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# COMPARATIVE STUDY ON DIFFERENT TUBULAR STRUCTURE FOR LATERAL LOADS AND ANALYSIS OF MASS AND STIFFNESS IRREGULARITY FOR FINEST TUBULAR STRUCTURE

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**Abstract** The analytical study of seismic and wind load behavior of different RCC tube structure constructions, and in order to accomplish this, a typical G+25 storey RCC building structure was modelled in ETABS software for zone v. The regular RCC structure and different forms of tubular structure are studied for dead load, live load, wind load, and seismic load. By using dynamic analysis, the seismic reactions and comparison investigation for both regular and different forms of tube structures have been observed. By comparing regular model with different forms of tube structure time period reduces around 32% in bundle tube structure, the displacement is reduced in bundle tube structure about 51% to 70% and drift reduces about 50% to 70% in bundle tube structure when regular model structure hence bundle tube structure is giving good results so when we design the bundle tube structure with stiffness and mass irregularity the values like time period, displacement and drift values is almost same hence bundle tube structure is most suitable type of structure to resist lateral loads in high rise structure with mass and stiffness irregularity or without mass and stiffness irregularity.

**Key Words**: seismic and wind load, bundle tube structure, mass and stiffness irregularity, Etabs.

## 1.INTRODUCTION

From the viewpoint of structural engineering, all tall structures must be able to endure lateral loads in addition to gravity. To make structures resistant to the effects of lateral loads, various structural techniques will be used. Rigid frame structures, braced frame structures, shear wall frame structures, outrigger systems, and tubular structures are only a few of the various types of structures. Tubular systems are the most widely used and respected lateral structural techniques for high-rise structures As a result of the huge population influx, towns and cities are expanding quickly. The entire planet is experiencing this phenomenon. The lack of available land for construction, particularly in big cities worldwide, is a challenge that frequently causes structures to develop more vertically than horizontally. Today, high-rise commercial buildings are seen as icons of modern society. These represent how business has an impact on the contemporary global economy. These also add a third dimension to the metropolis. Additionally, the company has added advantages from having a commercial space in a charming high-rise building on a smaller scale, including increased client confidence and a stronger corporate identity. India is not an exception to this trend; high-rise buildings with a significant number of floors are being developed in large towns and cities all over the world. Tall buildings with multiple stories have a flexible nature and are susceptible to wind's effects. The idea behind the tube system is that lateral loads can be resisted by building a structure as a hollow cantilever that is perpendicular to the ground. Deeply spaced columns that are joined by moment connections are frequently used to build the exterior of tubes. This arrangement of columns and beams forms a rigid frame that mimics a solid structural wall along the exterior of the building.

### Types of tube structure system

1. Framed Tube Structural System
2. Bundled Tube Structural System
3. Trussed Tube Structural System
4. Tube-in-Tube Structural System
5. Hybrid Tube Structural System

## IRREGULARITIES IN BUILDINGS

There are five seismic zones, each with a different potential for shaking strength, according to the Indian seismic code IS 1893-2002. Failure starts in the weakest area during an earthquake. This weakness could be brought on by the structure's discontinuity in mass, stiffness, and shape. One of the many important causes of earthquake structural failure is vertical irregularity, and discontinuous constructions are referred to as irregular structures. The weight, strength, and stiffness of vertical irregular constructions are distributed unevenly along the height of the building. The 2002 Indian seismic code edition clearly defines the irregular structure. The research and layout become more challenging when these structures are to be built in seismically active areas.

Vertical irregularities

1. Mass irregularity
2. Stiffness irregularity (soft storey)
3. Vertical geometric irregularity

## OBJECTIVES

- To study the effect of different forms of tube structures which are subjected to earthquakes.
- To predict the behaviour of the structure under earthquake loading by comparing maximum time period, storey displacement and inter storey drift, and base shear.
- To understand the behaviour of
  - Inner single tube structure
  - Bundled tube structures

- Tube-in-tube structures
- Outer single tube structures

- To investigate the G+25 storied RC frame's mass and stiffness using both static and dynamic analysis (response spectrum).

## 2. MODELLING AND ANALYSIS

MODEL 1(regular model with RCC structure)
Model 1 consists of a commercial building with ordinary moment resisting frame of length 36metres and breadth 24 meters each and height 88.4 meters namely 26floors. Is analysed for seismic zone V and the results and noted down

MODEL 2 (model with Inner Single Tube structure)
Model 2 consists of a commercial building with ordinary moment resisting frame of length 36 metres and breadth 24 metres each and height 88.4 meters namely 26floors is analysed for seismic zones V and the results and noted down

MODEL 3 (model with Bundle Tube structure)
Model 3 consists of a commercial building with ordinary moment resisting frame of length 36 meters and breadth 24 meters each and height 88.4 meters namely 26floors is analyzed for seismic zones V and the results and noted down

MODEL 4 (model with Tube in Tube structure)
Model 4 consists of a commercial building with ordinary moment resisting frame of length 36 meters and breadth 24 meters each and height 88.4 meters namely 26floors is analysed for seismic zones V and the results and noted down.

MODEL 5 (model with Outer Single Tube structure)
Model 5 consists of a commercial building with ordinary moment resisting frame of length 36 meters and breadth 24 meters each and height 88.4 meters namely 26floors is analysed for seismic zones V and the results and noted down.

FOR STIFFNESS AND MASS IRREGULARITIES

MODEL 1 (Model with ground-floor mass irregularity)
A regular-framed building with a mass irregularity at the ground floor, measuring 36 meters long, 24 meters wide, and 88.4 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

MODEL 1A ( Model with ground-floor mass irregularity)
Bundle Tube structure with a mass irregularity at the ground floor, measuring 36 meters long, 24 meters wide, and 88.4 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

MODEL 2 (model with mid floor mass irregularity)
A regular-framed building with a mass irregularity at the mid floor, measuring 36 meters long, 24 meters wide, and 88.4 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

MODEL 2A (model with mid floor mass irregularity)
Bundle Tube structure with a mass irregularity at the mid floor, measuring 36 meters long, 24 meters wide, and 88.4 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

MODEL 3 (model with top floor mass irregularity)
A regular-framed building with a mass irregularity at the top floor, measuring 36 meters long, 24 meters wide, and 88.4 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

MODEL 3A (model with top floor mass irregularity)
Bundle Tube structure with a mass irregularity at the top floor, measuring 36 meters long, 24 meters wide, and 88.4 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

MODEL 4 (Model with ground-floor stiffness irregularity)
A regular-framed building with a stiffness irregularity at the ground floor, measuring 36 meters long, 24 meters wide, and 91.2 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

MODEL 4A (Model with ground-floor stiffness irregularity)
Bundle Tube structure with a stiffness irregularity at the ground floor, measuring 36 meters long, 24 meters wide, and 91.2 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

MODEL 5 (Model with mid-floor stiffness irregularity)
A regular-framed building with a stiffness irregularity at the mid floor, measuring 36 meters long, 24 meters wide, and 91.2 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

MODEL 5A (Model with mid-floor stiffness irregularity)
Bundle Tube structure with a stiffness irregularity at the mid floor, measuring 36 meters long, 24 meters wide, and 91.2 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

MODEL 6 (Model with top-floor stiffness irregularity)

A regular-framed building with a stiffness irregularity at the top floor, measuring 36 meters long, 24 meters wide, and 91.2 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

MODEL 6A (Model with top-floor stiffness irregularity)

Bundle Tube structure with a stiffness irregularity at the top floor, measuring 36 meters long, 24 meters wide, and 91.2 meters tall, or 26 stories, is assessed for seismic zone V, and the results are recorded.

| **TITTLE** | Description |
|---|---|
| Structure | Concrete |
| Plan dimensions | 36 m × 24 m |
| Number of stories | G + 25 |
| Height of the structure | 80 m |
| Floor height | 3.2 m |
| Zone | Z-5 |
| Concrete grade | M55,<br>M30,<br>M25 |
| Steel grade | HYSD<br>500 |
| Column size | 750 × 750 mm |
| Beam size | 300 × 600 mm<br>600 × 800 mm<br>700 × 1000 mm |
| Slab thickness | 150 mm |
| Wall load (glass panels) 100mm | 4.4 KN/m |
| ACC block wall load 200mm for partition | 2.86 KN/m |
| Parapet Wall Load 100mm | 2.2 KN/m |
| Floor finish | 1.5 kN/m² |
| Live load | 4 kN/m² |
| Roof live load | 1.5 kN/m² |
| Lift dead load | 10 kN/m² |
| Lift Live load | 5 kN/m² |

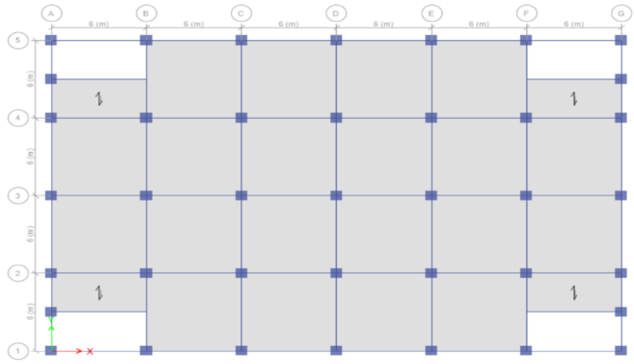


Figure 1 Etabs plane of Regular model

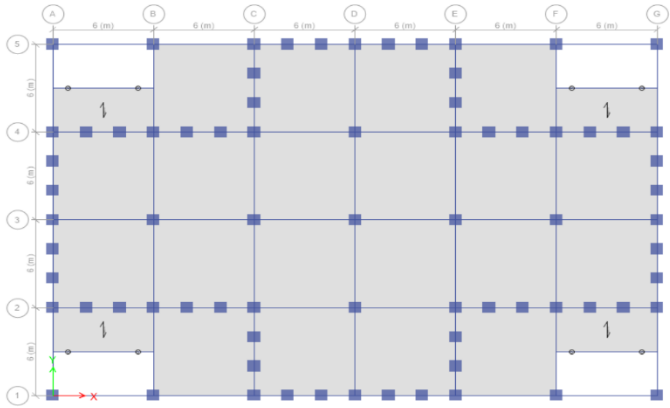


Figure 2 Etabs plan of Inner Single Tube model

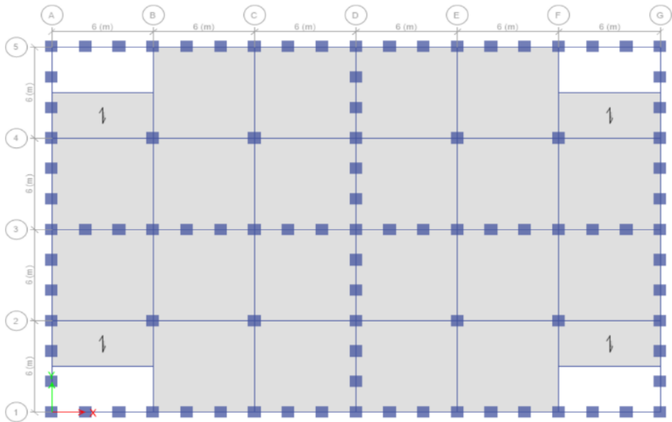


Figure 3 Etabs plan of Bundle tube model

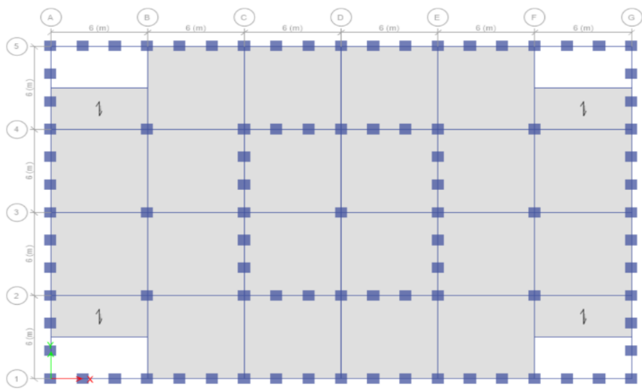


Figure 4 Etabs plan of Tube in Tube model

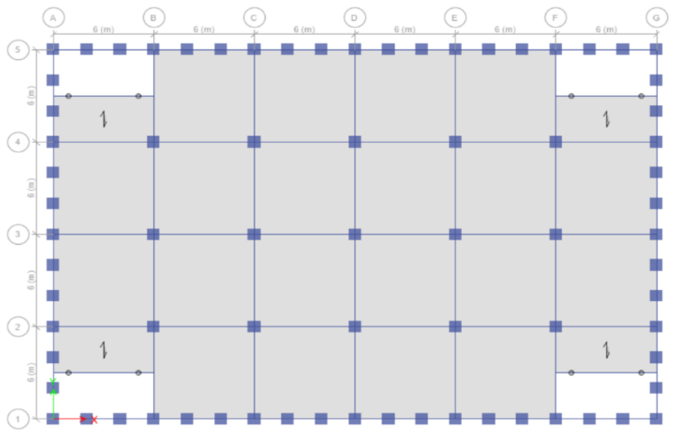
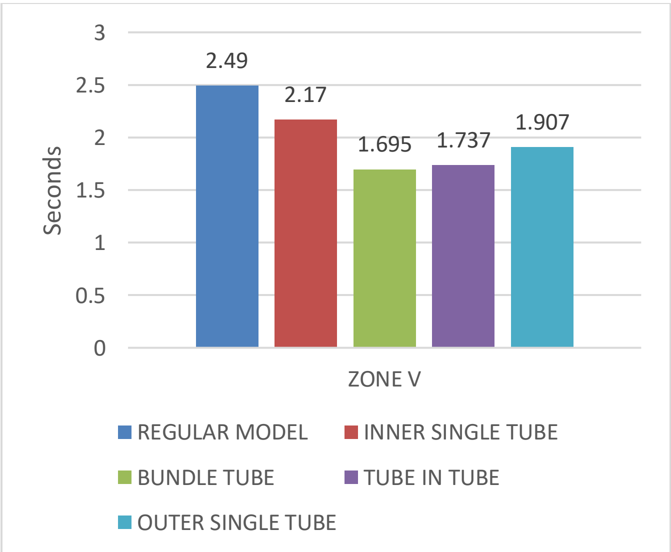


Figure 5 Etabs plan of outer single tube model

## 3.RESULTS

### Time period values for different tube structure for zones V

| Sl no | zones | Regular Model (sec) | Inner Single Tube (sec) | Bundle Tube (sec) | Tube in Tube (sec) | Outer Single Tube (sec) |
|---|---|---|---|---|---|---|
| 1 | V | 2.49 | 2.17 | 1.695 | 1.737 | 1.907 |

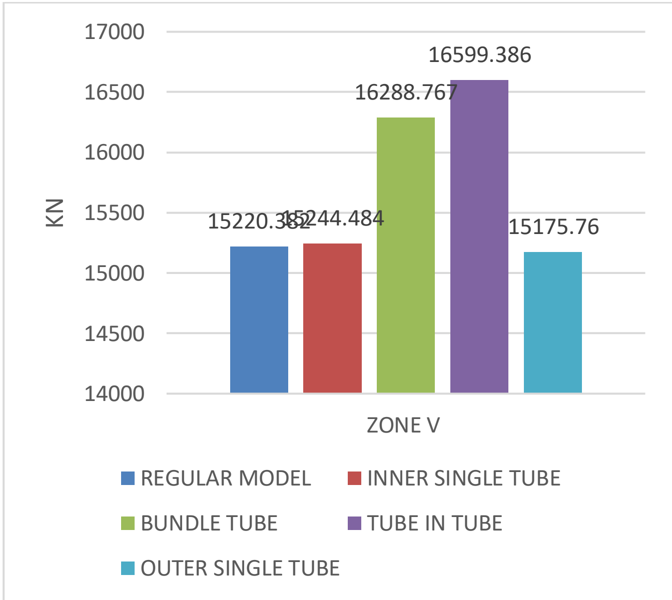



Graph of displacement variation for different forms of tube structure for static analysis in X direction

The reduction of time period for inner single tube, bundle tube, tube in tube and outer single tube model when compared to regular model is (12.85%, 31.92%, 30.24%, 23.41%) for zone V.

### Base shear values for different forms of tube structure along X direction

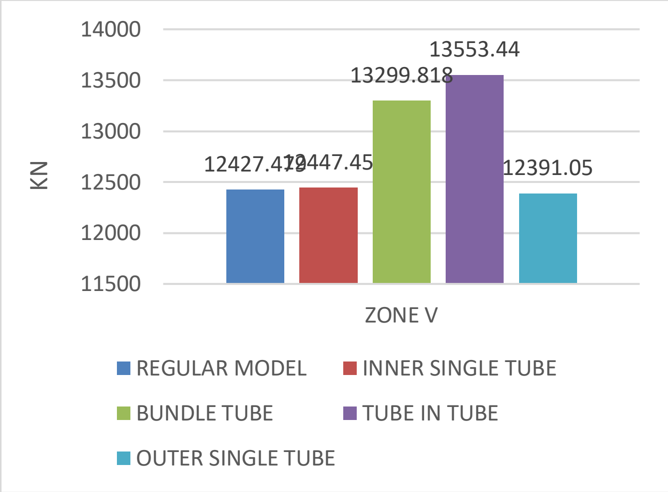
| Sl no | zones | Regular Model (KN) | Inner Single Tube (KN) | Bundle Tube (KN) | Tube in Tube (KN) | Outer Single Tube (KN) |
|---|---|---|---|---|---|---|
| 1 | V | 15220.382 | 15244.484 | 16288.767 | 16599.386 | 15175.76 |




The reduction of displacement for inner single tube, bundle tube, tube in tube and outer single tube model when compared to regular model along Y direction for response spectrum analysis is (-0.15%, -7.01%, -6.43%, 0.29%) for zone V.

### Base shear values for different forms of tube structure along Y direction

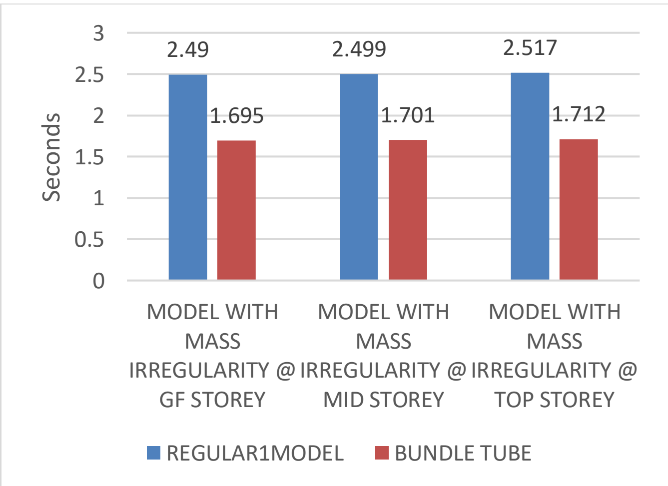
| Sl no | zones | Regular Model (KN) | Inner Single Tube (KN) | Bundle Tube (KN) | Tube in Tube (KN) | Outer Single Tube (KN) |
|---|---|---|---|---|---|---|
| 1 | V | 12427.479 | 12447.45 | 13299.818 | 13553.440 | 12391.05 |




The reduction of displacement for inner single tube, bundle tube, tube in tube and outer single tube model when compared to regular model along Y direction for response spectrum analysis is (-0.16%, -7.01%, -9.06%, 0.29%) for zone V.

**Max time period values for different storey mass irregularity models (Static analysis and response spectrum in X and Y direction**

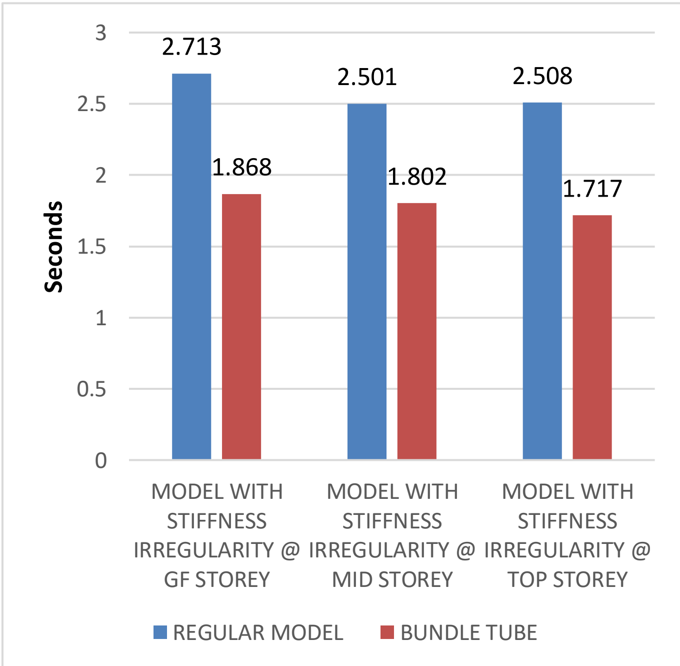
| Sl no | Models | Regular Model for zone V (sec) | Bundle tube for zone V(sec) |
|---|---|---|---|
| 1 | Model with mass irregularity @ GF storey | 2.49 | 1.695 |
| 2 | Model with mass irregularity @ mid storey | 2.499 | 1.701 |
| 3 | Model with mass irregularity @ top storey | 2.517 | 1.712 |




From the results of time period the reduction of time period in Model with mass irregularity for ground floor, middle floor, top floor model with bundle tube model when compared regular model is about (31.92%, 31.93%, 31.98%) for zone V.

**Max time period values for different storey stiffness irregularity models (Static analysis and response spectrum in X and Y direction)**

| Sl no | Models | Regular Model for zone V (sec) | Bundle tube for zone V(sec) |
|---|---|---|---|
| 1 | Model with mass irregularity @ GF storey | 2.713 | 1.868 |
| 2 | Model with mass irregularity @ mid storey | 2.501 | 1.802 |
| 3 | Model with mass irregularity @ top storey | 2.508 | 1.717 |




From the results of time period the reduction of time period in Model with stiffness irregularity for ground floor, middle floor, top floor model with bundle tube model when compared regular model is about (31.14%, 27.94%,31.53%) for zone V.

## 4. CONCLUSIONS

- From the modal analysis, it is observed that the lateral restraint reduces the time period of the structure. The bundle tube structure reduces the time period of 31.92% when compared to regular model.
- From the equivalent static analysis and response spectrum analysis along X and Y direction it is observed that bundle tube structure having lesser displacement around 51% to 70% when compare to regular structure.
- The drift values for static analysis in all models are almost similar and within the allowable limits. i.e., 0.004h. And bundle tube structure drift value is 50% to 70% lesser than regular model.
- The base shear values of static analysis and dynamic analysis will be same. However, the outer single tube models are having lesser base shear than other structure.
- By selected bundle tube model with mass and stiffness irregularity at ground floor, middle floor, and top floor the results like top storey displacement, drift, time period is almost same hence bundle tube model is safe against stiffness and mass irregularity structure
- For response spectrum, displacement, storey drift and time period considerably decreased in model with bundle tube.
- For static analysis, displacement, storey drift and time period considerably decreased in model with bundle tube.
- The overall analysis briefs that the bundle tube structures are better compared to other type of tube structure due to its reduction in displacement and increase in its stiffness.

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