Static and Dynamic analysis of RC Buildings considering the effect of Dual system

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CHAPTER 1

INTRODUCTION

1.1. General

Tall buildings are usually flexible and are sensitive to dynamic loads. Therefore, estimating the natural frequency for tall buildings is highly important for evaluation of building response due to Wind or Earthquake. Forced vibration response of tall buildings due to these loads always involves natural frequency as a key parameter. The accuracy of solution of free vibration and its natural frequencies depends on the selection of the mathematical model. The exact dynamic behaviour of structures could be obtained through three-dimensional analyses such as Finite Element Analysis (FEM), Even simple models require large computational effort in FEM analysis.

Figure 0:1 Typical High-Rise Buildings with different Geometry

Advancement in the basic frameworks of tall structures has been a persistently developing procedure since the development in tall structures started in 1880s. From structure specialist's perspective tall structures might be characterized as one that, in light of its stature, it is influenced by the lateral forces because of wind or earthquake to a degree that they assume a vital part in the design of structures. The factors responsible for tall structure improvement are accessibility of urban area, progresses in development innovation and high-quality materials, effective basic frameworks and computational strategies and so forth. If there should be a tall structure, stiffness is more critical than its quality. It is important to guarantee that the top story displacement, sidelong float and human solace level in tall structure are inside as far as possible. To fulfil these configuration prerequisites distinctive basic frameworks are created for tall structure as appeared.

1.2. High Rise Building

A High-Rise building is a building that has multiple floors above ground. High Rise buildings aim to increase the floor area of the building without increasing the area of the land. The High-Rise building can be transformed to tall building to increase the floor space further more. A building whose height creates different conditions in the design, construction, and use than those that exist in common buildings of a certain region and period. The tall building design is influenced by the lateral loads such as wind, seismic, etc.

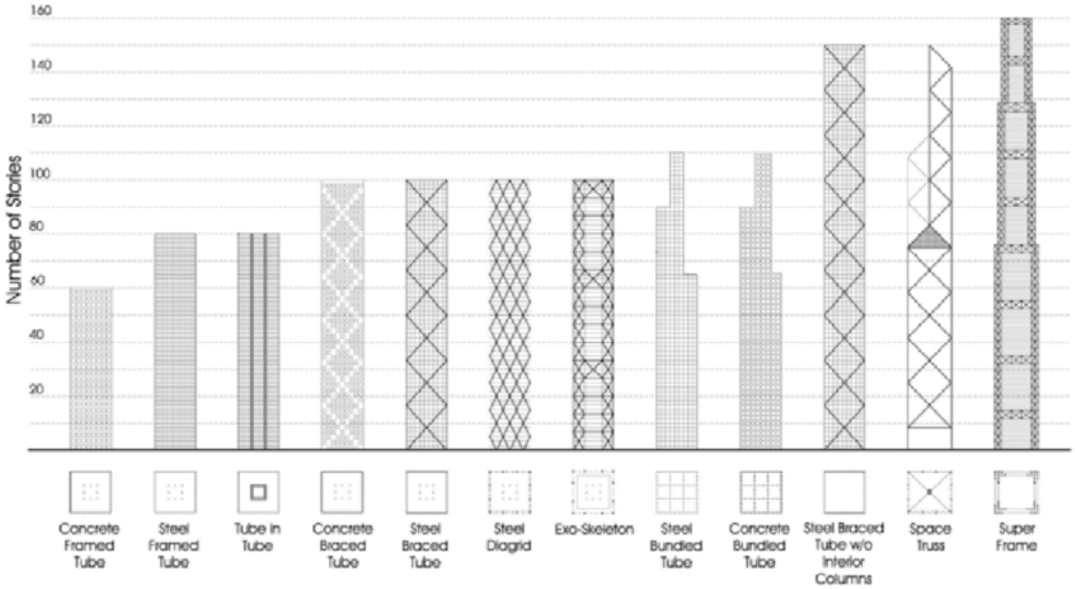


Figure 0:2 Typical High-Rise Buildings with different Structural Configuration

1.2.1.Demands for high rise frameworks

- Scarcity of land in urban areas.
- More demand for residential and commercial place.
- Economic development.
- Advancements in technology.
- Innovative works in structural systems.
- For architectural and aesthetic view in urban area.
- For reputation and cultural importance.
- To build in different way.

1.3. Different forms of Structural Systems

The common types of structural systems in tall structures are as follows:

- Rigid Frame System (Moment Resisting Frame System)
- Braced frame system
- Shear Wall System
- Coupled Wall System
- Advanced Structural forms- Tubular Systems

1.3.1.Rigid Frame System:

It is a system that utilizes the moment resisting connection between columns and beams along its total perimeter to resist the applied lateral loads. It can be utilized to provide lateral load resistance for low-rise buildings.

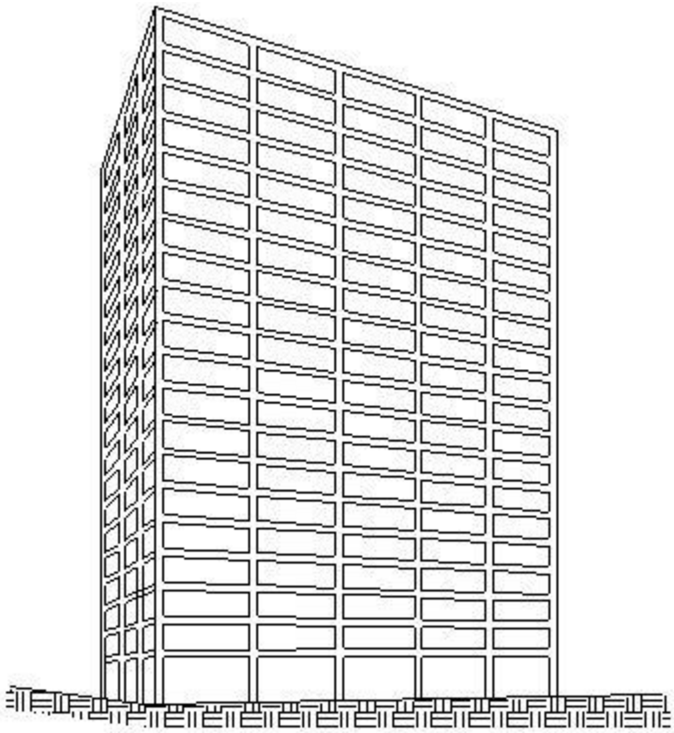


Figure 0:3 Rigid Frame System

Rigid frame, sometimes called continuous frame, offers a rotational stability that enhances how it carries vertical loads, increasing the longevity of the entire structure. Besides rigid frame, the same framing principles are used in the simple frame and partially restrained frame buildings. The joint connections can be fully fixed-end with fully restrained connections that cannot rotate, or they can be "pin connections," in which the members can freely rotate.

1.3.2. Braced frame system

To resist lateral deflections, the simplest method from the theoretical standpoint is an intersection of full diagonal bracing or X-bracing. It works well for 20 to 60 storey heights but does not give room for opening such as door and windows.

Figure 0:4 Braced Frame System

A framework of beams and columns in which inclined, often diagonal, structural members brace the building and provide strength and rigidity. The bracing can take a variety of forms. If diagonal members are stocky, they resist both tension and compression forces. However, if slender, they resist tension forces only. Usually, braced frame members are triangulated and meet at joints (similar to a vertical truss). Eccentrically Braced Frames are the exception - their inclined members are deliberately offset at joints in order to create ductile fuse regions in the steel beams. Braced Frames may or may not be infilled.

1.3.3. Shear Wall System

The lateral loads are assumed to be concentrated at floor levels. The rigid floors spread these forces to the columns or walls in the building. Specially designed reinforced concrete walls parallel to directions of load are used to resist a large part of the lateral loads caused by winds or earthquakes by acting as deep cantilever beams fixed at the foundation. These elements are called shear walls.

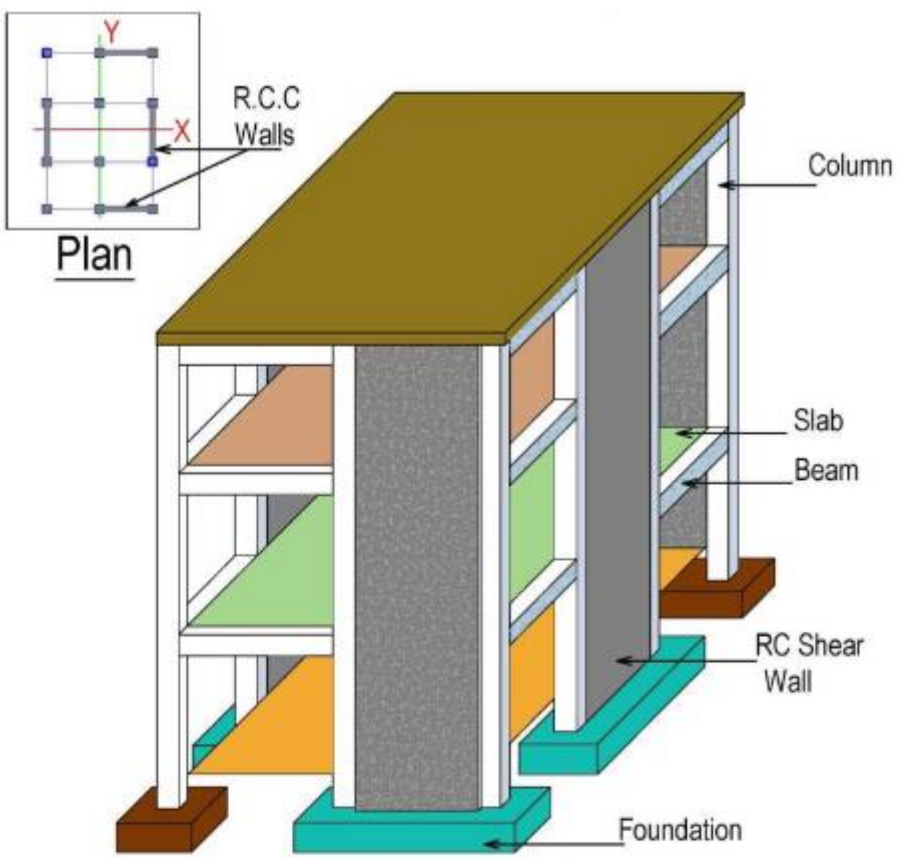


Figure 0:5 Shear Wall System

Shear wall is a structural member in a reinforced concrete framed structure to resist lateral forces such as wind forces. Shear walls are generally used in high-rise buildings subject to lateral wind and seismic forces. In reinforced concrete framed structures the effects of wind forces increase in significance as the structure increases in height. Codes of practice impose limits on horizontal movement or sway.

This frame can support weight from above—compression—as any load put on the upper beam is transferred through the columns to the base of the square. But if you put too much pressure on its sides—a lateral force—and the square will twist and collapse on itself unless it is braced by supports. Shear walls have these braces and are designed so that they don't collapse on themselves. In turn, they assure that no wind will blow your house down.

The support provided by shear walls does, however, create a design obstacle for architects. Whether the support against lateral forces is thanks to sheathing covering the frame or from other braces within it, any windows or doors must be limited in terms of the total area of the shear wall (and in some uses can't be used at all).

Advantages of Shear Walls:

- Provide large strength and stiffness in the direction of orientation.
- Significantly reduces lateral sway.
- Easy construction and implementation.
- Efficient in terms of construction cost and effectiveness in minimizing earthquake damage.
- Thinner walls.
- Light weight.
- Fast construction time.
- Fast performance.
- Enough well distributed reinforcements.
- Cost effectiveness.
- Minimized damages to structural and Non-structural elements.

1.3.4. Coupled Wall System

Structural wall systems are like vertically-oriented wide beams, behaves as a slender cantilever beam under lateral loads. That is resisting external loads by forming a couple at the base. By coupling individual flexural walls overturning moments are resisted partially by an axial compression–tension couple across the wall system rather than by the individual flexural action of the walls. When a coupled shear wall system is pushed from left to right under lateral loads the coupling beams are subjected to double curvature and resulting shear demands are transferred to the wall piers as axial tension and compression loads in left and right wall piers respectively.

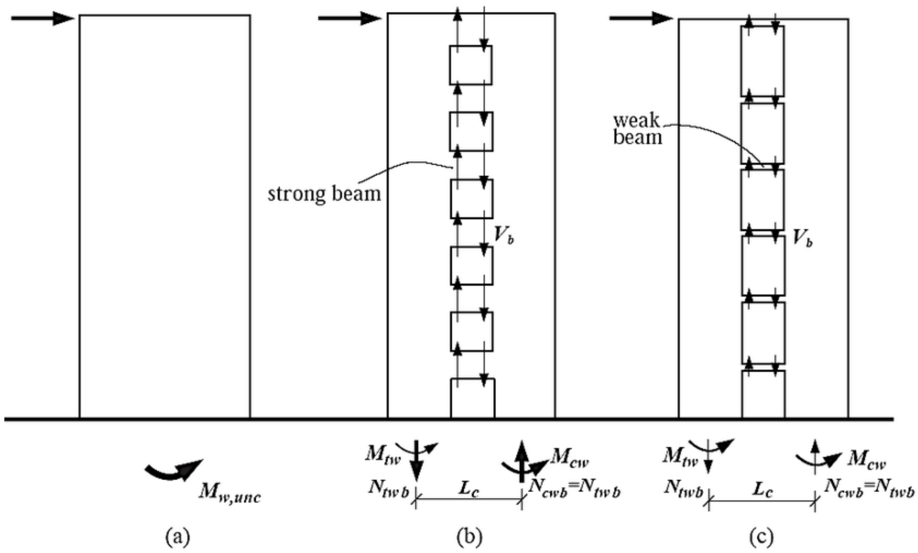


Figure 0:6 (a) Uncoupled wall (b) Coupled wall with Strong Beam (c) Coupled wall with weak beam.

Advantages of Coupled Shear Wall

- They provide an architecturally practical structural system
- Large lateral stiffness and strength is provided by the coupling effect
- Foundation restraint is more easily provided than for comparable isolated walls, because part of the base-overturning moment is resisted by axial loads
- Coupling beams provides an ideal energy dissipation mechanism, distributed along the height of the structure and away from the base, without significantly affecting the stability of the walls; and
- A tolerable level of damage can be specified in the coupling beams to balance the construction and post-earthquake repair costs.

1.3.5. Advanced Structural forms- Tubular Systems

The tubular system is to arrange the structural elements in such a way that the system can resist the imposed loads on the structure efficiently especially the lateral loads. This system comprises of various elements i.e., slabs, beams, girders, columns. The walls and cores are engaged to resist the lateral loads, in the tubular system the horizontal loads are resisted by column and spandrel beams at the perimeter level of the tubes.

Types of Tubular Systems:

- Framed tube structure.
- Braced tube structure.
- Tube in tube structure.
- Bundled tube structures.

Framed Tube Structures:

Frames comprises of closely spaced columns, 2 to 4 m between centres, with deep girders joining them. The ideology is to develop a tube-like structure which acts like a continuous perforated chimney or stack. The lateral resistance of this structure is provided by stiff moment resisting frames which form a tube throughout the periphery of the building.

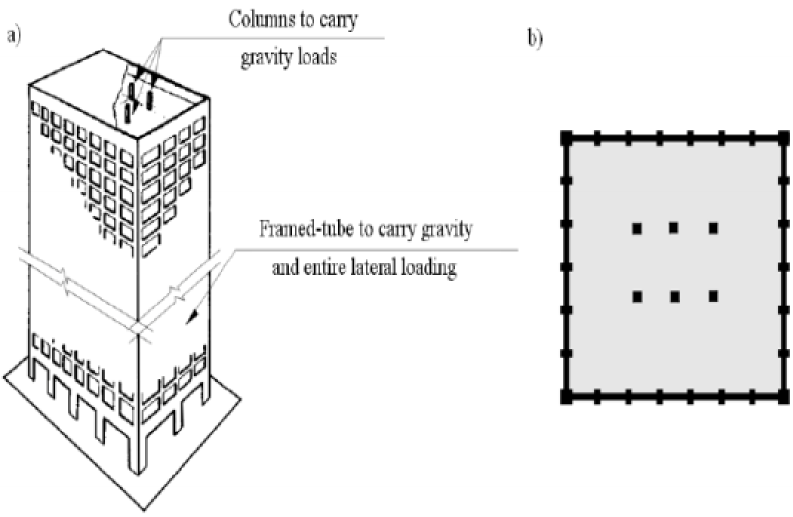


Figure 0:7 Framed Tube System

Braced Tube Structures:

The tubular structure is further improved and can be done by cross bracing the frame with X-bracings throughout the entire building. As the braced tube diagonals are connected to the column at each and every intersection, they virtually erase the shear lag effects in flange and web frames together. As a result, the structure behaves like a braced frame under lateral loads by reducing bending in the frame members.

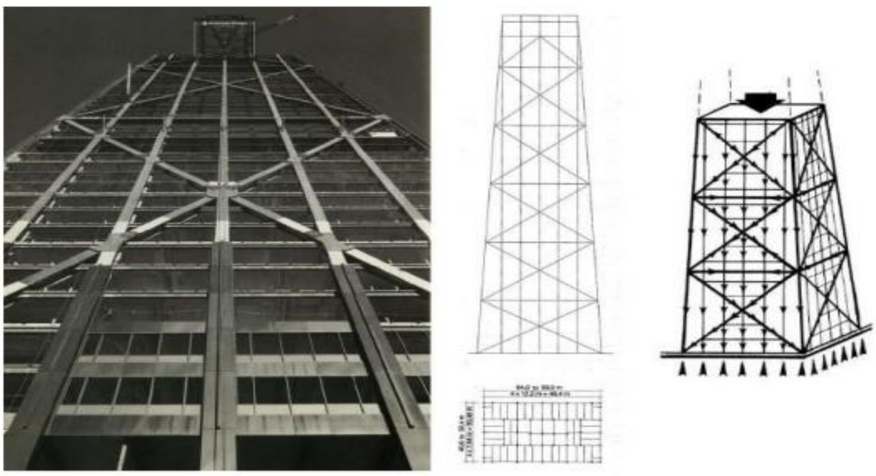


Figure 0:8 Braced Tube Structure

Tube- in -Tube Structures

This is another type of framed tube consisting of an outer-framed tube along with an internal elevator and service core. The inner tube consists of braced frames. The outer and the inner tubes act together to resist both gravity and lateral loads in steel framed buildings. However, outer tube always plays an important role because of its greater structural depth. This type of structures is also referred as hull and core structures.

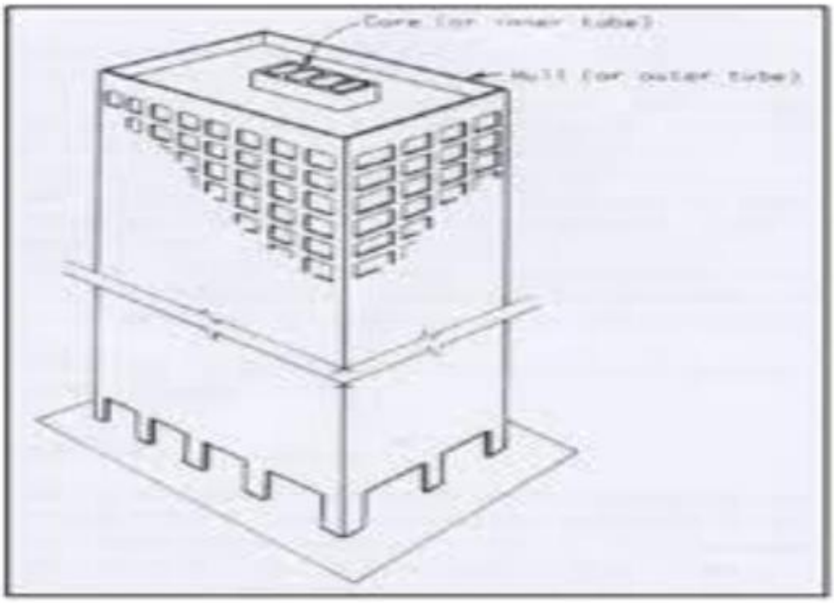


Figure 0:9 Tube in Tube Structure

Bundled Tube

The bundled tube system can be characterized as an assemblage of individual tubes which results in multiple cell tube. This System allows for great heights and large floor area. In this system, internal webs if introduced will greatly reduce the shear lag in the flange beams. Hence their columns are more uniformly stressed than in the single tube structures and they contribute more to the lateral stiffness.

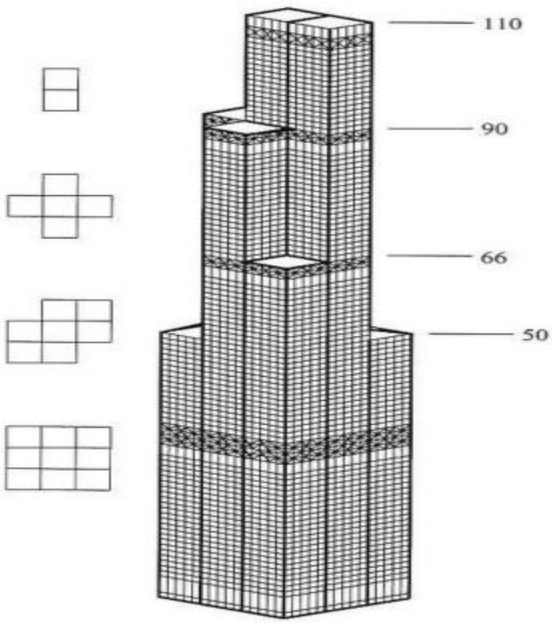


Figure 0:10 Bundled Tube Structure

1.4. Organization of Thesis

Chapter 01 – Introduction to the Project

Chapter 02 – It includes the Review of Literatures.

Chapter 03 – Here the Objectives and Methodology is discussed.

Chapter 04 – It deals with the Modelling procedure.

Chapter 05 – In this chapter Results and discussions are carried out.

Chapter 06 – It includes the conclusion part.

CHAPTER 02

2. LITERATURE REVIEW

2.1. General

The various literature has been studied and understood. The brief description of literature has been presented and discussed. The main intention of the Literature review is to understand the various works carried out by previous researchers and to learn from it. Further it will be helpful for carry out the works for future studies.

2.2. Journals

Lavanya.T et al (2017), In this paper, an approximate procedure is generated to perform the free vibration analysis of tube-in-tube tall buildings. In the absence of a rational method for determining the Fundamental Time Period of Tube-in-Tube High Rise Buildings in the Codes, in order to provide a new approximate method for the preliminary design, the tube-in-tube structure is simplified as a prismatic cantilever flexural shear beam with fixed base. In this Transfer Matrix method, the dynamic response of structure such as displacement, rotation angle, bending moment and shear force are expressed in the form of a transfer vector. The method suggested here enables us to calculate the natural frequency of tube-in-tube tall buildings accurately with the aid of computer programming.

Bipin H Naik et al (2017), In the present examination a 50 storied Steel building is considered, having general arrangement measurement of 48 m x 48 m along X and Y course. Steel structure is with floating columns are displayed. To examination the impact of general execution of the structure, steel X bracings are given. X bracings at various area at various statures are considered. Total five models are viewed as one customary steel structure, two Tube in Tube structure with floating columns and two models with bracing. Equivalent static and dynamic time history analysis is completed using ETAB Ver. 2015. Important outcomes like displacements, story drifts, peak displacements, base force and acceleration are shown. From the modular investigation it can be inferred that, steel tube structures are more adaptable than regular steel moment resisting frame, since they have additional time period and less frequency. Because of the expansion of external bracing time period will decrease. Additionally, time period relies upon column distance where despite everything it decreased with the nearer separating of column in steel tube – 2.

Ray P. S. Han et al (2016), An efficient three-dimensional analysis of framed tube structures with arbitrary cross sections, but of uniform panel properties, is presented. It is based on the finite strip method (FSM) and involves transforming the discrete structure into an elastically equivalent orthotropic tube. Unlike the usual FSM, the different modes in the stiffness matrix given here are uncoupled. This results in a much smaller matrix, and, consequently, the analysis of the highly redundant framed tube structures can be conveniently and economically handled on a microcomputer. To assess the accuracy of the proposed formulation, two unperforated tubes of rectangular and triangular cross sections are analysed, and the results are found to be in good agreement with solutions obtained using the finite element method (FEM). As an application, a 30-story framed tube structure is analysed. Comparison with solutions from a three-dimensional finite element program shows good agreement, with the overall stiffness reasonably well predicted.

Vikram J & Geethu Varghese et al (2017), In this project, a plan has been created for the bundled tube comprising four tubes using Auto-cad. The various loads such as dead load, live load and wind load are assigned using software. Analysis of the structure has been done using software. The components of the structure such as the slab, beam and column has been designed by manual calculations. The slab is designed as continuous slab. The load calculations for slab and beam are done manually. The load for column design has been obtained from staad analysis report. The pile foundation for the bundled tube structure has been designed. The two main components of pile foundation are pile and pile cap. The design of pile and pile cap has been done by manual calculations. The pile has been designed as a square pile. The design detailing of all the designs such as beam, column, slab, pile and pile cap has been made in Auto-cad.

Karthik A L et al (2016), In this work, five structural frameworks are considered in which are 1) Regular steel structure, 2) Tube structure, 3) Bundled tube structure, 4) Bundled tube structure with belt-truss, 5) Bundled tube structure with belt-truss and mega bracings. For the reason 110 story steel structure with rectangular arrangement of measurement 60mx60m is considered and analysed for gravity and lateral forces utilizing ETABS programming. Functioning characteristics like displacement, story shear, time period, story drift is extracted from ETABS. Results shows that the steel bundled tube structure with belt-truss and mega bracings framework is much stable than the other four structural frameworks.

In this Chapter we discuss about the results obtained from the analysis of bundled tube model which are obtained from the ETABS model. Analysis Results obtained from the software ETABS, from the analysis results like, story shear, displacement story drift and time period are extracted for five proposed models and are compared with each other to obtain a stable structural system.

Archana J et al (2016), The building is a G+15 story reinforced concrete building. The structure is approximately 48.3m tall, and is 23.000 m wide and 34.450 m length. The story height is 3.3 m at the first story and 3 m at the upper story. Proposed slab thickness is 150 mm for all typical floors. Area of building 792.35m2 .Member Properties, dimensions of the beams for all typical floors 200 mm × 600 mm, the column at the ground floor 300×1000 mm, and for the above floors 200×1000 mm, the thickness of the slab is provided as 150 mm, and the shear wall of thickness 200 mm. The live load is 3 kN/m2 , load due to masonry10.8 kN/m, load due to parapet wall of height 1.2m and thickness 15cm is 3.24kN/m and floor finish 1kN/m2 , wind load and seismic load calculations can be done directly by ETABS. The load combination is based on IS: 456 – 2000 and IS 1893 (Part 1): 2002. For modelling three sets of models are to be consider the first set of models is bare frame model A, second modal B which is the tube in tube building. And the third set of models, model C, which is the tube mega frame. In model B, the tube in tube structure is modelled with different positioning of the internal tube model B1 with canter tube, model B2 with edge tube, model B3 with inner tube. Model C is the tube mega frame.

Abhishek et al (2018), In order to do comparative study on the seismic performance of tube-in-tube structures and tubed mega frame structures different models were developed in ETABS software. In which the horizontal slabs and beams connecting vertical elements are assumed as continuous connecting medium having equivalent distributed stiffness properties. Generally, Tube in tube structures is formed by connecting peripheral frame tube and inner core tube. These tubes are interconnected by system of floor slabs and grid beams.as the columns of outer and inner core tubes are placed so closely; it is not seen as a solid system but it acts like a solid surface. In the tube in tube structure the high strength concrete central tube carries the major load. The total loads acting on the structures to be collectively shared between the inner and outer tubes. The tubed mega frames are new concept for tall building. It is formed by avoiding central core tube and peripheral tubes connected by perimeter wall instead of one central core. The main function of perimeter wall is to transfer load between the long vertical tubes.

E.H.Ghoniem et al (2018), The present work aims to demonstrate the performance of buildings considered with rigid frame, shear wall, shear wall-frame, shear-trussed frame, framed tube, braced tube and bundled tube systems. The buildings studied in this work are a reinforced concrete moment resisting frame 40 storey and 80 storeys designed for gravity and seismic. And are studied using Non-linear time history analysis. These models are analysed, using ETABS software. The results of the analyses, in terms of lateral displacements, respective storey drifts, base shears, overturning moments, time period are obtained and the conclusions are drawn thereof. As time history is realistic method, used for seismic analysis, it provides a better check to the safety of structures analysed and designed. The overall results suggested that bundled tube is excellent seismic control for high-rise and super high-rise buildings.

Subathra Kannan et al (2018), The study is regarding the seismic behaviour of RCC frame tube structures, thus to achieve this purpose typical G+25 story RCC building structure has been modelled in ETABS software for various zones in India. The frame tube structure and conventional structure are analysed for dead load, live load wind load and earthquake load and designed with the help of ETABS computer programming software. Load considered in modelling are dead load, live load, and earthquake load along with combination as specified in IS codes. In this dissertation the seismic responses and comparative study have been observed for both conventional and frame tube structure by dynamic analysis.

CHAPTER 03

3. OBJECTIVES AND METHODOLOGY

3.1. Objectives

- To study the seismic behaviour of different seismic resistant structural configuration.
  - Type 1- Bare frame with Bracing system
  - Type 2- Tubular shear wall system
  - Type 3- Bundled shear wall system
  - Type 4- Hybrid Tubular type 1
- Study is carried out to observe the response in both the static and dynamic time history analysis.
- The parameters such as base shear, displacement, storey drift, and time period are compared and discussed in detail.
- The analysis is carried out for the particular seismic zones to check the variations in the response.

3.2. Methodology

- To carryout extensive literature review, to establish the objective of the study.
- ETABS Software is used for the modeling and analysis of different building configurations.
- Analyze the models using all major Static (Equivalent static analysis) and Dynamic (Time History analysis) using IS 1893-2016.
- Concrete mix of M40 grade, reinforcing steel of Fe-500 & Structural steel of Fe350 will be considered for the analysis of the structural system.
- Preliminary member sizes are assumed for beams and columns, later member sizes are economized and based on the system adopted.
- Conclusions are made based on the performance of each system under study.

CHAPTER 04

4. MODELLING

4.1. General:

In this chapter, the common step by step procedure of modelling the regular structure is explained. The related modelling procedure is used to model the various other configurations, to study the seismic behaviour of different structural configuration of structure.

- Type 1- Bare frame with Bracing system
- Type 2- Tubular shear wall system
- Type 3- Bundled shear wall system
- Type 4- Hybrid Tubular type 1

4.2. Building Description

The proposed models are purely conventional RC structures other than hybrid structure. The models are 25 storey heights with regular square shaped structure. In the tube structure columns are placed at near spacing by 1.6m intervals. The below Table 4-1 shows material properties and design parameters used in this project.

Table 4.1- Material Properties and Design Parameters

Sl. No.	Description	Data
1.	Seismic Zone	IV
2.	Seismic Zone Factor (Z)	0.24
3.	Importance Factor (I)	1.5
4.	Response Reduction Factor (R)	5
5.	Damping Ratio	0.05

6.	Soil Type	Medium Soil (Type II)
7.	Height of the building	100m (25 Storeys)
8.	Story to story Height	4.0
9.	Span Length	5m
10.	Column Size used	450x450 , 300 x300 mm
11.	Thickness of Slab	150mm
12.	Floor Finish	1.5KN/m^2
13.	Live Load	4.0KN/m^2
14.	Grade of Concrete (f_{ck})	M 40
15.	Grade of Steel (f_y)	Fe 500
16.	Grade of Structural Steel	Fe 350

4.3. Various Models:

4.3.1. Model Type 1: Bare frame with Bracing system

The Figure 4.1 and Figure 4.2 shows the plan and 3 – Dimensional view of model 1 respectively.

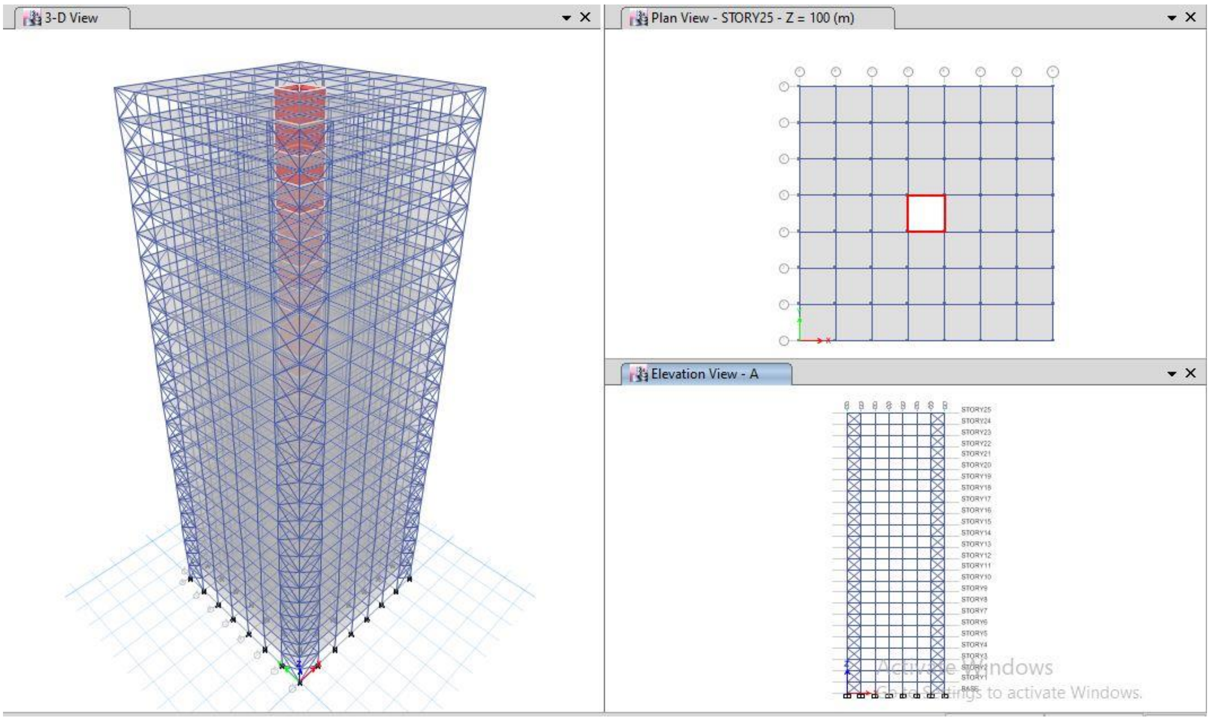


Figure 4.1 – Plan View – Model Type 1

In the figure 4.1 represents the plan view and Elevation view of model type 1. The model type 1 is a simple concrete framed structure. The model is a 50-storey tall high rise RCC structure.

4.3.2. Model Type 2: Tubular shear wall system

The Figure 4.2 shows the plan and 3 – Dimensional view of model 2 respectively.

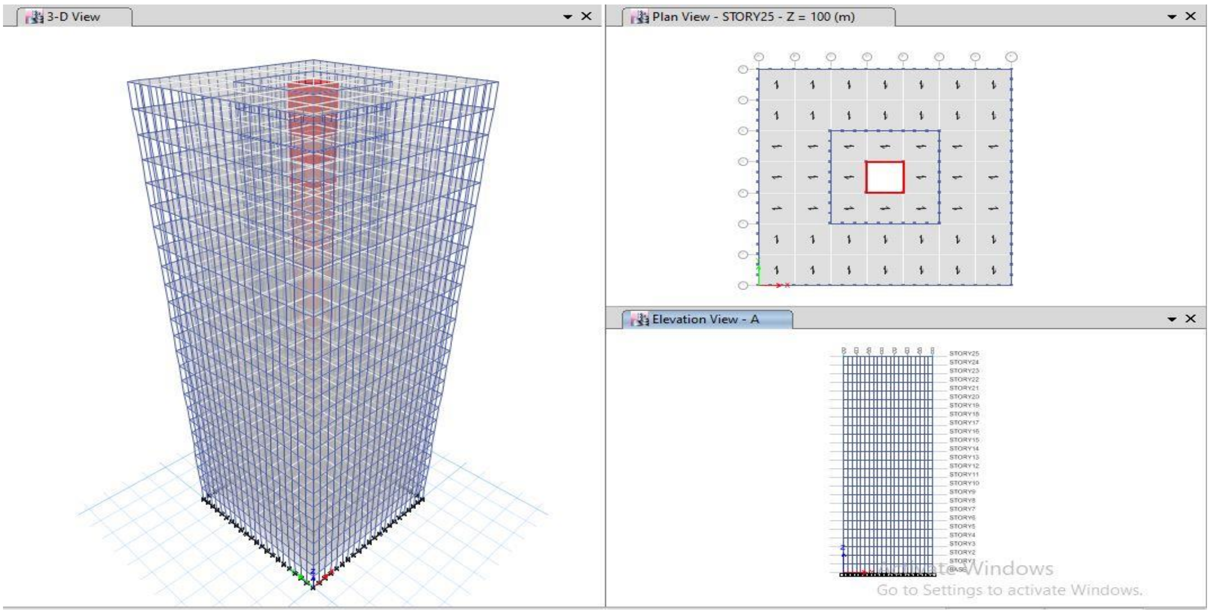


Figure 4.2 – Plan View – Model Type 2

In the figure 4.2 represents the plan view and Elevation view of model type 2. The model type 2 is a simple tubular structure. It is a 25-storey building with column spaced closely to exhibit tube structure.

4.3.3. Model Type 3: Bundled shear wall system

The Figure 4.3 shows the plan and 3 – Dimensional view of model 3 respectively.

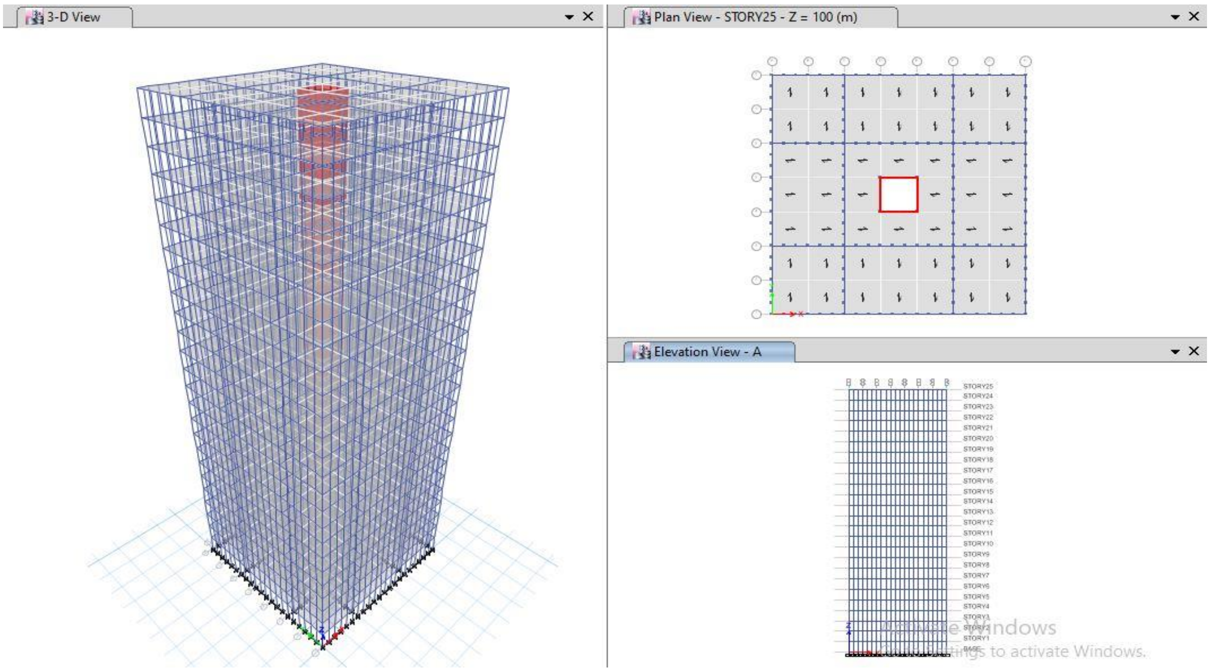


Figure 4.3 – Plan View – Model Type 3

In the above figure 4.3 represents the plan view and Elevation view of model type 3 respectively. The model type 3 is a tube in tube structure. It is a 25-storey building with column spaced closely and grouped to exhibit tube structure behaviour.

4.3.4. Model Type 4: Hybrid Tubular type 1

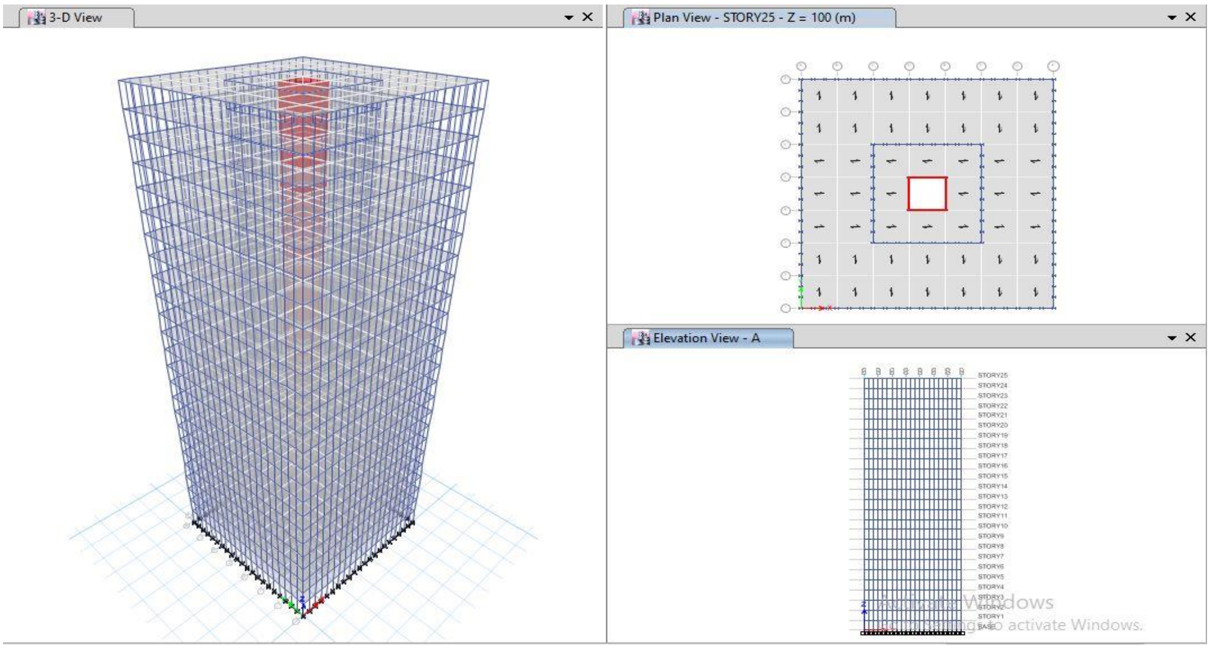
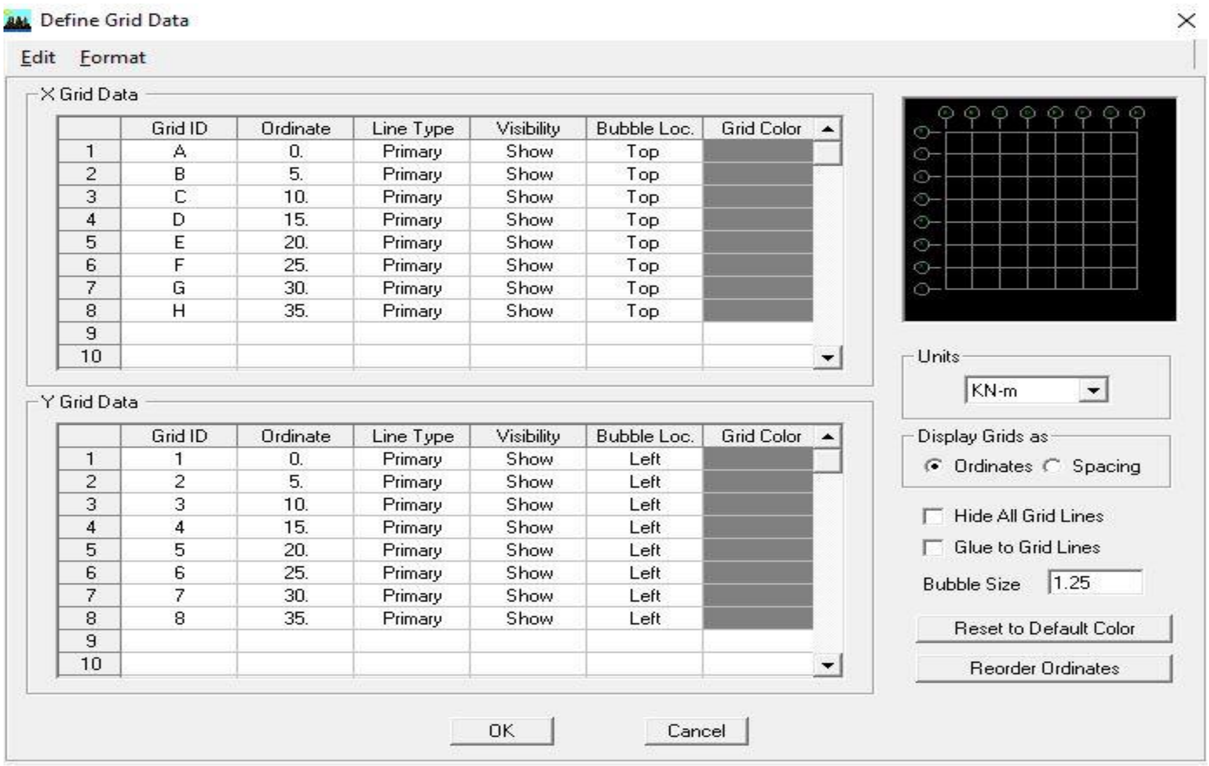


Figure 4.4 – Plan View – Model Type 4

In the above figure 4.4 represents the plan view and Elevation view of model type 4 respectively. The model type 4 is a simple tube hybrid structure. It is a 25-storey building with column spaced closely and grouped to exhibit tube structure behaviour. Here up to 15 storey, the structure is RCC and remaining upper floors as steel structure.

4.4. Etabs Modelling and Analysis Procedure:

The below image shows the story and grid data for the Models considered.



Define Grid Data

Edit Format

X Grid Data

	Grid ID	Ordinate	Line Type	Visibility	Bubble Loc.	Grid Color
1	A	0.	Primary	Show	Top	
2	B	5.	Primary	Show	Top	
3	C	10.	Primary	Show	Top	
4	D	15.	Primary	Show	Top	
5	E	20.	Primary	Show	Top	
6	F	25.	Primary	Show	Top	
7	G	30.	Primary	Show	Top	
8	H	35.	Primary	Show	Top	
9						
10						

Y Grid Data

	Grid ID	Ordinate	Line Type	Visibility	Bubble Loc.	Grid Color
1	1	0.	Primary	Show	Left	
2	2	5.	Primary	Show	Left	
3	3	10.	Primary	Show	Left	
4	4	15.	Primary	Show	Left	
5	5	20.	Primary	Show	Left	
6	6	25.	Primary	Show	Left	
7	7	30.	Primary	Show	Left	
8	8	35.	Primary	Show	Left	
9						
10						

Units: KN-m

Display Grids as: Ordinates / Spacing

Hide All Grid Lines

Glue to Grid Lines

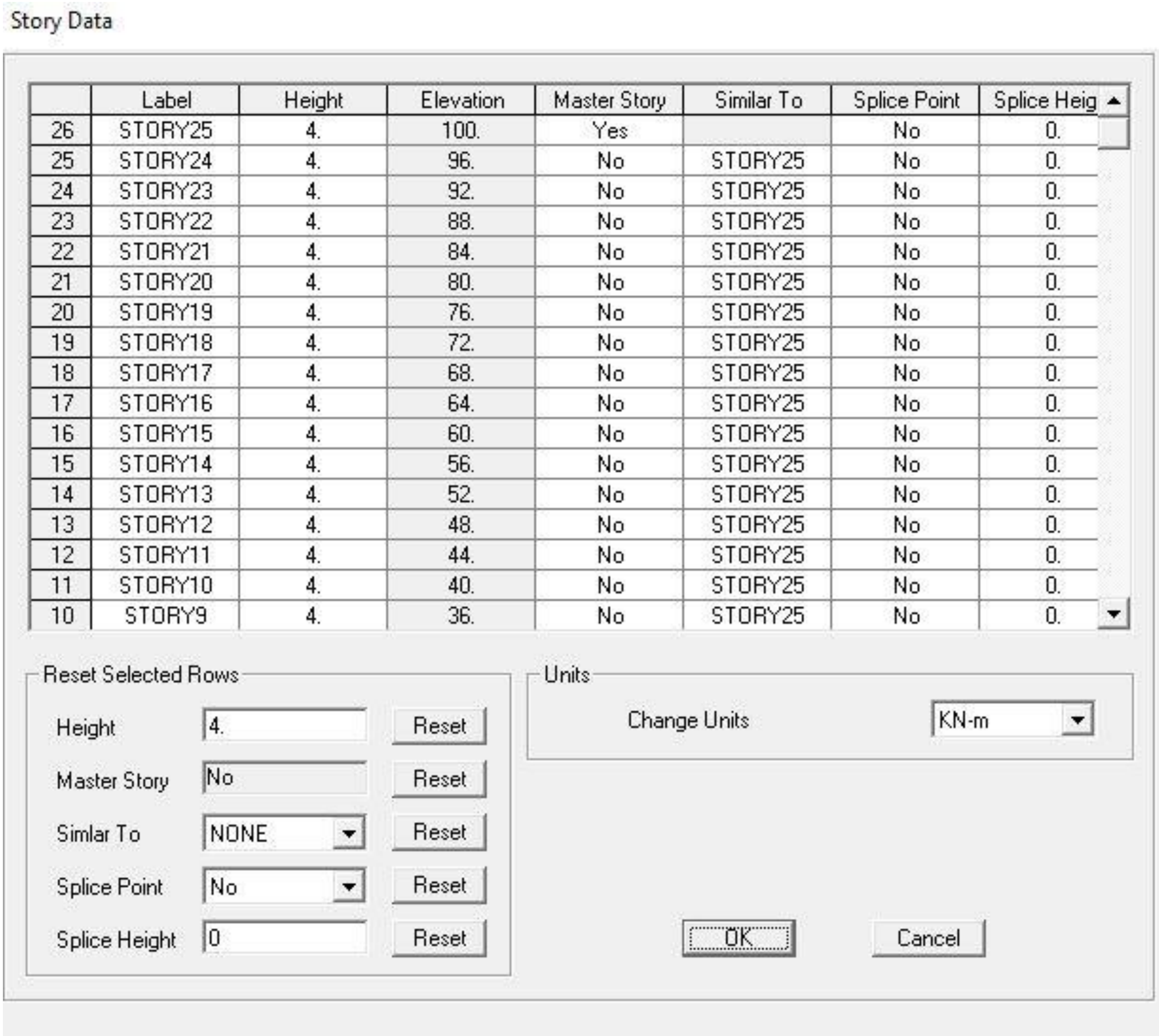
Bubble Size 1.25

Reset to Default Color

Reorder Ordinates

OK Cancel

Figure 4.5 – Grid System Data.



	Label	Height	Elevation	Master Story	Similar To	Splice Point	Splice Heig
26	STORY25	4.	100.	Yes		No	0.
25	STORY24	4.	96.	No	STORY25	No	0.
24	STORY23	4.	92.	No	STORY25	No	0.
23	STORY22	4.	88.	No	STORY25	No	0.
22	STORY21	4.	84.	No	STORY25	No	0.
21	STORY20	4.	80.	No	STORY25	No	0.
20	STORY19	4.	76.	No	STORY25	No	0.
19	STORY18	4.	72.	No	STORY25	No	0.
18	STORY17	4.	68.	No	STORY25	No	0.
17	STORY16	4.	64.	No	STORY25	No	0.
16	STORY15	4.	60.	No	STORY25	No	0.
15	STORY14	4.	56.	No	STORY25	No	0.
14	STORY13	4.	52.	No	STORY25	No	0.
13	STORY12	4.	48.	No	STORY25	No	0.
12	STORY11	4.	44.	No	STORY25	No	0.
11	STORY10	4.	40.	No	STORY25	No	0.
10	STORY9	4.	36.	No	STORY25	No	0.

Figure 4.6 – Story Data.

The Material Properties defined are indicated in the below image:

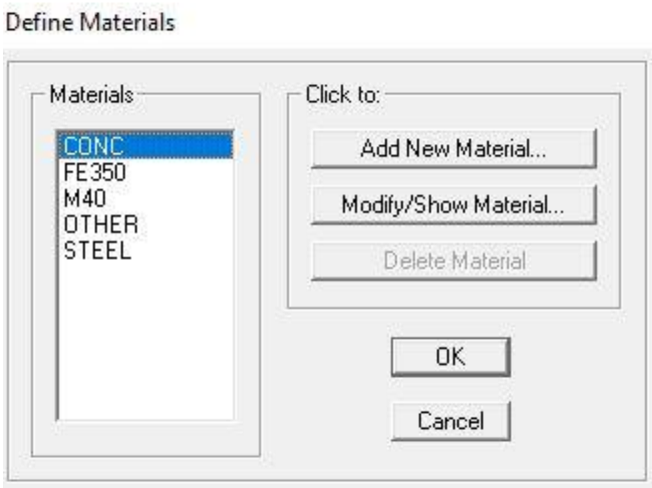


Figure 4.7 – Material Property.

The Material Properties for M40 grade is defined as indicated in the below image

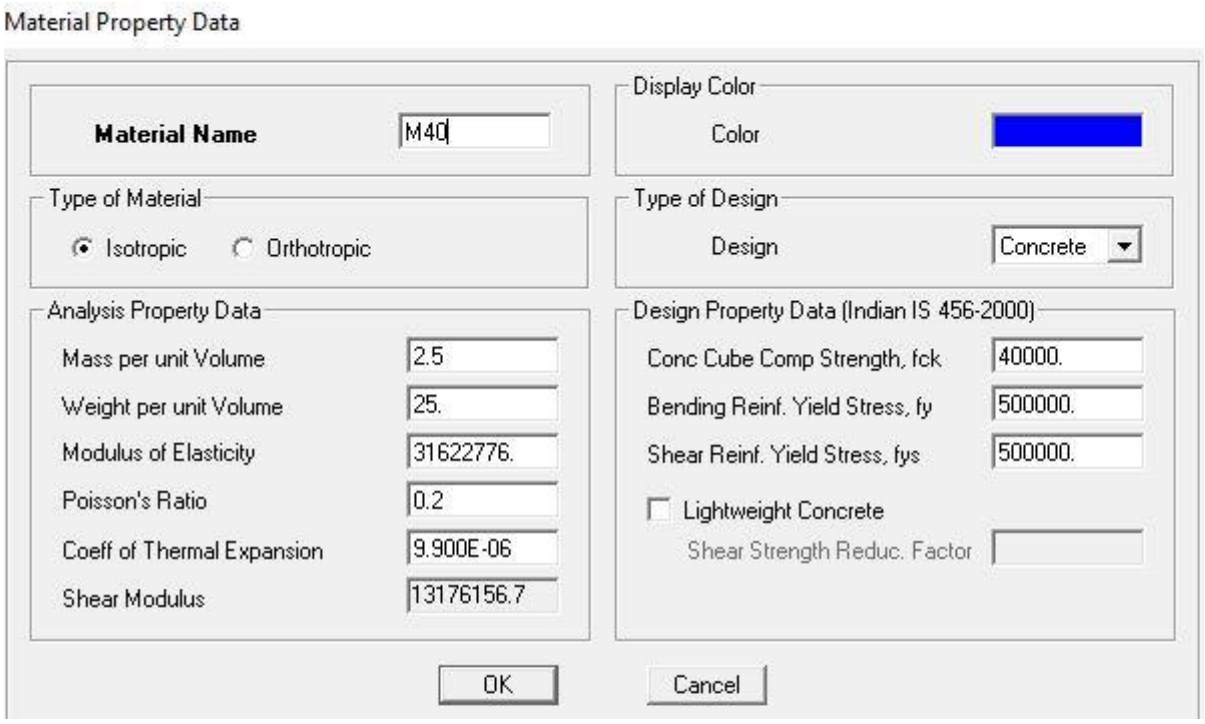


Figure 4.8 –M40 Concrete Material Property.

The Material Properties for Fe350 grade steel is defined as indicated in the below image fig.3.20

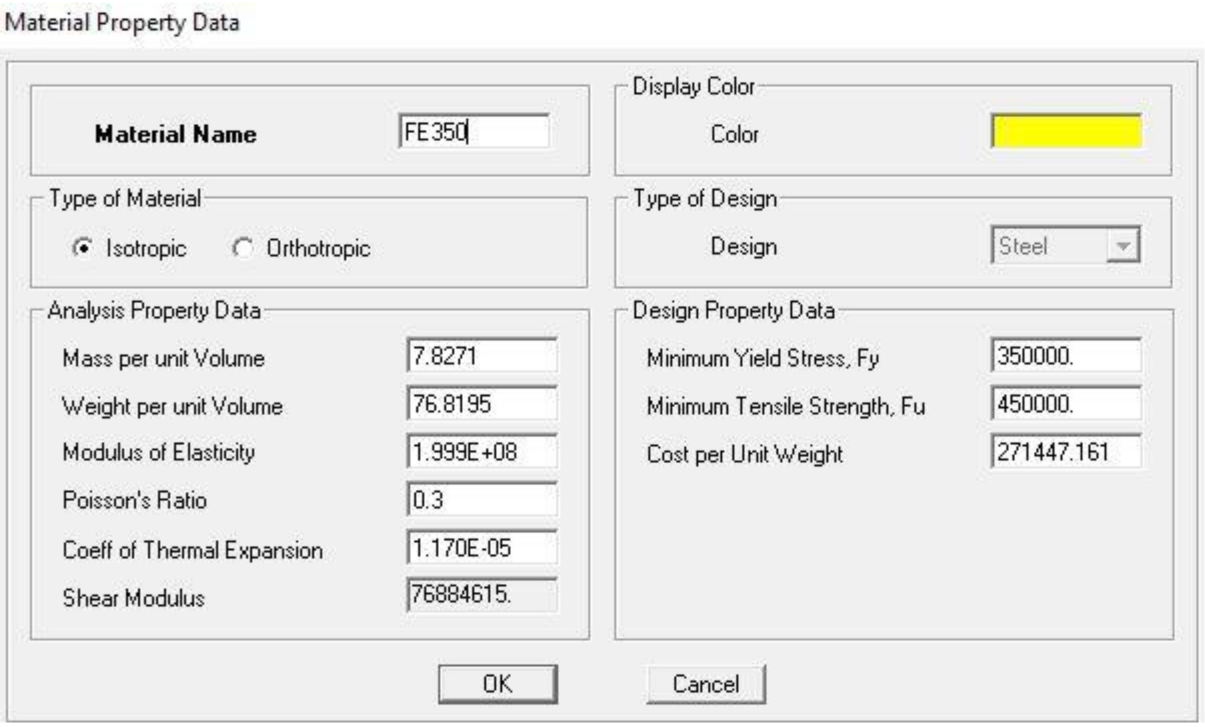


Figure 4.9 – Fe350 Structural Steel Material Property.

The below images indicate the frame sections and typical sections used for Steel and concrete Columns.

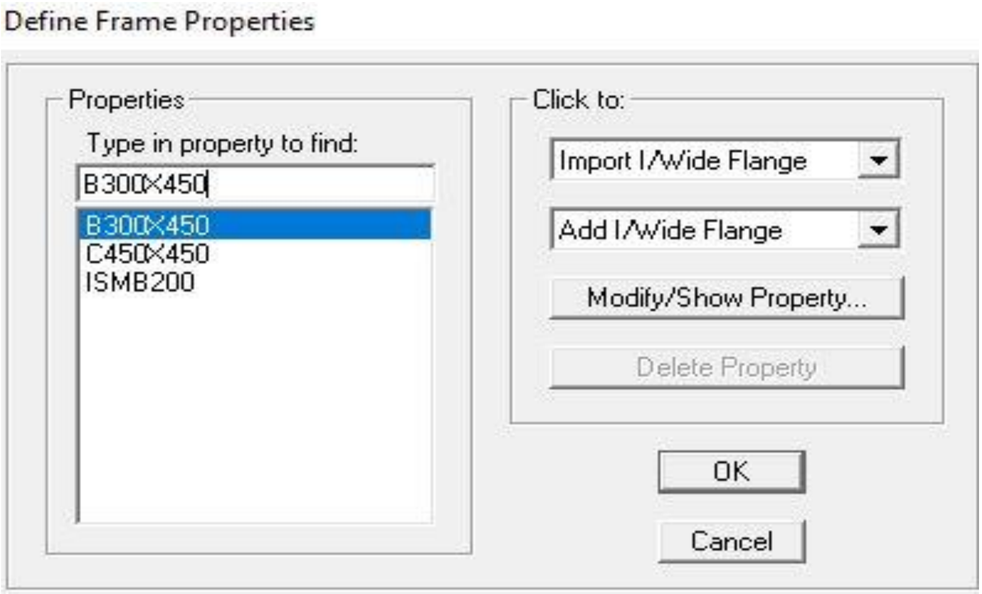


Figure 4.10 – Frame Sections

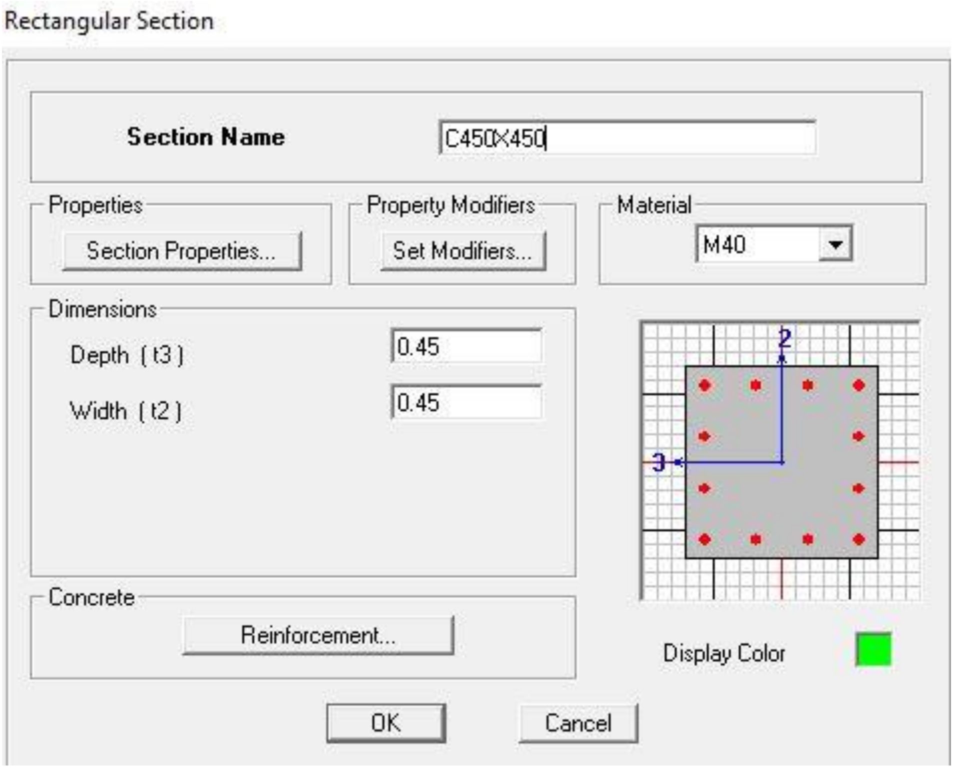


Figure 4.11 – RC Column Sections

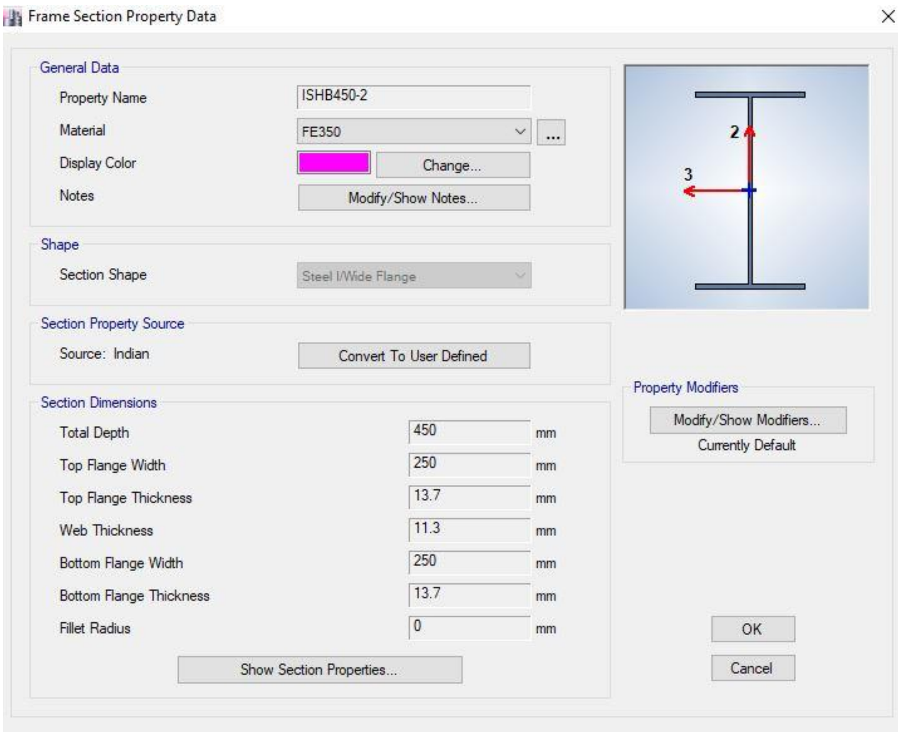


Figure 4.12 – Steel Column Sections

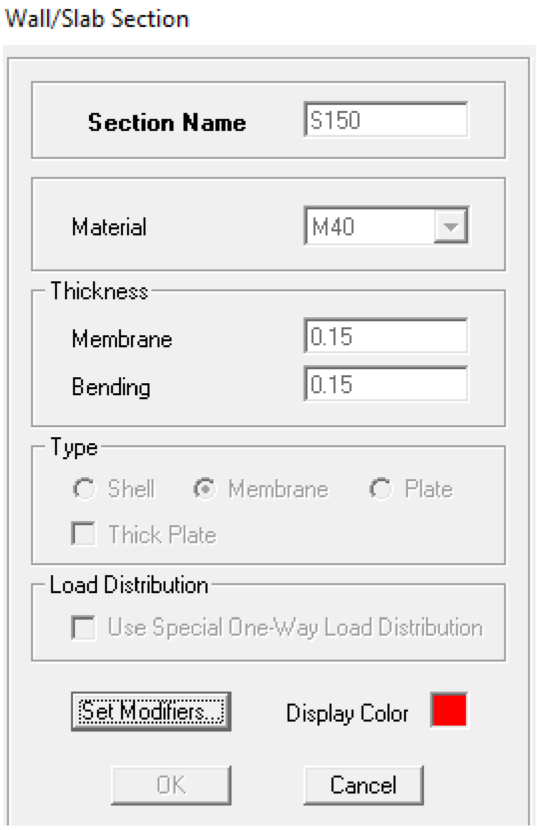


Figure 4.13 – Slab Section.

The Load case details of different loads are indicated below:

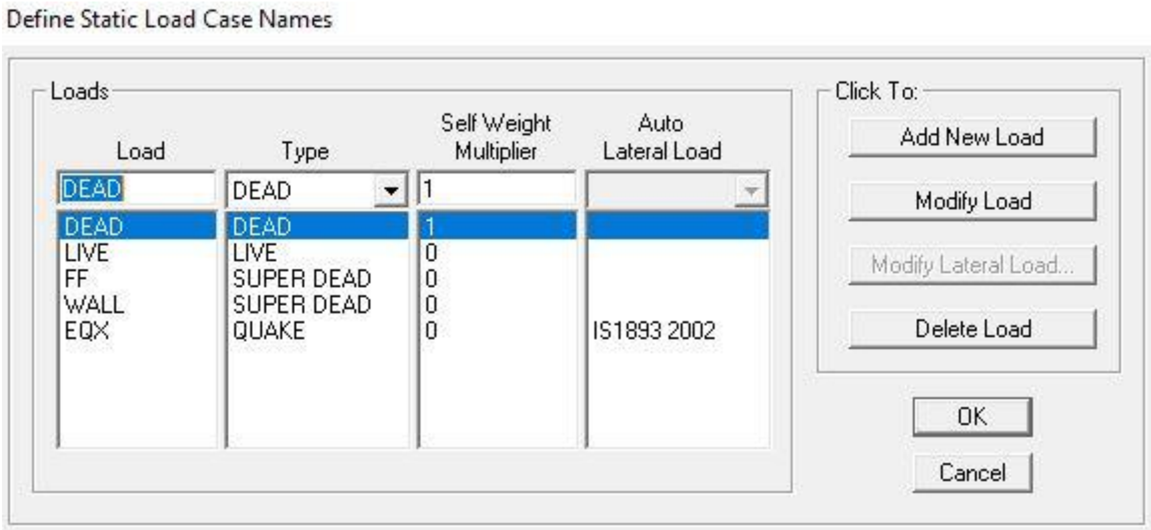


Figure 4.14 – Load Pattern.

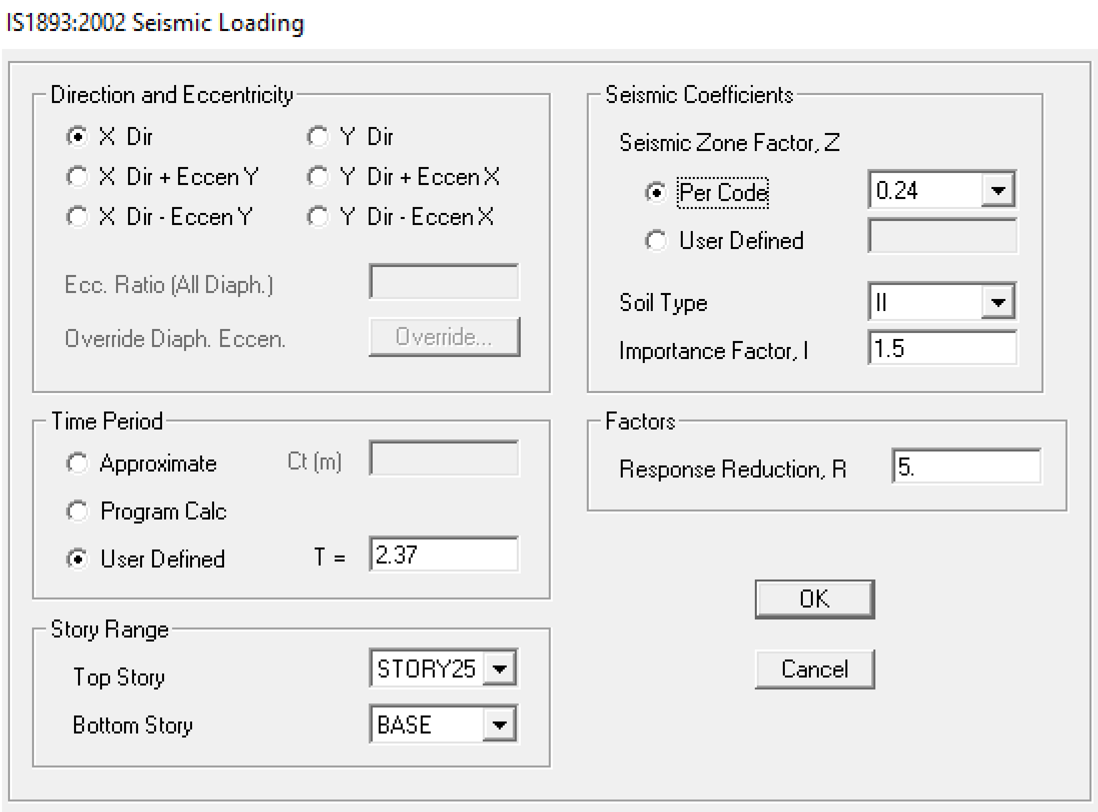


Figure 4.15 – Static Load Case Details

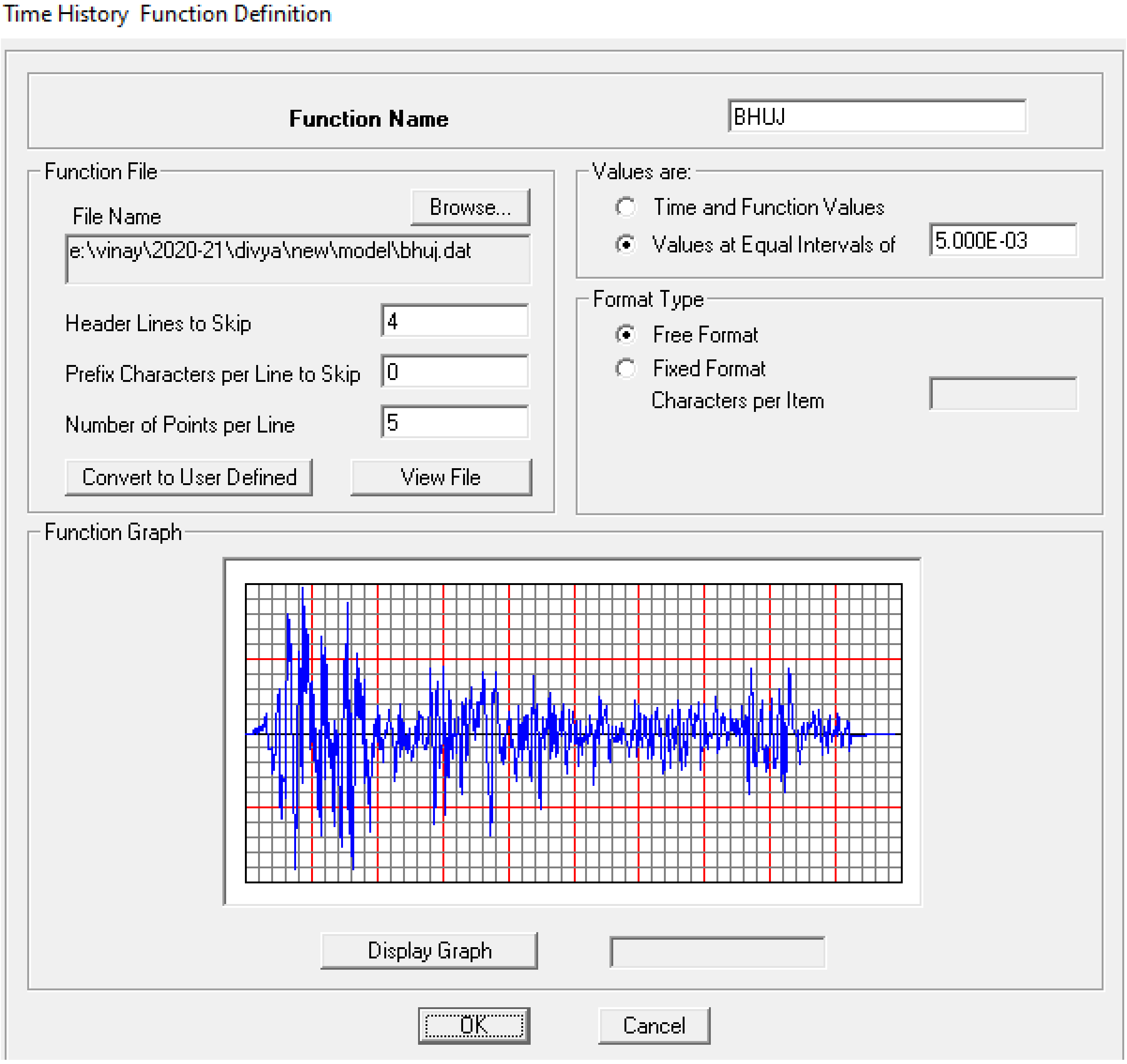


Figure 4.16 – Time History Function

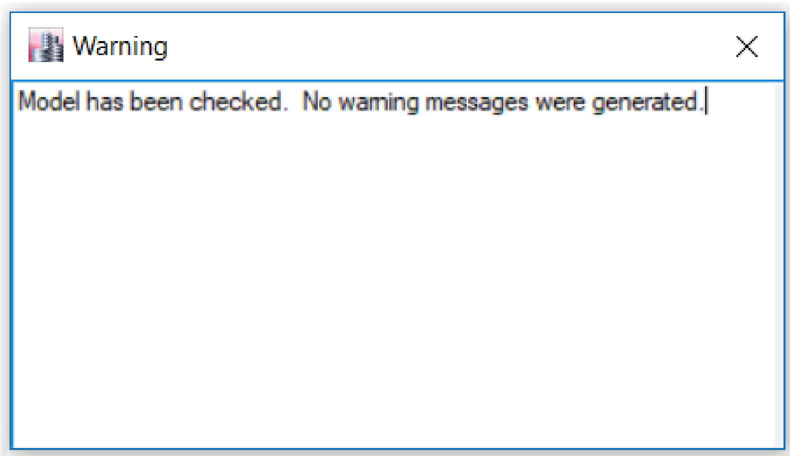


Figure 4.17 – Model Check

Similar way all types of models are created and checked for analysis. The Model are Run and the results are extracted and tabulated for comparison. The tabulated results are compared & discussed in the following chapters with the help of graphs and finally concluded for the result.

CHAPTER 5

5. RESULTS AND DISCUSSION:

All the models are given the identity as below and further used these for comparison of results.

- Type 1- Bare frame with Bracing system
- Type 2- Tubular shear wall system
- Type 3- Bundled shear wall system
- Type 4- Hybrid Tubular type 1

Post analysis, results are extracted. The response of the different configuration structures is obtained from ETABS software. The regular model and different structural systems are studied for different load cases. Static and dynamic analysis are carried out to compare the model response.

COMPARISION OF DIFFERENT MODELS:

5.1. Modal Analysis

5.1.1. Time Period

The table below shows that the different time periods for various models of earthquake in X direction

Table 5.1 Time Period

TIME PERIOD				
MODE	MODEL 1	MODEL 2	MODEL 3	MODEL 4
1	4.87	4.43	3.87	5.47
2	4.85	4.43	3.87	4.37
3	3.75	3.20	3.17	3.20
4	1.37	1.31	1.18	1.84
5	1.36	1.31	1.18	1.39
6	1.15	1.07	1.05	1.28
7	0.66	0.66	0.63	0.78
8	0.66	0.66	0.62	0.71
9	0.59	0.64	0.62	0.68
10	0.42	0.45	0.45	0.52
11	0.40	0.41	0.39	0.46
12	0.37	0.41	0.39	0.42

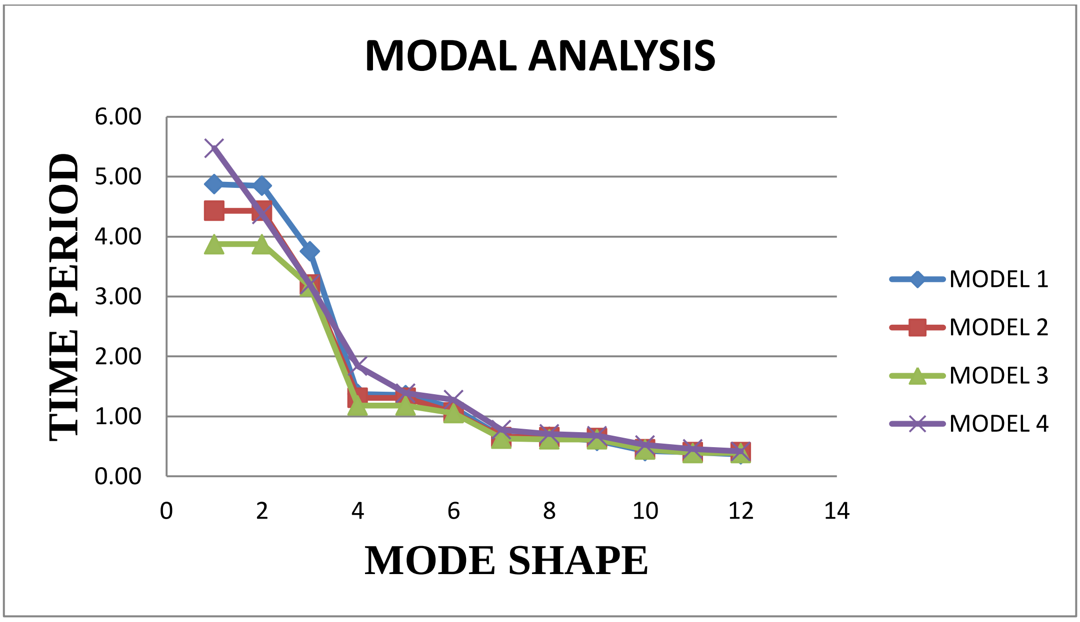


Figure 5.1 Mode Number v/s Time Period

In the above graph, the Model 3 is showing least time period, hence it is rigid and stiff compared to other models. The model 4 is having highest time period and having higher stiffness compared to other models. This shows the hybrid models works better in seismic prone areas.

5.1.2.Frequency

The table below shows that the different frequency for various models of earthquake in X direction

Table 5.2 Frequency

FREQUENCY				
MODE	MODEL 1	MODEL 2	MODEL 3	MODEL 4
1	0.21	0.23	0.26	0.18
2	0.21	0.23	0.26	0.23
3	0.27	0.31	0.32	0.31
4	0.73	0.76	0.85	0.54
5	0.74	0.76	0.85	0.72
6	0.87	0.94	0.95	0.78
7	1.51	1.52	1.59	1.29
8	1.52	1.52	1.62	1.41
9	1.69	1.57	1.62	1.47
10	2.37	2.20	2.23	1.91
11	2.49	2.46	2.56	2.18
12	2.73	2.46	2.56	2.40

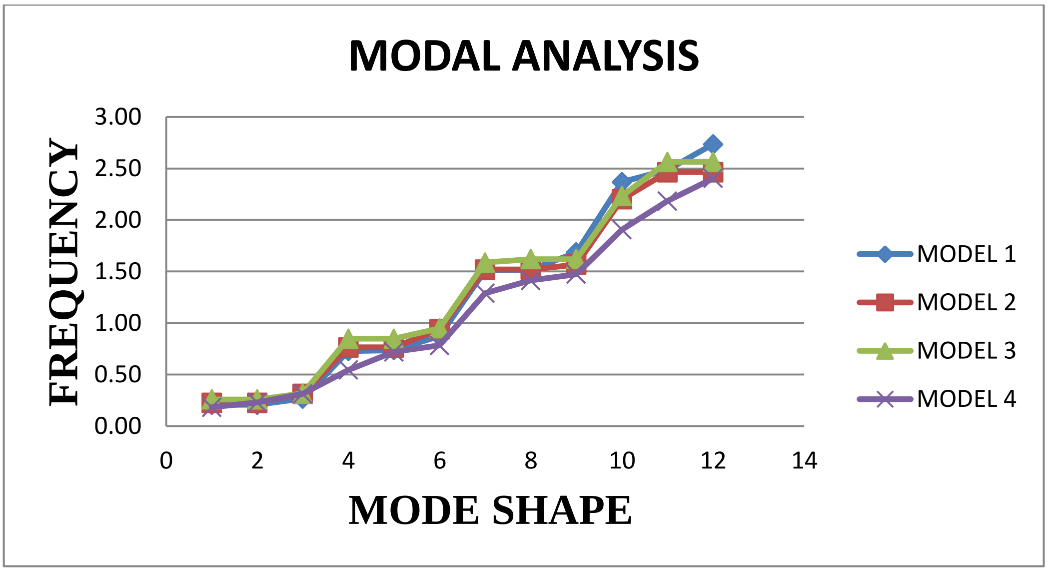


Figure 5.2 Mode Number v/s Frequency

The hybrid model is having lesser frequent compared to all other models. The model 3 is having highest frequency compared to all other models.

5.2. Equivalent Static Analysis :(ESA)

5.2.1.Displacement of Building

Displacement for Static analysis values, ESA in X – Direction.

Table 5.3Displacements –EQX

STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4
25	267	214	158	229
24	258	208	155	221
23	249	202	151	214
22	239	196	147	205
21	229	189	142	197
20	219	181	137	187
19	208	173	131	177
18	196	164	125	167
17	184	155	119	156
16	172	146	112	145
15	159	136	105	134
14	146	125	97	123
13	133	115	89	112
12	119	104	81	101
11	106	93	73	90
10	93	82	65	79
9	79	71	56	68

8	67	60	48	58
7	54	50	40	47
6	43	40	32	38
5	32	30	25	29
4	22	21	18	20
3	14	14	12	13
2	7	7	6	7
1	2	2	2	2
0	0	0	0	0

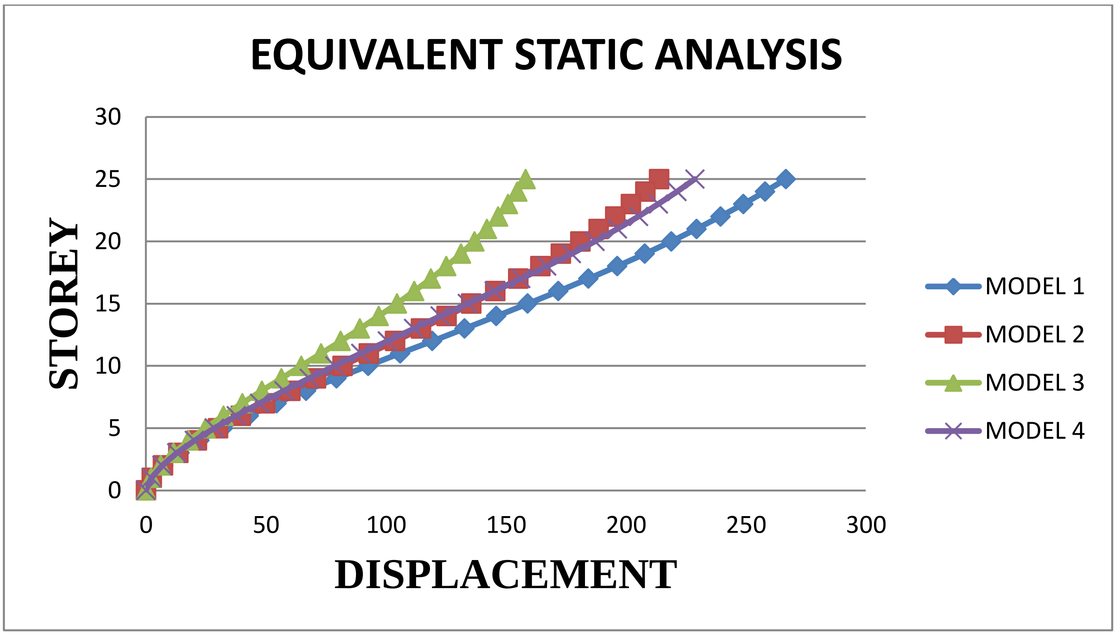


Figure 5.3 Storey V/S Displacement in X Direction.

The model 1 with RC framed structure with bracings exhibiting highest displacement compared to other models. And the model 3 is having least displacement compared to all other models. Hybrid model is also having second highest displacement since it is having highest flexibility.

5.2.2. Study of Inter Story Drift (ESA)

The drift values are the difference in displacement between successive storey. The values of Drift in X direction for Static Analysis are shown below:

Table 5.4 Inter Story Drift

STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4
25	9	6	3	7
24	9	6	4	8
23	10	7	4	8
22	10	7	5	9

21	11	8	5	9
20	11	8	6	10
19	12	9	6	10
18	12	9	7	11
17	12	10	7	11
16	13	10	7	11
15	13	10	8	11
14	13	11	8	11
13	13	11	8	11
12	13	11	8	11
11	13	11	8	11
10	13	11	8	11
9	13	11	8	10
8	12	11	8	10
7	12	10	8	10
6	11	10	8	9
5	10	9	7	8
4	8	8	6	7
3	7	6	5	6
2	5	5	4	4
1	2	2	2	2
0	0	0	0	0

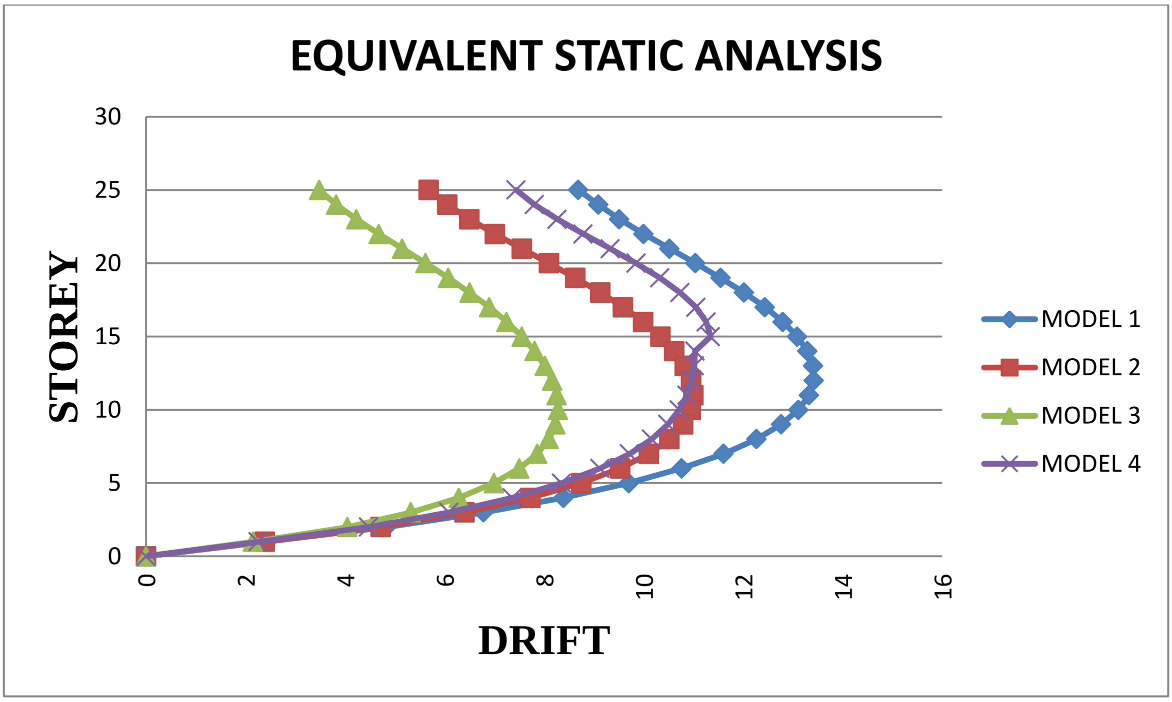


Figure 5.4 Storey v/s Storey Drift in X Direction.

The inter storey drift reflects the difference in the displacement. The Model 1 is exhibiting highest drift values, compared to all other models. The Model 3, tube in tube structure shows lowest drift compared to all the models. There is a sudden increase in drift values at the location where the model changes from RCC to Steel in model 3. This shows, the connections need to be taken care.

5.2.3.Study of Base Shear (ESA)

The table below shows different base shear values for 25 storey different models

Table 5.5 Base shear

BASE SHEAR			
MODEL 1	MODEL 2	MODEL 3	MODEL 4
9816	7833	8363	7361

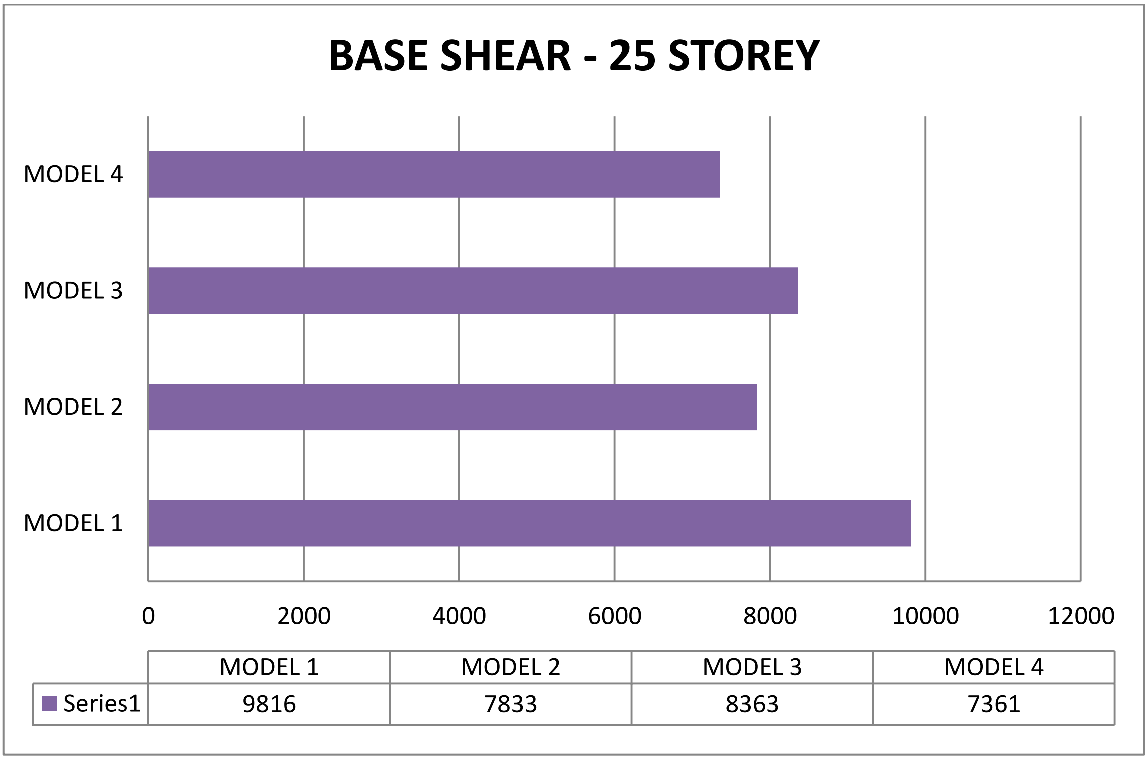


Figure 5.5 Base Shear v/s Models

The base shear is the summation of lateral forces acting on the structure. The force values depend on the weight of the structure and loads acting on it. The model 1 is showing highest base shear and mode l with steel reduces the base shear to large extent.

COMPARISION OF DIFFERENT MODELS:

5.3. Time History Analysis: (THX)

5.3.1. Displacement of Building

Displacement for Static analysis values, in X – Direction.

Table 5.6 Displacements – THX

STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4
25	70	86	64	88
24	66	80	61	83
23	63	75	58	77
22	63	68	54	71
21	62	64	52	65
20	62	61	50	62
19	62	59	49	60
18	62	60	47	60
17	61	59	45	59

16	60	57	45	57
15	58	55	44	54
14	56	51	42	50
13	53	47	40	45
12	49	43	37	41
11	45	40	33	38
10	41	38	31	36
9	38	36	29	34
8	34	33	26	32
7	30	30	23	28
6	26	26	20	25
5	21	21	16	20
4	16	17	12	15
3	11	11	8	11
2	6	6	5	6
1	2	2	2	2
0	0	0	0	0

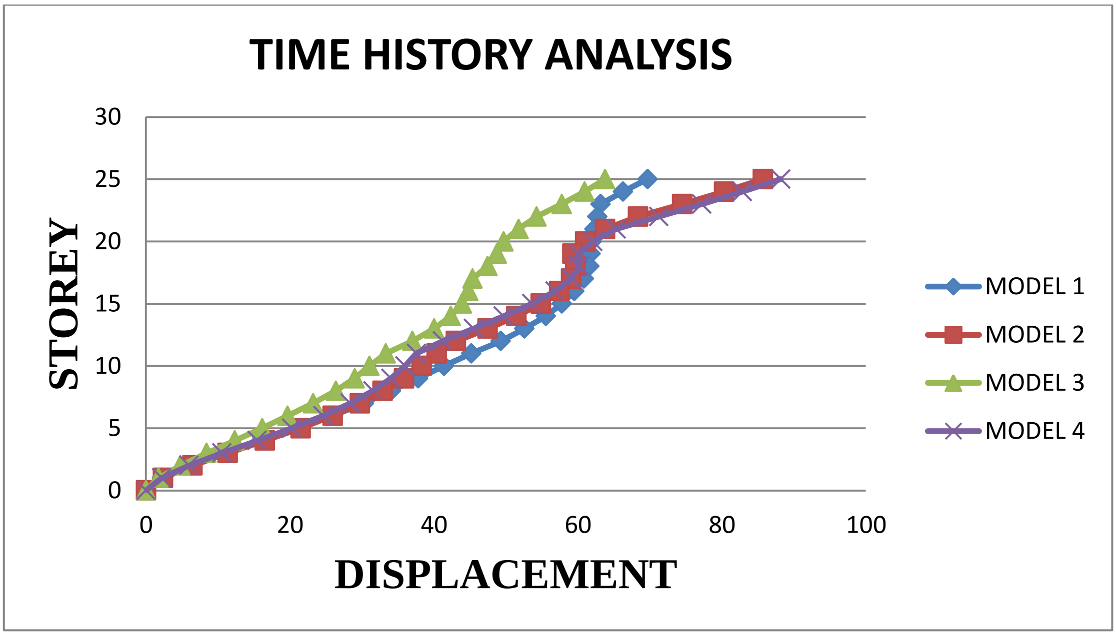


Figure 5.6 Storey V/S Displacement in X Direction.

The model 1 with RC framed structure with bracings exhibiting highest displacement compared to other models. And the model 3 is having least displacement compared to all other models. Hybrid model is also having second highest displacement since it is having highest flexibility.

5.3.2.Study of Inter Story Drift (THX)

The drift values are the difference in displacement between successive storeys. The values of Drift in X direction for Static Analysis are shown below:

Table 5.7 Inter Story Drift

STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4
25	3	5	3	5
24	3	6	3	6
23	0	6	3	6
22	0	5	3	6
21	0	3	2	3
20	0	2	1	2
19	0	0	1	0
18	1	1	2	1
17	1	2	1	2
16	2	3	1	3
15	2	3	2	4
14	3	4	2	4
13	3	4	3	4
12	4	3	4	4
11	4	2	2	2
10	4	2	2	2
9	4	3	3	3
8	4	3	3	3
7	4	4	4	4
6	5	4	4	4
5	5	5	4	5
4	5	5	4	5
3	5	5	4	5
2	4	4	3	4
1	2	2	2	2
0	0	0	0	0

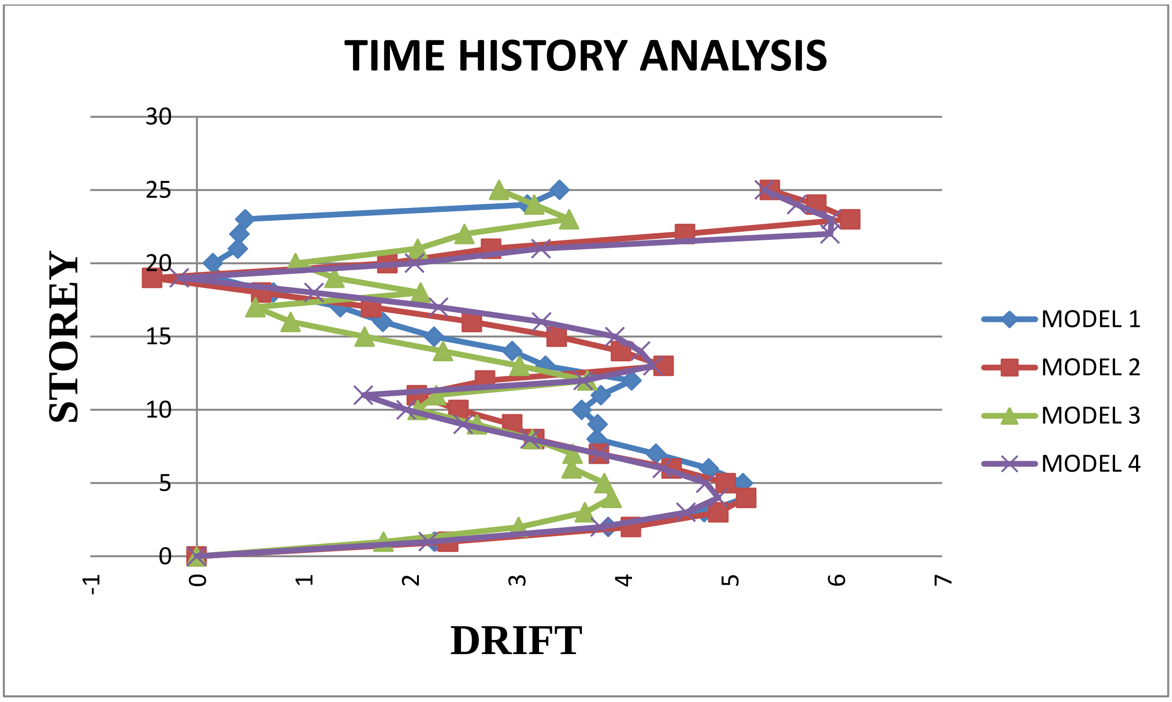


Figure 5.7 Storey Drift v/s Storey

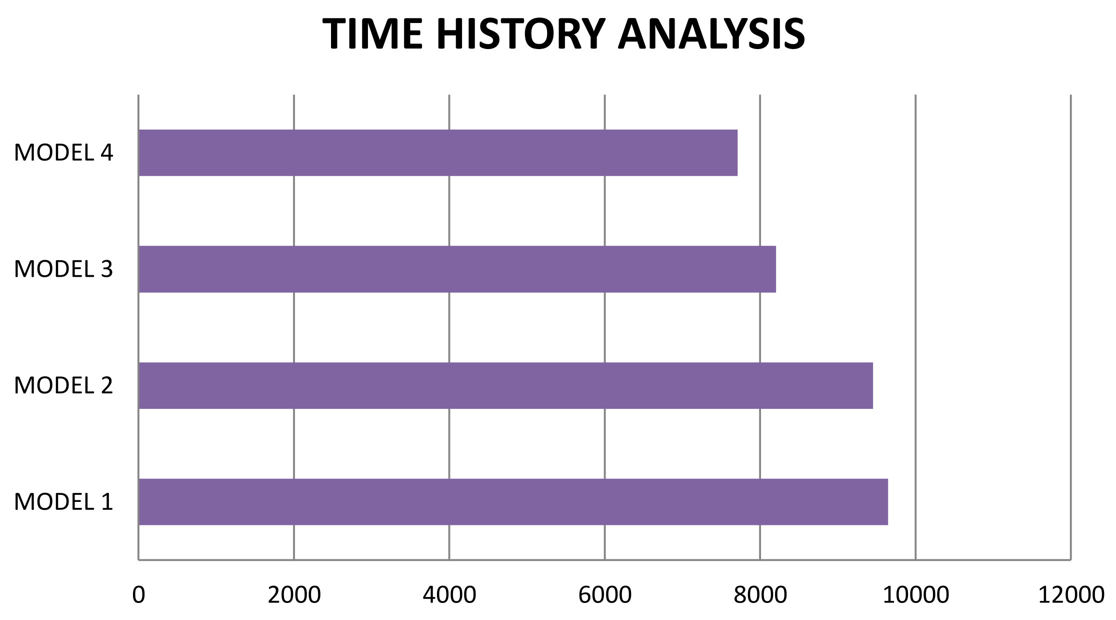
The inter storey drift reflects the difference in the displacement. The Model 1 is exhibiting highest drift values, compared to all other models. The Model 3, tube in tube structure shows lowest drift compared to all the models. There is a sudden increase in drift values at the location where the model changes from RCC to Steel in model 3. This shows, the connections need to be taken care.

5.3.3. Study of Base Shear (THX)

The table below shows different base shear values for 50 storey different models

Table 5.8 Base shear

BASE SHEAR			
MODEL 1	MODEL 2	MODEL 3	MODEL 4
9647	9453	8205	7709



	MODEL 1	MODEL 2	MODEL 3	MODEL 4
Series1	9647	9453	8205	7709

Figure 5.8 Base Shear v/s Models

The base shear is the summation of lateral forces acting on the structure. The force values depend on the weight of the structure and loads acting on it. The model 1 is showing highest base shear and mode l with steel reduces the base shear to large extent.

5.4. Peak Responses

Dynamic time history analysis has been carried out for BHUJ earthquake and key results are presented and summarised in this section. Figure below shows typical response plots from time history analysis.

Table 5-9 Time History Response Summary Chart – BHUJ

Models	Time History Analysis	
	Peak Acceleration	Peak Displacement
Model 1	1.238	89.03
Model 2	1.424	82.60
Model 3	1.189	63.02
Model 4	1.542	82.61

The model 4 is experiencing the highest acceleration. And the model 1 is exhibiting the highest displacement. The acceleration is due to lesser stiffness subjected to greater force. The below images shows the peak acceleration and displacement of Point 57 of the structure for consideration.

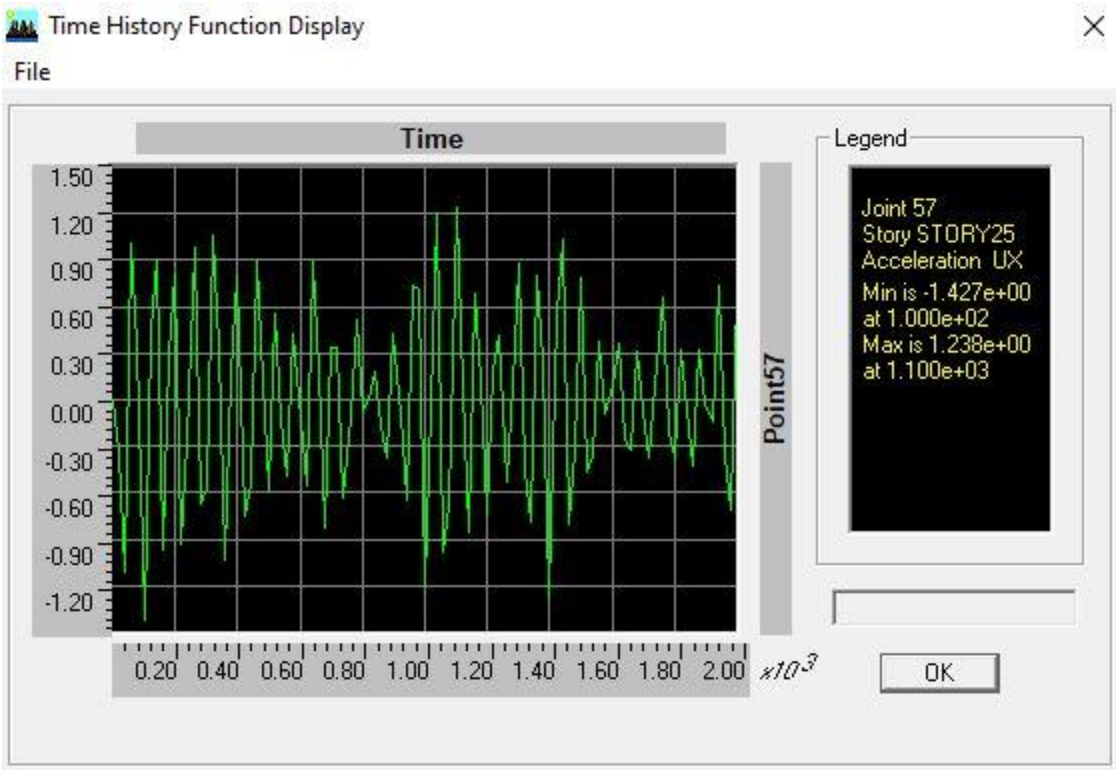


Figure 5-9 Peak Acceleration Response Model 1

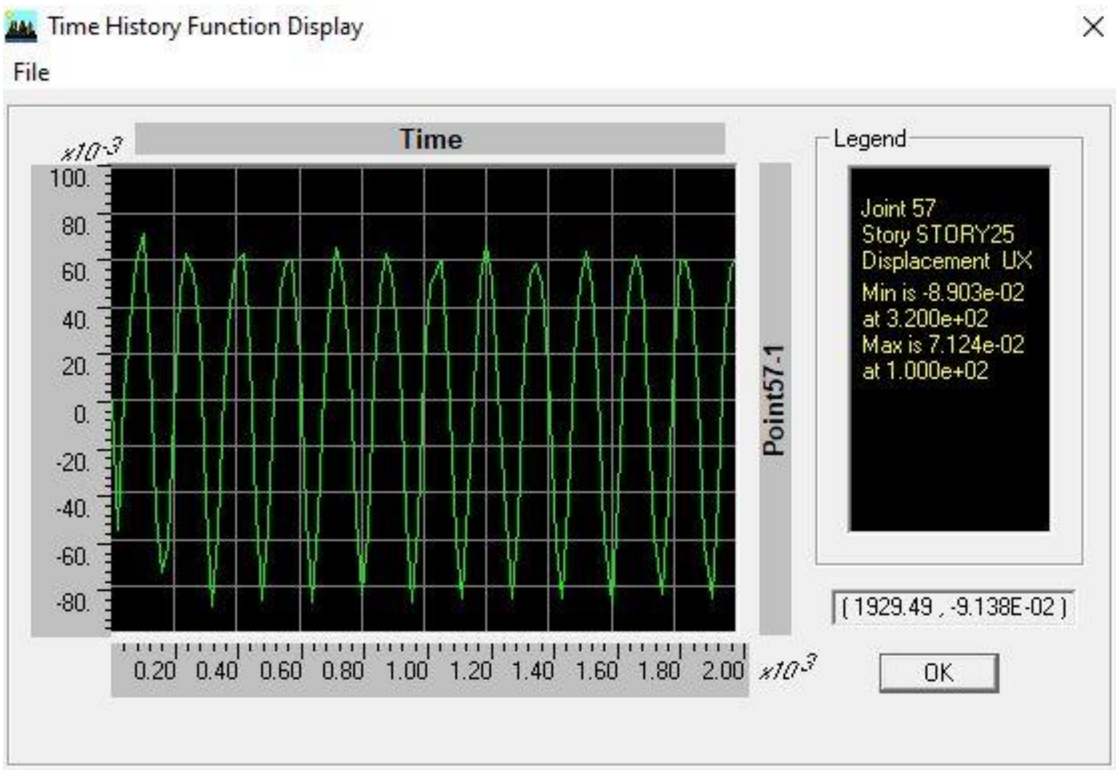


Figure 5-10 Peak Displacement Response Model 1

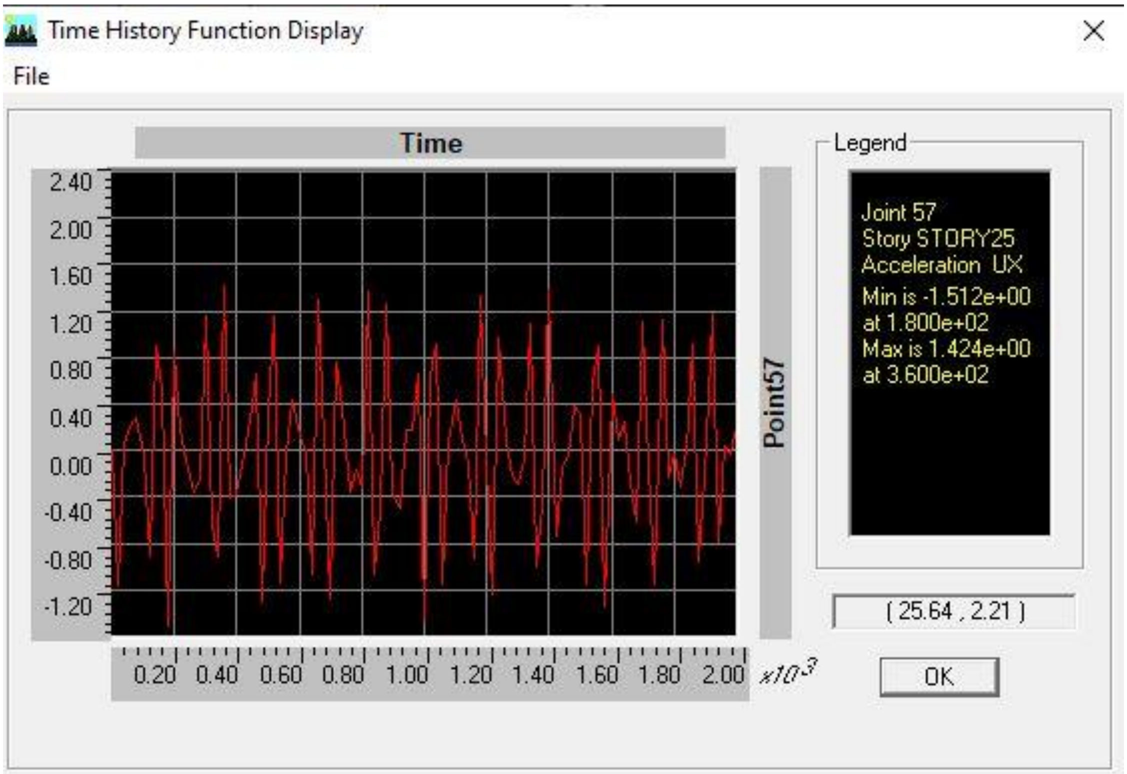


Figure 5-11 Peak Acceleration Response Model 2

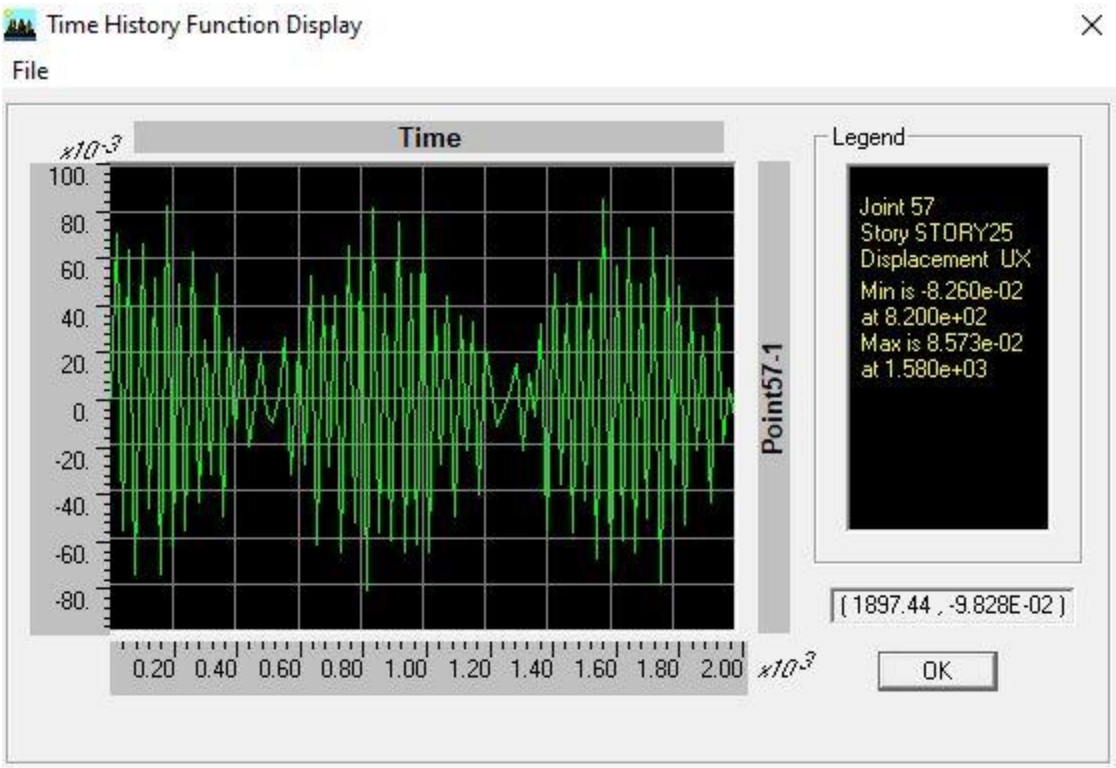


Figure 5-12 Peak Displacement Response Model 2

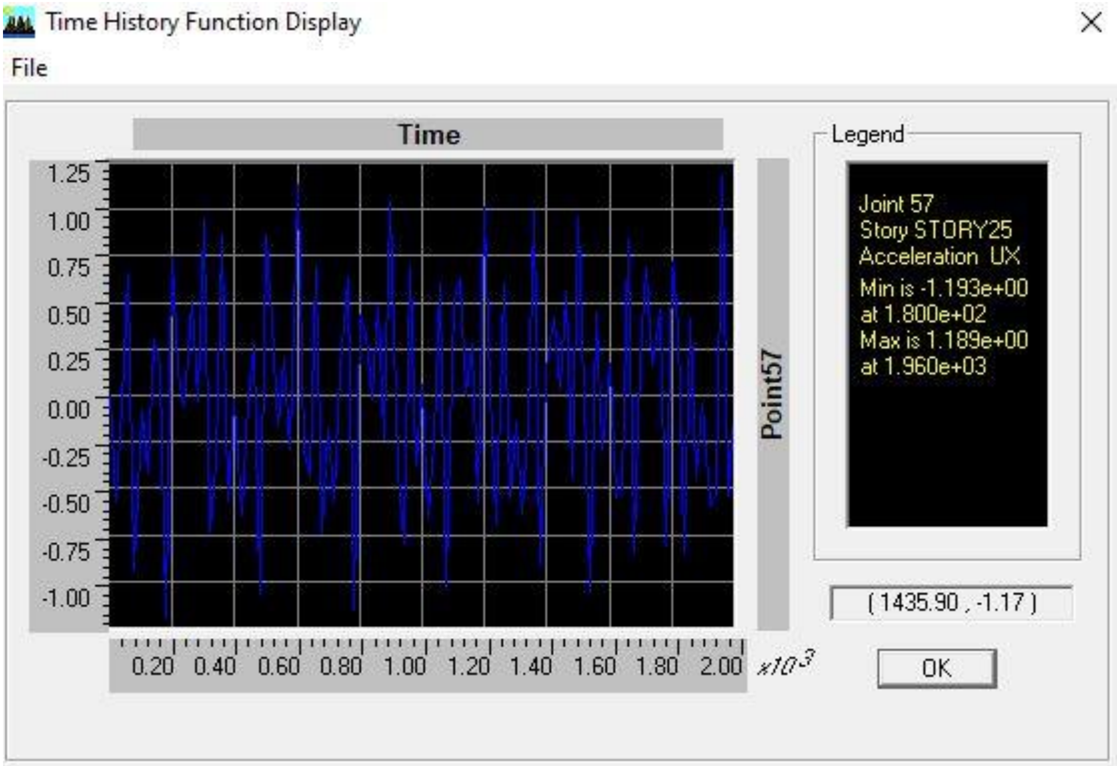


Figure 5-13 Peak Acceleration Response Model 3

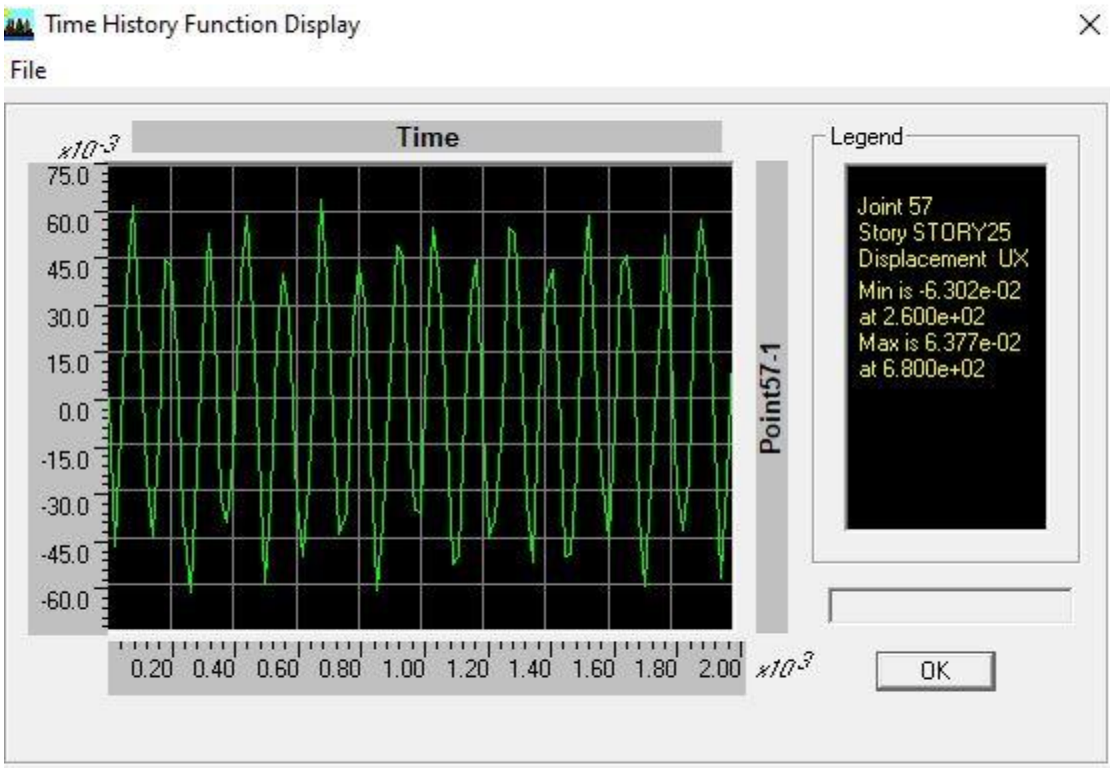


Figure 5-14 Peak Displacement Response Model 3

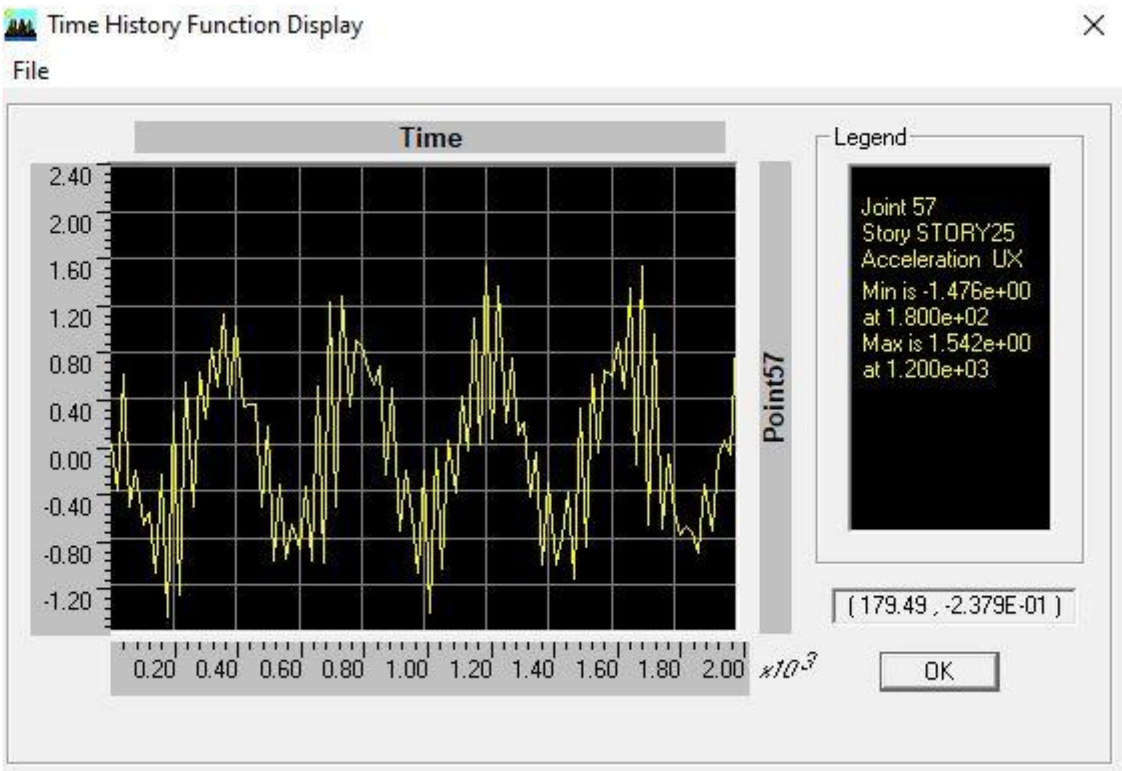


Figure 5-15 Peak Acceleration Response Model 4

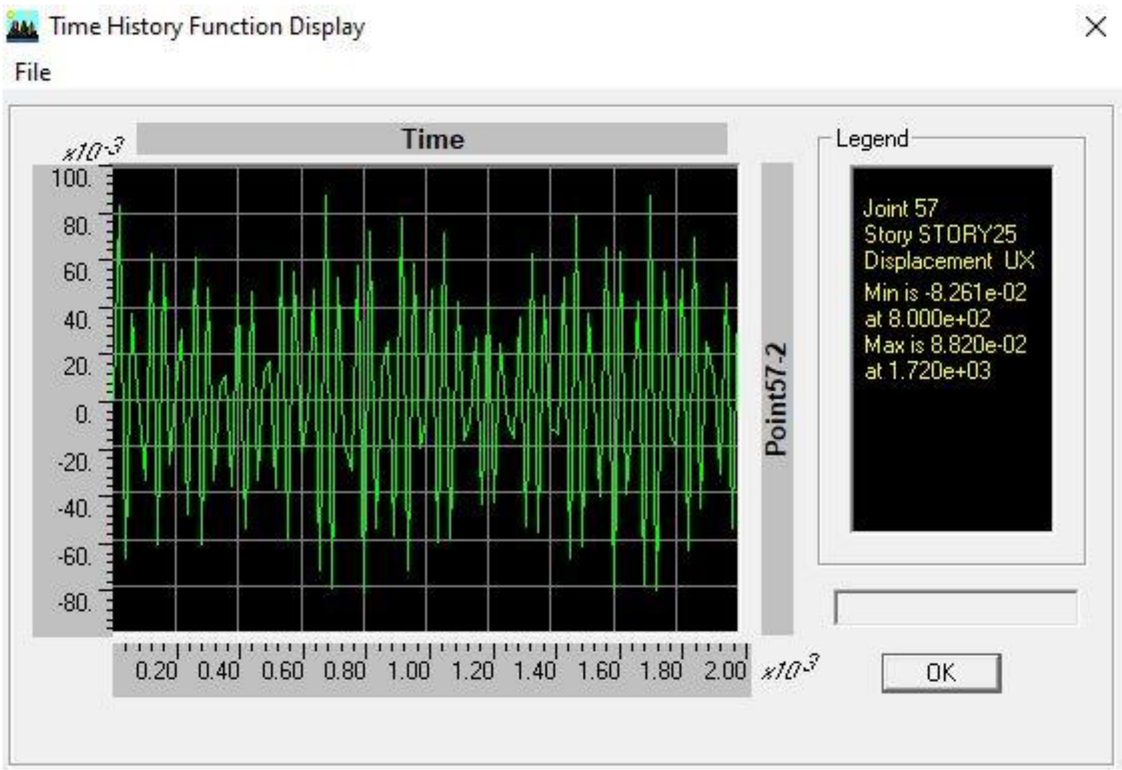


Figure 5-16 Peak Displacement Response Model 4

CHAPTER 6

6. CONCLUSIONS:

6.1. General:

- The time History analysis shows the realistic behaviour of the structure subjected to seismic forces and it seems exact compared to static analysis.
- The Displacement is drastically reduced in case of RCC tube structure compared with bracing structure. There is a reduction of 40% deflection in case of model 3 compared with model 1.
- The Hybrid structure is flexible for seismic forces; however, it is having lesser displacement than model 1 by 14%. In Equivalent static analysis.
- The displacement of Model 4 is more in case of time history analysis. The time history analysis shows the model 3 is again lesser since it is having higher rigidity compared to other models.
- However, there is a reduction of around 3.7 times of displacement values when compared with static and time history analysis. It concludes that the time history is the exact way of analysis, since it considers the earth quake response of the particular area where the structure has been built. And hence it is reliable.
- The drift values are higher in case of model 1 and model 4, however, it is with in the allowable limits i.e., h/250 = 4000/250 = 16 and hence acceptable.
- The time period of model 4 is more compared with all other models and hence it is treated as very much flexible and exhibit good behaviour in case of seismic events.
- The drift values are not linear in case of time history as it captures the exact behaviour of nonlinear effect and should be consider in case of high-rise structures.
- The peak response of the time history shows clear indication that the model 4 exhibits highest acceleration level compared with other models due to flexibility of the model. And hence the higher displacement.
- From the over all analysis, time history analysis to be compulsory adopted for high rise structures and the model 3 with bundled shear wall structure is expected to be work efficiently compared to all other models in case of seismic events.

6.2. Future Scope of Work:

- Further RCC structures can be compared with steel structure to check the efficiency.
- For such high rise structure composite structure will be an alternative to increase its efficiency.
- Soil structure interaction can be involved to get the exact behaviour of the structures.

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