# Study of Seismic Behaviour of Tube Structures

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***Abstract-****It is very essential to consider the effects of lateral loads induced from wind and earthquakes in the design of reinforced concrete structures, especially for high- rise buildings. The IS Code of Practice for Calculating Loads and Forces in Structural and Building Works, IS 875 Part III and IS 1893:2002 gives simplified methods for calculating such loads. In some cases effects of earthquakes are found to be dominant and more critical than wind effects. This depends on some factors defined by codes. In this research the both effects will be studied and compared according to the IS 1893: 2002. The codes are reviewed for wind and earthquake analysis and discussed to show all factors affecting the design. Application examples for buildings with different heights, floor weights and boundary conditions for earthquakes such as the intensity of the wind pressure, the seismic zone coefficient, the importance factor, structural system factor and the soil coefficient are analyzed and discussed for the purpose of comparison. Some recommendations are suggested to improve the resistance of the structural and environmental systems of the buildings with respect to lateral loads. Buildings of frame structure offer less resistance as compared to tube frame structure. Also various types of tubular structure are preferred in seismically sensitive zones. Finally Indian seismic map, structural systems are provided to help structural designers and researches during design process.*

***Keywords***-STADD-PRO, High rise buildings, Tube Structures, Seismic Response Analysis.

## I. INTRODUCTION

With the application of new materials and advanced technologies, modern tall buildings are becoming lighter and more slender than their predecessors, thus they are more sensitive to earthquake forces. In addition, along with the development of modern cities, a large number of tall buildings may be constructed in a small zone. The correct estimation of an earthquake forces acting on tall buildings is very essential for the safe design of structural elements. Such RCC buildings are analyzed and designed for earthquake under software environment. Since our project helps to reduce the seismic forces in earthquakes, by providing tube structure with different shapes. In this project we analyze the effect seismic forces on R.C.C. Tube structure & R.C.C Frame structure. Then we go for further analysis of tube structure in different zones & aspect ratios. These types of structures are effectively used in seismic sensitive countries such as china, Malaysia, Japan etc.These also beneficial for the corporate sectors as high rise building.

## II. CONCEPT

The tube system concept is based on the idea that a building can be designed to resist lateral loads by designing it as a hollow cantilever perpendicular to the ground. In the simplest incarnation of the tube, the perimeter of the exterior consists of closely spaced columns that are tied together with deep spandrel beams through moment connections. This assembly of columns and beams forms a rigid frame that amounts to a dense and strong structural wall along the exterior of the building.

This exterior framing is designed sufficiently strong to resist all lateral loads on the building, thereby allowing the interior of the building to be simply framed for gravity loads. Interior columns are comparatively few and located at the core. The distance between the exterior and the core frames is spanned with beams or trusses and intentionally left column-free. This maximizes the effectiveness of the perimeter tube by transferring some of the gravity loads within the structure to it and increases its ability to resist overturning due to lateral loads.

## III. LITERATURE REVIEW

***Hong Fan, Q.S. Li , Alex Y. Tuan, Lihua Xu, Seismic analysis of the world's tallest building,13 March 2008***

Paper presents Seismic analysis of the world’s tallest building .The Structural system- Mega frame system, CFT Columns, Steel brace core and Belt trusses which are combined to resist vertical & lateral loads. Shaking table test was conducted for determination constitutive relationships & FEM for CFT columns & steel members .Numerical Seismic response also investigated .An Earthquake spectrum generated for TAIPEI basin was adopted to calculate the lateral displacement & distribution of distribution of interior columns forces .Time history analyses of Elastic & Inelastic Seismic response carried out. He concluded that, building with such great mega frame was performed well in seismic condition.

***Lin-Hai Hana,, Wei Li , You-Fu Yang Seismic behaviour of concrete-filled steel tubular frame to RC shear wall high-rise mixed structures,28 October 2007***

Paper presents Seismic behaviour of Concrete-filled steel tubular frame to RC shear wall high rise mixed structure. In the world composite frames consisting of CFST columns along with steel beam are being used more & popularly. Three kinds of real Earthquake records with peak acceleration are used to demonstrate 2-30 storey building models. Composite structures mix with RC Shear wall were used in China to form High rise buildings. He concluded that, the composite frames co-operated well with Core RC shear wall structure under Earthquakes. As RC shear wall is most significant element in earthquake resistance, so proper placement of it much essential.

***Ting Zhou , Zhihua Chen , Hongbo Liu, Seismic behaviour of special shaped column composed of concrete filled steel tubes28 May 2011***

Paper presents experimentally investigated the behaviour of a special shaped column composed of CFT subjected to constant axial load & a cyclic varying flexural load .Effects of axial compression ratio & Length to Width ratio of SCFST columns where studied. The connection plate between 2 mono CFT columns was an important member for transferring shear force. The mono columns of SCFST columns worked together well and the seismic behaviour of SCFST columns was good. As increase in axial compression ratio increase the Stiffness with a decrease of energy dissipation ability, ductility and B.C.As increase in length to width ratio increase energy dissipation ability , ductility and decrease of stiffness ,B.C.

***Lin-Hai Han , Wei Li , ReidarBjorhovde Developments and advanced applications of concrete-filled steel tubular(CFST) structures: Members 12 June 2013***

Paper presents developments and advance applications of CFST structures. CFST structure offers numerous structural benefits and has been widely used in Civil Engineering Structures. The research development on CFST structural members in most recent years.

***Andre Tenchini , Mario D'Aniello , Carlos Rebelo , Raffaele Landolfo, Luis Simões da Silv, Luciano Lima , Seismic performance of dual-steel moment resisting frames 31 December 2013***

Paper presents Seismic performance of dual-steel moment resisting frames**.** Dual steel concept – Combined use of high strength steel (HSS) in non-dissipative members and mild carbon steel (MCS) in dissipative zones, in order to control the global frame behaviour in to a ductile overall failure mode. Study devoted to investigate the seismic design and performance of EURO CODE and compliant dual steel moment resisting frames (MRF) is presented and discuss. Seismic performance analyse against 3 limit states: (a) Damage limitation (DL)(b) Severe damage (SL)(c) Near collapse (NC).

***Yuxin Liu , Zhitao Lu , Methods of enforcing earthquake base motions in seismic analysis of structures, 9 December 2009***

This paper presents methods to enforce base excitations for designing structures, qualifying equipment, and assessing seismic fragility against such base motions in seismic analysis.

***A.M. Memari a,*, A.Y. Motlagh b, A. Scanlon, Seismic evaluation of an existing reinforced concrete framed tube building based on inelastic dynamic analysis, 24 July 1998***

A seismic assessment of an existing 32-story reinforced concrete framed tube building is performed using inelastic dynamic time history analysis to obtain force and deformation response of the structure subjected to three ground motion records. Recent recommendations for plastic hinge rotation and plastic hinge length modifications are discussed and the results of the application of some of these recommendations are evaluated.

## IV. METHODOLOGY

### RESPONSE SPECTRUM METHOD

This method is also known as modal method or mode superposition method. The method is applicable to those structures where modes other than the fundamental one significantly affect the response of the structure. Generally , the is applicable to analysis of the dynamic response of structures , which are asymmetrical or have areas discontinuity or irregularity, in their linear range of behavior .In particular, it is applicable to the analysis of forces and deformations in multistory buildings due to medium intensity ground shaking, which causes a moderately large but essentially linear response in the structure. This method is based on the fact that, for certain forms of damping- which are reasonable models for many buildings the response in each natural mode of vibration can be computed independently of the others, and the modal responses can be combined to determine the total response. Each mode responds with its own particular pattern of deformation (mode shape), with its own frequency (the modal frequency), and with its own modal damping. The time history of each modal response can be representative of the particular mode and the degree to which it is excited by the earthquake motion .

A complete modal analysis provides the history of response forces, displacements, and deformations of a structure to a specified ground acceleration history .However, the complete response history is rarely needed for design; the maximum values of response over the duration of the earthquake usually suffice. Because response in each vibration mode can be modeled by the response of a SDOF oscillator, the maximum response in the mode can be directly computed from the earthquake response spectrum. Procedures for combining the modal maxima to obtain estimates (but not the exact value) of the maximum of total response are available.

## V.PROBLEM STATEMENT

In this study I consider 12x24m G+9 building. The model of such building is made in staad pro software considering both tube structure and rcc framed structure. Both the models are checked for seismic loading with different zones. And models are made with different aspect ratios such as 0.5,0.75,0.8,1 and such models are checked for seismic loadings.

**Preliminary Data for G+9 building**

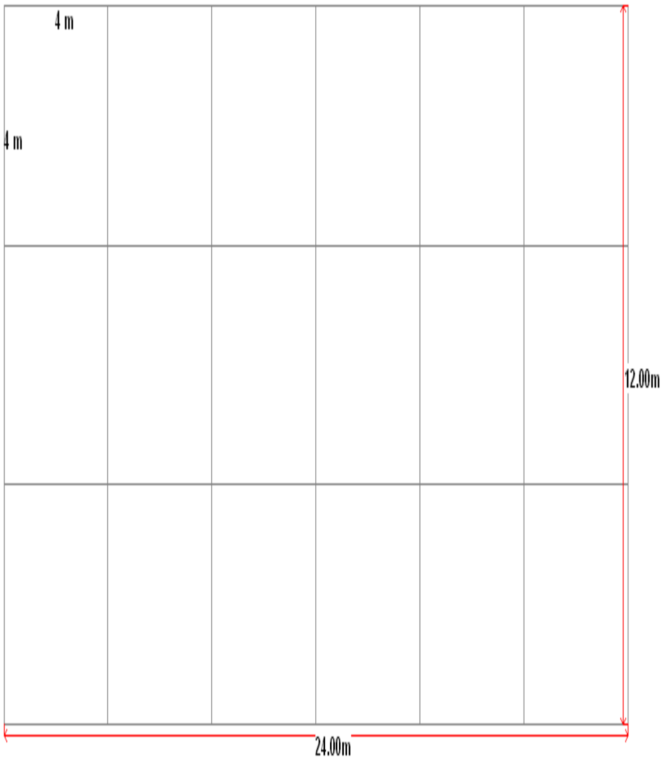


Fig. 1 Plan

| **Type Of Structure** | **R.C.C Tube Structure** | **R.C.C Normal Structure** |
|---|---|---|
| Zone | II | II |
| Storey Height | 3m | 3m |
| No. Of Storey | G+9 | G+9 |
| Material | Fe415,M20 | Fe415,M20 |
| Size Of Column<br>Outer<br>Inner | <br>0.8*0.3<br>0.6*0.23 | <br>0.6*0.23<br>0.6*0.23 |
| Size Of Beam | 0.46*0.23 | 0.46*0.23 |
| Slab Thickness | 0.150 | 0.150 |

Table 5.1

Different Seismic Parameters are taken from IS 1893:2002 for different zones.

## VI. RESULTS ( ACCORDING TO ZONES )

**ZONE II**

**Base Shear (KN)**

| **Structure**<br>**Loading** | **R.C.C. Tube Structure** | **R.C.C Normal Structure** |
|---|---|---|
| EQX | 341.16 | 322.26 |
| EQZ | 241.30 | 230.77 |

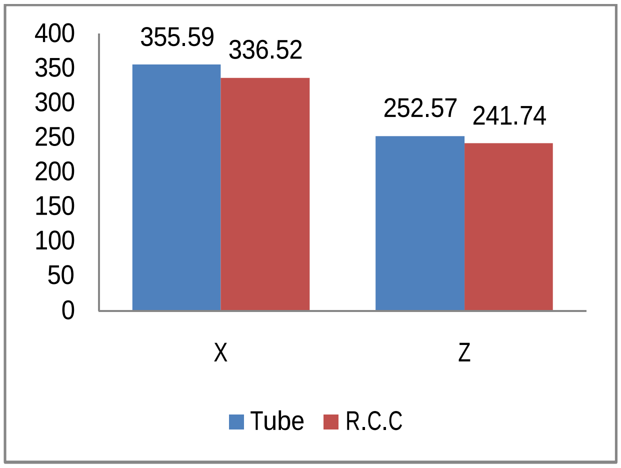
Table 6.1

### Node Displacement (mm)

| | **R.C.C. Tube Structure** | **R.C.C Normal Structure** |
|---|---|---|
| Node No. | 284 | 284 |
| Displacement | 9.173 | 9.613 |

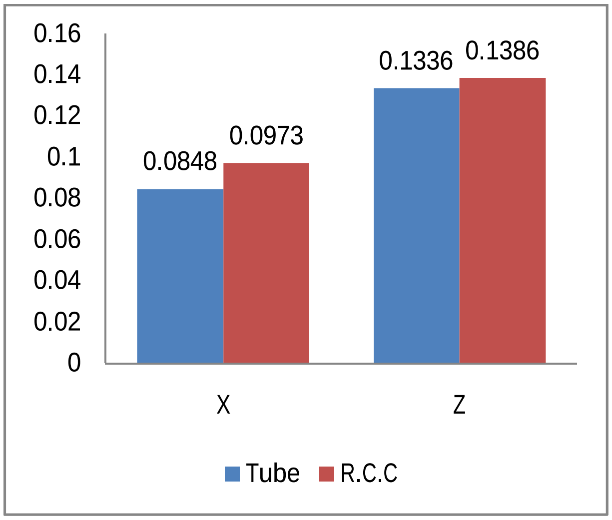
Table 6.2

### PEAK SHEAR (KN)



Graph 6.1

### STORY DRIFT(CM)



Graph 6.2

### ZONE III

### Base Shear (KN)

| **Structure**<br>**Loading** | **R.C.C. Tube Structure** | **R.C.C Normal Structure** |
|---|---|---|
| EQX | 1091.70 | 322.26 |
| EQZ | 772.17 | 230.77 |

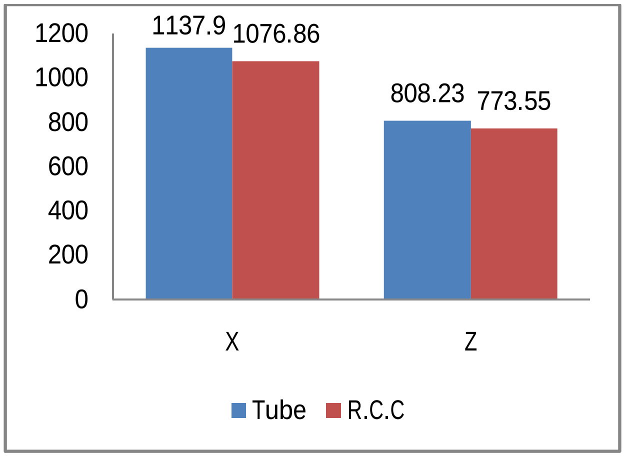
Table 6.3

### Node Displacement (mm)

| | **R.C.C. Tube Structure** | **R.C.C Normal Structure** |
|---|---|---|
| Node No. | 284 | 284 |
| Displacement | 30.763 | 44.039 |

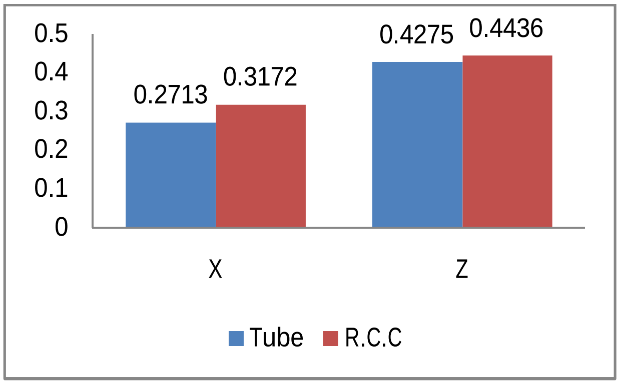
Table 6.4

### PEAK SHEAR (KN)



Graph 6.3

### STORY DRIFT(CM)



Graph 6.4

## ZONE IV

**Base Shear (KN)**

| Structure<br>Loading | R.C.C. Tube Structure | R.C.C Normal Structure |
|---|---|---|
| EQX | 2456.32 | 2320.00 |
| EQZ | 1787.39 | 1661.58 |

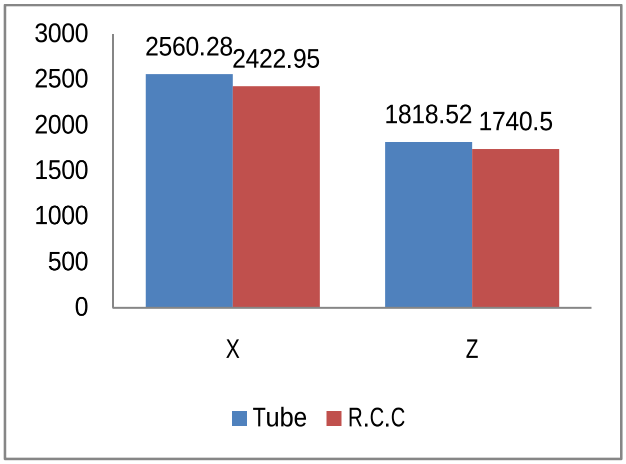
Table 6.5

**Node Displacement (mm)**

| | R.C.C. Tube Structure | R.C.C Normal Structure |
|---|---|---|
| Node No. | 306 | 306 |
| Displacement | 66.01730 | 69.217 |

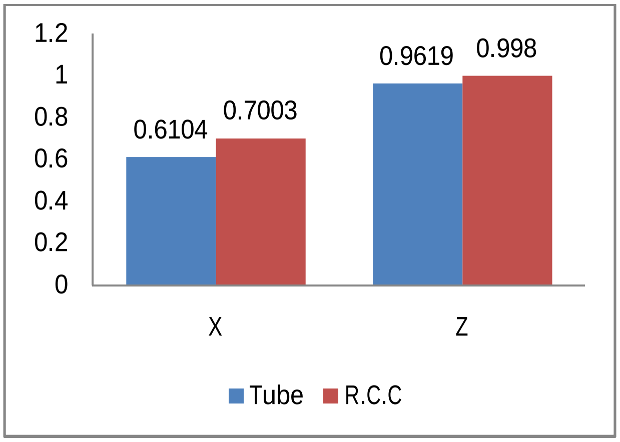
Table 6.6

### PEAK SHEAR(KN)



Graph 6.5

### STORY DRIFT (CM)



Graph 6.6

## RESULTS ( ACCORDING TO ASPECT RATIOS )

### ASPECT RATIO 0.5

**Base Shear (KN)**

| Structure<br>Loading | R.C.C Tube Structure |
|---|---|
| EQX | 818.77 |
| EQZ | 579.13 |

Table 6.7

**Node Displacement (mm)**

| | R.C.C Tube Structure |
|---|---|
| Node No. | 291 |
| Displacement | 24.675 |

Table 6.8

### ASPECT RATIO 0.75

**Base Shear (KN)**

| Structure<br>Loading | R.C.C Tube Structure |
|---|---|
| EQX | 550.12 |
| EQZ | 542.51 |

Table 6.9

**Node Displacement (mm)**

| | R.C.C Tube Structure |
|---|---|
| Node No. | 208 |
| Displacement | 34.881 |

Table 6.10

**ASPECT RATIO 0.80**

**Base Shear (KN)**

| **Structure**<br>**Loading** | **R.C.C Tube Structure** |
|---|---|
| EQX | 705.71 |
| EQZ | 694.98 |

Table 6.11

**Node Displacement (mm)**

| | **R.C.C Tube Structure** |
|---|---|
| Node No. | 310 |
| Displacement | 28.662 |

Table 6.12

**ASPECT RATIO 1.0**

**Base Shear (KN)**

| **Structure**<br>**Loading** | **R.C.C Tube Structure** |
|---|---|
| EQX | 615.65 |
| EQZ | 432.75 |

Table 6.13

**Node Displacement (mm)**

| | **R.C.C Tube Structure** |
|---|---|
| Node No. | 274 |
| Displacement | 26.994 |

Table 6.14

## VII. DISCUSSIONS

From above comparison & analysis given in previous chapter it is seen that, peak shear for R.C.C Tube structure is higher than R.C.C Frame structure on other hand it also seen that storey drift is less for R.C.C Tube structure which is major effect consider for seismic evaluation.

In zoning comparison it is seen that shear & drift values are increased as zone factor increases. It also gives result that tube structure is best for even very high sensitive zone.

In aspect ratio comparison it is seen that structure with high shear value, lesser value of storey drift. Structure with aspect ratio-0.8 performs well in seismic conditions.

## VIII. CONCLUSIONS

- Tube Structure strongly resists earthquake forces as compare to R.C.C. Normal Structure.
- Tube Structure strongly supports the earthquake design philosophy of Strong Column and Weak Beam.
- Tube Structure reduces Story Drift 16% as compared to Story Drift of R.C.C. Normal Structure.
- The Impulse Effect by earthquake is strongly resisted by Tube Structure then R.C.C. Normal Structure.
- Building with aspect ratio 0.80 performs well for seismic design.

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