DYNAMIC ANALYSIS OF TALL TUBULAR STEEL STRUCTURES FOR DIFFERENT GEOMETRIC CONFIGURATIONS

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Abstract - *In structural engineering, the structural frames are the load resisting systems. The analysis and design of structures particularly tall structures needs appropriate analysis methods, precise design concepts along with preliminary designs aided with optimisation, in order to resist the gravity as well as lateral load, so that structure remains safe thought its life span. In extremely tall buildings stiffness plays a very important role in controlling the global displacements. Hence new structural systems are developed by combining the previous structural systems in order to resist effectively the lateral loads due to earthquake and wind and to limit global displacements, drifts and accelerations under control. The tube structural concept had become more popular structural systems particularly for high rise steel structures. To understand the behaviour of the tall tubular steel structures for different geometric configurations like square, rectangle, triangular, hexagonal shapes in plan, in comparison with the steel beam column rigid frame system, were analysed using ETABS 2016. The effect of geometric configurations on behaviour of tall tubular steel structures are summarised using the obtained results, by concluding the optimum geometric configuration for tall tubular steel structures.*

Key Words**: Tube structure, Earthquake zones, wind load, Base shear, Story drift, Story displacement and ETABS.**

1. INTRODUCTION

The appropriate analysis methods are used for structural design and analysis of structures especially for multi-story structures, accurate design ideas alongside with initial designs supported with optimization, in order to withstand the vertical as well as horizontal load, so that building stay safe thought its life period. The major vital standard in structural engineering is strength, stability and serviceability of the structures. The purpose of structural engineers for high rise buildings is to resist the lateral forces like earth quake and wind force that are acting on structure. The purpose of structural engineers for high rise buildings is to resist the lateral forces like earth quake and wind force that are acting on structure. Many structural engineers carried out lot of work to analyses the effect of lateral forces regarding its height and they formulated some criteria to keep minimum deflection or fixed deflection for the forces acting on the structure. Among which the geometry of structure is also one of the important factor so in this study we have considered various geometry of structures.

1.1 Characteristics and importance of structural systems

In extremely developed urban areas there is a deficiency of land hence very large requirement for tall structural systems, increase in requirement for residential space and business, technical innovations, alteration in structural systems concept of town sea line and social dream to construct higher. The stiffness plays a very important role in tall buildings to controlling the overall displacements. Sao original structural systems are constructed by combining the earlier systems in order to co1unater attack adequately the lateral forces from earthquake and wind and accelerations, drifts and to minimize overall displacements or top put it in control. The structural system transmission loads from corresponding structural members. The members which carry's loads are considered to be structural system and they need to be designed all other members are non-structural members. In this metropolitan world the necessity of super tall structures are very necessary. The structures may go up to 300 to 500m height as a structural engineer we should ensure its safety as whole structure and as a unit for that purpose different structural system were developed.

1.2 STRUCTURAL SYSTEM CLASSIFICATIONS

Structural systems are classified into 4 types

Type 1 – Shear Frames

Type 2 – Interacting frames

Type 3 – Partial Tubular frames

Type 4 – Tubular Systems

1.3 Classification of Tube structures

Basic forms of tubular systems are

- Framed tube
- Braced tube

- Bundled tube
- Tube-in-tube
- Tubed mega frame

1.4 Objectives studies

1. To know the behavior of different geometric Configurations of tall tubular steel structures like square, rectangle, triangular, hexagonal shapes in plan, comparison with the square steel moment resisting frames system.
2. Equivalent static method is used to carry out earth quake Analysis, referring IS1893-2002 and ETABS 2016 is used to carry out the dynamic time history analysis. Also wind analysis is carried out to understand the behavior under the wind loads.
3. Base shear, story displacement and peak displacement, story drift and acceleration are found out for all geometric configurations.
4. By using obtained results the effect of geometric configurations on behavior of tall tubular steel structures are summarized.

2. DATA FOR DEVELOPING THE MODEL

Using ETAB 2016 Structural modeling of steel framed tall tubular structure is made for hexagon shape geometric configuration, with a regular steel moment resisting frame section. All the models having equal number of stories which is 88 numbers and constant floor area constant diaphragm to take lateral loads and transmits to beams are provided for all the models to obtain the consistent results for lighting, ventilation and service criteria a central core is permitted.

Table-1: Parameters Considered For the Development of Structure

SL NO	PARAMETERS	REMARKS
1	Type of Structure	Steel Moment Resisting Framed tube
2	Plan Configurations	Square, Rectangular, Triangular and Hexagonal
3	Story details	G+87 (88 Storied)
4	Each floor height	3.6m
5	Total building	316.8m
6	Total Floor area	3550m2
7	Type of Building	Office Building
8	Grade Steel	345Garde
9	Grade of concrete	M30 (Deck Slab)
10	Column Sections	Built up (ISWB 600)
11	Beam Sections	ISMB 600
12	Deck Section	200 mm thick
13	Live load	4 KN/m2
14	Floor finish	1.5 KN/m2
15	External Glazing	2.0 KN/m
16	Location of Building	In Moderate intensity (Z-II)
17	Soil type	type II (Medium)
18	Importance factor	1.0
19	Response reduction factor	5.0
20	Fundamental Natural Period	6.382 seconds

2.1 Dynamic Time History Analysis

Linear or nonlinear valuation of dynamic structural response provided by time-history analysis for loading which may differ according to the fixed time function. By using either modal or direct integration methods dynamic equilibrium equations, are solved. From the end of the past analysis Initial conditions may be place by continuing the structural state. The ELCENTRO time history data is considered in the present study, the following specifications of elcentro is given below.

Table-2: ELCENTRO Time history Data Specifications

SL NO	SPECIFICATIONS	REMARKS
1	Location	"Imperial Valley"
2	Date of earthquake occurred	19th May 1940
3	Time duration	4:39am
4	Station	"Ell Centro A rray#9"
5	Direction Horizontal	1800
6	Units of acceleration (g)	9.81m/s2(acceleration of gravity)
7	Number of time instants	4000
8	Sampling time(Δt)	0.01 s (f= 100 Hz)

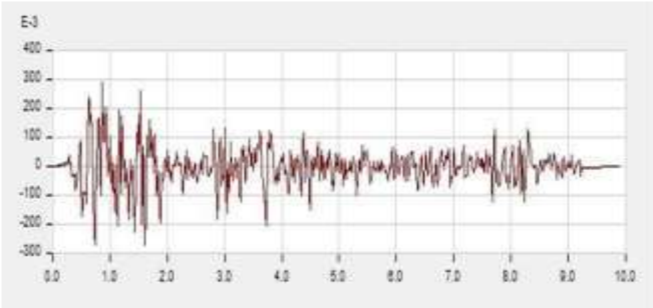

Fig-1: Time History Data for El-Centro

2.2 W1IND ANALYSIS

Wind loads is considered as per IS 875:1987

- Wind speed Vb = 33 m/s
- Terrain Category = 4
- Structure Class = c
- Risk Co-efficient = 1

2.3 DIFFERENT GEOMETRIC CONFIGURATIONS OF FRAMED TUBE STRUCTURES

a) Model 1: Plan of square steel moment resisting framed tube structures

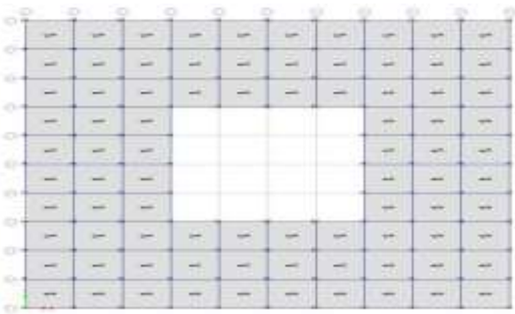

Fig2. Plan of square steel moment resisting framed tube structures

b) Model 2: Plan of square framed tube structures

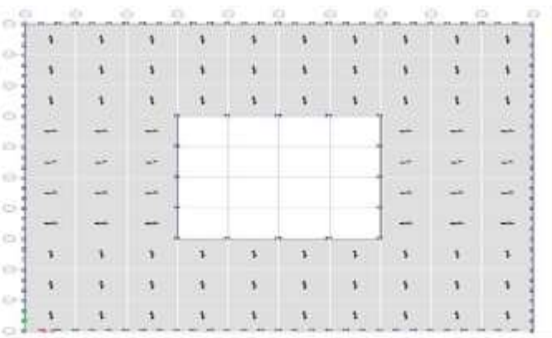

Fig3. Plan of square framed tube structures

c) Model 3: Plan of rectangle Framed tube structures

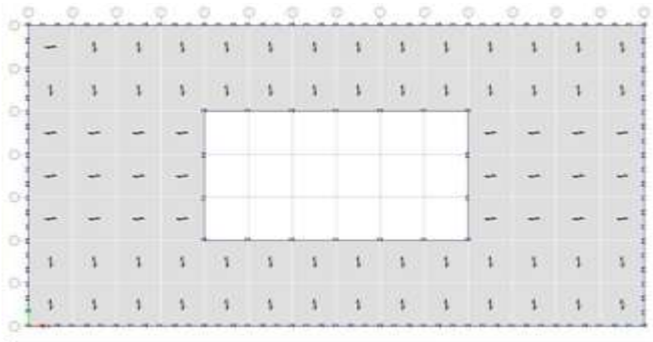

Fig3. Plan of rectangle Framed tube structures

d) Model 4: Plan of triangle Framed tube structures

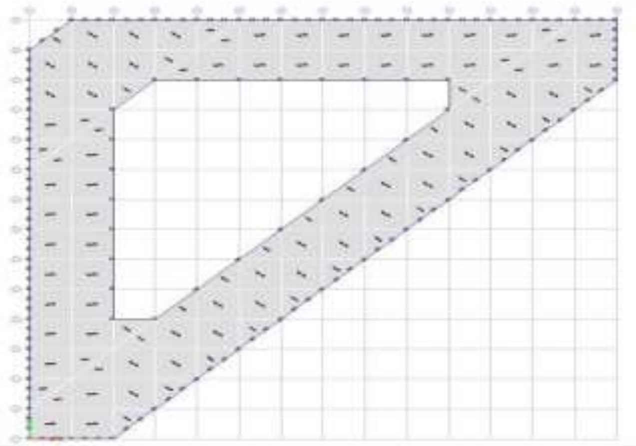

Fig4. Plan of triangle Framed tube structures

e) Model 5: Plan of Hexagonal Framed tube structures

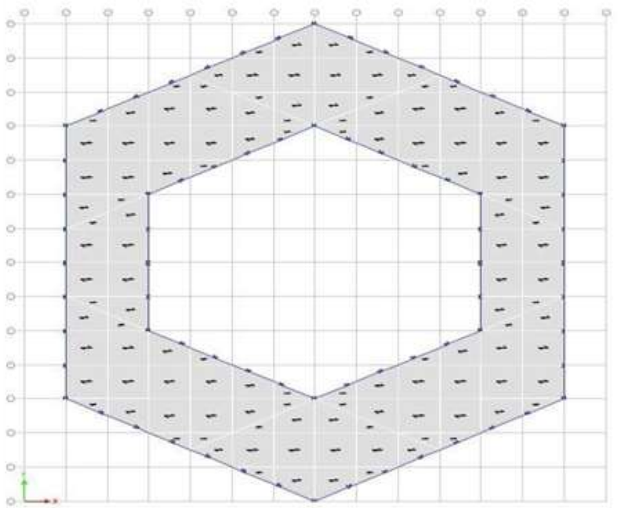

Fig5. Plan of Hexagonal Framed tube structures

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3. ANALYSIS OF RESULTS AND DISCUSSIONS

3.1 MODAL ANALYSIS

For all geometric configurations modal analysis has been carried out and listed the frequencies and time period in Table 4 and Table 5 respectively. For hexagonal tube structure having maximum compared to all other structure, time period for hexagonal tube structure is 34% high than that of square steel moment resisting frame structure and 29% compared to all other tube structures. For square tube structure having Maximum frequency is found i.e 0.063 cycles/sec.

a) Mode vs. Time Period

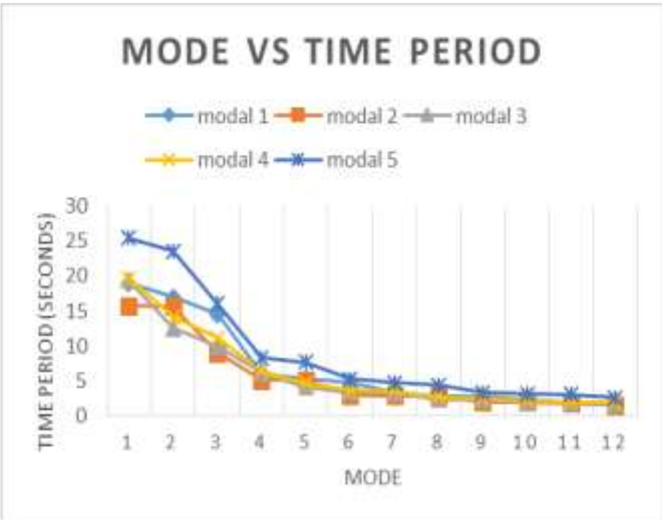

Chart 1. Mode V/s Time period for different tube structures

b) Mode vs. Frequency

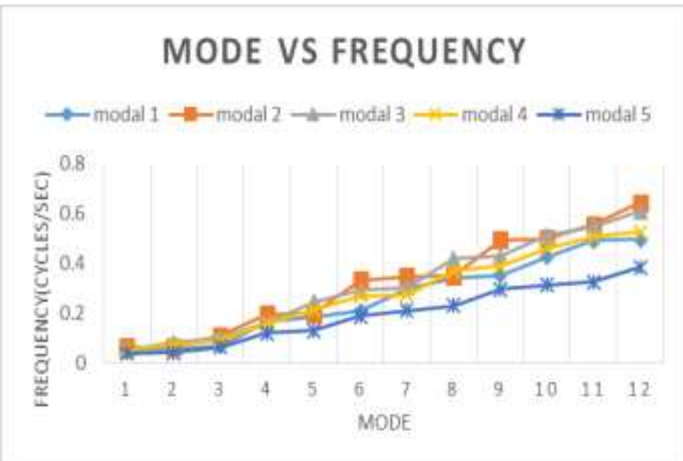

Chart 2: Mode V/s frequency for different models

3.2 RESULTS FOR EARTH QUAKE ANALYSIS

a) MAXIMUM BASE SHEAR

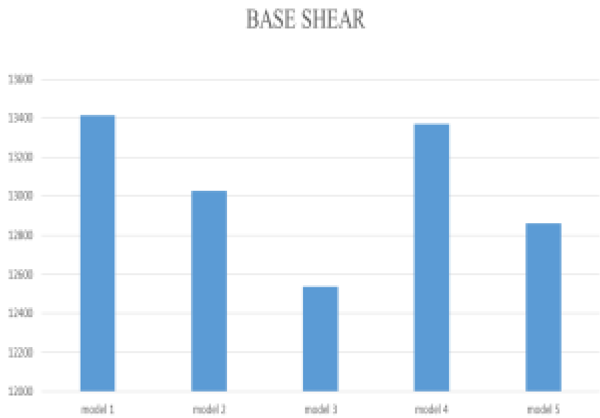

Chart 3. Maximum base shear

3.3 STORY DISPLACEMENTS FOR EARTHQUAKE LOADS

a)Story vs Displacement

Chart 4: Story Displacements graph for earthquake load

b) Story vs Drift ratio

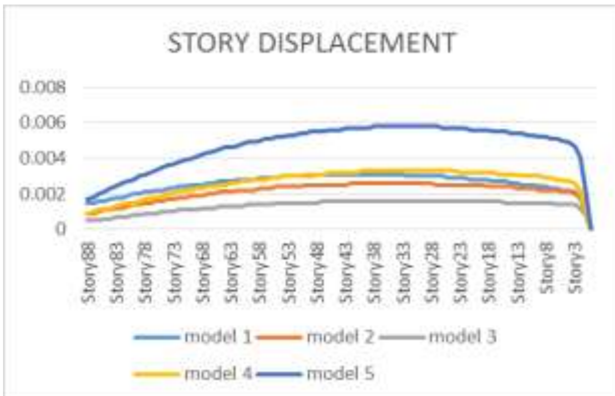

Chart 5: Story Drifts graph for earthquake load

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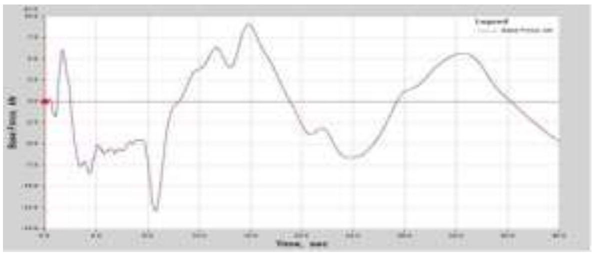
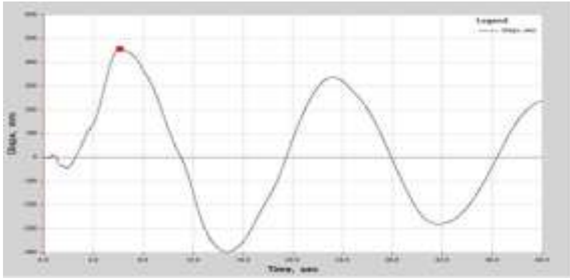
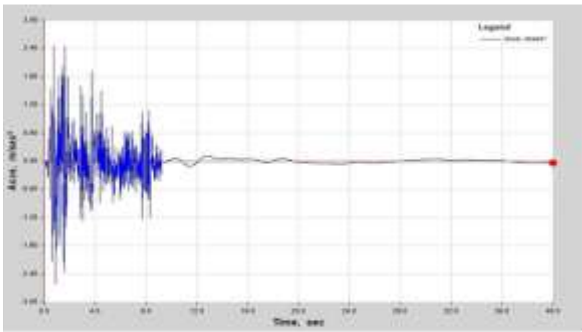
3.4 DYNAMIC TIME HISTORY ANALYSIS RESULTS

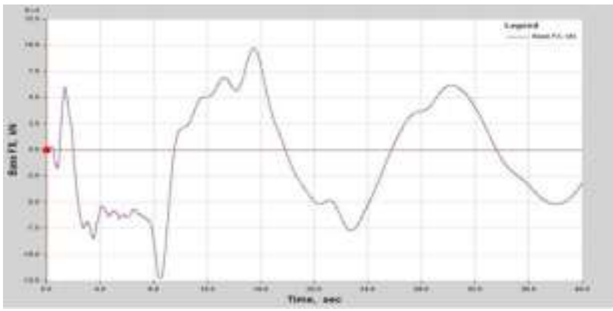
A) SQUARE STEEL MOMENT RESISTING FRAME

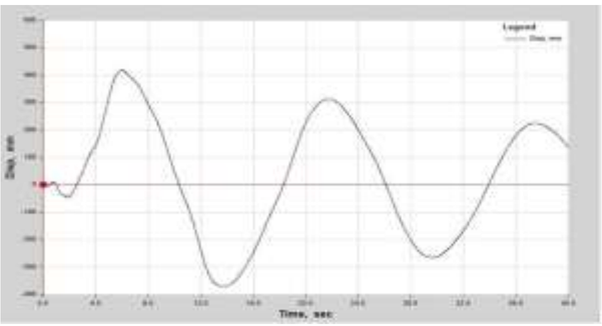


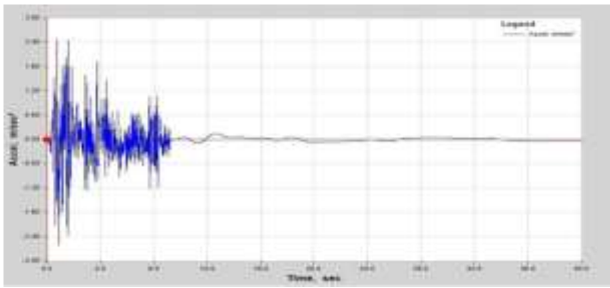




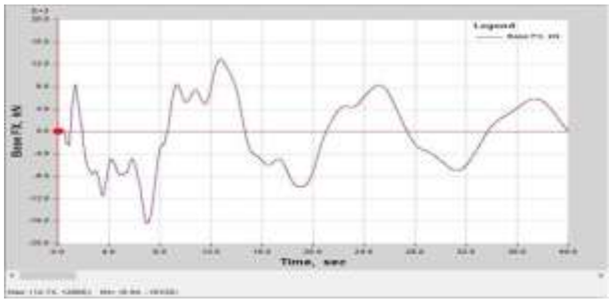
B) SQUARE FRAMED TUBE STRUCTURES IN PLAN

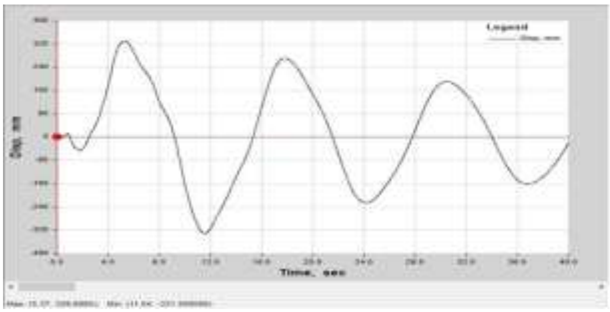


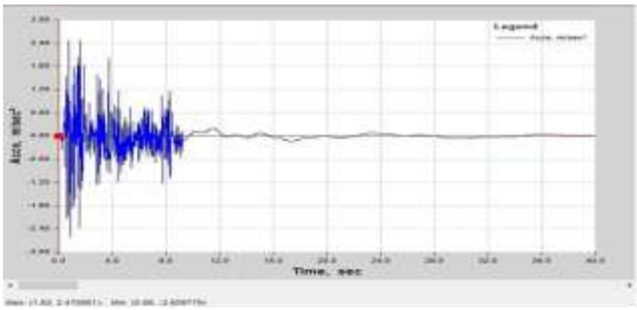




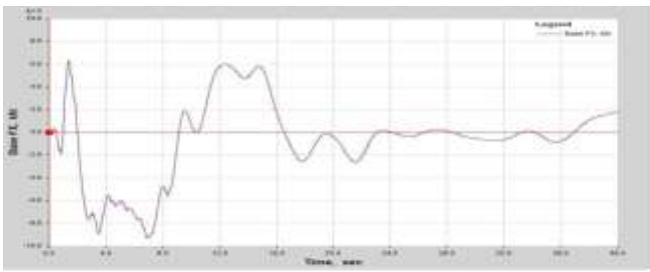
C) RECTANGULAR FRAMED TUBE STRUCTURES IN PLAN

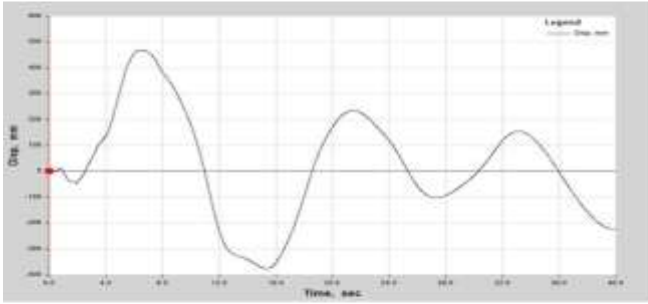


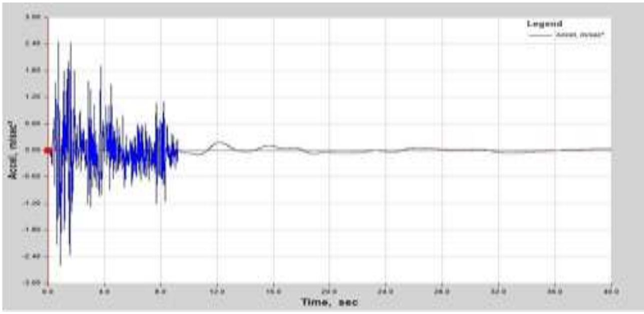




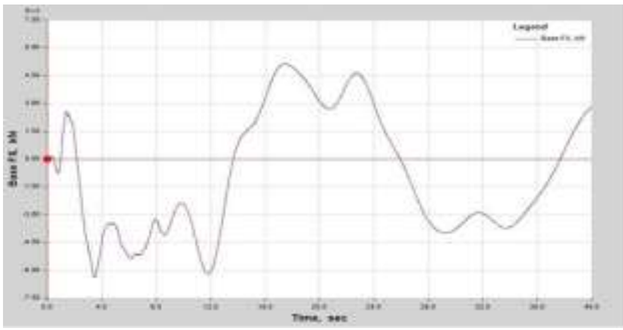
D) TRIANGULAR FRAMED TUBE STRUCTURES IN PLAN

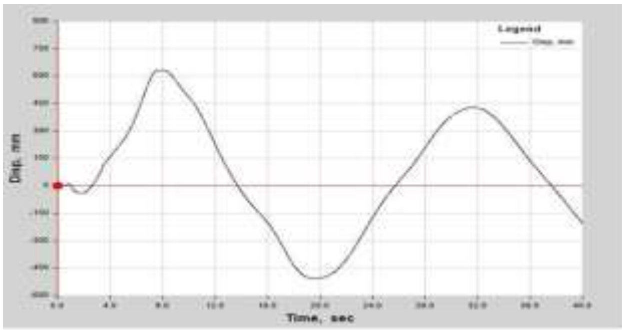


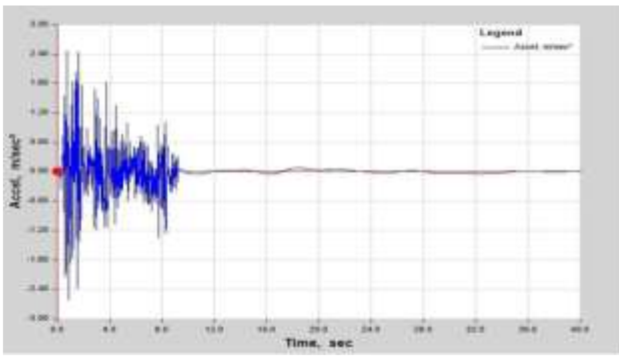




E) HEXAGONAL FRAMED TUBE STRUCTURE IN PLAN







3.5 RESULTS FOR WIND ANALYSIS

STORY DISPLACEMENTS FOR WIND LOADS

a) Story vs Displacement

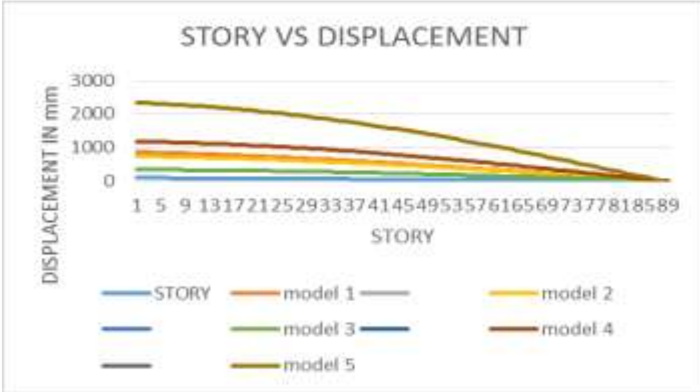


Chart 6. Story Displacements graph for – Wind Analysis

a) Story vs Drift ratio

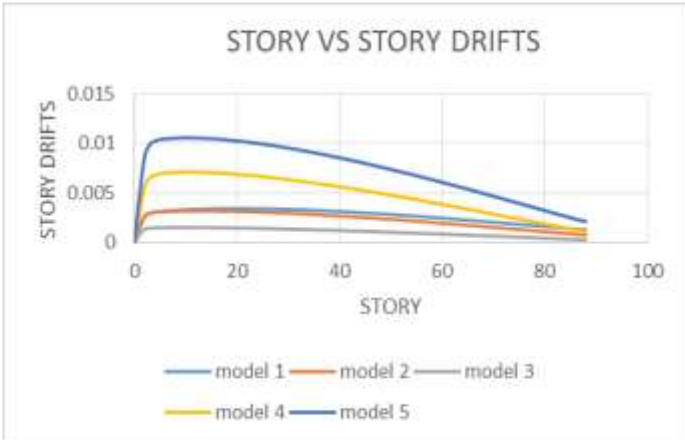


Chart 7. Story Drift ratio graph for – Wind Analysis

4 CONCLUSIONS

- From the above results and discussions of all modal analysis, it can be terminated that hexagonal tube structure is having higher time period i.e., 25.42 seconds and having lesser frequency 0.040 cycles per second. Hence from point of view of time period and frequency this framed tube structures can be considered as stable.
- From the lateral load analysis both earthquake and wind analysis, we found maximum displacement and story drifts are encountered for hexagonal shape framed tube structures.
- The behaviour and responses of Square and triangular frame tube structural systems are

similar in case of earthquake and wind load analysis.

- To compare equivalent static analysis the dynamic time history analysis results are lower. Hence to understand the correct behaviour of the high rise structural system, dynamic analysis is preferable.

- Form the above results and discussions it can be decided that tube structure is preferable for high rise structures in place of conventional beam column moment resisting frame steel system.

4.1 SCOPE OF FUTURE WORK

- In hexagonal frame tube structure the displacement, story drifts are reduced by using additional structural systems like diagrids, steel plate and shear walls.

- For all geometric configurations mega braces can be used to reduce the displacement.

- In complex shape tubular structures are also analysed.

- For same geometric configurations tube in tube structures can be analysed.

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