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Wind Analysis of RCC Tube in Tube Structure Using ETABS Software

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Abstract: The advancement in construction field is increased day by day. The numbers of buildings, height of building is increased. The effect of lateral load is increased with respect to the increase of height. Advance construction methods and structural systems are to be introduced to enhance the structural safety. There are different types of structural systems which are to be used to resist the effect of lateral loads on the buildings. tube, bundled tube, tube in tube, and tube mega frame structures tubular structures. A tube-in-tube structure Comprises of a peripheral framed tube and a core tube interconnected by floor slabs. The frame tube structure takes more of lateral load the efficiency of this system is derived from the great number of rigid joints acting along the periphery, creating a large tube. In which the horizontal slabs and beams connecting vertical elements are assumed as continuous connecting medium having Equivalent distributed stiffness properties. The tube-in-tube structure with central tube provides stability against lateral loading as well as gravity loading. The Static analysis is use for analysis of tubular structures and the output of the models are evaluate to have a comparative study of their wind performance in different terrain, Also, this system provides enough opening for stairways, elevators and ducts etc. It is suitable for high rise structure. The use of tube-in-tube structure allows speedy construction. It is suitable for RCC, constructions.

This study is focused on wind behavior of tube in tube structure for varying terrain category in India for the parameters like wind displacement, story drift, and time period.

Keywords: Tube in Tube Structure, Wind Loading, Terrain Category, Modal Mass Participations.

I. INTRODUCTION

A. General Introduction

The advancement in construction field is increased day by day. The numbers of buildings, height of building is 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. There are different types of structural systems which 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 considered as a better structural system for tall buildings. There are different types of tubular structural systems which are given as framed tube, braced tube, bundled tube, tube in tube, and tube mega frame structures tubular structures.

In recent years, tall buildings and structures have become slenderer, which increases the likelihood of excessive sway compared to older tall buildings. This creates additional difficulties for the engineering sector in resisting both lateral loads, such as wind and earthquake loads, and gravity loads. In the past, engineers primarily considered gravity loads when designing structures, but in recent years, due to the growth in height and seismic zone, they also consider lateral loads caused by wind and seismic forces. The height of tall structures is a comparative word. There is no globally applicable, precise definition for tall constructions. From a structural engineering standpoint, all tall structures must withstand both gravity and lateral loads. Due to the influx of a large population, towns and cities are expanding at a rapid rate. This phenomenon can be observed on every continent. The lack of available land for construction, especially in the world's biggest cities, is a widespread issue that has led to the vertical rather than horizontal development of structures. Today, high-rise commercial structures are symbols of modern society. These represent the strength of commerce in the current global economy. These also give the city a third dimension.

Additionally, on a micro level, having a commercial space in a beautiful high-rise structure provides the firm with additional benefits in terms of increased client confidence and brand recognition. Globally, major towns and cities are constructing high-rise buildings with a very large number of stories, and India is not an exception to this trend. Tall structures comprised of a framework with multiple stories are flexible and vulnerable to the effect of wind forces.

To resist the effect of lateral loads on the buildings, several structural systems must be employed. There are tube structures, rigid frame structures, braced frame structures, shear wall frame structures, outrigger systems, and braced frame structures. The tubular systems are widely employed and are regarded as the superior lateral structural solutions for high-rise buildings. The tubular constructions are subdivided into frame tube, braced tube, bundled tube, tube inside tube, and tube mega frame structures. Tube-in-tube structures and bundled tube structures are unique and novel tubular structure concepts. In towering buildings, tube-in-tube constructions will be increasingly utilized. In the subject of tubular constructions for tall buildings, bundled tube structures are the new concept. Nowadays, tubular constructions have become increasingly prevalent in tall buildings. Tube in tube structures is ideally suited for any tall structures. A tube-in- tube structure consists of a framed peripheral tube and a core tube that are joined by floor slabs. The overall structure resembles a large tube with a smaller tube in the centre. Both the inner and outer tubes share lateral loads. This paper includes an investigation of the vulnerability of different tubed structures to large wind loads when built as tube-in- tube structures and bundled tube structures. Tube-in-tube structures and bundled tube structures are unique and novel tubular structure concepts. In this project, ETABS software was used to conduct a comparison of tube- in-tube structure and bundled tube structures. Using ETABS, the modelling and analysis are performed.

B. Wind Effect on Tall Buildings

Since the wind varies over time, the wind spectrum and natural frequencies can be used to describe the difference in wind-related structural design of a typical high-rise building. In general, wind pressure and the resulting structural response are regarded as stationary random processes in which the time-averaged or mean component is separated from the fluctuating component. Tall buildings bluff bodies, and when wind blows against them, vortices are generated that result in an alternating force perpendicular to the direction of the wind. When the phenomena of vortex shedding occur along a substantial portion of the building's height, it can result in high forces and amplitudes. Wind loads linked with gustiness or turbulence produce substantially higher building responses than steady application of the same loads. Therefore, wind loads must be analysed as though they were inherently dynamic. The intensity of wind load depends on its rate of variation and the structure itself.
According to IS 875 part III, the Dynamic effects of wind loading are described as flexible thin structures and structural elements being evaluated to determine the wind- induced oscillations or excitations along and across the wind direction.

II. RESEARCH OBJECTIVE

Based on the literature review presented in Chapter 2, the salient objectives of the Present study have been identified as follows
The objectives of proposed work are as follows:

1) To study parametric design variables on the performance of a G+25 story building with different basic wind speed in terrain category III.
2) To study the behavior of the tube in tube RCC structure for dynamic analysis method using wind loads for different shapes i.e., square, rectangular and hexagonal etc.
3) Comparative analysis between tube in tube RCC structure with story open at different level.
4) To compare results between the models with respect to wind displacement and story drift.

III. PROJECT STATEMENT

The study will give more knowledge which result into benefits for future implementation with the help of RCC building actual design. To study the effect of shape on structural behavior.

A. Dynamic Analysis Method

Design Wind Pressure - The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity
The design wind pressure P_d can be obtained as,

$$P_d = K_d . K_a . K_c . P_z$$

where,
K_d = Wind directionality factor
K_a = Area averaging factor
K_c = Combination factor

$$P_z = 0.6\, V_z^2$$

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where,
P_z - design wind pressure in N/m^2 at height Z
V_z - design wind velocity in m/s at height Z

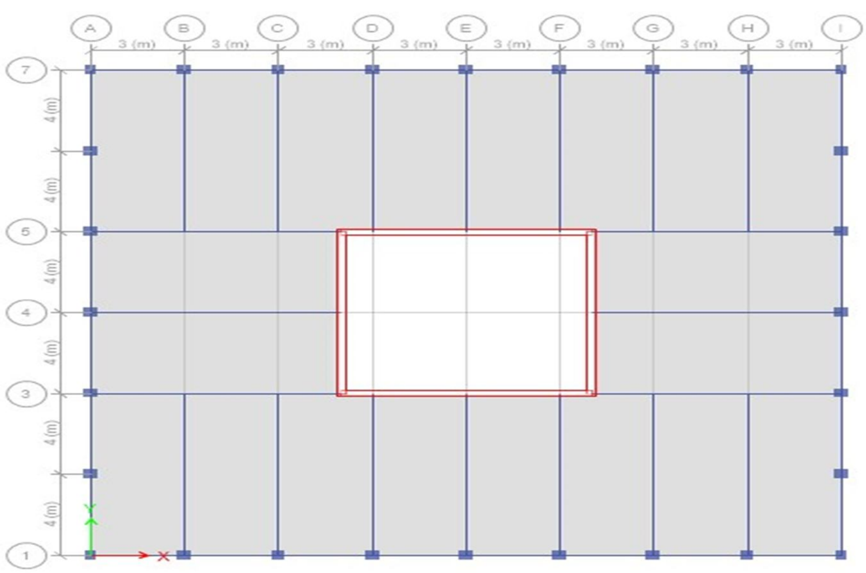
IV. PROBLEM FORMULATION

Type of structure	Frame structure
Moment-Resisting frame	SMRF
Basic wind speed	39 &55 m/sec
No of Stories	G+25
Height of each story	3m
Height of ground story	3m
Thickness of slab	125mm
Thickness of outer wall	150mm
Thickness of inner wall	100mm
Grade of reinforcing steel	Fe 415
Density of concrete	25 kN/m3
Density of Brick wall	20 kN/m3
Grade of concrete in slab	M30
Grade of concrete in beam	M30
Grade of concrete in column	M40
Analysis method	Equivalent Statics Analysis

Multi-storied ferroconcrete, moment defying space frame are anatomized using professional software ETABS2016. Model G+24 of erecting frame withthree kudos in vertical andthree kudos in side direction is anatomized by Response spectrum method.
The plan confines of structures are shown in table below.
The plan view of structure, elevation of colorful frames is shown in numbers below.

A. *Building Plan*

1) Square shape plan



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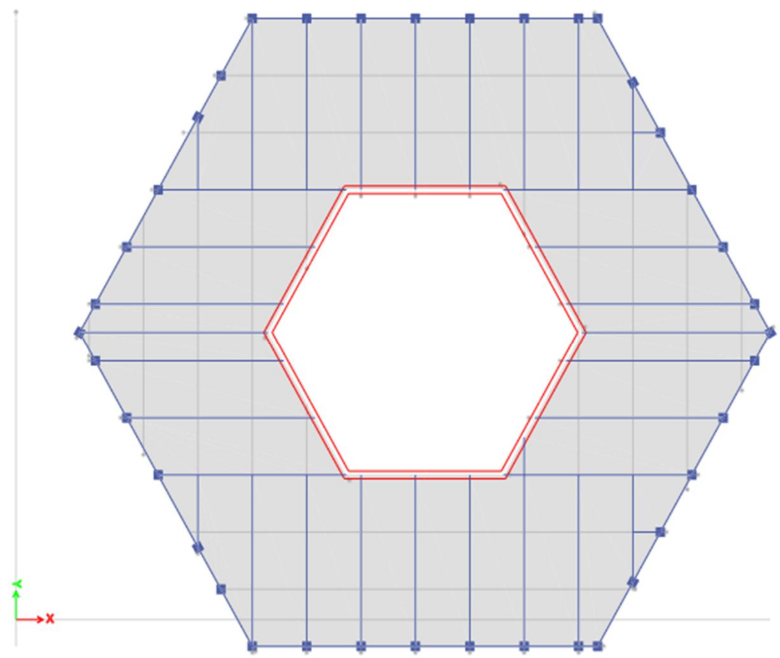
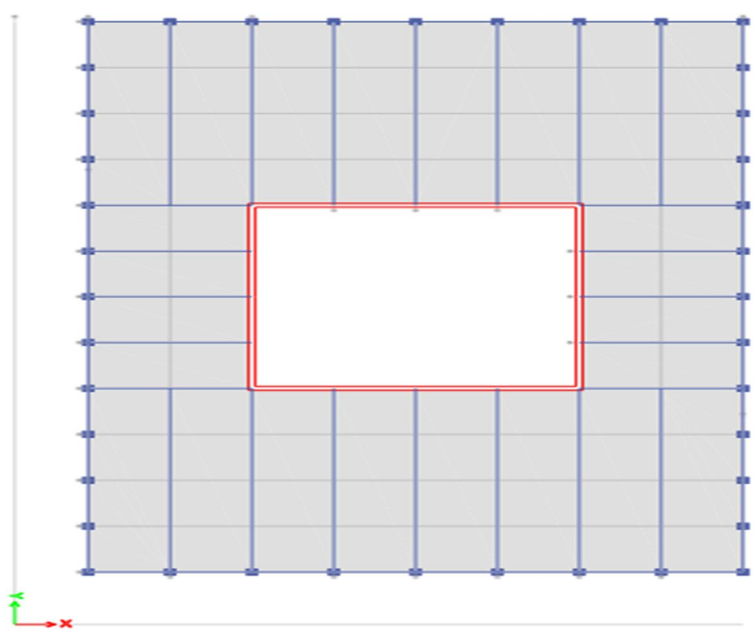
2) Hexagonal Shapes plan



3) Rectangular Shape Plan



V. RESULTS

Table 1.1 General Building Displacement Results Basic Wind Speed 39 M/Sec.

TABLE: Diaphragm Center of Mass Displacements					
Story	Diaphragm	Load Case/Combo	UX	UX	UX
			mm	mm	mm
Story26	D1	WL+X	11.898	13.817	10.374
Story25	D1	WL+X	11.37	13.217	9.919
Story24	D1	WL+X	10.833	12.605	9.455
Story23	D1	WL+X	10.29	11.985	8.985
Story22	D1	WL+X	9.739	11.355	8.508
Story21	D1	WL+X	9.181	10.717	8.025
Story20	D1	WL+X	8.617	10.07	7.536
Story19	D1	WL+X	8.057	9.422	7.044
Story18	D1	WL+X	7.493	8.766	6.549
Story17	D1	WL+X	6.928	8.108	6.052
Story16	D1	WL+X	6.364	7.45	5.556
Story15	D1	WL+X	5.802	6.793	5.061
Story14	D1	WL+X	5.249	6.153	4.583
Story13	D1	WL+X	4.702	5.52	4.111
Story12	D1	WL+X	4.167	4.899	3.649
Story11	D1	WL+X	3.646	4.294	3.198
Story10	D1	WL+X	3.143	3.708	2.763
Story9	D1	WL+X	2.672	3.157	2.356
Story8	D1	WL+X	2.223	2.631	1.967
Story7	D1	WL+X	1.801	2.137	1.601
Story6	D1	WL+X	1.411	1.678	1.262
Story5	D1	WL+X	1.058	1.262	0.953
Story4	D1	WL+X	0.752	0.899	0.684
Story3	D1	WL+X	0.488	0.585	0.45
Story2	D1	WL+X	0.27	0.326	0.255
Story1	D1	WL+X	0.102	0.126	0.101

Graph 1.1 General Building

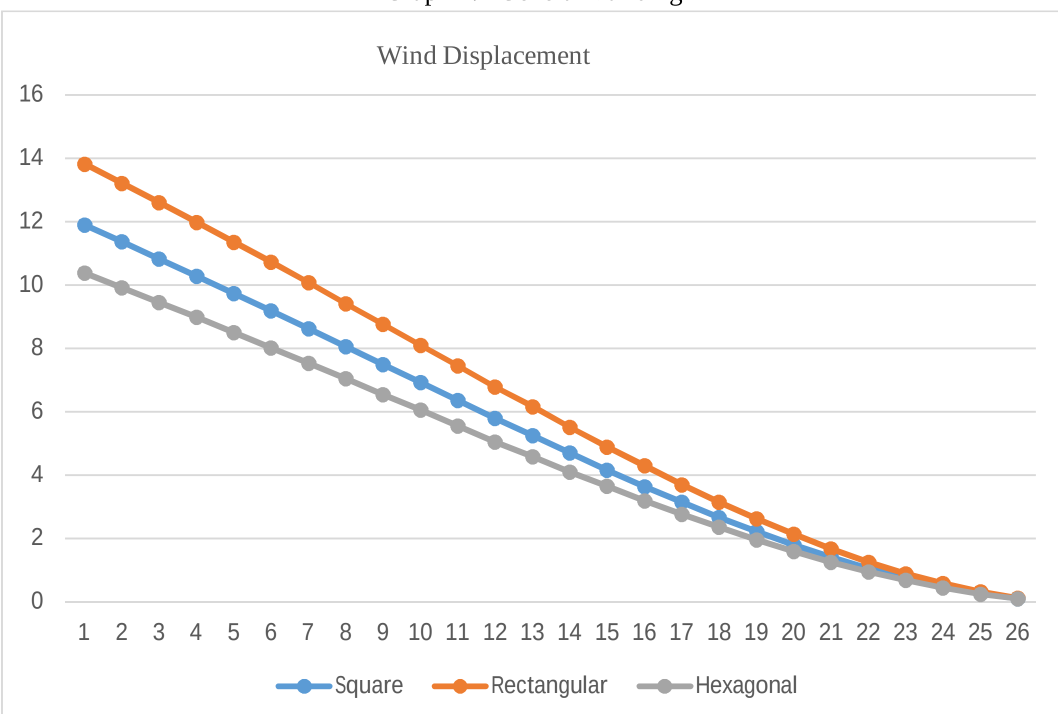
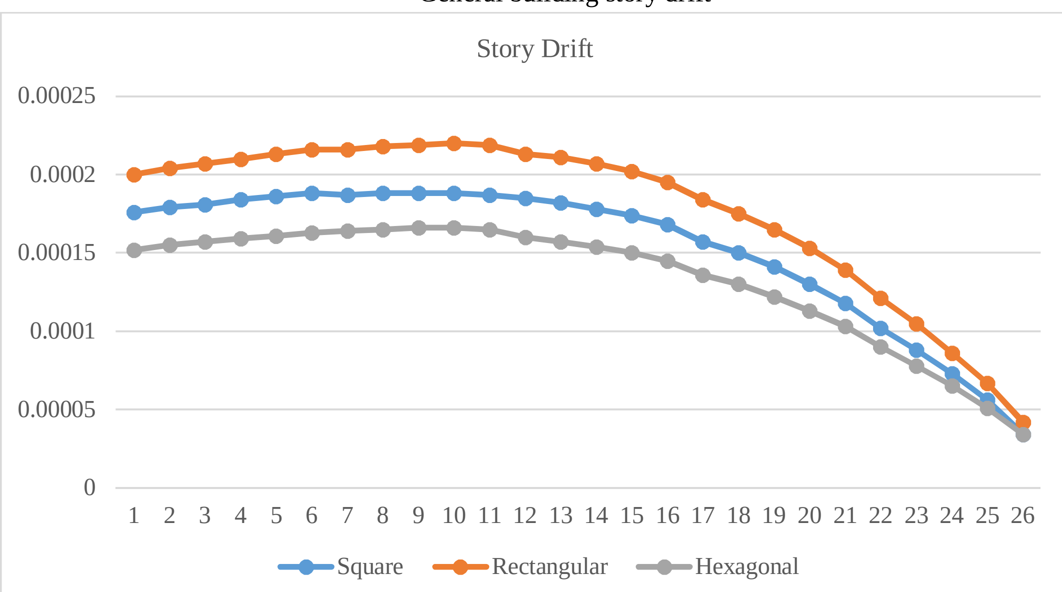


Table 1.2 General building story drift results basic wind speed 39 m/sec

TABLE: Story Drifts					
Story	Load Case/Combo	Direction	Drift	Drift	Drift
			m	m	m
Story26	WL+X	X	0.000176	0.0002	0.000152
Story25	WL+X	X	0.000179	0.000204	0.000155
Story24	WL+X	X	0.000181	0.000207	0.000157
Story23	WL+X	X	0.000184	0.00021	0.000159
Story22	WL+X	X	0.000186	0.000213	0.000161
Story21	WL+X	X	0.000188	0.000216	0.000163
Story20	WL+X	X	0.000187	0.000216	0.000164
Story19	WL+X	X	0.000188	0.000218	0.000165
Story18	WL+X	X	0.000188	0.000219	0.000166
Story17	WL+X	X	0.000188	0.00022	0.000166
Story16	WL+X	X	0.000187	0.000219	0.000165
Story15	WL+X	X	0.000185	0.000213	0.00016
Story14	WL+X	X	0.000182	0.000211	0.000157
Story13	WL+X	X	0.000178	0.000207	0.000154
Story12	WL+X	X	0.000174	0.000202	0.00015
Story11	WL+X	X	0.000168	0.000195	0.000145
Story10	WL+X	X	0.000157	0.000184	0.000136
Story9	WL+X	X	0.00015	0.000175	0.00013
Story8	WL+X	X	0.000141	0.000165	0.000122
Story7	WL+X	X	0.00013	0.000153	0.000113
Story6	WL+X	X	0.000118	0.000139	0.000103
Story5	WL+X	X	0.000102	0.000121	0.00009
Story4	WL+X	X	0.000088	0.000105	0.000078
Story3	WL+X	X	0.000073	0.000086	0.000065
Story2	WL+X	X	0.000056	0.000067	0.000051
Story1	WL+X	X	0.000034	0.000042	0.000034

General building story drift



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Bracing System In 39m/Sec Wind Speed

Table 5.3 wind displacement in bracing system in 39m/sec basic wind speed

TABLE: Diaphragm Center of Mass Displacements					
Story	Diaphragm	Load Case/Combo	UX	UX	UX
			mm	mm	mm
Story26	D1	WL+X	9.903	11.954	8.889
Story25	D1	WL+X	9.488	11.459	8.518
Story24	D1	WL+X	9.064	10.953	8.137
Story23	D1	WL+X	8.632	10.437	7.75
Story22	D1	WL+X	8.193	9.912	7.356
Story21	D1	WL+X	7.746	9.378	6.956
Story20	D1	WL+X	7.291	8.833	6.548
Story19	D1	WL+X	6.836	8.284	6.137
Story18	D1	WL+X	6.375	7.727	5.721
Story17	D1	WL+X	5.912	7.165	5.301
Story16	D1	WL+X	5.447	6.6	4.881
Story15	D1	WL+X	4.981	6.034	4.46
Story14	D1	WL+X	4.519	5.478	4.05
Story13	D1	WL+X	4.062	4.928	3.643
Story12	D1	WL+X	3.611	4.385	3.243
Story11	D1	WL+X	3.17	3.853	2.851
Story10	D1	WL+X	2.742	3.337	2.472
Story9	D1	WL+X	2.338	2.848	2.113
Story8	D1	WL+X	1.951	2.38	1.77
Story7	D1	WL+X	1.587	1.937	1.446
Story6	D1	WL+X	1.247	1.525	1.143
Story5	D1	WL+X	0.938	1.149	0.866
Story4	D1	WL+X	0.669	0.818	0.623
Story3	D1	WL+X	0.435	0.532	0.411
Story2	D1	WL+X	0.241	0.295	0.233
Story1	D1	WL+X	0.092	0.112	0.092

Graph 5.3 Bracing System Displacement Vs. Different Shape of Structure

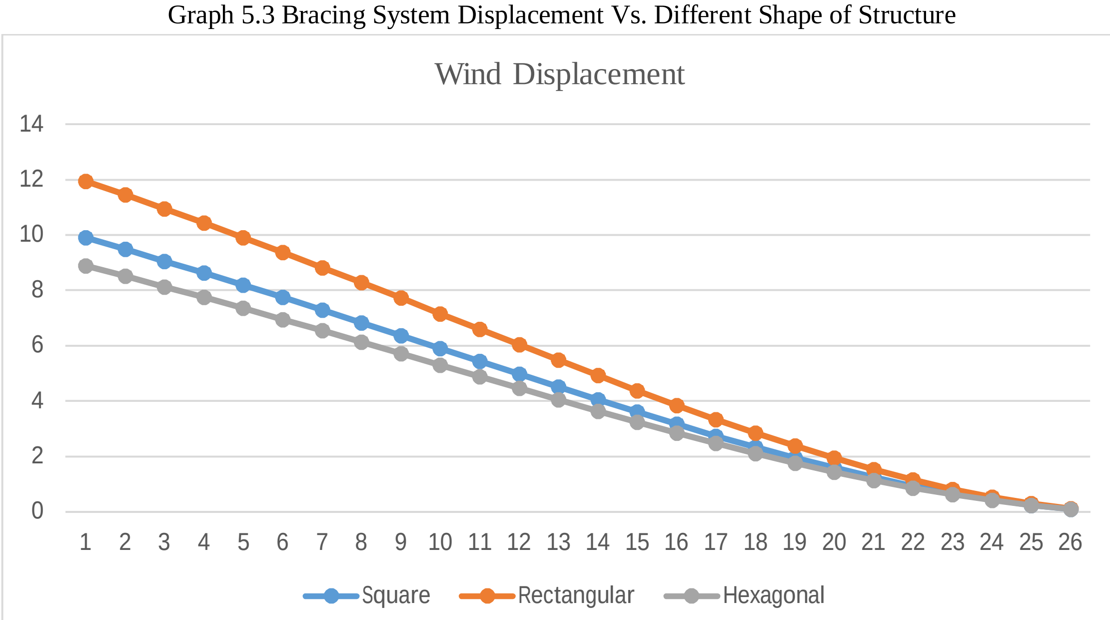

Table 5.4 story drift at bracing system in 39 m/sec basic wind speed

TABLE: Story Drifts					
Story	Load Case/Combo	Direction	Drift	Drift	Drift
			m	m	m
Story26	WL+X	X	0.000138	0.000165	0.000124
Story25	WL+X	X	0.000141	0.000169	0.000127
Story24	WL+X	X	0.000144	0.000172	0.000129
Story23	WL+X	X	0.000146	0.000175	0.000131
Story22	WL+X	X	0.000149	0.000178	0.000134
Story21	WL+X	X	0.000152	0.000181	0.000136
Story20	WL+X	X	0.000152	0.000183	0.000138
Story19	WL+X	X	0.000153	0.000186	0.000139
Story18	WL+X	X	0.000154	0.000187	0.00014
Story17	WL+X	X	0.000155	0.000188	0.000141
Story16	WL+X	X	0.000155	0.000189	0.000141
Story15	WL+X	X	0.000154	0.000185	0.000137
Story14	WL+X	X	0.000153	0.000184	0.000136
Story13	WL+X	X	0.00015	0.000181	0.000134
Story12	WL+X	X	0.000147	0.000177	0.000131
Story11	WL+X	X	0.000143	0.000172	0.000127
Story10	WL+X	X	0.000135	0.000163	0.00012
Story9	WL+X	X	0.000129	0.000156	0.000114
Story8	WL+X	X	0.000122	0.000147	0.000108
Story7	WL+X	X	0.000113	0.000137	0.000101
Story6	WL+X	X	0.000103	0.000125	0.000093
Story5	WL+X	X	0.00009	0.00011	0.000081
Story4	WL+X	X	0.000078	0.000095	0.000071
Story3	WL+X	X	0.000065	0.000079	0.00006
Story2	WL+X	X	0.00005	0.000061	0.000047
Story1	WL+X	X	0.000031	0.000037	0.000031

Graph 5.4 story drift in bracing vs. different shape of structure

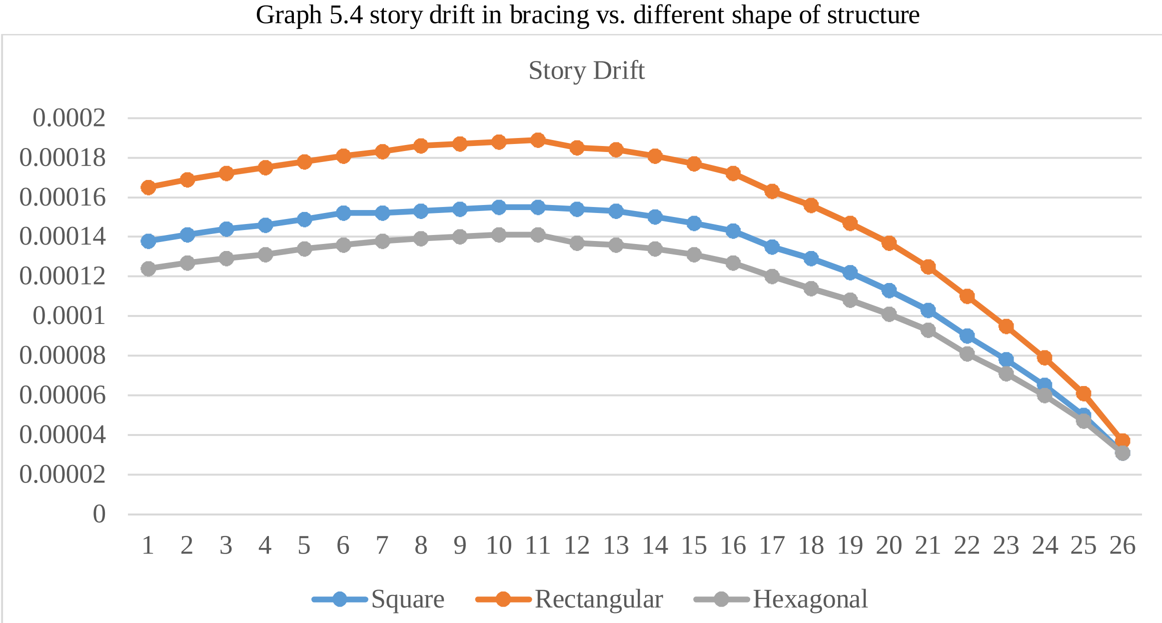

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Table 1.5 Displacement Results in Open Story In 39 M/Sec Basic Wind Speed

TABLE: Diaphragm Center of Mass Displacements					
Story	Diaphragm	Load Case/Combo	UX	UX	UX
			mm	mm	mm
Story26	D1	WL+X	5.068	4.904	5.53
Story25	D1	WL+X	4.847	4.695	5.292
Story24	D1	WL+X	4.621	4.481	5.048
Story23	D1	WL+X	4.391	4.263	4.799
Story22	D1	WL+X	4.158	4.04	4.546
Story21	D1	WL+X	3.92	3.814	4.289
Story20	D1	WL+X	3.682	3.586	4.031
Story19	D1	WL+X	3.445	3.358	3.771
Story18	D1	WL+X	3.205	3.125	3.507
Story17	D1	WL+X	2.964	2.891	3.242
Story16	D1	WL+X	2.722	2.656	2.976
Story15	D1	WL+X	2.483	2.423	2.713
Story14	D1	WL+X	2.247	2.196	2.458
Story13	D1	WL+X	2.014	1.971	2.206
Story12	D1	WL+X	1.784	1.749	1.958
Story11	D1	WL+X	1.561	1.532	1.715
Story10	D1	WL+X	1.346	1.324	1.483
Story9	D1	WL+X	1.144	1.127	1.265
Story8	D1	WL+X	0.952	0.939	1.057
Story7	D1	WL+X	0.771	0.762	0.86
Story6	D1	WL+X	0.603	0.598	0.677
Story5	D1	WL+X	0.452	0.449	0.512
Story4	D1	WL+X	0.321	0.32	0.368
Story3	D1	WL+X	0.208	0.208	0.243
Story2	D1	WL+X	0.115	0.115	0.137
Story1	D1	WL+X	0.043	0.044	0.054

Graph 5.5 open story building displacement in 39m/sec displacement

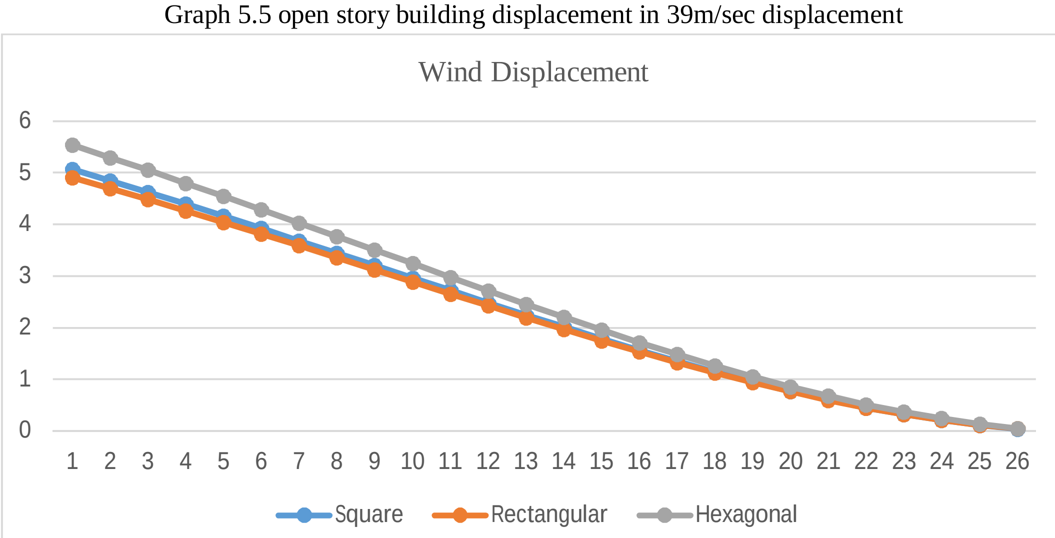

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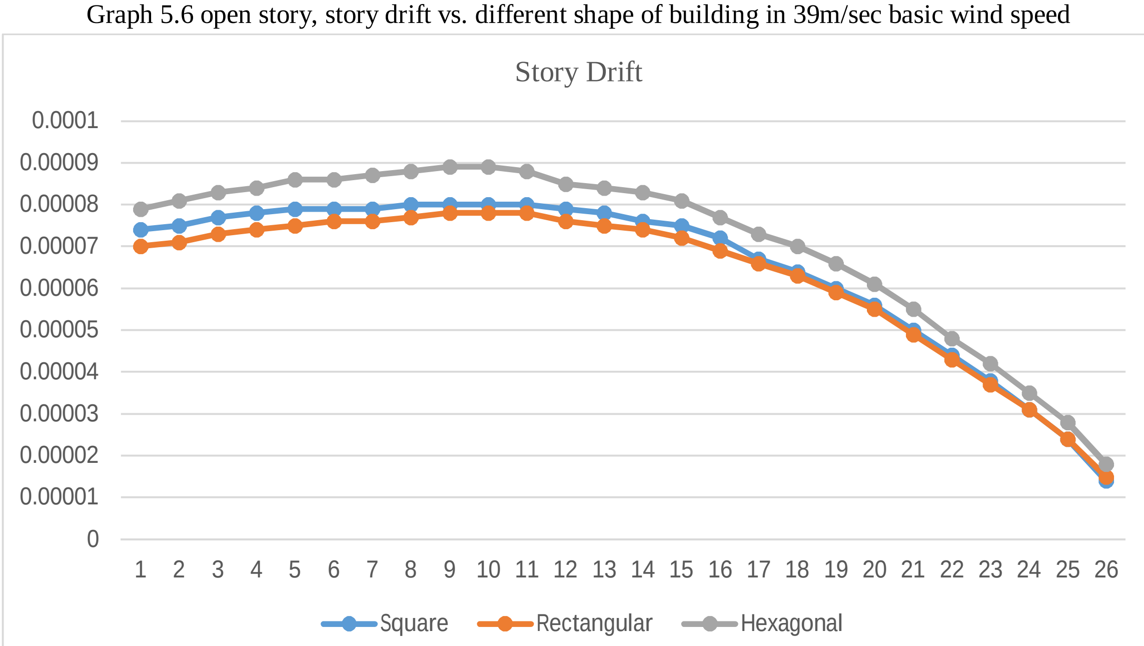
Table 5.6 open story drift vs. different shape of structure in 39m/sec

TABLE: Story Drifts					
Story	Load Case/Combo	Direction	Drift	Drift	Drift
			m	m	m
Story26	WL+X	X	0.000074	0.00007	0.000079
Story25	WL+X	X	0.000075	0.000071	0.000081
Story24	WL+X	X	0.000077	0.000073	0.000083
Story23	WL+X	X	0.000078	0.000074	0.000084
Story22	WL+X	X	0.000079	0.000075	0.000086
Story21	WL+X	X	0.000079	0.000076	0.000086
Story20	WL+X	X	0.000079	0.000076	0.000087
Story19	WL+X	X	0.00008	0.000077	0.000088
Story18	WL+X	X	0.00008	0.000078	0.000089
Story17	WL+X	X	0.00008	0.000078	0.000089
Story16	WL+X	X	0.00008	0.000078	0.000088
Story15	WL+X	X	0.000079	0.000076	0.000085
Story14	WL+X	X	0.000078	0.000075	0.000084
Story13	WL+X	X	0.000076	0.000074	0.000083
Story12	WL+X	X	0.000075	0.000072	0.000081
Story11	WL+X	X	0.000072	0.000069	0.000077
Story10	WL+X	X	0.000067	0.000066	0.000073
Story9	WL+X	X	0.000064	0.000063	0.00007
Story8	WL+X	X	0.00006	0.000059	0.000066
Story7	WL+X	X	0.000056	0.000055	0.000061
Story6	WL+X	X	0.00005	0.000049	0.000055
Story5	WL+X	X	0.000044	0.000043	0.000048
Story4	WL+X	X	0.000038	0.000037	0.000042
Story3	WL+X	X	0.000031	0.000031	0.000035
Story2	WL+X	X	0.000024	0.000024	0.000028
Story1	WL+X	X	0.000014	0.000015	0.000018

Graph 5.6 open story, story drift vs. different shape of building in 39m/sec basic wind speed



IV. CONCLUSION

A. Analysis of RCC tube in tube structure with different basic wind speed i.e., 39m/sec, and 55m/sec with medium soil condition at zone III has been done and significant variations in square building has been noted as compared to rectangular and hexagonal building.

B. Results indicate that same all value similar to tube in tube with open story, because of earthquake zone are same for both type of building.

C. Analysis of RCC tube in tube structure and tube in tube with open story structure in zone III with medium soil but overall performance of tube in tube with open story structure is healthier than remaining all structure.

D. Comparing the displacement in tube in tube structure and tube in tube with open story structure almost both displacement results are same, but the wind displacement is increased as compare to 39m/sec basic wind speed but relatively shows good performance in time ages.

E. The story drift in tube in tube structure and tube in tube with open story structure both structures are 4 to 4.5 % drift are available so structure behaviour are nonlinear. And also, in different shape structure 3 to 3.7 % drift are available, so structure is show linear behaviour.

F. Also, Analysis of RCC different shape of tube in tube structure i.e. rectangular, Square and Hexagonal shape structure in basic wind speed 39m/sec with 55m/sec in medium soil but overall performance of square shape of structure is healthier than remining all shape of structure.

REFFERENCES

[1] Analysis Of RCC Tube in Tube Structure with Different Basic Wind Speed I.E., 39m/Sec, and 55m/Sec with Medium Soil Condition at Zone III Has Been Done.

[2] Results Indicate That Same All Value Similar to Tube in Tube with Open Story, Because Of Earthquake Zone Are Same for Both Type of Building.

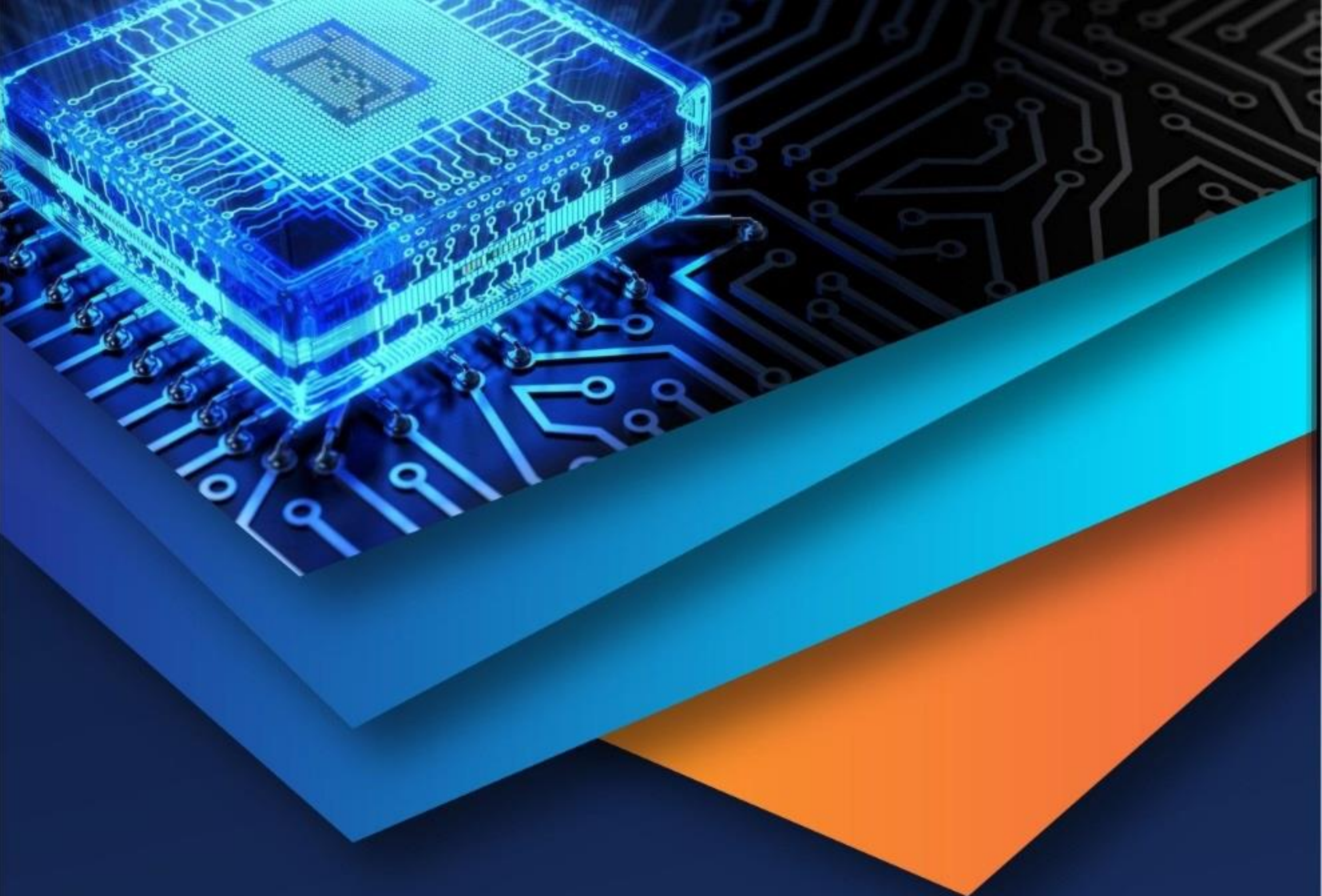
[3] Analysis Of RCC Tube In Tube Structure And Tube In Tube With Open Story Structure In Zone III With Medium Soil But Overall Performance Of Tube In Tube With Open Story Structure Is Healthier Than Remaining All Structure.

[4] Comparing The Wind Displacement In Tube In Tube Structure And Tube In Tube With Open Story Structure, In Wind Displacement Increased As Compare To 39m/Sec Basic Wind Speed But Relatively Shows Good Performance In Time Ages.

[5] The Story Drift In Tube In Tube Structure And Tube In Tube With Open Story Structure Both Structures Are 4 To 4.5 % Drift Are Available So Structure Behaviour Are Nonlinear. And Also, In Different Shape Structure 3 To 3.7 % Drift Are Available, So Structure Is Show Linear Behaviour.

[6] Also, Analysis of RCC Different Shape of Tube in Tube Structure I.E. Rectangular, Square and Hexagonal Shape Structure in Basic Wind Speed 39m/Sec With 55m/Sec in Medium Soil but Overall Performance of Square Shape of Structure Is Healthier Than Remining All Shape of Structure.

[7] Imposed Loads", Bureau of Indian Standards, New Delhi, 1987. IS 456, "Indian Standard Code of Practice for Plain and Reinforced Concrete", Bureau of Indian Standards, New Delhi, 2000. IS 1893 (Part I), "Criteria For Earthquake Resistant Design Of Structures", Bureau Of Indian Standards, New Delhi, 2002.



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