International Journal of Scientific Research in Civil Engineering
© 2022 | IJSRCE | Volume 6 | Issue 1 | ISSN : 2456-6667

Analysis of a High-Rise Structure Considering Shear Walls of different Materials with different Positioning using ETABS

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ABSTRACT

Article Info
Publication Issue :
Volume 6, Issue 1
January-February-2022
Page Number :
26-37
Article History
Accepted : 20 Jan 2022
Published : 27 Jan 2022

Shear walls are the structural systems which counteracts the effect of lateral loads such as wind and earthquake loads acting on a structure. They are usually provided as an encasement for the elevator cores, stairwells etc., thereby resisting the horizontal and vertical forces effectively.
In the present study, analysis of RCC building has been carried out by changing the locations of shear walls in the building. Also, the effect of variations in seismic zones as per IS codes has been presented.
The seismic analysis performed is linear dynamic response spectrum analysis using the well known analysis and design software ETABS16.2.0. Seismic performance of the building has been investigated based on parameters such as storey drift, base shear and storey displacements.
The research is based towards comparative analysis of shear wall in a structural design and its placement in three different location with shear wall made of three different material namely concrete, RCC and steel shear walls.
Keywords: ETABS, Asymmetric building, Shear walls, Response spectrum, seismic zones.

I. INTRODUCTION

Tremor is a type of calamity which happens because of Natural or Man-made mistakes bringing about outrageous harms to human progress and any type of design made by us. Late illustration of a particularly tragic tremor was found in our adjoining nation Nepal, bringing about huge obliteration to the whole nation annihilating its economy and putting a mishap of over 10 years. It was a particularly surprising calamity, that it is amazingly essential for endurance to guarantee the strength of the constructions against seismic powers. Along these lines, there is relentless exploration work going on around the world, pivoting around the headway of new and better techniques that can be combined in structures for better seismic execution. Constructions planned considering excellent strategies to oppose such powers and seismic powers have an extensively greater expense of improvement than common designs, yet for flourishing against strain on the construction under seismic powers, it is essential.

In this study we are analysing nine different cases of a tall structure G+10 considering shear wall at different positions with three different materials of shear wall namely concrete, RCC and Steel as shear wall structure considering P-delta analysis as per I.S. 1893-I:2002. An Earthquake can be characterized as vibration on the earth surface because of unexpected arrival of energy from the Earth center bringing about arrangement of seismic waves. Fierce seismic powers are adequately fit to annihilate whole metropolitan networks and cause enormous misfortune to life and property. The seismicity implies the size, type and repeat of tremors experienced throughout some time interval.

Seismometers are utilized to gauge the tremors. Quakes less than extent 5 revealed by public seismological observatories are estimated commonly on the nearby size scale, otherwise called the Richter greatness scale where-as the second size scale is generally utilized for tremors bigger than 5 are accounted for on the planet.

These two scales are mathematically similar to their extent of authenticity. Seismic powers of Magnitude 3 or lower are for the most part inconspicuous or delicate and of degree at least 7 possibly cause outrageous damage over enormous domains/regions. The seismic tremors of degree of more than 9 are incredibly cruel, despite the fact that there is no limitation to the possible size. Changed Mercalli scale is used to measure the Intensity of shaking of the ground.

II. SHEAR WALL

It is reinforced cement consistent vertical divider can convey parallel just as gravity loads. Its quality and firmness extremely high make them appropriate for a tall structure, for the most part, the developed centre of the structure is quite efficient. It tends to be developed into 35 stories. These dividers start from the establishment level and are constant all through the structure stature. Its thickness can be 150mm to 400mm in elevated structures. Shear dividers are typically given along both the length and width of structures as appeared in figure 1.3. Shear dividers resemble vertically-arranged wide bars that convey seismic tremor loads downwards to the establishment.

Appropriately structured and comprehensive structures with shear walls have demonstrated generally excellent execution during quakes. Shear dividers give huge quality and firmness to structures toward their direction, which essentially diminishes parallel removal of the structure and in this way lessens harm to the structure and its substance. Since shear dividers convey enormous level seismic tremor powers, the upsetting impacts on them are huge. Be that as it may, on the off chance that they are given along just a single heading, a legitimate framework of bars and sections in the vertical plane (called a minute safe edge) must be given along the other course to oppose solid earthquake impacts.

Figure 1 : Example of RCC Shear Wall

III. LITERATURE REVIEW

Karnati Vijetha and Dr. B. Panduranga Rao (2019) in the exploration work, G+15 multi Story building was investigated by utilizing shear divider and propped outline at external the vast majority of the construction and Comparison with multistoried design with main role to analyze the seismic reaction of the design. For straight versatile investigation, RC plane edges with and without shear divider were broke down and intended for gravity stacks according to IS 456:2000 and sidelong loads (tremor loads) according to IS 1893 (section 1):2002.

The outcomes presumed that presenting shear dividers diminishes the influence or uprooting. Giving shear dividers at satisfactory areas considerably diminishes the removals because of seismic tremor. Base Shear of Mentioned Structures Heavily Increases and makes the Structure stable against seismic stacking. The Natural time of the planned Structures are exceptionally decreased in the wake of putting of bracings and Shear dividers with correlation with Normal construction. The sidelong powers are opposing limit is profoundly expanded after the arrangement of Shear divider.

When looking at the above Structures Lateral removals are negligible when Shear divider and results esteems expressed Shear divider could improve the parallel Stability of the constructions.

Ambreshwar et. Al. (2018) the task considered 5x5 straight arrangement with G+14 story stature of working to be built in zone III by giving shear dividers of uniform thickness (200mm) in different areas of structures. "Direct comparable static technique" examination of the structure was finished utilizing ETABs 2015. In the examination, fundamental center was to decide the answer for shear divider area in multi story building. Adequacy of shear divider was researched thinking about five unique models. Model - I is exposed edge underlying framework and other four models are double sort primary framework. A tremor load was applied to a structure of 15 stories situated in zone III. The structure go about as an upward cantilever as discrete organizer dividers.

The outcomes expressed that the ideal area of shear divider is found toward the sides of the structure. Arrangement of Shear divider in the construction lessens the horizontal story relocations in the structure contrasted with Bare edge. Story float of the structure with the Shear dividers is found inside as far as possible, the story float is more in the center stories contrasted and the base and continuously lessens up to the highest point of the structure. The story shear of the design shifts with the arrangement of Shear dividers in structure, the Story Shear is most extreme in the base stories since it is fixed at the base and henceforth steadily diminishes at the above stories. Base shear of the construction with Shear dividers is discovered to be more contrasted with Bare casing. The arrangement of Shear divider diminishes the time-frame nearly with Bare edge in examination. Giving Shear divider expands the seismic exhibition of the constructions and the area of shear divider influences different primary boundaries like mass, firmness lattices.

Sylviya B and P. Eswaramoorthi (2018) the exploration paper introduced investigation of RCC working by changing the areas of shear dividers in the structure. Additionally, the impact of varieties in seismic zones according to IS codes has been introduced. The seismic investigation performed is straight unique reaction range examination utilizing the notable investigation and plan programming ETABS16.2.0. Seismic execution of the structure has been explored dependent on boundaries, for example, story float, base shear and story relocations.

Results expressed that the underlying dividers ought to be given all through the stature of structures for best quake execution. Setting the underlying dividers towards the focal point of the structure permits adaptability for structures to go through twist as the primary method of wavering, which isn't alluring. It was broke down that underlying dividers are best when set at the fringe of the structure. Zone factor of a specific area assumes a significant part in the conduct of a structure. Hazard of harm for structures of higher seismic zone is more thus, embracing unique second opposing casings are profoundly important. The story floats and removals are discovered to be more in Seismic Zone V structure contrasted with different zones. It was seen that the upsides of story shears are discovered to be expanding in higher seismic zones

OBJECTIVES

Objective of this research is to study the effect of different types of shear wall in three different location on the seismic Zone II, modelling of G+10 storeys RCC frame building is analysed using ETABS software.

- To study the Optimum location of shear wall having uniform thickness throughout the building.
- Comparison of different shear walls namely concrete, RCC and Steel shear wall.
- To study the storey shear for different location of shear wall.

IV. METHODOLOGY

General steps required for analysis and design of the multi-storey RCC building is given below:-

Step-1 Modelling of building frames

An RCC Structure is mainly an assembly of Beams, Columns, Slabs and foundation inter connected to each other as a single unit. Generally the transfer of load in these structures is from slab to beam, from beam to column and finally column to foundation which in turn transfers the entire load to the soil. Models selected for the study are as follows:

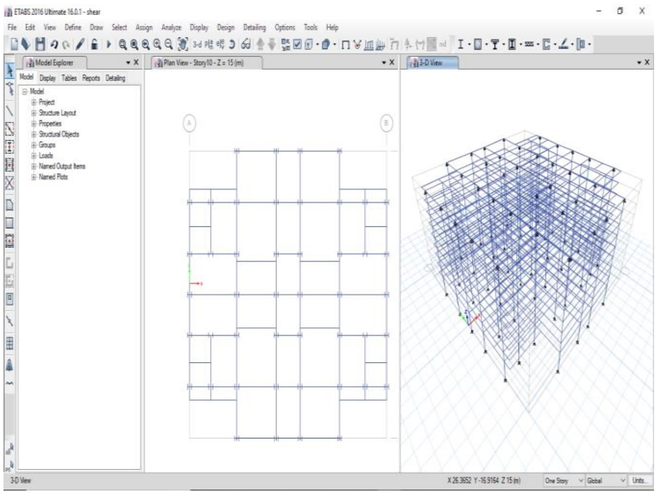


Fig 2 : Plan View

Case I Shear walls at the outer sides

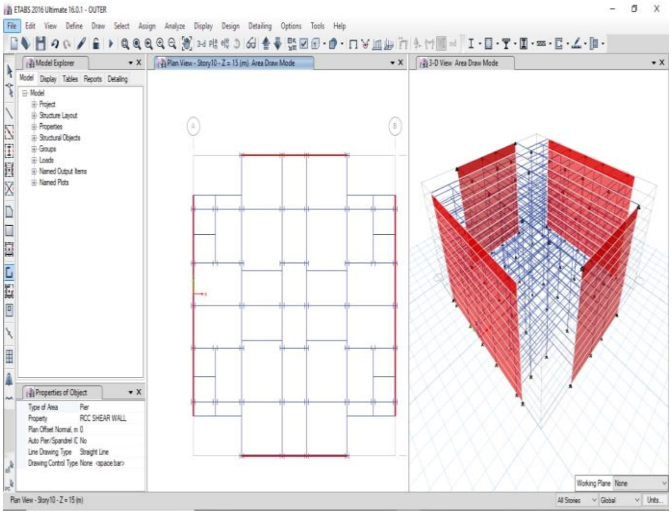
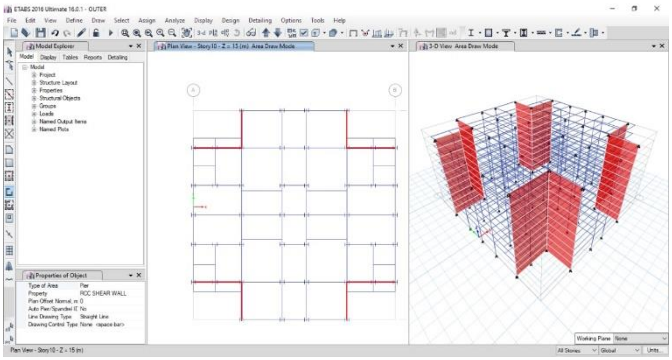
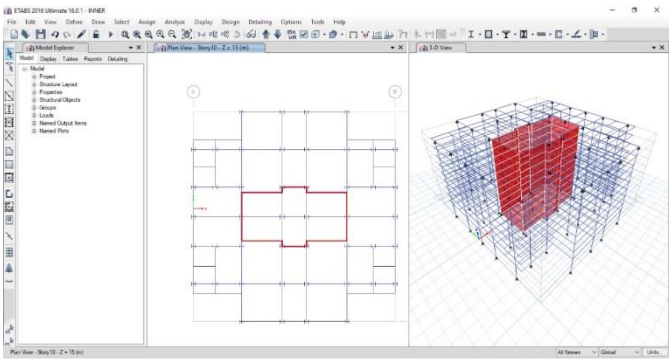


Figure 3.1 Flow Chart showing process of analysis and design of structure

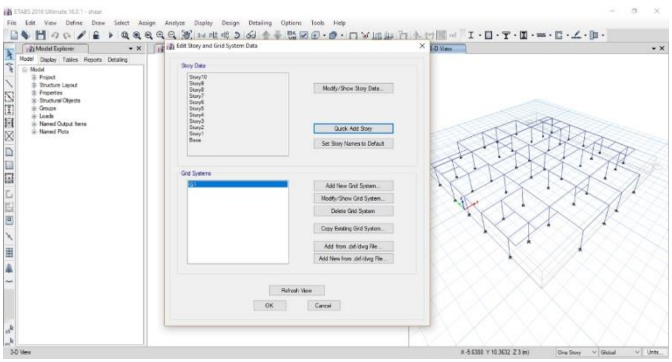
Case II Shear walls at the Corners



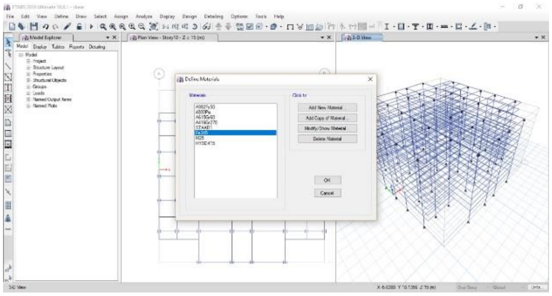
Case III Shear walls at the center



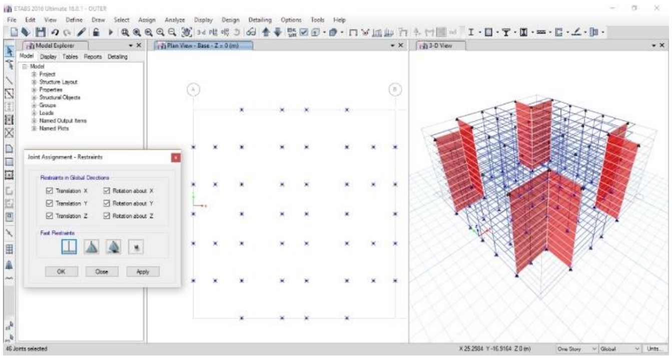
Step 2 Assigning Storey and Grid system Data



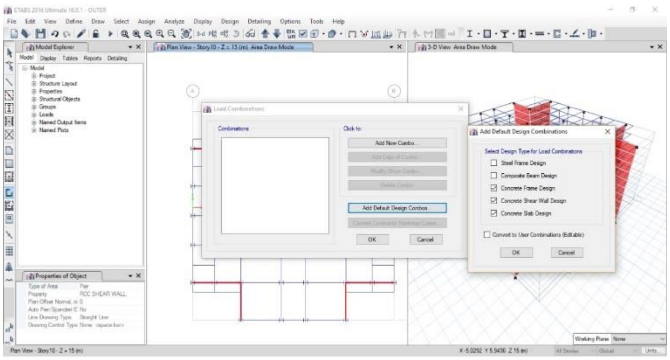
Step-3 This step included assigning Materials to the model



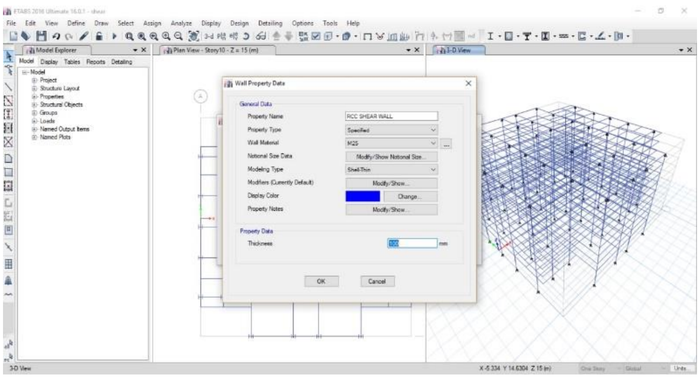
Step-4 Assigning Joint assignments as fixed support to all the models



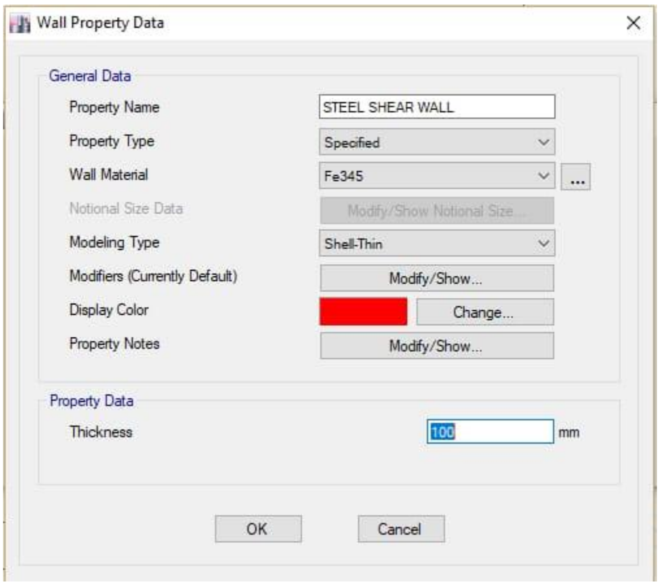
Step-5 Defining Shear wall Property



RCC Shear Wall

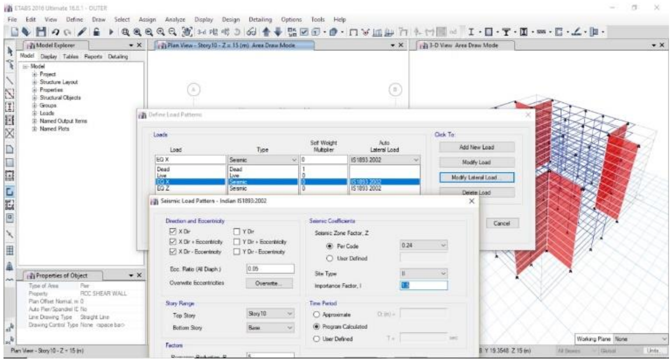


Steel Shear Wall

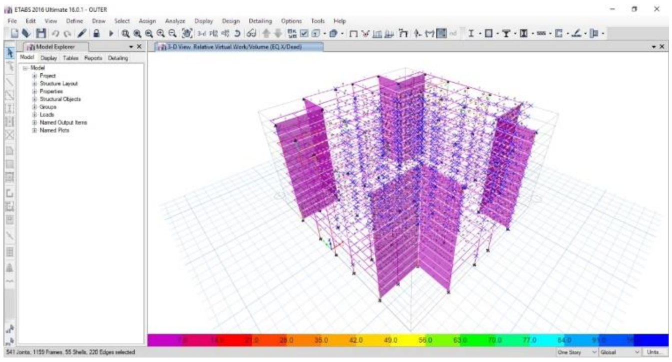


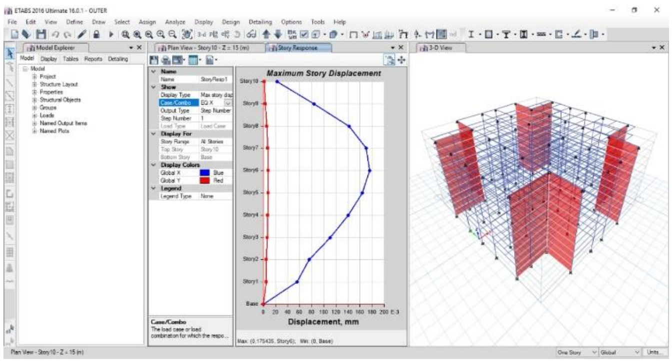
Step 6- Application of Loads

For the analysis of the structure all the load conditions to the structure are applied. The values of the design loads are calculated as per IS-875 Part I and II and IS-1893 part I 2016. Dead loads shall be calculated on the basis of unit weights of materials given in IS 875 (Part I) which shall be established taking into consideration the materials specified for construction. The distribution of dead load is shown in figure above. Imposed load is defined as the load that is applied to the structure that is not permanent and can be variable and shall be assumed in accordance with IS 87S (Part II).



Step-7 Results developed from the analysis





Step-8 Comparative studies of results in terms of displacement, moment, shear force and storey displacement.

Table 1 : Description of geometrical data

S. No.	Building Description	
1.	Plan Area	400 m^2
2.	X-Y Direction Grid Spacing	4m x 4m
3.	Storey Height	3.2 m
4.	Number of storey	G+10
5.	Beam Dimension	300mm x 400mm
6.	Column Dimension	400mm x 400mm
7.	Slab Thickness	150mm

8.	Thickness of shear wall	200mm
9.	Bottom Support Condition	Fixed
10.	Seismic Zone	II
12.	Zone Factor	0.10
13.	Soil Type	Soft
14.	Importance Factor	1.5
15.	Response Reduction Factor	5
16.	Eccentricity Ratio	0.05

V. ANALYSIS RESULTS

Max. Storey Displacement:

	Concrete Block			**RCC**			**Steel**		
Storey	**corner**	**side**	**inner**	**corner**	**side**	**inner**	**corner**	**side**	**inner**
Storey10	25.816	25.239	21.24	9.959	8.949	7.738	20.2	15.8	19.8
Storey9	24.713	24.155	20.179	8.884	7.938	7.227	17.7	13.6	17.4
Storey8	22.966	22.437	18.682	7.7	6.838	6.484	15.2	11.4	15
Storey7	20.701	20.213	16.737	6.476	5.715	5.605	12.6	9.3	12.4
Storey6	18.05	17.613	14.407	5.243	4.597	4.667	10.1	7.3	10
Storey5	15.126	14.75	11.786	4.036	3.516	3.725	7.7	5.4	7.6
Storey4	12.029	11.721	8.98	2.897	2.507	2.819	5.4	3.8	5.3
Storey3	8.841	8.606	6.115	1.87	1.608	1.974	3.4	2.3	3.3
Storey2	5.63	5.473	3.373	1.007	0.858	1.202	1.7	1.2	1.7
Storey1	2.478	2.399	1.092	0.356	0.301	0.509	0.5	0.4	0.5
Base	0	0	0	0	0	0	0	0	0

Maximum Storey Drift in mm

Maximum Storey Drift in mm									
	Concrete Block			RCC			Steel		
Storey	**corner**	**side**	**inner**	**corner**	**side**	**inner**	**corner**	**side**	**inner**
Storey10	0.00045	0.00036	0.00039	0.00048	0.00035	0.00037	0.000362	0.00039	0.00036
Storey9	0.0005	0.00039	0.0004	0.00051	0.00037	0.0004	0.000573	0.0006	0.00038
Storey8	0.00053	0.00039	0.00041	0.00053	0.00037	0.00041	0.000741	0.00076	0.00039
Storey7	0.00053	0.00039	0.00041	0.00054	0.00037	0.00041	0.000867	0.00089	0.0004
Storey6	0.00055	0.00041	0.00041	0.00053	0.00036	0.00041	0.000954	0.00098	0.0004
Storey5	0.00052	0.00035	0.00041	0.0005	0.00034	0.00042	0.00101	0.00104	0.00041
Storey4	0.00048	0.0009	0.00033	0.00046	0.0003	0.00034	0.001038	0.00107	0.00036
Storey3	0.00021	0.00029	0.00029	0.00039	0.00025	0.00029	0.001045	0.00107	0.00029
Storey2	0.00037	0.00023	0.00023	0.0003	0.00019	0.00022	0.001025	0.00105	0.00023
Storey1	0.00023	0.00021	0.00021	0.00016	0.0001	0.00012	0.0008	0.00086	0.00017
Base	0	0	0	0	0	0	0	0	0

Storey Shear (kN)										
		Concrete Block			RCC			Steel		
Storey	**Location**	**corner**	**side**	**inner**	**corner**	**side**	**inner**	**corner**	**side**	**inner**
Storey10	Top	1381.117	1390.79	1243.65	1216.117	1280.79	1206.65	348.432	381.77	330.241
	Bottom	1381.117	1390.79	1243.65	1216.117	1280.79	1206.65	348.432	381.77	330.241
Storey9	Top	2900.446	2999.65	2570.34	2428.446	2594.65	2436.34	655.902	740.816	609.864
	Bottom	2990.446	2999.65	2570.34	2428.446	2594.65	2436.34	655.902	740.816	609.864
Storey8	Top	3789.336	3871.77	3760.94	3386.336	3632.77	3407.94	898.841	1024.51	830.8
	Bottom	3789.336	3871.77	3760.94	3386.336	3632.77	3407.94	898.841	1024.51	830.8
Storey7	Top	4354.721	4861.58	4550.83	4119.721	4427.58	4151.83	1084.84	1241.71	999.954
	Bottom	4354.721	4861.58	4550.83	4119.721	4427.58	4151.83	1084.84	1241.71	999.954
Storey6	Top	4871.534	5201.52	4870.35	4658.534	5011.52	4698.35	1221.49	1401.28	1124.23

	Bottom	4871.534	5201.52	4870.35	4658.534	5011.52	4698.35	1221.49	1401.28	1124.23
Storey5	Top	5132.71	5543.03	5210.89	5032.71	5417.03	5077.89	1316.39	1512.1	1210.53
	Bottom	5132.71	5543.03	5210.89	5032.71	5417.03	5077.89	1316.39	1512.1	1210.53
Storey4	Top	5302.182	5776.56	5410.79	5272.182	5676.56	5320.79	1377.13	1583.02	1265.77
	Bottom	5302.182	5776.56	5410.79	5272.182	5676.56	5320.79	1377.13	1583.02	1265.77
Storey3	Top	5506.886	5922.54	5490.42	5406.886	5822.54	5457.42	1411.29	1622.92	1296.84
	Bottom	5506.886	5922.54	5490.42	5406.886	5822.54	5457.42	1411.29	1622.92	1296.84
Storey2	Top	5566.754	61010.4	5539.15	5466.754	5887.43	5518.15	1426.47	1640.65	1310.65
	Bottom	5566.754	6101.43	5539.15	5466.754	5887.43	5518.15	1426.47	1640.65	1310.65
Storey1	Top	5581.721	6261.65	5561.33	5481.721	5903.65	5533.33	1430.27	1645.08	1314.1
	Bottom	5581.721	6261.65	5561.33	5481.721	5903.65	5533.33	1430.27	1645.08	1314.1
Base	Top	0	0	0	0	0	0	0	0	0
	Bottom	0	0	0	0	0	0	0	0	0

Storey Stiffnes (kN-m)

Maximum Storey Stiffness in kN-m									
	Concrete Block			RCC			Steel		
Storey	corner	side	inner	corner	side	inner	corner	side	inner
Storey10	883141.3	1103760	1247656	329596.1	332595.01	647128.9	881041.3	1101660	1245556
Storey9	1606079	2070326	2375375	393139.1	419925.28	1020658	1603579	2067826	2372875
Storey8	2140929	2799567	3255895	421260.3	454527.3	1243490	2138608	2797246	3253574
Storey7	2572480	3387267	3986229	436274	472419.34	1435918	2568590	3383377	3982339
Storey6	2957917	3917437	4661121	446609.7	484843.07	1627437	2952517	3912037	4655721
Storey5	3368001	4485772	5396134	455624.9	495518.15	1839425	3360201	4477972	5388334
Storey4	3894161	5217674	6349711	465284.8	506519.87	2095096	3883161	5206674	6338711
Storey3	4696735	6340174	7813640	477508	519658.08	2426784	4682063	6325502	7798968
Storey2	6217107	8404844	10532860	496227.2	538402.52	2899211	6198207	8385944	10513960
Storey1	12256370	16074927	20235529	611972.5	651917.08	4352119	12227370	16045927	20206529
Base	0	0	0	0	0	0	0	0	0

Bending Moment (kN-m)

Bending Moment in kN-m									
	Concrete Block			RCC			Steel		
Storey	corner	side	inner	corner	side	inner	corner	side	inner
Storey10	1703.45	1590.32	1589.76	1092.4	1104.34	980.34	988.76	921.25	870.43
Storey9	1633.32	1504.21	1477	1028.55	1046.21	903.45	910.3	854.4	806.76
Storey8	1563.19	1418.1	1364.24	964.7	988.08	826.56	831.84	787.55	743.09
Storey7	1493.06	1331.99	1251.48	900.85	929.95	749.67	753.38	720.7	679.42

Storey6	1422.93	1245.88	1138.72	837	871.82	672.78	674.92	653.85	615.75
Storey5	1352.8	1159.77	1025.96	773.15	813.69	595.89	596.46	587	552.08
Storey4	1282.67	1073.66	913.2	709.3	755.56	519	518	520.15	488.41
Storey3	1212.54	987.55	800.44	645.45	697.43	442.11	439.54	453.3	424.74
Storey2	1142.41	901.44	687.68	581.6	639.3	365.22	361.08	386.45	361.07
Storey1	1072.28	815.33	574.92	517.75	581.17	288.33	282.62	319.6	297.4
Base	0	0	0	0	0	0	0	0	0

Cost Optimization

Concrete Block						
S.no.	**concrete volume in cu.m**	**S.O.R rates**	**Total cost of concrete**	**Rebar Volume in kg**	**S.O.R rates**	**Total cost of Rebar**
Corner	915	4200	3843000	8200	60.5	496100
Inner	912.4	4200	3832080	8009.3	60.5	484562.7
Side	920	4200	3864000	8103.4	60.5	490255.7

R.C.C. Wall						
S.no.	**concrete volume in cu.m**	**S.O.R rates**	**Total cost of concrete**	**Rebar Volume in kg**	**S.O.R rates**	**Total cost of Rebar**
Corner	892.2	4200	3747240	7800.5	60.5	471930.3
Inner	878.21	4200	3688482	7190.64	60.5	435033.7
Side	894.5	4200	3756900	8050.78	60.5	487072.2

Steel Wall						
S.no.	**concrete volume in cu.m**	**S.O.R rates**	**Total cost of concrete**	**Rebar Volume in kg**	**S.O.R rates**	**Total cost of Rebar**
Corner	820.65	4200	3446730	7600.76	60.5	459846
Inner	780	4200	3276000	7005.75	60.5	423847.9
Side	824.6	4200	3463320	785.65	60.5	47531.83

VI. CONCLUSION

The entire research was focused towards analyzing nine models. Objective of the research was to study the effect of different types of shear wall in three different location on the seismic Zone II, modelling of G+10 storeys RCC frame building is analysed using ETABS software. The concrete, RCC and steel frame models were analysed and compared for various parameters through linear static analysis method considering seismic effect.

- It has been observed that the values of storey displacement was maximum in concrete block shear wall in comparison to RCC shear wall and steel plate shear wall and in terms of position inner edge is reflecting more stability.

- Storey stiffnes was maximum in concrete block shear wall and steel plate shear wall in comparison to RCC shear wall as the model proved to be more stable in comparison to other models.
- When compared all nine models for the best location in the building, the steel plate shear wall (SPSW) provided at the middle (tubular form) and corner of the building has been found the best.
- It has been concluded that steel plate shear wall system is comparatively more suitable than concrete block and RCC shear wall in a building.
- Story displacements are generally reduced by the provision of shear wall the reason behind this is the shear wall increases the stiffness and lateral strength of the structure. In this study it has been observed that structure with shear wall at close loop is more stable than other structure whereas conventional structure is resulting as the worst. There has been a variation of 15.3% is observed.
- In terms of storey shear all the structure except conventional are in permissible limit, but in comparison structure with close loop shear wall results in minimum displacement in two consecutive floors which results as most stable structure.
- It was found that seismic base shear values are much varied by the addition of shear walls since the seismic weight increases and conventional structure have maximum storey shear value compared to the other models due to absence of shear wall.
- In terms of moment it can be said that steel wall is resulting in more stable and less moment is observed where as concrete block wall is resulting in worts case. In terms of position inner edge is resulting in most suitable type whereas side position is resulting worst.
- In terms of optimization of section it can be said that steel wall structure is economical and most suitable type.

VII. SUMMARY

In comparative study it can be said that structure with shear wall at close loop can be consider as the most stable structure whereas conventional structure can be said as worst case in analysis.

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Cite this article as :

Vishek Bisen, Pradeep Ku. Nirmal, Lokesh Singh, "Analysis of a High-Rise Structure Considering Shear Walls of different Materials with different Positioning using ETABS", International Journal of Scientific Research in Civil Engineering (IJSRCE), ISSN : 2456-6667, Volume 6 Issue 1, pp. 26-37, January-February 2022.

URL : https://ijsrce.com/IJSRCE22614