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Dynamic Wind Load Analysis of Different configuration of Bundled tube RCC structural systems

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Abstract
The tubular system has been mostly used for construction of high rice building. Tube structural system is proved to be economical and suitable system due to the current situation India of increasing population and land scarcity we have to developed in vertical direction only. In the tall structure, wind is one of the critical loads that needs to be considered for safety of structures. we also need to understand the dynamic wind effect on structures according to the provisions given in IS 875(part 3) is revised in 2015.
In this study, the analysisbundled tube RCC structure with different structural systems is taken for analysis. The five configurations i.e., Moment resisting frame with shear wall, Square bundled tube with shear wall, Square bundled tube, Triangle bundled tube and Diagonal bundled tube taken for evaluating wind load by using gust factor method. The parameters considered for study are maximum Story Displacement, Story Driftand Time Period on the basis of Wind load analysis by Gust factor method to finding out most effective configuration of bundled tube structural system on basis these responses.

Keywords: *Tubular structure, bundled tube structure, Wind load analysis, Gust factor method, Story Displacement, Story Drift, Time period*

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I. INTRODUCTION

Tube is a structural system use for high rise building to resist the lateral loads on structure. It acts as cantilevered perpendicular to ground to withstand with heavy wind loads and seismic loads.The system was developed in 1963 by the engineer Fazlur Rahman khan since then it has been mostly used for construction of high rice building. Tube structural system is proved to be economical and suitable system due to the current situation India of increasing population and land scarcity we have to developed in vertical direction only i.e. we have to build tall or high-rise building.

Tubular system is a three-dimensional frame that can withstand against heavy lateral loads with the outer perimeter structure. It consists of inner core surrounded by exterior closely spaced column at outer perimeter tied with deep beam connection forming as a whole rigid frame.Tubular system is of four types i.e., Frame tube structure, tube in tube structure, braced tube or trussed tube structure and bundled tube structure. In a bundled tube structural system, instead of one tube it is interconnected with several tubes to form as multi tube. It helps to create aesthetic view of structure. Willis's tower, Chicago is the first of its kind of structure also it is combination several tube together so, it helps to prevent overturning of structure and to resist lateral loads

Tall structures are subjected tolateral loads caused by wind or earthquake, one of the critical loads acting on above-ground structures is due to the wind, so it is important to design structure for wind load to achieving safety and serviceably of structure. For achieving the serviceability with economy of construction we need to follow all parameter of wind and conditions which are given in IS 875(Part 3):2015

II. AIM AND OBJECTIVES

The aim of the present study is to analyze the behavior of 45 story bundled tube structure against Dynamic wind load for Terrain category 3 with 44 m/s (Mumbai region) wind speed is taken tofind out most effective structural system on basis of performance of the structure.

OBJECTIVES

- To understand the working of bundled tube structural systems against lateral loads.
- Comparing Square bundled tube with shear wall, Square bundled tube, Triangle bundled tube and Diagonal bundled tube building with Moment resisting frame with shear wall.
- To analyze the effect of wind gust using Dynamic wind load analysis by using gust factor method

- Carry out comparison for all cases of bundled tube for different parameters like story displacement, story drift and time period.
- To suggest most effective structural system on basis of the performance of structure.

III. Methodology

- In this project, 45 story RCC bundled tube structural systems with different configuration considered for the analysis.
- Basic wind load 44 m/s as per 875 part-3 2015 for Mumbai (zone III) with terrain category 3 is taken for wind load calculation.
- As per IS 875-part 3 tall structure are wind sensitive and it should be design for Dynamic wind load. (As per cluse 9.1 of Indian standard IS 875 part 3 2015)
- For Dynamic wind load, Wind load is calculated by Gust factor method using the formulae from IS 875-part 3 (2015), clause 10 with the help of excel spreadsheet in plan directions.
- Cracked RC section properties as per table 6 of IS 16700(2017) where, Unfactored loads properties are applied for Dynamic wind analysis.
- Parameters considered for analysis are Story Displacement, Story Drift and Time Period in plan direction.
- Modelling and analysis done using Etabs 2018.1.1. software.

A. CONFIGURATION OF MODELS

Table 1. configuration of models

Model	Description of models
Model 1	Moment Resisting Frame with Shear Wall
Model 2	Square Bundled Tube with Shear Wall
Model 3	Square Bundled Tube
Model 4	Diagonal Bundled Tube
Model 5	Triangle Bundled Tube

B. Descriptions of structure

Table 2. Input Parameters

Plan size	36m X36m
Spacing between column c/c in both direction	3 m c/c and 6 m c/c
Height of building	157.5 m
Slab thickness	150 mm
Shear wall thickness	300 mm
Floor to floor height	3.5m
Column size	
From story 36th - 45th	600 mm x 800 mm
From story 26th - 35th	800 mm x 1000 mm
From story Base to 25th	1000 mm x 1200 mm
Beam size	
From story 36th - 45th	350 mm x 500 mm
From story 26th - 35th	380 mm x 550 mm
From story Base to 25th	400 mm x 600 mm

Table 3. material properties considered for analysis

Grade of concrete	M60
Grade of steel	Fe500
Density of RCC	25 KN/m^3
Density of steel	78.5 KN/m^3
Density of light weight block work	10 KN/m^3

Table 4. Wind parameters [as per IS 875 part-3 2015]

Wind speed	44 m/s (Mumbai)
Terrain category	3

Table 5. Loading [as per IS 875 part 2 1987]

Live load	Floors =3 KN/m^2 Terrace=1.5 KN/m^2
Floor finish load	1.2 KN/m^2
Wall load	Floors =6.9KN Terrace= 3.45 KN

C. PLAN AND 3D VIEW OF STRUCTURE

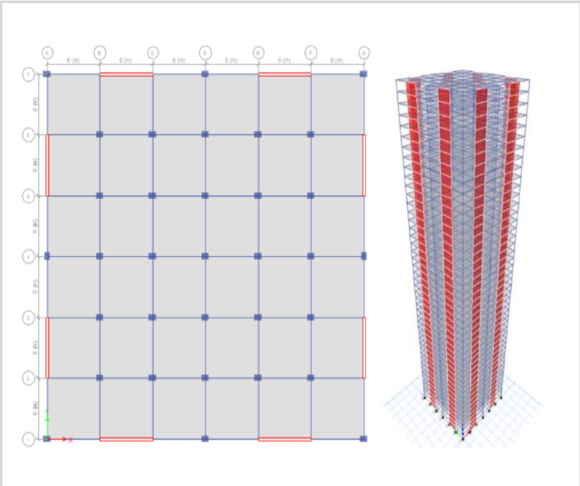

Fig. 1. Plan and 3D view of Moment resisting frame with shear wall

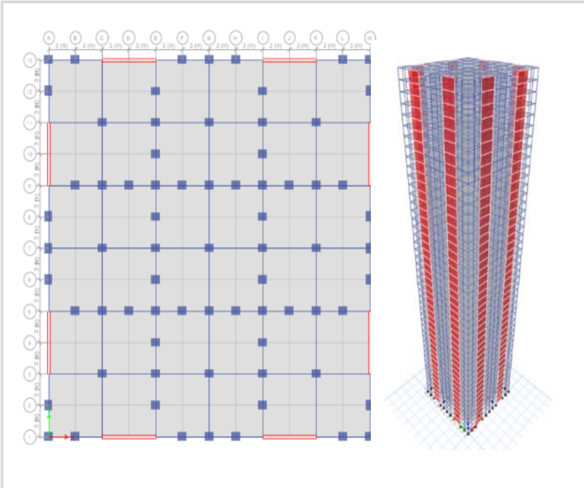

Fig. 2. Plan and 3D view of Square Bundlled tube with shear wall

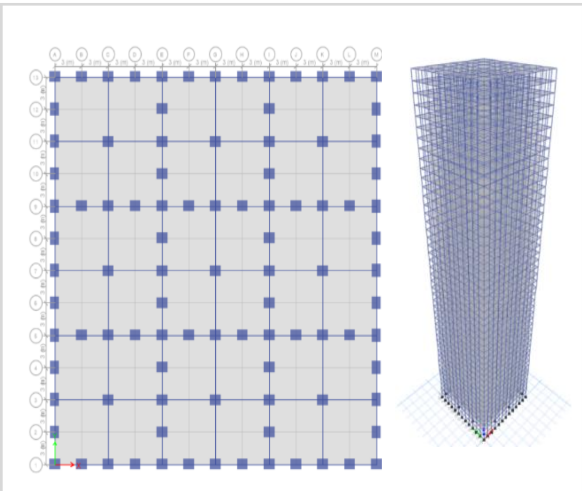

Fig. 3. Plan and 3D view of Square Bundlled tube

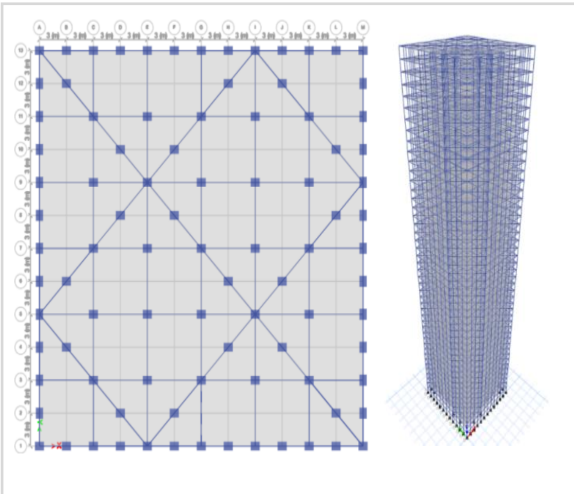

Fig. 4. Plan and 3D view of Diagonal Bundled tube

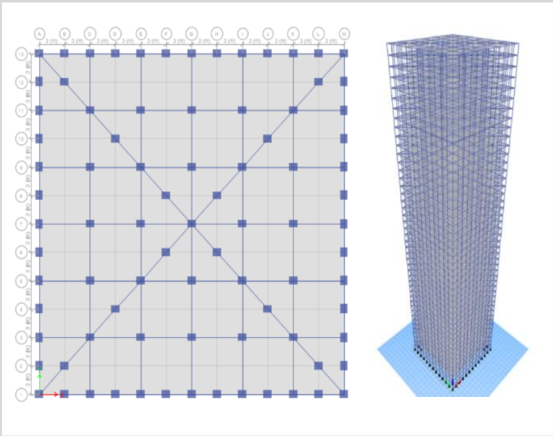

Fig. 5. Plan and 3D view of Triangle Bundlled tube

IV. RESULTS AND DISCUSSIONS

The responses of structure i.e., Story Displacement, Story Driftand Time Period for Dynamic wind load analysis using Gust factor method for all models are compared and analyzed.

STORY DISPLACEMENT

Story Displacement is defined as relative lateral displacement between base of structure to the story under consideration.

The maximum permissible displacement allowed for tall structure is **hs/500**, where hs is the height of structure. The maximum allowed displacement of model = 157.5/500 =0.315m i.e., 315 mm.

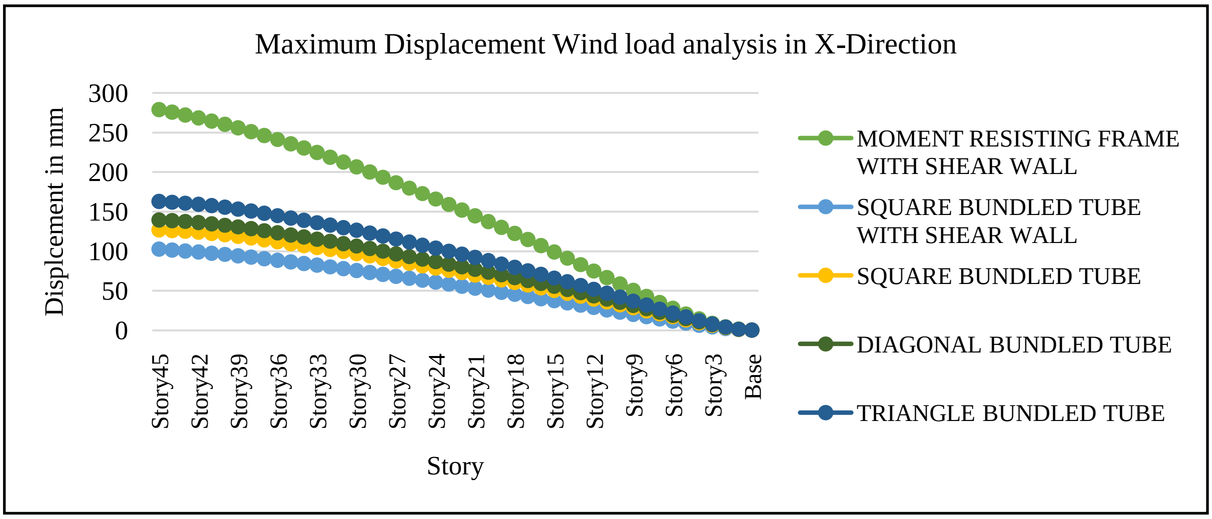

Fig. 6. Maximum Displacement for Wind Load Analysis in X-Direction in mm

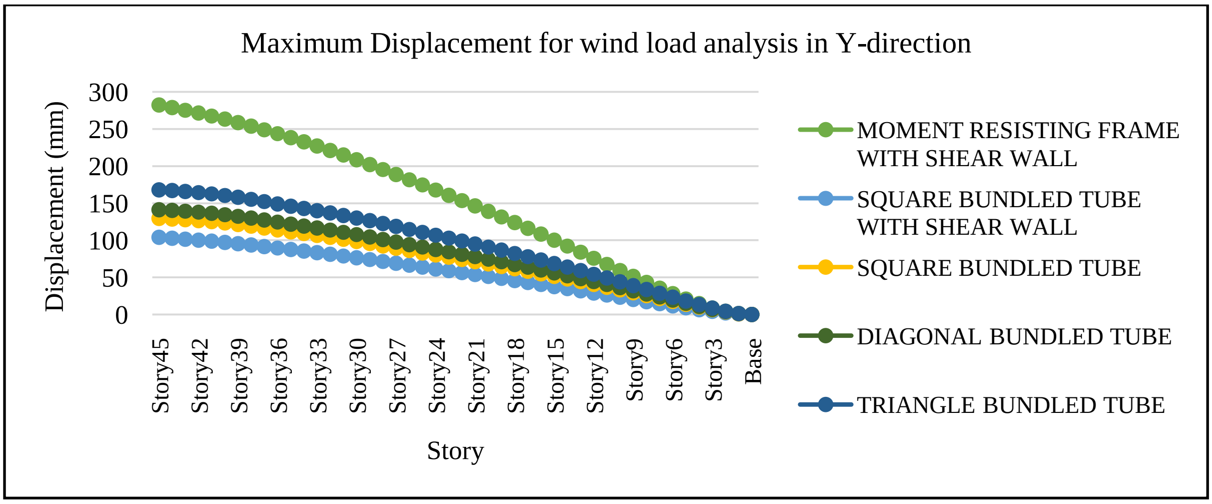

Fig. 7. Maximum Displacement for wind load Analysis in Y-Direction in mm

From fig. 6. and fig. 7., It is observed that moment resisting frame with shear wall has maximum story displacement in X and Y direction than other models.

- The maximum story displacement for moment resisting frame with shear wall is 279.131mm and 282.599 mm in X and Y Direction respectively.
- The maximum story displacement for Square bundled tube with shear wall, Square bundled tube, Diagonal bundled tube and Triangle bundled tube in X-Direction is102.647 mm, 127.097 mm, 139.505 mm, 163.132 mm and in Y-Direction is 104.062 mm, 129.544 mm, 141.473 mm, 168.263 mm respectively.
- All models are within permissible limit of maximum displacement i.e., 315 mm, so they are safe for maximum displacement criteria.
- For Wind analysis of model, the maximum displacement for Square bundled tube with shear wall, square bundled tube, diagonal bundled tube and triangle tube are less about 63.23%, 54.47%, 50.02% and 41.56% respectively in X-Direction and 63.18%, 54.16%, 49.94% and 40.46% in Y-Direction respectively as compared to moment resisting frame with shear wall.

STORY DRIFT

Story Drift is defined as per IS 1893 part 1 (2015), it is a relative Displacement between floors above or below the story under consideration.

For wind load analysis, the permissible story drift according to IS16700 (2017) clause 5.4.1, pg. 5 it is **hi/400**=3.5/400 =0.00875 m = 8.75 mm wind analysis models.

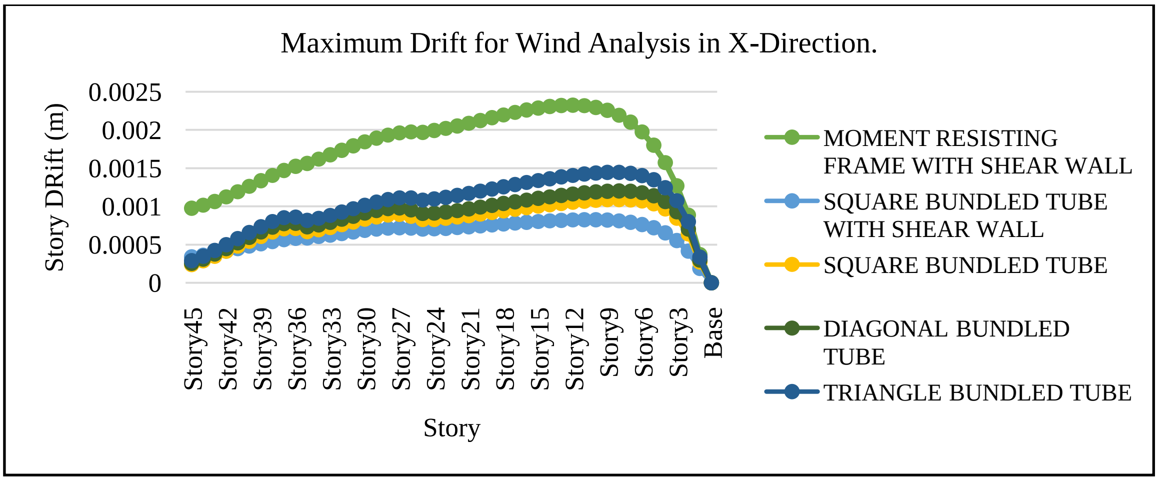

Fig. 8. Story Drift for wind load analysis in X-Direction in m.

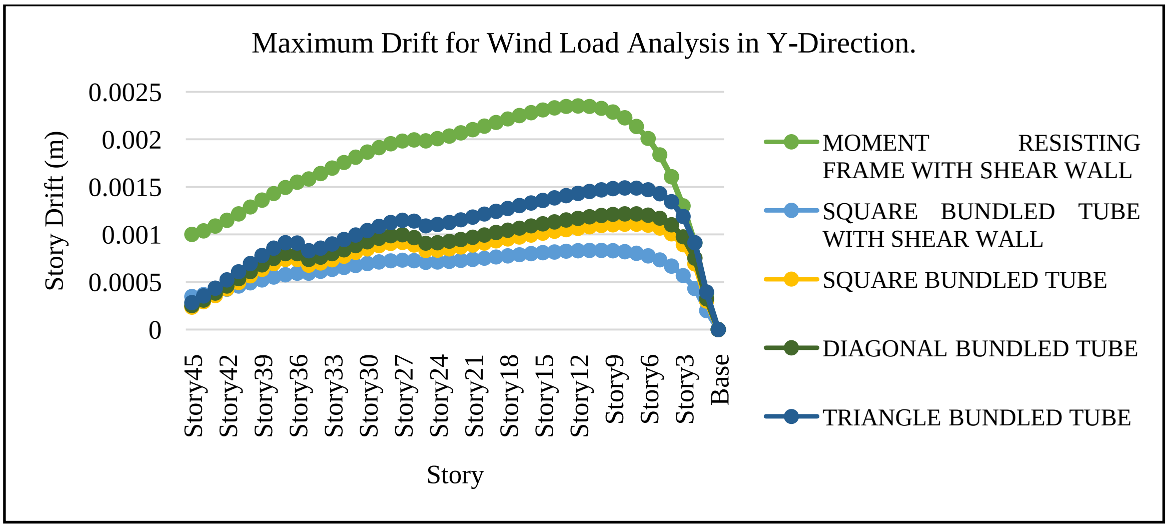

Fig. 9. Story Drift for wind load in Y-Direction in m.

- The Moment resisting frame with shear wall has higher story drift than other models of 0.002326 m in X-Direction and 0.002351 m in Y-Direction
- The maximum story drift for Square bundled tube with shear wall, Square bundled tube, Diagonal bundled tube and Triangle bundled tube in X-Direction is0.000826 m, 0.00109 m, 0.001203 m, 0.001445 m and in Y-Direction is 0.000834 m, 0.000834 m, 0.001108 m, 0.001217 m, 0.001488 m respectively.
- For wind analysis, Square bundled tube with shear wall, square bundled tube, Diagonal bundled tube and Triangle bundled tube shows less story drift about 64.53%, 53.14%, 48.28% and 37.88% respectively in X-Direction whereas in Y Direction 64.53%, 52.87%, 48.23% and 36.71% respectively as compared to moment resisting frame with shear wall.

TIME PERIOD

It is time taken by structure to complete one cycle of oscillation that means During Seismic activity structure moves as the wave passes and return to its original position in single oscillation.

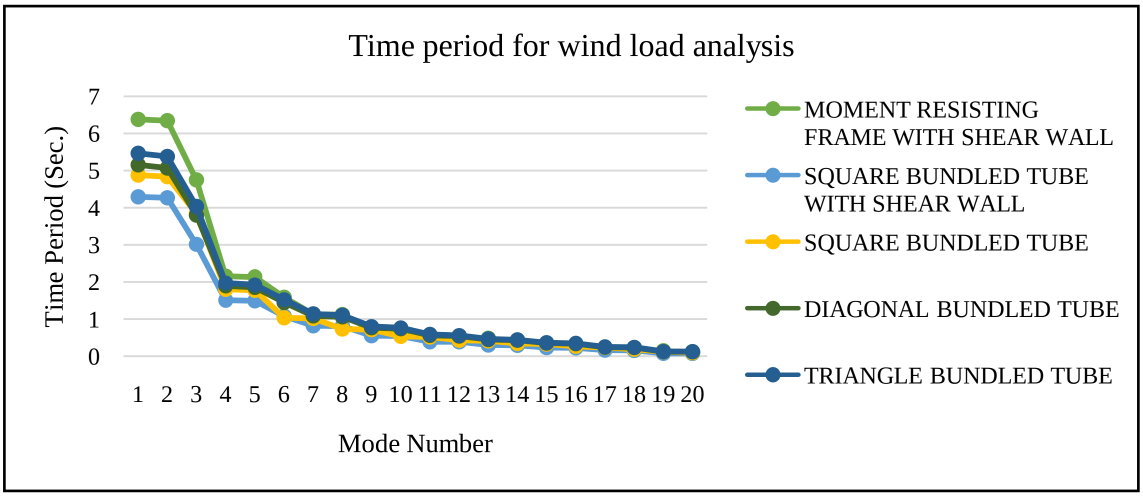

Fig. 10. Time period for wind load analysis in seconds.

- For wind load analysis, maximum time period is for moment resisting frame with shear wall i.e., 6.343 seconds in X-Direction and 6.38 seconds in Y-Direction.
- The time period for Square bundled tube with shear wall, Square bundled tube, Diagonal bundled tube and Triangle bundled tube in X-Direction is 4.263 seconds,4.834 seconds, 5.064 seconds, 5.382 seconds, and in Y-Direction is 4.29 seconds,4.878 seconds, 5.152 seconds, 5.467 seconds respectively.
- The time period of square bundled tube with shear wall, square bundled tube, diagonal bundled tube and triangle tube is less about in X-Direction 32.79%, 23.79%, 20.16%, 15.15% and Y-direction 32.76%, 23.54%, 19.25%, 14.31% as compared to Moment resisting frame with shear wall.

V. CONCLUSIONS

Following conclusion have been drawn based on the result obtained from the analysis of all bundled tube structural configurations.

- Square bundled tube with shear wall and square bundled tube shows reduction in story displacement about 63.23%, 54.47% in X-direction and 63.18%,54.16%in Y-direction respectively with respect to story displacement of moment resisting frame with shear wall.
- Square bundled tube with shear wall and square bundled tube shows reduction in story drift is 64.53%, 53.14%in X-direction and 64.53%, 52.87%in Y-direction respectively as compared to story displacement of moment resisting frame with shear wall.
- Reduction in Time period of square bundled tube with shear wall and square bundled tube is about 32.79%, 23.79% in X-direction and 32.76%, 23.54% in Y-direction respectively as compared to moment resisting frame with shear wall.
- Moment resisting frame with shear wall shows highest displacement values and story drift values
- Square bundled tube with shear wall and Square bundled tube has lowest story displacement, story drift and time period values amongst all models.
- After comparing all results of parameters, Square bundled tube with shear wall and square bundled tube shows better results as compared to diagonal bundled tube, triangle bundled tube and moment resisting frame with shear wall.

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