

Comparative Study on Tube in Tube Structures and Tubed Mega Frames

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ABSTRACT: Tubular structures are common structural system for tall buildings over past few years. The tubular structures are of different types in which tube in tube structures are more suitable for high rise buildings. A tube in tube structure is formed by outer framed tube and inner core tube connected by floor slab. It is act like a huge tube (i.e. Peripheral tube) with a smaller tube(i.e., core tube) in middle of it. The load is transfer between these two tubes. In which a strong center tube of high strength concrete is the main load carrying structure. Avoiding this center tube a new structural system for tall building is developed known as tubed mega frames. In which the load is carried by long vertical tubes at perimeter of building connected by periphery walls. This structural system improves the structural stability and increases the floor space to be utilized. In this project, a comparative study of tube in tube structure and tube mega frame system with bare frame structure has been done.

KEYWORDS: Tube in tube structures, core tube, peripheral tube, tubed mega frames, peripheral walls.

I.INTRODUCTION

The advancement in construction field is increased day by day. The numbers of buildings, height of building are increased. The effect of lateral load is increased with respect to the increase of height. Modern construction methods and structural systems are to be introduced to enhance the structural safety. Different types of structural systems are to be used to resist the effect of lateral loads on the buildings. Rigid frame structures, braced frame structures, shear wall frame structures, outrigger systems, tubular structures are the different types of structural systems used in the buildings to enhance structural safety by reduce the effect of lateral loads on the buildings. The tubular systems are widely used and which is to be considered as a better structural systems for tall buildings. The different types of tubular structural systems are frame tube, braced tube, bundled tube, tube in tube, and tube mega frame structures. The frame tube structures are the first type of tubular systems and which is made by closely spaced columns on the outer side of the building. Advancement in frame tube structures are done by providing X bracings on each stories and these bracings are diagonally connected which is known as braces frame structures. The bundled tube structures are made by connecting number of tubes. The tube in tube structures and tube mega frame structures are the new development in the tubular structures. The tube in tube structures are to be widely used in tall buildings. And the tubed mega frame structures are the new concept in the field of tubular structures for tall buildings.

Tube in tube structures are formed by connecting peripheral frame tube and inner core tube. These tubes are connected by floor slabs. The columns of peripheral and inner core tubes are placed closely, it is not seen as a solid system but it is act as a solid surface. The loads acting on the structures are to be shared between the inner and outer tubes. The tubed mega frames are new concept for tall building. It is formed by peripheral tubes connected by perimeter wall instead of one central core. The main function of perimeter wall is transfer load between vertical tubes. The high strength concrete central tube is carrying carrying load in tube in tube structures, in tubed mega frames instead of one central tube several vertical tubes are carrying the lateral loads. And the space utilization is increased in tubed mega frames.

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II. RELATED WORK

The first form of tube structures are frame tube structures the studies on tube structures was introduced by Ray. P. S Han [1]. The frame tube structure is to be formed by closely spaces columns and beams which is to be analyzed by FEA method is done. A M Memari [2] 32 story reinforced concrete building is analysed by inelastic time history analysis. Myoungsu Shin [3] was studied the shear lag behaviour of tube in tube structure buildings. Hamid Mirzahosseini [4] the objective of the study is the effect of different design paramers of tube action and shear lag of buildings. NimmyDileep [5] the main objective of the study is to investigate the performance of tubed buildings by using SAP 2000.

III. SCOPE OF THE WORK

The construction of multistorey building is to be increased day by day the scope of this project is to suggest a better structural system for the construction of multi storied building. By investigate the performance of a tube in tube structure with different positioning of the internal tube and tube mega frame structures.

IV. MODELLING OF BUILDING

The building is a G+15 story reinforced concrete building. The structure is approximately 48.3m tall, and is 23.000 m wide and 34.450 m length .The story height is 3.3 m at the first story and 3 m at the upper story. Proposed slab thickness is 150 mm for all typical floors .Area of building 792.35m². Member Properties, dimensions of the beams for all typical floors 200 mm × 600 mm, the column at the ground floor 300×1000 mm, and for the above floors 200×1000 mm, the thickness of the slab is provided as 150 mm, and the shear wall of thickness 200 mm. The live load is 3 kN/m², load due to masonry 10.8 kN/m, load due to parapet wall of height 1.2m and thickness 15cm is 3.24kN/m and floor finish 1kN/m², wind load and seismic load calculations can be done directly by ETABS. The load combination is based on IS: 456 – 2000 and IS 1893 (Part 1): 2002.

For modelling three sets of models are to be consider the first set of model is bare frame model A, Second modal B which is the tube in tube building. And the third set of model, model C, which is the tube mega frame. In model B, the tube in tube structure is modelled with different positioning of the internal tube model B1 with canter tube, model B2 with edge tube, model B3 with inner tube. Model C is the tube mega frame.

Figure shows the modelling of bare frame, tube in tube structures and tube mega frame structures. Figure 1(a) shows the modelling of model A, which is the bare frame building considering shear wall at the lift location.

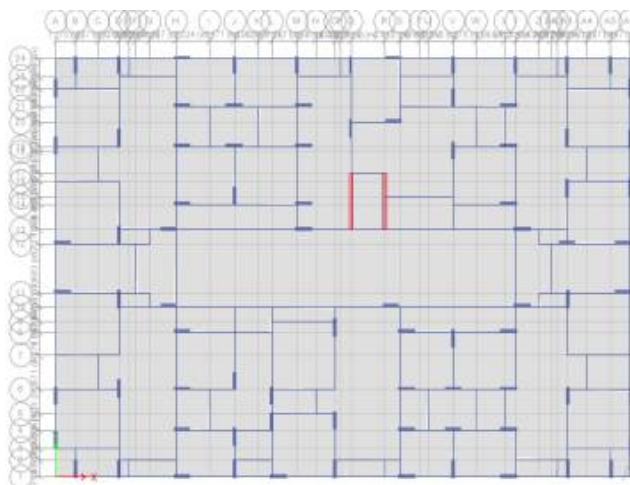


Fig.1 Modelling of bare frame

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Figure 2 is the modelling of model B and model C, in model B, the tube in tube structure is modelled with different positioning of the internal tube model B1 with center tube, model B2 with edge tube, model B3 with inner tube. (a) modelling of model B1, which is the tube in tube structure with center tube, (b) modelling of model B2, which is the tube in tube structure with edge tube, (c) modelling of model B3, which is the tube in tube structure with inner tubes, (d) modelling of model C tubed mega frames.

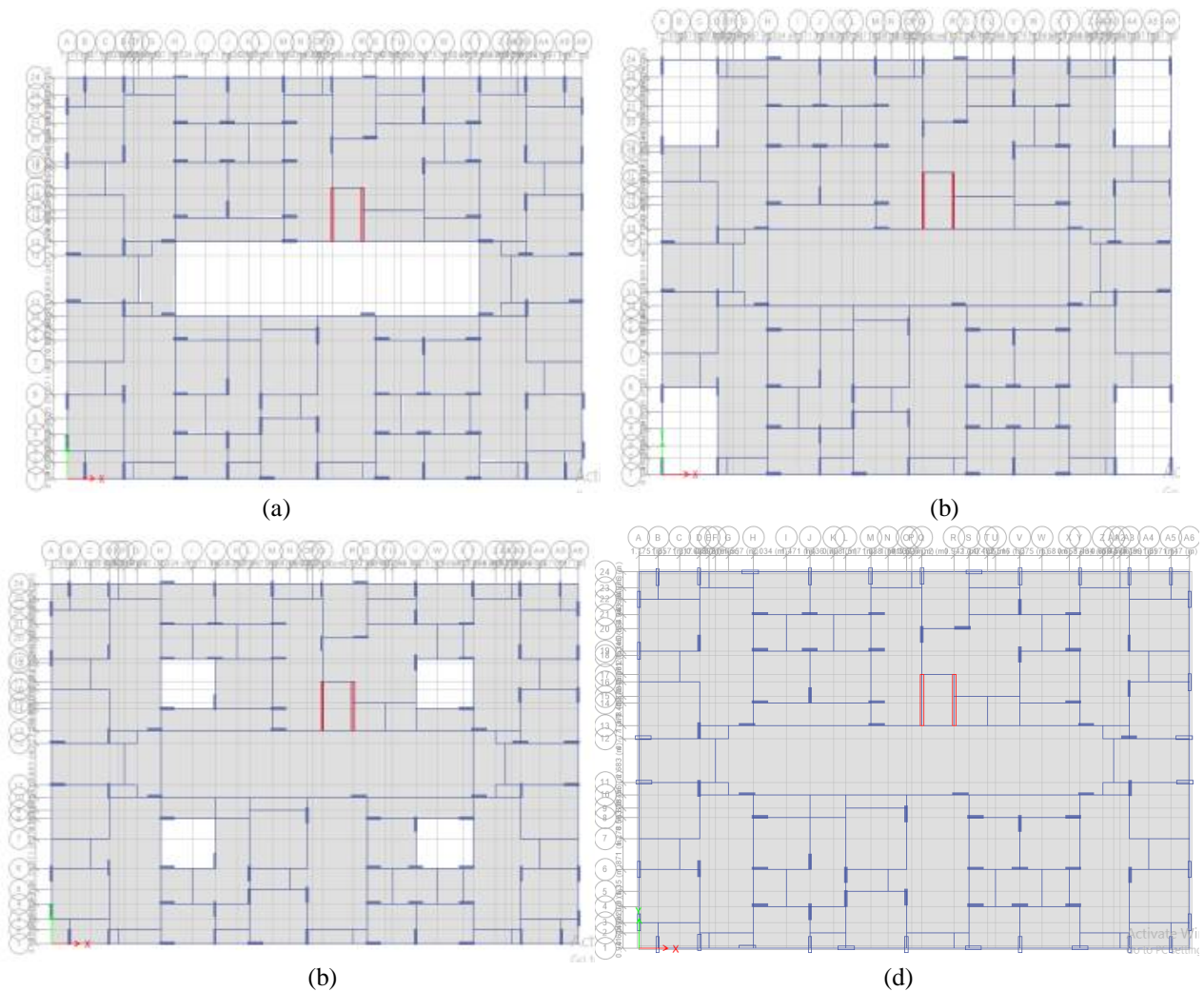


Fig.2 Modelling of Model B and Model C

V .ANALYSIS

The two types of analysis method is are carried out equivalent static analysis and response spectrum analysis. The equivalent static as well as response spectrum analysis of bare frame (model A), tube in tube structure (model B) i.e., tube in tube structure with center tube (model B1), tube in tube structure with edge tube (model B2), tube in tube structure with inner tube (model B3) and tube mega frame structure (model C) are done using ETABS 2015. The results considered for each analysis are story displacement, story drift and story shear for each model.

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VI. ANALYSIS RESULT

From first set model (model A) which is bare frame structure considering shear wall at lift location. Table 1 shows the maximum value of displacement, story drift, and story shear from the analysis result of bare frame in static and response spectrum analysis.

Table 1 Analysis result of bare frame

	Static analysis	Response spectrum analysis
Max Story displacement (mm)	4.3	4.9
Max story drift	0.00025	0.000295
Max story shear (kN)	2570	2605

From second set model (model B) which is tube in tube structure, in which model B1 tube in tube structure with center tube. Table 2 shows the maximum value of displacement, story drift, and story shear from the analysis result of tube in tube structure with center tube in static and response spectrum analysis.

Table 2 Analysis result of tube in tube structure with center tube

	Static analysis	Response spectrum analysis
Max Story displacement (mm)	2.3	2.5
Max story drift	0.000106	0.000117
Max story shear (Kn)	946.841	1012.127

From second set model (model B) which is tube in tube structure, in which model B2 tube in tube structure with edge tube. Table 3 shows the maximum value of displacement, story drift, and story shear from the analysis result of tube in tube structure with edge tube in static and response spectrum analysis.

Table 3 Analysis result of tube in tube structure with edge tube

	Static analysis	Response spectrum analysis
Max Story displacement (mm)	3.5	3.9
Max story drift	0.000246	0.000292
Max story shear (kN)	989.229	2515.776

From second set model (model B) which is tube in tube structure, in which model B3 tube in tube structure with inner tube. Table 4 shows the maximum value of displacement, story drift, and story shear from the analysis result of tube in tube structure with inner tube in static and response spectrum analysis.

Table 4 Analysis result of tube in tube structure with inner tube

	Static analysis	Response spectrum analysis
Max Story displacement (mm)	2.5	3.4
Max story drift	0.000112	0.000244
Max story shear (kN)	950.226	2055.655

From first set model (model C) which is tubed mega frame structure considering shear wall at lift location. Table 5 shows the maximum value of displacement, story drift, and story shear from the analysis result of tubed mega frame in static and response spectrum analysis.

Table 5 Analysis result tubed mega frames

	Static analysis	Response spectrum analysis
Max Story displacement (mm)	3.5	3.6
Max story drift	0.000111	0.000135
Max story shear (kN)	981.15	1283.98

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VII.COMPARISON OF RESULTS

From first set model (model A) which is bare frame structure considering shear wall. Table 1 shows the analysis result of bare frame in static and response spectrum analysis.

Comparison of results from the analysis of tube in tube structures

From second set of models(model B) which is tube in tube structure with shear wall .In which model B, which is the shear wall building with center tube shows less displacement, drift, and story shear compared to other two models. In the case of shear wall building with edge tube shows large values of displacement, drift, and story shear than that of shear wall building with inner tube. The table 6 shows the equivalent static and response spectrum analysis results of shear wall building with center tube.

Table 6 Analysis result of tube in tube structure with centre tube

	Static analysis	Response spectrum analysis
Max Story displacement (mm)	2.28	2.52
Max story drift	0.000106	0.000114
Max story shear (kN)	946	1012

From the comparison of model A, bare frame and model B1,tube in tube structure with center tube. The tube in tube structure with center core shows better result in equivalent static analysis and response spectrum analysis. Tube in tube structure with center core shows less values in story displacement, story shear and story drift.

Static and dynamic analysis are to be done in tubed mega frame buildings. The table 5 shows the analysis results of tubed mega frame.

From the analysis results of tube in tube structure and tube mega frame structure , tube in tube building with center core shows less values in story displacement, story drift and story shear in both equivalent static analysis and response spectrum analysis.

Comparison of bare frame with tube in tube structure and tube mega frame(Displacement)

Table 7 shows the displacement of bare frame, tube in tube structure and tube mega frame and figure 3 shows the comparison of displacements of each model from equivalent static analysis and response spectrum analysis.

Table 7 displacement of models

	Bare frame	Tube in tube structure with Centre tube	Tube mega frame
Equivalent static analysis	4.3	2.28	3.49
Response spectrum analysis	4.9	2.52	3.6

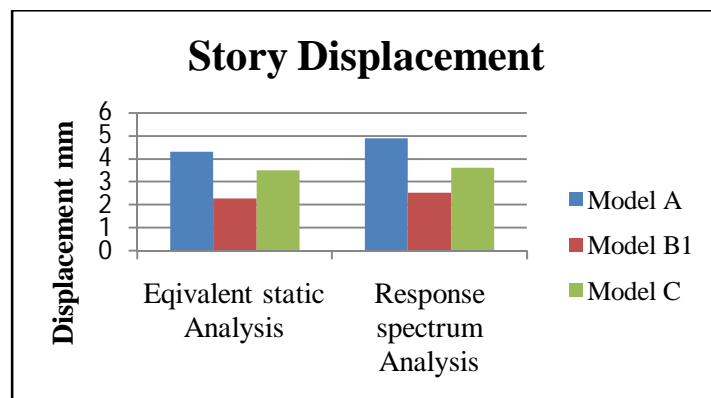


Fig.3: Comparison of displacement

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From the comparison the bare frame shows high displacement than that of tube in tube structure and tube mega frame structures. From the comparison the tube in tube structure shows a 46.98% of displacement reduction than that of bare frame and for tube mega frame which is of 18.84% displacement reduction in equivalent static analysis. And in response spectrum analysis the tube in tube structure shows a 48.6% of displacement reduction than that of bare frame and for tube mega frame which is of 26.5% displacement reduction.

Comparison of bare frame with tube in tube structure and tube mega frame (Story Drift)

Table 8 shows the story drift of bare frame, tube in tube structure and tube mega frame and figure 4 shows the comparison of story drift of each model from equivalent static analysis and response spectrum analysis.

Table 8 Story drift of models

	Bare frame	Tube in tube structure with Centre tube	Tube mega frame
Equivalent static analysis	0.00025	0.000106	0.000111
Response spectrum analysis	0.000295	0.000114	0.000135

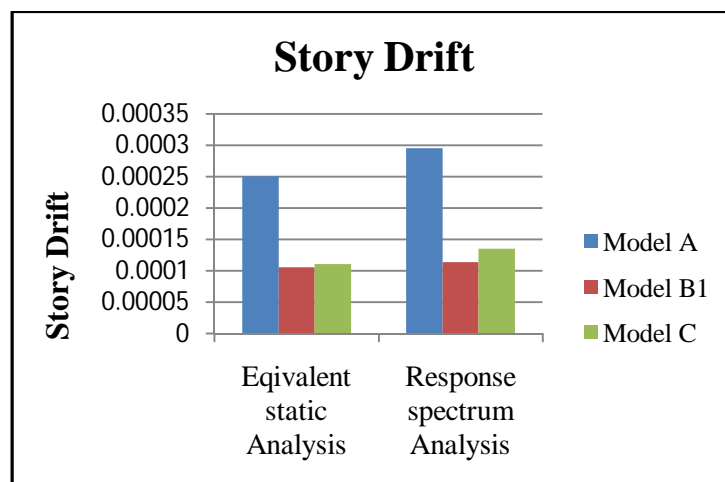


Fig.4: Comparison of Story Drift

From the comparison the bare frame shows high drift than that of tube in tube structure and tube mega frame structures. From the comparison the tube in tube structure shows a 57.6% of story drift reduction than that of bare frame and for tube mega frame which is of 55.6% drift reduction in equivalent static analysis. And in response spectrum analysis the tube in tube structure shows a 61.36% of drift reduction than that of bare frame and for tube mega frame which is of 54.24% drift reduction.

Comparison of bare frame with tube in tube structure and tube mega frame (Story Shear)

Table 9 shows the story shear of bare frame, tube in tube structure and tube mega frame and fig 5 shows the comparison of story shear of each model from equivalent static analysis and response spectrum analysis.

Table 9 Story shear of models

	Bare frame	Tube in tube structure with Centre tube	Tube mega frame
Equivalent static analysis	2570	946	981.1
Response spectrum analysis	2605	1012	1283.98

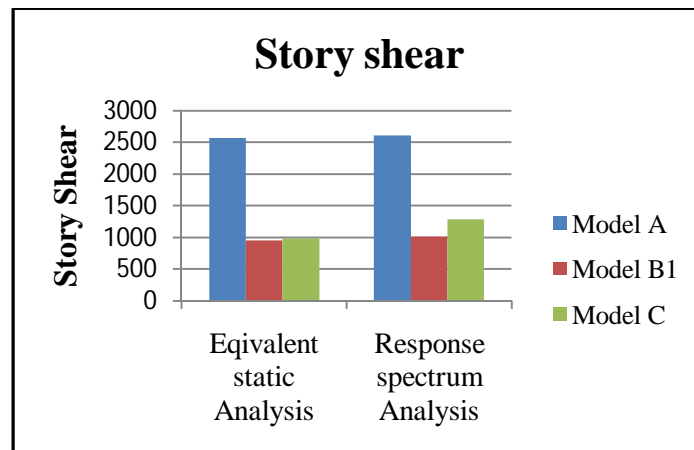


Fig.5: Comparison of story shear

From the comparison the bare frame shows high story shear than that of tube in tube structure and tube mega frame structures. From the comparison the tube in tube structure shows a 63.19% of story shear reduction than that of bare frame and for tube mega frame which is of 61.82% story shear reduction in equivalent static analysis. And in response spectrum analysis the tube in tube structure shows a 61.15% of shear reduction than that of bare frame and for tube mega frame which is of 50.71% shear reduction.

VII.CONCLUSION

The equivalent static and response spectrum analysis were conducted in bare frame, tube in tube structures and tube mega frame structures. From analysis results the tube in tube structure with centre tube shows better result than that of bare frame and tube mega frame structures. In static and response spectrum analysis, tube in tube structures with centre tube shows least values in story displacement, story drift and story shear. As a comparison, tube in tube structure with centre tube can be suggested as a better structural system for tall buildings. Comparing bare frame structure with other two systems, it is found that tube mega frames shows better floor space to be utilized. From the analysis result both in static and response spectrum analysis tube in tube structure shows 46.98% and 48.6% reduction in displacement than that of bare frame, and for tube mega frame structural system 18.84% displacement reduction than that of bare frame in equivalent static analysis and 26.5% displacement reduction in response spectrum analysis. From the comparison of analysis result tube in tube structure with centres tube is recommended as a better structural system for tall building than bare frame structures and tube mega frame structures.

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