International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 08 | Aug 2021 www.irjet.net p-ISSN: 2395-0072

OPTIMUM STRUCTURAL DESIGN OF VARIOUS STRUCTURAL LAYOUTS FOR 21 STOREY HIGH RISE STRUCTURE

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ABSTRACT: Nowadays high-rise structures have become very common because of the scarcity of the land available hence various structural layouts have been introduced to optimize the structure. Structural layouts such as moment frame structure with core, moment frame structure with shear walls at corners, tube structure & tube in tube structure have been introduced and hence with the help of such structural layouts story drifts, maximum story displacements can be reduced to a greater extent when subjected to seismic forces. The objective of this paper is to obtain the optimum structural layout with the help of five different structural layouts for the same plan using static equivalent static method. Five different structural layouts are simple moment frame structure, moment frame structure with shear wall at the corners, moment frame structure with shear wall at the core, tube structure & tube in tube structure. Hence all the structural layouts will be designed for equivalent static method and will be compared with the parameters like maximum story displacement, base shear and story drifts and hence optimum structural layout will be considered out of the five structural layouts.

Keywords: **moment frame structure, moment frame structure with shear wall at the corners, moment frame structure with shear wall at the core, tube structure & tube in tube structure.**

I. INTRODUCTION

Tall buildings have been in existence from ancient times. The bygone structures like tower of Babel, Kutub Minar, Egyptian pyramids, Mayan temples, Colossus of Rhodes. Complex geometry and building height make job of structural engineer more difficult when dealing with Earthquake and wind forces specially. Hence structural engineer needs to adopt different structural layout which resist earthquake and wind forces. Nowadays we can see that tall structure are growing slender and slender hence challenges with respect to earthquake and seismic forces are getting high one more factor that governs the design of high rise structure is its cost so structural engineers are looking for innovative designs such that the total cost of structural system to be reduced. Hence structural engineers have come up with different structural layouts which are very innovative and also reduce cost of the high-rise structure, typically structural cost for tall buildings is around 40-70% of the total project cost generally, cost of lateral bracings above 25 storey's is almost 30% of the total cost of structure. Hence, the structural cost for resisting the lateral load is around 17% - 30%. Tall buildings lead to saving in areas, thus it is suitable for metropolitan cities like Mumbai, Delhi Bangalore etc. Hence in this paper various structural layouts have been compared when subjected to same seismic forces. Here five models have been modelled for the same architectural plan hence all the structural layouts will be analyzed and checked for maximum story displacement, base shear and story drifts hence from the results we will be selecting the best performed structural layout out of the five models. Here to reduce load on the structure Aerocon panels have been used such that uniformly distributed load is considerably reduced. A 21-storey apartment is modelled in ETABS with various structural layouts for the same architectural plan with a floor height of 3.2004m or 10'6". The location of the site is selected as Hubli which comes under the Zone 3. In this study equivalent static method is used for seismic analysis.

The various types of layouts compared are Moment framed structure, Moment framed Structure with shear wall at corners, Moment frame structure with shear wall at the core, Tube structure & Tube in Tube structure. Hence will be selecting the optimum structural layout out of the five layouts created with respect to Seismic force.

II. OBJECTIVE

To analyze and compare the performance of Moment frame structure, Moment frame structure with shear wall at corners, Moment frame structure with shear wall at core, Tube structure, Tube in tube structure and also to study and compare different parameters like story drift in X and Y direction, Base shear of the structure, Maximum story displacement in X and Y direction for 21 story structure with respect to Static

Coefficient method in ETABS. Hence will be selecting the optimum structural layout out of the five layouts created with respect to Seismic force.

III. METHODOLOGY

A 21-storey apartment is modelled in ETABS software with various structural layouts for the same Architectural plan with a floor height of 3.2004m or 10'6". The location of the site is selected as Hubli which comes under the Zone 3. In this study equivalent static method is used for seismic analysis. Various structural layouts used in this study are

- Moment frame structure.
- Moment frame structure with shear wall at the corners.
- Moment frame structure with shear wall at the core.
- Tube structure.
- Tube in tube structure.

This all the five structural layouts will be modelled with respect to seismic forces. Equivalent static method will be used to compare Story drifts, Maximum story displacement and base shear of the structure.

IV. MODELING AND ANALYSIS

IV.1 MOMENT FRAME STRUCTURE

It is a conventional RCC framed structure consisting of beams and column without any shear walls as shown in the figure. The properties of the structure are as follows,

- All Columns sizes used are 600x600mm square column.
- All beams are of size 228x457mm.
- Story height 3.2004m.
- Dead load on the slab=1.5KN/m^2.
- Live load on the slab=2KN/m^2.
- UDL on the beams=3.75KN/m as the light weight Aerocon panels are used.
- Grade of concrete used is M40.
- Grade of steel used is Fe-500.
- Zone factor=0.16.
- Soil type=TYPE (1) Rock or Hard soil.
- Bay spacing in X direction is 5m and in Y direction is 5.5m.

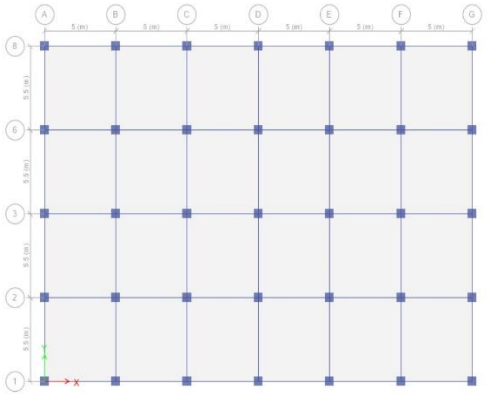
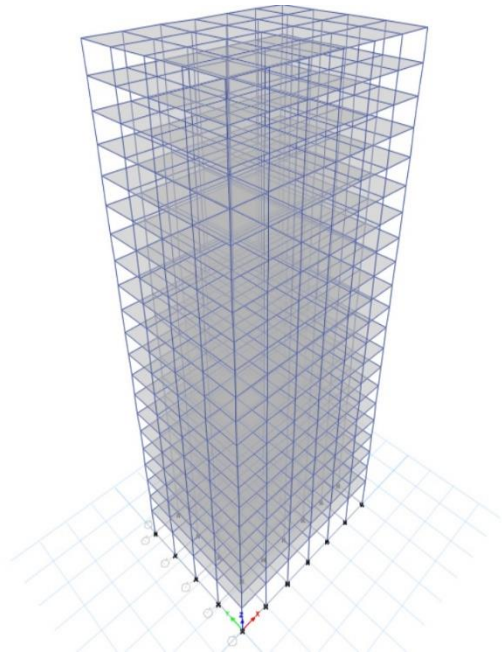


Figure 1-Plan of Moment frame structure.

Figure 2- 3D View of Moment frame structure.



IV.2 MOMENT FRAMED STRUCTURE WITH SHEAR WALL AT THE CORNERS

It is an RCC framed structure consisting of beams and column with shear wall at the corners as shown in the figure. The properties of the structure are as follows

- All Columns sizes used are 600x600mm square column.
- All beams are of size 228x457mm.
- Story height 3.2004m.
- Dead load on the slab=1.5KN/m^2.
- Live load on the slab=2KN/m^2
- Shear wall thickness=228mm

- UDL load on the beams=3.75KN/m as the light weight Aerocon panels are used
- Grade of concrete used is M40
- Grade of steel used is Fe-500
- Zone factor=0.16
- Soil type=TYPE (1) Rock or Hard soil

Bay spacing in X direction is 5m and in Y direction is 5.5m.

Figure 3-Plan of Moment frame structure with shear wall at the corners.

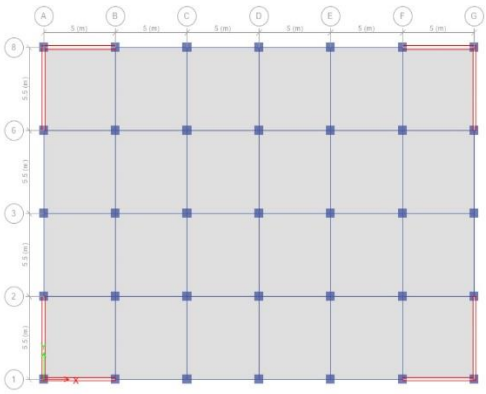
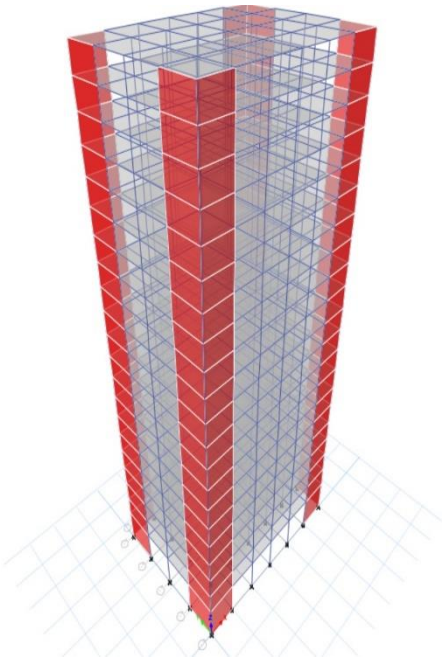


Figure 4-3D view of Moment frame structure with shear wall at the corners.



IV.3 MOMENT FRAMED STRUCTURE WITH SHEAR WALL AT THE CORE.

It is an RCC framed structure consisting of beams and column with shear wall at the core as shown in the figure. The properties of the structure are as follows,

- All Columns sizes used are 600x600mm square column.
- All beams are of size 228x457mm.
- Story height 3.2004m.
- Dead load on the slab=1.5KN/m^2
- Live load on the slab=2KN/m^2
- Shear wall thickness=228mm.
- Uniform dead load on the beams=3.75KN/m as the light weight Aerocon panels are used.
- Grade of concrete used is M40.
- Grade of steel used is Fe-500.
- Zone factor=0.16.
- Soil type=TYPE (1) Rock or Hard soil.

  Bay spacing in X direction is 5m and in Y direction is 5.5m.

Figure 5- Plan of Moment frame structure with shear wall at the core.

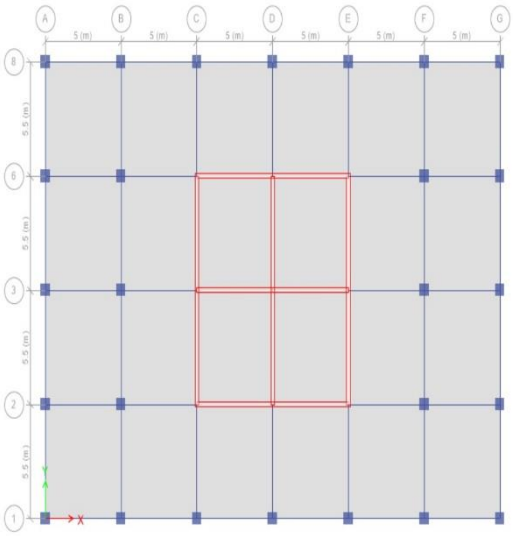
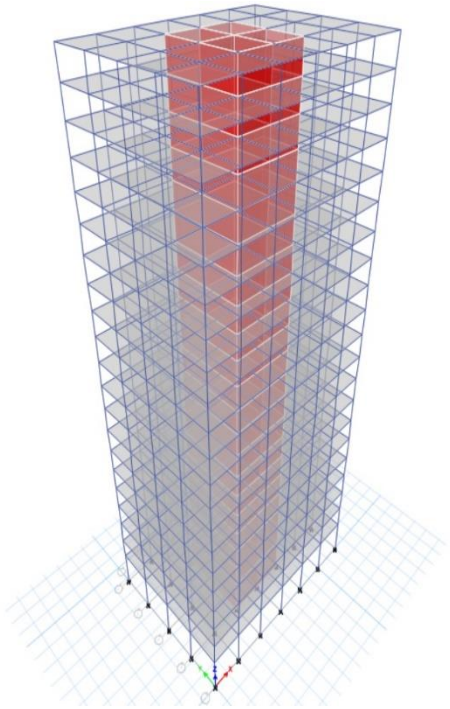


Figure 6- 3D view of Moment frame structure with shear wall at the core.



IV.4 Tube Structure

It is an RCC framed tube structure consisting of beams and columns. It consists of closely spaced columns at the peripheral of the building acting as tubes thus resisting both gravity as well as lateral loads. The properties of the structure are as follows,

- All Columns sizes used are 457X457mm square column.
- All beams are of size 228x457mm.
- Story height 3.2004m.
- Dead load on the slab=1.5KN/m^2
- Live load on the slab=2KN/m^2
- Uniform dead load on the beams=3.75KN/m as35 47U.L/ the light weight Aerocon panels are used.
- Grade of concrete used is M40.
- Grade of steel used is Fe-500.
- Zone factor=0.16.
- Soil type=TYPE (1) Rock or Hard soil.
- Bay spacing used in periphery in X and Y direction are 1.66m and 1.83m.

Figure 7- Plan of Tube structure.

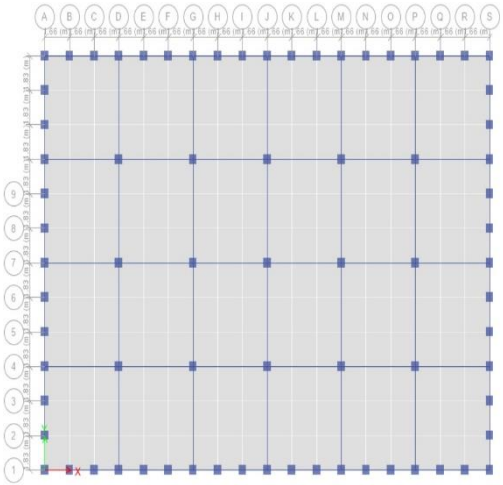
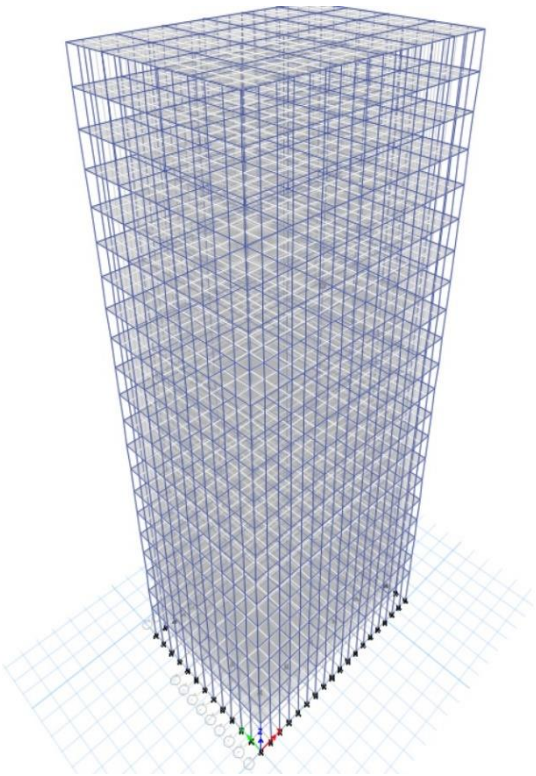


Figure 8- 3D view of Tube structure.



IV. 5 TUBE IN TUBE STRUCTURE

It is an RCC framed tube in tube structure consisting of beams and columns. It consists of closely spaced columns at the peripheral and at the inner core of the building acting as tube holding one tube thus resisting both gravity as well as lateral loads. The properties of the structure are as follows,

- All Columns sizes used are 457x457mm square column.
- All beams are of size 228x457mm.
- Story height 3.2004m.
- Dead load on the slab=1.5KN/m^2
- Live load on the slab=2KN/m^2
- Uniform dead load on the beams=3.75KN/m as the light weight Aerocon panels are used.
- Grade of concrete used is M40.
- Grade of steel used is Fe-500.
- Zone factor=0.16.
- Soil type=TYPE (1) Rock or Hard soil.
- Bay spacing used in periphery in X and Y direction are 1.66m and 1.83m.
- Bay spacing used in core in X and Y direction are 1.66m and 1.83m.

Figure 9- Plan of Tube in Tube structure.

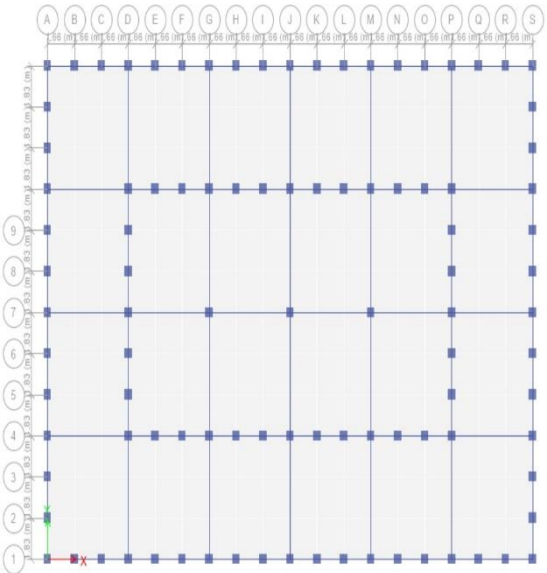
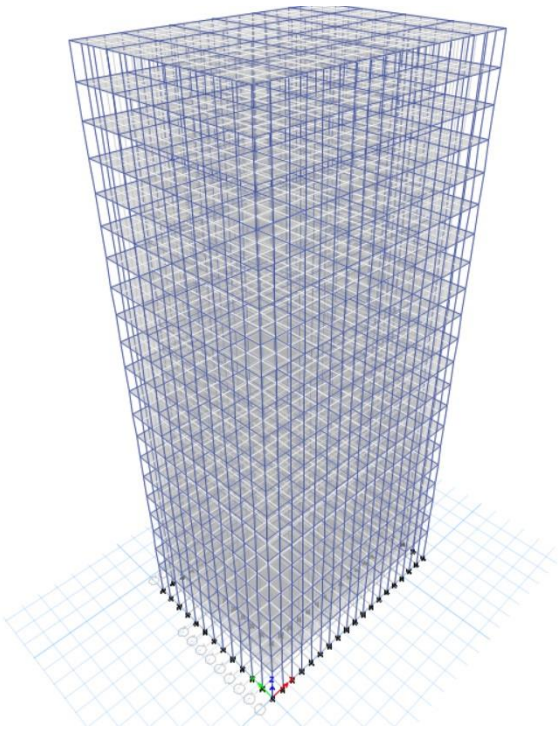


Figure 10- 3D view of Tube in Tube structure.



V. RESULTS

Structural System	Results
Moment Frame	Base Shear (EQX): 713.569KN Base Shear (EQY): 673.739KN Max. Storey displacement (EQX): 23.511mm Max. Storey displacement (EQY): 25.726mm Max. Drift (EQX): 2.94mm Max. Drift in (EQY): 3.12mm
Moment Frame with shear wall at corners	Base Shear (EQX): 1298.73KN Base Shear (EQY): 1322.85KN Max. Storey displacement (EQX): mm Max. Storey displacement (EQY): 25.726mm Max. Drift (EQX):2.15 mm Max. Drift in (EQY): 1.98mm
Moment frame with shear wall at core	Base Shear (EQX): 1968.46KN Base Shear (EQY): 2041.65KN Max. Storey displacement (EQX): 10.275mm Max. Storey displacement (EQY): 9.922mm Max. Drift (EQX): 1.75mm Max. Drift in (EQY): 1.68mm
Tube structure	Base Shear (EQX): 3411.63KN Base Shear (EQY): 2937.42KN Max. Storey displacement (EQX): 16.115mm Max. Storey displacement (EQY): 6.761mm Max. Drift (EQX): 1.86mm Max. Drift in (EQY): 1.9mm
Tube in Tube	Base Shear (EQX): 1269.11KN Base Shear (EQY): 1039.90KN

structure	Max. Storey displacement (EQX): 14.549mm Max. Storey displacement (EQY): 17.867mm Max. Drift (EQX): 1.4mm Max. Drift in (EQY): 1.45mm

VI. CONCLUSIONS

- Hence from this comparison we can find out that Moment frame structure has very low base shear when compared to all different layouts but has maximum displacement and drift when compared to all different layouts hence this cannot be optimized solution.

- Shear wall at the corners behaves good when compared to Moment frame structure but lacks to give good performance when compared to shear wall at the core

- Tube and tube in tube structures behaves very well but tube structure does not perform as good as Moment frame with the core.

- When we compare Moment frame with core and Tube in tube structure slightly tube in tube behaves good but not suited with respect to architectural point of view and also consumption of concrete is more in tube and tube structure.

- Thus, from this paper we can suggest that Moment frame with core performed good when compared to all different layouts with respect to architectural and structural point of view. Thus, we can suggest that Moment frame with core is optimized structural layout which can be used for High rise structure.

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