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Wind Analysis of RCC Tube in Tube Structure

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***Abstract:** Modern tall buildings have efficient structural systems, and utilize high-strength materials, resulting in reduced building height, and thus, become slenderer and more flexible with low damping. These flexible buildings are very sensitive to wind excitation and earthquake load causing discomfort to the building occupants. Therefore, in order to mitigate such an excitation and to improve the performance of tall buildings against wind loads and earthquake loads, the tube in tube structures and tube frame structures are the innovative and fresh concept in the tubular structures. Generally, tube in tube structures is formed by connecting peripheral frame tube and inner core tube so closely, it is not seen as a solid system but it acts like a solid surface. The total loads acting on the structures to be collectively shared between the inner and outer tubes. The tubed frames Structure are new concept for tall building. In tubed mega frames instead of one central tube several vertical tubes are carrying the lateral loads. a comparative study of tube in tube structures and tubed mega frame system with different building geometry has been done using ETABS software.*

***Keywords:** Tube in tube, High Rise Buildings, Load Analysis, Wind Load, Terrain Category.*

I. 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. Nowadays, tubular constructions have become increasingly prevalent in tall buildings. Tube in tube structures are 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.

II. CONCEPT OF TUBE IN TUBE STRUCTURE

This is a type of framed tube consisting of an outer-framed tube together with an internal elevator and service core. The exterior tube and the interior tube are designed to act together. The exterior tube has relatively large width and hence it is designed to resist the entire bending moment caused by lateral forces. The interior tubes are designed to carry shear produced by the lateral forces. This type of structures is also called as Hull (Outer tube) and Core (Inner tube) structures.

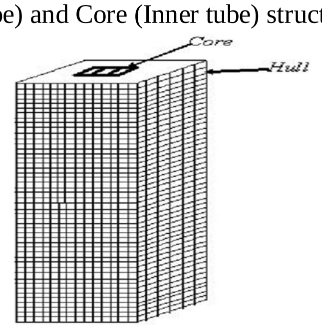


Fig Tube in Tube

III. PROBLEM FORMULATION

A. *Proposed Work*

After exclusive study of literature carried by various researchers, the unfocused area is identified as problem for proposed dissertation. carried out using following points

1) To study parametric design variables on the performance of a G+25 story building with different basic wind speed in terrain category II.
2) Comparative wind analysis between tube in tube RCC structure with story open at every 5th floor.

IV. MODEL PROPERTIES

G+25 storied building with different wind speeds, storey open at different levels with basic wind speed 39 m/s and different shapes i.e. hexagonal, octagonal, square and rectangular are model using conventional beams, columns, shear walls & slabs. They are loaded with Dead, Live, wind and Seismic Forces (according to IS 875:2015(Part-3) and IS:1893:2016). These models are then analysed using wind analysis method for earthquake zone 3 of India (Zone Factor = 0.16). The details of the modelled building are listed below.

Mechanical Property of Reinforcement Steel

Floors	Sizes(mm)	
	Corner	Others
G-G4	530X530	450X800
G5-G6	500X500	450X750
G7-G10	450X500	450X700
G11-G15	450X450	450X600
G16-G20	450X380	450X500
G21-G25	450X300	450X450

A. *Types of Loads*

Unless otherwise specified, all loads listed, shall be considered in design for the Indian Code following load combinations shall be considered.

Load **case**

1) DL: Dead load
2) LL: Live load
3) EQ: Earthquake load

B. *Load Combination*

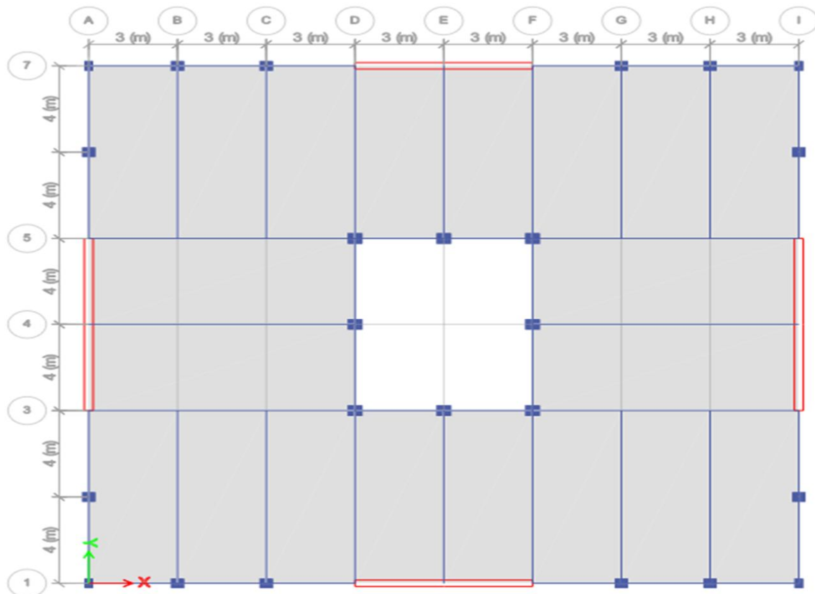
1.5 (DL + LL)	1.2 (DL + LL ± WLX)	0.9DL ± 1.5WLX
1.2 (DL + LL ± EQX)	1.2 (DL + LL ± WLY)	0.9DL ± 1.5WLY
1.2(DL + LL ± EQY)	1.5(DL ± WLX)	0.9DL ± 1.5EQX
1.5(DL ± EQX) 1.5(DL ± EQY)	1.5(DL ± WLY)	0.9DL ± 1.5EQY

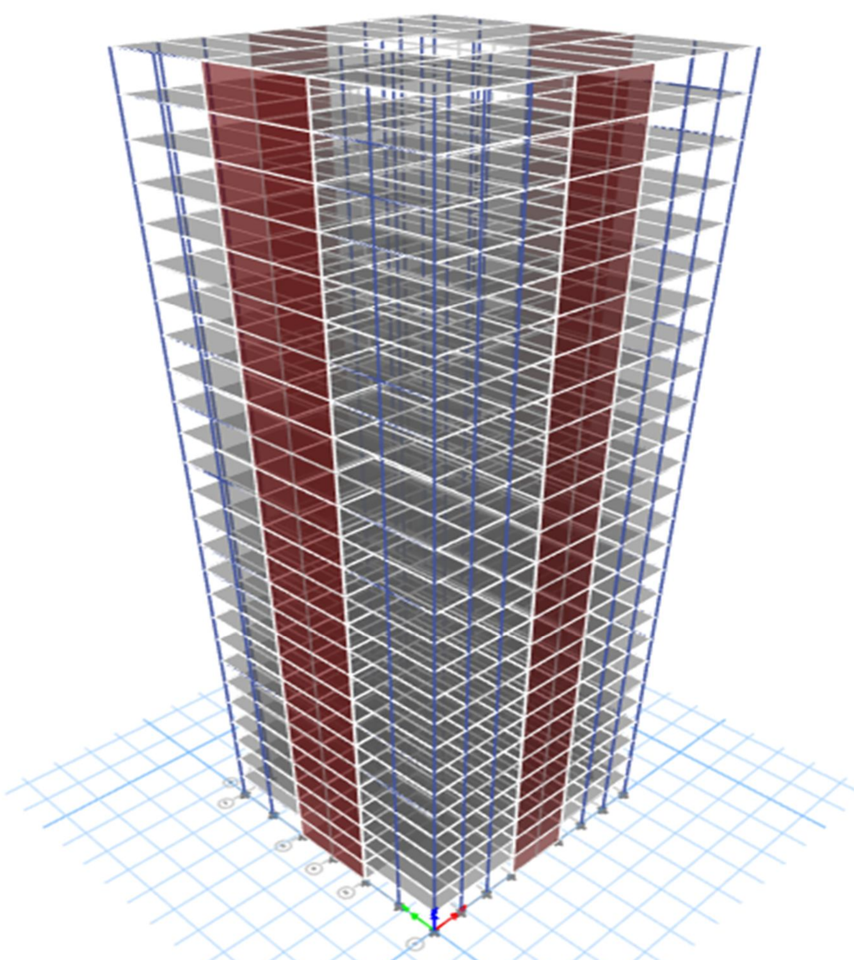
Where,

DL = Dead load, LL = Live load

EQX and EQY = Earthquake load in X and Y direction WLX and WLY = Wind load in X and Y direction.

V. SOFTWARE PLAN AND 3D MODEL





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VI. RESULTS

A. *Displacement due to Wind*

Displacement dur to wind in different basic wind speed in X- direction.

Story	Displacement (mm)			
	Model 1	Model 2	Model 3	Model 4
Story26	39.566	50.362	57.463	65.033
Story25	38.631	49.172	56.105	63.496
Story24	37.654	47.927	54.686	61.89
Story23	36.62	46.612	53.185	60.191
Story22	35.517	45.207	51.582	58.377
Story21	34.334	43.702	49.865	56.434
Story20	33.067	42.09	48.025	54.352
Story19	31.715	40.369	46.061	52.129
Story18	30.274	38.535	43.969	49.761
Story17	28.745	36.588	41.747	47.247
Story16	27.13	34.532	39.401	44.592
Story15	25.432	32.371	36.936	41.801
Story14	23.662	30.119	34.366	38.893
Story13	21.822	27.777	31.693	35.869
Story12	19.92	25.355	28.93	32.741
Story11	17.964	22.866	26.09	29.527
Story10	15.968	20.325	23.191	26.246
Story9	13.95	17.756	20.26	22.929
Story8	11.924	15.178	17.318	19.599
Story7	9.914	12.618	14.398	16.294
Story6	7.946	10.115	11.541	13.061
Story5	6.059	7.712	8.8	9.959
Story4	4.302	5.476	6.248	7.071
Story3	2.729	3.474	3.964	4.486
Story2	1.417	1.804	2.058	2.329
Story1	0.468	0.596	0.68	0.77
Base	0	0	0	0

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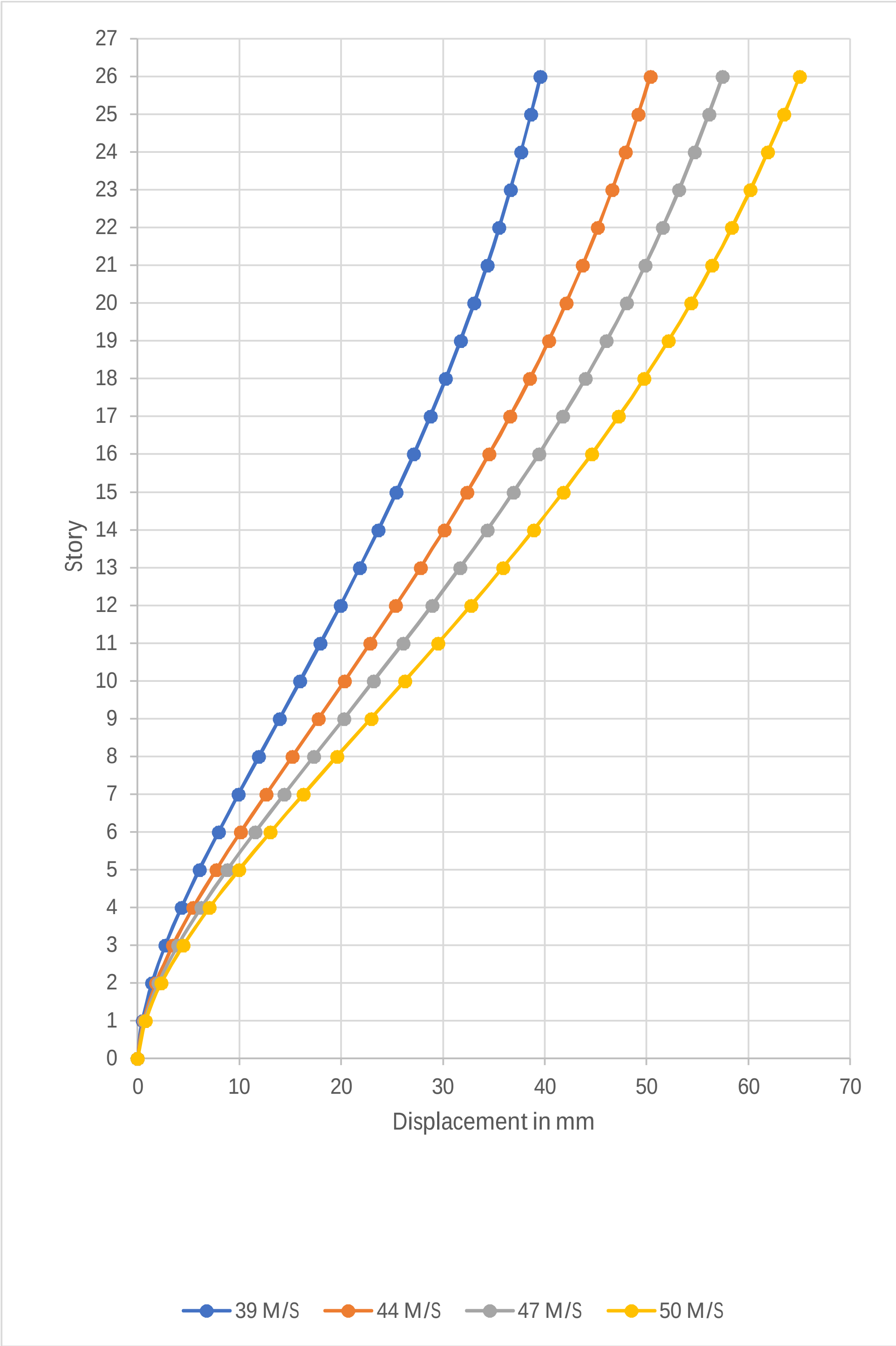


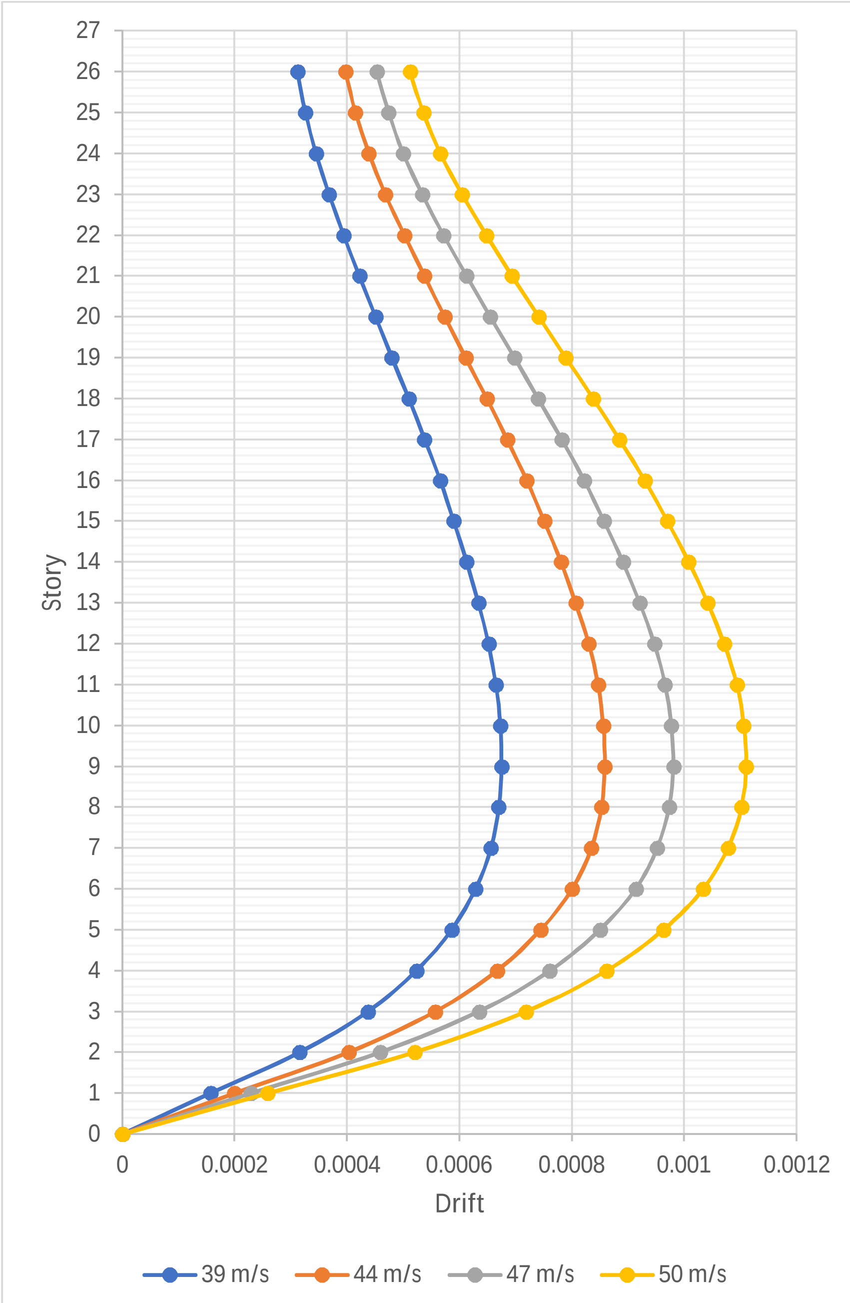
Displacement due to wind Vs. Different basic wind speed

Analysis of RCC tube in tube structure with different basic wind speed i.e., 39m/sec, 44m/sec, 47m/sec and 50m/sec with medium soil condition at zone III has been done. The displacement in x and y direction due to wind of structure with basic wind speed 44m/s, 47m/s, and 50m/s is increased 22%, 31% and 39% as compared to 39m/s basic wind speed.

B. Story Drift

Story Drift At different basic wind speed and earthquake zone III in X-direction.

Story	Story Drift			
	Model 1	Model 2	Model 3	Model 4
Story26	0.000312	0.000397	0.000453	0.000512
Story25	0.000326	0.000415	0.000474	0.000536
Story24	0.000345	0.000439	0.0005	0.000566
Story23	0.000368	0.000468	0.000534	0.000605
Story22	0.000394	0.000502	0.000572	0.000648
Story21	0.000422	0.000538	0.000613	0.000694
Story20	0.000451	0.000574	0.000655	0.000741
Story19	0.00048	0.000611	0.000698	0.000789
Story18	0.00051	0.000649	0.00074	0.000838
Story17	0.000538	0.000685	0.000782	0.000885
Story16	0.000566	0.00072	0.000822	0.00093
Story15	0.00059	0.000751	0.000857	0.00097
Story14	0.000613	0.000781	0.000891	0.001008
Story13	0.000634	0.000807	0.000921	0.001042
Story12	0.000652	0.00083	0.000947	0.001071
Story11	0.000665	0.000847	0.000966	0.001094
Story10	0.000673	0.000856	0.000977	0.001106
Story9	0.000675	0.000859	0.000981	0.00111
Story8	0.00067	0.000853	0.000973	0.001102
Story7	0.000656	0.000835	0.000952	0.001078
Story6	0.000629	0.000801	0.000914	0.001034
Story5	0.000586	0.000745	0.00085	0.000963
Story4	0.000524	0.000667	0.000761	0.000862
Story3	0.000437	0.000557	0.000635	0.000719
Story2	0.000316	0.000403	0.000459	0.00052
Story1	0.000157	0.0002	0.000229	0.000259



Story Drift Vs. Different Basic Wind Speed

The story drift of structure with different basic wind speeds has been analyzed and it has been seen that story drift in X- direction is more for 9th floor and in Y-direction is more for 11th floor. It has been seen that in model 1 story drift reduces by 26.81%, 45.33% and 62% as compared to model 2, model 3 and model 4 respectively.

C. Comparative wind analysis between tube in tube RCC structure with story open at every 5th floor.

The Wind Analysis of tube in tube structure with open story at every 5th story has been done for same model with different basic wind speeds as given in 4.3 section. The calculations have done manually and in excel sheets because it is not possible to show the open story in software. After calculations, the values have been put in wind load cases in software and done the analysis. Following are the results,

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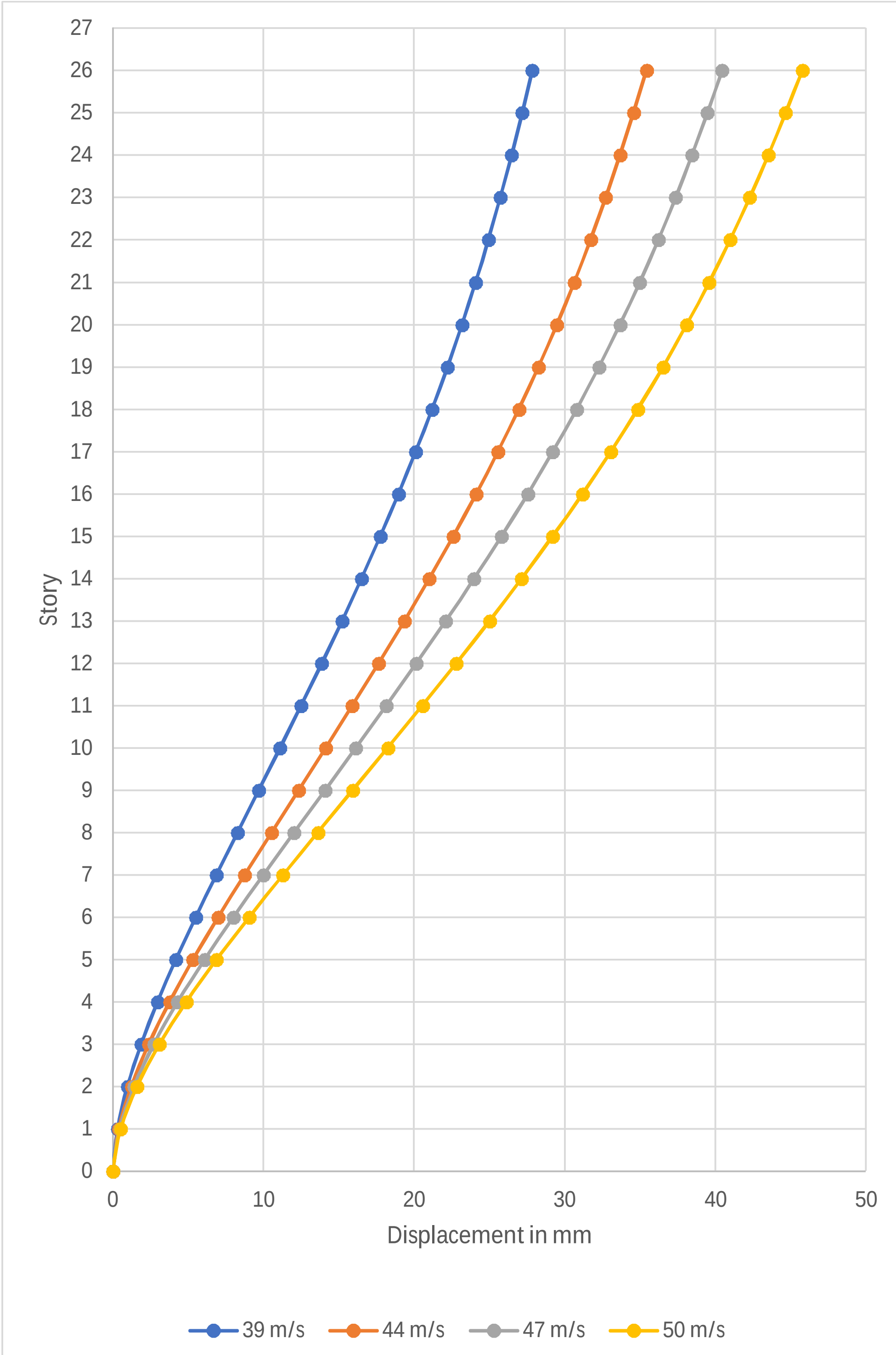
D. Displacement Due to Wind

Displacement due to wind in different basic wind speed

Story	Displacement (mm)			
	Model 1	Model 2	Model 3	Model 4
Story26	27.853	35.428	40.451	45.78
Story25	27.178	34.57	39.472	44.671
Story24	26.473	33.673	38.448	43.513
Story23	25.73	32.727	37.368	42.291
Story22	24.938	31.719	36.218	40.989
Story21	24.091	30.642	34.988	39.597
Story20	23.186	29.49	33.674	38.109
Story19	22.222	28.263	32.274	36.525
Story18	21.197	26.959	30.785	34.84
Story17	20.111	25.578	29.208	33.056
Story16	18.967	24.121	27.546	31.175
Story15	17.766	22.594	25.803	29.202
Story14	16.517	21.005	23.989	27.149
Story13	15.221	19.355	22.106	25.018
Story12	13.882	17.653	20.162	22.818
Story11	12.509	15.906	18.168	20.561
Story10	11.109	14.126	16.135	18.26
Story9	9.697	12.33	14.083	15.938
Story8	8.281	10.529	12.026	13.611
Story7	6.877	8.745	9.988	11.304
Story6	5.507	7.002	7.997	9.051
Story5	4.193	5.332	6.09	6.893
Story4	2.973	3.781	4.318	4.887
Story3	1.883	2.394	2.735	3.095
Story2	0.975	1.24	1.416	1.603
Story1	0.321	0.408	0.466	0.527
Base	0	0	0	0



Graph Displacement due to wind Vs. Different basic wind speed

The wind analysis has been done with different basic wind speeds with story open at every 5th story. From that wind displacement is increased about 30% in tube in tube structure with different wind speeds as compared to tube in tube structure with story open at every 5th level.

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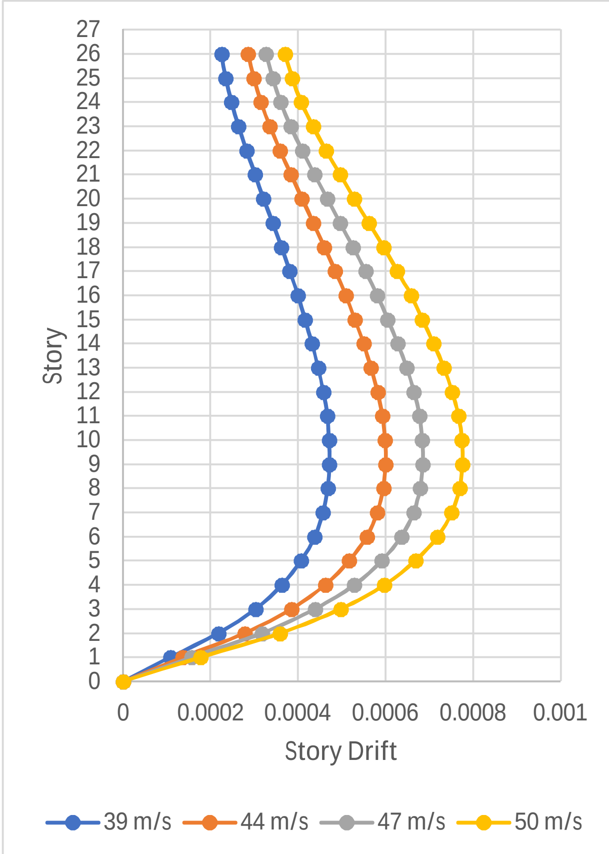
E. Story Drift

Story Drift At different basic wind speed and open story at different level in X-direction.

Story	Story drift			
	Model 1	Model 2	Model 3	Model 4
Story26	0.000225	0.000286	0.000327	0.00037
Story25	0.000235	0.000299	0.000342	0.000387
Story24	0.000248	0.000315	0.00036	0.000407
Story23	0.000264	0.000336	0.000383	0.000434
Story22	0.000282	0.000359	0.00041	0.000464
Story21	0.000302	0.000384	0.000438	0.000496
Story20	0.000321	0.000409	0.000467	0.000528
Story19	0.000342	0.000435	0.000496	0.000562
Story18	0.000362	0.00046	0.000526	0.000595
Story17	0.000381	0.000485	0.000554	0.000627
Story16	0.0004	0.000509	0.000581	0.000658
Story15	0.000416	0.00053	0.000605	0.000684
Story14	0.000432	0.00055	0.000628	0.00071
Story13	0.000446	0.000567	0.000648	0.000733
Story12	0.000458	0.000582	0.000665	0.000752
Story11	0.000467	0.000593	0.000678	0.000767
Story10	0.000471	0.000599	0.000684	0.000774
Story9	0.000472	0.0006	0.000685	0.000776
Story8	0.000468	0.000595	0.000679	0.000769
Story7	0.000457	0.000581	0.000664	0.000751
Story6	0.000438	0.000557	0.000636	0.000719
Story5	0.000407	0.000517	0.000591	0.000668
Story4	0.000363	0.000462	0.000528	0.000597
Story3	0.000303	0.000385	0.000439	0.000497
Story2	0.000218	0.000278	0.000317	0.000359
Story1	0.000108	0.000137	0.000157	0.000177



Graph Story Drift Vs. Different Basic Wind Speed with open story

The story drift of structure with different basic wind speeds has been analyzed and it has been seen that story drift in X- direction is more for 9th floor and in Y-direction is more for 11th floor. It has been seen that in model 1 story drift reduced by 27.11%, 43.85% and 64.40% as compared to model 2, model 3 and model 4 respectively.

VII. CONCLUSIONS

1) The wind displacement of model 2, model 3 and model 4 is increased by 22%, 21% and 39% as compared to model 1. Also, the base shear of model 1 due to wind load in x and y direction is less by 21.43%, 31.14% and 39.16 % for model 2, model 3, and model 4 respectively.
2) Analysis of RCC tube in tube structure and tube in tube with open story structure has been done and it has been seen that overall performance of tube in tube structure with story open at different level is healthier than remining all structure. The wind displacement is increased about 30% in normal tube in tube structure as compared to tube in tube structure story open at every 5th level.
3) The story drift in normal tube in tube structure and tube in tube with open story structure is within permissible limits so structure shows linear behavior. It has been seen that in model 1 story drift reduces by 26.81%, 45.33% and 62% as compared to model 2, model 3 and model 4 respectively at 9th and 11th floor.

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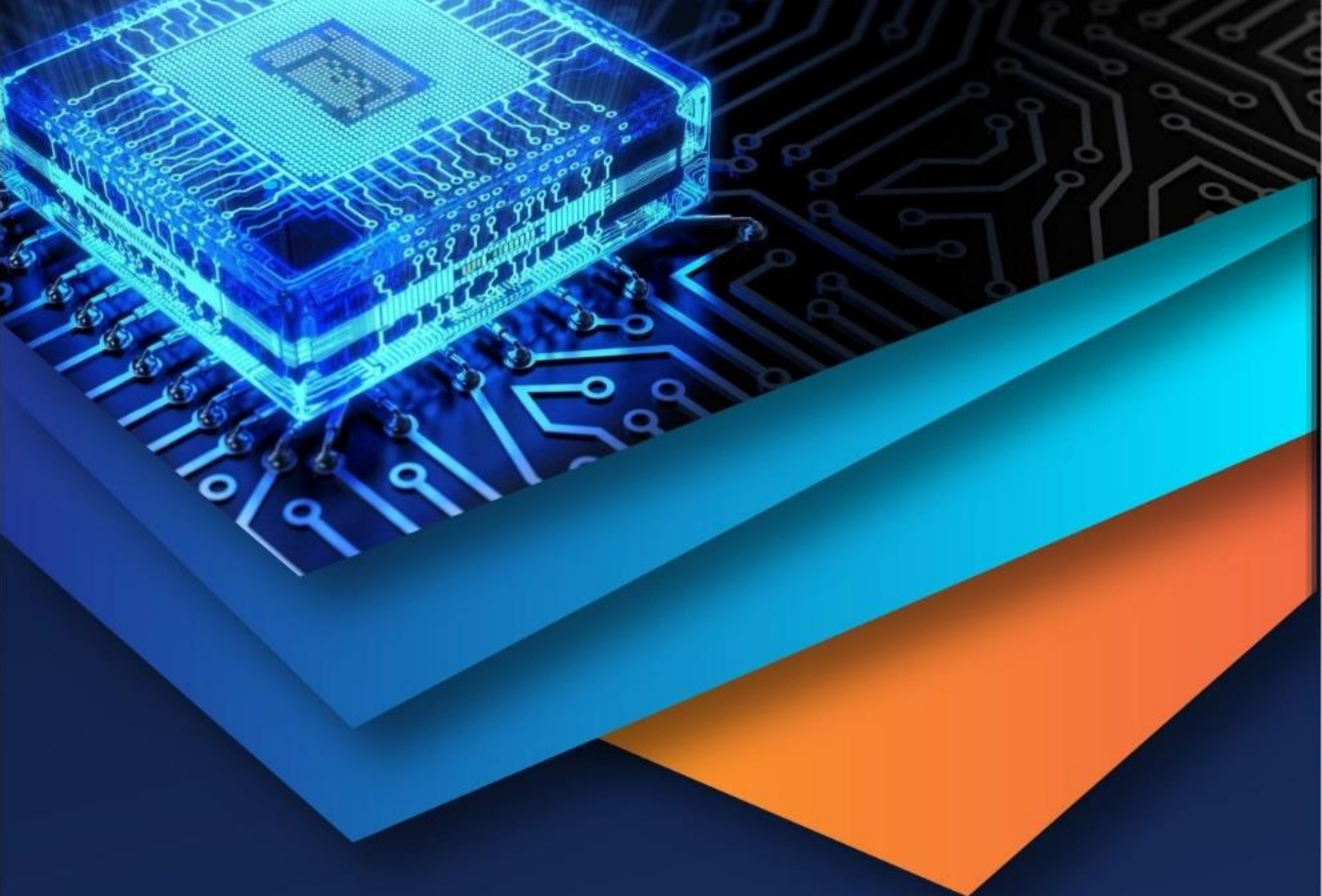

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