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An Interpretation of Seismic Behavior of Tube in Tube Building and Moment Resisting Building

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Abstract: ***Lately, Tubular structures have been broadly utilized as structural key for tall structures in the field of structural engineering. Tubular structure of different types, are generally utilized because of their high solidness in opposing lateral loads, increase in the utilization of floor spacing and more economic in construction.***

The parametric analysis was completed on two 40-storey RCC buildings using the software ETABS. Here in this paper, the performance of Tube in Tube building and a moment resisting frame building will be investigated. The models are studied employing continuum approach in which the continual connecting means i.e. beams connecting vertical members and horizontal slabs are assumed to have equitably dispersed stiffness properties. Equivalent static method and Response spectrum method is applied and the analysis results of moment resisting frame and tube in tube buildings are studied to have a comparative analysis of their seismic performance.

Key Words: ETABS, seismic load, Tube in Tube

I. INTRODUCTION

Due to availability of limited area and increase in expansion of urbanization there is no alternative choice left to expand in vertical direction than in horizontal direction. And due to increasing vertical urbanization it is essential to adopt to more stable structure. Tubular structure is one such structure, where the columns are placed at the peripheral of the structure and these columns are connected by deep spandrel beams and floor slabs. Compared to conventional structure the tube in tube structure is more stable in resisting lateral loads, allows more interior space and helps save around 30% of material.

Nowadays, multistory structures and tall buildings have become more slender due to which there is increase in the chances of lateral sway in contrast to erstwhile tall structures. And these difficulties are fetching additional problems for the structural engineers to design a building for wind load and seismic load along with gravity load. In the former times buildings were designed to resist gravity loads only. However, nowadays with increase in height of the building and with idea of seismic zone, the lateral loads due wind and Earth quake are also taken into consideration.

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Conferring to the studies the building geometry cannot be a solitary basic criteria of design to the slender and high-rise buildings, because the story drift of the structure is also liable for incurred stresses in the structures.

Tube-in-Tube structure is new technology with advancement to the framed tube structure. In these structures along with an outer frame tube which is called as the Hull there is an additional internal frame tube called as Core.

Both gravity and lateral loads are resisted by the Hull and Core together. In these type of structures outer framed tube hull acts as shear component and the inner core acts as the flexural component.

II. OBJECTIVES OF STUDY

1. Relative comparison between tube in tube building and moment resisting building.
2. The results are compared between the models with respect to displacement, story-drift, time period and base shear.

III. METHODOLOGY

GENERAL

In order to study the comparative analysis of seismic behavior of structures, two seismic methods are adopted for the study.

a) Equivalent static method and

b) Response spectrum method

1. Equivalent Static Method

This method is also known as Linear static method. It is found to be the simple method among all the other methods of Seismic Analysis of Buildings since this method needs few mathematical attempts and is in accordance to formulae as per the Indian Standard code of practice IS 1893 (Part 1) : 2016. At first the design base shear for the whole building is calculated, after which the obtained base shear is distributed to the entire building at each floor level to individual lateral load resisting member.

2. Response Spectrum Method

Response spectrum is a plot of response of a system subjected to ground motion in which response is plot along the ordinate and corresponding time period or natural frequency along abscissa. This method is also known as a linear dynamic method of analysis. In this method, the earthquake response (or Design spectrum) spectrum directly gives the peak response of an assembly during an earthquake. For the structural design this method gives quite accurate results.

A number of modes of response for a building during the time of an earth quake is taken into consideration in this method. Later a response is obtained by design spectrum for each mode on the basis of modal mass and modal participation factor. Then the responses of all the modes are collectively tabulated to calculate the total response of a building.

The methodology followed for the study is as follows:

Plan of a multi-story building

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Modeling of buildings in ETABS

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Model 1 – Moment Resisting building
Model 2 – Tube in Tube building

↓

Carrying out seismic analysis one by one for both models in Zone IV

↓

Comparing the results between both models

↓

Results and Conclusions

IV. MODELING AND ANALYSIS

The study was done on 2 Models. The plan layout for both the Models is as shown in the figure below.

Model Geometry

- The models considered are 40 storey RCC building of plan dimension 30m X 30m both.
- The height of story is 3.6m and base is 2m.
- Total height of the building is 142.4m.
- Number of bays in both direction of X and Y is 5 for model 1and 10 for model 2 respectively.
- Spacing between each column, for model 1 is 6m and for model 2 is 3m.

Model 1: Moment Resisting Building

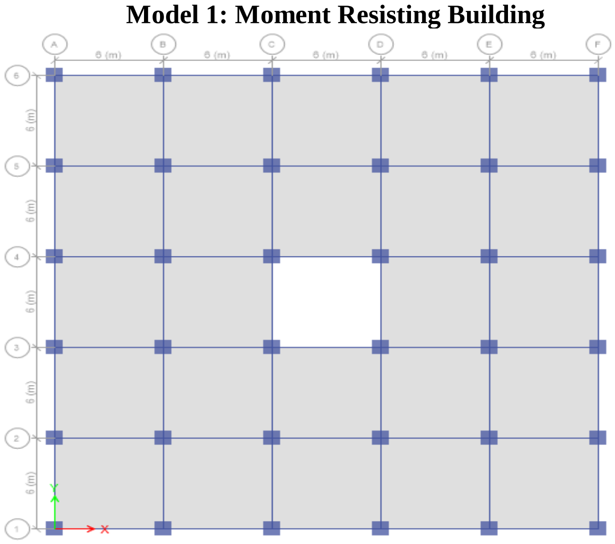

Fig -1: Plan of Model 1

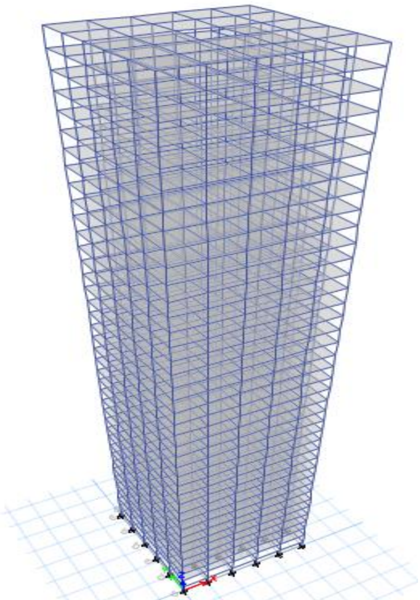

Fig -2: 3D view of Model 1

Model 2: Tube in Tube Model

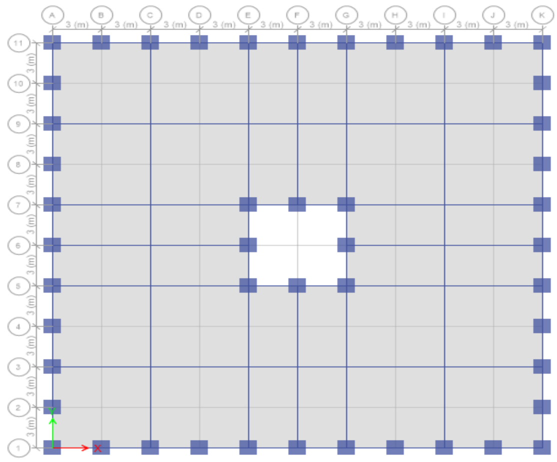

Fig -3: Plan of Model 2

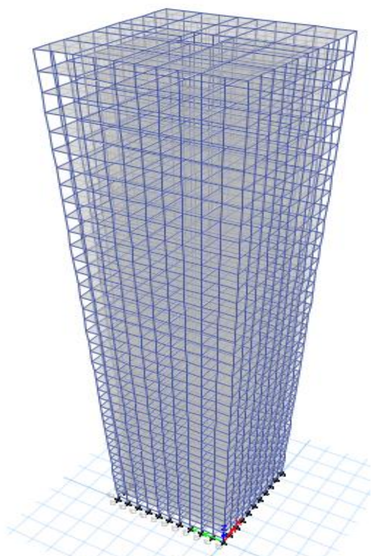

Fig -4: 3D view of Model 2

Design Data

Material Properties:

PROPERTIES	VALUES
Young's modulus of concrete	25X10^{6} KN/m^{2}
Density of Reinforced Concrete	25 KN/m^{3}
Density of Steel	78.5 KN/m^{3}
Poisson's Ratio of Steel	0.30
Grade of Concrete	M45
Grade of Steel	Fe 500

Member Properties:

MEMBER	SIZE
Slab section	200mm (for all models)
Column size for Moment resisting frame	900mm X 900mm
Column size for Tube in Tube Model	1100mm X 1100mm
Beam size for Moment resisting frame	300mm X 600mm
Main Beam size for Tube in Tube Model	400mm X 800mm
Secondary beam size for Tube in Tube Model	300mm X 600mm

Applied Loads:

The loading consist of applying external loads only to the building since, the self-weight of the members are calculated by ETABS software automatically.

(a) **Gravity load** :

Live Load – 4 KN / m^{2}
Floor Finish – 1.2 KN / m^{2}
Wall load – 8 KN / m^{2}

(b) **Seismic inputs :**

As per IS 1893 (Part 1) : 2016
Location of Structure – Severe Intensity (ZoneIV))
Soil Type – Type II (Medium Soil)
Importance Factor – 1
Response Reduction – 5
Zone Factor – 0.24 (ZONE IV)

V. RESULTS

Following are the chart and tables for displacement, story-drift, time period and base shear along both the directions analyzed by the two seismic methods i.e. equivalent static/linear static method and response spectrum method.

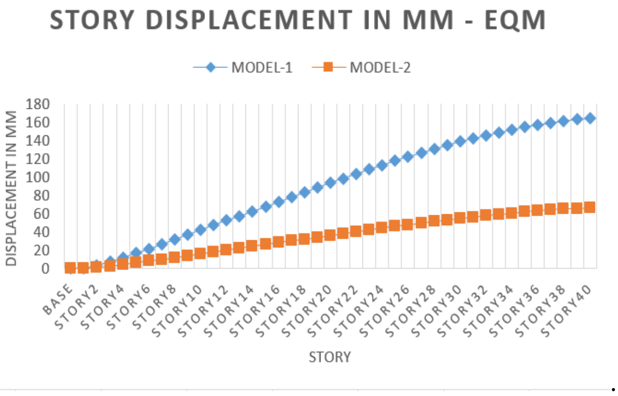

Chart 5.1 Story Displacement by Equivalent static Method

Table 5.1 Maximum Story Displacement by Equivalent static Method

MODEL	MAX DISPLACEMENT IN mm BY EQM	PERCENTAGE (%) REDUCTION (COMPARED TO MODEL 1)
MODEL-1	164.4	0
MODEL-2	66.51	60

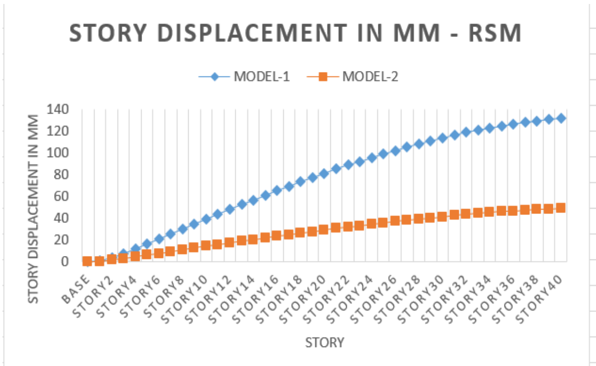

Chart 5.2 Story Displacements by Response Spectrum Method

Table 5.2 Maximum Story Displacement by Response Spectrum Method

MODEL	MAX DISPLACEMENT IN mm BY RSM	PERCENTAGE (%) REDUCTION (COMPARED TO MODEL 1)
MODEL-1	131.80	0
MODEL-2	49.11	62

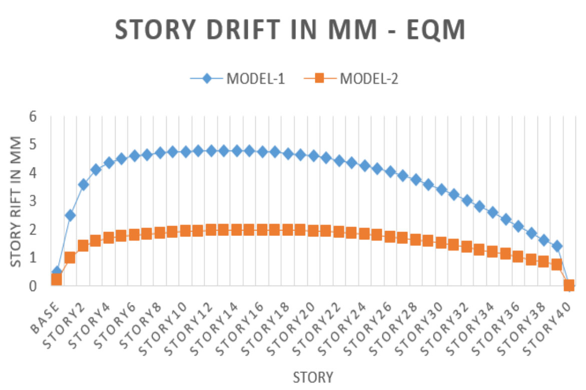

Chart 5.3 Story Drift by Equivalent static Method

Table 5.3 Maximum Story Drift by Equivalent static Method

MODEL	MAX STOREY DRIFT IN mm BY EQM	PERCENTAGE (%) REDUCTION (COMPARED TO MODEL 1)
MODEL-1	4.78	0
MODEL-2	1.97	58

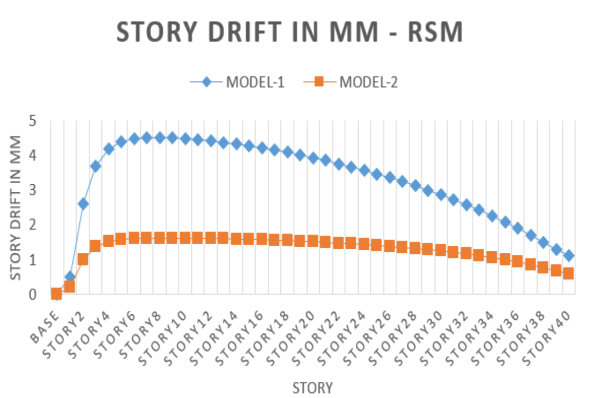

Chart 5.4 Story Drift by Response Spectrum Method

Table 5.4 Maximum Story Drift by Response Spectrum Method

MODEL	MAX STOREY DRIFT IN mm BY RSM	PERCENTAGE (%) REDUCTION (COMPARED TO MODEL 1)
MODEL-1	4.5	0
MODEL-2	1.62	64

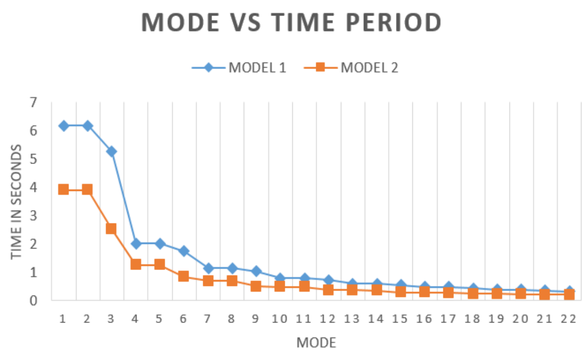

Chart 5.5 Mode vs. Time Period

Table 5.6 Time Period Values

MODEL	TIME PERIOD in Seconds	PERCENTAGE (%) REDUCTION (COMPARED TO MODEL 1)
MODEL-1	6.16	0
MODEL-2	3.89	36

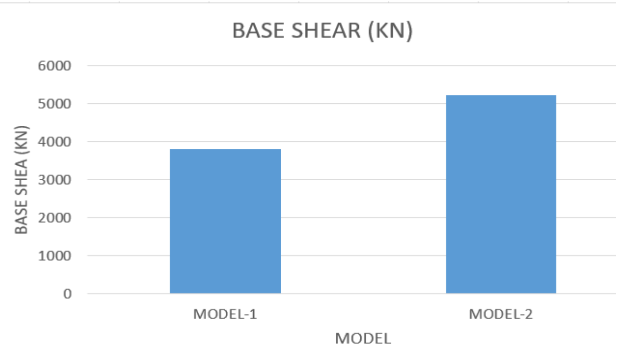

Chart 5.7 Base Shear

Table 5.8 Base Shear Values

MODEL	BASE SHEAR IN (KN)	PERCENTAGE (%) INCREASE (COMPARED TO MODEL 1)
MODEL-1	3814	0
MODEL-2	5228	37

VI. CONCLUSION

1) The seismic analysis results showed that, the displacement values due to seismic loads for model 1 i.e. moment resisting frame model were maximum and model 2 i.e. Tube-in-Tube model exhibited least displacement values both in equivalent static and response spectrum analysis in zone IV.

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2) The maximum seismic displacements of model 2 got reduced by 60% in equivalent static analysis and 62% in response spectrum analysis respectively when compared with model 1.
3) The seismic analysis results also showed that, the storey drift values due to seismic loads for model 1 i.e. moment resisting frame model were maximum and model 2 i.e. Tube-in-Tube model exhibited least storey drift values both in equivalent static method and response spectrum method of analysis in zone IV.
4) The maximum storey drifts of model 2 got reduced by 58% in equivalent static analysis and 64% in response spectrum analysis respectively when compared with model 1.
5) From the analysis, it can be concluded that model 1 i.e. moment resisting frame model exhibited the highest time period value and model 2 i.e. Tube-in-Tube model exhibited least time period value.
6) The time period of model 2 got reduced by 36%, when compared with model 1.
7) When the base shear values of both models are compared, the moment resisting frame model i.e., model 1 showed the lowest base shear value and Tube in Tube model i.e., model 2 exhibited the highest base shear value in zone IV. These values clearly shows that the rigidity of model 2 is very high compared to model 1 which makes it more efficient in resisting lateral loads.
8) The base shear of model 2 is increased by 37% when compared with model 1.
9) The model 2 i.e. Tube-in-Tube model has minimum displacements, minimum storey drifts, minimum time period and maximum base shear values when compared to model 1 i.e. moment resisting frame model, which exhibits more rigidity and higher stiffness of model 2 in zone IV hence, making it more efficient. Therefore, the study concludes that Tube in Tube structures are more efficient in resisting the seismic loads.
10) This study also concludes that the Tube in Tube structures are comparatively more efficient in resisting the seismic loads than that of a conventional moment resisting frame structures.

REFERENCES

1. Mohammad Tabrez Shadulla, Kiran K M " *Analysis of Tube in Tube Structures with Different Size of Inner Tube* " International Journal of Technical Innovation in Modern Engineering & Science ISSN: 2455-2585, Volume-4, Issue 10, October-2018
2. Bipin H Naik, B S Suresh Chandra, " *Comparative Analysis between Tube-In-Tube Structure and Conventional Moment Resisting Frame* ", IRJET, ISSN: 2395-0056, Volume-4, Issue 10, October 2017.
3. Mohan K T, Rahul Y and Virendra Kumara K N, " *Analysis of Different Forms of Tube-in-Tube Structures Subjected To Lateral Loads* ", IJIRT, ISSN: 2349-6002, Volume-4, Issue 2, July 2017.
4. Archana J, Reshmi P R, " *Comparative Study on Tube-In-Tube Structures and Tubed Mega Frames* ", IJIRSER, ISSN: 2319-8753, Volume-5, Issue 8, August 2016
5. Basavanagouda A Patil and Kavitha.S, " Dynamic Analysis of Tall Tubular Steel Structures for Different Geometric Configurations " International Journal of Engineering Research, ISSN: 2321-7758, Volume-4. Issue-4. 2016 (July-August).
6. J. S. Arvind and M. Helen Santhi, " *Effect of Column Shortening on the Behavior of Tubular Structures* ", Indian Journal of Science and Technology, Volume-8(36), ISSN : 0974-6846, December 2015.
7. Lavanya.T, Sathyanarayana Sridhar.R " *Dynamic Analysis Of Tube-In-Tube Tall Buildings* ", International Journal Of Engineering and Technology, e-ISSN: 2395-0056, p-ISSN: 2395-0072, Volume-04, Issue-04, April-2017
8. Nimmy Dileep1, Renjith R, " *Analytical Investigation on the Performance of Tube-In-Tube Structures Subjected to Lateral Loads* ", IJTRA, ISSN: 2320-8163, Volume-3, Issue 4, July 2015.
9. IS: 1893(Part1)-2016, Criteria for earthquake resistant design of structure, General Provision and Building.

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