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RESEARCH ARTICLE OPEN ACCESS

Comparative Study of Tube in Tube, Multiple Tube and Tubed Mega Frame Structures

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ABSTRACT:
The tube in tube structures, tube mega frame structures and multiple tube structures are the most recent imaginative idea. The tube system framework idea depends on the possibility that the structure can be made to withstand lateral loads by planning it as an empty cantilever opposite to the ground. Conventionally tube in tube structures are formed by connecting outer frame tube and inner tube frame or hull core tube so closely that, it isn't viewed as a strong framework yet it acts like a strong surface. All in conveying the lateral loads. In this project a comparative study on tube in tube, multiple tube and tubed mega frame structures has been done using ETABS software.

Keywords: tube in tube, multiple tubes, tubed mega frame

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I. INTRODUCTION:

The tube structure is the latest modernization in structural engineering systems that are used in high rise structures. This allows them to resist lateral lodes (Wind and Seismic Load). The tube or tube in tube system framework idea is based on the idea that the structure can be made to repel lateral loads by designing it as a hollow cantilever perpendicular to the ground. In modest form the tube structure can be defined as Closely-Spaced columns are secured together by deep beams known as spandrel beams, through moment connections as the part of exterior perimeter tube. This assembly of beams and columns forms a dense and strong structural tube around the exterior. Since lateral loads can be resisted by stiff external tube frame, the interior of the building can be purely framed for gravity loads. And the floor space can be left free of columns. Hence the floor space can be used more efficiently.

The tube in tube system consists of heavy columns which are closely arranged together making a closed-loop unified by deep spandrel beams. This assembly forms the initial part of horizontal load resisting system. And a dense RC structural wall (shear wall) secured together which forms a shaft known as hull core this forms the second part of the structural system.

The tube in tube system is made of outer tube frame with an inner tube frame or hull core (central core).

The various types of tabular system are classified as

1. Frame tube
2. Braced tube
3. Bundled tube
4. Tube in tube

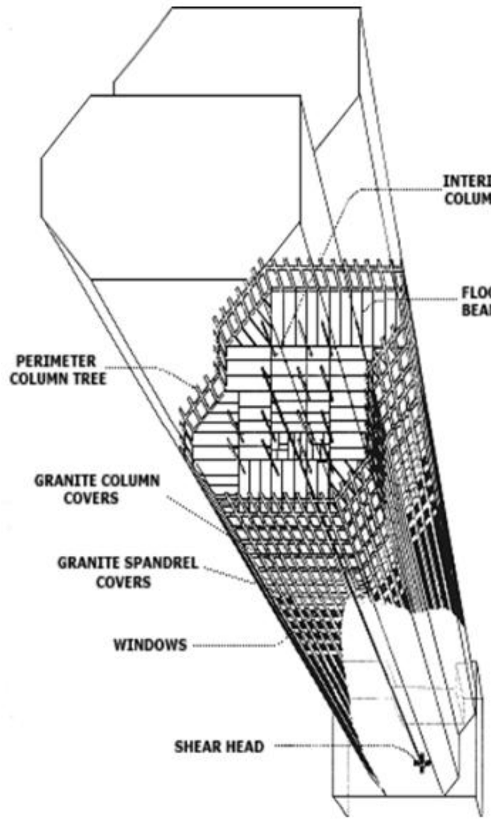
The connection between central core and the perimeter tube is most important for this purpose a series of grid beam are used consisting of primary, secondary and tertiary beams.

The primary beams are the beams which are those running between hull core and perimeter tube**.**

The secondary beams are those which are running between the columns such that no column is left out from rest of structural system.

Tertiary beams are those which only connect beams and are not connected to any of the columns.

In this aspects of tube system the perimeter tube attracts most of the horizontal loads on the building during seismic and wind action. Where in traditional building with hull core most of the horizontal loads are carried by central reinforced concrete core (shear wall).



II. FIGURE TABULAR SYSTEM

Objective

A. To evaluate the response of different tubular structure and bare frame subjected to lateral loads (wind & seismic) as per IS1893 (Part 1):2000 & IS 875(Part 3)-1987 code provision.
B. To identify & compare the suitable tubular system to resist the lateral load efficiently.
C. To perform seismic analysis using equivalent static and response spectrum method.
D. To perform wind analysis using static method.
E. To draw a comparative difference with different tubular forms.
F. To compare the results obtained by storey displacement, storey drift and base shear for all different models.
G. Comparative study between the traditional and tubular system.

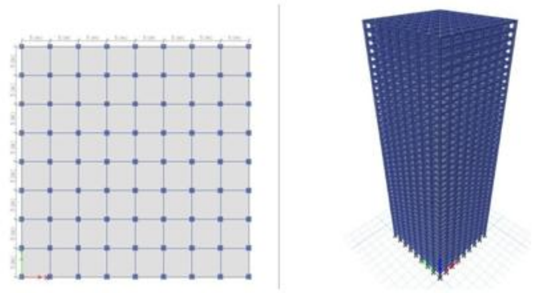
III. METHODOLOGY

A. Multi storey building having tabular structural system and traditional system having same floor plan multi storey building having same floor plan are modeled.
B. Seven different models are to be considered, all seven set of models with same plan and bay size with same storey height.
C. Three types of analysis methods are carried out equivalent static analysis, response spectrum analysis & wind analysis for all the seven models using ETABS.
D. The results are considered for each analysis are storey displacement, inter storey drift and base shear for each model.
E. Results obtained are tabulated, discussed and conclusions are drawn.

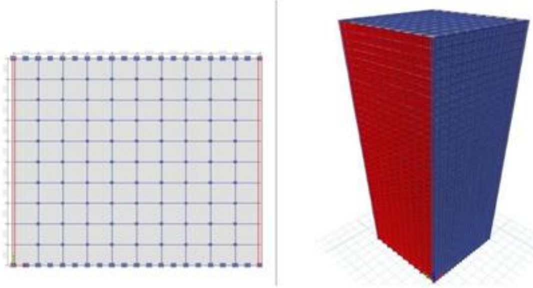
A. Table Description of models

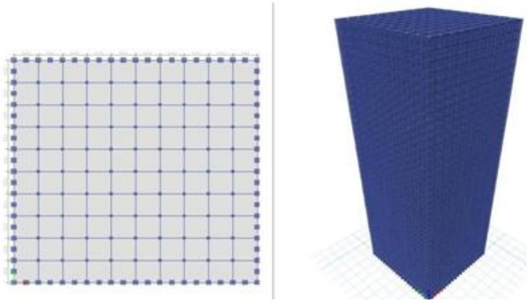
Serial no.	Model name	Description
1	**M1**	Bare frame structure
2	**M2**	Mega wall frame tubular structure
3	**M3**	Mega frame tube
4	**M4**	Tube in tube structure (both inner and outer frame tubes considered)
5	**M5**	Tube in tube structure (both outer frame tube and inner core, Hull core considered)
6	**M6**	Multiple tube structure(Both external and internal frame tube with inner core tube)
7	**M7**	Multiple tube structure (external frame tube and internal cores)

1. Figure plan and 3D view of Model 1 (M1)

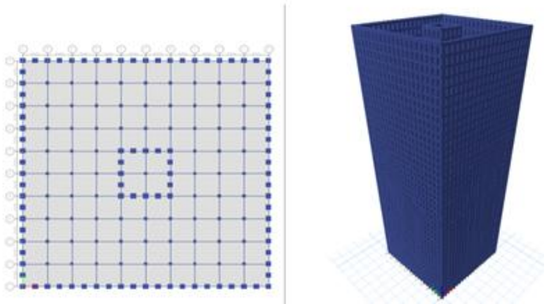


2. Figure plan and 3D view of Model 2 (M2)

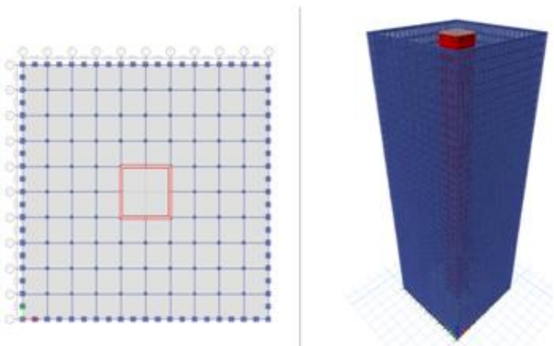




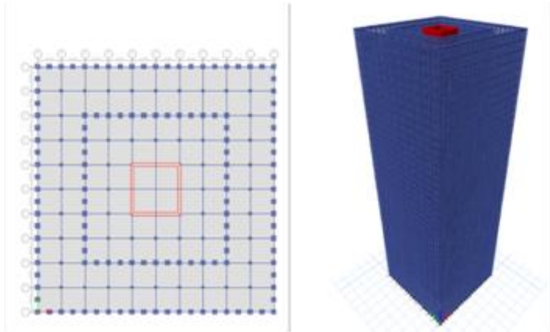
3. Figure plan and 3D view of Model 3 (M3)



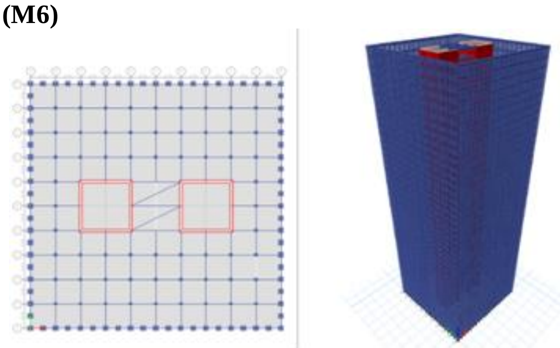
4. Figure plan and 3D view of Model 4 (M4)



5. Figure plan and 3D view of Model 5 (M5)



6. Figure Plan and 3D view of Model 6 (M6)



7. Figure Plan and 3D view of Model 7 (M7)

3.1 Input details
Grade of concrete M30
Grade of reinforcing steel: fe550

Geometric parameters considered

No of storey: 40(G + 39)
Plan dimension: 40 **x** 40 m (square plan)
Bay size:
a) For bare frame X=5m , Y=5m
b) For tube structure X=4m , Y=4m

For Tube Structure:
Column sizes: Perimeter column, 900x900mm
Gravity column, 550x550mm
Beam: external column connecting beams, 400x800mm.
Internal column connecting beam, 300x600mm.
Shear wall thickness: 450 mm.
Slab thickness: 150mm**.**
For Bare Frame
Column size: 900x900mm.
Beam size: 300*600 mm.

3.2 Loads Considered
Loads are assigned according to code provision different types of loads like live load, dead load,

wind load and seismic loads.

Live load on each floor: 4KN/m
Live load on roof: 1.5KN/m
Floor finish on each floor: 1.2KN/m
Floor finish on roof: 1.75KN/m

3.2.1 Earthquake loads [IS 1893(part-1):2002]

B. Table Seismic details as per code IS 1893-2002

Details	Zone III
R (reduction factor)OMRF	3
I(importance factor)	1
Z(zone factor)	0.16
Sa/g	Medium soil

3.2.2 WIND LOADS [IS: 875(PART-3):1987

C. Table Wind details as per code IS 875(part 3):1987

Wind speed, Vb m/s	50
Terrain category	2
Structure class	B
Risk co-efficient factor(k1)	1
Topography (k3)	1
Wind ward co-efficient,Cp	0.8
Lee ward co-efficient , Cp	0.5

3.2.3 Material properties
D. Table material property details.

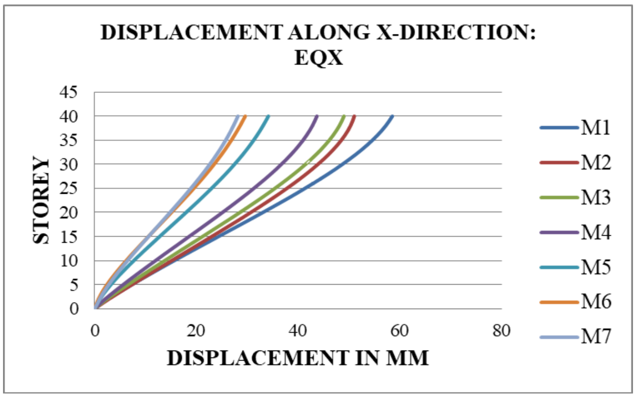
Column	M30	
Beam	M30	
Slab	M30	
Density of concrete	25	N/m³

IV. RESULTS AND DISCUSSION:

The behavior of each model is examined and the outcomes are classified.

A. storey displacement:

a. Storey displacement along X-Direction for Equivalent Static Method (EQX).



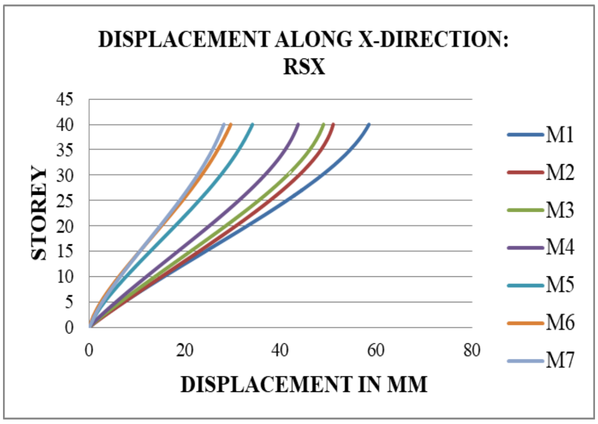
I. Displacement graph for EQX.

Discussion:

a) From the comparison M1 (bare frame) shows high displacement than that of all other tubular models, as we see from the results displacement is maximum at the top storey.

b) The Maximum displacement of M7 model is 52% less than M1, M6 model is 49% less, M5 is 41% less ,M4 model 25% less , M3 is 16% less and M2 model is 13% less than bare frame model.

b. Storey displacement along X-Direction for Response Spectrum Method (RSX).



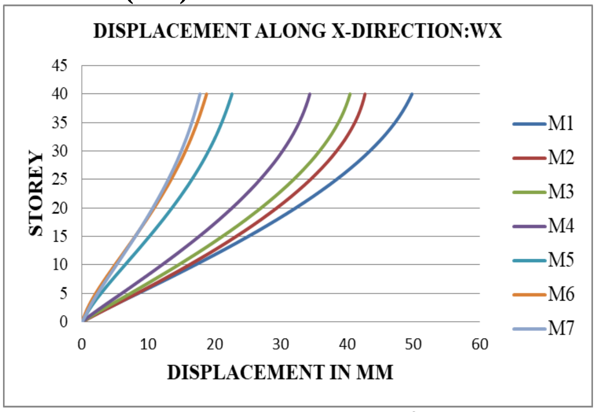
II. Displacement Graph for RSX.

Discussion:

a) The Maximum displacement of M7 model is 30% less than M1, M6 model is 28.7% less, M5 is 22% less ,M4 model 14% less , M3 is 8% less and M2 model is 4% less than bare frame model.

b) The minimum displacement is observed in M7 (multiple tube structure).

c. Storey displacement along X-direction for Wind load (WX).



III. Displacement Graph for WX.

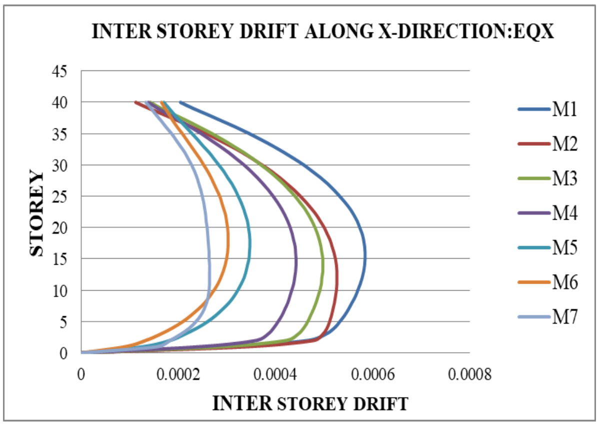
Discussion:

a) Comparing with the earthquake force results wind force has less effect on displacements for each model.

b) By comparing the mega framed tube(M3), tube in tube (M5) and multiple tube model(M7) displacements, multiple tube model has got 56% less displacement and tube in tube has got 44% less compared to mega frame tube model.

B. Inter storey drift:

a. Inter storey drift along X-Direction For Equivalent static method (EQX).



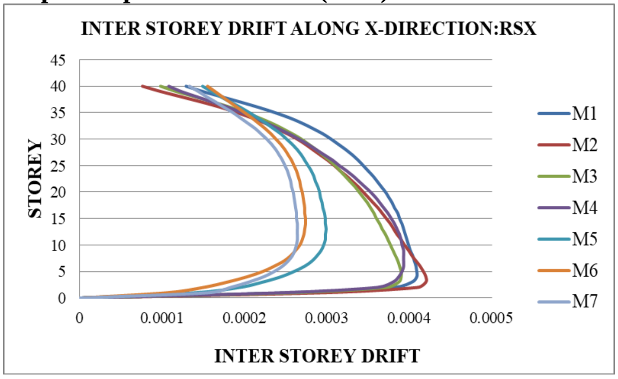
IV. Inter storey drift graph for EQX.

Discussion:

a) The inter storey drift is maximum in M1 model at storey15 and minimum in M7 model at storey 14.

b) Inter storey drift in M7 model at 14th storey 55 % less than M1 model (bare frame), M6 model is 48% less, M5 is 40% less, M4 model is 24% less ,M3 is 15% less and M2 model is 10% less than M1 model.

c) Inter storey drift along X-Direction for Response spectrum method (RSX).



V. Inter storey drift graph for RSX

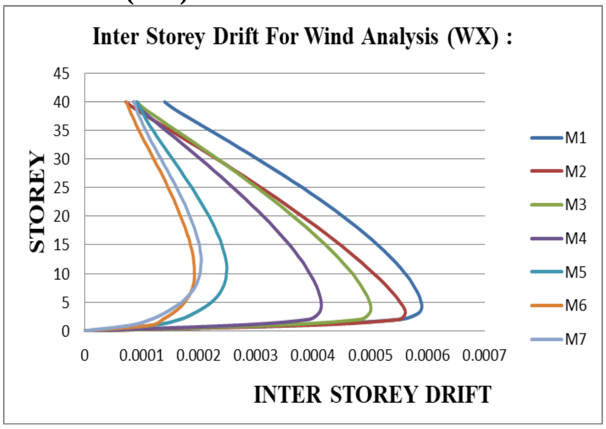
Discussion:

a) The inter storey drift maximum in M2 model at storey 5 and minimum in M7 model at storey 12.

b) Inter storey drift in M7 model is 37% less than the M2 model, M6 is 36% less ,M5 model is 29% less, M4 is 6% less, M3 is 6.4% less, M1 model is 2% less than M2 model.

c) Comparing the mega frame tube (M3) , tube in tube(M5) and multiple tube(M7) models M7 has less storey drift it has 32% less , M5 is 23% less than (M3) mega frame tube model.

VI. **Inter storey drift along X-Direction for Wind load (WX).**



V. Inter storey drift graph for EQX.

Discussion:

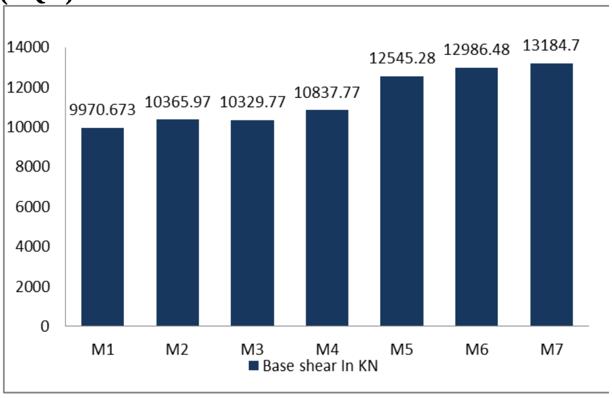
a) Compared to seismic action, wind has little more effect on inter storey drift with all the models.

b) The inter storey drift is maximum in bare frame model (M1) at storey 4 and minimum in multiple tube model (M6) at storey10.

c) The inter storey drift in M7 is 65% less, M6 is 67% less, M5 is 57% less, M4 is 30% less, M3 is 15% less, M2 is 5% less than (M1) bare frame model.

C. Base Shear:

a. Base Shear for Equivalent Static Method (EQX).



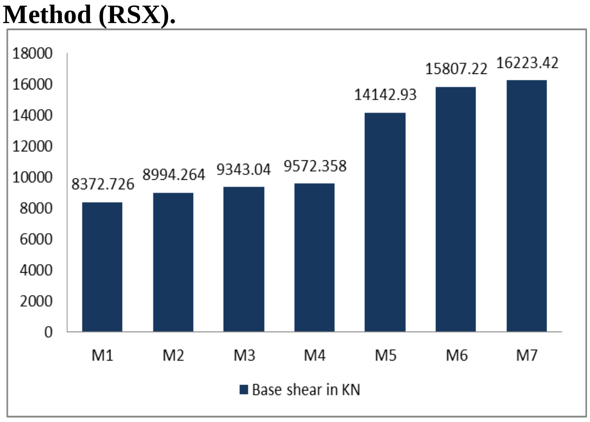
VI. Base shear graph for EQX.

Discussion:

a) The Base shear is maximum in M7 due to its higher stiffness and minimum in M1 model.

b) The base shear has gradually increased with increment in stiffness of the model.

b. Base Shear for Response Spectrum Method (RSX).



VI. Base shear graph for EQX.

Discussion:

a) The Base shear is maximum in M7 due to its higher stiffness and minimum in M1 model.

b) M1 model is 48% less than M7, M2 is 44% less, M3 is 42% less, M4 is 41% less, M5 is 12% less, and M6 is 2.5% less than M7 model.

V. CONCLUSION:

The below conclusion can be drawn from the present investigation.

Over all building displacement, storey drift can be viably decreased by increasing the stiffness or stiffness properties of flange frame members, like depth of column, width and depth of beam.

The displacement has decreased as the structural stiffness or structural elements are increased with different models.

Inter storey drift is maximum in case of bare frame compare to other models.

Comparing with the earthquake force results wind force has less effect on displacements for each model.

The base shear has gradually increased with increase in stiffness of the model. And it is observed that the Base shear values for linear static method and response spectrum method the results of 1st four models i.e. M1,M2,M3,M4 are less in case of response spectrum method and for M5, M6, AND M7 model its more than equivalent static method this variation is due to sensitivity analysis.

The beams with a higher depth have greater rotational inertia and greater stiffness which helps in better bonding of middle and corner columns together.

In general, the influence of tube action is most enhanced when increasing the stiffness or the depth of column, related to both the rectilinear stiffness and strength of RC high-rise framed-tube systems.

By comparing all the models results, In conclusion the multiple tube concepts can be effectively utilized and is efficient for all the parameters considered.

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