Analysis of different types of reinforced concrete tubular structures

A project submitted in partial fulfilment of the requirements for the award of the degree of

MASTER OF TECHNOLOGY

In

STRUCTURAL ENGINEERING

Submitted by

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CERTIFICATE

This is to certify that this report entitled **"Analysis of different types of reinforced concrete tubular structures"** is an authentic report of the Major project part-II done by the undersigned. This is a bona fide record of his own work carried by him under the guidance of Dr. Ashok Kumar Gupta in partial fulfilment of the requirement for the award of the Degree of Master of Technology in Structural Engineering at the Delhi Technological University, Delhi.

The matter embodied in this project has not been submitted for the award of any other degree.

(Nitish Chauhan)
2K13/STE/26

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Dr. ASHOK KUMAR GUPTA
Professor

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I would like to express my sincere gratitude to my project guide *Dr. ASHOK KUMAR GUPTA* for giving me the opportunity to work on this topic. It would never be possible for me to complete this project without his precious guidance and his relentless support and encouragement.

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(2K13/STE/26)

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CHAPTER 1

Introduction

1.1 General

An efficient and economical tall building cannot be designed without a thorough understanding of the significant factors affecting the selection of the structural system and knowledge of how the structural system will interrelate with architectural, mechanical and electrical aspects. Usually two to three different structural systems will be selected for comparison.

1.2 Tall Buildings as Lateral Load Resisting Systems

As socio-economic trends demanded taller buildings, structural engineers were pressed to provide lateral load resisting systems that would minimize, (or at least optimize), cost of structural and reinforcing steel for buildings of greater height to width aspect ratios and varying vertical profiles. Initially, rigid frame construction was used extensively in tall buildings, but as aspect ratio increased, stiffness rather than strength criteria begins to control design and tall buildings pay a “premium for wind “, i.e. that amount of structural steel required beyond that required to sustain gravity loading.

In order to control building response to lateral loading structural engineers may utilize one or more of the following:

1. Increase stiffness of the system
2. Increase building weight
3. Increase density of the structure with fill-ins
4. Use efficient shapes

5. Generate additional damping forces (tuned mass dampers)

This work will focus on systems that evolved from efforts to increase building stiffness. Tall buildings structural system can be classified into four basic groups; rigid and semi rigid frames, shear wall or braced frames structures, shear wall or truss-frame interactive structures, and tube structures. Tube structures can be further categorized into frames tube systems and high efficiency tube systems. High efficiency tube systems evolved from the basic frame tube. methodology of preliminary design of tall building is shown below.

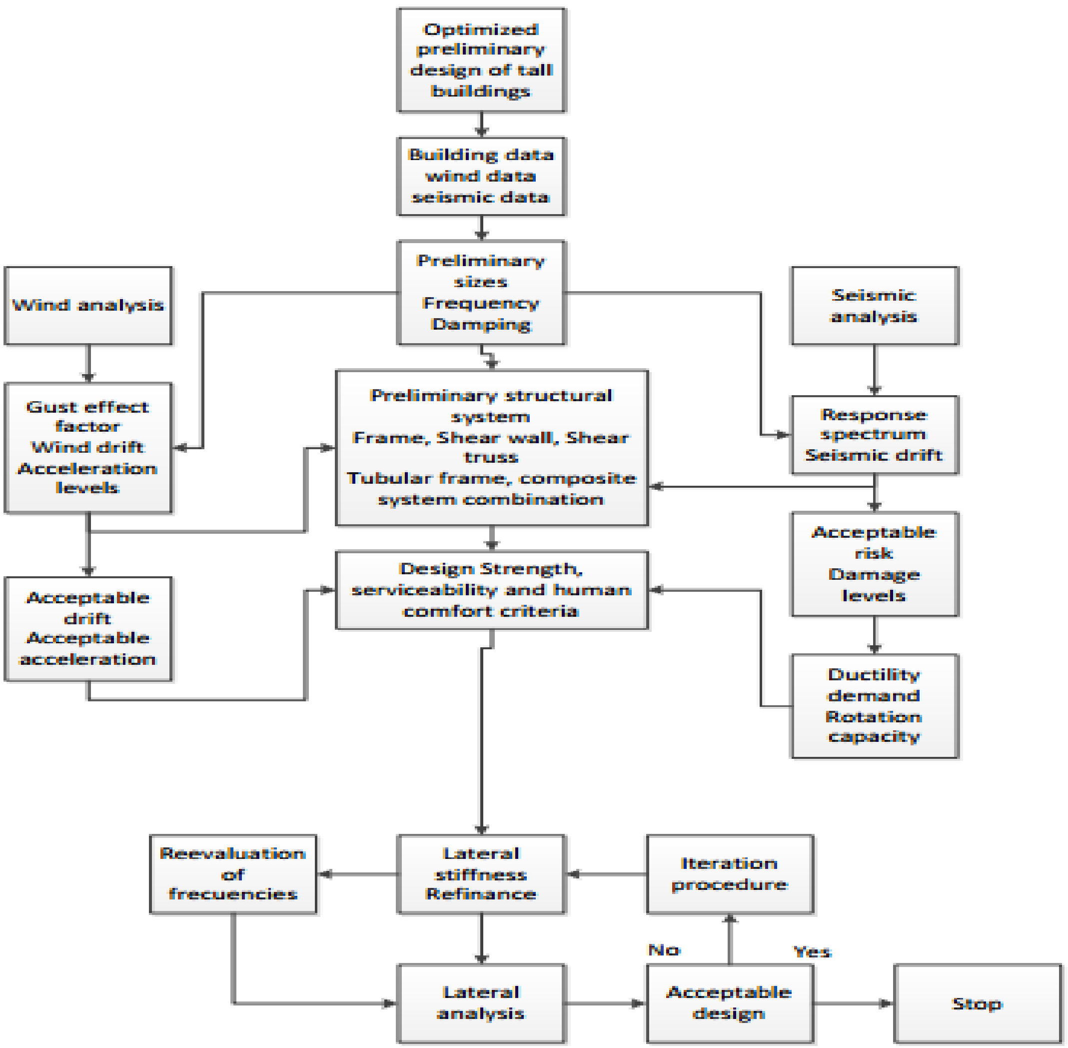

Figure1.0: Methodology of preliminary design of Tall buildings

Tall buildings structural system can be classified into four basic groups

a) Rigid and semi rigid frames
b) Shear wall or braced frames structures
c) Shear wall or truss-frame interactive structures
d) Tube structures.

1.3 Tubular structure

The tubular system is structural engineering system that is used in high-rise buildings, empower them to resist lateral loads from seismic and wind pressures and so on. It behaves like a hollow cylinder, that is cantilevered perpendicular to the ground. The system was initially developed in the 1960s by the engineer Fazlur Rahman Khan, & has been used to design and construct most high-rise buildings since then.

The tube system can be designed and constructed using concrete, steel or composite of both. In its simplest form, closely-spaced columns are tied together with deep spandrel beams through moment connections as part of the external perimeter of the building. The rigid frame that this assembly of columns and beams forms results in a dense and strong structural 'tube' around the exterior.

Since lateral loads can be resisted by this stiff exterior framing, interior columns can be located at the core and are fewer in number. The interior can be simply framed for gravity loads and floor space is left free from columns.

The first building designed by Khan using a tube frame was the DeWitt-Chestnut building, Chicago, in 1963. The first skyscraper to use the system was Chicago's Willis Tower.

1.4 Types of tubular structures

Tube structures can be further categorized into following categories:

a) Frames Tube structures

b) Braced Tube structures

c) Tube-in-Tube structures

d) Bundled Tube structures

1.4.1 Frame Tube System

In this system, the perimeter of the building consists of closely spaced columns connected by deep spandrel beams. The system works quite efficiently as a hollow vertical cantilever. However, lateral drift due to the axial displacement of the columns commonly referred to as chord drift and web drift, caused by shear and bending deformations of the spandrels and columns, may be quite large depending upon the tube geometry. For example, if the plan aspect ratio is large, say, much in excess of 1:2.5, it is likely that supplemental lateral bracing may be necessary to satisfy drift limitations.

The economy of the tube system therefore depends on factors such as spacing and size of columns, depth of perimeter spandrel beams, and the plan aspect ratio of the building. This system should, however, be given serious consideration for buildings taller than about 40 stories. In its simplest terms, a framed tube can be defined as a three-dimensional system that engages the entire building perimeter to resist lateral loads. A necessary requirement to create a wall-like three-dimensional structure is to place columns on the building exterior relatively close to each other, joined by deep spandrel girders. In practice, columns are placed 10 ft (4 m) to as much as 20 ft (6.1 m) apart, with spandrel beam depths varying from about 3 to 5 ft (0.90 to 1.52 in).

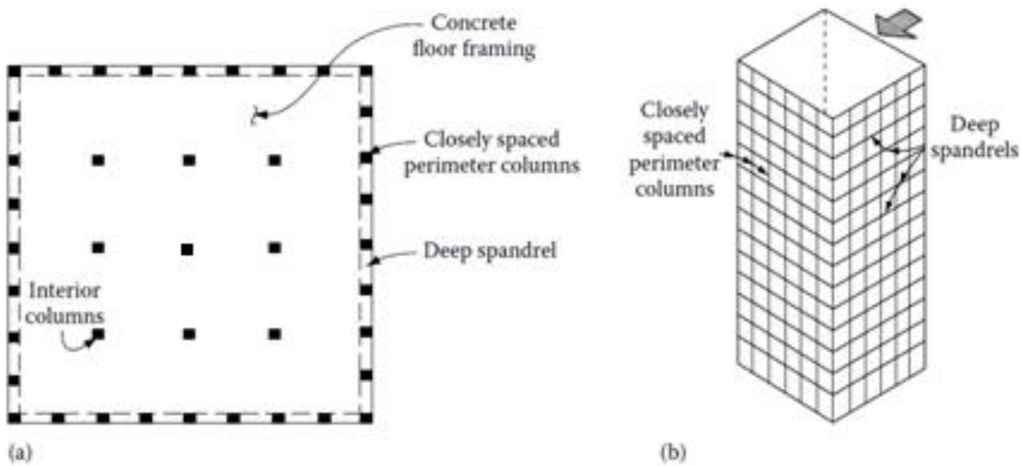

Figure 1.1 Frame Tube building (a) Schematic plan and (b) isometric view

Behaviour of Framed Tube structure:

In case of a framed tube structure, the entire lateral resistance is provided by closely spaced exterior columns and deep spandrel beams. The floor system, typically considered rigid in its own plane, distributes the lateral load to various elements according to their stiffness. Its contribution to lateral resistance in terms of out-of-plane stiffness is considered negligible. The lateral load-resisting system thus comprises four orthogonally oriented, rigidly jointed frame panels forming a tube in plan, as shown in Figure below. The "strong" bending direction of the columns is typically aligned along the face of the building, in contrast to a typical transverse rigid frame where it is aligned perpendicular to the face. The frames parallel to the lateral load act as webs of the perforated tube, while the frames normal to the load act as the flanges. When subjected to bending, the columns on opposite sides of the neutral axis of the tube are subjected to tensile and compressive forces. In addition, the frames parallel to the direction of the lateral load are subjected to the in-plane bending and the shearing forces associated with an independent rigid frame action. The discrete columns and spandrel beams distributed around the building periphery may be considered, in a conceptual sense, equivalent to a hollow tube cantilevering from the ground. Although the structure has a tube-like form, its behaviour is much more complex than that of a solid tube. Unlike a solid tube, it is subjected to the effects of shear lag, which has a tendency to modify the axial distribution in the columns. The influence of shear lag, considered presently in the following section, is to increase the axial stresses in the corner columns while simultaneously reducing the same in the inner columns of the flange and the web panels. The tube is similar to a hollow cantilever, in reality its response to lateral loads is in a combined bending and shear mode. The bending mode is due to axial shortening and elongation tube of the columns, whereas the shear mode is due to bending of individual columns and spandrel beams. The underlying principle for an efficient design is to eliminate or minimize shear deformation.

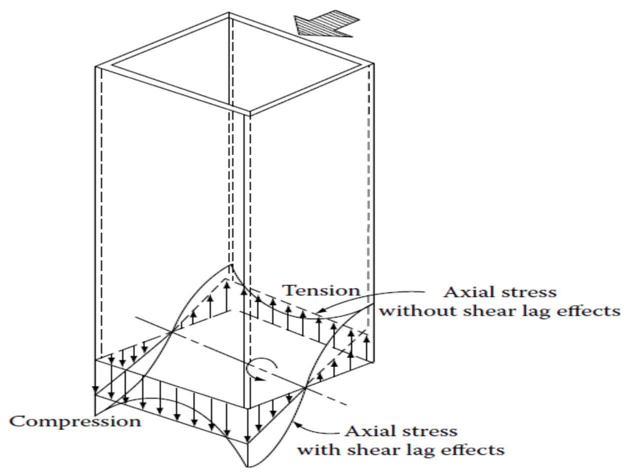

Figure 1.2 Axial stress distribution in a square hollow tube with and without shear lag

1.4.2 Braced Tube Structures

Further improvements of the tubular system can be made by cross bracing the frame with X-bracing over many stories, as illustrated in Fig. 1.3. This arrangement was first used in Chicago's John Hancock Building in 1969. As the diagonals of a braced tube are connected to the columns at each intersection, they virtually eliminate the effects of shear lag in both the flange and web frames. As a result the structure behaves under lateral loads more like a braced frame reducing bending in the members of the frames. Hence, the spacing of the columns can be increased and the depth of the girders will be less, thereby allowing large size windows than in the conventional framed tube structures. Design of Steel Structures Prof. S.R. Satish Kumar and Prof. A.R. Santha Kumar Indian Institute of Technology Madras In the braced tube structure, the braces transfer axial load from the more highly stressed columns to the less highly stressed columns and eliminates differences between load stresses in the columns.

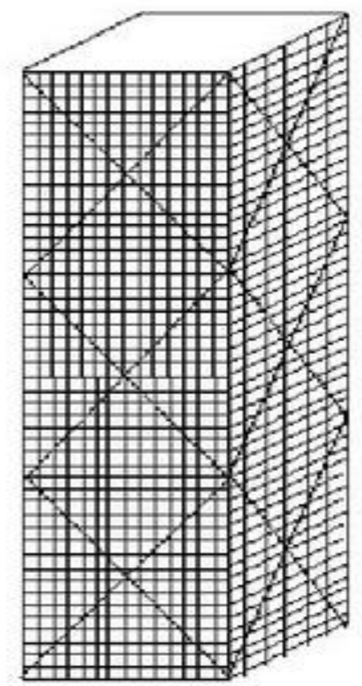

Figure 1.3 Isometric view of Braced Tube structure

1.4.3 Tube-in-Tube Structures

This is a type of framed tube consisting of an outer-framed tube together with an internal elevator and service core. The inner tube may consist of braced frames. The outer and inner tubes act jointly in resisting both gravity and lateral loading in steel-framed buildings. However, the outer tube usually plays a dominant role because of its much greater structural depth. This type of

structures is also called as Hull (Outer tube) and Core (Inner tube) structures. A typical Tube-in-Tube structure is shown in Fig. 1.4.

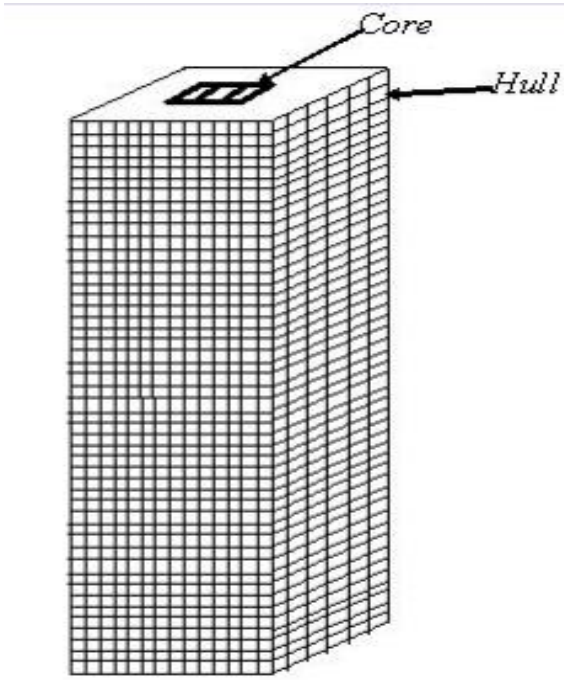

Figure 1.4 Isometric view of Tube-in-Tube structure

1.4.4 Bundled Tube Structures

The bundled tube system can be visualised as an assemblage of individual tubes resulting in multiple cell tube. The increase in stiffness is apparent. The system allows for the greatest height and the most floor area. This structural form was used in the Sears Tower in Chicago. In this system, introduction of the internal webs greatly reduces the shear lag in the flanges. Hence, their columns are more evenly stressed than in the single tube structure and their contribution to the lateral stiffness is greater.

- The concept allows for wider column spacing in the tubular walls than would be possible with only the exterior frame tube form.
- The spacing which make it possible to place interior frame lines without seriously compromising interior space planning.
- The ability to modulate the cells vertically can create a powerful vocabulary for a variety of dynamic shapes therefore offers great latitude in architectural planning of a tall building.

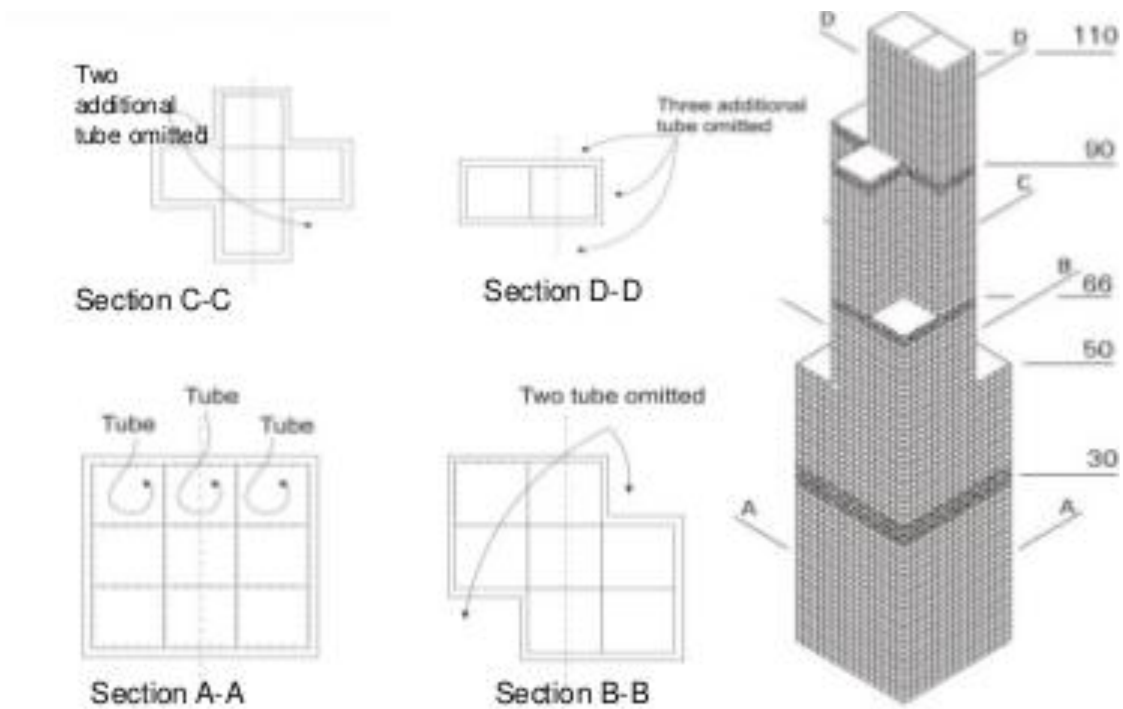

Figure 1.5 Bundled Tube structure

1.5 Objectives and Scope of Study

The object of the study is to conduct a comprehensive analysis in between four different types of reinforced concrete tubular structures. These tubular structures are analysed for four different heights (i.e., 20, 40, 60 and 80 stories). Behaviour of these different types of reinforced concrete tubular structures have been compared. The building is modelled and analysed using ETABS software. All these tubular structures considered in this study are rectangular in plan. To study the behaviour of this tubular structure, analysis is carried out and results are compared for story displacement and story drift along both lateral directions. Results of model mass participation factor and base shear are also compared.

CHAPTER 2
Literature review

2.1 Introduction

The objective of this chapter is to review various documents on behaviour of tubular structures. Lateral load effects on high rise buildings are quite significant and increase rapidly with increase in height. In high rise structures, the behaviour of the structure is greatly influenced by the type of lateral system provided and the selection of appropriate. The term structural form systems in structural engineering refer to lateral load-resisting system of a structure. The structural forms employed in the high-rise structures transfers loads through structural components which are connected with each other in an efficient manner. The commonly used structural forms can be classified into different categories, depending on the type of stresses that may arise in the structural members due to the application of loads. The selection is dependent on many aspects such as structural behaviour of the system economic feasibility and availability of materials. Few of the lateral structural systems are Shear wall system, Braced frame system, Framed tube system, Tube in tube system, Bundled tube system.

2.2 Earlier research

Panchal.N.B et al.(2014), had done a comparison study of 20-storey simple frame building and diagrid structural system building in terms of top storey displacement, storey drift, steel and concrete consumption. ETABS 9.7.4 software is adopted for modelling analysis and design of diagrid structure and simple frame building. The gravity load , earth quake load and wind load are assigned to both structure with all load combinations. Analysis and design of beam, column and diagonal members is carried out as per IS: 456-2000. The compressive strength of concrete is 40 N/mm2 and for steel 415 N/mm2 is considered. The beam and column sizes are preliminary decided for both the building. Then after analysis the sizes are changed to prevent the failure and excessive top storey displacement.

From the analysis it was concluded that the top storey displacement is very much less in diagrid structure as compared to the simple frame building. The storey drift and storey shear is very much less for diagrid structural system. Diagrid building system are more effective as compared to simple frame structure.

Sarath.B.N et al.(2015), studied that, significant effects of lateral load on high rise buildings. The lateral structural systems give the structure the stiffness, which would considerably decrease the lateral displacements. A Plain frame system, a Shear wall system and Framed tube system for 30, 40, 50 and 60 story structures were considered for analysis. The analysis had been carried out using software Etabs. The roof displacements, internal forces (Support Reactions, Bending Moments and Shear Forced) of members and joint displacements were studied and compared. It was seen that the Shear wall system is very much effective in resisting lateral loads for the structures up to 30 stories and for structures beyond 30 stories the Framed tube system is very much effective than Shear wall system in resisting lateral loads.

Paulino.M.R et al.(2010), attempted to study techniques for preliminary analysis of various tall building systems subjected to lateral loads. He had presented three computer programs in Matlab graphical user interface language for use on any personal computer. Two of these programs incorporate interactive graphics. A program called Wall_Frame_2D was introduced for two-dimensional analysis of shear wall-frame interactive structures, using the shear-flexural cantilever analogy. The rigid outrigger approach was utilized to develop a program called

Outrigger Program to analyze multi-outrigger braced tall buildings. In addition, a program called Frame Tube was developed which allows analysis of single and quad-bundled framed tube structures. The tube grids were replaced with an equivalent orthotropic plate, and the governing differential equations were solved in closed form. Results for lateral deflections, rotations, and moment, shear, and torque distributions within the various resisting elements were compared against other preliminary and "exact" matrix analysis methods for several examples. SAP2000 was used to obtain "exact" results. The approximate analyses were found to give reasonable results and a fairly good indication of the behaviour of the actual structure. These programs were proposed for inclusion in a knowledge-based approach to preliminary tall building design. The tall building design process was outlined and criteria were given for the incorporation of these "Resource Level Knowledge Modules" into an integrated tall building design system.

Patil.S.Rao et al.(2015) studied effect of shear lag phenomenon considering axial force under the action of lateral loading. They studied the non-dimensional structural parameters governing shear lag phenomenon with the help of review of literature on various journal papers and concluded that several attempts have been made to explain the shear lag anomaly but the existing studies lack a more general and physical explanation on the origin of negative shear lag. Also not much studies have been attempted to describe the positive shear lag and variation of shear lag effect along a tubular (hollow) structure.

CHAPTER 3
Seismic Evaluation Methods

3.1 Introduction

Determination of earthquake demands on the structure is one of the challenging jobs in the field of structural engineering. Lot of research is carried out in this area to propose simplified methods that will predict results with reasonable accuracy. It was found that except detailed non linear time history analysis, the available methods have limited areas of the application and cannot be used for all type of buildings. The seismic analyses methods so far used in estimating the demand on the structure can be classified in the following four groups

1) Linear Static Analysis

2) Linear Dynamic Analysis

3) Nonlinear Static Analysis

4) Nonlinear Dynamic Analysis.

It is seen from the basics of the Structural Dynamics that the response of the structure can be estimated as the sum of modal responses. For majority of the structures, consideration of first three or four modal contributions yields sufficiently accurate results. This forms the basis for all the above mentioned analysis procedures.

3.2 Linear static method

The linear static method also known as Equivalent Static Method is used to estimate the demand for the buildings whose response is particularly dominated by the first mode and expected to behave in elastic range.

In this method the lateral loads are calculated based on the fundamental period of the structural and applied on the design centre of mass at every floor level and the demands are estimated. The magnitude of these pseudo lateral loads has been selected with the intention that when applied to the linearly elastic model of the building, it will result in design displacement expected during the design earthquake.

If the building responds elastically to the design earthquake, the calculated internal forces will be reasonable approximation of those expected during the design earthquake. If the building responds in elastically to the design earthquake as is quite common in most of the cases, the actual internal forces that would develop in the yielding building will be less than the internal forces calculated using the pseudo lateral load. To take these inelasticity account the Response reduction factor (R) is used to calculate the reduced forces. IS1893:2002 uses the empirical formulae to estimate the fundamental time period of the structure. It is used for spectral acceleration determination from the response spectrum, which in turn is used for the calculation of Base shear modified by some coefficient. Then this base shear is distributed in the parabolic fashion along the height of building. The effect of the torsion is taken into consideration by calculating the design centre of mass by means of design eccentricity. Design eccentricity is the sum of the actual eccentricity (distance between centre of mass and centre of rigidity at floor level) and accidental eccentricity (5% of the horizontal dimension at the given floor level measured perpendicular to the direction of the applied load). For two dimensional modelling the design forces are suitably increased to account for torsion.

3.3 Linear Dynamic Method

For the building whose response is dominated by more than one mode, the Linear Dynamic Method is used to estimate the demand of the structure. There are two ways to carry out the Linear Dynamic Analysis.

A) Response Spectrum Method

B) Time History Method

3.3.1 Response Spectrum Method

In this method the load vectors are calculated corresponding to predefined number of modes. These load vectors are applied at the design centre of mass to calculate the respective modal responses. These modal responses are then combined according to SRSS or CQC rule to get the total response. From the fundamentals of dynamics it is quite clear that modal response of the structure subjected to particular ground motion, is estimated by the combination of the results of static analysis of the structures subjected to corresponding modal load vector and dynamic analysis of the corresponding single degree of freedom system subjected to same ground motion. Static response of MDOF system is then multiplied with the spectral ordinate obtained from dynamic analysis of SDOF system to get that modal response. Same procedure is carried out for other modes and the results are obtained through SRSS or CQC rule. In response spectrum analysis the spectral values are read from the design spectrum which are directly multiplied with the modal load vector and the static analysis is performed to determine the corresponding modal peak responses. This method is known as the CLASSICAL MODAL ANALYSIS.

3.3.2 Time History Analysis (Response History Analysis)

Dynamic analysis using the time history analysis calculates the building responses at discrete time steps using discretized record of synthetic time history as base motion. If three or more time history analyses are performed, only the maximum responses of the parameter of interest are selected.

3.4 Non-linear Static Method

This can be defined as the procedure in which the structure (taking into account the material nonlinearity) is pushed till collapse to generate the pushover curve, which is then used to estimate the target displacement at which the response quantity is extracted from the deformed modal.

3.5 Pushover analysis

This Pushover methodology is developed by Chopra et al (2002).This method takes into account the higher mode effect for the seismic evaluation of structures. The method consist in application of invariant modal lateral load pattern to the structure, performing pushover analysis, determining target displacement from the proposed force displacement relationship of Equivalent Single Degree of Freedom System (ESDF) system and extracting the demands at that target displacement. Similar steps are carried out for other mode and modal responses are then combined according to the SRSS modal combination rule.

Approximate method of Ramirez et al 2001

Base shear strength of frame Vy, defined as the base shear at the collapse stage, can be derived as,

$$V_y = \frac{1}{\sum_{i=1}^{N} \lambda i.hi}[(n+1)Mpc + 2n.\sum_{i=1}^{N}(Mpbi.xi)]$$

Where

Mpc= plastic moment at base of first-storey column

Mpbi= plastic moment of beam at level i

N= number of stories

Hi =height of level i above the hinge at the base of the structure

λi= a force distribution factor that depends on the lateral force patterns(first mode ,modal uniform, etc) utilized to push over the structure.

$$Xi = \frac{1}{1-2\propto i}$$

Where $\propto i$ =ebp/Lb=length factor for beam hinge location at level I,

epb being the distance of hinge from the beam end and Lb the beam length

assuming a patterns of load proportion to the first mode of the frame under elastic condition λiis calculated as

$$\lambda i = \frac{Wi\phi 1}{\sum_{m=1}^{N} Wi\phi 1}$$

Fundamental period of the building under elastic condition , T1 as the yield displacement can be obtained from the relation between the base shear strength, Vy, and the

$$Dy = \left(\frac{g}{4\pi 2}\right) T_1 \left(\frac{Vy}{W1}\right) . T_1^{\ 2}$$

Where

$$T_1 = \frac{W_1}{\sum_{m=1}^{N} W_m \o_{m1}}$$

Is the modal participation factor and the first modal weight

$$W_1 = \frac{\left(\sum_{i=1}^{N} W_i \o_{i1}\right)^2}{\sum_{i=1}^{N} W_i \o_{i1}^{\ 2}}$$

3.6 Non-linear Dynamic Analysis

This is the most accurate method to determine the seismic responses of structures. In this method the structure is subjected to actual ground motion which is the representation of the ground acceleration vs time. The ground acceleration is determined at small time step to give the ground motion record. Then the structure response is calculated at every time instant, to know its time history and the peak value from this time history is chosen to be the design demand. Hence "a Mathematical model directly incorporating the nonlinear characteristic of individual component and element of the building shall be subjected to earthquake shaking represented by ground by ground motion time history to obtain forces and the displacement"(FEMA 356). Since numerical model directly accounts for the effect of material nonlinearity, inelastic responses and calculated internal forces will be reasonably approximate to those expected during the design earthquake.

There are two methods by which the time history analysis is carried out

1) Nonlinear Modal Time History Analysis.

2) Nonlinear Direct Integration Time History Analysis

CHAPTER-4

Analysis of Different Types of Reinforced Concrete Tubular Structure

4.1 General

This chapter covers the details & description of four different types reinforced concrete tubular structure to be analyzed. These different types of tubular structure are analysed and checked as per the IS 456:2000 specifications in ETAB software.

4.2 Object of study

In this report, efforts have been made to explain the behaviour of four different types of reinforced concrete tubular structures. These tubular structures are analyzed using ETAB Software. These structures are analysed for four different heights (i.e., 20, 40, 60 and 80 stories). Behaviour of all the four types of reinforced concrete tubular structures for four different heights has been compared. Limit state method is considered for the analysis. All these tubular structures considered in this study are rectangular in plan. To study the behaviour of this tubular structure, analysis is carried out and results are compared for story displacement and story drift along both lateral directions. Results of model mass participation factor, story shear and base shear are also compared

4.3 Problem description

Four different types of reinforced concrete tubular structures are considered for the analysis purpose. The buildings are considered in Delhi, Zone-IV, with six bay in the longitudinal direction and three bay in transverse direction, in the present study. Centre-to-centre distance between columns is 4 m in both perpendicular directions. The dimensions of proposed building are 24 m x 48 m in plan. The floor-to-floor height of the super structure is 3.2m for each floor. These buildings are having 0.23m thick external and internal walls of brick masonry. These buildings are having 4 staircase/lift shafts also. Thickness of RCC slabs are 125mm. Live load considered on each floor is 4 kN/m² and live load on terrace is 1.5 kN/m². For concrete, the modulus of elasticity is taken as that recommended by IS456, that is, $5000\sqrt{\boldsymbol{fck}}$Mpa where fck is 28-day characteristic cube strength in MPA. The building is modelled in ETABS software, for analysis.

4.4 Models

A comparative study has been done between four different types of reinforced concrete tubular structures. These structures are analysed for four different heights (i.e., 20, 40, 60 and 80 stories). For this purpose 16 models have been prepared (i.e., each of these four types of tubular structure with four different heights). Comparison between the results of these 16 models has been done in four different sets (i.e., on the basis of no. of story) as follows:

Set-I: The four different Tubular structures with 20 story height

Set-II: The four different Tubular structures with 40 story height

Set-III: The four different Tubular structures with 60 story height

Set-IV: The four different Tubular structures with 80 story height

4.5 Description of Models

Table: 4.1 Sectional properties for different structural R/C members of framed tube structure

DISCRIPTION	SET-1 20 STORY	SET-2 40 STORY	SET-3 60 STORY	SET-4 80 STORY
Secondary beam	300 x 450	300 x 450	300 x 450	300 x 450
Main beam	400 x 550	400 x550	400 x 550	400 x550
Outer peripheral beam	600 x 850	750 x 1000	800 x1250	1000 X 1500
Bracing beam	300 x 600	300 x 600	300 x 600	300 X 600
Slab	125	125	125	125
Wall	250	350	400	450
Outer/peripheral column	850 x 500	1000 x 650	1300 x 750	2500 X 1000
Interior column	850 x 850	1000 x 1000	1200 x 1200	1500 X 1500
Grade of concrete for column and wall	M40	M40	M40	M40
Grade of concrete for beams and slab	M30	M30	M30	M30

Grade of steel	Fe 500	Fe 500	Fe 500	Fe 500

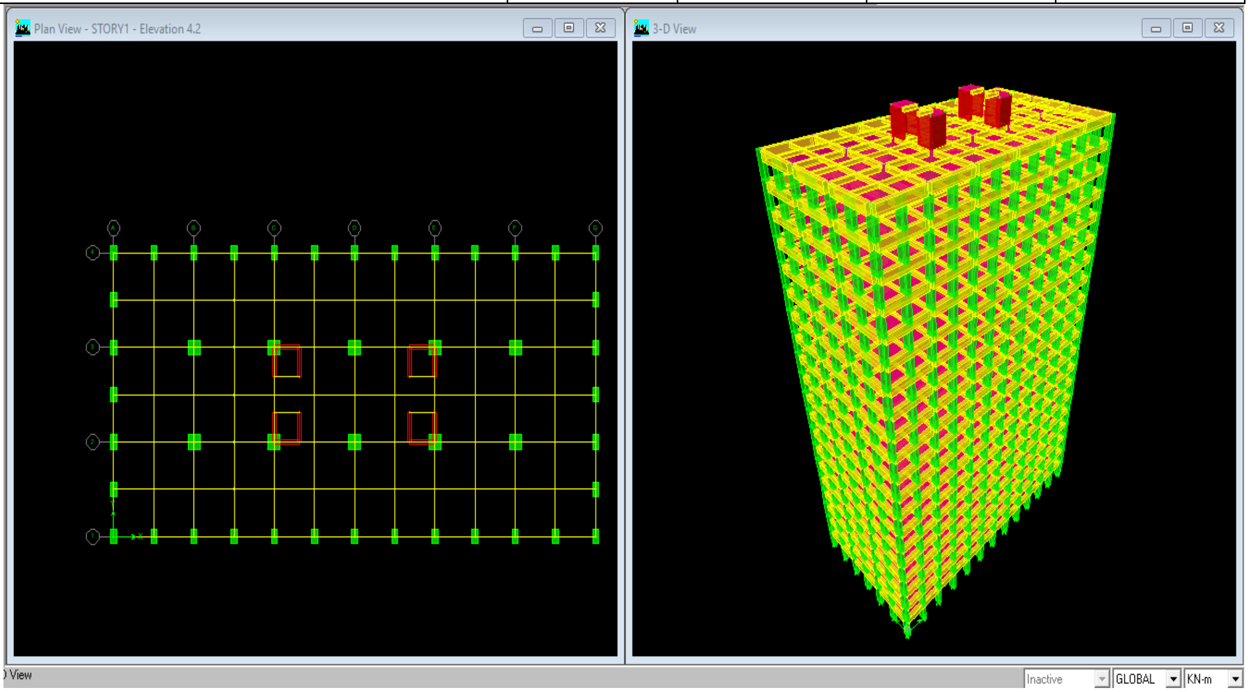

Fig-4.1: Plan view and 3-D view of 20 storied Framed Tube structure building

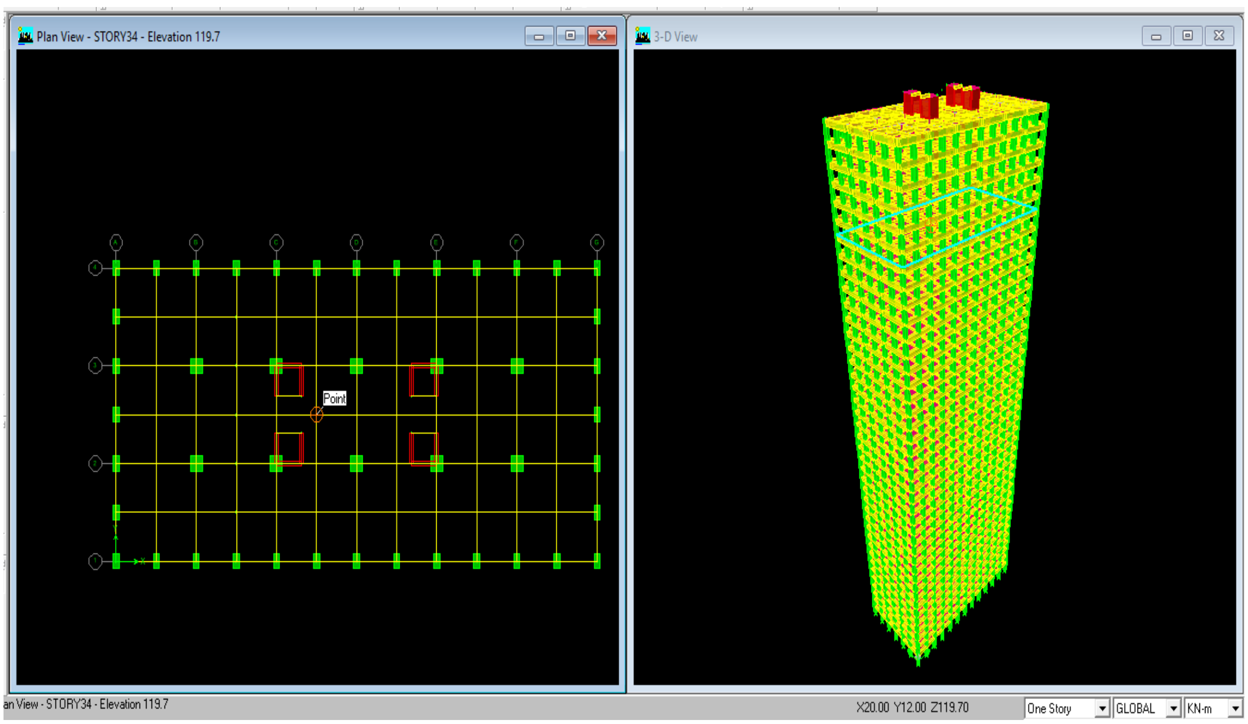

Fig-4.2: Plan view and 3-D view of 40 storied Framed Tube structure building

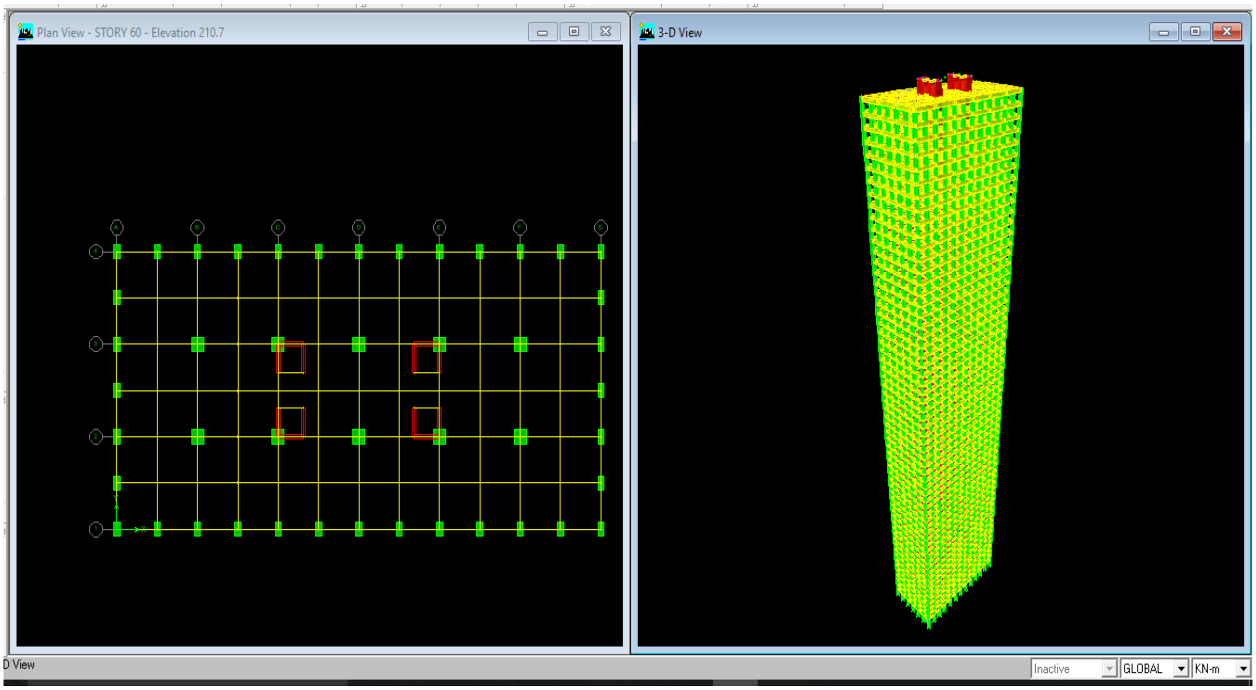

Fig-4.3: Plan view and 3-D view of 60 storied Framed Tube structure building

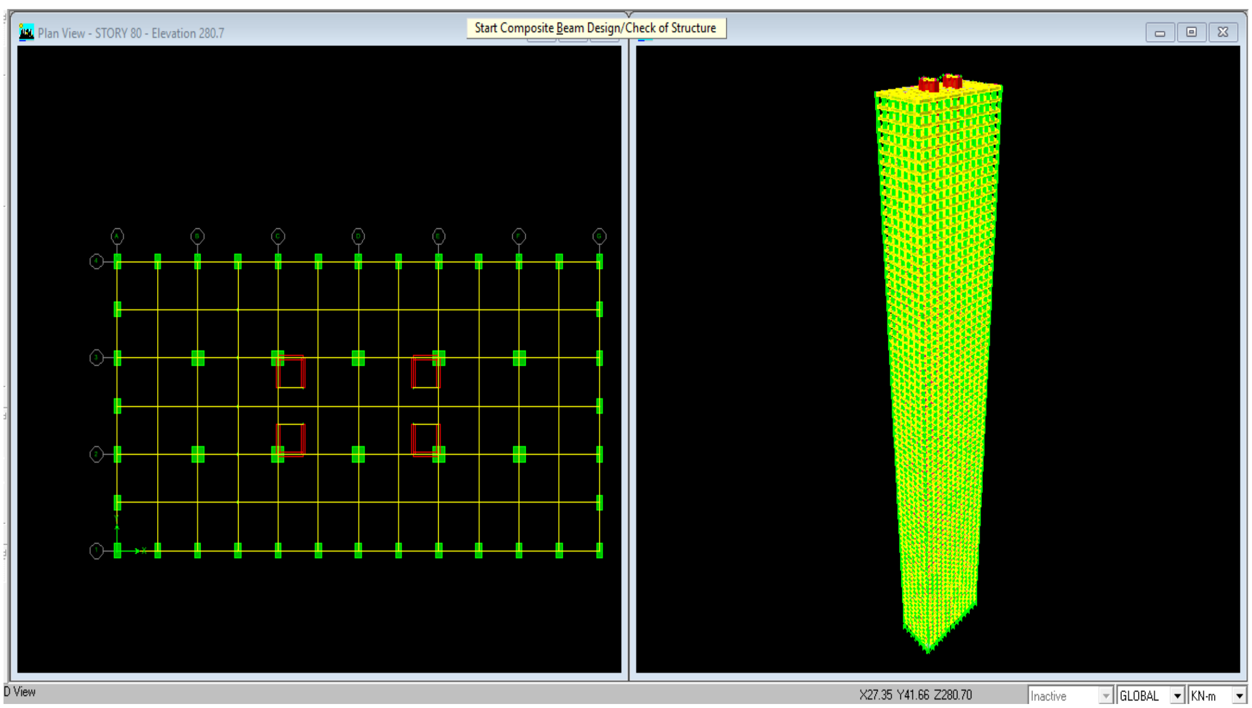

Fig-4.4: Plan view and 3-D view of 80 storied Framed Tube structure building

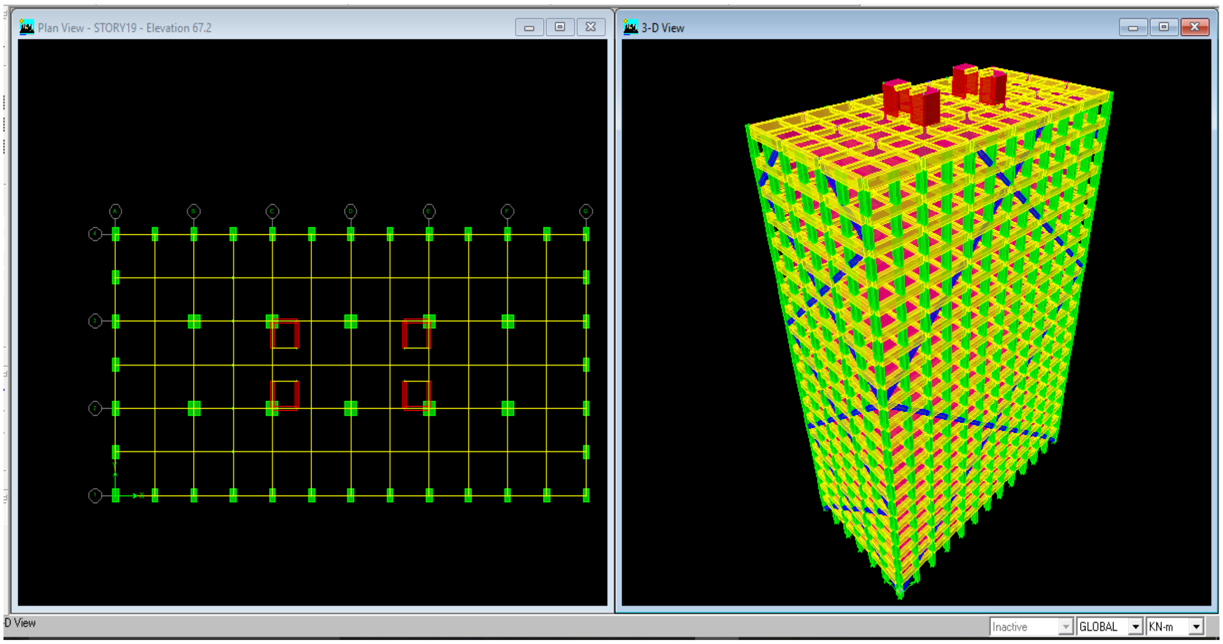

Fig-4.5: Plan view and 3-D view of 20 storied Braced Tube structure building

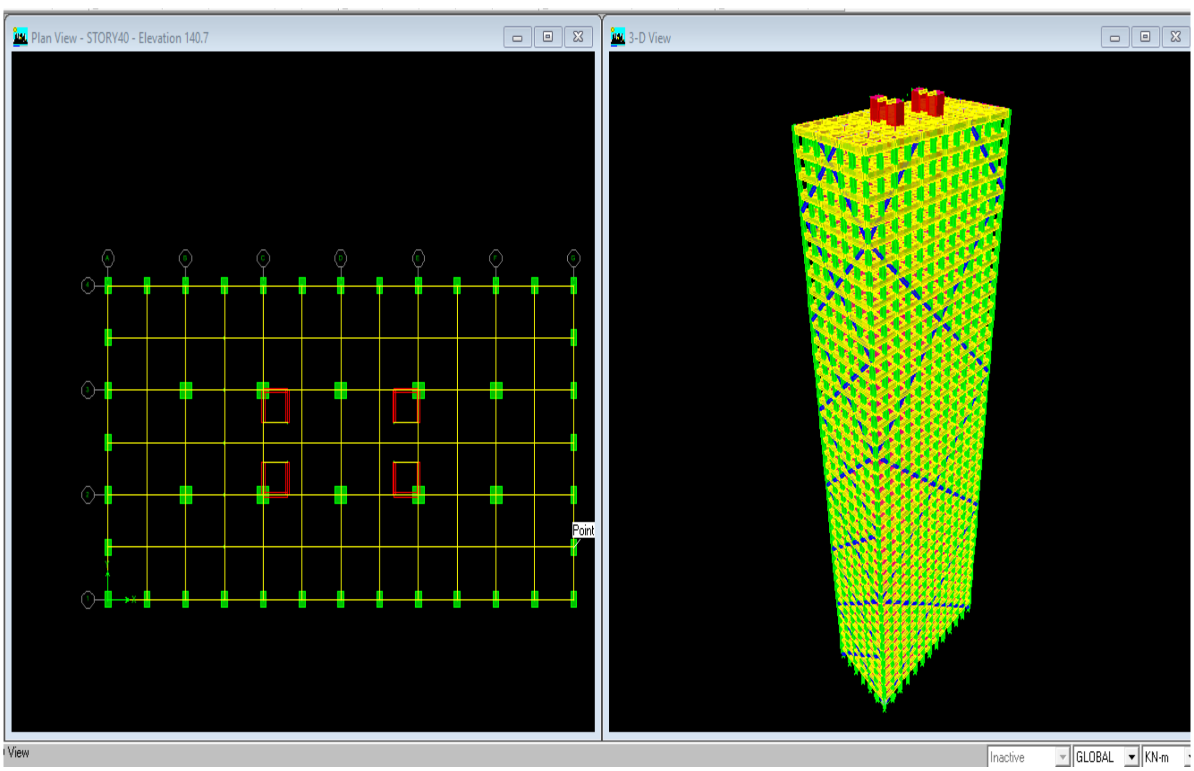

Fig-4.6: Plan view and 3-D view of 40 storied Braced Tube structure building

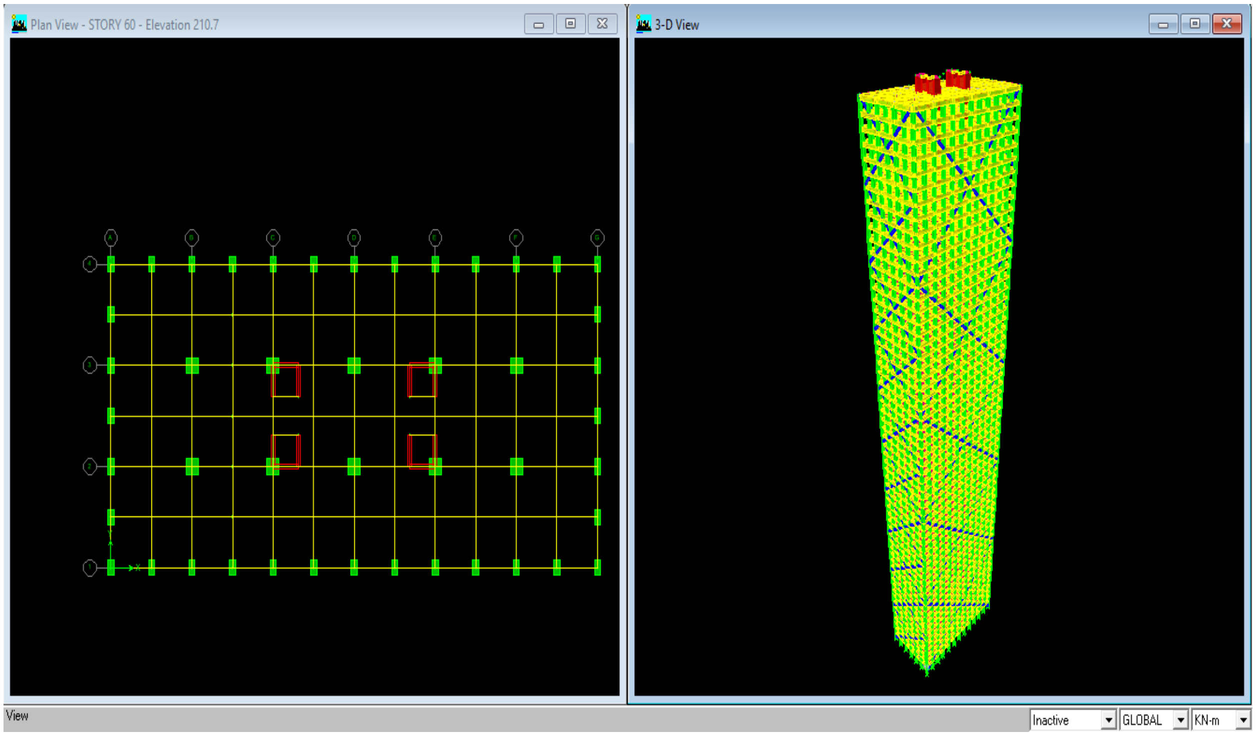

Fig-4.7: Plan view and 3-D view of 60 storied Braced Tube structure building

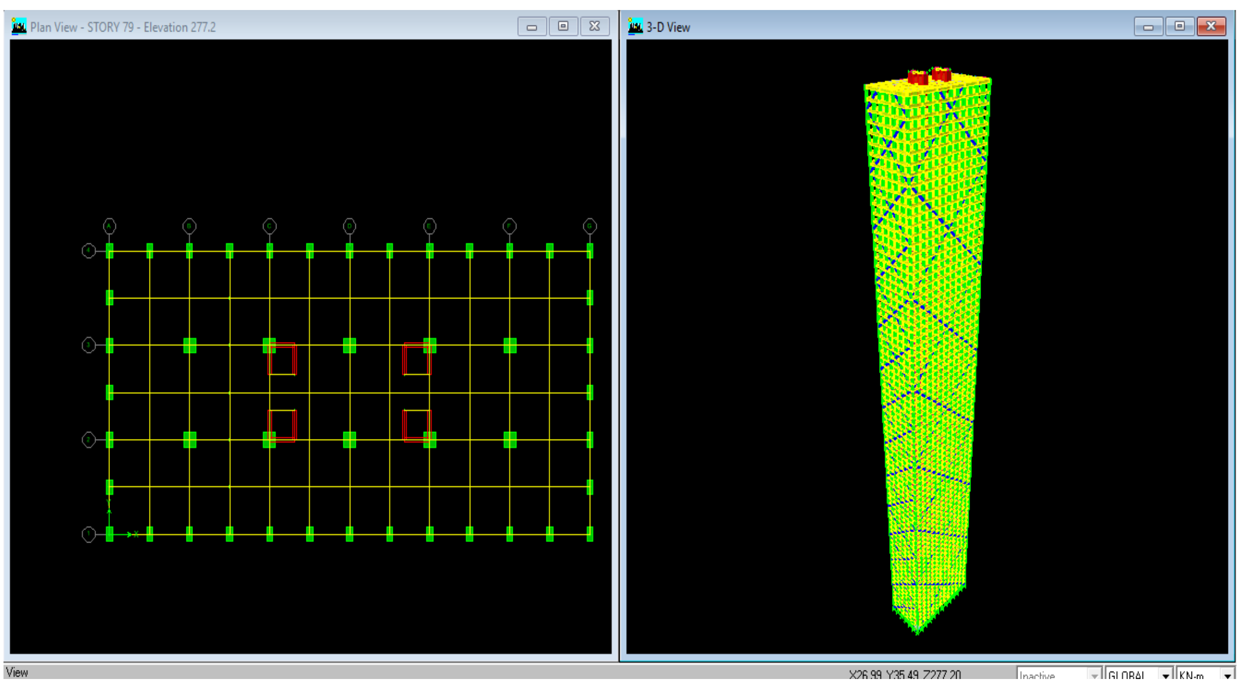

Fig-4.8: Plan view and 3-D view of 80 storied Braced Tube structure building

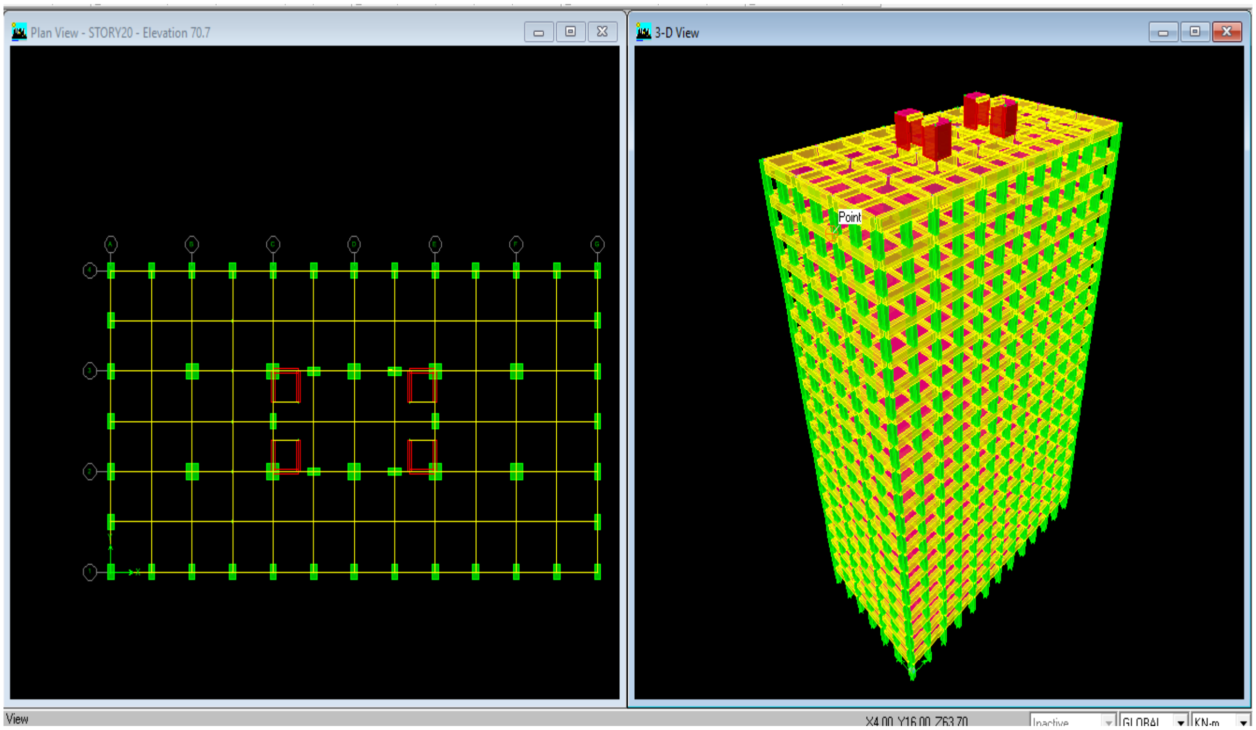

Fig-4.9: Plan view and 3-D view of 20 storied Tube-in-Tube structure building

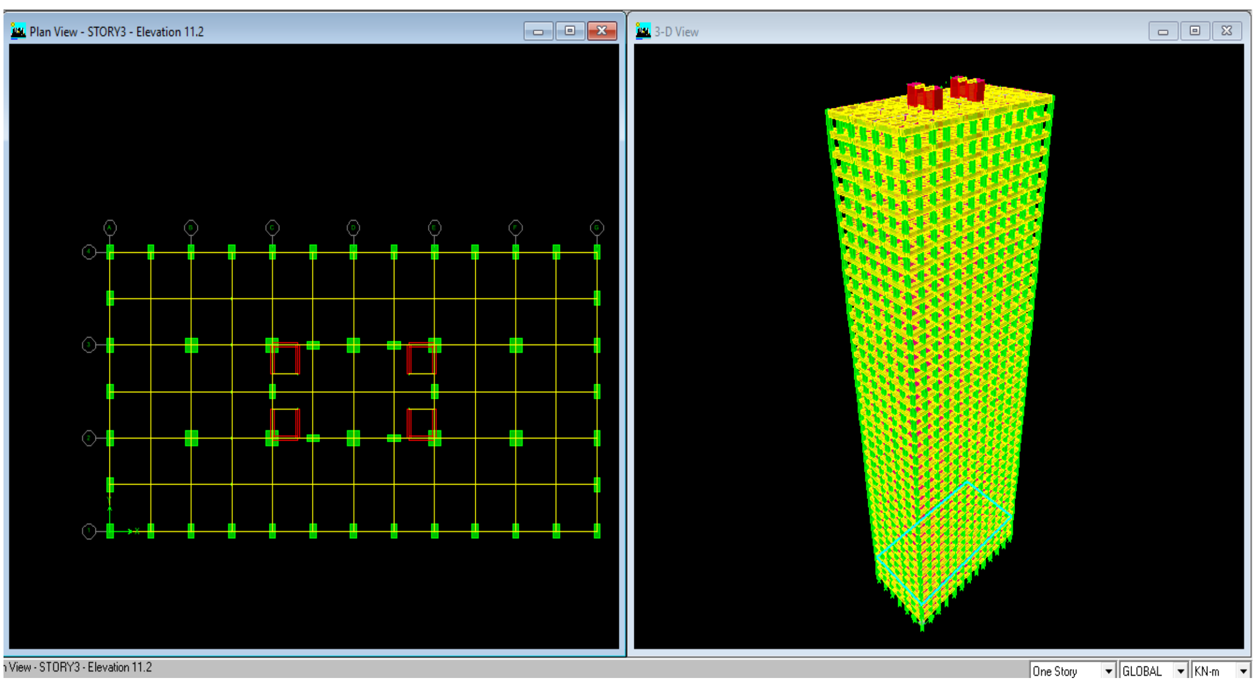

Fig-4.10: Plan view and 3-D view of 40 storied Tube-in-Tube structure building

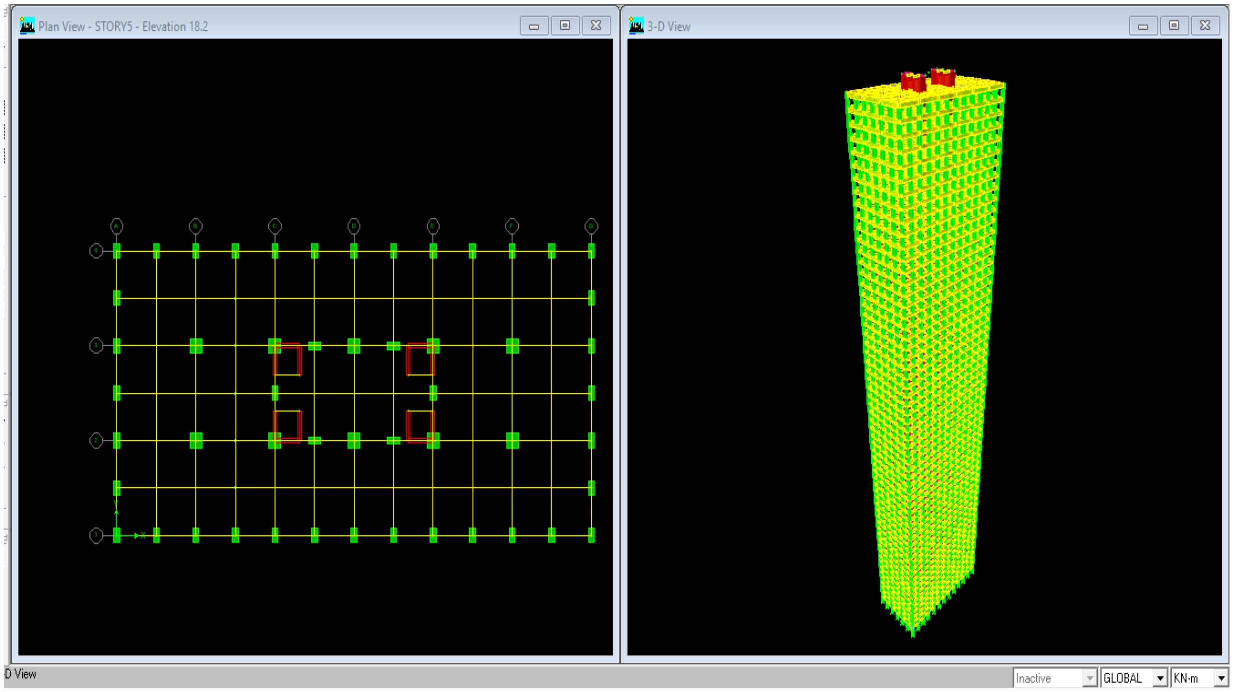

Fig-4.11: Plan view and 3-D view of 60 storied Tube-in-Tube structure building

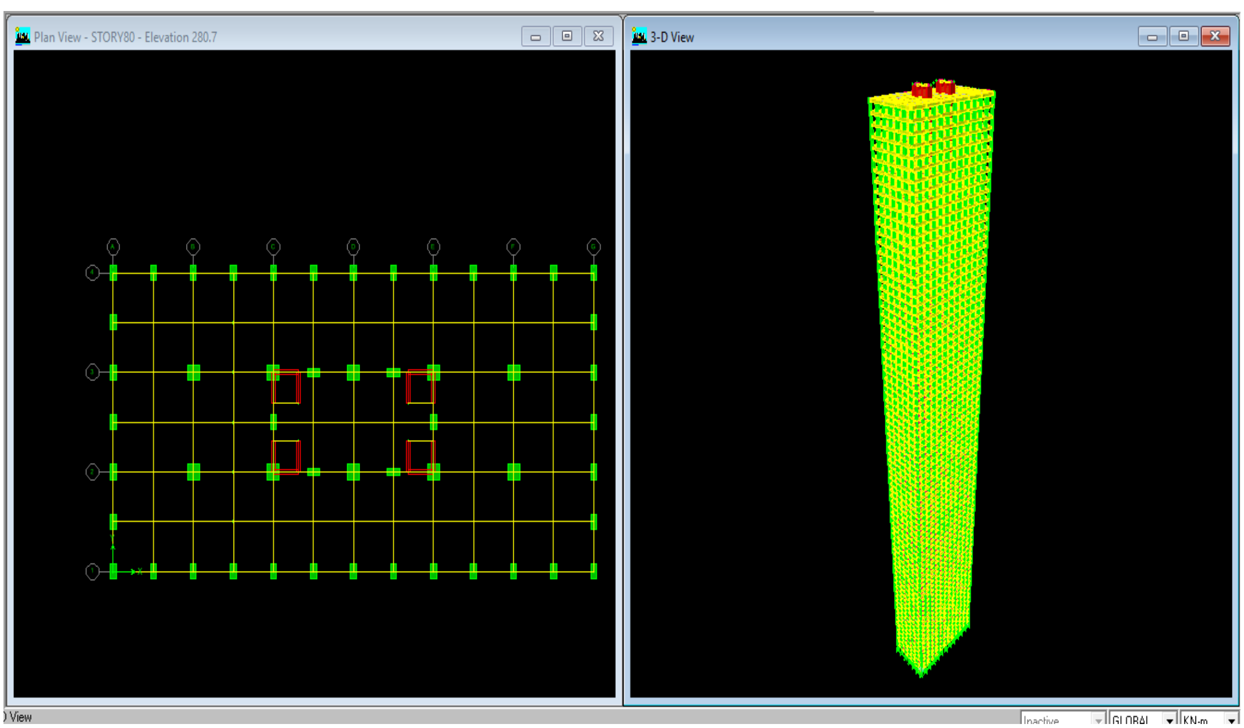

Fig-4.12: Plan view and 3-D view of 80 storied Tube-in-Tube structure building

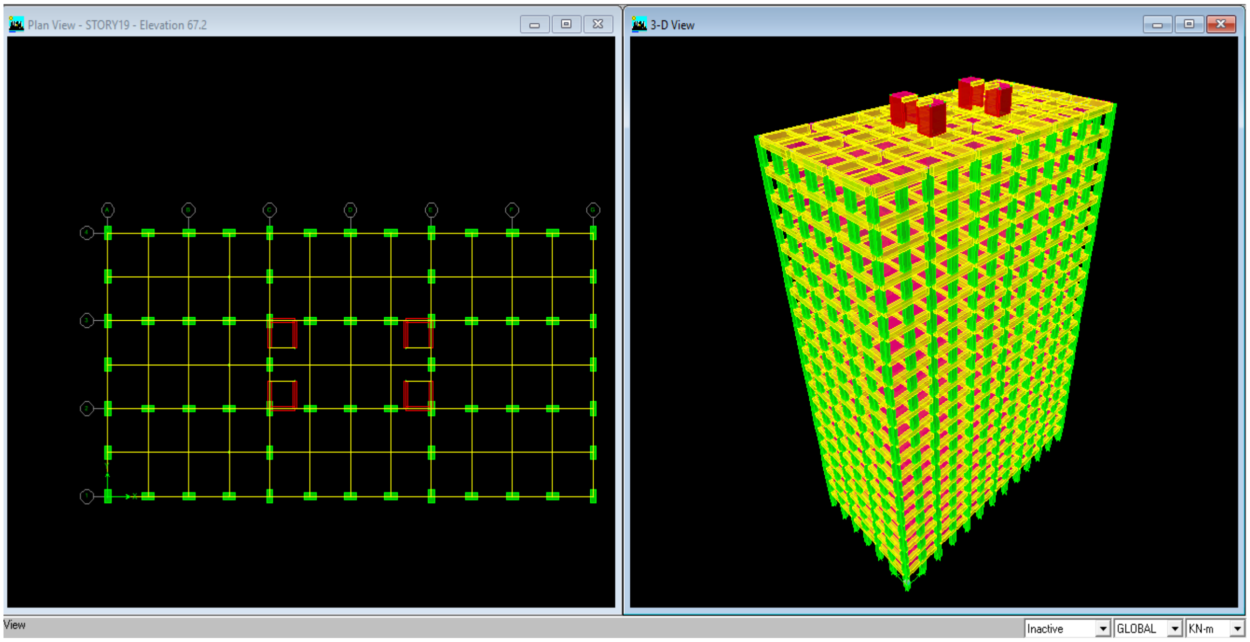

Fig-4.13: Plan view and 3-D view of 20 storied Bundled Tube structure building

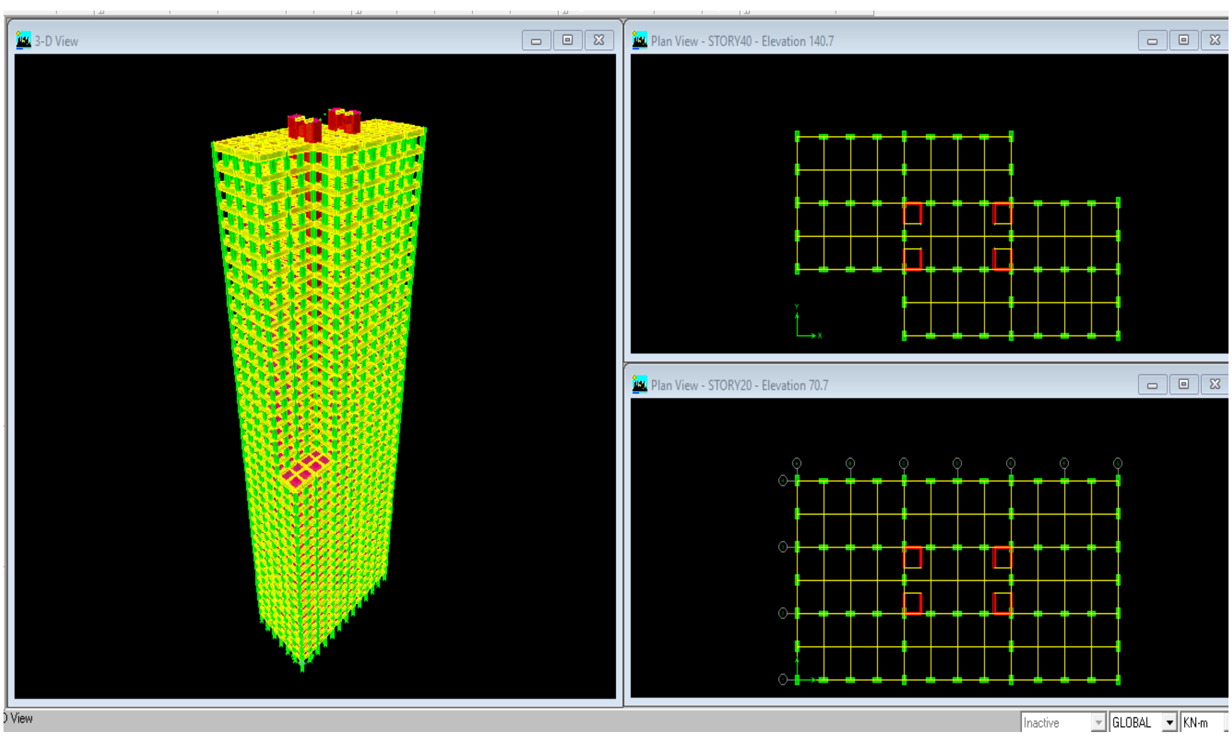

Fig-4.14: Plan view and 3-D view of 40 storied Bundled Tube structure building

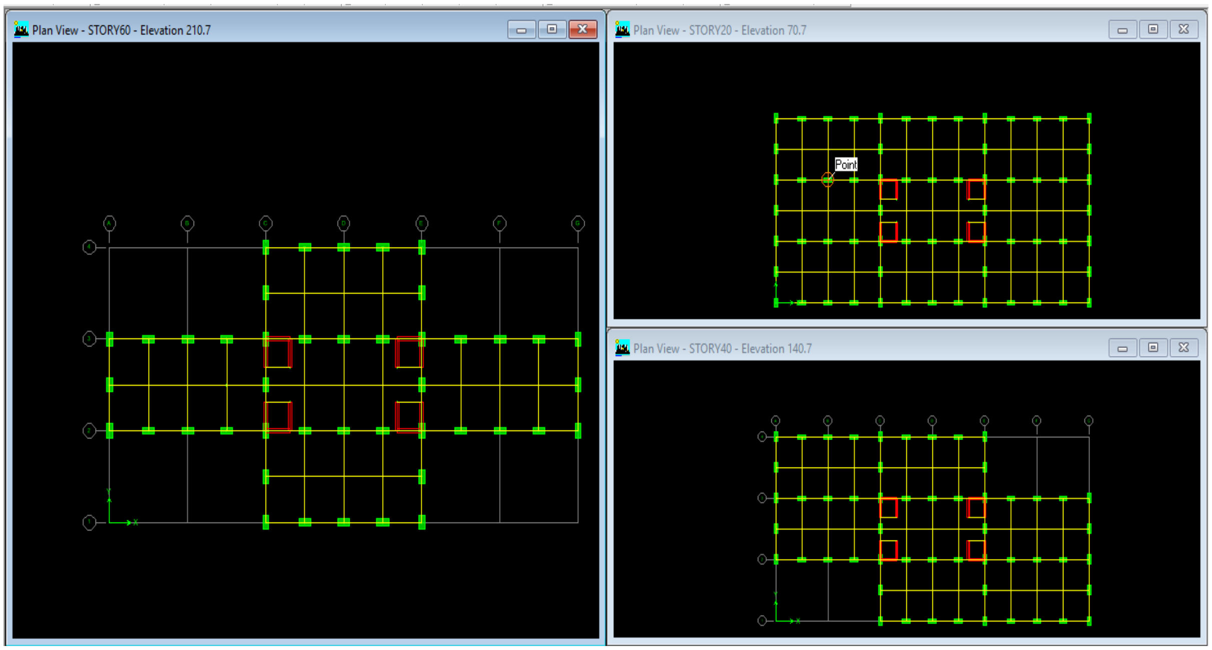

Fig-4.15(a): Plan view of 60 storied Bundled Tube structure building

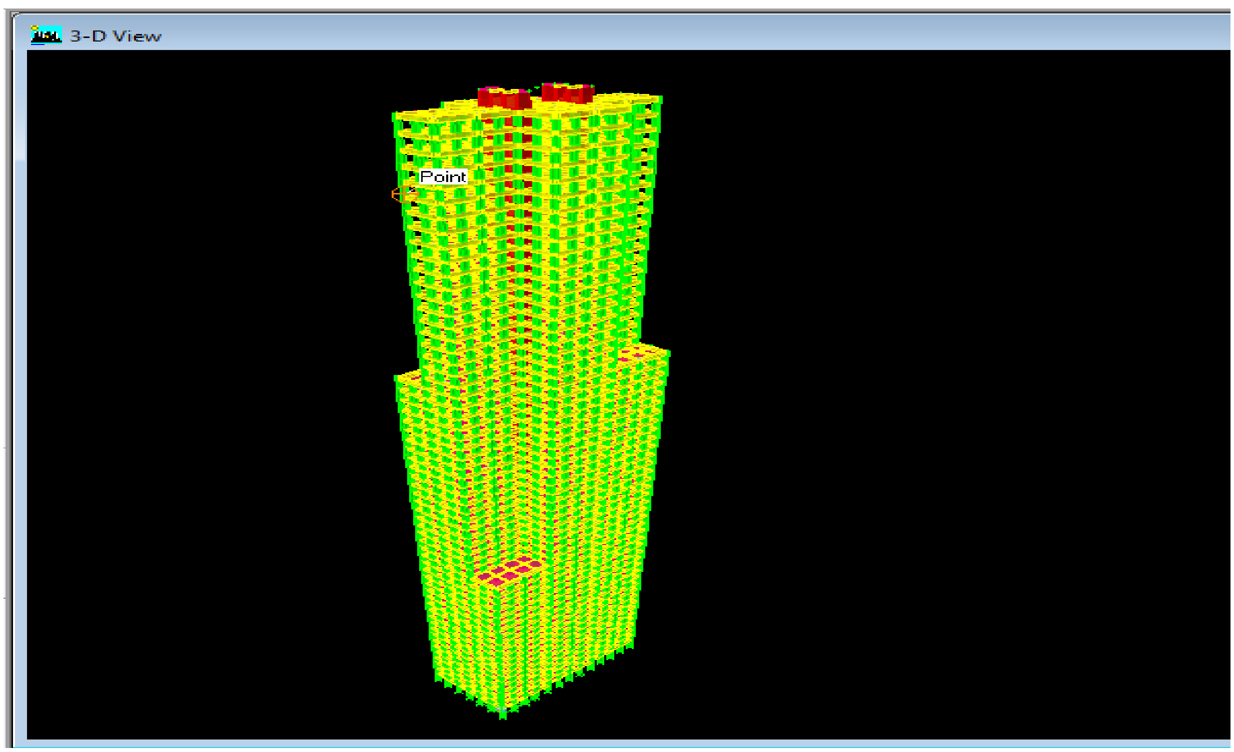

Fig-4.15(b): 3-D view of 60 storied Bundled Tube structure building

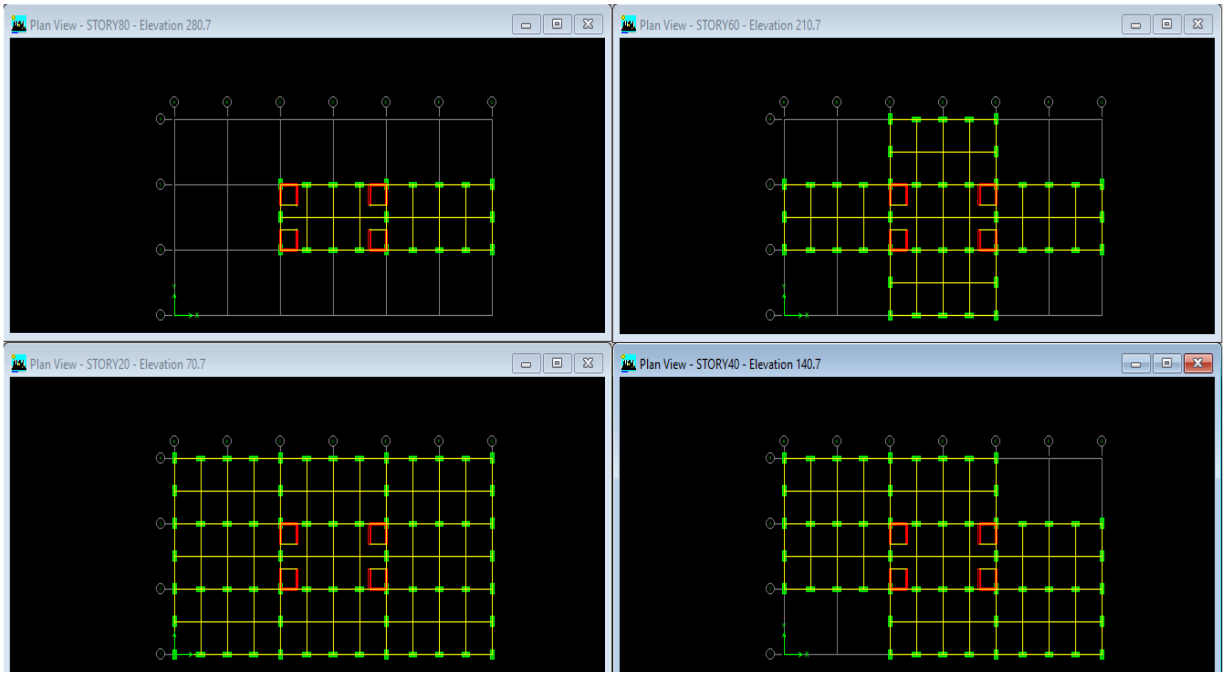

Fig-4.16(a): Plan view of 80 storied Bundled Tube structure building

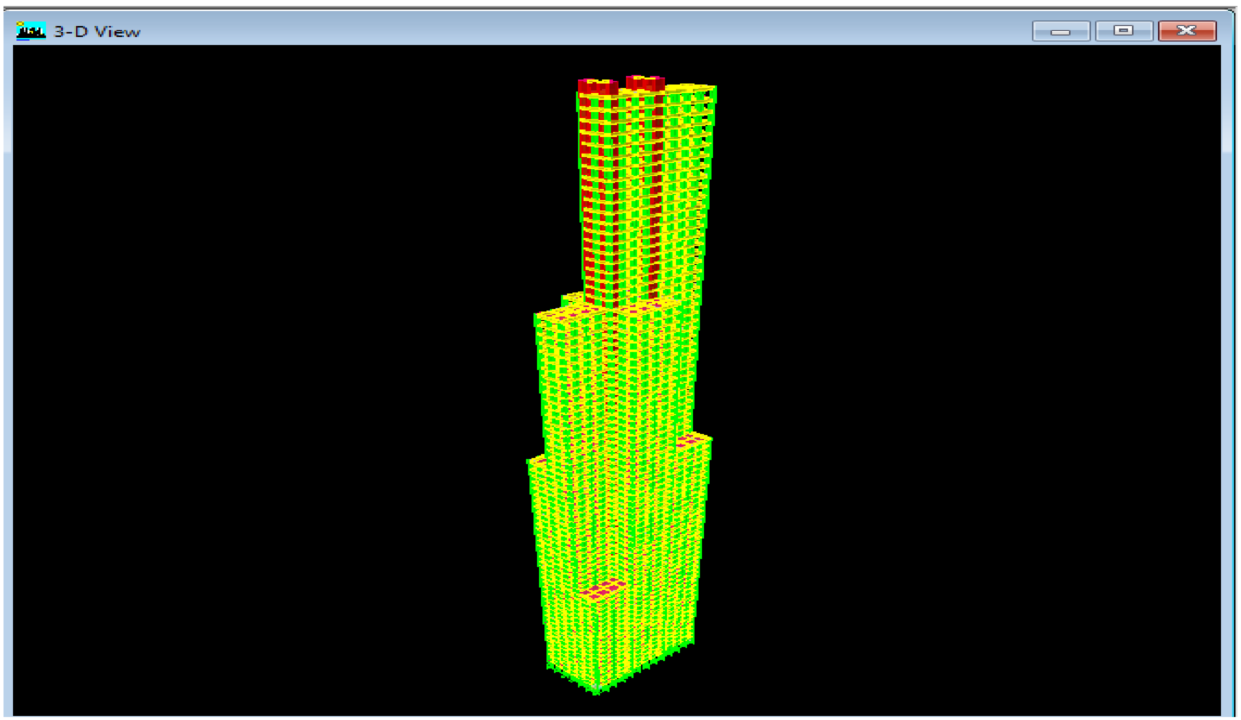

Fig-4.16(b): 3-D view of 80 storied Bundled Tube structure building

4.4 Load combinations for analysis

Limit state design method is used for the analysis and design of the building. As per IS 875 (part-5), these load combinations have been considered.

(1). Set of load combinations considering earthquake effect:

Earthquake load combinations have been considered as per Clause-6.3.1.2 of IS 1893(part-1): 2002. These are as follows:

1. 1.0 (Dead Load) + (k) (Live load)
2. 1.5 (Dead Load + seismic force in x-direction)
3. 1.5 (Dead Load + seismic force in y-direction)
4. 1.5 (Dead Load - seismic force in x-direction)
5. 1.5 (Dead Load - seismic force in y-direction)
6. 1.2 (Dead Load+ (k)Live load + seismic force in x-direction)
7. 1.2 (Dead Load+ (k)Live load + seismic force in y-direction)
8. 1.2 (Dead Load+ (k)Live load - seismic force in x-direction)
9. 1.2 (Dead Load+ (k)Live load - seismic force in y-direction)
10. 0.9 (Dead Load) + 1.5 (seismic force in x-direction)
11. 0.9 (Dead Load) + 1.5 (seismic force in y-direction)
12. 0.9 (Dead Load) - 1.5 (seismic force in x-direction)
13. 0.9 (Dead Load) - 1.5 (seismic force in y-direction)

Note: Where, $k = 0.25$ (if live load ≤ 3 kN/m^2); $k = 0.5$ (if live load > 3 kN/m^2)

(2). Set of load combinations considering Wind load effect:

These are as follows:

1. 1.0 (Dead Load) + 1.0 (Live load)
2. 1.5 (Dead Load + wind force in x-direction)
3. 1.5 (Dead Load + wind force in y-direction)
4. 1.5 (Dead Load - wind force in x-direction)
5. 1.5 (Dead Load - wind force in y-direction)
6. 1.2 (Dead Load+ Live load + wind force in x-direction)
7. 1.2 (Dead Load+ Live load + wind force in y-direction)
8. 1.2 (Dead Load+ Live load - wind force in x-direction)
9. 1.2 (Dead Load+ Live load - wind force in y-direction)
10. 0.9 (Dead Load) + 1.5 (wind force in x-direction)
11. 0.9 (Dead Load) + 1.5 (wind force in y-direction)
12. 0.9 (Dead Load) - 1.5 (wind force in x-direction)
13. 0.9 (Dead Load) - 1.5 (wind force in y-direction)

CHAPTER-5

Results and Conclusion

5.0 Introduction

This chapter covers the results of analysis of all four types of reinforced concrete tubular structure, (i) Framed Tube structures, (ii) Braced Tube structures, (iii) Tube-in-Tube structures, (iv) Bundled Tube structures. These tubular structures are analyzed for four different heights (i.e., 20, 40, 60 and 80 stories). The results of max. Story displacement, story drift, model mass participation factor, story shear and base shear (in both longitudinal directions, say, X & Y directions) of all these reinforced concrete tubular structure are compared in this chapter.

This chapter is divided in four sets. Each of these sets having following five parts:

i. Results of Max. Story displacement of all four types of reinforced concrete tubular structure is compared for longitudinal directions, say, X & Y directions.

ii. Results of Story drift of all four types of reinforced concrete tubular structure is compared for both longitudinal directions, say, X & Y directions.

iii. Results of Model mass participation factor of all four types of reinforced concrete tubular structure are compared.

iv. Results of Story shear of all four types of reinforced concrete tubular structure is compared for both longitudinal directions, say, X & Y directions.

v. Comparative study of Base shears of all four types of reinforced concrete tubular structure has been done for longitudinal directions, say, X & Y directions.

5.1 Results of analysis

5.1.1 Comparison between four different Tubular structures with 20 story height

5.1.1.1 Storey Displacement: Comparison of max storey displacement between all four types of reinforced concrete tubular structure for longitudinal directions, say, X & Y directions, among 20 storey buildings.

Table: 5.1.1.1(a) Max. Story Displacement (along X direction)

MAX. STORY DISPLACEMENT (AMONG 20 STOREY BUILDINGS)					
		Displacement in X direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 20	136	75.8	104.9	63.3
2	Story 19	132.9	74.2	102.1	61.9
3	Story 18	129.2	72.3	98.8	60.3
4	Story 17	124.9	70	95.1	58.3
5	Story 16	119.9	67.4	90.9	55.9
6	Story 15	114.2	64.3	86.2	53.3
7	Story 14	107.8	60.7	81.1	50.3
8	Story 13	100.9	56.6	75.7	47.1
9	Story 12	93.4	52.1	69.8	43.7
10	Story 11	85.5	47.2	63.7	40.1
11	Story 10	77.2	42.5	57.4	36.4
12	Story 9	68.6	37.7	50.9	32.5
13	Story 8	59.9	33	44.3	28.6
14	Story 7	51	28.2	37.7	24.6
15	Story 6	42.1	23.5	31.2	20.6
16	Story 5	33.3	18.8	24.8	16.7
17	Story 4	24.9	14.3	18.6	12.8
18	Story 3	16.9	9.9	12.8	9.1
19	Story 2	9.8	5.9	7.6	5.7
20	Story 1	4	2.5	3.3	2.6
21	base	0	0	0	0.8

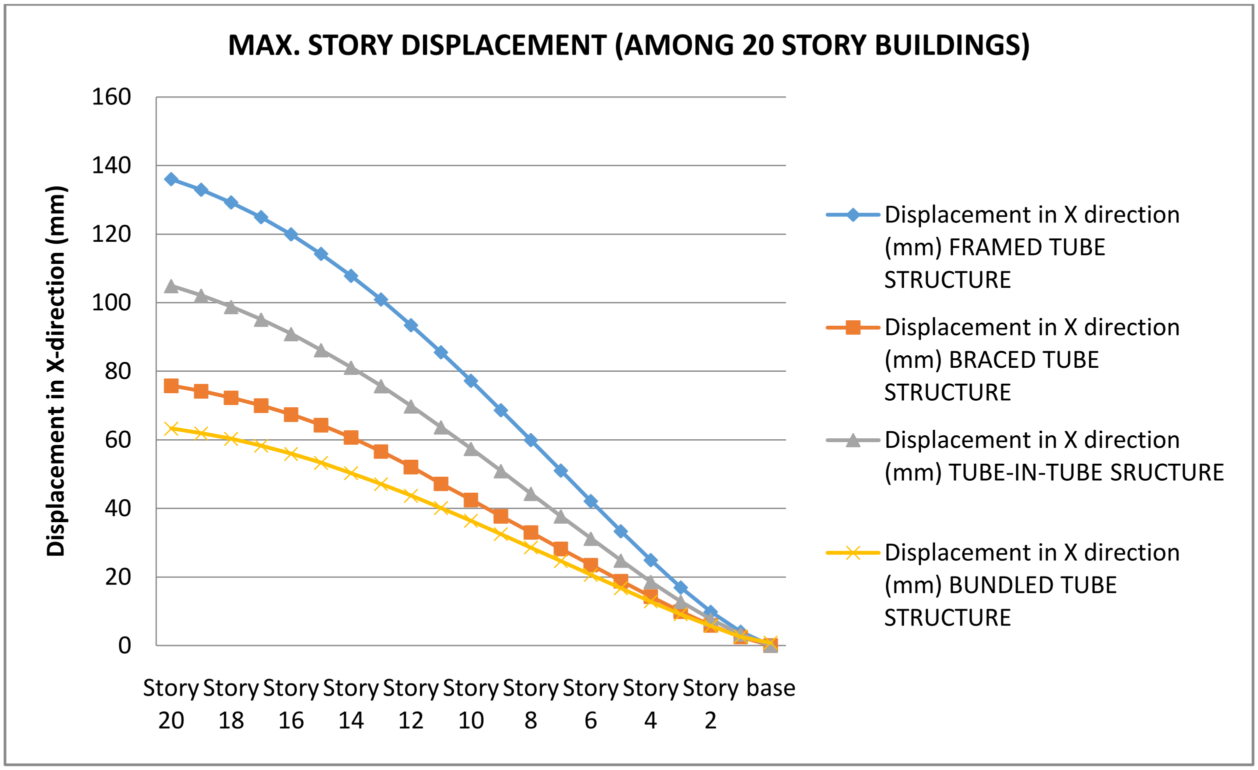

Fig-5.1.1.1(a): Max. Story Displacement in X-direction (among 20 story buildings)

Table: 5.1.1.1(b) Max. Storey Displacement (along Y direction)

MAXIMUM STORY DISPLACEMENT (AMONG 20 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Displacement in Y direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 20	119.6	74.7	94.3	65.2
2	Story 19	116.2	72.1	90.6	63.1
3	Story 18	112.5	69.2	86.6	60.8
4	Story 17	108.1	66.1	82.2	58.3
5	Story 16	103.2	62.7	77.6	55.4
6	Story 15	97.8	59.2	72.7	52.3

7	Story 14	91.8	55.4	67.5	49
8	Story 13	85.5	51.4	62.2	45.4
9	Story 12	78.8	47.2	56.7	41.8
10	Story 11	71.8	42.7	51.1	38
11	Story 10	64.6	38.3	45.5	34.1
12	Story 9	57.2	33.9	39.9	30.2
13	Story 8	49.6	29.5	34.3	26.3
14	Story 7	42.1	25	28.8	22.4
15	Story 6	34.6	20.5	23.5	18.6
16	Story 5	27.3	15.9	18.4	14.8
17	Story 4	20.1	11.6	13.6	11.2
18	Story 3	13.5	7.8	9.2	7.8
19	Story 2	7.5	4.4	5.2	4.6
20	Story 1	2.8	1.6	2	1.9
21	base	0	0	0	0

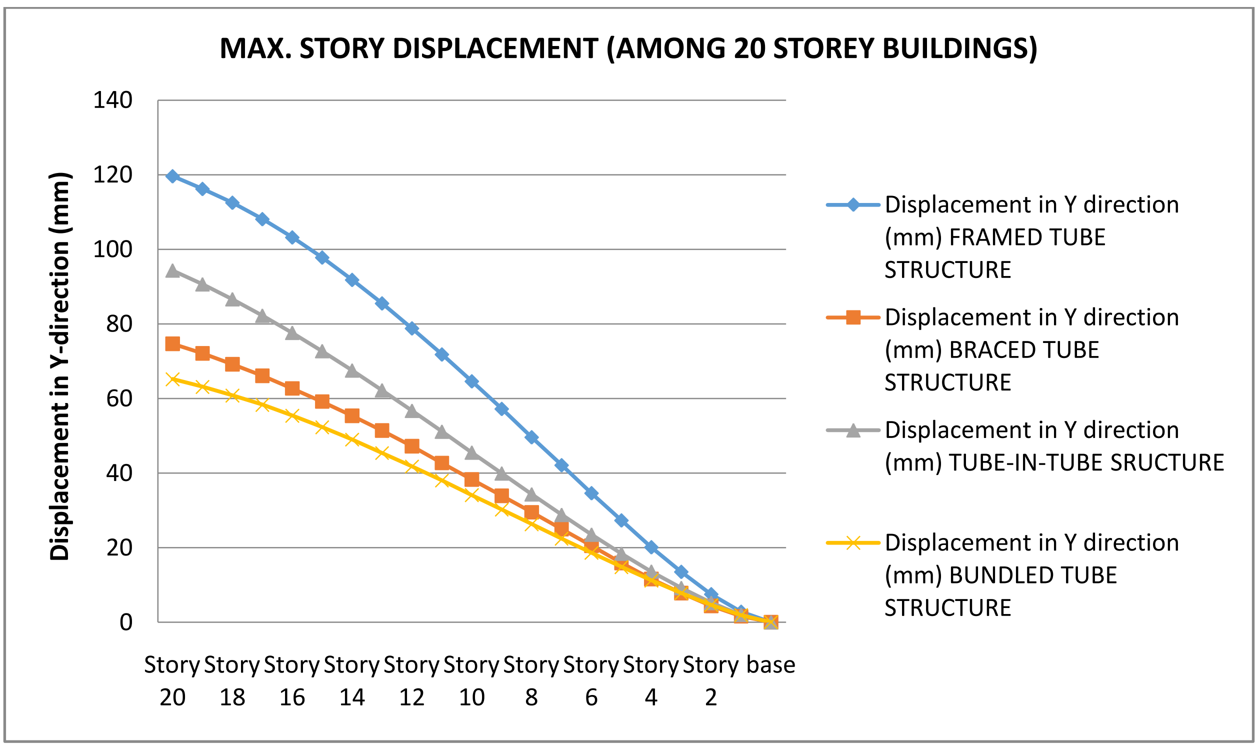

Fig-5.1.1.1(b): Max. Story Displacement in Y-direction (among 20 story buildings)

5.1.1.2 Storey Drift: Comparison of max storey drift between all four types of reinforced concrete tubular structure for longitudinal directions, say, X & Y directions, among 20 storey buildings.

Table: 5.1.1.2(a) Storey Drift (along x direction)

MAX. STORY DRIFT (AMONG 20 STOREY BUILDINGS)					
		Drift in X direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 20	0.000959	0.000459	0.000811	0.000421
2	Story 19	0.000891	0.000542	0.000927	0.000382
3	Story 18	0.001047	0.000648	0.00106	0.000475
4	Story 17	0.001234	0.000765	0.001198	0.000573
5	Story 16	0.001434	0.000886	0.001332	0.000669
6	Story 15	0.00163	0.001022	0.001456	0.000759
7	Story 14	0.001816	0.001164	0.001567	0.000841
8	Story 13	0.001985	0.001303	0.001664	0.000913
9	Story 12	0.002134	0.001377	0.001744	0.000976
10	Story 11	0.002261	0.001368	0.001808	0.001028
11	Story 10	0.002366	0.001358	0.001854	0.00107
12	Story 9	0.002448	0.001355	0.001881	0.001102
13	Story 8	0.002506	0.001356	0.001888	0.001124
14	Story 7	0.002536	0.001351	0.001873	0.001136
15	Story 6	0.002537	0.001335	0.001833	0.001138
16	Story 5	0.002501	0.001303	0.001761	0.001128
17	Story 4	0.002418	0.001244	0.00165	0.001103
18	Story 3	0.002272	0.001141	0.001482	0.00106
19	Story 2	0.002033	0.000973	0.001242	0.000877
20	Story 1	0.001668	0.000595	0.000782	0.000615
21	base	0.000947	0	0	0

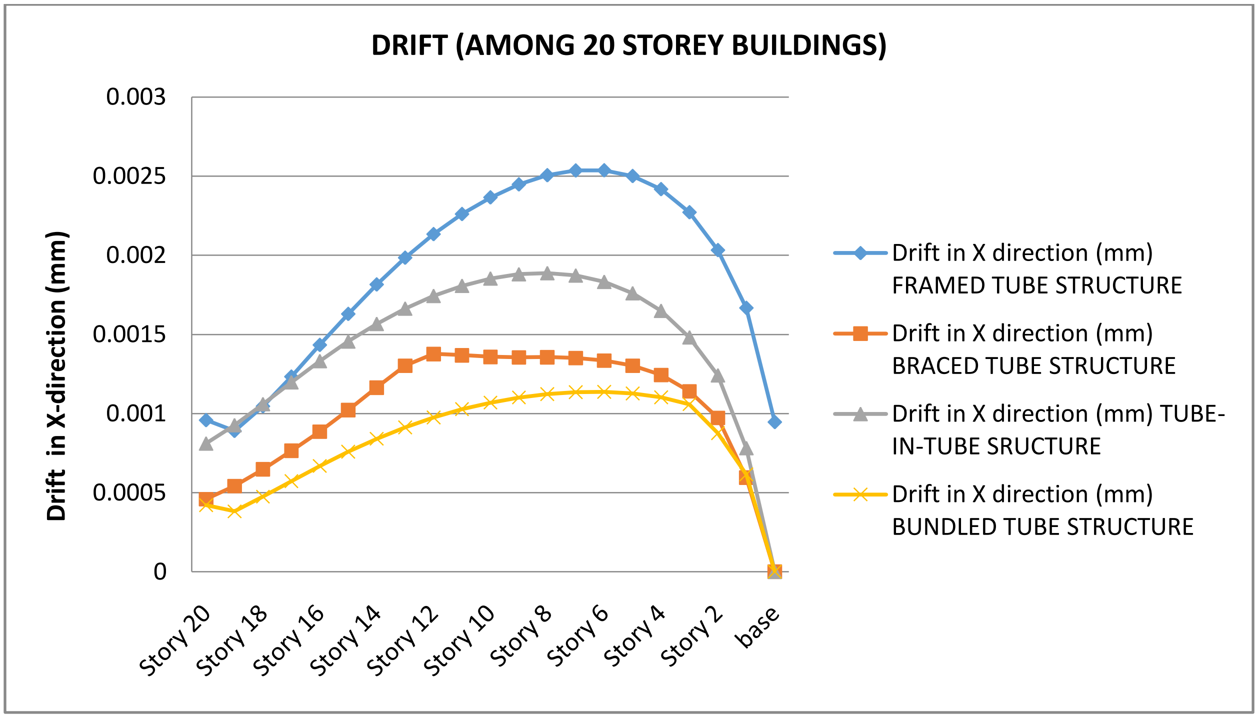

Fig-5.1.1.2(a): Story Drift along X-direction (in mm)

Table: 5.1.1.2(b) Storey Drift (along Y- direction)

MAX. STORY DRIFT (AMONG 20 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Drift in Y direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 20	0.000955	0.000747	0.001075	0.000584
2	Story 19	0.000964	0.000823	0.001151	0.000656
3	Story 18	0.001085	0.000899	0.001238	0.000738
4	Story 17	0.001237	0.000958	0.001323	0.000817
5	Story 16	0.001396	0.001012	0.001402	0.000889
6	Story 15	0.00155	0.001074	0.001469	0.000951
7	Story 14	0.00169	0.001146	0.001525	0.001004

8	Story 13	0.001813	0.001217	0.001567	0.001047
9	Story 12	0.001918	0.001262	0.001595	0.00108
10	Story 11	0.002004	0.001264	0.001609	0.001103
11	Story 10	0.002071	0.001255	0.001594	0.001116
12	Story 9	0.002119	0.001257	0.001564	0.001119
13	Story 8	0.002147	0.001279	0.001518	0.001113
14	Story 7	0.002156	0.001313	0.001456	0.001097
15	Story 6	0.002143	0.001308	0.001374	0.001071
16	Story 5	0.002103	0.001214	0.001269	0.001034
17	Story 4	0.00203	0.0011	0.001126	0.000982
18	Story 3	0.001906	0.000969	0.001001	0.000906
19	Story 2	0.001701	0.000782	0.000703	0.00078
20	Story 1	0.00136	0.000391	0.000482	0.000445
21	base	0.000658	0	0	0

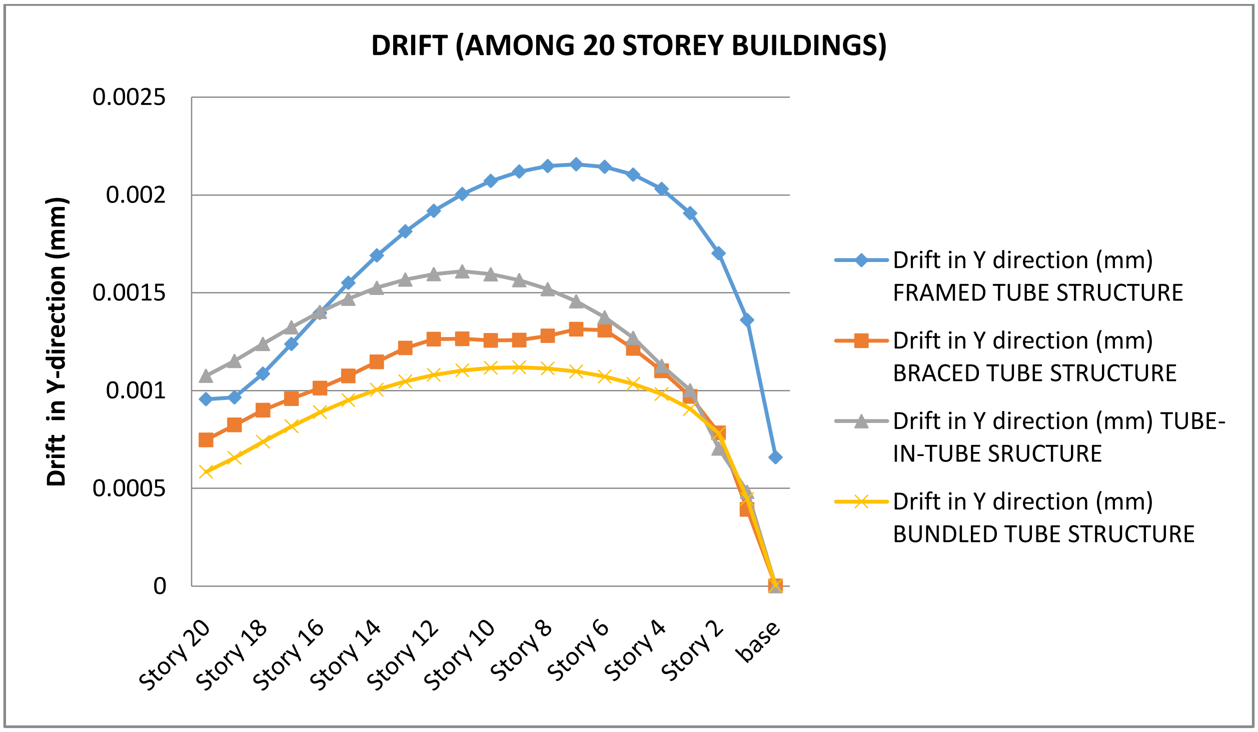

Fig-5.1.1.2(b): Story Drift along Y-direction (in mm)

5.1.1.3 Modal Mass Participation Factor

Here the modal mass participation factor of different modes obtained from analysis is discussed for all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 20 storey buildings.

Table: 5.1.1.3(a) Modal mass participation factor for framed tube structure

Modal Participation factor (FRAMED TUBE STRUCTURE) (AMONG 20 STOREY BUILDINGS)					
Mode	**Period**	**UX**	**UY**	**SumUX**	**SumUY**
1	**2.497313**	0.023769	160.3954	-161.749	160.4194
2	2.282108	-161.772	0.023965	-161.779	0.099713
3	1.784959	-0.00632	0.075748	-0.01466	-63.1381
4	0.770573	-0.00833	-63.2139	-60.554	-63.206
5	0.713069	-60.5457	0.007851	-60.5435	-0.02916
6	0.586032	0.002175	-0.03701	-0.00192	-37.6097
7	0.407804	-0.0041	-37.5727	38.6063	-37.5765
8	0.385188	38.6104	-0.0038	38.60896	0.027473
9	0.339608	-0.00145	0.03127	-0.00378	-28.1872
10	0.262928	-0.00234	-28.2184	28.98915	-28.2206
11	0.249183	28.99149	-0.00216	28.99345	-0.03703
12	0.235867	0.001961	-0.03487	0.001961	-0.03487

Table: 5.1.1.3(b) Modal mass participation factor for braced tube structure

Modal Participation factor (BRACED TUBE STRUCTURE) (AMONG 20 STOREY BUILDINGS)					
Mode	**Period**	**UX**	**UY**	**SumUX**	**SumUY**
1	**1.942625**	0.009282	159.6993	162.2997	159.6899
2	1.706014	162.2905	-0.00937	162.2928	-0.03781
3	1.220201	0.00232	-0.02844	0.007036	66.26906
4	0.596782	0.004716	66.29749	-62.72	66.30197
5	0.550766	-62.7247	0.004475	-62.7254	0.018002
6	0.397946	-0.00069	0.013527	0.001781	38.29243
7	0.316695	0.00247	38.2789	-35.8125	38.28154
8	0.300773	-35.8149	0.002637	-35.8153	0.012216
9	0.235136	-0.00039	0.009579	0.008639	28.68062
10	0.213714	0.009024	28.67104	28.58266	28.66204

11	0.211781	28.57363	-0.009	28.57395	-0.01889
12	0.171134	0.000314	-0.00989	0.000314	-0.00989

Table: 5.1.1.3(c) Modal mass participation factor for tube-in-tube structure

Modal Participation factor (TUBE-IN-TUBE STRUCTURE) (AMONG 20 STOREY BUILDINGS)					
Mode	Period	UX	UY	SumUX	SumUY
1	2.147662	0.042223	159.2347	-162.737	159.2716
2	1.982458	-162.779	0.036918	-162.71	0.074175
3	1.730257	0.069386	0.037257	0.167489	71.52048
4	0.628817	0.098103	71.48322	64.06871	71.37599
5	0.614451	63.97061	-0.10723	63.91192	-0.14457
6	0.564473	-0.05868	-0.03734	39.36467	0.020125
7	0.328994	39.42336	0.057467	39.21741	0.46224
8	0.32335	-0.20595	0.404773	-0.26214	39.46751
9	0.321187	-0.05619	39.06274	0.003205	39.09871
10	0.224487	0.059395	0.035972	-28.7946	-0.00682
11	0.215497	-28.854	-0.04279	-28.8072	-28.0032
12	0.210451	0.046799	-27.9604	0.046799	-27.9604

Table: 5.1.1.3(d) Modal mass participation factor for Bundled Tube structure

Modal Participation factor (BUNDLED TUBE STRUCTURE) (AMONG 20 STOREY BUILDINGS)					
Mode	Period	UX	UY	SumUX	SumUY
1	1.827259	-0.00219	169.0238	0.000273	169.0326
2	1.637393	0.002459	0.008756	171.9323	0.010903
3	1.564759	171.9299	0.002147	171.9289	70.18346
4	0.566207	-0.00095	70.18131	-0.00152	70.17545
5	0.537594	-0.00057	-0.00586	64.69608	-0.00466
6	0.500302	64.69665	0.001198	64.69745	-0.00386
7	0.311663	0.000799	-0.00505	-0.00029	38.79828
8	0.303131	-0.00109	38.80333	-38.8362	38.8023
9	0.278653	-38.8351	-0.00104	-38.8352	-0.00203
10	0.217768	-0.00012	-0.00099	0.000654	-27.9709
11	0.203989	0.000778	-27.9699	28.15204	-27.9692

12	0.188824	28.15126	0.000748	28.15126	0.000748

Table: 5.1.1.3(e) Comparison chart between mode and time period(among 20 story buildings):

Modal Participation factor (Among 20 Story Buildings)				
	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE STRUCTURE	BUNDLED TUBE STRUCTURE
Mode	**Time Period(sec)**			
Mode-1	2.497313	1.942625	2.147662	1.827259
Mode-2	2.282108	1.706014	1.982458	1.637393
Mode-3	1.784959	1.220201	1.730257	1.564759
Mode-4	0.770573	0.596782	0.628817	0.566207
Mode-5	0.713069	0.550766	0.614451	0.537594
Mode-6	0.586032	0.397946	0.564473	0.500302
Mode-7	0.407804	0.316695	0.328994	0.311663
Mode-8	0.385188	0.300773	0.32335	0.303131
Mode-9	0.339608	0.235136	0.321187	0.278653
Mode-10	0.262928	0.213714	0.224487	0.217768
Mode-11	0.249183	0.211781	0.215497	0.203989
Mode-12	0.235867	0.171134	0.210451	0.188824

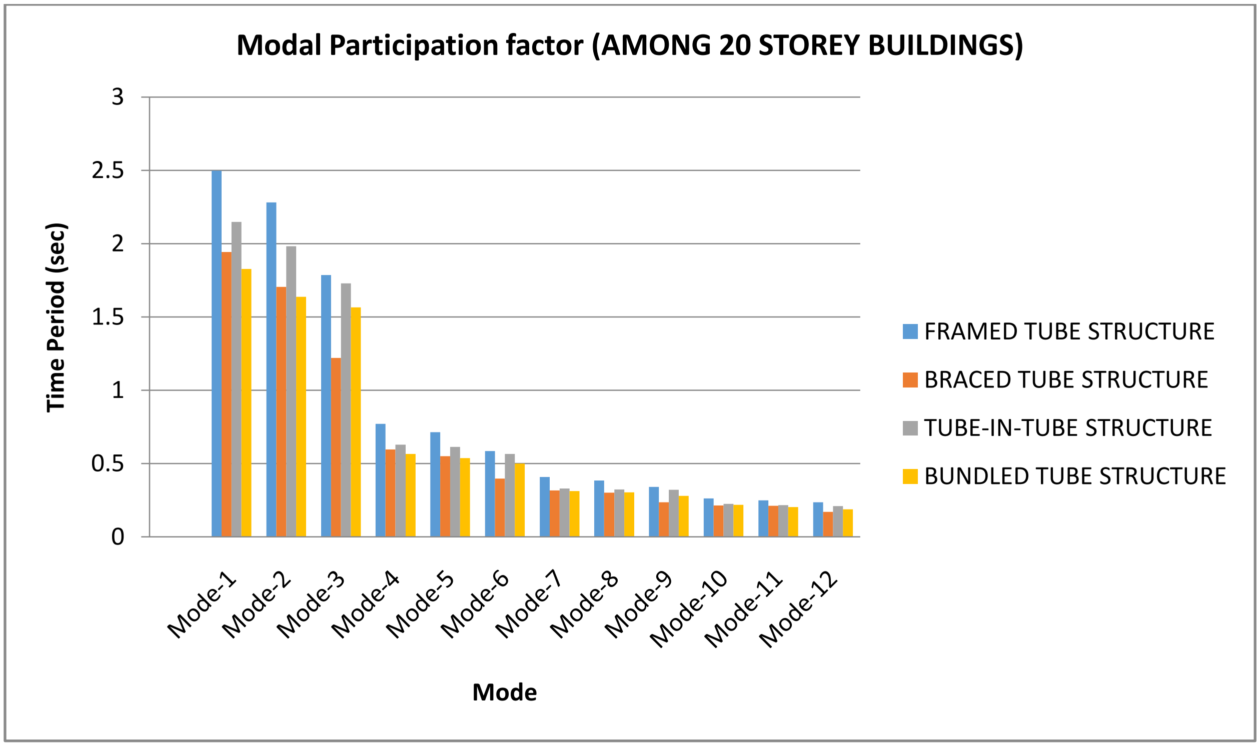

Fig- 5.1.1.3: Graph between mode and time period(among 20 story buildings)

5.1.1.4 Story Shear

Story shear obtained from analysis is discussed for all four types of reinforced concrete tubular structure for longitudinal directions, say, X & Y directions, among 20 storey buildings.

Table: 5.1.1.4 (a) Story Shear along X direction (among 20 story buildings):

STORY SHEAR (AMONG 20 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Story Shear in X direction(VX) (kN)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 20	1902.1	1907.73	1984.41	2067.79
2	Story 19	4183.59	4198.17	4302.77	4603.24
3	Story 18	6233.62	6256.23	6385.93	6881.47

4	Story 17	8064.56	8094.35	8246.46	8916.22
5	Story 16	9688.79	9724.95	9896.93	10721.24
6	Story 15	11118.68	11160.45	11349.93	12310.31
7	Story 14	12366.62	12413.28	12618.04	13697.16
8	Story 13	13444.98	13495.87	13713.83	14895.56
9	Story 12	14366.14	14420.64	14649.87	15919.26
10	Story 11	15142.49	15200.03	15438.76	16782.02
11	Story 10	15786.38	15846.45	16093.06	17497.6
12	Story 9	16310.22	16372.34	16625.36	18079.74
13	Story 8	16726.36	16790.12	17048.23	18542.21
14	Story 7	17047.2	17112.21	17374.25	18898.75
15	Story 6	17285.1	17351.05	17616	19163.14
16	Story 5	17452.45	17519.05	17786.05	19349.12
17	Story 4	17561.62	17628.65	17896.99	19470.44
18	Story 3	17625	17692.27	17961.39	19540.87
19	Story 2	17654.95	17722.35	17991.83	19574.16
20	Story 1	17664.01	17731.44	18001.03	19584.22

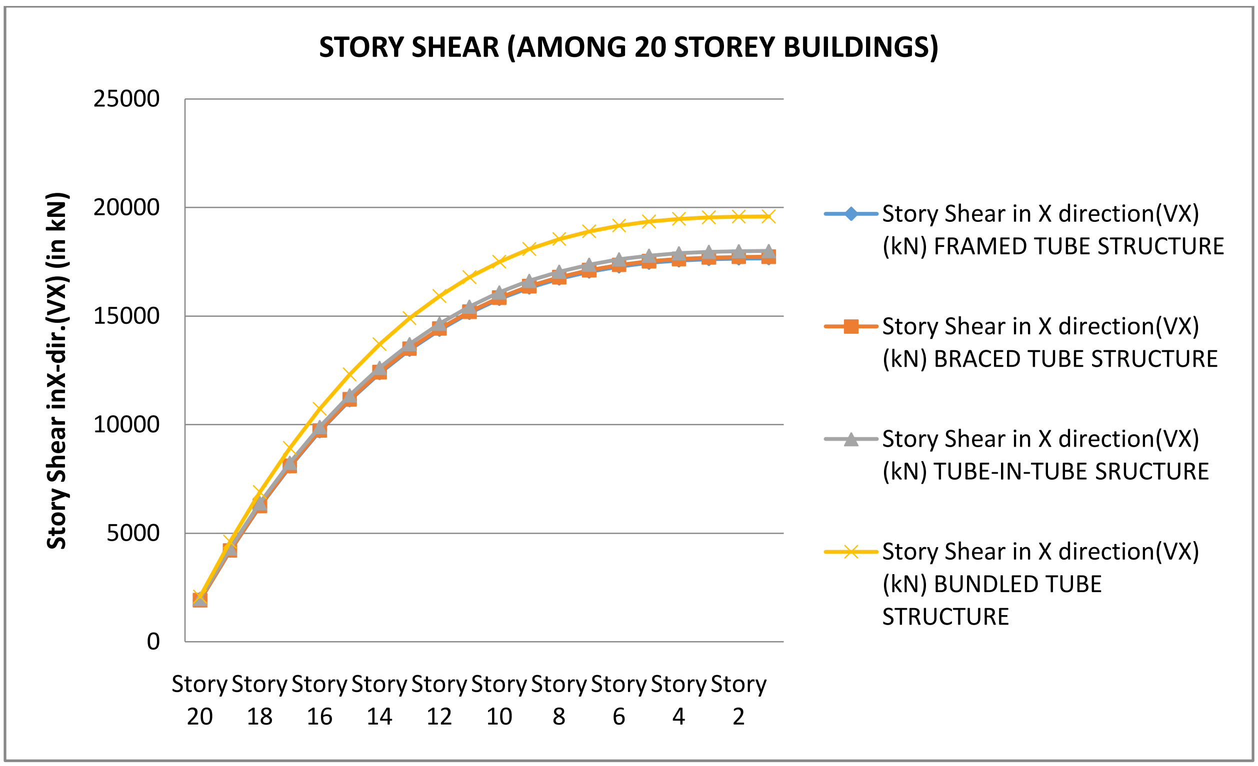

Fig-5.1.1.4 (a): Story Shear along X-direction (in mm) (among 20 story buildings)

Table: 5.1.1.4 (b) Story Shear along Y direction (among 20 story buildings):

STORY SHEAR (AMONG 20 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Story Shear in Y direction(VY) (kN)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 20	1353.59	1357.59	1412.16	1471.49
2	Story 19	2977.16	2987.53	3061.97	3275.8
3	Story 18	4436.02	4452.11	4544.41	4897.04
4	Story 17	5738.97	5760.16	5868.41	6345.03
5	Story 16	6894.81	6920.54	7042.93	7629.54
6	Story 15	7912.36	7942.09	8076.93	8760.36
7	Story 14	8800.43	8833.64	8979.35	9747.28
8	Story 13	9567.82	9604.04	9759.14	10600.1
9	Story 12	10223.35	10262.13	10425.26	11328.59
10	Story 11	10775.82	10816.77	10986.65	11942.56
11	Story 10	11234.03	11276.78	11452.27	12451.78
12	Story 9	11606.81	11651.01	11831.07	12866.05
13	Story 8	11902.95	11948.32	12132	13195.15
14	Story 7	12131.26	12177.53	12364	13448.88
15	Story 6	12300.56	12347.49	12536.04	13637.03
16	Story 5	12419.65	12467.05	12657.05	13769.37
17	Story 4	12497.34	12545.04	12736	13855.71
18	Story 3	12542.44	12590.32	12781.83	13905.83
19	Story 2	12563.76	12611.72	12803.49	13929.52
20	Story 1	12570.2	12618.18	12810.04	13936.68

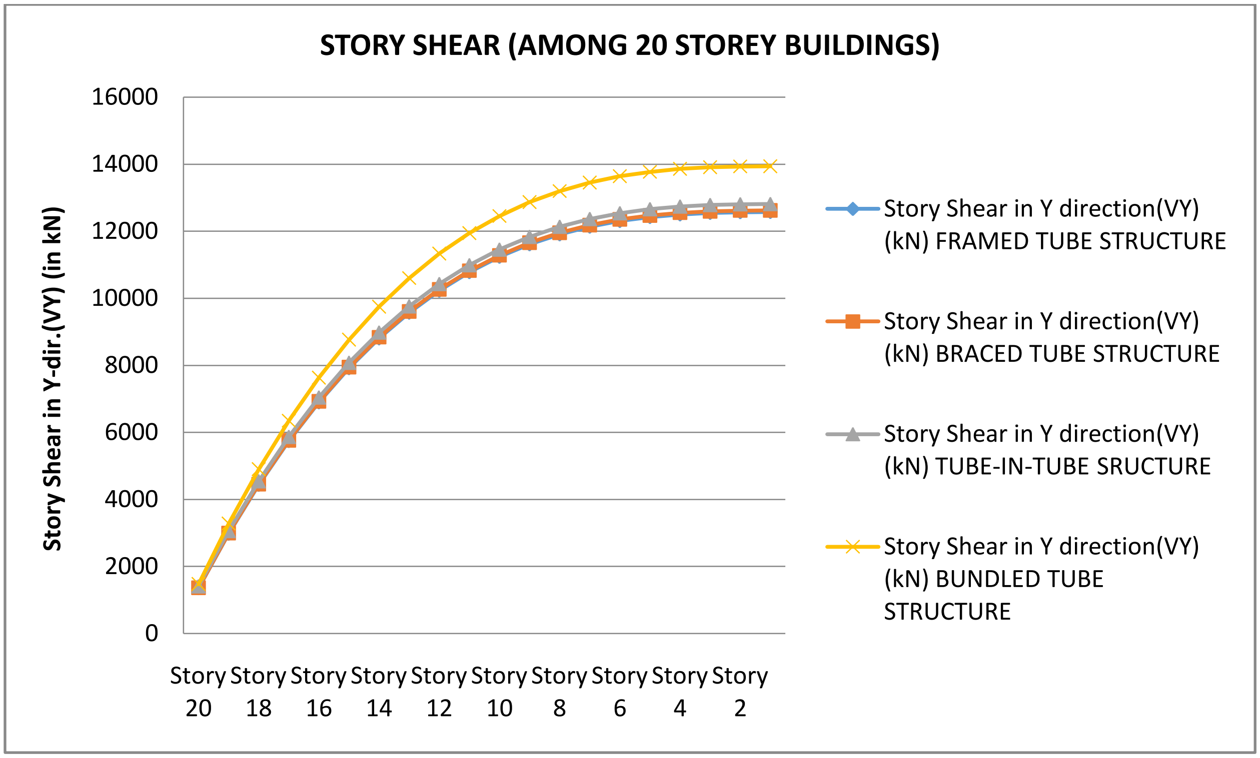

Fig-5.1.1.4 (b): Story Shear along Y-direction (in mm) (among 20 story buildings)

5.1.1.5 Base shear:-

Comparison of total base shears between all four types of reinforced concrete tubular structure for longitudinal directions, say, X & Y directions, among 20 storey buildings.

Table: 5.1.1.5 Base shear in four types of RCC Tubular structures(among 20 story buildings):

Base Shear (in kN)	**FRAMED TUBE STRUCTURE**	**BRACED TUBE STRUCTURE**	**TUBE-IN-TUBE SRUCTURE**	**BUNDLED TUBE STRUCTURE**
In X-Direction	17664.01	17731.44	18001.03	19584.22
In Y-Direction	12570.2	12618.18	12810.04	13936.68

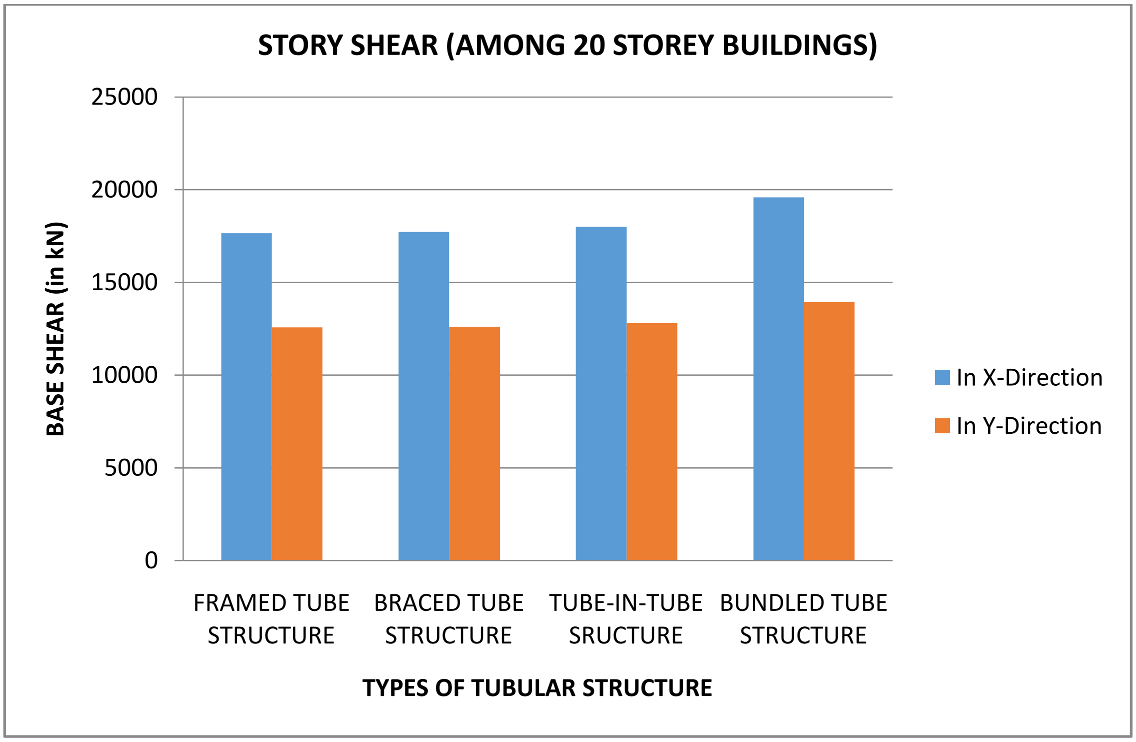

Fig-5.1.1.5: Base Shear along X & Y-direction (in mm) (among 20 story buildings)

5.1.2 Comparison between four different Tubular structures with 40 story height

5.1.2.1Storey Displacement: Comparison of max storey displacement between all four types of reinforced concrete tubular structure for longitudinal directions, say, X & Y directions, among 40 storey buildings.

Table: 5.1.2.1(a) Max. Storey Displacement (along X direction)

MAXIMUM STORY DISPLACEMENT (AMONG 40 STOREY BUILDINGS)		
Loadcase Eqx & Eqy static		
S.No	Story	Displacement in X direction (mm)

	No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 40	222.5	157.6	210	107.1
2	Story 39	220	155.5	207.4	105.3
3	Story 38	217.2	153.2	204.6	103.3
4	Story 37	214.2	150.6	201.6	101.3
5	Story 36	210.9	147.9	198.4	99.1
6	Story 35	207.3	144.9	194.9	96.9
7	Story 34	203.4	141.8	191.1	95.5
8	Story 33	199.2	138.5	187	94.4
9	Story 32	194.7	135.2	182.7	89.3
10	Story 31	189.9	131.8	178.2	86.5
11	Story 30	189.9	128.2	173.4	82.7
12	Story 29	184.9	124.5	168.4	80.8
13	Story 28	179.6	120.6	163.1	77.8
14	Story 27	174.2	116.5	157.7	74.8
15	Story 26	168.5	112.3	152.1	71.6
16	Story 25	162.6	107.8	146.4	68.5
17	Story 24	156.5	103.2	140.5	65.3
18	Story 23	150.3	98.4	134.5	62.1
19	Story 22	137.5	93.7	128.3	58.8
20	Story 21	130.9	89	122.1	55.6
21	Story 20	124.2	84.4	115.8	52.4
22	Story 19	117.4	79.8	109.3	49.4
23	Story 18	110.6	75.2	102.9	46.4
24	Story 17	103.7	70.6	96.4	43.4
25	Story 16	96.8	66	89.8	40.5
26	Story 15	89.9	61.3	83.3	37.5
27	Story 14	82.9	56.6	76.7	34.6
28	Story 13	75.9	51.8	70.2	31.7
29	Story 12	69	46.8	63.7	28.8
30	Story 11	62.1	41.8	57.2	25.9
31	Story 10	62.1	37	50.8	23.1
32	Story 9	55.2	32.4	44.5	20.4
33	Story 8	48.4	27.9	38.3	17.7
34	Story 7	41.7	23.6	32.2	15
35	Story 6	35.2	19.4	26.4	12.5
36	Story 5	28.8	15.4	20.7	10
37	Story 4	22.6	11.5	15.4	7.6
38	Story 3	16.7	7.9	10.4	5.4

39	Story 2	11.3	4.7	6	3.3
40	Story 1	6.5	1.9	2.5	1.5
41	base	2.6	0	0	0

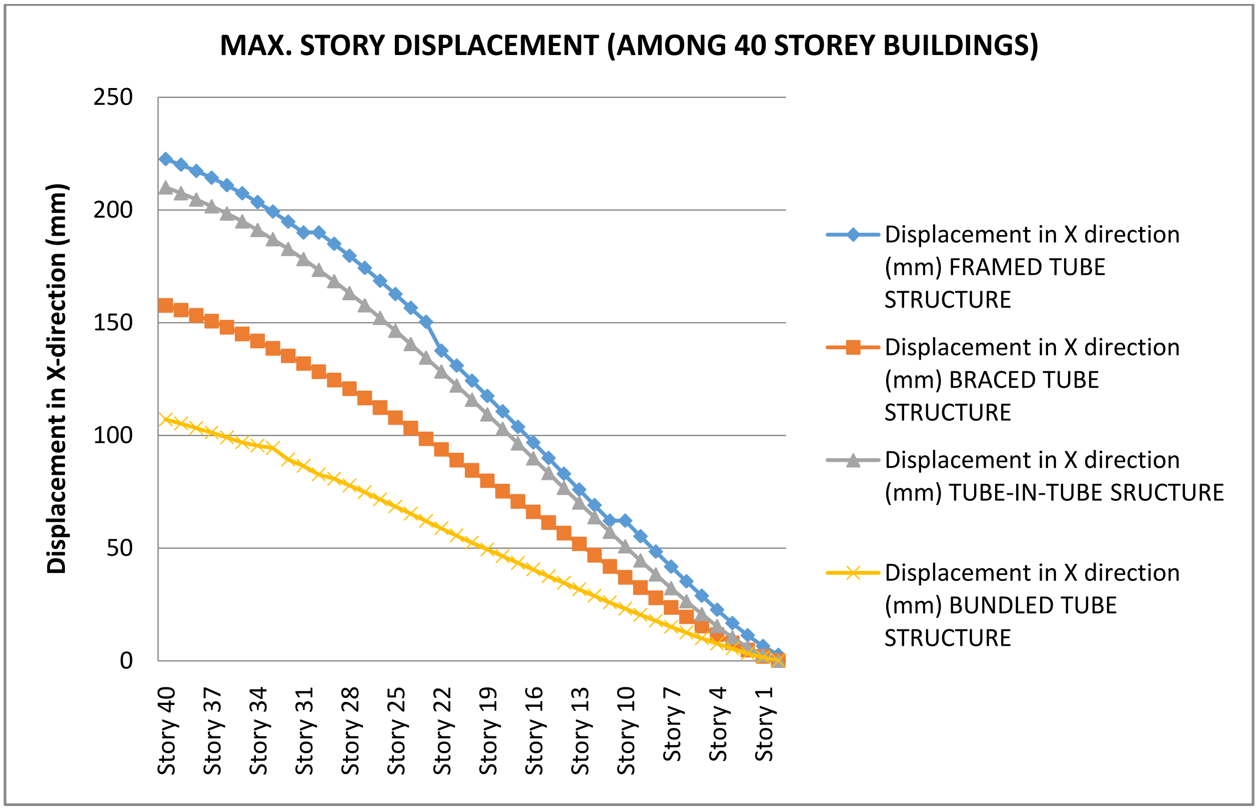

Fig-5.1.2.1(a): Max. Story Displacement in X-direction (among 40 story buildings)

Table: 5.1.2.1(b) Max. Storey Displacement (along Y direction)

MAXIMUM STORY DISPLACEMENT (AMONG 40 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Displacement in Y direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 40	263.8	204.8	246.5	161.7

2	Story 39	259	200.6	241.6	157.6
3	Story 38	254.1	196.3	236.6	153.5
4	Story 37	249	191.9	231.4	149.3
5	Story 36	243.6	187.3	226	145
6	Story 35	238	182.5	220.4	140.5
7	Story 34	232.1	177.6	214.6	136
8	Story 33	226	172.5	208.5	131.4
9	Story 32	219.6	167.2	202.3	126.7
10	Story 31	213	161.8	195.9	121.9
11	Story 30	213	156.2	189.4	117.1
12	Story 29	206.2	150.5	182.6	112.2
13	Story 28	199.3	144.8	175.8	107.2
14	Story 27	192.1	139	168.8	102.3
15	Story 26	184.8	133.1	161.8	97.3
16	Story 25	177.4	127.1	154.6	92.3
17	Story 24	169.8	121.1	147.4	87.3
18	Story 23	162.1	115	140.1	82.4
19	Story 22	146.6	108.9	132.7	77.4
20	Story 21	138.7	102.9	125.4	72.6
21	Story 20	130.8	96.8	118	67.9
22	Story 19	122.9	90.7	110.7	63.4
23	Story 18	115	84.5	103.4	58.9
24	Story 17	107.1	78.4	96.1	54.6
25	Story 16	99.3	72.4	88.9	50.3
26	Story 15	91.5	66.5	81.7	46.1
27	Story 14	83.8	60.8	74.7	42
28	Story 13	76.1	55.2	67.7	38
29	Story 12	68.7	49.6	60.9	34
30	Story 11	61.3	44.1	54.2	30.2
31	Story 10	61.3	38.8	47.7	26.5
32	Story 9	54	33.6	41.4	23
33	Story 8	47	28.7	35.3	19.6
34	Story 7	40.1	24	29.4	16.3
35	Story 6	33.4	19.4	23.8	13.3
36	Story 5	27	14.9	18.4	10.4
37	Story 4	20.9	10.7	13.4	7.7
38	Story 3	15.2	7	8.9	5.2

39	Story 2	10	3.9	4.9	3
40	Story 1	5.5	1.4	1.8	1.2
41	base	2	0	0	0

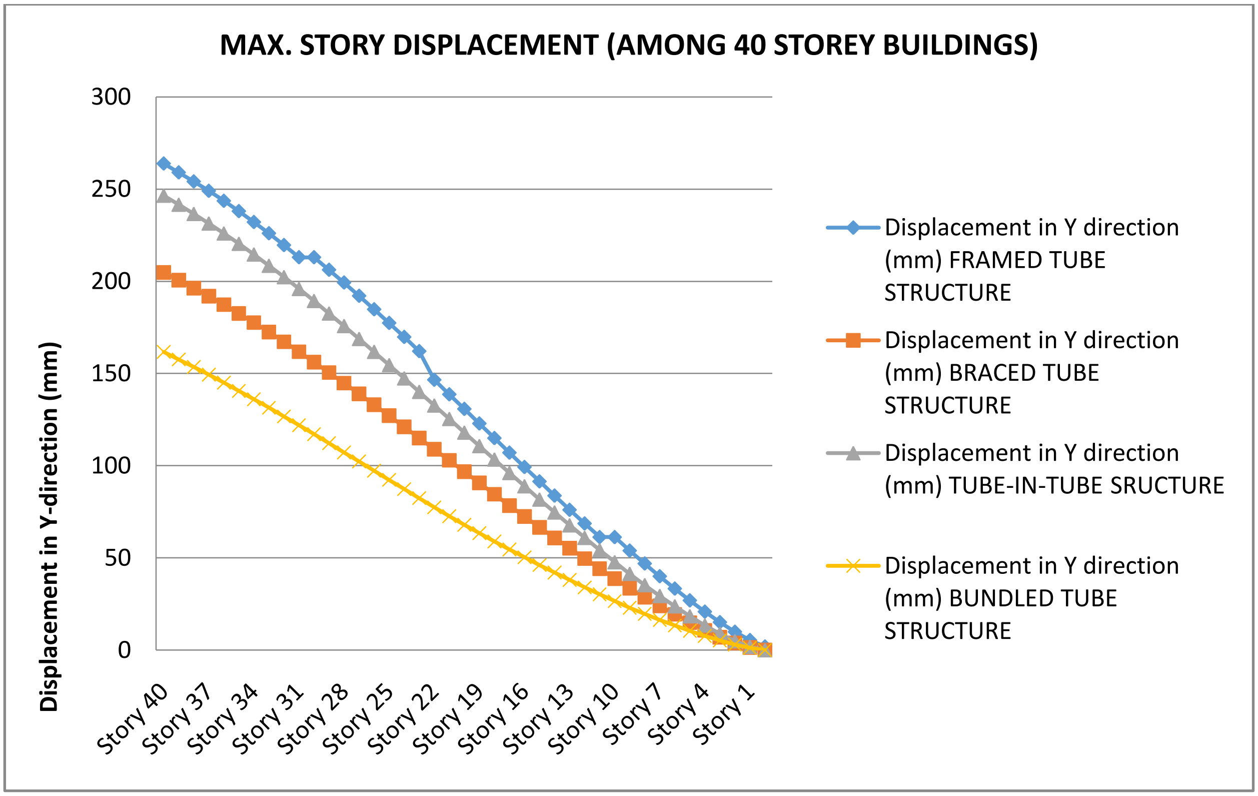

Fig-5.1.2.1(b): Max. Story Displacement in Y-direction (among 40 story buildings)

5.1.2.2 Storey Drift: Comparison of max storey drift between all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 40 storey buildings.

Table: 5.1.2.2(a) Storey Drift (along x direction)

MAX. STORY DRIFT (AMONG 40 STOREY BUILDINGS)

Loadcase Eqx & Eqy static					
		Drift in X direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 40	0.000735	0.000613	0.00074	0.000515
2	Story 39	0.000791	0.000662	0.00079	0.000547
3	Story 38	0.000863	0.000726	0.000856	0.000582
4	Story 37	0.000945	0.000792	0.000928	0.000618
5	Story 36	0.00103	0.000847	0.001005	0.000654
6	Story 35	0.001116	0.000888	0.001082	0.000689
7	Story 34	0.0012	0.000922	0.001158	0.000722
8	Story 33	0.001282	0.000953	0.001231	0.000753
9	Story 32	0.001359	0.000985	0.001302	0.000782
10	Story 31	0.001433	0.001021	0.001369	0.000809
11	Story 30	0.001502	0.001062	0.001432	0.000833
12	Story 29	0.001566	0.001108	0.001491	0.000854
13	Story 28	0.001625	0.001158	0.001545	0.000873
14	Story 27	0.00168	0.001213	0.001596	0.000889
15	Story 26	0.00173	0.001272	0.001642	0.000903
16	Story 25	0.001775	0.001333	0.001684	0.000913
17	Story 24	0.001816	0.001364	0.001722	0.000921
18	Story 23	0.001852	0.001353	0.001755	0.000924
19	Story 22	0.001883	0.001336	0.001784	0.000923
20	Story 21	0.001911	0.001323	0.001809	0.000909
21	Story 20	0.001934	0.001313	0.00183	0.000858
22	Story 19	0.001953	0.001309	0.001847	0.000855
23	Story 18	0.001967	0.001311	0.00186	0.000851
24	Story 17	0.001978	0.001318	0.001868	0.000848
25	Story 16	0.001985	0.001331	0.001873	0.000844
26	Story 15	0.001988	0.001351	0.001873	0.000838
27	Story 14	0.001988	0.001378	0.001869	0.000831
28	Story 13	0.001983	0.001413	0.00186	0.000823
29	Story 12	0.001973	0.001425	0.001847	0.000813
30	Story 11	0.001959	0.001375	0.001828	0.000801
31	Story 10	0.00194	0.001323	0.001804	0.000788
32	Story 9	0.001913	0.001278	0.001772	0.000772

33	Story 8	0.001878	0.001237	0.001732	0.000754
34	Story 7	0.001831	0.001196	0.001681	0.000733
35	Story 6	0.001767	0.001153	0.001615	0.000708
36	Story 5	0.001678	0.001101	0.001529	0.000678
37	Story 4	0.001553	0.00103	0.001412	0.00064
38	Story 3	0.001371	0.000928	0.001249	0.00059
39	Story 2	0.001111	0.000778	0.001019	0.000519
40	Story 1	0.000616	0.000463	0.000589	0.00036
41	base	0	0.000001	0	0.000001

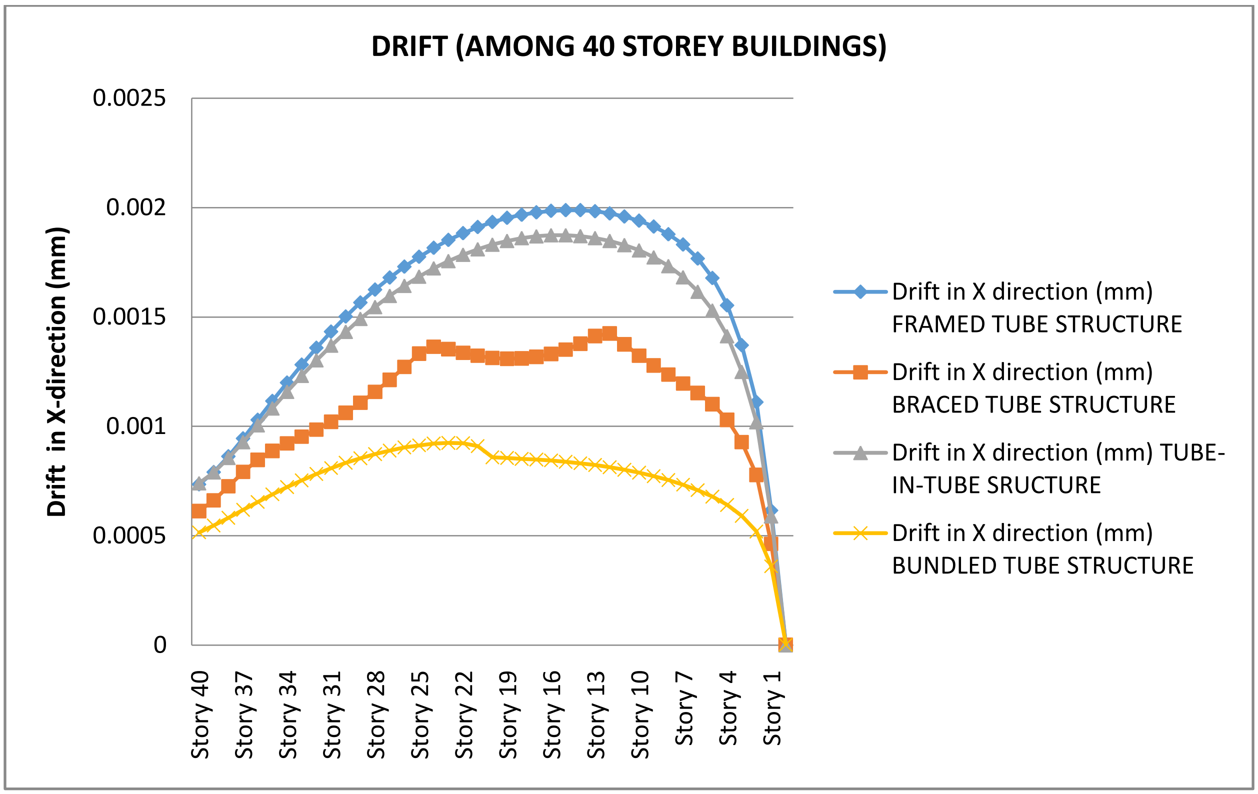

Fig-5.1.2.2(a): Story Drift along X-direction (in mm)

Table: 5.1.2.2(b) Storey Drift (along Y- direction)

MAX. STORY DRIFT (AMONG 40 STOREY BUILDINGS)		
Loadcase Eqx & Eqy static		
S.No	Story	Drift in Y direction (mm)

	No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 40	0.001354	0.001193	0.001394	0.00115
2	Story 39	0.001401	0.001225	0.001433	0.001177
3	Story 38	0.001464	0.001267	0.001486	0.001207
4	Story 37	0.001535	0.001313	0.001545	0.001237
5	Story 36	0.001608	0.00136	0.001605	0.001267
6	Story 35	0.001681	0.001407	0.001665	0.001295
7	Story 34	0.001752	0.001454	0.001722	0.001321
8	Story 33	0.001819	0.0015	0.001777	0.001345
9	Story 32	0.001882	0.001549	0.001828	0.001365
10	Story 31	0.001941	0.001599	0.001875	0.001383
11	Story 30	0.001995	0.001632	0.001918	0.001398
12	Story 29	0.002044	0.001646	0.001956	0.00141
13	Story 28	0.002088	0.001658	0.001991	0.001418
14	Story 27	0.002127	0.001676	0.002021	0.001423
15	Story 26	0.002161	0.0017	0.002046	0.001425
16	Story 25	0.002191	0.001726	0.002067	0.001422
17	Story 24	0.002215	0.001742	0.002083	0.001416
18	Story 23	0.002233	0.001738	0.002094	0.001404
19	Story 22	0.002247	0.001731	0.002101	0.001384
20	Story 21	0.002256	0.00173	0.002103	0.001348
21	Story 20	0.00226	0.001742	0.0021	0.001289
22	Story 19	0.002258	0.00176	0.002093	0.001265
23	Story 18	0.002252	0.001759	0.002081	0.001244
24	Story 17	0.002241	0.001717	0.002063	0.001224
25	Story 16	0.002225	0.001671	0.002042	0.001202
26	Story 15	0.002203	0.001634	0.002015	0.001177
27	Story 14	0.002177	0.001611	0.001983	0.00115
28	Story 13	0.002146	0.001599	0.001947	0.00112
29	Story 12	0.002109	0.001581	0.001905	0.001088
30	Story 11	0.002067	0.001523	0.001858	0.001053
31	Story 10	0.002019	0.001457	0.001806	0.001014
32	Story 9	0.001965	0.001398	0.001748	0.000972

33	Story 8	0.001902	0.001355	0.001683	0.000928
34	Story 7	0.001829	0.001326	0.00161	0.000879
35	Story 6	0.001742	0.001286	0.001526	0.000826
36	Story 5	0.001634	0.001182	0.001427	0.000769
37	Story 4	0.001492	0.001054	0.001302	0.000704
38	Story 3	0.001294	0.000903	0.001134	0.000626
39	Story 2	0.001004	0.000703	0.000888	0.00052
40	Story 1	0.000467	0.000002	0.000427	0.000286
41	base	0	0.000135	0	0.000135

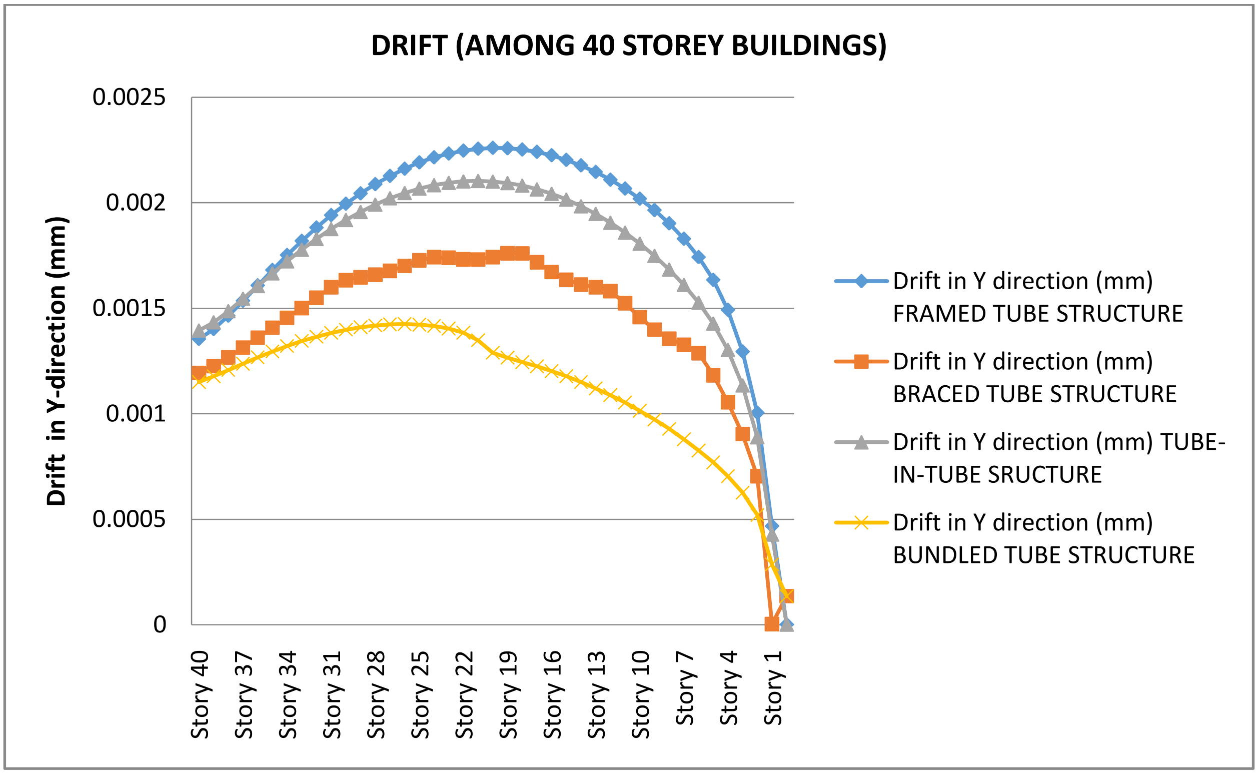

Fig-5.1.2.2(b): Story Drift along Y-direction (in mm)

5.1.2.3 Modal Mass Participation Factor

Here the modal mass participation factor of different modes obtained from analysis is discussed for all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 40 storey buildings.

Table: 5.1.2.3(a) Modal mass participation factor for framed tube structure

Modal Participation factor (FRAMED TUBE STRUCTURE) (AMONG 40 STOREY BUILDINGS)					
Mode	**Period**	**UX**	**UY**	**SumUX**	**SumUY**
1	5.067194	-0.01101	-235.013	240.0948	-235.024
2	4.055033	240.1059	-0.01115	240.1005	0.019805
3	2.90725	-0.00535	0.030951	-0.01002	-102.772
4	1.525736	-0.00467	-102.803	-92.6024	-102.799
5	1.290982	-92.5977	0.004561	-92.5961	-0.01243
6	0.955852	0.001626	-0.01699	0.00462	55.32922
7	0.798093	0.002994	55.34621	53.6489	55.34359
8	0.711014	53.6459	-0.00262	53.64506	-0.00167
9	0.554586	-0.00085	0.000948	0.000628	40.07434
10	0.532855	0.001475	40.07339	39.86329	40.07181
11	0.479642	39.86182	-0.00158	39.86126	-0.11493
12	0.389495	-0.00056	-0.11335	-0.00056	-0.11335

Table: 5.1.2.3(b) Modal mass participation factor for braced tube structure

Modal Participation factor (BRACED TUBE STRUCTURE) (AMONG 40 STOREY BUILDINGS)					
Mode	**Period**	**UX**	**UY**	**SumUX**	**SumUY**
1	4.403016	0.000026	-234.093	-240.26	-234.091
2	3.371389	-240.26	0.001729	-240.241	-0.00231
3	2.261115	0.018781	-0.00404	0.019204	108.1924
4	1.284991	0.000423	108.1965	-97.2262	108.1958
5	1.07168	-97.2266	-0.00068	-97.2289	0.070983
6	0.741671	-0.00228	0.071662	-0.00307	-56.7812
7	0.66035	-0.00079	-56.8529	54.48596	-56.8522
8	0.586184	54.48675	0.000684	54.48597	-40.3562
9	0.440339	-0.00078	-40.3569	0.041741	-40.0557
10	0.429274	0.042519	0.301249	-39.7822	0.300843
11	0.407599	-39.8247	-0.00041	-39.8253	-31.5368
12	0.324842	-0.00062	-31.5364	-0.00062	-31.5364

Table: 5.1.2.3(c) Modal mass participation factor for tube-in-tube structure

Modal Participation factor (TUBE-IN-TUBE STRUCTURE) (AMONG 40 STOREY BUILDINGS)					
Mode	**Period**	**UX**	**UY**	**SumUX**	**SumUY**

1	4.849973	-0.00212	235.2228	241.2277	235.2248
2	3.922697	241.2298	0.002042	241.237	-0.00418
3	2.873757	0.007234	-0.00622	0.008417	-106.891
4	1.426476	0.001183	-106.885	-94.4212	-106.886
5	1.238272	-94.4224	-0.00147	-94.4194	-0.00399
6	0.942892	0.00296	-0.00251	0.001894	56.89178
7	0.735378	-0.00107	56.8943	-55.2009	56.89299
8	0.675975	-55.1998	-0.0013	-55.2018	0.000183
9	0.545311	-0.00202	0.001487	-0.00104	-40.5347
10	0.490277	0.000975	-40.5362	-40.8189	-40.5372
11	0.453579	-40.8198	-0.00096	-40.8215	1.9E-05
12	0.382433	-0.00165	0.00098	-0.00165	0.00098

Table: 5.1.2.3(d) Modal mass participation factor for Bundled Tube structure

Modal Participation factor (BUNDLED TUBE STRUCTURE)					
(AMONG 40 STOREY BUILDINGS)					
Mode	**Period**	**UX**	**UY**	**SumUX**	**SumUY**
1	3.677571	8.398561	231.3456	-231.852	242.4113
2	2.626586	-240.25	11.06563	-240.249	11.06439
3	2.384041	0.000865	-0.00124	16.99552	122.8791
4	1.119267	16.99466	122.8804	16.99849	122.8815
5	0.905381	0.003835	0.001088	109.1483	-14.9784
6	0.885472	109.1445	-14.9795	101.088	-77.4307
7	0.546447	-8.05653	-62.4512	-8.05747	-62.4529
8	0.496746	-0.00095	-0.00165	57.58294	-5.17012
9	0.465189	57.58389	-5.16847	60.28092	38.48799
10	0.368274	2.697026	43.65646	2.696387	43.65317
11	0.357441	-0.00064	-0.00329	42.06219	-2.03943
12	0.324446	42.06283	-2.03615	42.06283	-2.03615

Table: 5.1.2.3(e) Comparison chart between mode and time period(among 40 story buildings)

Modal Participation factor (Among 40 Story Buildings)

Mode	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE STRUCTURE	BUNDLED TUBE STRUCTURE
	Time Period(sec)			
Mode-1	5.067194	4.403016	4.849973	3.677571
Mode-2	4.055033	3.371389	3.922697	2.626586
Mode-3	2.90725	2.261115	2.873757	2.384041
Mode-4	1.525736	1.284991	1.426476	1.119267
Mode-5	1.290982	1.07168	1.238272	0.905381
Mode-6	0.955852	0.741671	0.942892	0.885472
Mode-7	0.798093	0.66035	0.735378	0.546447
Mode-8	0.711014	0.586184	0.675975	0.496746
Mode-9	0.554586	0.440339	0.545311	0.465189
Mode-10	0.532855	0.429274	0.490277	0.368274
Mode-11	0.479642	0.407599	0.453579	0.357441
Mode-12	0.389495	0.324842	0.382433	0.324446

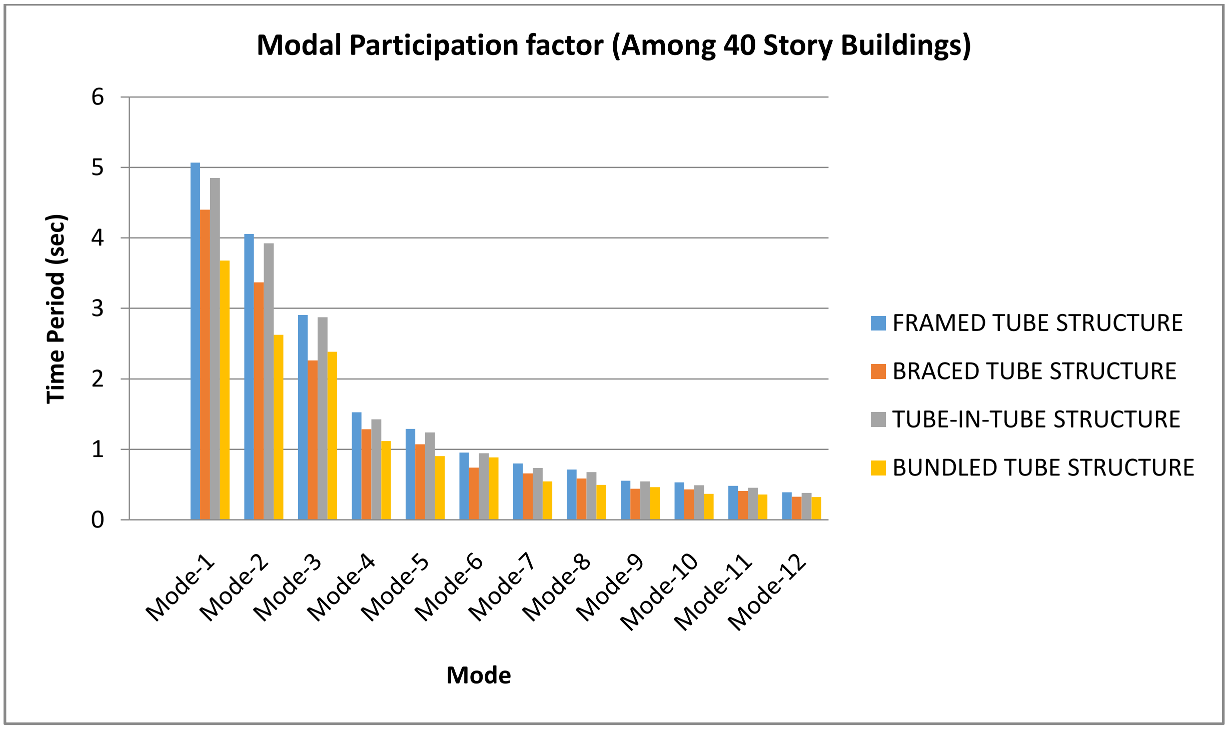

Fig- 5.1.2.3: Graph between mode and time period(among 40 story buildings)

5.1.2.4 Story Shear

Story shear obtained from analysis is discussed for all four types of reinforced concrete tubular structure for longitudinal directions, say, X & Y directions, among 40 storey buildings.

Table: 5.1.2.4(a) Story Shear along X direction (among 40 story buildings)

STORY SHEAR (AMONG 40 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
S.No	Story No.	Story Shear in X direction(VX) (kN)			
		FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 40	1106.66	1111.86	1135.73	1190.99
2	Story 39	2486.21	2505.67	2534.26	2601.34
3	Story 38	3796.27	3829.27	3862.35	3940.65
4	Story 37	5038.64	5084.48	5121.82	5210.76
5	Story 36	6215.11	6273.11	6314.48	6413.5
6	Story 35	7327.49	7396.98	7442.17	7550.71
7	Story 34	8377.56	8457.9	8506.68	8624.22
8	Story 33	9367.11	9457.68	9509.86	9635.88
9	Story 32	10297.96	10398.14	10453.51	10587.5
10	Story 31	11171.88	11281.1	11339.47	11480.94
11	Story 30	11990.69	12108.36	12169.54	12318.03
12	Story 29	12756.16	12881.75	12945.54	13100.59
13	Story 28	13470.1	13603.07	13669.31	13830.47
14	Story 27	14134.31	14274.14	14342.66	14509.51
15	Story 26	14750.58	14896.77	14967.4	15139.54
16	Story 25	15320.7	15472.79	15545.37	15722.39
17	Story 24	15846.47	16003.99	16078.38	16259.89
18	Story 23	16329.68	16492.2	16568.24	16753.9
19	Story 22	16772.14	16939.23	17016.79	17206.23
20	Story 21	17175.63	17346.89	17425.83	17618.74
21	Story 20	17541.96	17717	17797.2	18071.16
22	Story 19	17872.91	18051.38	18132.71	18485.26
23	Story 18	18170.29	18351.83	18434.18	18857.35
24	Story 17	18435.89	18620.17	18703.43	19189.68
25	Story 16	18671.5	18858.21	18942.28	19484.48
26	Story 15	18878.92	19067.78	19152.56	19744.02
27	Story 14	19059.95	19250.67	19336.08	19970.52
28	Story 13	19216.37	19408.72	19494.66	20166.25

29	Story 12	19350	19543.72	19630.12	20333.45
30	Story 11	19462.61	19657.5	19744.29	20474.36
31	Story 10	19556.02	19751.87	19838.97	20591.23
32	Story 9	19632	19828.64	19916.01	20686.31
33	Story 8	19692.37	19889.63	19977.2	20761.84
34	Story 7	19738.91	19936.66	20024.39	20820.07
35	Story 6	19773.42	19971.52	20059.37	20863.25
36	Story 5	19797.7	19996.05	20083.98	20893.63
37	Story 4	19813.53	20012.05	20100.03	20913.44
38	Story 3	19822.73	20021.34	20109.35	20924.95
39	Story 2	19827.07	20025.73	20113.76	20930.38
40	Story 1	19828.39	20027.06	20115.1	20932.04

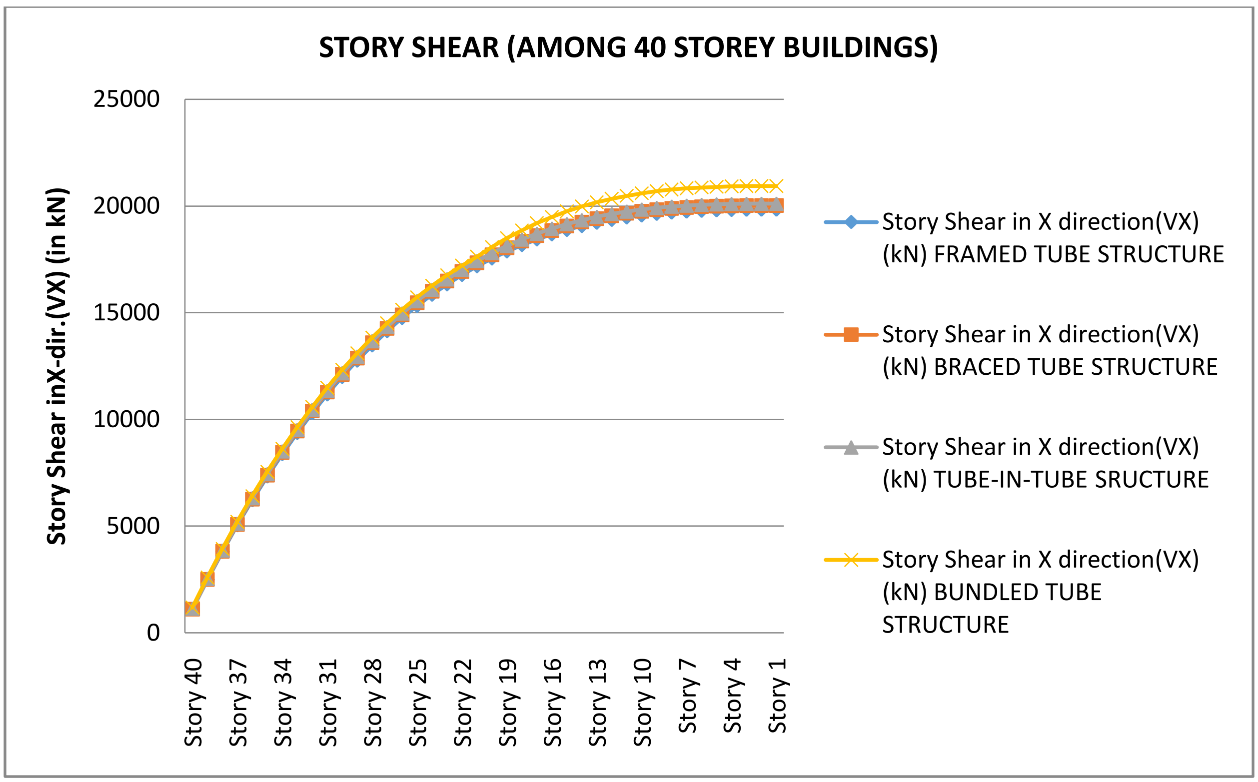

Fig-5.1.2.4(a): Story Shear along X-direction (in mm) (among 40 story buildings)

Table: 5.1.2.4(b) Story Shear along Y direction (among 40 story buildings)

STORY SHEAR (AMONG 40 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
S.No	Story No.	Story Shear in Y direction(VY) (kN)			
		FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 40	780.66	784.34	801.17	840.15
2	Story 39	1753.84	1767.57	1787.74	1835.05
3	Story 38	2677.99	2701.27	2724.61	2779.84
4	Story 37	3554.39	3586.73	3613.07	3675.81
5	Story 36	4384.3	4425.22	4454.4	4524.25
6	Story 35	5169	5218.02	5249.9	5326.47
7	Story 34	5909.75	5966.42	6000.84	6083.75
8	Story 33	6607.81	6671.7	6708.51	6797.4
9	Story 32	7264.45	7335.13	7374.18	7468.7
10	Story 31	7880.94	7957.99	7999.16	8098.96
11	Story 30	8458.55	8541.56	8584.71	8689.46
12	Story 29	8998.53	9087.13	9132.13	9241.5
13	Story 28	9502.17	9595.96	9642.69	9756.38
14	Story 27	9970.72	10069.35	10117.69	10235.39
15	Story 26	10405.45	10508.58	10558.4	10679.83
16	Story 25	10807.62	10914.91	10966.11	11090.98
17	Story 24	11178.51	11289.64	11342.11	11470.16
18	Story 23	11519.39	11634.03	11687.67	11818.64
19	Story 22	11831.51	11949.38	12004.09	12137.73
20	Story 21	12116.14	12236.95	12292.64	12428.72
21	Story 20	12374.56	12498.04	12554.61	12747.87
22	Story 19	12608.02	12733.92	12791.29	13039.99
23	Story 18	12817.8	12945.86	13003.96	13302.47
24	Story 17	13005.16	13135.16	13193.89	13536.9
25	Story 16	13171.37	13303.08	13362.39	13744.87

26	Story 15	13317.69	13450.91	13510.72	13927.95
27	Story 14	13445.39	13579.93	13640.18	14087.73
28	Story 13	13555.74	13691.42	13752.04	14225.81
29	Story 12	13650	13786.66	13847.6	14343.75
30	Story 11	13729.44	13866.92	13928.14	14443.15
31	Story 10	13795.33	13933.49	13994.94	14525.6
32	Story 9	13848.93	13987.65	14049.28	14592.67
33	Story 8	13891.52	14030.67	14092.45	14645.95
34	Story 7	13924.35	14063.84	14125.73	14687.03
35	Story 6	13948.69	14088.44	14150.41	14717.49
36	Story 5	13965.82	14105.74	14167.77	14738.92
37	Story 4	13976.99	14117.03	14179.09	14752.89
38	Story 3	13983.47	14123.58	14185.67	14761.01
39	Story 2	13986.54	14126.68	14188.78	14764.84
40	Story 1	13987.47	14127.62	14189.72	14766.01

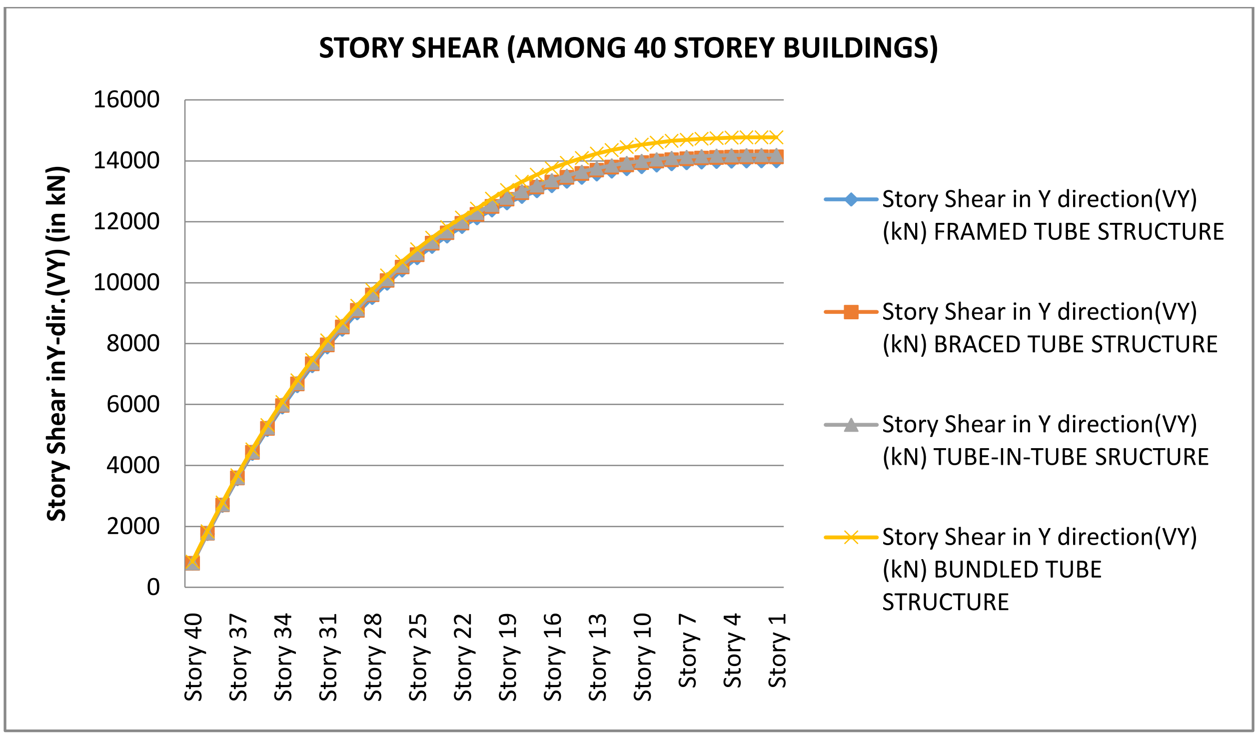

Fig-5.1.2.4(b): Story Shear along Y-direction (in mm) (among 40 story buildings)

5.1.2.5 Base shear:-

Comparison of total base shears between all four types of reinforced concrete tubular structure for longitudinal directions, say, X & Y directions, among 40 storey buildings.

Table: 5.1.2.5 Base shears in four types of RCC Tubular structures (among 40 story buildings)

Base Shear (in kN)	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
In X-Direction	19828.39	20027.06	20115.1	20932.04
In Y-Direction	13987.47	14127.62	14189.72	14766.01

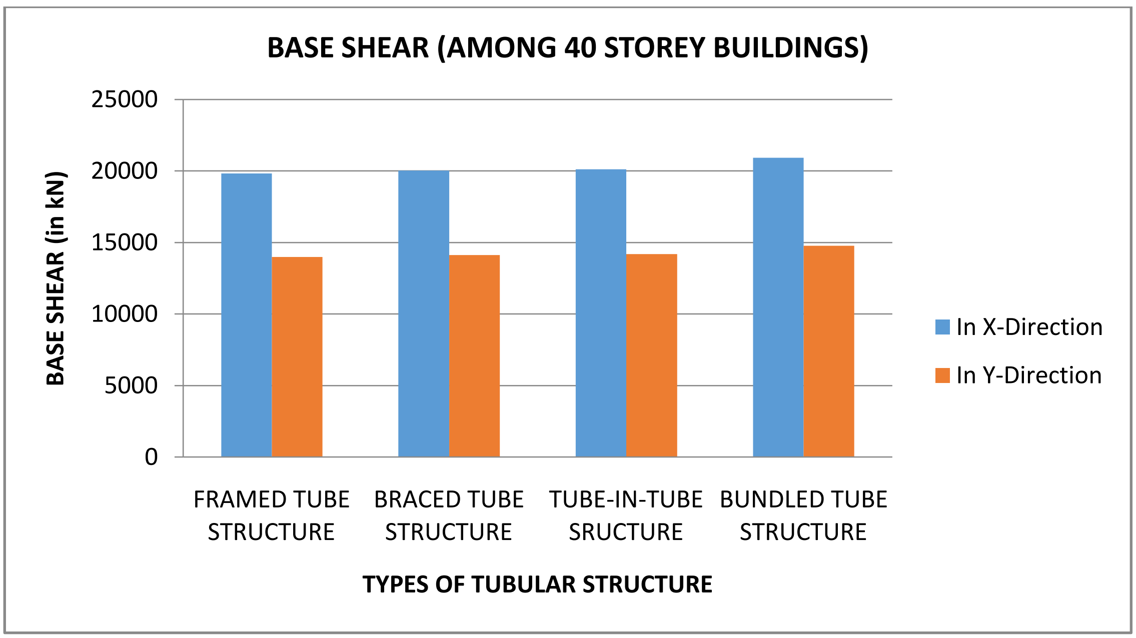

Fig-5.1.2.5: Base Shear along X & Y-direction (in mm) (among 40 story buildings)

5.1.3 Comparison between four different Tubular structures with 60 story height

5.1.3.1Storey Displacement: Comparison of max storey displacement between all four types of reinforced concrete tubular structure for longitudinal directions, say, X & Y directions, among 60 storey buildings.

Table: 5.1.3.1(a) Max. Storey Displacement (along X direction)

MAXIMUM STORY DISPLACEMENT (AMONG 60 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Displacement in X direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 60	281.8	240.7	275.1	151.1
2	Story 59	278.8	237.8	272.1	148.6
3	Story 58	275.7	234.8	269	146
4	Story 57	272.5	231.8	265.8	143.4
5	Story 56	269.1	228.6	262.5	140.7
6	Story 55	265.6	225.4	259.1	138
7	Story 54	262	222.1	255.5	135.2
8	Story 53	258.2	218.6	251.8	132.4
9	Story 52	254.3	215.1	247.9	129.5
10	Story 51	250.3	211.4	243.9	126.6
11	Story 50	246.1	207.6	239.8	123.7
12	Story 49	241.8	203.7	235.6	120.7
13	Story 48	237.4	199.7	231.3	117.6
14	Story 47	232.9	195.5	226.8	114.6
15	Story 46	228.2	191.4	222.3	111.5
16	Story 45	223.5	187.1	217.7	108.4
17	Story 44	218.7	182.9	212.9	105.2
18	Story 43	213.8	178.6	208.1	102.1
19	Story 42	208.8	174.3	203.2	98.9
20	Story 41	203.7	169.9	198.2	95.7
21	Story 40	198.5	165.5	193.2	92.6
22	Story 39	193.3	161	188.1	89.6

23	Story 38	188	156.4	182.9	86.5
24	Story 37	182.7	151.8	177.7	83.5
25	Story 36	177.3	147	172.4	80.5
26	Story 35	171.9	142.2	167.1	77.4
27	Story 34	166.4	137.4	161.7	74.4
28	Story 33	160.9	132.6	156.4	71.4
29	Story 32	155.4	128	151	68.4
30	Story 31	149.9	123.3	145.5	65.4
31	Story 30	144.3	118.7	140.1	62.4
32	Story 29	138.8	114	134.7	59.5
33	Story 28	133.2	109.4	129.2	56.6
34	Story 27	127.6	104.7	123.8	53.7
35	Story 26	122.1	100.1	118.3	50.8
36	Story 25	116.5	95.3	112.9	48
37	Story 24	111	90.5	107.5	45.2
38	Story 23	105.5	85.8	102.1	42.5
39	Story 22	100	81	96.7	39.8
40	Story 21	94.5	76.4	91.4	37.2
41	Story 20	89.1	71.9	86.1	34.7
42	Story 19	83.7	67.5	80.8	32.4
43	Story 18	78.4	63.2	75.6	30.1
44	Story 17	73.1	58.9	70.4	27.9
45	Story 16	67.9	54.7	65.3	25.8
46	Story 15	62.7	50.6	60.3	23.7
47	Story 14	57.6	46.4	55.3	21.7
48	Story 13	52.5	42.3	50.4	19.7
49	Story 12	47.6	38.2	45.6	17.7
50	Story 11	42.7	34	40.8	15.8
51	Story 10	37.9	30	36.2	14
52	Story 9	33.2	26.2	31.7	12.2
53	Story 8	28.6	22.5	27.2	10.5
54	Story 7	24.1	18.9	22.9	8.9
55	Story 6	19.8	15.5	18.8	7.3
56	Story 5	15.6	12.3	14.8	5.9
57	Story 4	11.6	9.2	11.1	4.5
58	Story 3	7.9	6.3	7.6	3.1
59	Story 2	4.6	3.7	4.5	1.9
60	Story 1	1.9	1.6	1.9	0.9
61	base	0	0	0	0

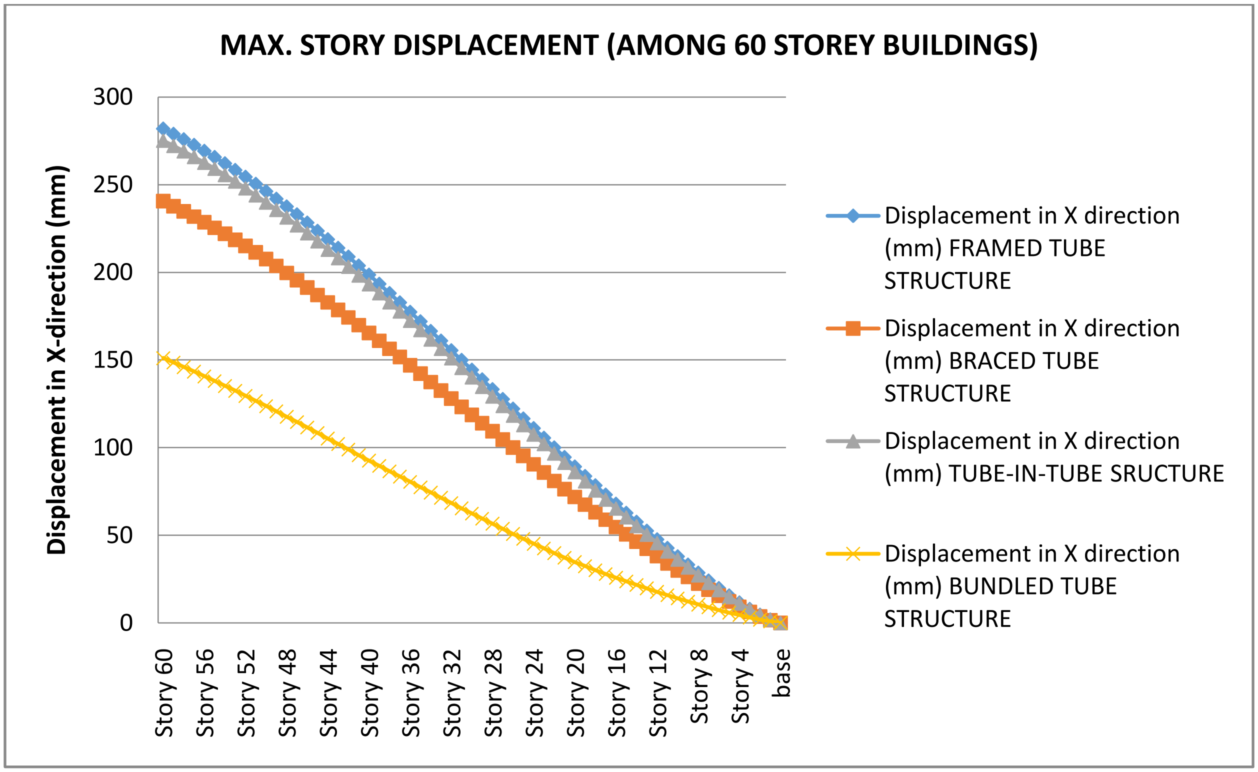

Fig-5.1.3.1(a): Max. Story Displacement in X-direction (among 60 story buildings)

Table: 5.1.3.1(b) Max. Storey Displacement (along Y direction)

MAXIMUM STORY DISPLACEMENT (AMONG 60 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
S.No	Story No.	Displacement in Y direction (mm)			
		FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 60	413.1	372.3	402.8	291.1
2	Story 59	406.8	366.2	396.4	285.1
3	Story 58	400.4	360.1	390	279
4	Story 57	393.9	353.9	383.4	272.8
5	Story 56	387.4	347.5	376.8	266.6
6	Story 55	380.6	341.1	370	260.4
7	Story 54	373.8	334.7	363.1	254.1

8	Story 53	366.8	328	356.1	247.8
9	Story 52	359.7	321.4	349.1	241.5
10	Story 51	352.5	314.6	341.9	235.1
11	Story 50	345.2	307.7	334.6	228.7
12	Story 49	337.8	300.8	327.2	222.2
13	Story 48	330.3	293.8	319.7	215.8
14	Story 47	322.7	286.7	312.1	209.3
15	Story 46	314.9	279.6	304.5	202.8
16	Story 45	307.1	272.4	296.8	196.4
17	Story 44	299.3	265.1	289	189.9
18	Story 43	291.3	257.8	281.1	183.4
19	Story 42	283.3	250.4	273.3	177
20	Story 41	275.3	243	265.3	170.7
21	Story 40	267.2	235.5	257.3	164.4
22	Story 39	259	228.1	249.3	158.2
23	Story 38	250.8	220.7	241.3	152.1
24	Story 37	242.6	213.2	233.2	146
25	Story 36	234.4	205.7	225.2	140
26	Story 35	226.1	198.2	217.1	134
27	Story 34	217.9	190.8	209	128
28	Story 33	209.7	183.4	201	122.2
29	Story 32	201.4	176	192.9	116.3
30	Story 31	193.2	168.6	184.9	110.6
31	Story 30	185.1	161.2	177	104.9
32	Story 29	176.9	153.8	169	99.3
33	Story 28	168.8	146.5	161.2	93.8
34	Story 27	160.8	139.3	153.3	88.4
35	Story 26	152.8	132.3	145.6	83.1
36	Story 25	144.9	125.2	137.9	77.9
37	Story 24	137.1	118.3	130.3	72.8
38	Story 23	129.3	111.4	122.8	67.9
39	Story 22	121.7	104.6	115.5	63.1
40	Story 21	114.1	97.9	108.2	58.4
41	Story 20	106.7	91.4	101	54
42	Story 19	99.4	85	94	49.9
43	Story 18	92.2	78.7	87.1	46
44	Story 17	85.2	72.4	80.3	42.1

45	Story 16	78.3	66.3	73.7	38.5
46	Story 15	71.6	60.5	67.3	34.9
47	Story 14	65	54.8	61	31.5
48	Story 13	58.6	49.4	54.9	28.1
49	Story 12	52.4	44	49	25
50	Story 11	46.4	38.8	43.3	22
51	Story 10	40.6	33.8	37.9	19.1
52	Story 9	35	29.1	32.6	16.3
53	Story 8	29.7	24.7	27.6	13.8
54	Story 7	24.6	20.4	22.8	11.3
55	Story 6	19.7	16.3	18.3	9.1
56	Story 5	15.2	12.5	14.1	7
57	Story 4	11	9	10.2	5.1
58	Story 3	7.2	5.8	6.7	3.5
59	Story 2	3.9	3.2	3.7	2
60	Story 1	1.4	1.2	1.4	0.8
61	base	0	0	0	0

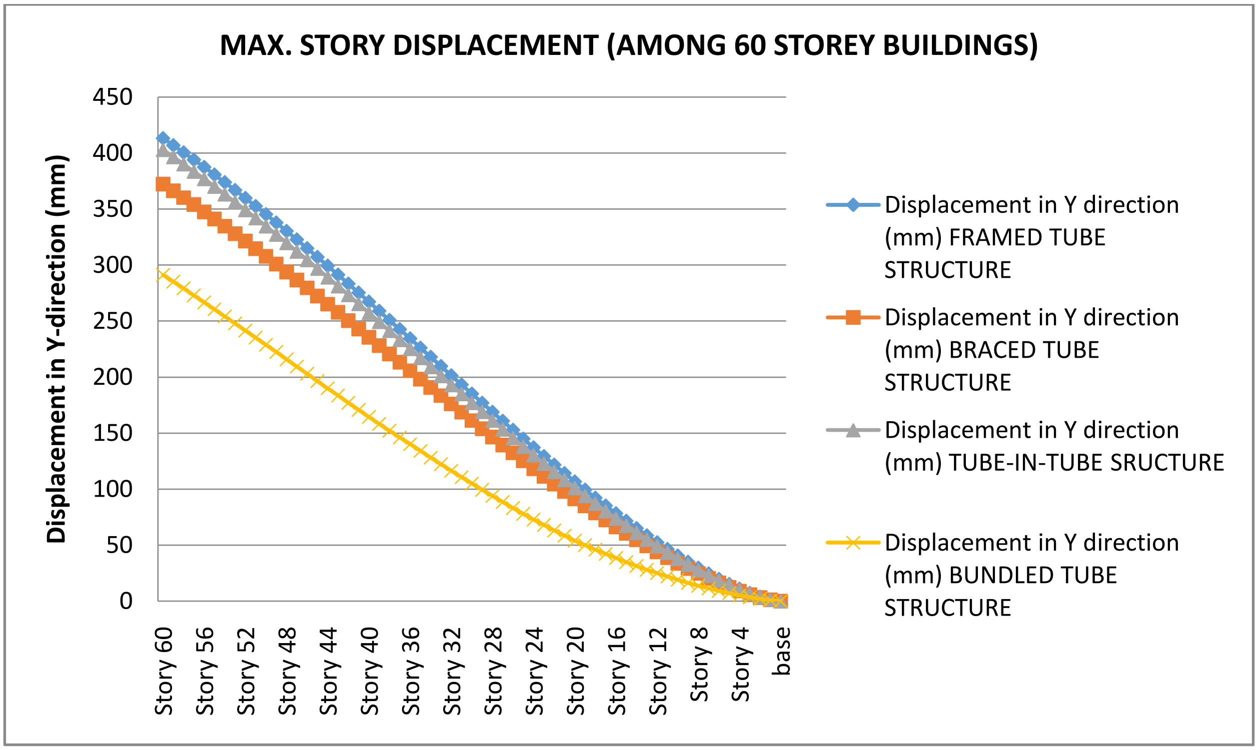

Fig-**5.1.3.1(b)**: Max. Story Displacement in Y-direction (among 60 story buildings)

5.1.3.2Storey Drift: Comparison of max storey drift between all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 60 storey buildings.

Table: 5.1.3.2(a) Storey Drift (along x direction)

MAX. STORY DRIFT (AMONG 60 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Drift in X direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 60	0.000855	0.000829	0.000855	0.000717
2	Story 59	0.000882	0.000849	0.00088	0.000731
3	Story 58	0.000917	0.000871	0.000913	0.000746
4	Story 57	0.000956	0.000896	0.000949	0.000762
5	Story 56	0.000996	0.000922	0.000987	0.000777
6	Story 55	0.001037	0.00095	0.001025	0.000792
7	Story 54	0.001077	0.00098	0.001063	0.000807
8	Story 53	0.001117	0.001013	0.0011	0.00082
9	Story 52	0.001155	0.001047	0.001136	0.000833
10	Story 51	0.001192	0.001083	0.001171	0.000846
11	Story 50	0.001227	0.00112	0.001205	0.000857
12	Story 49	0.001261	0.001156	0.001238	0.000867
13	Story 48	0.001293	0.001182	0.001269	0.000876
14	Story 47	0.001324	0.001194	0.001298	0.000884
15	Story 46	0.001353	0.001203	0.001326	0.000891
16	Story 45	0.00138	0.001213	0.001352	0.000897
17	Story 44	0.001405	0.001222	0.001377	0.000901
18	Story 43	0.001429	0.001234	0.0014	0.000904
19	Story 42	0.001451	0.001248	0.001422	0.000903
20	Story 41	0.001472	0.001265	0.001442	0.000896
21	Story 40	0.001491	0.001285	0.00146	0.000867
22	Story 39	0.001508	0.001308	0.001477	0.000867
23	Story 38	0.001523	0.001335	0.001492	0.000867

24	Story 37	0.001537	0.001362	0.001505	0.000866
25	Story 36	0.001549	0.001376	0.001517	0.000866
26	Story 35	0.00156	0.001367	0.001528	0.000864
27	Story 34	0.001569	0.001354	0.001537	0.000862
28	Story 33	0.001577	0.001342	0.001544	0.000859
29	Story 32	0.001582	0.001333	0.00155	0.000854
30	Story 31	0.001587	0.001326	0.001554	0.000849
31	Story 30	0.00159	0.001323	0.001557	0.000843
32	Story 29	0.001591	0.001324	0.001558	0.000836
33	Story 28	0.001591	0.001328	0.001557	0.000827
34	Story 27	0.001589	0.001337	0.001556	0.000818
35	Story 26	0.001586	0.00135	0.001553	0.000807
36	Story 25	0.001581	0.001366	0.001548	0.000794
37	Story 24	0.001575	0.001372	0.001542	0.000781
38	Story 23	0.001568	0.001346	0.001534	0.000765
39	Story 22	0.001559	0.001314	0.001525	0.000746
40	Story 21	0.001549	0.001285	0.001515	0.000716
41	Story 20	0.001537	0.001259	0.001503	0.000655
42	Story 19	0.001525	0.001237	0.00149	0.00064
43	Story 18	0.00151	0.001218	0.001475	0.000626
44	Story 17	0.001495	0.001202	0.001459	0.000612
45	Story 16	0.001478	0.00119	0.001441	0.000598
46	Story 15	0.00146	0.001183	0.001422	0.000584
47	Story 14	0.00144	0.00118	0.001401	0.00057
48	Story 13	0.001419	0.001184	0.001378	0.000554
49	Story 12	0.001396	0.001143	0.001353	0.000538
50	Story 11	0.001371	0.001098	0.001326	0.000522
51	Story 10	0.001344	0.001055	0.001296	0.000505
52	Story 9	0.001314	0.001015	0.001263	0.000486
53	Story 8	0.001281	0.000974	0.001227	0.000467
54	Story 7	0.001242	0.000931	0.001185	0.000447
55	Story 6	0.001195	0.000882	0.001135	0.000425
56	Story 5	0.001135	0.00082	0.001075	0.000401
57	Story 4	0.001055	0.000737	0.000997	0.000374
58	Story 3	0.000942	0.00062	0.000891	0.000342
59	Story 2	0.000781	0.000371	0.00074	0.000302
60	Story 1	0.00045	0.000002	0.000443	0.000212

61	base	0.00012	0.000002	0.00012	0.00012

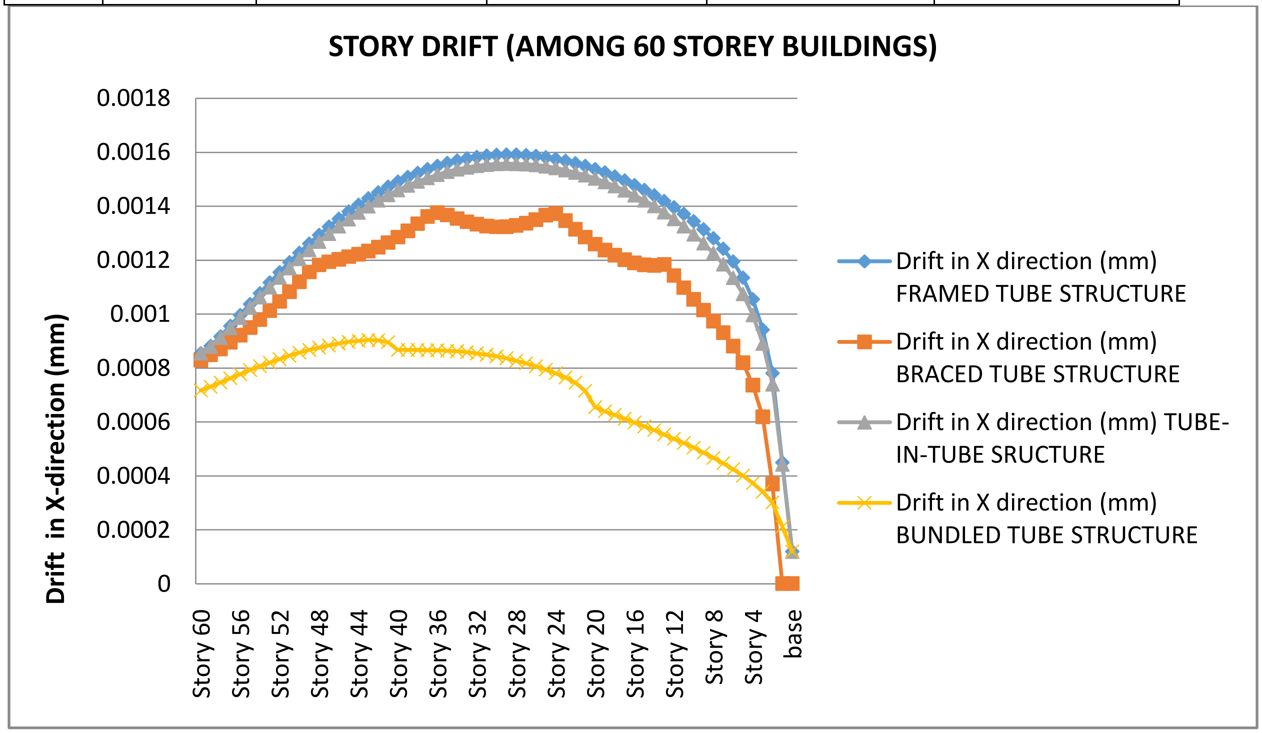

Fig-5.1.3.2(a): Story Drift along X-direction (in mm)

Table: 5.1.3.2(b) Storey Drift (along Y- direction)

MAX. STORY DRIFT (AMONG 60 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Drift in Y direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 60	0.001796	0.001728	0.001825	0.00173
2	Story 59	0.001818	0.001748	0.001845	0.001741
3	Story 58	0.001848	0.001774	0.001871	0.001754
4	Story 57	0.001882	0.001802	0.001902	0.001768
5	Story 56	0.001918	0.001831	0.001933	0.001781
6	Story 55	0.001954	0.001861	0.001965	0.001793
7	Story 54	0.001989	0.001886	0.001996	0.001805

8	Story 53	0.002024	0.00191	0.002027	0.001815
9	Story 52	0.002058	0.001933	0.002056	0.001825
10	Story 51	0.00209	0.001956	0.002085	0.001833
11	Story 50	0.002121	0.00198	0.002112	0.001839
12	Story 49	0.00215	0.002003	0.002137	0.001844
13	Story 48	0.002177	0.002023	0.002161	0.001848
14	Story 47	0.002203	0.00204	0.002184	0.001849
15	Story 46	0.002227	0.002056	0.002204	0.001849
16	Story 45	0.002249	0.002073	0.002223	0.001846
17	Story 44	0.002269	0.002092	0.00224	0.001841
18	Story 43	0.002287	0.002113	0.002256	0.001834
19	Story 42	0.002303	0.002124	0.002269	0.001821
20	Story 41	0.002317	0.002124	0.00228	0.001799
21	Story 40	0.002329	0.002124	0.002289	0.001762
22	Story 39	0.002339	0.002125	0.002297	0.001748
23	Story 38	0.002346	0.00213	0.002302	0.001736
24	Story 37	0.002352	0.002137	0.002305	0.001724
25	Story 36	0.002355	0.002139	0.002306	0.001711
26	Story 35	0.002355	0.002132	0.002305	0.001697
27	Story 34	0.002354	0.002122	0.002301	0.001681
28	Story 33	0.00235	0.002115	0.002295	0.001663
29	Story 32	0.002344	0.002113	0.002288	0.001643
30	Story 31	0.002336	0.002114	0.002277	0.001622
31	Story 30	0.002325	0.002107	0.002265	0.001599
32	Story 29	0.002312	0.002081	0.00225	0.001573
33	Story 28	0.002297	0.002051	0.002233	0.001546
34	Story 27	0.002279	0.002026	0.002213	0.001517
35	Story 26	0.002259	0.002005	0.002192	0.001485
36	Story 25	0.002237	0.001989	0.002167	0.001451
37	Story 24	0.002212	0.001973	0.002141	0.001414
38	Story 23	0.002184	0.001938	0.002112	0.001373
39	Story 22	0.002155	0.001899	0.00208	0.001325
40	Story 21	0.002122	0.001864	0.002046	0.00126
41	Story 20	0.002088	0.001835	0.00201	0.001171
42	Story 19	0.002051	0.001813	0.001971	0.001128
43	Story 18	0.002011	0.001786	0.00193	0.001091
44	Story 17	0.001969	0.001732	0.001886	0.001055

45	Story 16	0.001924	0.001672	0.001839	0.001019
46	Story 15	0.001876	0.001615	0.00179	0.000982
47	Story 14	0.001826	0.001566	0.001738	0.000944
48	Story 13	0.001773	0.001525	0.001684	0.000905
49	Story 12	0.001717	0.001487	0.001626	0.000865
50	Story 11	0.001658	0.001422	0.001566	0.000823
51	Story 10	0.001595	0.001349	0.001502	0.00078
52	Story 9	0.001529	0.001278	0.001435	0.000736
53	Story 8	0.001458	0.001214	0.001363	0.00069
54	Story 7	0.001381	0.00116	0.001287	0.000642
55	Story 6	0.001297	0.001105	0.001203	0.000591
56	Story 5	0.001199	0.001009	0.00111	0.000539
57	Story 4	0.001083	0.000892	0.001	0.000483
58	Story 3	0.000932	0.000755	0.000862	0.00042
59	Story 2	0.00072	0.00058	0.00067	0.000342
60	Story 1	0.000337	0.000302	0.000322	0.000188
61	base	0.000108	0.000218	0.000108	0.000108

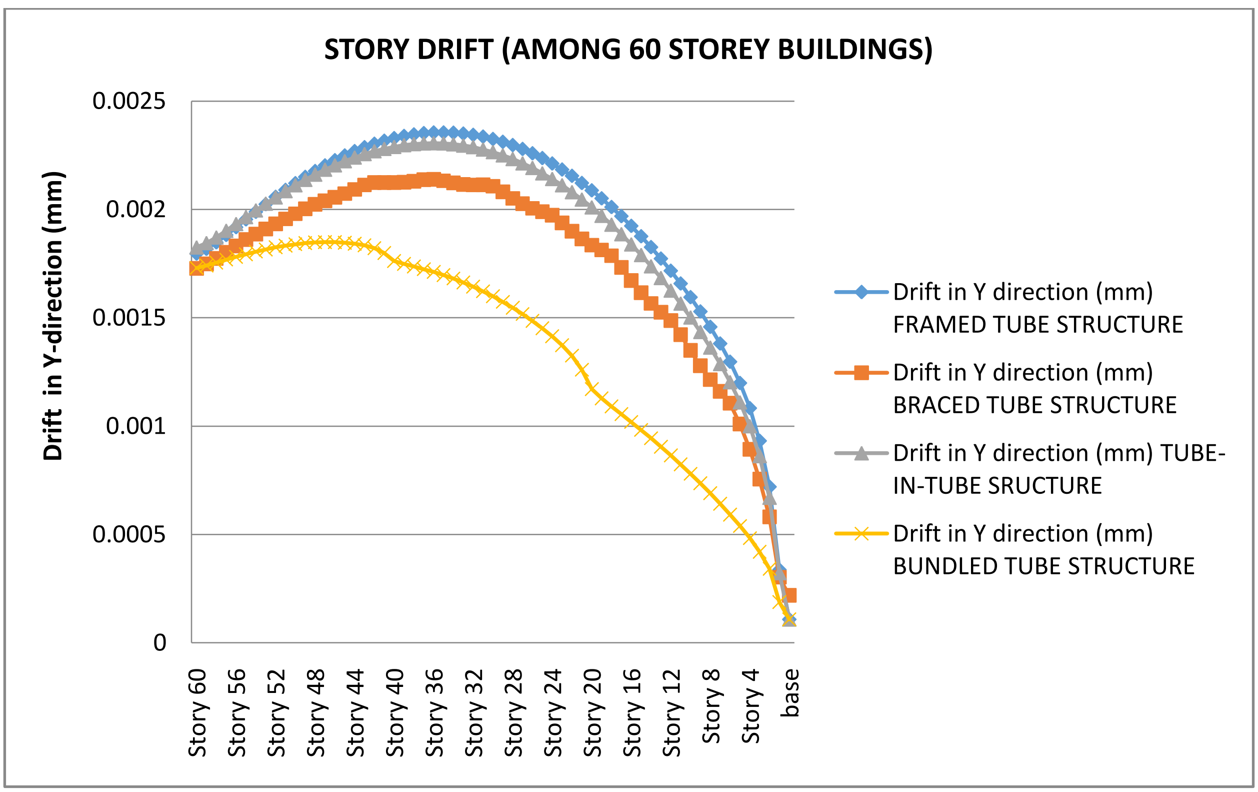

Fig-5.1.3.2(b): Story Drift along Y-direction (in mm)

5.1.3.3Modal Mass Participation Factor

Here the modal mass participation factor of different modes obtained from analysis is discussed for all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 60 storey buildings.

Table: 5.1.3.3(a) Modal mass participation factor for framed tube structure

Modal Participation factor (FRAMED TUBE STRUCTURE) (AMONG 60 STOREY BUILDINGS)					
Mode	**Period**	**UX**	**UY**	**SumUX**	**SumUY**
1	7.523686	-0.00649	-298.295	-307.185	-298.288
2	5.42402	-307.179	0.006526	-307.175	-0.00071
3	3.438451	0.003341	-0.00724	0.006551	145.2639
4	2.104542	0.00321	145.2711	131.7744	145.2678
5	1.686307	131.7712	-0.00332	131.7723	0.004159
6	1.127043	0.00111	0.00748	0.00307	75.11455
7	1.057941	0.00196	75.10707	-69.3501	75.10904
8	0.906103	-69.352	0.00197	-69.3533	-52.5362
9	0.705489	-0.00125	-52.5381	-0.00193	-52.5191
10	0.653578	-0.00067	0.01903	49.86031	0.017766
11	0.623618	49.86099	-0.00126	49.86005	-40.1292
12	0.520231	-0.00094	-40.1279	-0.00094	-40.1279

Table: 5.1.3.3(b) Modal mass participation factor for braced tube structure

Modal Participation factor (BRACED TUBE STRUCTURE) (AMONG 60 STOREY BUILDINGS)					
Mode	**Period**	**UX**	**UY**	**SumUX**	**SumUY**
1	7.079043	0.000892	297.4457	-306.397	297.4483
2	4.956331	-306.398	0.002649	-306.406	-0.03621
3	2.979134	-0.00739	-0.03886	-0.00845	149.4675
4	1.913576	-0.00106	149.5064	137.4065	149.5073
5	1.513775	137.4075	0.000941	137.3982	0.448842
6	0.975153	-0.00932	0.447901	-0.00914	77.63264
7	0.946346	0.000181	77.18474	70.65187	77.18538
8	0.801848	70.65169	0.000644	70.65209	53.6145
9	0.627311	0.000407	53.61386	0.115455	53.67938
10	0.565358	0.115048	0.065523	50.66393	0.066305

11	0.55235	50.54888	0.000782	50.5483	-40.3606
12	0.462369	-0.00058	-40.3613	-0.00058	-40.3613

Table: 5.1.3.3(c) Modal mass participation factor for tube-in-tube structure

Modal Participation factor (TUBE-IN-TUBE STRUCTURE) (AMONG 60 STOREY BUILDINGS)					
Mode	Period	UX	UY	SumUX	SumUY
1	7.392061	0.000519	-300.086	309.7935	-300.086
2	5.349536	309.793	0.00048	309.7888	0.003208
3	3.420237	-0.00419	0.002728	-0.00456	148.8014
4	2.02517	-0.00036	148.7987	133.6251	148.7992
5	1.652942	133.6255	0.000503	133.6274	-0.00062
6	1.119654	0.001907	-0.00112	0.001408	77.25605
7	1.007378	-0.0005	77.25716	-71.0309	77.25685
8	0.883022	-71.0304	-0.00032	-71.03	-53.612
9	0.668451	0.000477	-53.6117	0.00163	-53.6145
10	0.648153	0.001153	-0.00281	51.26155	-0.00246
11	0.604145	51.2604	0.000351	51.2607	-40.708
12	0.492606	0.000306	-40.7083	0.000306	-40.7083

Table: 5.1.3.3(d) Modal mass participation factor for Bundled Tube structure

Modal Participation factor (BUNDLED TUBE STRUCTURE) (AMONG 60 STOREY BUILDINGS)					
Mode	Period	UX	UY	SumUX	SumUY
1	5.610974	21.0439	271.6354	304.1145	242.6379
2	3.48794	283.0706	-28.9975	283.0703	-28.9974
3	2.498376	-0.00037	0.000124	-27.6605	-170.367
4	1.543683	-27.6602	-170.368	131.8265	-185.268
5	1.112649	159.4867	-14.9008	159.4854	-14.9002
6	1.021918	-0.00131	0.000609	-0.72369	-91.7266
7	0.751368	-0.72238	-91.7272	-0.72154	-91.7263
8	0.628171	0.000845	0.000861	-82.3454	-0.66886
9	0.585201	-82.3462	-0.66972	-82.401	58.75797
10	0.469021	-0.05475	59.42769	-0.05401	59.42826
11	0.405218	0.000739	0.000572	-54.8579	-0.82668
12	0.382204	-54.8587	-0.82725	-54.8587	-0.82725

Table: 5.1.3.3(e) Comparison chart between mode and time period (among 60 story buildings)

Modal Participation factor (Among 60 Story Buildings)				
Mode	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE STRUCTURE	BUNDLED TUBE STRUCTURE
	Time Period(sec)			
Mode-1	7.523686	7.079043	7.392061	5.610974
Mode-2	5.42402	4.956331	5.349536	3.48794
Mode-3	3.438451	2.979134	3.420237	2.498376
Mode-4	2.104542	1.913576	2.02517	1.543683
Mode-5	1.686307	1.513775	1.652942	1.112649
Mode-6	1.127043	0.975153	1.119654	1.021918
Mode-7	1.057941	0.946346	1.007378	0.751368
Mode-8	0.906103	0.801848	0.883022	0.628171
Mode-9	0.705489	0.627311	0.668451	0.585201
Mode-10	0.653578	0.565358	0.648153	0.469021
Mode-11	0.623618	0.55235	0.604145	0.405218
Mode-12	0.520231	0.462369	0.492606	0.382204

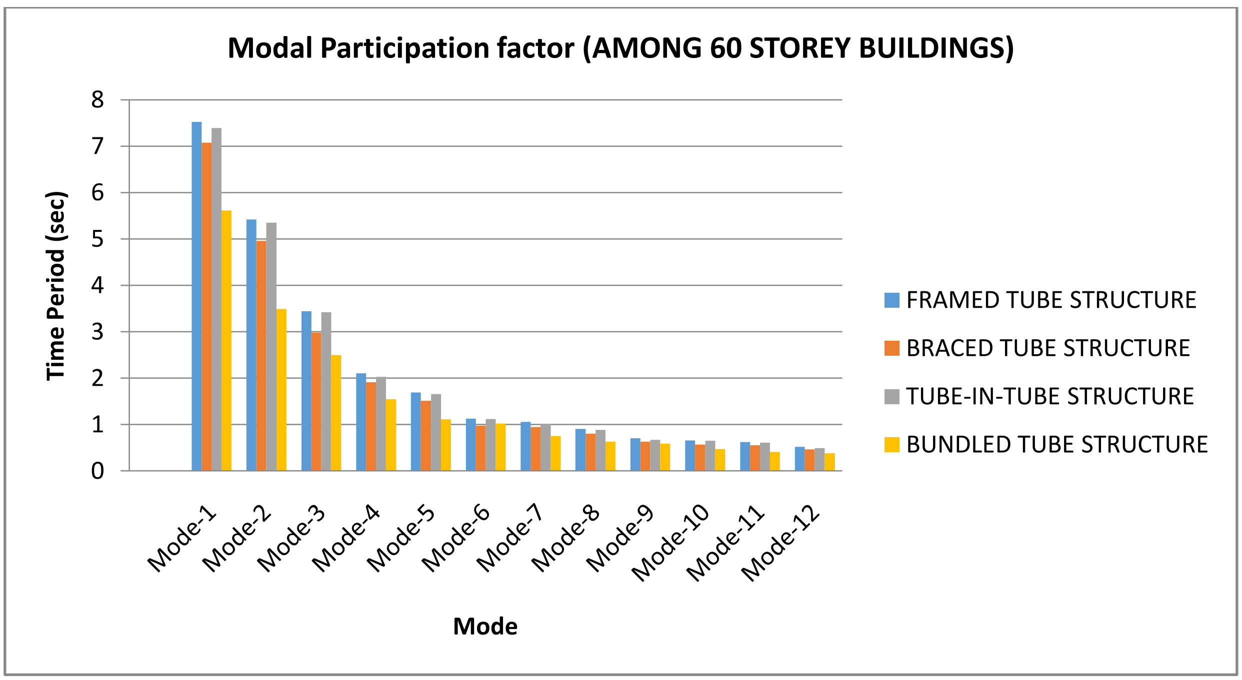

Fig-5.1.3.3: Graph between mode and time period(among 60 story buildings)

5.1.3.4 Story Shear

Story shear obtained from analysis is discussed for all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 40 storey buildings.

Table: 5.1.3.4(a) Story Shear along X direction (among 60 story buildings)

STORY SHEAR (AMONG 60 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
S.No	Story No.	Story Shear in X direction(VX) (kN)			
		FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 60	827.79	831.24	851.67	842.68
2	Story 59	1884.85	1898	1930.21	1786.13
3	Story 58	2906.5	2929.03	2972.62	2697.97
4	Story 57	3893.35	3924.93	3979.52	3578.74
5	Story 56	4845.99	4886.31	4951.52	4428.99
6	Story 55	5765.03	5813.78	5889.23	5249.25
7	Story 54	6651.08	6707.96	6793.28	6040.06
8	Story 53	7504.73	7569.44	7664.27	6801.96
9	Story 52	8326.59	8398.84	8502.83	7535.49
10	Story 51	9117.26	9196.77	9309.57	8241.18
11	Story 50	9877.35	9963.83	10085.1	8919.57
12	Story 49	10607.46	10700.64	10830.04	9571.2
13	Story 48	11308.19	11407.8	11545.01	10196.62
14	Story 47	11980.15	12085.92	12230.62	10796.35
15	Story 46	12623.93	12735.61	12887.48	11370.94
16	Story 45	13240.15	13357.48	13516.22	11920.92
17	Story 44	13829.4	13952.14	14117.45	12446.84
18	Story 43	14392.29	14520.2	14691.77	12949.23
19	Story 42	14929.43	15062.26	15239.82	13428.63
20	Story 41	15441.41	15578.93	15762.2	13885.58
21	Story 40	15928.83	16070.83	16259.53	14430.64
22	Story 39	16392.31	16538.56	16732.43	14959.79

23	Story 38	16832.44	16982.73	17181.5	15462.3
24	Story 37	17249.83	17403.95	17607.37	15938.83
25	Story 36	17645.09	17802.83	18010.66	16390.1
26	Story 35	18018.8	18179.98	18391.96	16816.77
27	Story 34	18371.59	18536	18751.92	17219.55
28	Story 33	18704.04	18871.5	19091.13	17599.11
29	Story 32	19016.77	19187.1	19410.21	17956.16
30	Story 31	19310.38	19483.4	19709.78	18291.37
31	Story 30	19585.47	19761.01	19990.46	18605.44
32	Story 29	19842.64	20020.54	20252.86	18899.05
33	Story 28	20082.5	20262.6	20497.59	19172.9
34	Story 27	20305.65	20487.8	20725.27	19427.67
35	Story 26	20512.69	20696.74	20936.52	19664.05
36	Story 25	20704.23	20890.04	21131.95	19882.74
37	Story 24	20880.87	21068.3	21312.18	20084.41
38	Story 23	21043.21	21232.13	21477.82	20269.76
39	Story 22	21191.86	21382.14	21629.49	20439.47
40	Story 21	21327.42	21518.95	21767.8	20594.24
41	Story 20	21450.49	21643.15	21893.38	20762.53
42	Story 19	21561.68	21755.36	22006.82	20917.18
43	Story 18	21661.59	21856.18	22108.76	21056.14
44	Story 17	21750.82	21946.23	22199.8	21180.25
45	Story 16	21829.97	22026.11	22280.57	21290.35
46	Story 15	21899.66	22096.44	22351.67	21387.28
47	Story 14	21960.48	22157.81	22413.72	21471.87
48	Story 13	22013.03	22210.85	22467.35	21544.97
49	Story 12	22057.92	22256.15	22513.15	21607.41
50	Story 11	22095.76	22294.34	22551.76	21660.03
51	Story 10	22127.14	22326.01	22583.77	21703.68
52	Story 9	22152.67	22351.77	22609.82	21739.19
53	Story 8	22172.95	22372.24	22630.51	21767.39
54	Story 7	22188.59	22388.01	22646.47	21789.14
55	Story 6	22200.18	22399.72	22658.3	21805.27
56	Story 5	22208.34	22407.95	22666.62	21816.61
57	Story 4	22213.66	22413.31	22672.05	21824.01
58	Story 3	22216.74	22416.43	22675.2	21828.31
59	Story 2	22218.2	22417.91	22676.69	21830.34

60	Story 1	22218.65	22418.35	22677.14	21830.96

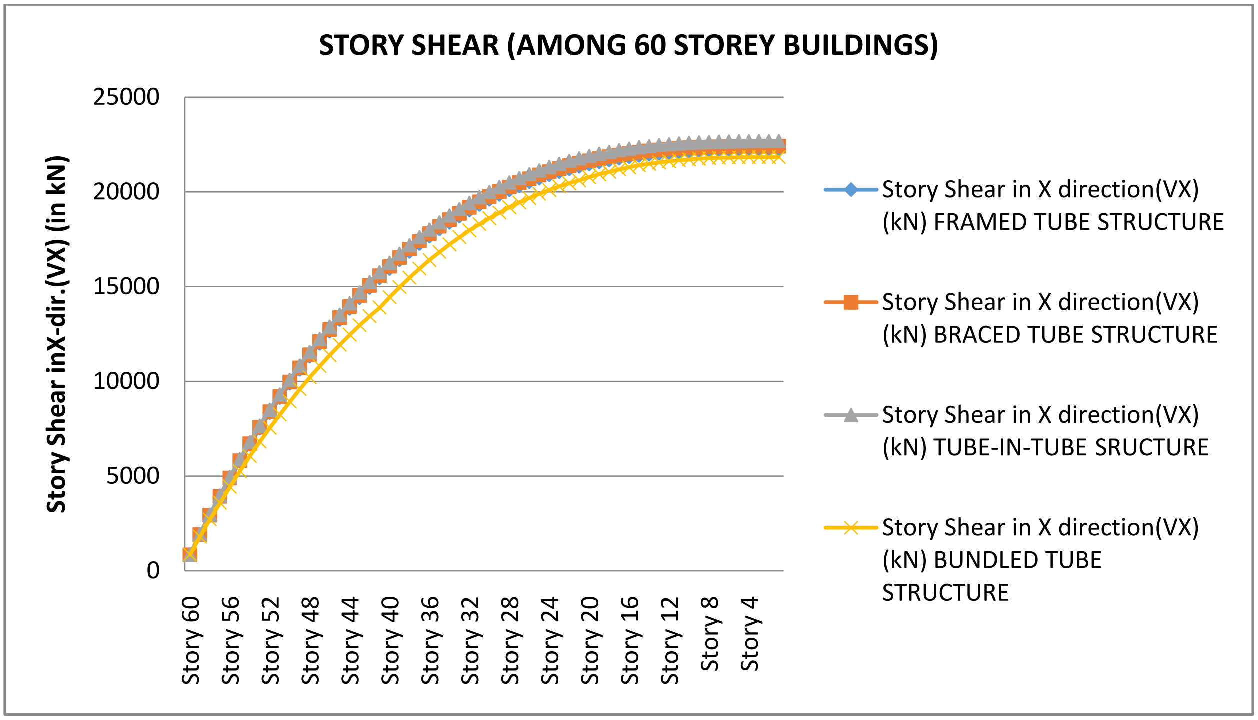

Fig-**5.1.3.4(a)**: Story Shear along X-direction (in mm) (among 60 story buildings)

Table: 5.1.3.4(b) Story Shear along Y direction (among 60 story buildings)

STORY SHEAR (AMONG 60 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Story Shear in Y direction(VY) (kN)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 60	583.94	586.38	600.79	594.45
2	Story 59	1329.62	1338.9	1361.62	1259.98
3	Story 58	2050.32	2066.21	2096.97	1903.22
4	Story 57	2746.47	2768.75	2807.26	2524.54
5	Story 56	3418.49	3446.93	3492.93	3124.33
6	Story 55	4066.81	4101.2	4154.42	3702.96
7	Story 54	4691.84	4731.97	4792.16	4260.82

8	Story 53	5294.03	5339.68	5406.58	4798.28
9	Story 52	5873.79	5924.76	5998.12	5315.73
10	Story 51	6431.56	6487.64	6567.21	5813.54
11	Story 50	6967.74	7028.75	7114.3	6292.1
12	Story 49	7482.78	7548.51	7639.8	6751.78
13	Story 48	7977.1	8047.36	8144.15	7192.96
14	Story 47	8451.11	8525.73	8627.8	7616.03
15	Story 46	8905.25	8984.03	9091.17	8021.36
16	Story 45	9339.95	9422.72	9534.7	8409.33
17	Story 44	9755.62	9842.21	9958.82	8780.33
18	Story 43	10152.7	10242.93	10363.97	9134.73
19	Story 42	10531.61	10625.31	10750.57	9472.91
20	Story 41	10892.77	10989.79	11119.07	9795.26
21	Story 40	11236.62	11336.79	11469.9	10179.75
22	Story 39	11563.57	11666.74	11803.49	10553.03
23	Story 38	11874.05	11980.07	12120.28	10907.51
24	Story 37	12168.49	12277.21	12420.7	11243.67
25	Story 36	12447.31	12558.59	12705.19	11562.01
26	Story 35	12710.94	12824.63	12974.18	11862.99
27	Story 34	12959.8	13075.78	13228.1	12147.12
28	Story 33	13194.32	13312.45	13467.38	12414.88
29	Story 32	13414.93	13535.09	13692.47	12666.75
30	Story 31	13622.05	13744.1	13903.8	12903.21
31	Story 30	13816.1	13939.94	14101.8	13124.77
32	Story 29	13997.52	14123.02	14286.9	13331.89
33	Story 28	14166.72	14293.77	14459.54	13525.07
34	Story 27	14324.14	14452.63	14620.15	13704.79
35	Story 26	14470.19	14600.03	14769.17	13871.54
36	Story 25	14605.31	14736.38	14907.03	14025.81
37	Story 24	14729.91	14862.13	15034.17	14168.07
38	Story 23	14844.43	14977.7	15151.02	14298.82
39	Story 22	14949.3	15083.53	15258.01	14418.54
40	Story 21	15044.92	15180.03	15355.58	14527.72
41	Story 20	15131.74	15267.65	15444.16	14646.44
42	Story 19	15210.18	15346.8	15524.19	14755.53
43	Story 18	15280.65	15417.93	15596.1	14853.56
44	Story 17	15343.6	15481.45	15660.33	14941.11
45	Story 16	15399.44	15537.8	15717.3	15018.77

46	Story 15	15448.6	15587.41	15767.46	15087.15
47	Story 14	15491.5	15630.71	15811.23	15146.82
48	Story 13	15528.57	15668.12	15849.06	15198.39
49	Story 12	15560.24	15700.08	15881.37	15242.43
50	Story 11	15586.93	15727.01	15908.6	15279.56
51	Story 10	15609.07	15749.35	15931.19	15310.35
52	Story 9	15627.08	15767.53	15949.56	15335.39
53	Story 8	15641.38	15781.96	15964.16	15355.29
54	Story 7	15652.41	15793.1	15975.41	15370.64
55	Story 6	15660.59	15801.35	15983.76	15382.01
56	Story 5	15666.35	15807.16	15989.63	15390.01
57	Story 4	15670.1	15810.94	15993.46	15395.23
58	Story 3	15672.28	15813.14	15995.68	15398.26
59	Story 2	15673.31	15814.18	15996.73	15399.7
60	Story 1	15673.62	15814.5	15997.05	15400.13

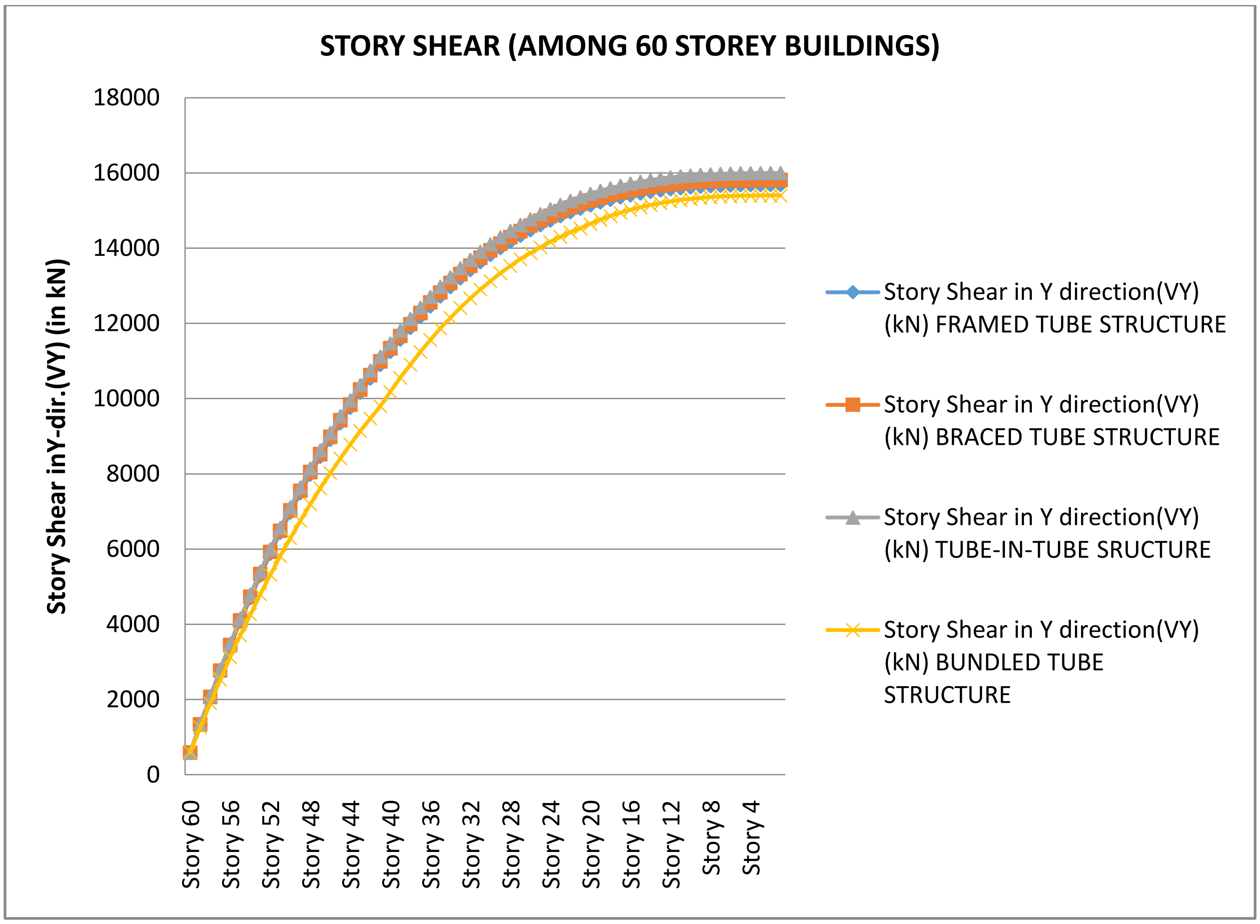

Fig-5.1.3.4(b): Story Shear along Y-direction (in mm) (among 60 story buildings)

5.1.3.5 Base shear:-

Comparison of total base shears between all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 60 storey buildings.

Table: 5.1.3.5 Base shears in four types of RCC Tubular structures(among 60 story buildings)

Base Shear (in kN)	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
In X-Direction	22218.65	22418.35	22677.14	21830.96
In Y-Direction	15673.62	15814.5	15997.05	15400.13

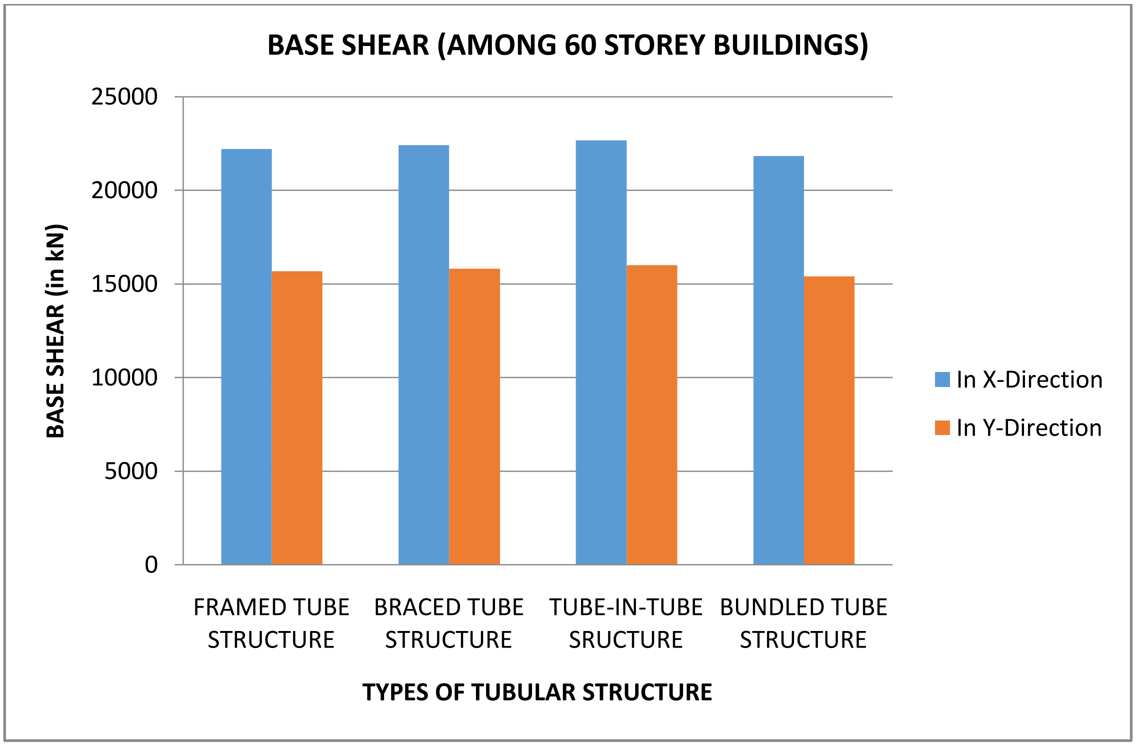

Fig-5.1.3.5: Base Shear along X & Y-direction (in mm) (among 60 story buildings)

5.1.4 Comparison between four different Tubular structures with 80 story height

5.1.4.1 Storey Displacement: Comparison of max storey displacement between all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 80 storey buildings.

Table: 5.1.4.1(a) Max. Storey Displacement (along X direction)

MAXIMUM STORY DISPLACEMENT (AMONG 80 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Displacement in X direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 80	249.8	232.9	246.4	141
2	Story 79	247.2	230.3	243.8	138.9
3	Story 78	244.6	227.7	241.1	136.8
4	Story 77	241.9	225.1	238.3	134.6
5	Story 76	239.2	222.4	235.6	132.4
6	Story 75	236.4	219.6	232.7	130.3
7	Story 74	233.5	216.8	229.9	128
8	Story 73	230.6	214	226.9	125.8
9	Story 72	227.7	211	224	123.5
10	Story 71	224.7	208.1	220.9	121.3
11	Story 70	221.6	205.1	217.9	119
12	Story 69	218.5	202.1	214.7	116.6
13	Story 68	215.4	199.1	211.6	114.3
14	Story 67	208.9	196	208.4	112
15	Story 66	205.6	192.9	205.2	109.6
16	Story 65	202.3	189.8	201.9	107.3
17	Story 64	199	186.6	198.6	104.9
18	Story 63	195.6	183.4	195.2	102.5
19	Story 62	192.2	180.1	191.8	100.2

20	Story 61	188.7	176.9	188.4	97.8
21	Story 60	185.2	173.5	185	95.6
22	Story 59	181.7	170.2	181.5	93.4
23	Story 58	178.2	166.8	178	91.3
24	Story 57	174.6	163.4	174.5	89.1
25	Story 56	171	160.1	171	87
26	Story 55	167.4	156.7	167.4	84.8
27	Story 54	163.8	153.3	163.9	82.7
28	Story 53	160.2	149.9	160.3	80.5
29	Story 52	156.5	146.5	156.7	78.3
30	Story 51	152.9	143.1	153	76.1
31	Story 50	149.2	139.7	149.4	73.9
32	Story 49	145.5	136.2	145.8	71.8
33	Story 48	141.9	132.7	142.1	69.6
34	Story 47	138.2	129.2	138.5	67.4
35	Story 46	134.5	125.7	134.9	65.3
36	Story 45	130.8	122.2	131.2	63.1
37	Story 44	127.1	118.8	127.6	60.9
38	Story 43	123.5	115.4	123.9	58.8
39	Story 42	119.8	112	120.3	56.7
40	Story 41	116.1	108.6	116.7	54.6
41	Story 40	112.5	105.2	113.1	52.6
42	Story 39	108.8	101.8	109.5	52.4
43	Story 38	105.2	98.5	105.9	50.5
44	Story 37	101.6	95.1	102.3	46.8
45	Story 36	98	91.7	98.7	44.9
46	Story 35	94.4	88.3	95.2	43
47	Story 34	90.9	84.9	91.7	41.1
48	Story 33	87.4	81.6	88.2	39.3
49	Story 32	83.9	78.4	84.7	37.5
50	Story 31	80.4	75.2	81.3	35.7
51	Story 30	77	72	77.9	32.1
52	Story 29	73.6	68.9	74.5	30.4
53	Story 28	70.2	65.8	71.1	28.7
54	Story 27	66.8	62.8	67.8	27.1
55	Story 26	63.5	59.7	64.6	25.4
56	Story 25	60.3	56.7	61.3	23.8
57	Story 24	57.1	53.7	58.1	22.3
58	Story 23	53.9	50.6	55	20.8
59	Story 22	50.8	47.7	51.9	19.3

60	Story 21	47.7	44.8	48.8	17.9
61	Story 20	44.6	42	45.8	16.7
62	Story 19	41.6	39.3	42.8	15.5
63	Story 18	38.7	36.6	39.9	14.3
64	Story 17	35.8	34	37.1	13.1
65	Story 16	33	31.4	34.2	12
66	Story 15	30.2	28.9	31.5	10.9
67	Story 14	27.5	26.5	28.8	9.9
68	Story 13	24.9	24.1	26.2	9
69	Story 12	22.3	21.7	23.6	8.9
70	Story 11	19.8	19.3	21.1	7.9
71	Story 10	17.3	17	18.7	6.9
72	Story 9	14.9	14.8	16.4	6
73	Story 8	12.6	12.7	14.1	5.1
74	Story 7	10.4	10.7	11.9	4.3
75	Story 6	8.3	8.8	9.8	3.5
76	Story 5	6.2	6.9	7.8	2.8
77	Story 4	4.3	5.2	5.9	2.1
78	Story 3	2.6	3.6	4.1	1.4
79	Story 2	1.1	2.2	2.4	0.9
80	Story 1	0.4	0.9	1.1	0.4
81	base	0	0	0	0

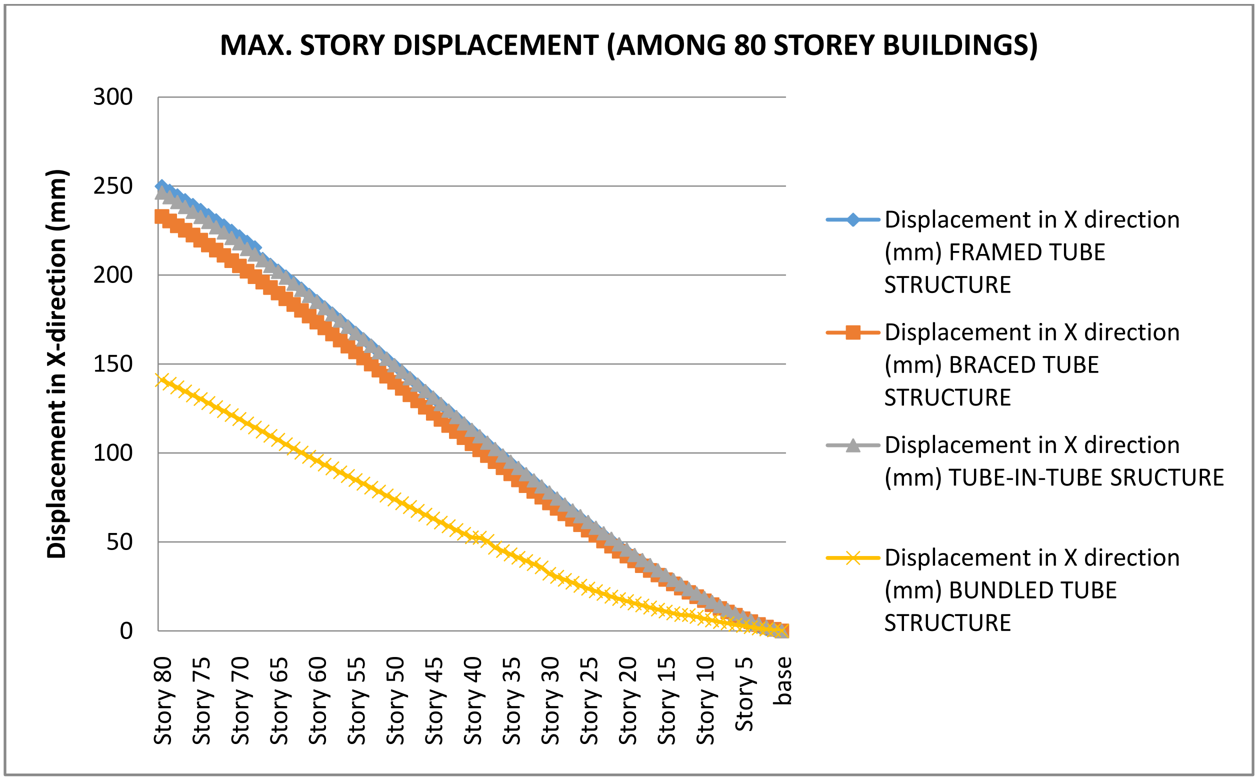

Fig-5.1.4.1(a): Max. Story Displacement in X-direction (among 80 story buildings)

Table: 5.1.4.1(b) Max. Storey Displacement (along Y direction)

MAXIMUM STORY DISPLACEMENT (AMONG 80 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Displacement in Y direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 80	552.2	523.2	543.3	425.8
2	Story 79	545.1	516.1	536.1	418
3	Story 78	538	509	528.8	410.1
4	Story 77	530.8	501.9	521.5	402.1
5	Story 76	523.5	494.8	514.1	394.1
6	Story 75	516.2	487.6	506.7	386.1
7	Story 74	508.8	480.3	499.2	378
8	Story 73	501.3	473	491.6	369.9
9	Story 72	493.7	465.6	484	361.8
10	Story 71	486.1	458.2	476.3	353.6
11	Story 70	478.5	450.7	468.6	345.5

12	Story 69	470.7	443.1	460.8	337.3
13	Story 68	462.9	435.5	453	329.1
14	Story 67	447.2	427.9	445.1	320.9
15	Story 66	439.2	420.2	437.1	312.8
16	Story 65	431.1	412.5	429.1	304.6
17	Story 64	423.1	404.7	421.1	296.6
18	Story 63	414.9	396.9	413	288.6
19	Story 62	406.8	389.1	404.9	280.7
20	Story 61	398.6	381.1	396.8	273
21	Story 60	390.3	373.3	388.6	265.5
22	Story 59	382	365.4	380.4	258.4
23	Story 58	373.7	357.4	372.1	251.5
24	Story 57	365.4	349.4	363.9	244.6
25	Story 56	357.1	341.4	355.6	237.8
26	Story 55	348.7	333.4	347.3	231
27	Story 54	340.3	325.4	339	224.3
28	Story 53	331.9	317.3	330.7	217.6
29	Story 52	323.5	309.3	322.4	211
30	Story 51	315.1	301.3	314.1	204.3
31	Story 50	306.7	293.3	305.7	197.8
32	Story 49	298.4	285.3	297.4	191.2
33	Story 48	290	277.3	289.2	184.8
34	Story 47	281.6	269.4	280.9	178.3
35	Story 46	273.3	261.4	272.6	172
36	Story 45	265	253.5	264.4	165.7
37	Story 44	256.7	245.6	256.2	159.4
38	Story 43	248.4	237.8	248.1	153.3
39	Story 42	240.2	229.9	240	147.2
40	Story 41	232	222.1	231.9	141.3
41	Story 40	223.9	214.4	223.8	135.5
42	Story 39	215.8	206.7	215.9	129.9
43	Story 38	207.8	199.1	207.9	124.5
44	Story 37	199.9	191.6	200.1	119.1
45	Story 36	192	184.1	192.3	113.8
46	Story 35	184.2	176.7	184.6	108.6
47	Story 34	176.4	169.3	176.9	103.5
48	Story 33	168.7	162	169.3	98.4
49	Story 32	161.2	154.9	161.9	93.4
50	Story 31	153.7	147.8	154.5	88.5
51	Story 30	146.3	140.7	147.2	79
52	Story 29	139	133.8	139.9	74.4
53	Story 28	131.8	127	132.8	69.8
54	Story 27	124.7	120.2	125.8	65.4
55	Story 26	117.7	113.6	119	61.1

56	Story 25	110.9	107.2	112.2	56.9
57	Story 24	104.1	100.8	105.6	52.9
58	Story 23	97.5	94.5	99	49
59	Story 22	91.1	88.4	92.7	45.2
60	Story 21	84.7	82.4	86.4	41.7
61	Story 20	78.5	76.6	80.3	38.5
62	Story 19	72.5	70.9	74.4	35.4
63	Story 18	66.6	65.4	68.6	32.4
64	Story 17	60.9	59.9	62.9	29.6
65	Story 16	55.4	54.6	57.4	26.8
66	Story 15	50	49.5	52.1	24.1
67	Story 14	44.8	44.7	47	21.6
68	Story 13	39.8	40	42.1	20.8
69	Story 12	35	35.4	37.3	19.1
70	Story 11	30.4	31.1	32.7	16.8
71	Story 10	26	26.9	28.4	14.6
72	Story 9	21.8	22.9	24.2	11.8
73	Story 8	17.8	19.2	20.3	9.8
74	Story 7	14.2	15.8	16.6	8.7
75	Story 6	10.7	12.5	13.2	6.4
76	Story 5	7.6	9.4	10	5.3
77	Story 4	4.9	6.7	7.1	3.9
78	Story 3	2.6	4.2	4.6	2.6
79	Story 2	0.9	2.3	2.5	1.5
80	Story 1	0.5	0.8	0.9	0.5
81	base	0	0	0	0

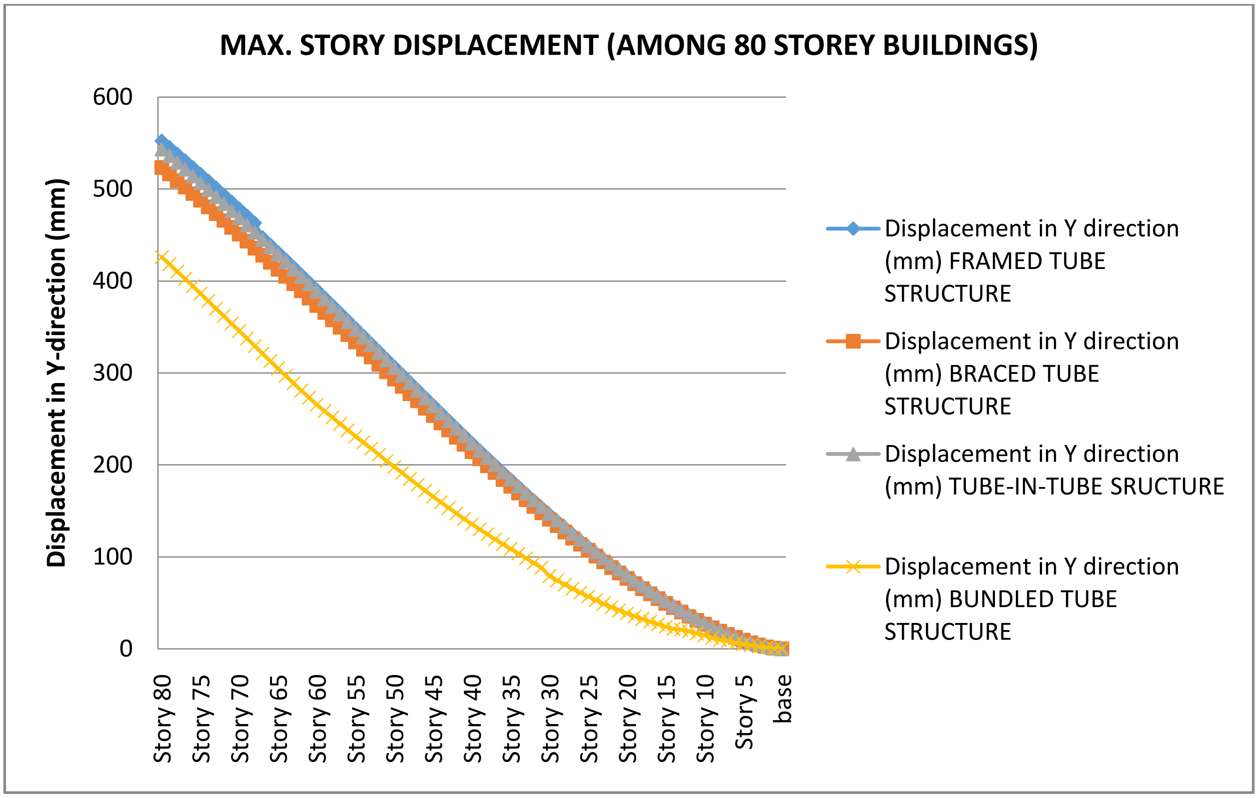

Fig-5.1.4.1(b): Max. Story Displacement in Y-direction (among 80 story buildings)

5.1.4.2 Storey Drift: Comparison of max storey drift between all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 80 storey buildings.

Table: 5.1.4.2(a) Storey Drift (along x direction)

MAX. STORY DRIFT (AMONG 80 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Drift in X direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 80	0.000742	0.000735	0.000756	0.0006

2	Story 79	0.000753	0.000745	0.000767	0.000606
3	Story 78	0.000768	0.000757	0.00078	0.000613
4	Story 77	0.000783	0.000771	0.000794	0.000619
5	Story 76	0.000799	0.000785	0.000808	0.000626
6	Story 75	0.000814	0.0008	0.000822	0.000633
7	Story 74	0.00083	0.000816	0.000836	0.000639
8	Story 73	0.000845	0.000831	0.00085	0.000646
9	Story 72	0.000859	0.000843	0.000864	0.000651
10	Story 71	0.000873	0.000852	0.000877	0.000657
11	Story 70	0.000887	0.000861	0.00089	0.000662
12	Story 69	0.0009	0.000869	0.000902	0.000666
13	Story 68	0.000913	0.000877	0.000914	0.00067
14	Story 67	0.000925	0.000886	0.000925	0.000673
15	Story 66	0.000937	0.000895	0.000936	0.000675
16	Story 65	0.000948	0.000905	0.000946	0.000677
17	Story 64	0.000958	0.000915	0.000956	0.000677
18	Story 63	0.000968	0.000927	0.000966	0.000675
19	Story 62	0.000978	0.000939	0.000974	0.000671
20	Story 61	0.000987	0.000951	0.000983	0.000653
21	Story 60	0.000995	0.00096	0.00099	0.000612
22	Story 59	0.001003	0.000961	0.000998	0.000612
23	Story 58	0.00101	0.000962	0.001004	0.000614
24	Story 57	0.001017	0.000962	0.001011	0.000616
25	Story 56	0.001023	0.000963	0.001016	0.000618
26	Story 55	0.001029	0.000965	0.001021	0.000619

27	Story 54	0.001033	0.000968	0.001026	0.000621
28	Story 53	0.001038	0.000972	0.00103	0.000622
29	Story 52	0.001042	0.000977	0.001033	0.000623
30	Story 51	0.001045	0.000983	0.001036	0.000623
31	Story 50	0.001048	0.000991	0.001038	0.000623
32	Story 49	0.00105	0.000999	0.00104	0.000622
33	Story 48	0.001051	0.001004	0.001041	0.000621
34	Story 47	0.001052	0.000998	0.001041	0.000619
35	Story 46	0.001053	0.00099	0.001041	0.000617
36	Story 45	0.001053	0.000983	0.001041	0.000613
37	Story 44	0.001052	0.000977	0.00104	0.000609
38	Story 43	0.001051	0.000971	0.001038	0.000604
39	Story 42	0.001049	0.000967	0.001036	0.000597
40	Story 41	0.001046	0.000965	0.001033	0.000584
41	Story 40	0.001043	0.000964	0.00103	0.000558
42	Story 39	0.00104	0.000964	0.001026	0.000552
43	Story 38	0.001036	0.000966	0.001021	0.000547
44	Story 37	0.001031	0.00097	0.001016	0.000543
45	Story 36	0.001026	0.000971	0.001011	0.000538
46	Story 35	0.00102	0.000959	0.001004	0.000532
47	Story 34	0.001013	0.000943	0.000998	0.000527
48	Story 33	0.001007	0.000929	0.000991	0.000521
49	Story 32	0.000999	0.000915	0.000983	0.000514
50	Story 31	0.000991	0.000903	0.000974	0.000507
51	Story 30	0.000983	0.000892	0.000966	0.0005
52	Story 29	0.000974	0.000883	0.000956	0.000492
53	Story 28	0.000964	0.000875	0.000946	0.000483

54	Story 27	0.000954	0.000869	0.000936	0.000474
55	Story 26	0.000943	0.000865	0.000925	0.000465
56	Story 25	0.000932	0.000864	0.000913	0.000455
57	Story 24	0.00092	0.000862	0.000901	0.000444
58	Story 23	0.000908	0.000844	0.000888	0.000432
59	Story 22	0.000895	0.000822	0.000875	0.000417
60	Story 21	0.000882	0.000801	0.000861	0.000395
61	Story 20	0.000868	0.000781	0.000847	0.000359
62	Story 19	0.000854	0.000762	0.000832	0.000348
63	Story 18	0.000839	0.000745	0.000817	0.000338
64	Story 17	0.000824	0.000729	0.000801	0.000329
65	Story 16	0.000808	0.000714	0.000784	0.000319
66	Story 15	0.000791	0.000701	0.000767	0.00031
67	Story 14	0.000774	0.000691	0.00075	0.000301
68	Story 13	0.000757	0.000684	0.000731	0.000291
69	Story 12	0.000739	0.000679	0.000712	0.000281
70	Story 11	0.00072	0.000655	0.000692	0.000271
71	Story 10	0.0007	0.000628	0.000672	0.00026
72	Story 9	0.00068	0.000601	0.00065	0.000249
73	Story 8	0.000659	0.000575	0.000627	0.000237
74	Story 7	0.000636	0.000549	0.000603	0.000225
75	Story 6	0.00061	0.000522	0.000577	0.000213
76	Story 5	0.000581	0.000493	0.000546	0.0002
77	Story 4	0.000545	0.000459	0.00051	0.000185
78	Story 3	0.000497	0.000416	0.000463	0.000167
79	Story 2	0.000427	0.000356	0.000396	0.000142
80	Story 1	0.000257	0.000218	0.000253	0.000008

81	base	0	0	0	0

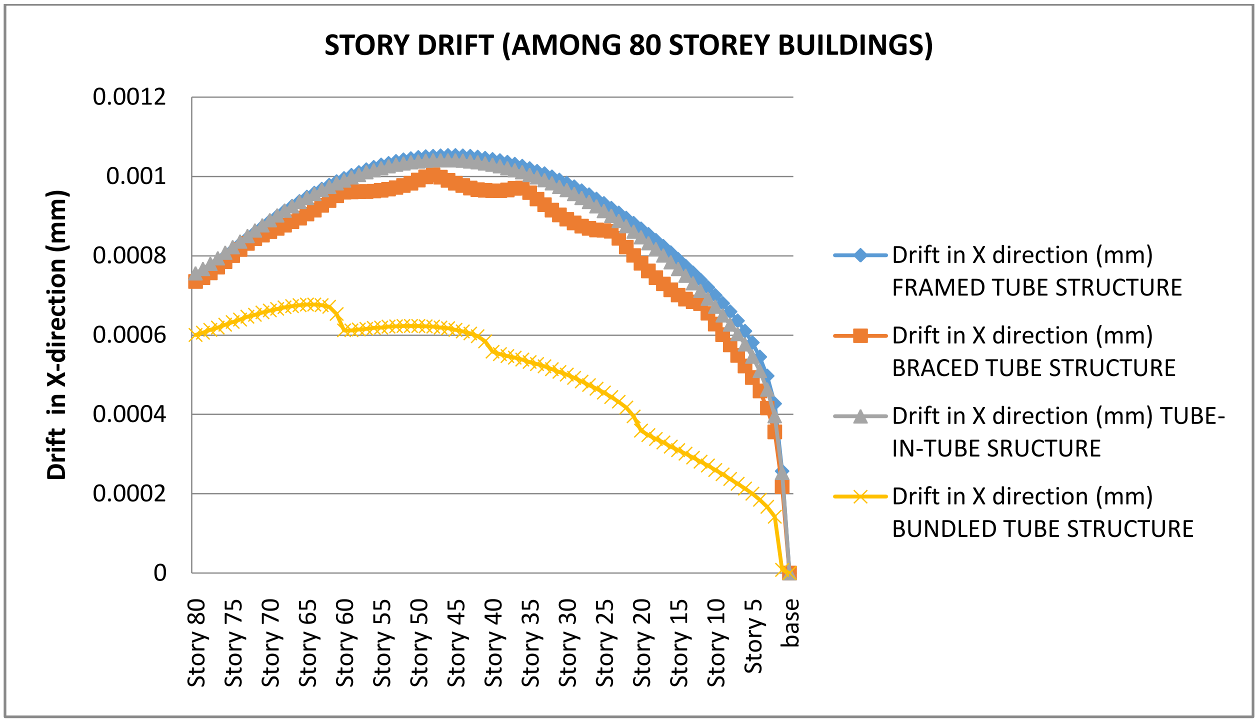

Fig-5.1.4.2(a): Story Drift along X-direction (in mm)

Table: 5.1.4.2(b) Storey Drift (along Y- direction)

MAX. STORY DRIFT (AMONG 80 STOREY BUILDINGS)					
Load case Eqx & Eqy static					
		Drift in Y direction (mm)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 80	0.002032	0.00201	0.002068	0.002248
2	Story 79	0.002043	0.002019	0.002078	0.002258
3	Story 78	0.002058	0.002031	0.002091	0.00227
4	Story 77	0.002076	0.002046	0.002107	0.002283
5	Story 76	0.002095	0.002061	0.002124	0.002295

6	Story 75	0.002115	0.002077	0.002141	0.002306
7	Story 74	0.002134	0.002093	0.002158	0.002316
8	Story 73	0.002154	0.002109	0.002176	0.002325
9	Story 72	0.002174	0.002124	0.002193	0.002331
10	Story 71	0.002193	0.002139	0.002209	0.002336
11	Story 70	0.002211	0.002155	0.002225	0.002338
12	Story 69	0.002229	0.00217	0.002241	0.002338
13	Story 68	0.002247	0.002185	0.002256	0.002335
14	Story 67	0.002263	0.002199	0.00227	0.002329
15	Story 66	0.002279	0.002212	0.002283	0.002319
16	Story 65	0.002294	0.002221	0.002296	0.002305
17	Story 64	0.002308	0.00223	0.002308	0.002285
18	Story 63	0.002321	0.00224	0.002319	0.002255
19	Story 62	0.002333	0.002249	0.002329	0.002211
20	Story 61	0.002345	0.002259	0.002338	0.002134
21	Story 60	0.002355	0.002267	0.002346	0.002019
22	Story 59	0.002364	0.002272	0.002353	0.001982
23	Story 58	0.002372	0.002277	0.00236	0.001962
24	Story 57	0.00238	0.002282	0.002365	0.001946
25	Story 56	0.002386	0.002288	0.002369	0.001934
26	Story 55	0.002391	0.002293	0.002372	0.001923
27	Story 54	0.002395	0.002296	0.002374	0.001912
28	Story 53	0.002397	0.002293	0.002375	0.001901
29	Story 52	0.002399	0.002289	0.002375	0.001889
30	Story 51	0.002399	0.002286	0.002374	0.001877
31	Story 50	0.002398	0.002283	0.002371	0.001864
32	Story 49	0.002396	0.002281	0.002367	0.00185
33	Story 48	0.002393	0.002278	0.002363	0.001835
34	Story 47	0.002388	0.00227	0.002356	0.001819
35	Story 46	0.002383	0.002261	0.002349	0.001801

36	Story 45	0.002376	0.002252	0.002341	0.001782
37	Story 44	0.002367	0.002244	0.002331	0.00176
38	Story 43	0.002358	0.002238	0.00232	0.001734
39	Story 42	0.002347	0.002228	0.002308	0.001701
40	Story 41	0.002335	0.002211	0.002294	0.001652
41	Story 40	0.002322	0.002192	0.002279	0.001582
42	Story 39	0.002307	0.002173	0.002263	0.001555
43	Story 38	0.002291	0.002156	0.002246	0.001533
44	Story 37	0.002273	0.00214	0.002227	0.001512
45	Story 36	0.002255	0.002124	0.002207	0.001491
46	Story 35	0.002235	0.002102	0.002186	0.00147
47	Story 34	0.002213	0.002077	0.002163	0.001448
48	Story 33	0.002191	0.002052	0.002139	0.001425
49	Story 32	0.002166	0.00203	0.002114	0.0014
50	Story 31	0.002141	0.002009	0.002087	0.001375
51	Story 30	0.002114	0.001986	0.002059	0.001349
52	Story 29	0.002086	0.001954	0.00203	0.001321
53	Story 28	0.002056	0.001918	0.001999	0.001292
54	Story 27	0.002025	0.001882	0.001967	0.001261
55	Story 26	0.001993	0.001849	0.001933	0.001229
56	Story 25	0.001959	0.001818	0.001898	0.001195
57	Story 24	0.001923	0.001789	0.001862	0.001158
58	Story 23	0.001886	0.001751	0.001824	0.001118
59	Story 22	0.001848	0.001708	0.001784	0.00107
60	Story 21	0.001808	0.001666	0.001744	0.001006
61	Story 20	0.001767	0.001627	0.001701	0.000922
62	Story 19	0.001724	0.00159	0.001657	0.000883
63	Story 18	0.001679	0.001554	0.001612	0.00085
64	Story 17	0.001633	0.001504	0.001565	0.00082
65	Story 16	0.001585	0.001449	0.001516	0.00079
66	Story 15	0.001536	0.001395	0.001465	0.00076
67	Story 14	0.001484	0.001343	0.001413	0.000729

68	Story 13	0.001431	0.001295	0.001359	0.000698
69	Story 12	0.001375	0.00125	0.001303	0.000666
70	Story 11	0.001318	0.001191	0.001245	0.000633
71	Story 10	0.001257	0.001127	0.001185	0.0006
72	Story 9	0.001194	0.001061	0.001121	0.000566
73	Story 8	0.001127	0.000997	0.001055	0.00053
74	Story 7	0.001055	0.000936	0.000984	0.000494
75	Story 6	0.000976	0.000875	0.000908	0.000456
76	Story 5	0.000887	0.00079	0.000823	0.000416
77	Story 4	0.000783	0.000689	0.000725	0.000372
78	Story 3	0.000654	0.000569	0.000606	0.000322
79	Story 2	0.000485	0.00042	0.000452	0.000256
80	Story 1	0.000216	0.000191	0.000208	0.000132
81	base	0	0	0	0

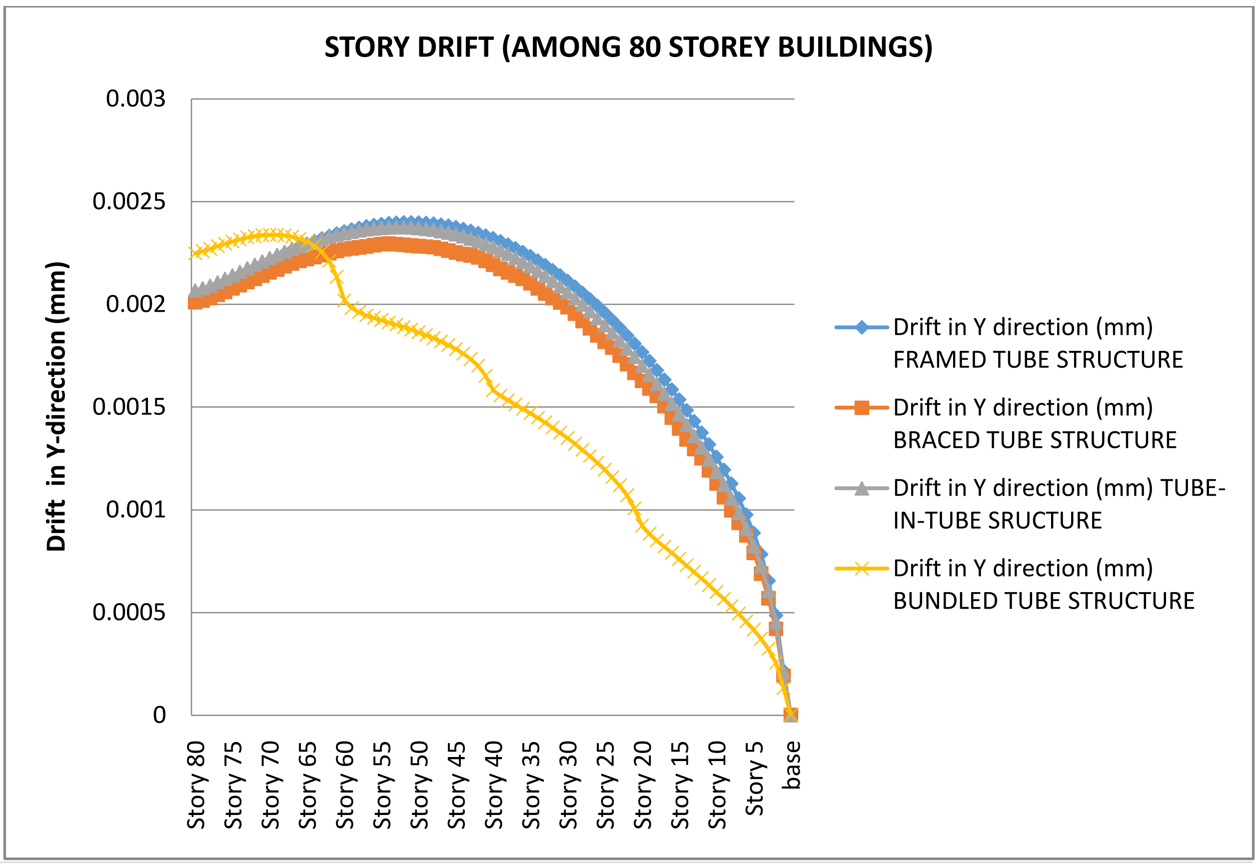

Fig-5.1.4.2(b): Story Drift along Y-direction (in mm)

5.1.4.3Modal Mass Participation Factor

Here the modal mass participation factor of different modes obtained from analysis is discussed for all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 80 storey buildings.

Table:5.1.4.3(a) Modal mass participation factor for framed tube structure

Modal Participation factor (FRAMED TUBE STRUCTURE)					
(AMONG 80 STOREY BUILDINGS)					
Mode	Period	UX	UY	SumUX	SumUY
1	8.682118	0.003025	389.737	-400.061	389.74
2	5.721888	-400.064	0.003062	-400.065	0.001922
3	3.286685	-0.00144	-0.00114	0.000075	200.3633
4	2.265204	0.001515	200.3644	-191.614	200.366
5	1.679795	-191.615	0.001588	-191.616	-103.04
6	1.10222	-0.00086	-103.042	-0.0003	-103.089
7	1.078904	0.000558	-0.04661	-94.9946	-0.04599
8	0.86927	-94.9951	0.000618	-94.9945	71.67953
9	0.72397	0.000641	71.67891	0.001094	71.67062
10	0.630038	0.000453	-0.00829	-66.1995	-0.00785
11	0.598359	-66.2	0.000434	-66.1993	54.33193
12	0.529704	0.00061	54.33149	0.00061	54.33149

Table:5.1.4.3(b) Modal mass participation factor for braced tube structure

Modal Participation factor (BRACED TUBE STRUCTURE)					
(AMONG 80 STOREY BUILDINGS)					
Mode	Period	UX	UY	SumUX	SumUY
1	8.399174	0.001193	-389.969	399.8838	-389.969
2	5.480609	399.8826	-0.0005	399.8843	-0.11083
3	2.996494	0.001673	-0.11033	-0.00076	204.4627
4	2.123288	-0.00243	204.5731	197.1438	204.5746
5	1.571871	197.1462	0.001495	197.1462	105.457
6	1.019762	-3.4E-05	105.4555	-0.01194	104.9035
7	0.982701	-0.01191	-0.55202	97.0669	-0.55167
8	0.803992	97.07881	0.000353	97.07984	73.1393
9	0.665602	0.001035	73.13895	-0.07223	73.11268
10	0.573491	-0.07327	-0.02627	67.2263	-0.02599

11	0.551487	67.29956	0.000278	67.30086	55.21207
12	0.48585	0.001298	55.21179	0.001298	55.21179

Table:5.1.4.3(c) Modal mass participation factor for tube-in-tube structure

Modal Participation factor (TUBE-IN-TUBE STRUCTURE) (AMONG 80 STOREY BUILDINGS)					
Mode	Period	UX	UY	SumUX	SumUY
1	8.570116	-5.9E-05	396.4327	-407.407	396.4327
2	5.661629	-407.407	-5.4E-05	-407.409	0.000222
3	3.148821	-0.00175	0.000276	-0.00168	-207.116
4	2.179168	0.000067	-207.116	-197.412	-207.116
5	1.641374	-197.412	-6.5E-05	-197.412	106.9118
6	1.048758	-9.6E-05	106.9118	-0.00106	106.9203
7	1.032329	-0.00096	0.008468	-98.2119	0.00835
8	0.842957	-98.211	-0.00012	-98.2109	74.02122
9	0.68505	0.000052	74.02134	0.000715	74.01998
10	0.601871	0.000663	-0.00136	-68.5339	-0.00141
11	0.577061	-68.5345	-5.1E-05	-68.5348	-55.887
12	0.500302	-0.00022	-55.8869	-0.00022	-55.8869

Table:5.1.4.3(d) Modal mass participation factor for Bundled Tube structure

Modal Participation factor (BUNDLED TUBE STRUCTURE) (AMONG 80 STOREY BUILDINGS)					
Mode	Period	UX	UY	SumUX	SumUY
1	5.886211	28.25311	323.1285	-311.66	360.3628
2	3.421809	-339.913	37.23432	-342.432	-65.0633
3	2.181841	-2.51974	-102.298	-15.5579	-285.508
4	1.765335	-13.0381	-183.211	-224.146	-202.155
5	1.14064	-211.107	-18.9444	-230.498	103.5634
6	0.998074	-19.3908	122.5078	-25.6063	197.9372
7	0.90542	-6.2154	75.42942	19.39244	98.50429
8	0.626684	25.60785	23.07487	-90.8672	33.7777
9	0.617069	-116.475	10.70283	-118.794	-83.9297
10	0.578654	-2.31933	-94.6325	-2.54273	-105.741
11	0.458504	-0.2234	-11.1088	82.42884	-7.83399

12	0.414218	82.65224	3.274824	82.65224	3.274824

Table:5.1.4.3(e) Comparison chart between mode and time period(among 80 story buildings)

Modal Participation factor (Among 80 Story Buildings)				
	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE STRUCTURE	BUNDLED TUBE STRUCTURE
Mode	**Time Period(sec)**			
Mode-1	8.682118	8.399174	8.570116	5.886211
Mode-2	5.721888	5.480609	5.661629	3.421809
Mode-3	3.286685	2.996494	3.148821	2.181841
Mode-4	2.265204	2.123288	2.179168	1.765335
Mode-5	1.679795	1.571871	1.641374	1.14064
Mode-6	1.10222	1.019762	1.048758	0.998074
Mode-7	1.078904	0.982701	1.032329	0.90542
Mode-8	0.86927	0.803992	0.842957	0.626684
Mode-9	0.72397	0.665602	0.68505	0.617069
Mode-10	0.630038	0.573491	0.601871	0.578654
Mode-11	0.598359	0.551487	0.577061	0.458504
Mode-12	0.529704	0.48585	0.500302	0.414218

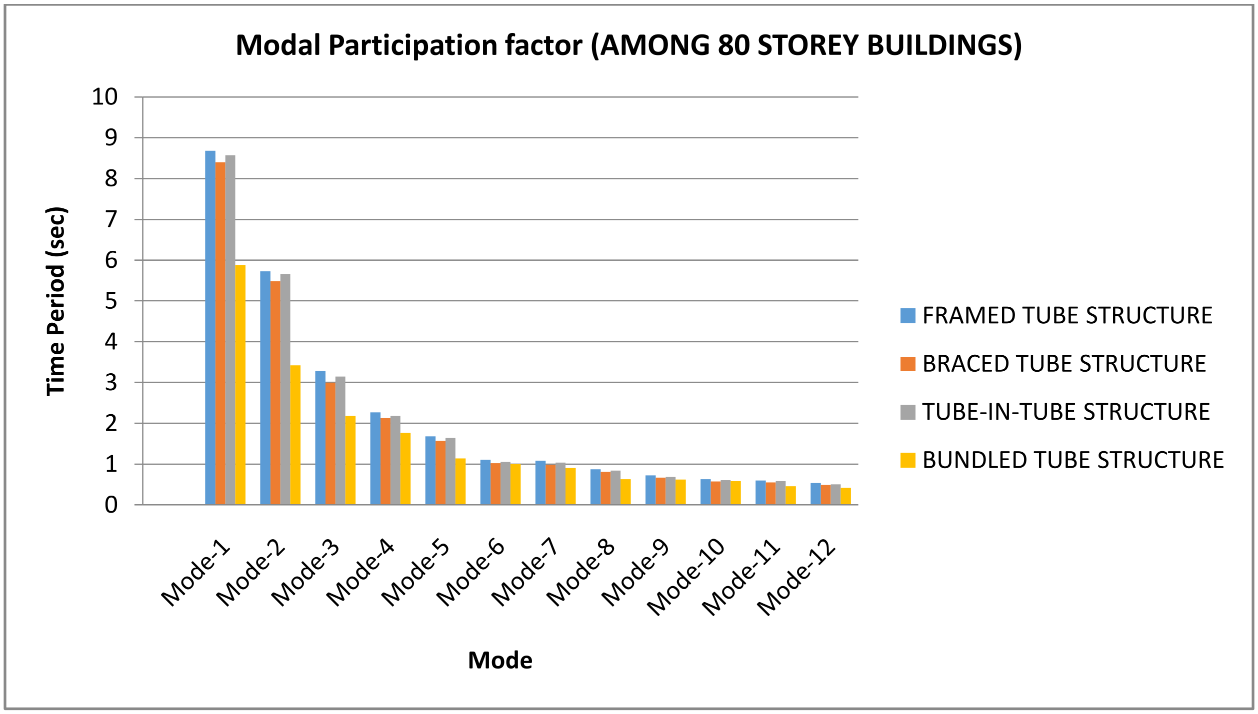

Fig- 5.1.4.3: Graph between mode and time period(among 80 story buildings)

5.1.4.4 Story Shear

Story shear obtained from analysis is discussed for all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 80 storey buildings.

Table: 5.1.4.4(a) Story Shear along X direction (among 80 story buildings)

STORY SHEAR (AMONG 80 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
		Story Shear in X direction(VX) (kN)			
S.No	Story No.	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 80	783.01	788.52	816.1	509.67
2	Story 79	1844.34	1862.88	1923.73	1091.69
3	Story 78	2879.03	2910.29	3003.58	1659.11
4	Story 77	3887.43	3931.07	4055.98	2212.1
5	Story 76	4869.88	4925.59	5081.29	2750.86
6	Story 75	5826.71	5894.17	6079.87	3275.58

7	Story 74	6758.26	6837.17	7052.07	3786.43
8	Story 73	7664.87	7754.92	7998.24	4283.6
9	Story 72	8546.88	8647.76	8918.73	4767.29
10	Story 71	9404.62	9516.04	9813.91	5237.66
11	Story 70	10238.44	10360.11	10684.11	5694.92
12	Story 69	11048.68	11180.3	11529.7	6139.25
13	Story 68	11835.66	11976.95	12351.02	6570.82
14	Story 67	12599.74	12750.41	13148.44	6989.83
15	Story 66	13341.25	13501.03	13922.3	7396.46
16	Story 65	14060.52	14229.14	14672.96	7790.91
17	Story 64	14757.9	14935.08	15400.77	8173.34
18	Story 63	15433.72	15619.21	16106.08	8543.95
19	Story 62	16088.33	16281.86	16789.25	8902.93
20	Story 61	16722.05	16923.37	17450.62	9250.46
21	Story 60	17335.24	17544.09	18090.57	9926.79
22	Story 59	17928.22	18144.35	18709.42	10659.25
23	Story 58	18501.34	18724.51	19307.55	11367.17
24	Story 57	19054.93	19284.91	19885.3	12050.97
25	Story 56	19589.34	19825.88	20443.02	12711.07
26	Story 55	20104.89	20347.77	20981.07	13347.89
27	Story 54	20601.94	20850.92	21499.81	13961.84
28	Story 53	21080.81	21335.68	21999.58	14553.35
29	Story 52	21541.85	21802.38	22480.74	15122.84
30	Story 51	21985.4	22251.38	22943.64	15670.71
31	Story 50	22411.79	22683.01	23388.63	16197.38
32	Story 49	22821.36	23097.61	23816.07	16703.29
33	Story 48	23214.45	23495.53	24226.32	17188.84
34	Story 47	23591.4	23877.11	24619.71	17654.45
35	Story 46	23952.55	24242.69	24996.62	18100.54
36	Story 45	24298.23	24592.62	25357.38	18527.52
37	Story 44	24628.78	24927.23	25702.36	18935.83
38	Story 43	24944.55	25246.88	26031.9	19325.86
39	Story 42	25245.86	25246.88	26346.37	19698.05
40	Story 41	25533.07	25551.9	26646.11	20052.81
41	Story 40	25806.5	25842.63	26931.47	20463.63
42	Story 39	26066.5	26119.42	27202.81	20869.24

43	Story 38	26313.4	26382.62	27460.49	21254.41
44	Story 37	26547.55	26632.55	27704.85	21619.68
45	Story 36	26769.27	26869.57	27936.25	21965.58
46	Story 35	26978.92	27094.02	28155.04	22292.63
47	Story 34	27176.82	27306.24	28361.58	22601.36
48	Story 33	27363.32	27506.58	28556.22	22892.3
49	Story 32	27538.75	27695.36	28739.3	23165.98
50	Story 31	27703.46	27872.95	28911.2	23422.93
51	Story 30	27857.77	28039.68	29072.25	23663.66
52	Story 29	28002.04	28195.89	29222.81	23888.72
53	Story 28	28136.59	28341.93	29363.23	24098.63
54	Story 27	28261.77	28478.14	29493.87	24293.91
55	Story 26	28377.92	28604.86	29615.09	24475.1
56	Story 25	28485.37	28722.43	29727.22	24642.73
57	Story 24	28584.46	28831.2	29830.64	24797.31
58	Story 23	28675.53	28931.5	29925.68	24939.38
59	Story 22	28758.91	29023.69	30012.71	25069.47
60	Story 21	28834.96	29108.11	30092.07	25188.1
61	Story 20	28904	29185.08	30164.12	25314.25
62	Story 19	28966.37	29254.97	30229.22	25431.82
63	Story 18	29022.42	29318.11	30287.71	25537.46
64	Story 17	29072.47	29374.85	30339.95	25631.8
65	Story 16	29116.88	29425.52	30386.29	25715.5
66	Story 15	29155.97	29470.47	30427.09	25789.18
67	Story 14	29190.09	29510.04	30462.7	25853.49
68	Story 13	29219.57	29544.58	30493.46	25909.05
69	Story 12	29244.75	29574.42	30519.75	25956.52
70	Story 11	29265.98	29599.91	30541.9	25996.53
71	Story 10	29283.58	29621.4	30560.27	26029.71
72	Story 9	29297.9	29639.22	30575.21	26056.7
73	Story 8	29309.28	29653.72	30587.09	26078.14
74	Story 7	29318.05	29665.23	30596.24	26094.67
75	Story 6	29324.55	29674.11	30603.03	26106.93
76	Story 5	29329.13	29680.69	30607.8	26115.56
77	Story 4	29332.11	29685.33	30610.92	26121.18
78	Story 3	29333.85	29688.35	30612.73	26124.45
79	Story 2	29334.67	29690.1	30613.58	26125.99

80	Story 1	29334.92	29690.93	30613.85	26126.47

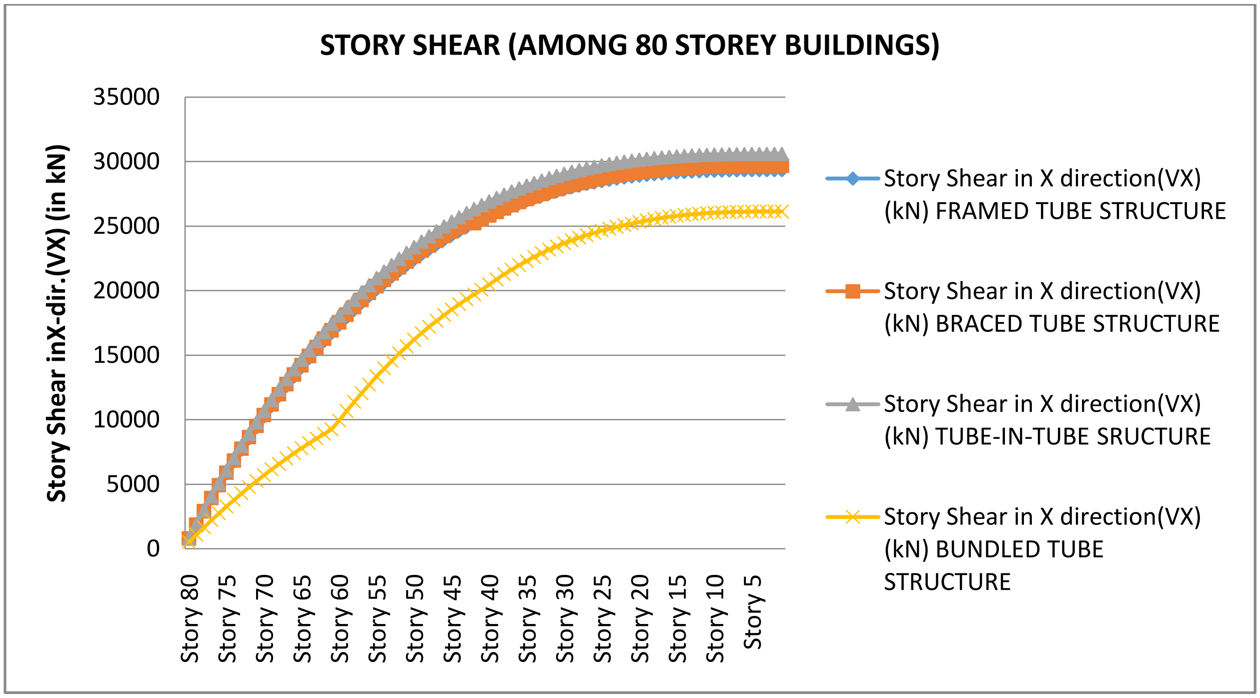

Fig-5.1.4.4(a): Story Shear along X-direction (in mm) (among 80 story buildings)

Table: 5.1.4.4(b) Story Shear along Y direction (among 80 story buildings)

STORY SHEAR (AMONG 80 STOREY BUILDINGS)					
Loadcase Eqx & Eqy static					
S.No	Story No.	Story Shear in Y direction(VY) (kN)			
		FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
1	Story 80	712.54	717.55	742.65	463.8
2	Story 79	1678.35	1695.22	1750.6	993.44
3	Story 78	2619.92	2648.36	2733.25	1509.79
4	Story 77	3537.56	3577.28	3690.94	2013.01
5	Story 76	4431.59	4482.29	4623.97	2503.29
6	Story 75	5302.3	5363.7	5532.68	2980.78
7	Story 74	6150.01	6221.82	6417.38	3445.65
8	Story 73	6975.03	7056.97	7278.4	3898.08

9	Story 72	7777.66	7869.46	8116.05	4338.23
10	Story 71	8558.21	8659.6	8930.65	4766.28
11	Story 70	9316.98	9427.7	9722.54	5182.38
12	Story 69	10054.3	10174.07	10492.02	5586.71
13	Story 68	10770.45	10899.02	11239.43	5979.45
14	Story 67	11465.76	11602.88	11965.08	6360.75
15	Story 66	12140.53	12285.94	12669.29	6730.78
16	Story 65	12795.07	12948.52	13352.39	7089.72
17	Story 64	13429.69	13590.93	14014.7	7437.74
18	Story 63	14044.69	14213.48	14656.53	7775
19	Story 62	14640.38	14816.49	15278.21	8101.67
20	Story 61	15217.07	15400.26	15880.07	8417.92
21	Story 60	15775.06	15965.12	16462.41	9033.38
22	Story 59	16314.68	16511.36	17025.57	9699.91
23	Story 58	16836.22	17039.31	17569.87	10344.12
24	Story 57	17339.99	17549.26	18095.62	10966.38
25	Story 56	17826.3	18041.55	18603.15	11567.07
26	Story 55	18295.45	18516.47	19092.78	12146.58
27	Story 54	18747.76	18974.34	19564.83	12705.28
28	Story 53	19183.54	19415.47	20019.62	13243.55
29	Story 52	19603.09	19840.17	20457.47	13761.78
30	Story 51	20006.71	20248.75	20878.71	14260.34
31	Story 50	20394.73	20641.53	21283.65	14739.62
32	Story 49	20767.44	21018.82	21672.63	15199.99
33	Story 48	21125.15	21380.93	22045.95	15641.84
34	Story 47	21468.17	21380.93	22403.94	16065.55
35	Story 46	21796.82	21728.17	22746.92	16471.49
36	Story 45	22111.39	22060.85	23075.22	16860.05
37	Story 44	22412.19	22379.28	23389.15	17231.6
38	Story 43	22699.54	22683.78	23689.03	17586.54
39	Story 42	22973.74	22974.66	23975.19	17925.23
40	Story 41	23235.09	23252.23	24247.96	18248.06
41	Story 40	23483.92	23516.79	24507.64	18621.91
42	Story 39	23720.52	23768.67	24754.56	18991
43	Story 38	23945.2	24008.18	24989.04	19341.51
44	Story 37	24158.27	24235.62	25211.41	19673.91

45	Story 36	24360.04	24451.31	25421.99	19988.68
46	Story 35	24550.82	24655.56	25621.09	20286.29
47	Story 34	24730.91	24848.68	25809.04	20567.24
48	Story 33	24900.62	25030.98	25986.16	20832
49	Story 32	25060.26	25202.78	26152.77	21081.04
50	Story 31	25210.15	25364.39	26309.19	21314.86
51	Story 30	25350.57	25516.11	26455.74	21533.93
52	Story 29	25481.86	25658.26	26592.75	21738.74
53	Story 28	25604.3	25791.16	26720.54	21929.75
54	Story 27	25718.21	25915.11	26839.43	22107.46
55	Story 26	25823.91	26030.42	26949.73	22272.34
56	Story 25	25921.68	26137.41	27051.77	22424.88
57	Story 24	26011.86	26236.39	27145.88	22565.55
58	Story 23	26094.73	26327.67	27232.37	22694.84
59	Story 22	26170.61	26411.56	27311.56	22813.22
60	Story 21	26239.81	26488.38	27383.78	22921.17
61	Story 20	26302.64	26558.43	27449.35	23035.97
62	Story 19	26359.4	26622.03	27508.59	23142.95
63	Story 18	26410.4	26679.48	27561.82	23239.08
64	Story 17	26455.95	26731.11	27609.35	23324.94
65	Story 16	26496.36	26777.22	27651.53	23401.1
66	Story 15	26531.93	26818.13	27688.65	23468.15
67	Story 14	26562.98	26854.14	27721.05	23526.67
68	Story 13	26589.81	26885.56	27749.05	23577.24
69	Story 12	26612.73	26912.72	27772.97	23620.43
70	Story 11	26632.04	26935.92	27793.13	23656.84
71	Story 10	26648.06	26955.47	27809.84	23687.03
72	Story 9	26661.09	26971.69	27823.44	23711.6
73	Story 8	26671.44	26984.88	27834.25	23731.11
74	Story 7	26679.43	26995.36	27842.58	23746.15
75	Story 6	26685.34	27003.44	27848.76	23757.31
76	Story 5	26689.51	27009.43	27853.1	23765.16
77	Story 4	26692.22	27013.65	27855.94	23770.28
78	Story 3	26693.8	27016.4	27857.58	23773.25
79	Story 2	26694.55	27017.99	27858.36	23774.65
80	Story 1	26694.78	27018.75	27858.6	23775.09

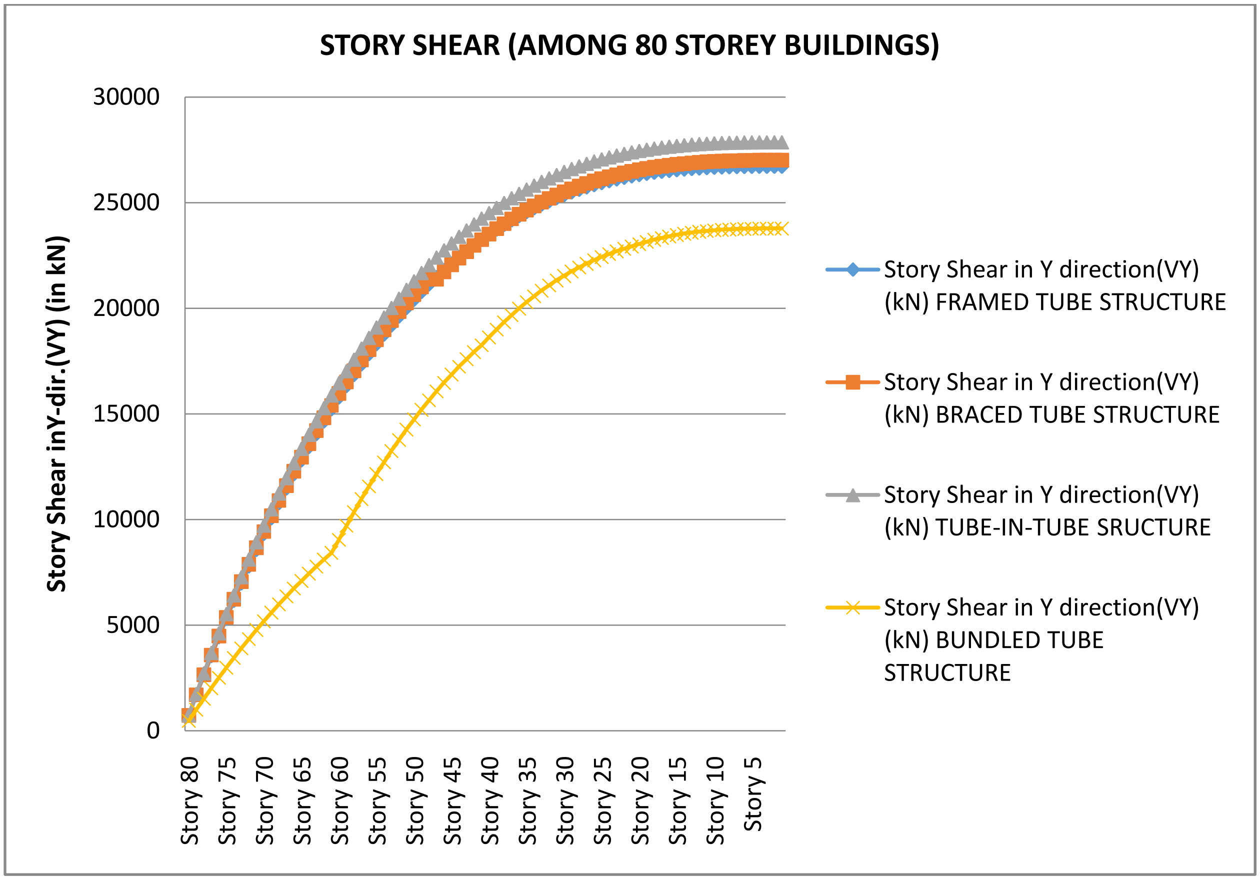

Fig-5.1.4.4(b): Story Shear along Y-direction (in mm) (among 80 story buildings)

5.1.4.5 Base shear:-

Comparison of total base shears between all four types of reinforced concrete tubular structure for both longitudinal directions, say, X & Y directions, among 80 storey buildings.

Table: 5.1.4.5 Base shears in four types of RCC Tubular structures(among 80 story buildings)

Base Shear (in kN)	FRAMED TUBE STRUCTURE	BRACED TUBE STRUCTURE	TUBE-IN-TUBE SRUCTURE	BUNDLED TUBE STRUCTURE
In X-Direction	29334.92	29690.93	30613.85	26126.47
In Y-Direction	26694.78	27018.75	27858.6	23775.09

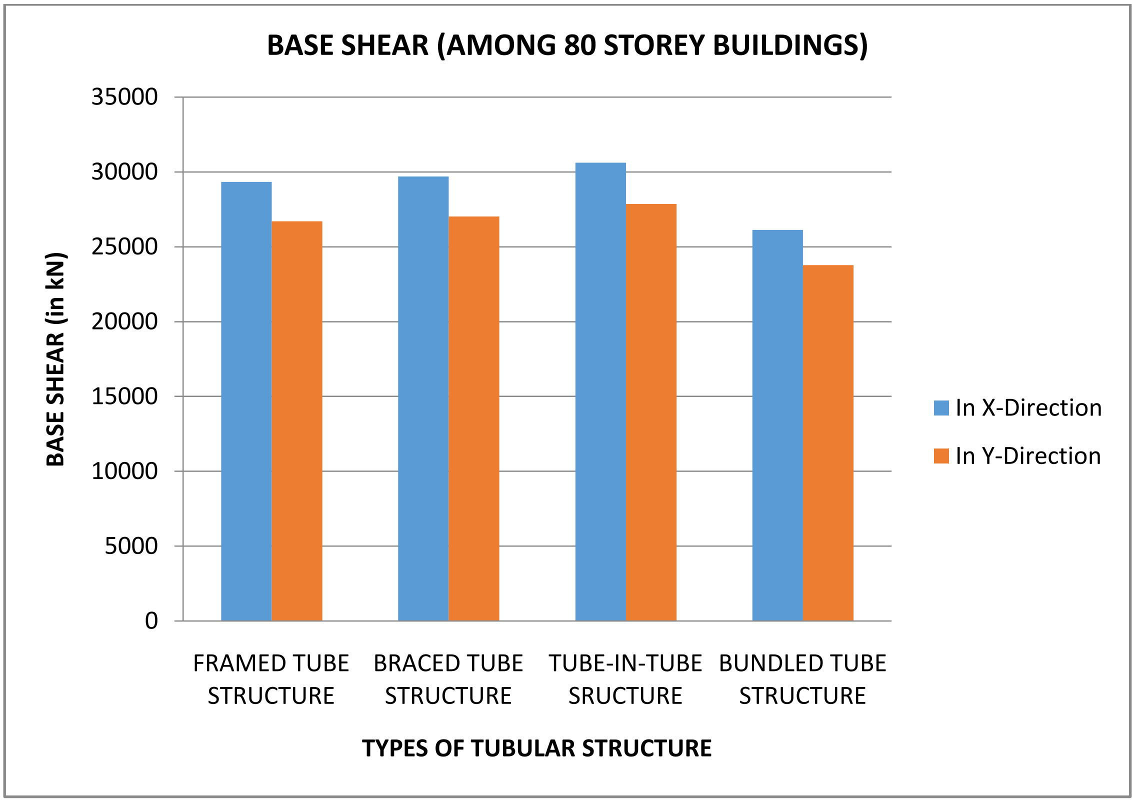

Fig-5.1.4.5: Base Shear along X & Y-direction (in mm) (among 80 story buildings)

5.2 Conclusion and Discussion

The Prime objective of this study was to know the modelling technique of different type of reinforced concrete tubular structure form, and then analyzes to know the best suited & effective tubular structural form for resisting the lateral force with varying height of structure at the same location.

The following conclusions have been drawn from result obtained by performing the analysis.

a) Form the result of story displacement & story drift it was clearly noted that ,form all tubular structural form the braced tube & bundle tube structure are most effective for resisting the lateral load at any height (i.e. 20,40,60,80 story).
b) In case of 20 story bundle tube structure model time period gets reduced by 27.11% as compare to framed tube structure. In case of braced tube & tube in tube structure this value is 22.08%, 14.05% respectively.
c) Whereas with increasing the height of building it has been noted that, in case of braced tube and tube in tube structure the percentage reduction in model time period is less as compare to

bundle tube structure. Therefore it can be concluded that bundle tube structure offer maximum stiffness to resist the lateral load as compare to all tubular structure form.

d) As compare to the frame tube structure of 20 & 40 stories building height, base shear (i.e. in both x & y directions) has increased for braced tube, tube in tube & bundle tube structure respectively. Whereas with increase the structure height (i.e. 60 & 80 Stories) in case of bundle tube structure, base shear gets reduced due to less seismic weight of the building. However in case of tube in tube & Braced tube structure at 60 & 80 stories, base shear has increased as it had increased in case in 20 & 40 Stories building.

e) As compared to the framed tube structure (i.e. for 20 stories building) maximum top story displacement is 53.4 % and 45.4% less in x and y direction for bundle tube structure. In case of braced tube and tube in tube structure, these values are 44.2%, 22.8 % in x direction & 37.5%, 21.1% in y direction respectively.

f) Similarly, the same behaviour has been noted with increase the height of structure (i.e. 40, 60, 80 stories building), the value of maximum top story displacement is very less in case of braced tube and bundle tube structure as compared with framed tube & tube in tube structure. Therefore it can be concluded that smaller & lighter structural components can be economically used in braced and bundle tube structure.

g) Bracings in braced tube structural form provide more resistance and stiffness in the building which makes system more effective then framed tube and tube in tube structure.

h) Tubular structural system provides more flexibility in planning interior space and facade of the building

i) When compared with the framed tube structure the story drift in case of bundle tube structure is 48.3% and 55.2% less in x and y direction respectively. In case of tube in tube structure and framed tube structure these value are 40.38%, 4.6% and 29.2%, 25.2% respectively.

j) Form the graph of maximum story drift for 20, 40, 60 & 80 story building, same behaviour has been observed as discussed above.

k) Therefore from the above study, it can be concluded that up to 40 story building the use of tube in tube & framed tube structure is effective and economical because story drift and story displacement are within permissible limit and the structural components can be resized accordingly. Whereas with increase the height of the structure at the same location, the braced tube structure was found more efficient to resist the lateral load.

l) The bundle tube structure was found the most economical for greater height buildings (i.e. 60 & 80 Story), to resist the lateral load.

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