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Study of Wind Load on Tall RC Frame Building with Shear Wall in Coastal Region

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Abstract—*In this research work, the resistance of a Tall RC frame building without a shear wall and the optimal shear wall configuration to lateral loads is investigated. It is very important to design structures that perform well in various lateral load actions. The G + 31 high RC frame building is considered for the design and analysis of various parameters. This RC frame building structure is subjected to a lateral load at an average basic wind speed of 50 m / sec. The analysis of this frame structure is performed according to Indian Standard Code IS 875: 2015 Part III. A different arrangement of shear walls is used to protect the structure from critical wind loads. The results are as natural time period, drift of story, and story displacement. After the analysis of the results, the optimal location of the shear wall is obtained.*

Keywords: *Lateral Loads, Wind Load, Simple Diaphragm Method, Shear Wall, ETABS 2017.*

1. INTRODUCTION

In India, the population is gradually increasing and the land needed for subsistence is limited, but this is the basic requirement to survive anywhere. For this reason, in subway cities, where smaller assets are delivered, multi-storey buildings are the best choice. Since the designer knows that a multi-storey structure provides large floor area in a small plan area, this is beneficial for more people housing. So, we need to assemble a high-rise structure, tall building or skyscrapers. If high-rise structures or tall buildings are built, many structural problems arise, such as the effect of lateral load, lateral displacement and stiffness, and so on.

This research paper is a work on study the impact of wind load on RC frame building that is assumed to behave as elastic cladding surface to resist the impact of wind load.

To resist the wind force four shear wall systems are applied. A shear wall is a structural element used to withstand lateral forces, i.e., parallel to the plane of the wall. For slender walls with greater bending deformation, the shear wall is resistant to loads due to Cantilever Action. In other words, shear walls are vertical member of the horizontal force-resistant system. Shear walls are especially important in high-rise buildings exposed to crosswinds and seismic forces. Typically, the shear walls are flat or flanged, and the core walls are formed by channel sections. They also provide enough strength and rigidity to control lateral displacements.

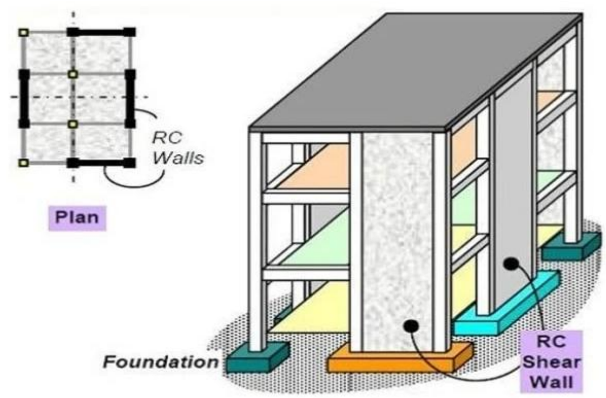


Figure 1: Shear wall system (Courtesy: C. V. R. Murthy)

2. OBJECTIVE OF WORK

The main objective of the present research work is to analyze and the study of multi-story RC Frame tall building (G+31) subjected to wind loads with self-load of the structure.

Some key point to observe from this research study are as follows:

1. To investigate the effect of wind load on the structural system of an RC frame building in the coastal region.
2. To study the parameters i. e. The natural time period, the displacement of the story and the drift of the story on the performance of the structure due to wind load.
3. Examine the parameter, taking into account the different layout of the shear wall, and find out which is more pronounced in the coastal region.

3. STRUCTURAL BUILDING DETAIL

The structure that is taken in account have following properties:

Location	Puducherry
Type of Building	RC Tall Building (G+31)
Plan Dimension	20m * 20m
Type of structure	RC Frame structure
No. of bays in X-Adirection	5No@4m
No. of bays in Y-Adirections	5No@4m
Storyelevation	3.0m
Utmostheight of building	93.60m
Slab's thickness	140mm
Column	600mm*600mm
Beam	300mm*600mm
Glass Panel	6.5mm thick
Lintel	300mm*150mm
Basic wind speed	50m/sec
Risk Co-efficient(k1)	1
Terrain category (k2)	Category 2
Topography factor (k3)	1
Class of building	Class-B
Windward Co-efficient (cp)	0.8
Leeward Co-efficient (cv)	0.5

Loadings:

According to the loading standards of the Indian Standard, it consists of IS 875: 1987 Part 1, IS 875: 1987 Part (II) and IS 875: 2015 Part (III) and IS 1893: 2016 Part (I) for Dead Load, Live Load, Wind and earthquake load respectively. According to Indian standards of calculation and according to the structural load on the studied model, a live load of 4 KN / m^2 and a dead load of 4.5 KN / m^2 is taken and applied to the frame of the structure.

4. PROBLEM FORMULATION

This study focused on the wind load response of a multi-storey RC frame (G + 31) building with different shear wall system layouts. According to the IS code guidelines, using the ETAB'S-2017 software, calculation is performed and structure is situated in the seismic zone II having zone factor .10 and the average basic wind speed is 50m / sec.

Wind load calculations

It is calculated as per IS 875(part 3): 2015

$$Vz= Vbx\ K1 \times K2 \times K3 \times K4 \ldots. [1]$$

Where

V_Z = design wind speed at any height z in m/s,

Vbis the basic wind speed for the zone.

K_1 = probability factor (risk coefficient) (Clause 6.3.1 of IS 875 Part III:2015)

K_2 = terrain roughness and height factor (Clause 6.3.2 of IS 875 Part III:2015)

K_3 = topography factor (Clause 6.3.3 of IS 875 PartIII:2015), And

K_4 = importance factor for the cyclonic region (Clause 6.3.4 of IS 875 Part III:2015).

After finding the design wind speed, the pressure due towind at that point is found out by the Eq

$$Pz=0.6 \times Vz^2 \ldots [2]$$

Where,

Pzis the wind pressure at a height ''z'', in N/sqm.

Then the design wind pressure (Pd) is computed with the Eq (2).

$$Pd = Kd \times Ka \times Kc \times Pz \ldots[3]$$

Where,

Pd is the design wind pressure at a height ''z'', in N/sqm.

Kd =swind directionality factor;

Ka = aarea averaging factor;

Kc =bcombination factor;

Then the Force F is calculated from following eq^n:

$$F= (Cpe-Cpi) \times A \times Pd \ldots..[4]$$

Where,

Cpe=external pressure coefficient;

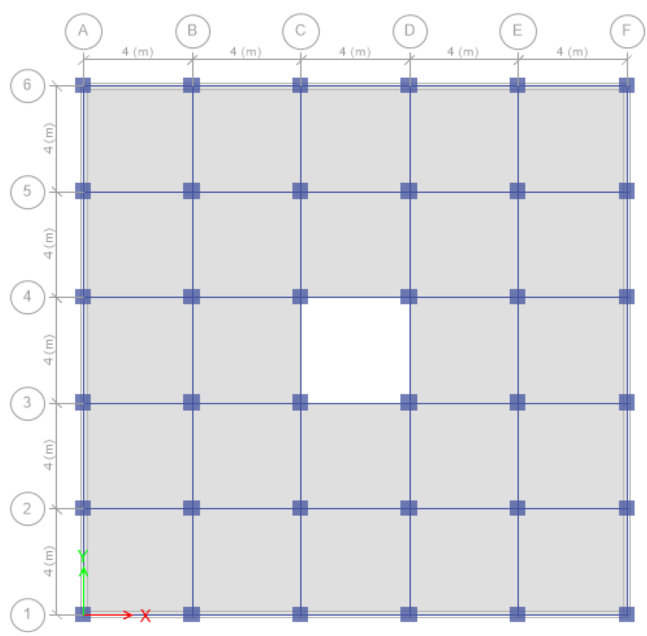
Cpi=Internal pressure coefficient;

A= Surface area of a structure or part of a structure;

Model considered for analysis:

i. Model 1 RC Tall Building (G+31) without shear wall (Wind analysis)
ii. Model 2 RC Tall Building (G+31) with corner shear wall
iii. Model 3 RC Tall Building (G+31) with outer center shear wall
iv. Model 4 RC Tall Building (G+31) with core shear wall

Plan and elevations of considered model are as follows:



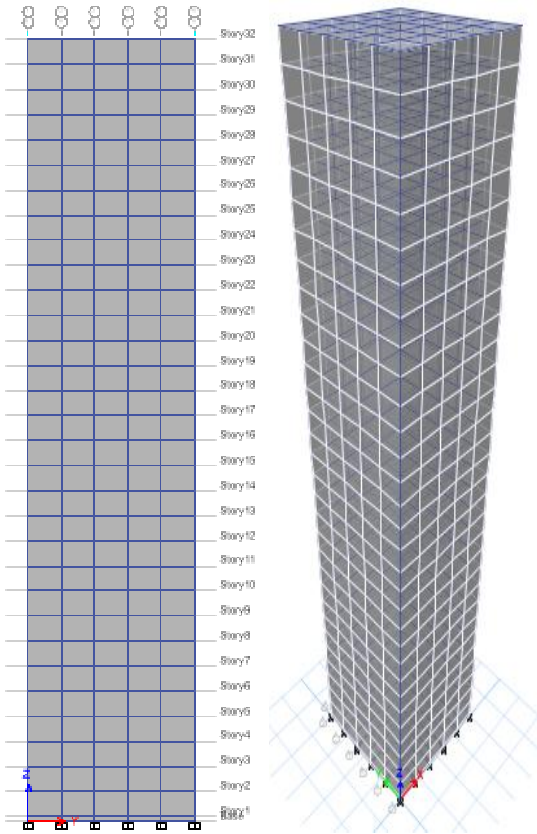
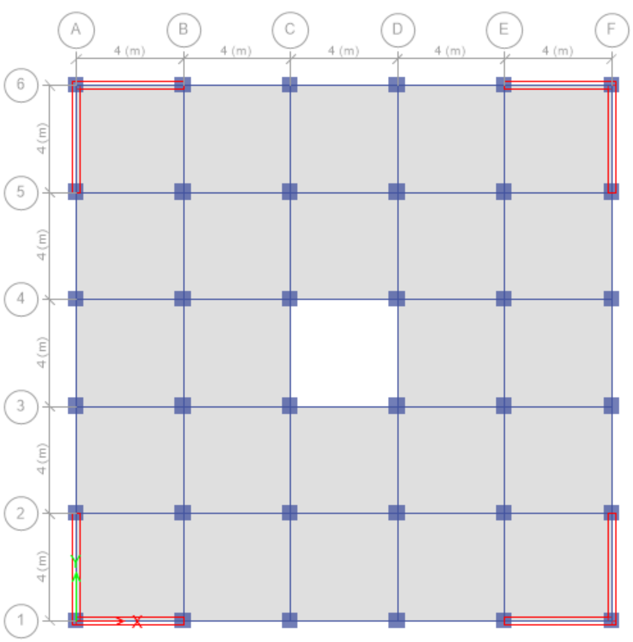


Figure 2: Plan, Elevation and 3D view of Model 1



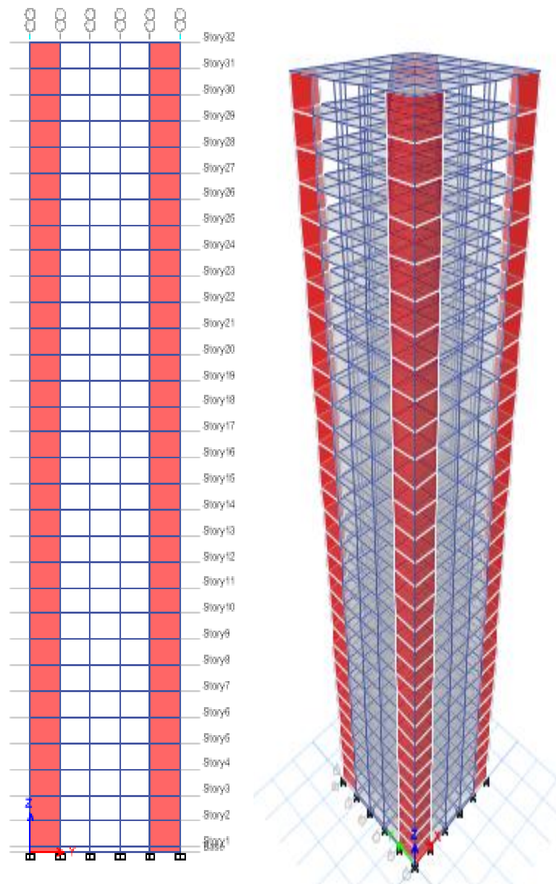
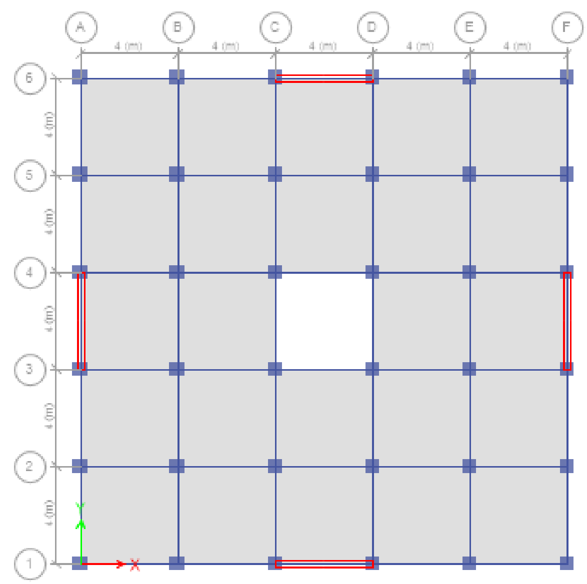


Figure 3: Plan, Elevation and 3D view of Model 2



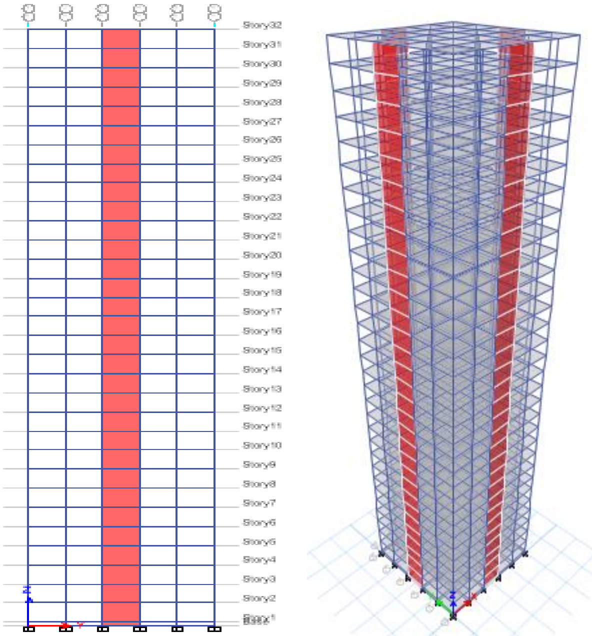


Figure 4: Plan, Elevation and 3D view of Model 3

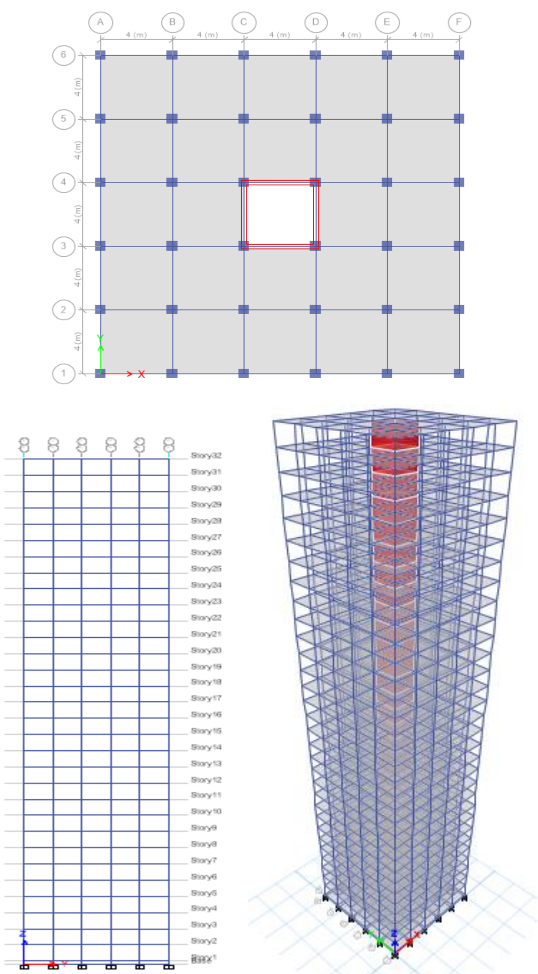


Figure 5: Plan, Elevation and 3D view of Model 4

5. RESULT & DISCUSSION

This study analyzes various parameters such as natural period, story drift, and story displacement or shift. This is analyzed as follows:

a. Natural Time Period

$$Tn = 2\pi\sqrt{m/k}$$

Table 1: Natural Time Period

Mode	Wind load	Corner S. W.	Outer center S. W.	Core S.W.
1	2.521	2.088	2.24	2.247
2	2.521	2.088	2.24	2.247
3	2.007	1.474	1.58	1.53
4	0.801	0.592	0.67	0.635
5	0.801	0.592	0.67	0.635
6	0.665	0.405	0.49	0.508
7	0.44	0.286	0.35	0.311
8	0.44	0.286	0.35	0.311
9	0.395	0.187	0.26	0.305
10	0.307	0.172	0.22	0.215
11	0.307	0.172	0.22	0.193
12	0.279	0.117	0.16	0.193

*S. W. is stand for Shear Wall

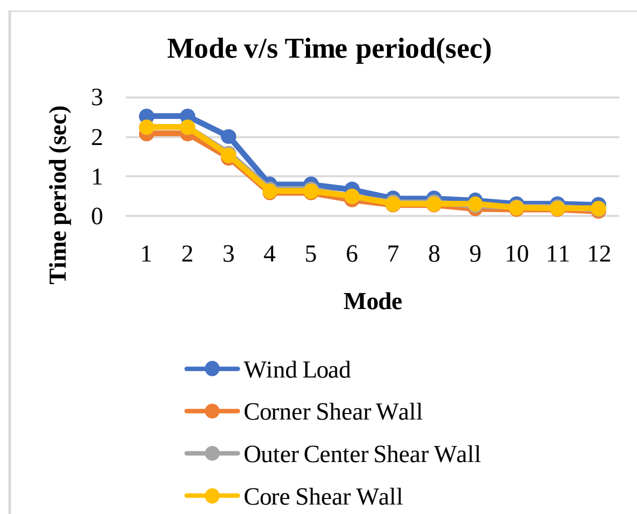


Figure 6: Fundamental natural time period

b. Story Drift

Story drift is the relative displacement between floors above or below the previewed story. According to IS 1893 (Part I): 2016 (clause 7.11.1.1), the story drift in any case should not exceed 0.004 of each floor height due to the shear of the design base, thus the permissible drift value for a floor height of 3 m is 0.004 * 3 = 12 mm.

Table 2: Story Drift(mm)

Story	Wind load	Corner S. W.	Outer center S. W.	Core S.W.
1	8.859	1.149	1.957	1.651
2	11.994	2.032	3.329	2.74
3	12.601	2.723	4.269	3.569
4	12.74	3.264	4.911	4.209
5	12.761	3.684	5.339	4.696
6	12.727	4.005	5.613	5.061
7	12.654	4.244	5.776	5.329
8	12.547	4.413	5.859	5.517
9	12.408	4.525	5.88	5.641
10	12.236	4.588	5.856	5.712
11	12.036	4.609	5.796	5.74
12	11.809	4.595	5.709	5.732
13	11.559	4.551	5.599	5.693
14	11.287	4.482	5.472	5.629
15	10.993	4.392	5.329	5.543
16	10.678	4.284	5.173	5.439
17	10.345	4.162	5.007	5.318
18	9.994	4.026	4.831	5.185
19	9.629	3.882	4.647	5.04
20	9.249	3.729	4.456	4.886
21	8.856	3.571	4.26	4.725
22	8.452	3.41	4.059	4.558
23	8.036	3.248	3.855	4.338
24	7.611	3.087	3.649	4.216
25	7.177	2.93	3.443	4.045
26	6.736	2.779	3.241	3.878
27	6.287	2.637	3.045	3.718
28	5.834	2.508	2.86	3.57
29	5.378	2.396	2.693	3.437
30	4.93	2.307	2.554	3.328
31	4.548	2.231	2.441	3.23

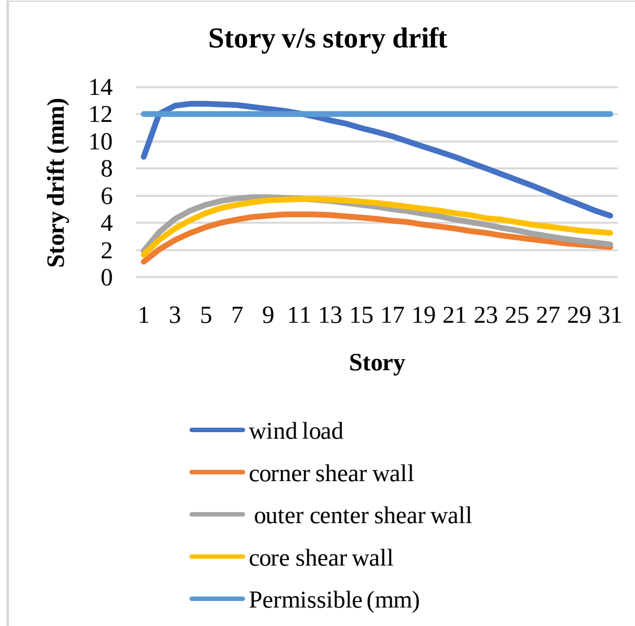


Figure 7: Comparison of Story Drift

Story drift due to wind load is exceeds permissible limit and corner shear wall is best in different arrangements of shear walls.

c. Story Displacement

Story displacement means that total displacement of the floor in relation to the floor due to lateral forces acting on the building. The displacement of story is the shift of a particular story in relation to the ground.

The displacement according to IS 1893 (Part I): 2016 is limited to H / 250.

Table 3: Story Displacement (mm)

Story	Wind load	Corner S. W.	Outer center S. W.	Core S.W.
1	9.248	1.215	2.06	1.743
2	21.242	3.247	5.39	4.484
3	33.843	5.969	9.659	8.053
4	46.583	9.233	14.569	12.262
5	59.344	12.917	19.908	16.958
6	72.071	16.922	25.521	22.019
7	84.725	21.165	31.297	27.348
8	97.273	25.579	37.156	32.865
9	109.68	30.104	43.036	38.506
10	121.916	34.691	48.892	44.219
11	133.952	39.3	54.688	49.959
12	145.761	43.894	60.396	55.69
13	157.32	48.445	65.995	61.383
14	168.607	52.928	71.467	67.012

15	179.6	57.32	76.796	72.555
16	190.278	61.923	81.969	77.994
17	200.622	65.766	86.976	83.312
18	210.617	69.792	91.807	88.497
19	220.245	73.674	96.454	93.537
20	229.494	77.403	100.91	98.424
21	238.35	80.975	105.17	103.149
22	246.802	84.385	109.229	107.707
23	254.838	87.633	113.083	112.095
24	262.449	90.72	116.732	116.312
25	269.626	93.65	120.176	120.357
26	276.362	96.429	123.416	124.235
27	282.649	99.066	126.461	127.954
28	288.483	101.574	129.321	131.523
29	293.862	103.97	132.014	134.96
30	298.791	106.277	134.568	138.288
31	303.339	108.508	137.009	141.518

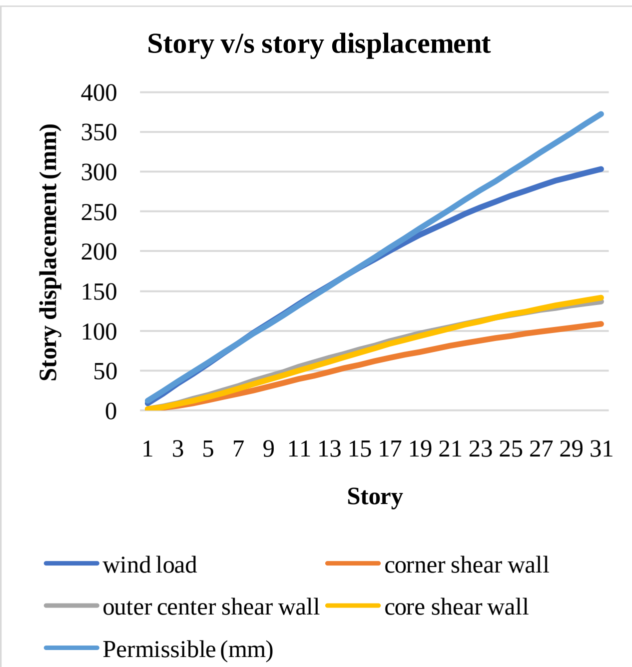


Figure 8: Comparison of Story Displacement

6. CONCLUSIONS

From the above study the following conclusion are given below:

i. From the research work we found that normal frame subjected to wind load have max time period because it is not restrained at any joint by any provision of shear wall, by using corner shear wall it gives max stiffness to the structure and cause min time period.
ii. Among all 4 models normal frame have max drift (12.761mm) then outer center shear wall (5.88mm)and core shear wall(5.74mm) have drift values corner shear wall have min drift(4.609mm).
iii. Natural Time period (sec) of the model is decreased in case of corner shear wall due to increased stiffness although its mass increases.
iv. Displacement is minimum (108.508mm) in case of corner shear walldue tostiffening the structure, max displacement (303.339mm) in case of normal frame.

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