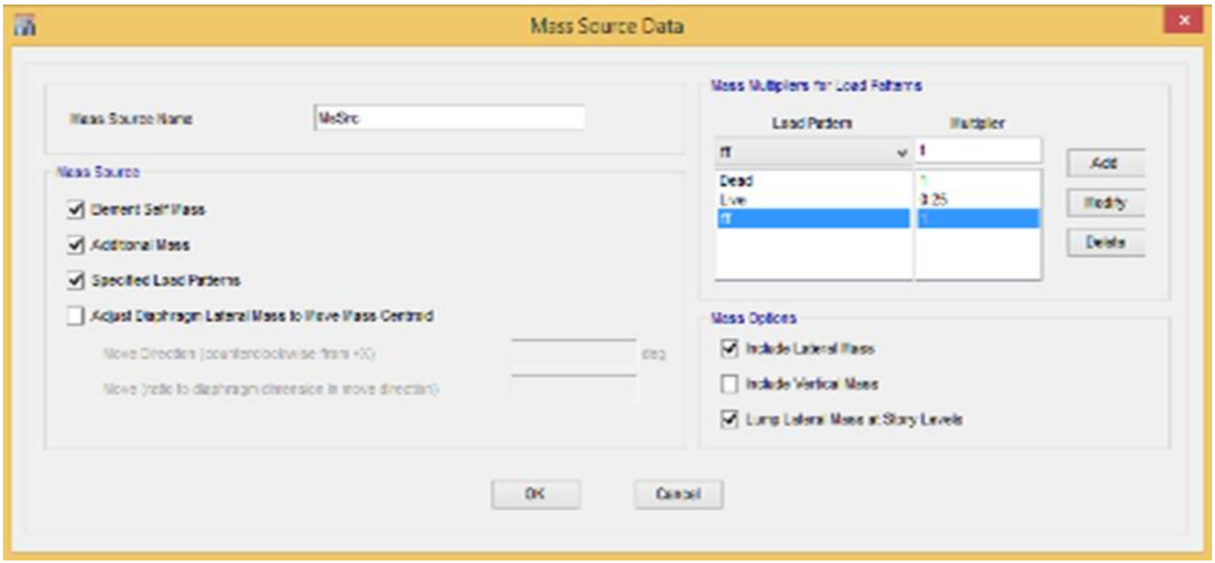

Figure. 15: Mass Source Data

16. Clasic response spectrum function as per IS 1893:2002.

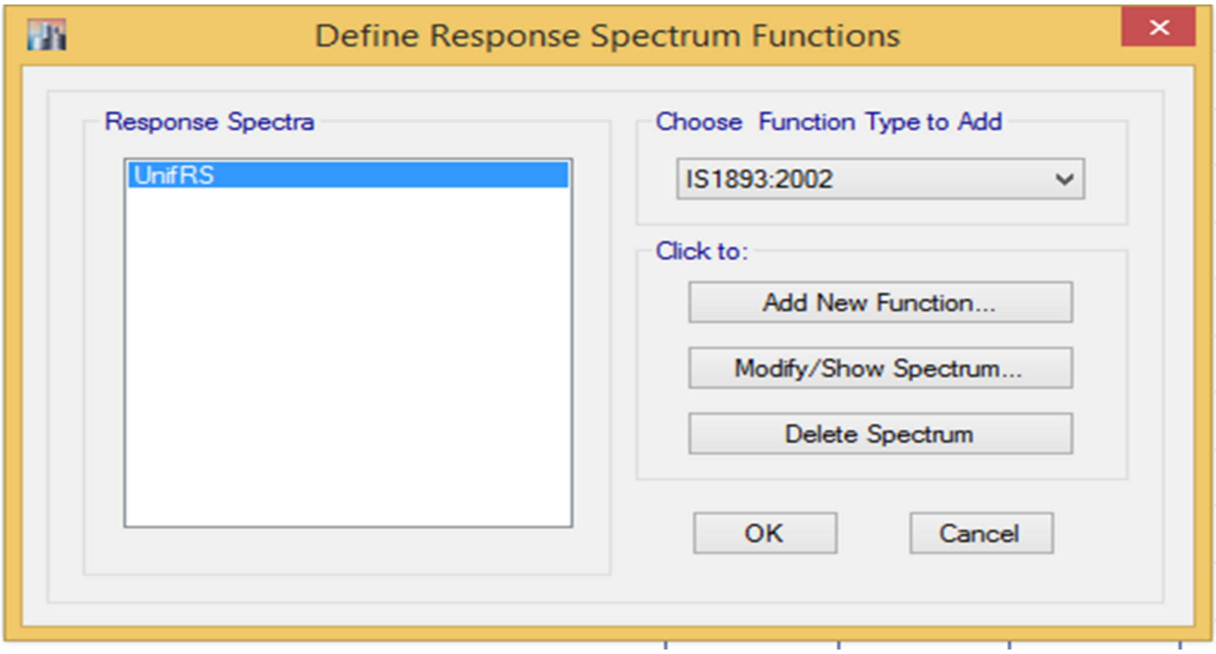

Figure. 16: Define Response Spectrum Function

17. Defining load combination data for modal combination

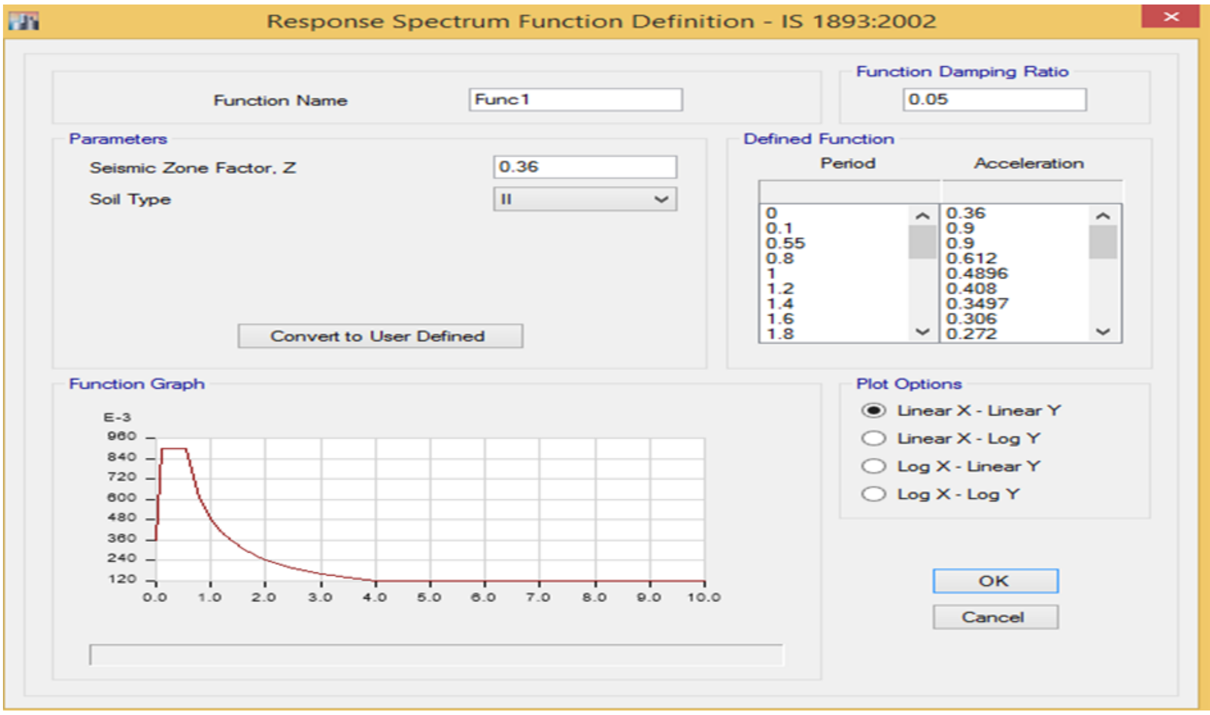

Figure. 17: Response Spectrum Function Definition

18. Defining load combination data for modal combination.

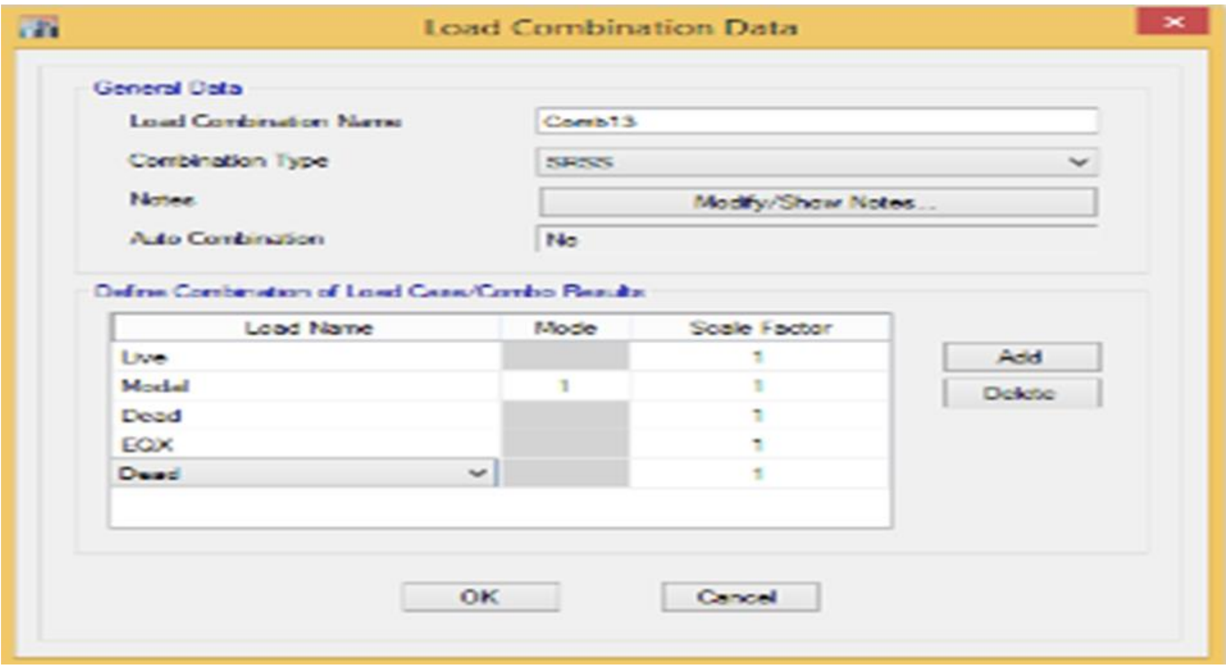

Figure.18: Load Combination Data

19. Defining time history function

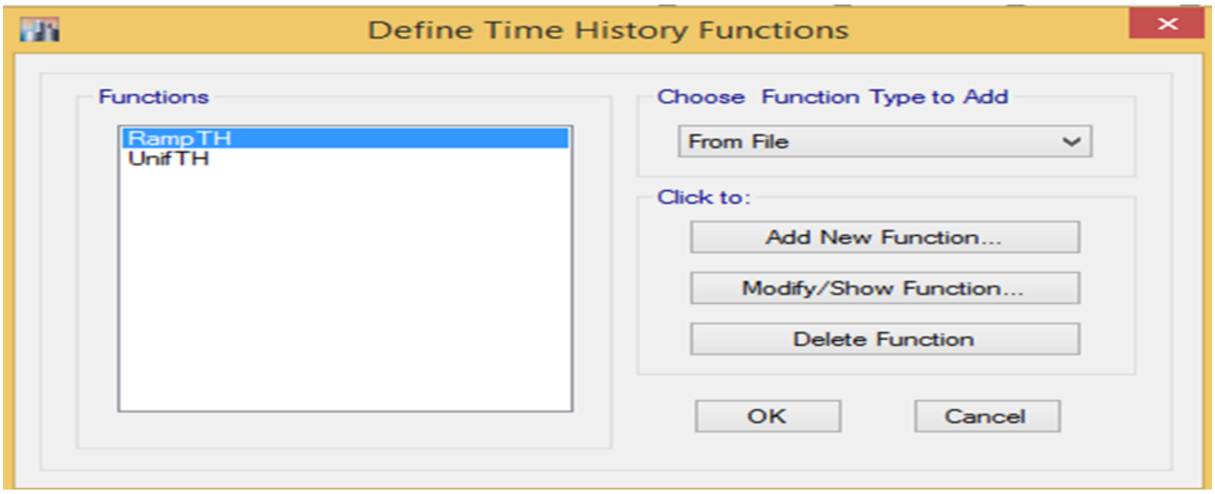

Figure. 19: Define Time History Functions

20. Selection of Default time history data from ETABS

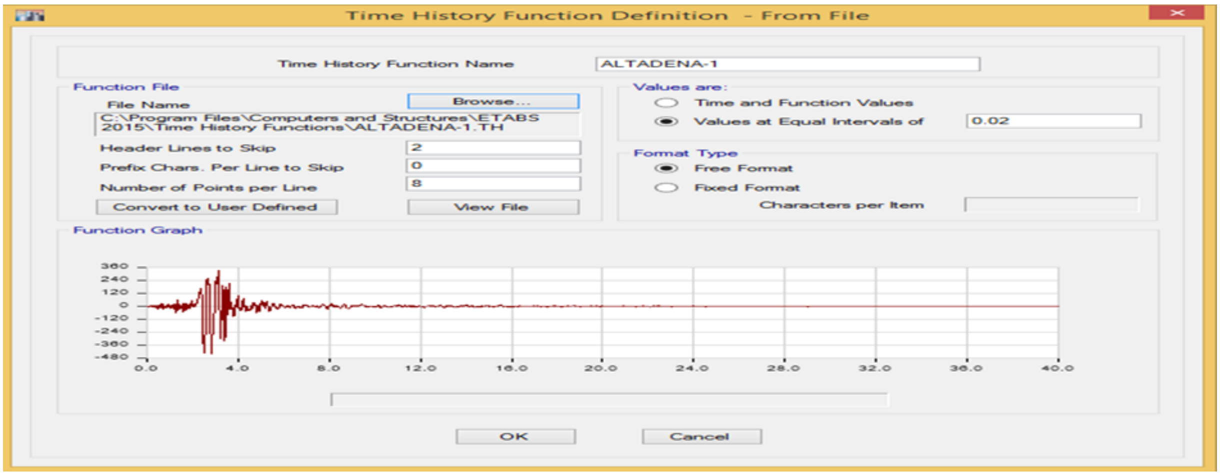

Figure.20: Time History Functions Definition.

21. Defining load case data for response spectrum analysis.

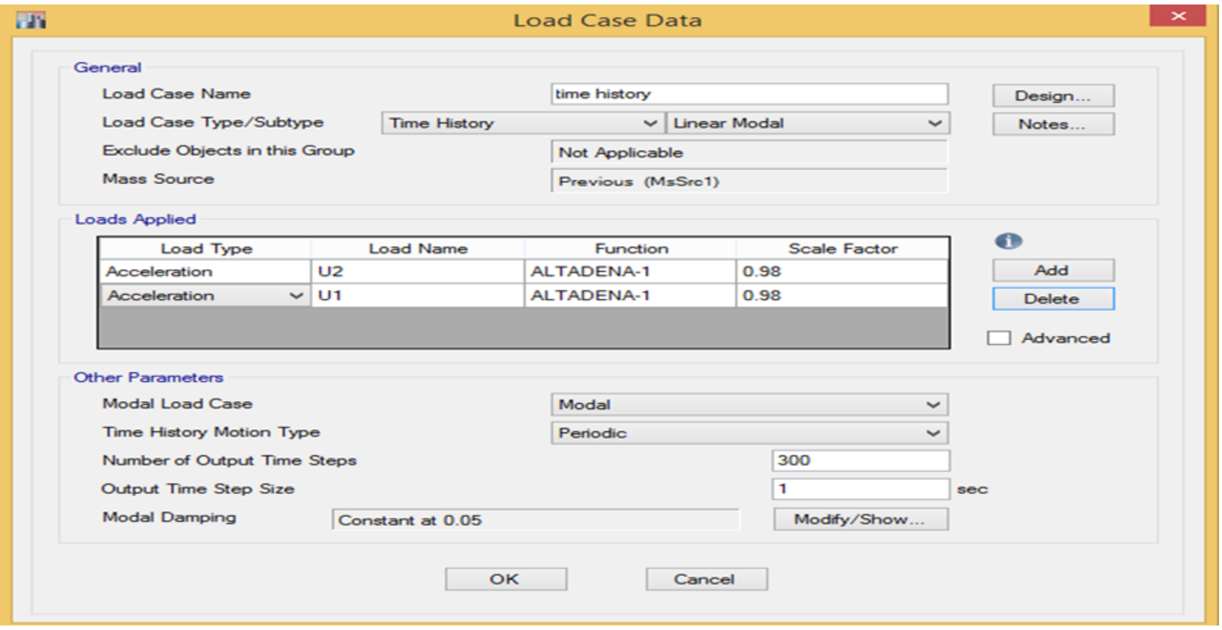

Figure. 21: Load Case Data

22. Bending moment diagram over the entire height of the building.

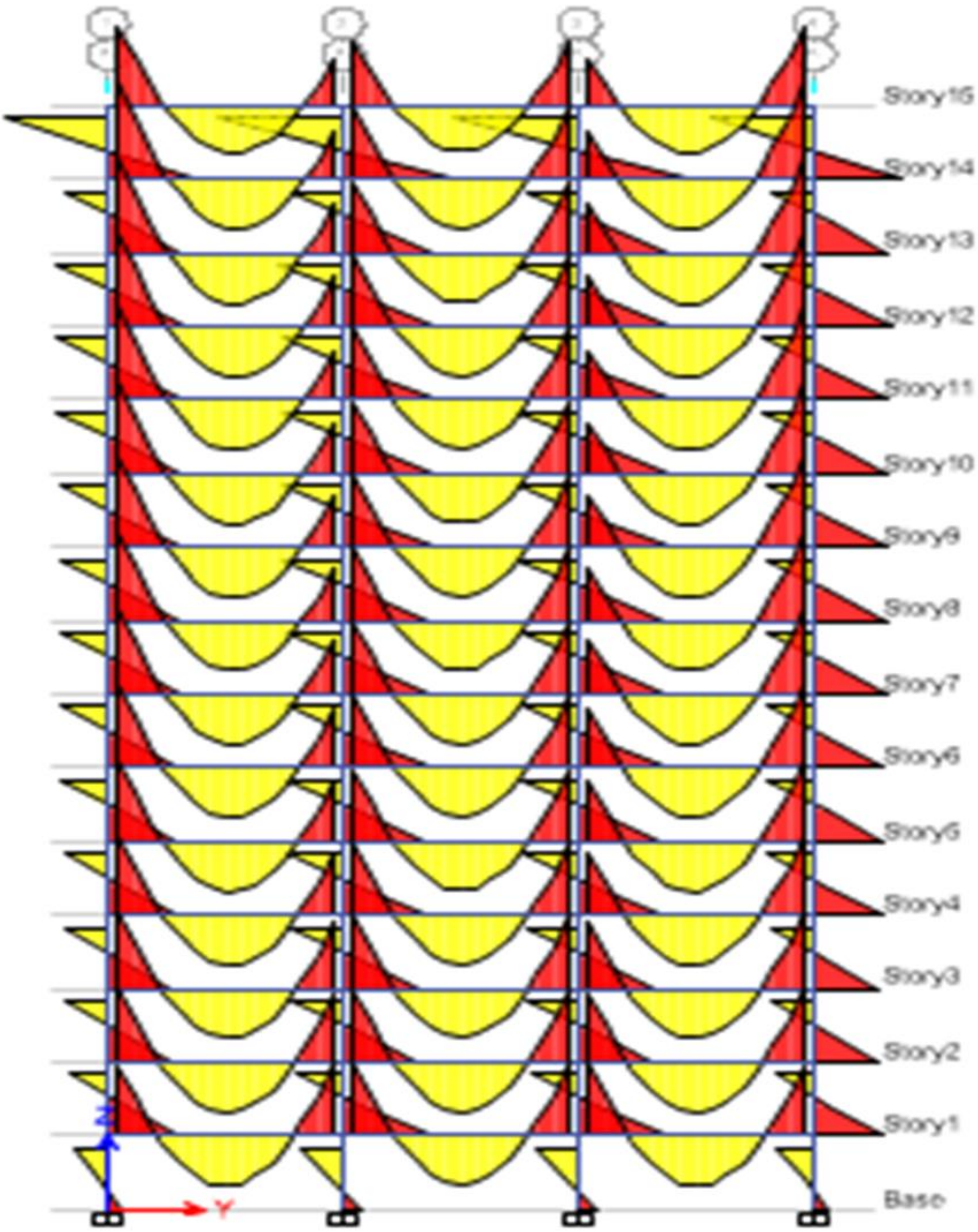

Figure. 22: Bending Moment Diagram of the Designed Structure

23. Shear force diagram over the entire height of the building.

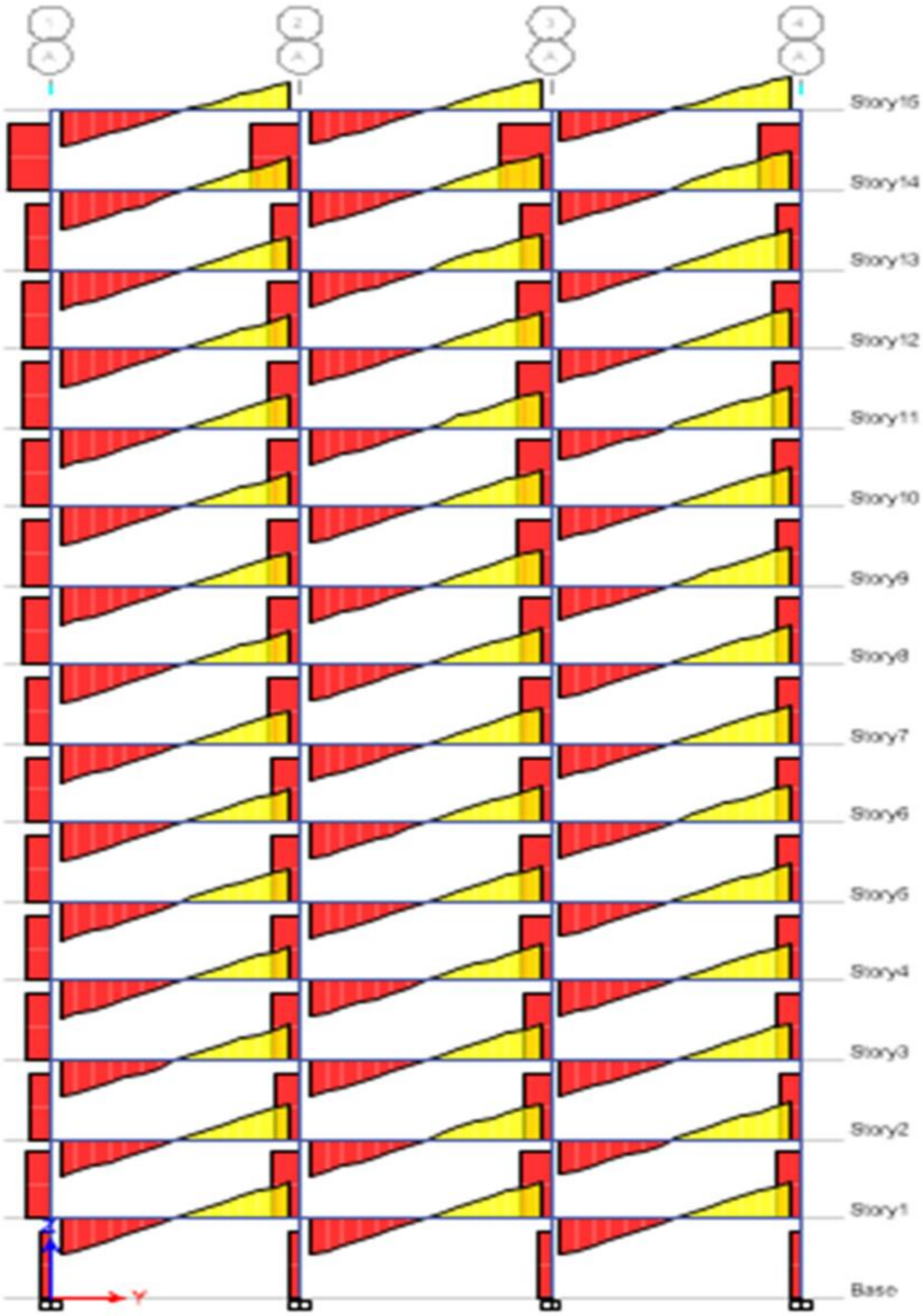

Figure. 23: Shear Force Diagram

24. Typical variation of shear, moment and deflected profile for any beam considered.

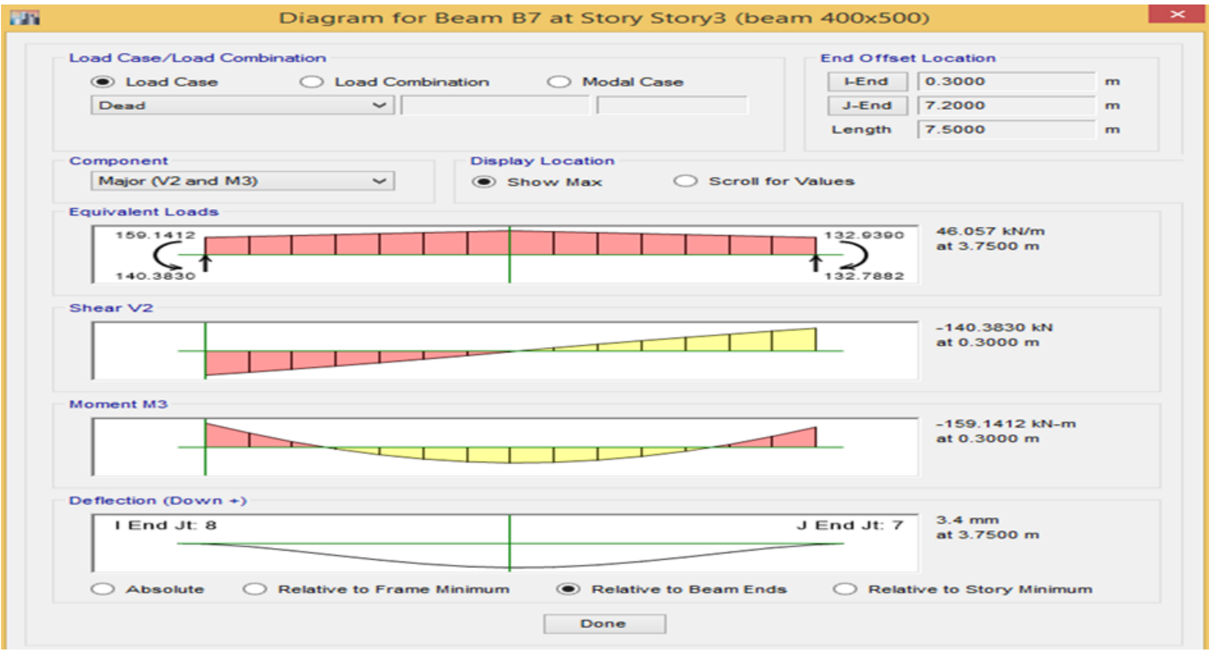

Figure. 24: Diagrams for beam B7

3.Results

The following results have been obtained when the ETABS analysis was conducted on the desired structure model:

Regions	Base Shear (kN)
II	442.15
III	707.46
IV	1061.18
V	1591.75

A. Base Shear of the structure:

Table 3: Base shear of structure for respective regions

The value for maximum base shear obtained in seismic region 5 is 1591.75 kN. The trend also indicates that the base shear increments with increments in seismic regions.

Regions	Displacement (mm)
II	22
III	35.2
IV	52.8
V	79.1

B. Storey Displacement for Various Seismic Regions:

Table 4: Storey displacement of the structure for different regions

Similar to base shear, storey displacement also increases with increases in region with region 5 having highest value of storey displacement i.e.79.1 mm.

C. Storey Drift At Each Floor

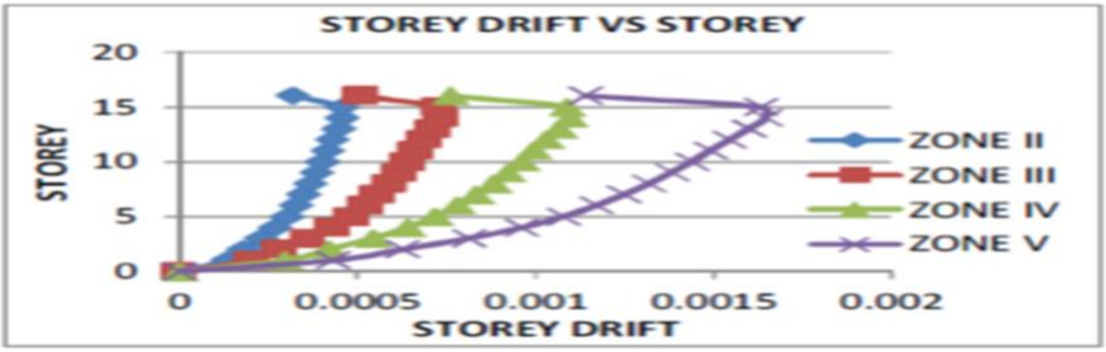

Figure.25: Graphical Comparison of Storey drifts w.r.t Storeys in the designed structure

It can be concluded that from base to the 14th storey, storey drift moderately increases, whereas under 15th and 16th storey, a rapid decrease in storey drift takes place. This is due to the fact that maximum storey drift occurs at the central part of the structure.

4. Conclusions

When analysis of desired structure is done using ETABS and response spectrum analysis is considered for the different seismic regions, the following conclusions can be drawn for the structure:

- With increment in region factors, there's gradual increase in the base shear and lateral displacement in the structure.
- The drift is observed to be increasing with increase in storey levels until 14th storey after which there's a rapid decline in storey drift.
- Stiffness becomes directly proportional to the frequency of the structure.

From the present study, it can be concluded that with increases in seismic activity; base shear and storey displacement shows increment from seismic region-2 to seismic region-5, indicating that to endure higher seismic action, the strength parameters should be altered equally or proportionally.

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