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ANALYSIS OF TALL BUILDING UNDER EARTHQUAKE AND WIND LOADING FOR VARIOUS SHEAR WALL LOCATIONS

PANKAJ D TIWADE[1], PROF. V. G. MESHRAM[2]

1. PG Student, Yeshwantrao Chavan College of Engineering, Nagpur.
2. Professor, Department of Civil Engineering, Yeshwantrao Chavan College of Engineering, Nagpur

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Abstract: Shear wall are most popular system to resist lateral load due to earthquake, wind etc. in tall building. In this study, modeling and analysis is done with equivalent static method on STAAD-PRO software for the assessment of the relative effectiveness of the various lateral load resisting systems. Five models were used, one for moment resisting frame & 04 models each for the lateral load resisting systems (Shear wall system). Each model consists of G +16 storey frame structure having total height of 58.0 m. In this paper comparison is done with different types of models for earthquake and wind load cases like Storey Displacement, bending moment and Axial force in column is carried out. The results of the work showed that the Shear wall system was the most efficient lateral-load resisting system based on displacement criteria, as they yielded the least values for absolute displacements .The moment frame yielding the highest values of absolute displacement. Hence Moment frame was the least stiff than lateral load resisting systems. In comparison absolute displacement was maximum in earthquake load case than wind load case. And base shear is less in moment resisting frame than shear wall system.

Keywords: Moment Frame, Shear Wall, Absolute Displacement, Seismic Load, Wind Load, Base shears etc.

Corresponding Author: MR. PANKAJ D TIWADE

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INTRODUCTION

Shear wall in tall building are used to resist lateral force due to earthquake and wind. In high rise building height of building increases, its overall response to lateral load (such as earthquake and wind) increase. In this paper moment resisting frame model and shear wall model are used. Frame system are rigid beams subjected to lateral loads and Shear wall systems resist the lateral loads these walls are separated or connected by beams.

Shear walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 200mm, or as high as 400mm in high rise buildings. Shear walls are easy to construct, because reinforcement detailing of walls is relatively straight-forward and therefore easily implemented at site.

Structures are designed for the effect of earthquake forces and wind forces in addition to gravity load. Earthquake forces are estimated as per the provision of IS 1893(Part 1):2002 while the wind forces are estimated by IS 875(Part 3):1985. As per the historical wind velocity data India is divided into no. of zones and designed wind velocity is considered according to wind map of India. While the country is divided into four different seismic zone as per geological features and seismic history as per provision of IS 1893(Part 1):2002. Earthquake and maximum wind cannot be considered simultaneously thus it is required to have both wind analysis and seismic analysis of structure. In this paper, estimating wind and earthquake forces on moment resisting frame model and different types shear wall model combining with column and investigate the performance of the structures against earthquake and wind loads. In earthquake and wind load case properly design shear wall with column reduces the effects of displacement, stiffness and strength.

WORK CARRIED OUT

The STAAD-PRO software is used to develop 3D model and to carry out the analysis. The lateral loads and wind load to be applied on the buildings are based on the Indian standards. The study is performed for seismic zone –III as per IS 1893:2002 (Earthquake load), IS875: 1984(Wind Load). The building consists of reinforced concrete and brick masonry elements. G+16 storied moment resisting frame building analyzed for seismic and wind forces. G+16 storied building with different types Shear wall combining with column analyzed with seismic and wind forces. Find out Lateral displacement, Story shear, axial forces, bending moment for all type of model.

3.1 MODEL DATA

Types of Structure	OMRF
No. Of stories	G+16
Storey Height	3.5 m
Material property	
Grade of concrete	M25
Grade of Steel	Fe 415
Member Properties	
Thickness of slab	0.150 m
Beam Size	0.23 x 0.3 m
Column Size	0.3 x 0.50 m
Load Intensities	
Seismic Zone	III
Location	Mumbai
Height of building	58 m
Live load	3 KN/M2
Roof load	1.5 KN/M2
Shear wall Thickness	0.200m

3.2 MODELLING

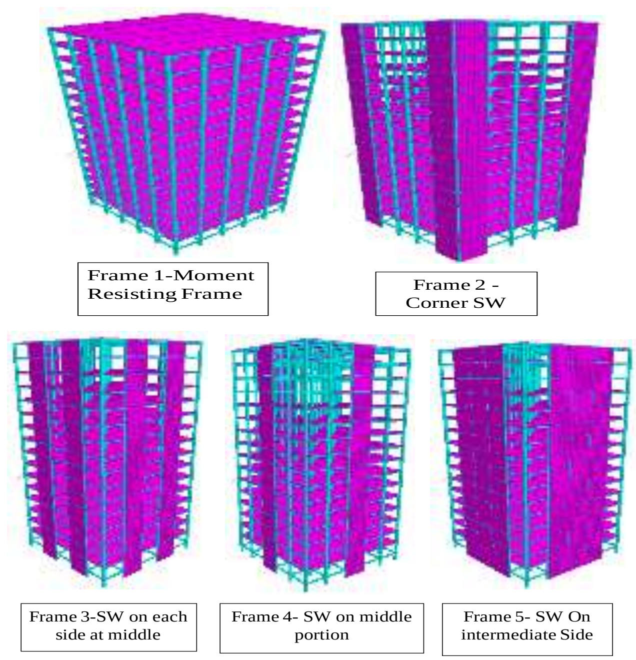


Figure Shows modelling of structure with moment resisting frame and different type of shear wall

3.3 ANALYSIS OF THE BUILDING

Analyses has been performed as per IS 1893 (part-1) 2002 for each model using STADD Pro V8i (computer and structures) software. Earthquake Load case calculation and its distribution along the height is done. The seismic weight is calculated using full dead load plus 25% of live load. Wind load calculation done as per IS 875.

For Wind analysis:-The design wind speed (V_z) is calculated as per IS 875

$V_z = V_b\ k_1\ k_2\ k_3$

The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity.

$P_z = 0.6\ V_z^2$

Wind Load on Individual Members (F) for roof and walls, and individual cladding units and their fittings, it is essential to take account of the pressure difference between opposite force such elements or units. For clad structures necessary to know the internal pressure as well as the external pressure.

$F = (C_{pe} – C_{pi})\ A\ P_d$

For Earthquake analysis: - The total design lateral force or design seismic base shear (V_B) along any principal direction shall be determine by the following expression using IS: 1893 (Part 1)-2002.

$V_B = A_h\ W$

The design horizontal seismic coefficient (A_h) is given by

$Z=\frac{Z\ I\ Sa}{2\ R\ g}$

The fundamental natural period (Ta) is taken for moment resisting frame building without brick infill panels as

$T_a = 0.075h^{o.75}$

And then Distribution of design force (Qi)

$Qi=V_B \frac{Wi\ hi^2}{\sum_{j=1}^{n} Wj\ hj^2}$

Where, Q_i = Design lateral force at floor i, W_i = Seismic weight of floor i, h_i = height of floor i measure from base, and n = Number of stories.

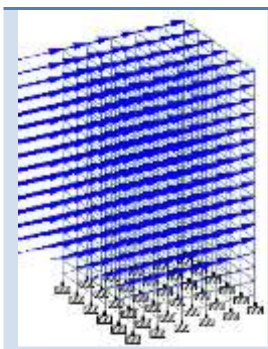
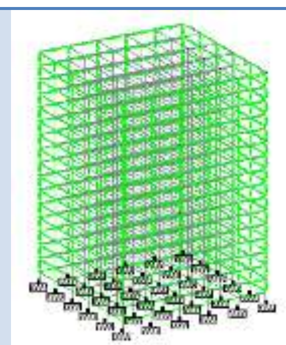
The results obtained from analyses are compared with respect to the following parameters

3.4 BASE SHEAR CALCULATION

Base shear calculate for the different type of structure to calculated by STAAD-Pro Software. And there is time period is same for all model.

Model	Base Shear in KN
Model 1	4788.47
Model 2	5096.54
Model 3	5075.66
Model 4	4932.06
Model 5	5261.02

Also calculate Earthquake force and wind pressure on different type of structure and then apply on the structures using STAAD-PRO Software.

Application of earthquake force on structure using STAAD-Pro.	Application of wind pressure on structure using STAAD-Pro.
	

For calculation of forces, moments and displacement consider two important load cases are taken for the analysis

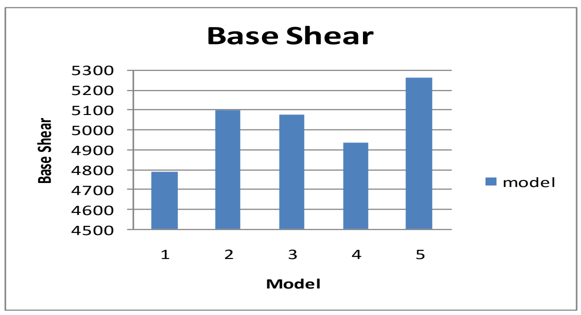
a) 1.2(DL+LL+WL) – for wind analysis.

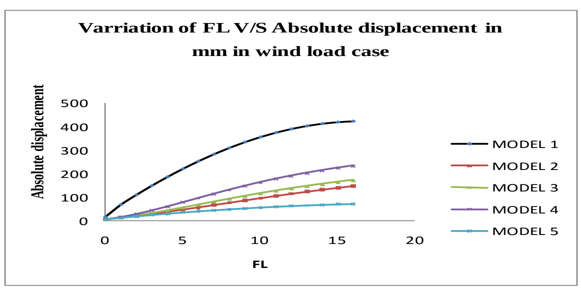
b) 1.5(DL+EQ) – for earthquake analysis.

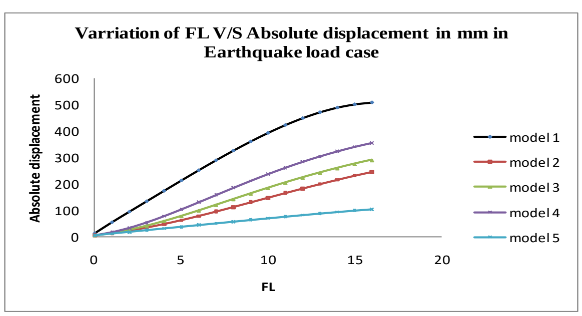
4. RESULTS

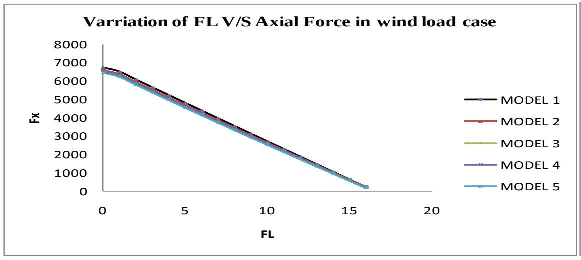
The variation of base shear in KN, Absolute displacement in mm, Axial Force in KN, Shear force in KN and Bending moment in KNm is evaluated for all these models in wind load case and earthquake load case. The parametric study to know base shear, story displacement, axial force and Moment in case of all models is performed here.

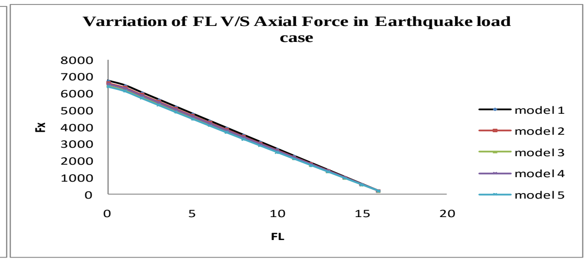
From the result, graphs for base shear Displacements, Forces, and Moment are drawn below:

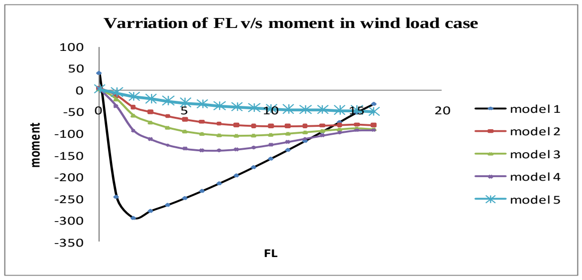


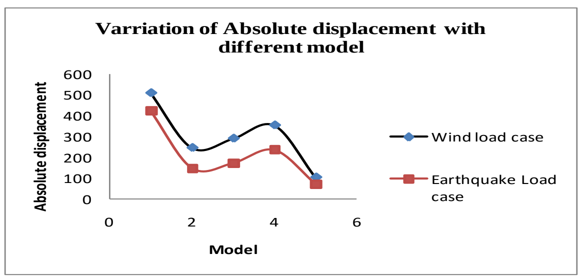


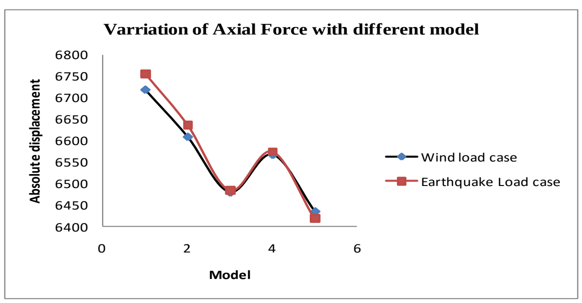


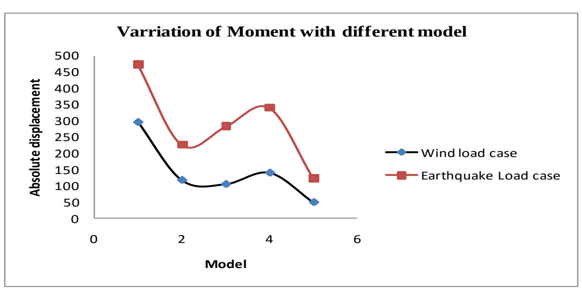

Varriation of FL V/S Axial Force in wind load case
Fx
FL
MODEL 1
MODEL 2
MODEL 3
MODEL 4
MODEL 5


Varriation of FL V/S Axial Force in Earthquake load case
Fx
FL
model 1
model 2
model 3
model 4
model 5


Varriation of FL v/s moment in wind load case
moment
FL
model 1
model 2
model 3
model 4
model 5


Varriation of Absolute displacement with different model
Absolute displacement
Model
Wind load case
Earthquake Load case


Varriation of Axial Force with different model
Absolute displacement
Model
Wind load case
Earthquake Load case


Varriation of Moment with different model
Absolute displacement
Model
Wind load case
Earthquake Load case

5. OBSERVATIONS & CONCLUSIONS

- From the results of this work the following conclusions can be made:
- The base shear in Model-V is maximum as compared to other frames whereas moment frame (Model-I) shows least among all.
- The Absolute displacement in moment frame (Model-I) is the greatest among all lateral load resisting systems investigated. Amongst the Absolute displacement in dual frames, Model V is the least while other frames have higher values in earthquake and wind load case..
- In earthquake and wind load cases value of axial force is greatest in Model-I as compared to other model and minimum in Model-V.
- Model-I (Moment frame) shows maximum base moment as compared to other model.
- In case of dual systems, model-V shows least value of base moments.
- If all the parameters are taken into consideration to choose a safe, laterally stiff and economical frame then, model- V of dual system is the most efficient solution. Means Shear wall combining with column is best appropriate system.
- Absolute displacement, axial force, base moment in wind load case is lesser than earthquake load case.

Story-wise Absolute displacement,Axial Force and bending Moment in Wind Load case															
	Model-1			Model-2			Model-3			Model-4			Model-5		
Floor Level	Abs Displacement in mm	Axial Force	B.M	Displacement in	Axial Force	B.M	Displacement in	Axial Force	B.M	Displacement i	Axial Force	B.M	Displacement i	Axial Force	B.M
0	16.125	6719.959	38.425	4.172	6609.413	4.388	4.158	6479.87	2.89	4.566	6567.238	3.817	3.968	6435.936	1.538
1	68.073	6501.33	-246.118	11.606	6391.253	-12.945	12.028	6262.156	-20.706	14.693	6349.352	-37.079	10.718	6218.406	-5.984
2	109.866	6072.192	-294.827	19.461	5963.93	-40.406	21.095	5836.193	-58.345	27.659	5922.647	-93.561	17.08	5792.674	-15.564
3	149.001	5644.988	-278.568	27.856	5538.931	-51.449	31.466	5413.595	-74.361	43.041	5498.237	-113.725	23.089	5370.71	-20.809
4	185.98	5219.128	-264.721	36.767	5115.883	-60.927	42.854	4994.139	-86.454	59.98	5076.154	-127.443	28.757	4952.225	-25.447
5	220.681	4794.564	-249.177	46.113	4694.899	-68.413	54.949	4577.84	-95.199	77.8	4656.465	-135.859	34.096	4537.292	-29.624
6	252.975	4371.188	-232.635	55.777	4275.969	-74.172	67.417	4164.721	-100.809	95.911	4239.216	-139.651	39.111	4125.917	-33.235
7	282.754	3948.898	-215.26	65.632	3859.044	-78.412	79.973	3754.685	-103.991	113.848	3824.36	-139.974	43.805	3718.014	-36.37
8	309.914	3527.586	-197.073	75.553	3444.038	-81.326	92.371	3347.601	-105.125	131.244	3411.812	-137.525	48.176	3313.44	-39.024
9	334.357	3107.148	-178.109	85.427	3030.834	-83.103	104.417	2943.289	-104.655	147.826	3001.445	-133.006	52.226	2912.012	-41.239
10	356.005	2687.479	-158.518	95.156	2619.292	-83.943	115.964	2541.523	-102.945	163.399	2593.094	-127	55.952	2513.482	-43.035
11	374.786	2268.479	-138.375	104.665	2209.251	-84.03	126.915	2142.073	-100.375	177.845	2186.582	-120.067	59.353	2117.611	-44.471
12	390.629	1850.05	-117.649	113.896	1800.546	-83.537	137.21	1744.629	-97.233	191.113	1781.674	-112.682	62.43	1724.036	-45.526
13	403.463	1432.102	-96.37	122.813	1393.001	-82.62	146.85	1348.997	-93.985	203.229	1378.202	-105.455	65.187	1332.568	-46.354
14	413.225	1014.566	-74.588	131.391	986.455	-81.353	155.85	954.689	-90.645	214.273	975.816	-98.698	67.623	942.622	-46.743
15	419.875	597.266	-52.308	139.65	580.596	-80.004	164.344	561.515	-88.052	224.466	574.263	-93.368	69.762	554.049	-47.065
16	423.598	181.236	-32.604	147.361	177.21	-81.586	172.177	171.644	-90.13	233.616	175.342	-92.784	71.538	169.17	-49.665

Story-wise Absolute displacement,Axial Force and bending Moment in Earthquake Load Case															
	Model-1			Model-2			Model-3			Model-4			Model-5		
Floor Level	Abs Displacement in mm	Axial Force	B.M	Displacement in	Axial Force	B.M	Displacement in	Axial Force	B.M	Displacement i	Axial Force	B.M	Displacement i	Axial Force	B.M
0	12.67	6755.386	-102.603	4.256	6636.104	-14.41	4.326	6484.743	-19.086	4.812	6574.3	-25.43	3.973	6418.065	-5.009
1	54.646	6481.975	355.16	12.513	6363.162	41.535	13.564	6212.076	57.034	16.606	6301.768	82.356	10.79	6145.698	17.108
2	94.463	6057.803	470.422	22.301	5939.959	110.693	25.737	5790.841	158.121	33.012	5880.188	218.571	17.402	5725.039	42.481
3	134.033	5634.548	461.984	33.895	5518.479	138.107	40.931	5372.667	196.014	53.597	5460.819	263.111	23.924	5308.107	55.54
4	173.542	5211.884	464.25	47.162	5098.416	162.988	58.531	4957.303	227.328	77.154	5043.359	297.17	30.412	4894.554	67.399
5	212.801	4789.845	461.079	61.871	4679.927	183.066	77.958	4544.782	251.075	102.736	4627.895	320.41	36.901	4484.452	77.926
6	251.514	4368.382	454.16	77.742	4263.048	198.803	98.631	4135.128	267.217	129.51	4214.436	333.743	43.406	4077.772	86.998
7	289.328	3947.457	442.748	94.486	3847.779	210.476	120.038	3728.266	277.187	156.782	3802.948	339.104	49.923	3674.418	94.707
8	325.842	3527.021	426.302	111.816	3434.082	218.422	141.717	3324.085	281.521	183.95	3393.356	337.442	56.434	3274.239	101.065
9	360.604	3107.021	404.257	129.466	3021.888	222.995	163.268	2922.429	281.041	210.502	2985.552	329.809	62.912	2877.047	106.146
10	393.114	2687.402	376.057	147.194	2611.103	224.594	184.349	2523.096	276.413	236.003	2579.392	317.077	69.323	2482.594	109.991
11	422.825	2268.104	341.153	164.79	2201.615	223.626	204.681	2125.881	268.479	260.097	2174.726	300.239	75.632	2090.644	112.74
12	449.143	1849.071	299.013	182.076	1793.304	220.533	224.056	1730.499	257.984	282.521	1771.35	280.388	81.799	1700.848	114.377
13	471.432	1430.25	249.115	198.907	1386.039	215.714	242.356	1336.776	246.32	303.127	1369.119	259.057	87.798	1313.019	115.301
14	489.028	1011.602	191.28	215.169	979.698	209.427	259.528	944.261	233.789	321.902	967.738	237.739	93.591	926.614	115.085
15	501.355	593.055	125.107	230.852	574.05	202.532	275.762	552.758	222.952	339.09	566.96	219.564	99.203	541.448	114.37
16	508.599	175.181	67.741	245.16	170.504	204.942	290.461	164.333	228.975	353.976	168.53	213.046	104.271	159.879	121.414

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