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A Comprehensive Study of Dynamic Response of High-Rise Buildings Under the Influence of Shear Walls

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ABSTRACT- Buildings undergo a lot of vibrations at the time of earthquakes or strong winds acting upon it. These vibrations make the building more prone to damages and create a sort of fear psychosis among the people residing in it. Thus, buildings need to be first analyzed for these vibrations, so as to design the building in such a way that its vibrations produced are minimized to a large extend, thereby eliminating the fear psychosis of people and making the building safer. High rise buildings undergo much more vibrations and lateral drifts as compared to low height buildings. Thus tall buildings are provided with shear walls to counteract and minimize the effect of lateral loads acting on the structure. The properties of these seismic shear walls dominate the response of the buildings, and therefore, it is important to evaluate the seismic response of the walls appropriately.

In this present study, main focus is to determine the solution for shear wall location in high rise building and to cater the vibrations of the buildings produced due to lateral loading acting on the floors. In this project dynamic behavior of the building is to be studied carefully, so as to reduce the lateral drifts produced in the building and thus making the building resistant to the lateral loads. STAAD-Pro V8i software will be used to perform all the parametric study analysis of these lateral loads upon the structure. Complicated and high-rise structures need very time taking and cumbersome calculations using conventional manual methods. STAAD-Pro provides us a fast, efficient, easy to use and accurate platform for analysing and designing structure. In this study different models were studied on the basis of different positions of shear walls, out of which model 4 (with lift core wall and shear wall at corners) showed better performance in regarding all the parameters of study which included storey drifts, base shear, frequency and axial forces. Two methods were taken for the analysis out of which response spectrum method showed better and precise results.

KEYWORDS- Shear Wall, Lift Core Wall, Storey Drift, Base Shear, High Rise Building, Lateral Drift, Staad-Pro V8i.

I. INTRODUCTION

The primary goal of structural analysis is to learn how a structure responds to a given stimulus. This may be due to the weight of people or objects, the force of the wind or snow, or the accumulation of snow and ice, or it may be the result of an earthquake or the trembling of the ground as a result of a close hit. Because of the world's increasing population, more sophisticated methods of erecting tall structures have become indispensable; nonetheless, such structures are especially vulnerable to seismic damage and collapse in the contemporary day. Shear wall constructions have been shown to be the most effective in the field for this application. These structures function effectively under both static and dynamic loads. It is clear that many well-designed structures have been damaged by earlier earthquakes. Therefore, it is necessary to assess and analyses the structures for seismic loads. A building may be analyzed in several ways, some of which include a comparison of static and dynamic approaches. The level of excitement and how often these tests are performed distinguish between them. Determining dynamic relocation, looking at the building's temporal history, and doing a modular analysis are all components of a dynamic analysis.

- Buildings should be safe during even moderate earthquakes (DBE).
- Buildings should be resistant to direct seismic shocks (DBE) without major structural damage but with some non-basic damage.
- Buildings must be able to withstand moderate to severe seismic events (MCE) without collapsing.

For the purposes of this paper, the term "Design Basis Earthquake" (DBE) will be used to refer to the strongest earthquakes that may be reasonably expected to hit the site at least once over the lifespan of the building. Although the earthquakes cannot be prevented or anticipated, making buildings more vulnerable to destruction, the magnitude and other factors may be estimated with high accuracy. The buildings may be made in a way that ensures the residents' safety and aids in reducing the amount of damage and injury that occurs. In order to mitigate these consequences as much as possible, it is essential to use appropriate techniques while doing structural analysis. The most relevant outcomes have been seen to be derived from the Response Spectrum approach and the Static Pushover analysis. Linear elastic approaches are insufficient for assessing the potential seismic damage to a building over the course of its estimated lifespan.

For both regular and irregular structures, as described by IS-1893-Part-1-2000 in clause 7.8.1, dynamic analytical methods are used to determine the planned seismic power and its distribution along the building's height to various levels and to the various parallel lateral load resisting parts.

A. Advantages of Shear Wall

In general, shear walls provide the following benefits
One other benefit is improved water drainage. Water seepage through exterior walls is a common defect sought by mortgage holders. The findings as a whole also showed that the most common cause of water leakage via exterior walls is the use of single layer block partitions. The majority of the leaking water was caused by cracks in the put block partitions. The residents can't stand it if water seeps in through the outside walls.

II. LITERATURE REVIEW

- First, in the work by **Dinesh J. Sabu and Dr. P.S. Pajgade [1]-** This study presents the results of a seismic analysis performed on an existing reinforced concrete structure It was compared against three different modelling formats (bare frame, brick infill frame, and infill + soil effect interaction model) to see how much of an impact the additional support had.
- Wakchaure M.R. presented the findings of his study of the G+9 building, which he had modelled and evaluated using **ETABS. also Ped S. P [2]-**Here, we compare and contrast all of the models by utilizing the identical input parameters (base shear, story displacement, and story drift). It was discovered that the presence of infill walls reduced displacement, shortened the time period, and increased the base shear. Brick work infill must be taken into consideration for an accurate evaluation of a moment-resistant reinforced concrete frame under seismic loading.
- This research, conducted by Srikanth B. and Ramesh V.[3]-, focuses on the two approaches to assessing the earthquake resilience of multi-story buildings. Base shear, lateral force, and Floor moments were the variables examined. This research concludes that the Response Spectrum Method should be relied on even in symmetric multi-story buildings.
- Focusing on the impact of different shear wall designs on tall buildings, **Drs. B. Kameshwari and G. Elangovan [4]-**wrote a article. Five models were chosen, each with a different arrangement of shear walls, and the drift and inter-story drift of the structure was evaluated and compared to that of a bare frame. Based on the results of this research, it was determined that a zigzag shear wall layout is superior to others in dampening the effects of an earthquake.
- A multi-story RC building in Khartoum city was analyzed for its seismic stability by **Hassaballa E., Adam F. M., et al [5]-**In this research, the response spectrum approach was used to analyze the frame and calculate the seismic deformations and stresses. The results demonstrated unequivocally that the node displacements steered off course by a factor of two to three times the typical deviations. Maximum compressive and tensile stresses in columns were about the same, while bending moments in columns and beams due to seismic excitation notably exhibited high values compared to those due to static loads.
- **Maske. A. A, Maske.N.A. et al [6]-**In this research, we use the widely available software SAP2000 to conduct a push over analysis on multi-story frame buildings. Two adjacent buildings, one with five stories and the other with twelve, were used separately to reach this goal. The results obtained show that a properly-designed frame.
- **Mantha.V.,sanghaiS.S [7]-**In this study, we use the much less complicated Static method to investigate the ability of a SAP 2000-programmed, G+17-story building to withstand seismic tremor powers.
- **Dr.Dubey s.k Sangamnerkarp et al [8]-**In this research, STAAD-Pro was used to simulate a multi-story irregular structure (G+19) in India's seismic zone-4. Building dynamics during the 2002 Alaskan earthquake, DELINA (ALASKA), were studied for this article. In this article, we'll examine the similarities and differences between the Time History Method and the Response Spectrum Method.
- **Imam Usman Shekh, UdaysinhRedekar et al [9]-** used IS Code Methods and Software's to do an in-depth structural study, design, and estimate for a G+7 story building. Using staad.pro software, the outline idea has been taken according to the IS standards, and the slab, beam, column, rectangle footing, and staircase have all been designed using the limit state approach, which is safe at control of deflection and in all perspectives. The strategy can't fail under any circumstance. The areas of the beam, column, footing, and slab needed by AST are substantially identical to the requirement based on comparison with the drawing, manual design, and geometrical model made in staad.pro.
- **Pradeep. p. S, Dr. Elavenil.S [10]-**The purpose of this article is to analyze the representation of various plan irregularities during seismic events. The main purpose of this investigation is to analyze tall buildings using STAAD. Time period, natural frequency, deformations, displacements, and floor responses have all been determined after a dynamic analysis was performed using a + shaped model. According to IS 1893(Part-I) - 2002, the research takes into account the joint effort of 90% of the building mass in each major horizontal direction of response via the use of a full Quadratic Combination (CQC).
- **Thomas J. Dr. Patel R [11]-**The goal of this project is to determine where the shear wall should be placed and whether or not the construction should have one at all. This has led to the consideration of three distinct designs for a 10-story structure, including one without a shear wall, another with a shear wall, and yet a third that combines the two (i.e., internal and external part).

III. METHODOLOGY

A. Summary of Applicable Software

- STAAD-PROV8i STAAD-Pro, the commercial version, is one of the most widely used basic analysis and design programmers in the world. Numerous design codes are supported by this program me. Pro now has guide connections to these and other programmers. Design professionals all around the globe rely on STAAD Pro V8i for their unique analytical requirements. A user interface, visualization tools, and international design codes are all part of the solution it offers for finite element analysis and design. Any building that experiences a dynamic reaction, earthquake, wind load, or soil-structure interaction may be analyzed using this tool. A few benefits of doing this program me include:

- When it comes to making an accurate three-dimensional copy of the desired building or structure, STAAD-Pro V8i relies on the latest programming innovation. The whole new STAAD-Pro software comes with state-of-the-art graphical settings and over 70 universal outline codes in 7 different languages. The availability of a large variety of sophisticated structural analysis and design elements contributes to STAAD-Pro V8i's flexible demonstration condition.
- A wide range of design codes are available to users thanks to the incorporation of concrete and steel design into STAAD.Pro v8i software. This tool can easily determine the drift, deflection, and depth of any structure thanks to the wide availability of design codes. Concrete columns, beams, and shear walls may all have their reinforcement calculated using this tool.
- Interconnected and open design. Unlike competing structural design programs, STAAD.Pro may be modified to meet specific requirements. All the data and output capabilities for STAAD.Pro are already built in thanks to the open engineering used in its development; it is known as Open STAAD. The product also comes with a stockpile of often used structures including trusses, structures, matting, and so on that may be reconfigured as needed. The product's design may also be updated to provide new options[12]. Due to its status as an open-source engineering tool, you may link your model to Excel or Match CAD, ensuring that any updates made to your model will be reflected in Excel as well. An exciting feature of this product is the built-in VBA that gives you permission to create your own layouts and templates.
- CONTAINS All Features of Structural Engineering: The STAAD.Pro software suite provides the structural engineer with all the necessary building design tools in one convenient package. In a similar vein, the program takes into account the specifics of engineering bridges and pipelines.

IV. EVALUATION OF BUILDING

The building's floor plan is 12.5 by 19 meters, and it has three meters of vertical height. To be specific, this building is a G+9 standard building. The M30 grade of concrete and the Fe415 grade of steel were used for the beams and columns, respectively, throughout the whole construction

MODELLINGOFBUILDING

The modeling process included specifying member property specifications, as well as conditions of support and loading.

Member Property Specification and Support Condition

In the beginning, we gave the members their own properties. The construction was then given some props and held in place. The following loading conditions were used in the modeling.

A. Loading

1) Dead Load

As per IS 875(Part1)-1987 Dead load includes self-weight of columns, beams, slabs, brick walls, floor finish etc

- Dead load of 151mm thick slab
- Self-weight of slab = 1.00 x 1.00 x 0.15 x 25.0 = 3.75 kN/m2Brick wall loading(210mm)= 20.0x.21= 4.20kN/m2Totaldeadload on slab= 7.95 kN/m2
- Live Load According to Indian Standard 875-2 (1987)
- Live load for flooring = 4.0kN/m2 Live load for roof equals 0.50kN per square metre
- c) The burden of wind
- According to IS 875- 3 (1987)
- Standard wind speed: 39.00metres per second
- Topography factor K3: 1.0 Risk factor K1: 1.0 (design life of 50 years)
- Classification of the terrain as well as the buildings: 2 and A DESIGN WIND PRESSURE

Table 1: Wind Pressure Pz for different floors

Height (m)	Vb(m/s)	K1	K2	K3	Vz(m/s)	Windpressure Pz (N/m^2)
10.0	39	1.0	1	1	39	912.6
15.0	39	1.0	1.05	1	40.95	1006.1415
20.0	39	1.0	1.007	1	41.73	1044.83
30.0	39	1.0	1.012	1	43.68	1144.76

The length of the building in the x direction is equal to 12.05 meters, and the length of the building in the z direction is equal to 19 meters. As a result, wind load in the x-direction equals Pz times Lx times height, which equals 429.028 kN. The force of the wind in the z-direction is equal to: Pz x Lz x height = 652.0513 kN

2) Seismic Load

Calculations were made on the seismic load values using the IS 1893-2002 standard. Total seismic load = 23068 KN

VB, the design base shear, equals Ah multiplied by W

Where W is the seismic weight of the structure (cl.7.4.2), which is equivalent to 23068 KN

Ah = value of the design for the horizontal acceleration spectrum = Z I Sa 2 Rg

Where Z = the zone factor, which is equal to 0.36 and corresponds to zone V. I = Importance factor = 1 R is the response reduction factor, which equals 5. (Table 7)

The value of design base shear is higher than either the horizontal or vertical values of wind load. Because of this, seismic force is regarded to be the most important.

B. Load Combinations

There are many different load configurations that must be taken into account during a building's study, and IS 456:2000 and IS 1893(Part-1):2002 provide such load configurations.

1.05 DL + 1.05 LL

One point two double-digit double-digitdouble-digitdouble-digitdouble-digitdouble-digitdouble-digitdouble-digit double- The formula is: 1.02 D + 1.02 L + 1.02 E (-X)

The formula is: 1.02 DL + 1.02 LL + 1.02 EQZ 1.2 DL + 1.2 LL + 1.2 EQ(-Z) (-Z)
1.05 DL + 1.05 EQX 1.05 DL + 1.05 EQ (-X)
1.05 DL + 1.05 EQZ 1.05 DL + 1.05 EQ (-Z)
Expressed as: 0.09 DL + 1.05 EQX 0.09 DL + 1.05 EQ (-X)
0.09 DL + 1.05 EQZ 0.09 DL + 1.05 EQ (-Z).

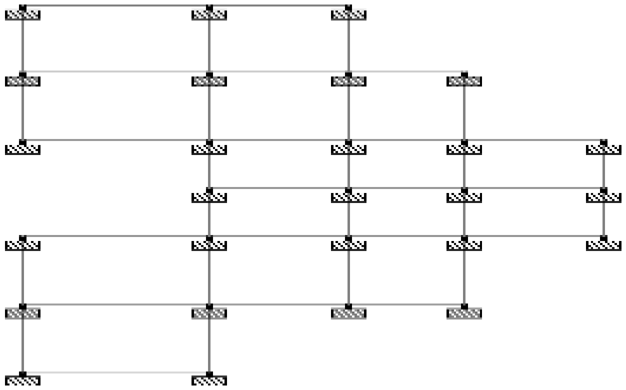

Figure 1: Constructing a Scheme

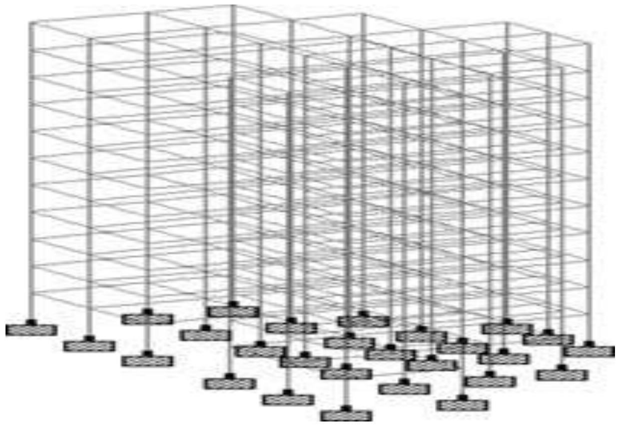

Figure 2: Structure Plan in Three Dimensions

V. RESULT AND DISCUSSION

Here, in this experimental study we have taken 4 models with same floor height but with different shear wall conditions i.e, without shear wall, with lift core wall, shear wall at corners only and with the lift core wall and the shear wall at corners (given in fig 3,4,5, and 6 respectively).

A. Frequency without SW

Table 2: Low-frequency Noise without Sideband Modulation

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
M-1	0.736	1.36022
M-2	0.737	1.35692
M-3	0.828	1.20907
M-4	2.003	0.49951
M-5	2.294	0.43602
M-6	2.309	0.43334
M-7	2.532	0.39518
M-8	2.592	0.38589
M-9	3.140	0.31750
M-10	3.299	0.30326

B. Frequency in Conjunction with the Lift Core Wall

Table 3: The frequency of lifts with regard to the wall core

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
M-1	0.863	1.15742
M-2	1.091	0.91753
M-3	1.363	0.73445
M-4	2.727	0.36789
M-5	3.276	0.30530
M-6	3.446	0.29029
M-7	4.245	0.23562
M-8	4.656	0.21479
M-9	4.757	0.28987
M-10	4.916	0.20346

C. Frequency with SW at Corners Only

Table 4: Only frequency with SW on corners

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
M-1	0.999	1.00240
M-2	1.091	0.91754
M-3	1.802	0.55510
M-4	3.066	0.32627
M-5	3.076	0.32517
M-6	3.827	0.26135
M-7	4.562	0.21917
M-8	4.633	0.21596
M-9	4.933	0.20278
M-10	4.934	0.20274

D. Frequency with Shear Wall at Corners and Lift Core Wall

Table 5: The frequency of occurrence with the lift core wall and the shear wall at corners

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
M-1	1.348	0.74237
M-2	1.440	0.69023
M-3	1.844	0.54245
M-4	3.881	0.25772
M-5	4.873	0.20527
M-6	4.950	0.20166
M-7	5.016	0.19941
M-8	5.180	0.19272
M-9	5.968	0.16759
M-10	6.001	0.16641

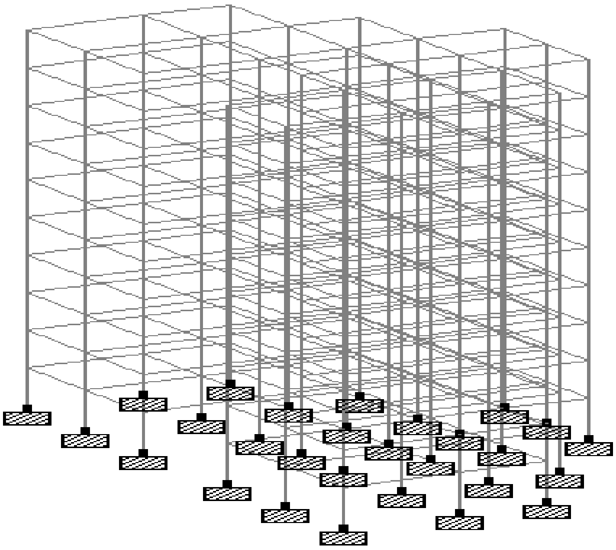

Figure 3: Model 1 without shear wall

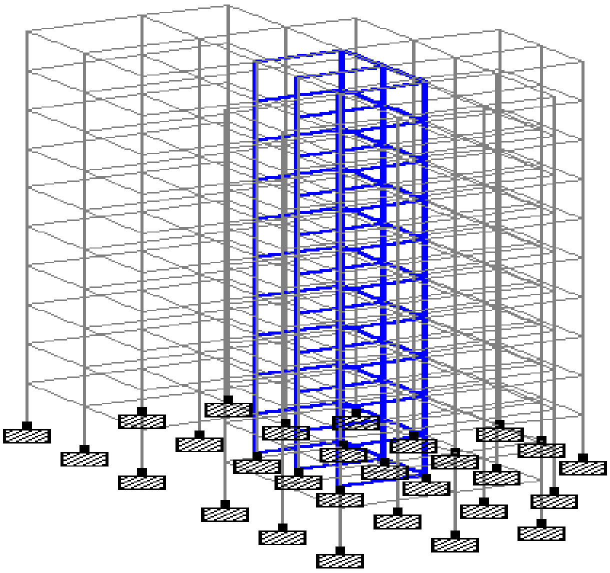

Figure 4: Model 2 with lift core wall

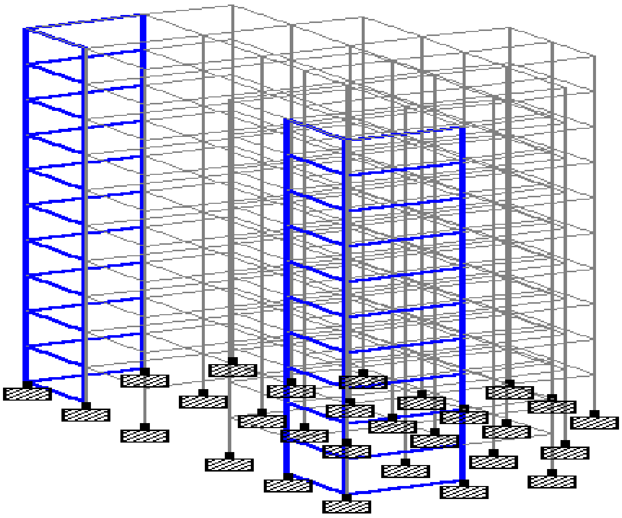

Figure 5: Model 3 with shear wall at corners

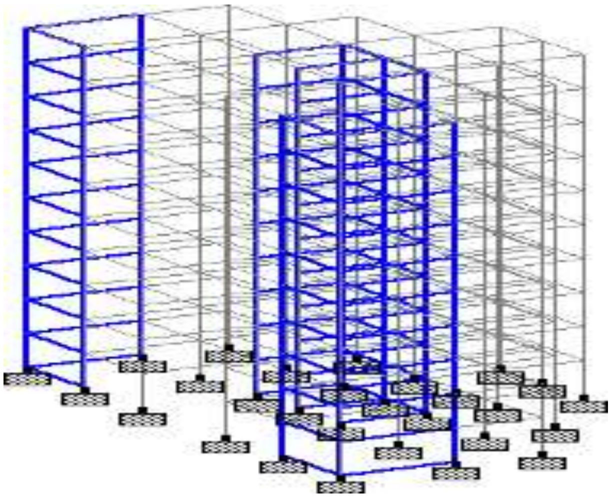

Figure 6: Model 4 with LCW &SW at corner

E. Base Shear as Calculated by RSM for All Models

Table 6: Bases hear

MODEL	BASESHEAR(KN)	
	X DIRECTION	Z DIRECTION
1	974.99	770.70
2	1394.2	1391.82
3	1436.4	1280.06
4	1695.39	1800.6

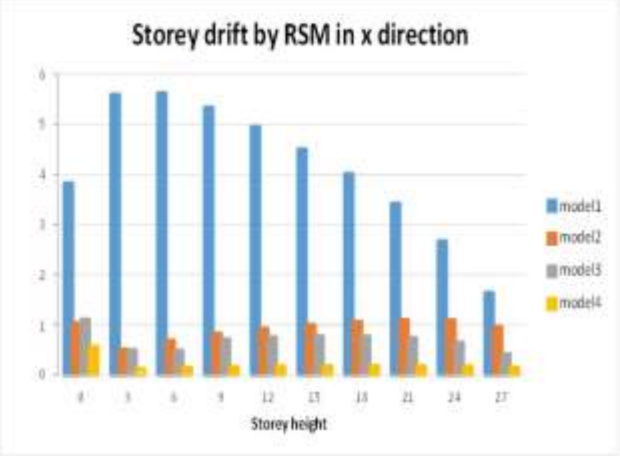

Figure 7: Base shear in x direction

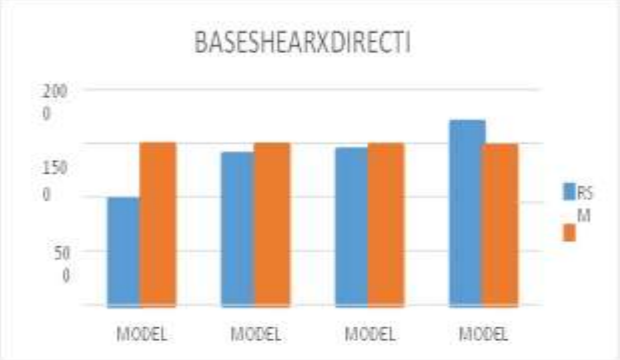

Figure 8: Base shear in z direction

F. Floor Drift by RSM & ESM

Table 7: Floor drift in x direction

FLOOR	FLOOR HEIGHT	FLOOR DRIFTIN X DIRECTION			
		MODEL1	MODEL 2	MODEL 3	MODEL 4
1	0	3.825	1.031	1.105	0.559
2	3	5.596	0.508	0.498	0.116
3	6	5.625	0.687	0.4819	0.130
4	9	5.330	0.821	0.708	0.157
5	12	4.948	0.922	0.749	0.168
6	15	4.505	0.998	0.768	0.174
7	18	4.008	1.050	0.766	0.176
8	21	3.423	1.098	0.737	0.175
9	24	2.668	1.091	0.643	0.171
10	27	1.637	0.962	0.413	0.143

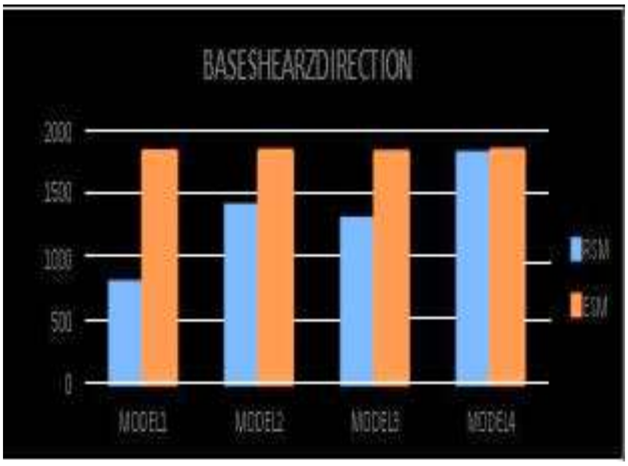

Figure 9: storey drift in x direction

G. Floor Drift by ESM

Table 8: Floor drift in x direction

FLOOR	FLOORH EIGHT	FLOORDRIFT IN XDIRECTION			
		MODEL1	MODEL 2	MODEL 3	MODEL 4
1	0	4.528	1.311	1.476	0.875
2	3	6.741	0.377	0.651	0.174
3	6	7.019	0.463	0.868	0.216
4	9	6.980	0.517	1.044	0.248
5	12	6.794	0.555	1.194	0.271
6	15	6.422	0.586	1.322	0.286
7	18	5.846	0.608	1.419	0.295
8	21	5.025	0.611	1.447	0.297
9	24	3.852	0.562	1.341	0.293
10	27	2.065	0.318	0.928	0.241

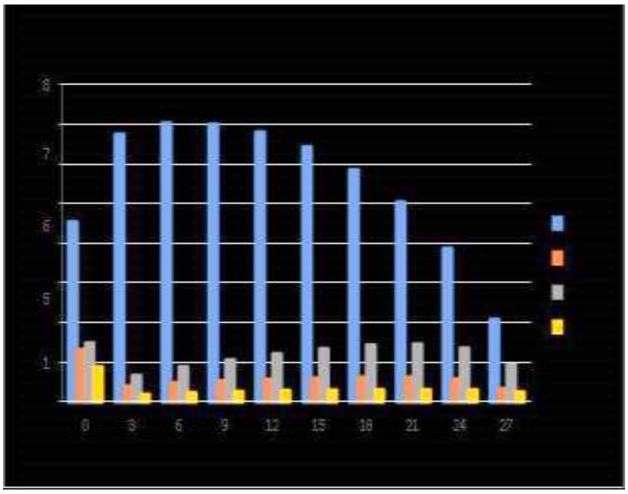

Figure 10: Floor drift by ESM in z direction

In this study we have computed the frequency for all 10 modes in the above mentioned 4 models. The frequency computed is given in tables 2, 3, 4 and 5 respectively with different share wall conditions provided in models. From this study we concluded that the frequency is maximum for mode shape 10 in all the cases but in model 4 (with lift core wall & shear wall at corners) the frequency is maximum than other 3 models.

The base share calculated from Response spectrum method is given in table no. 6 and fig no. 7,8. on comparing the model 4 with other models the maximum percentage of base shear comes with model 1 (56.93%) & minimum with model 2 (23.13%).

Also, the storey drift is computed both by response spectrum method and equivalent static method . firstly , storey drift is computed by RSM for all 4 all 10 modes in 4 models which is explained in table no. 7 and fig no. 9 and then again it is analyzed by ESM for all 10 modes given by table no. 8 and fig no. 10 respectively. And on comparing the results obtained ,`the storey drift least in case of model 4 which is 0.143 and 0.241 in RSM and ESM respectively.

VI. CONCLUSION

From this project the following conclusions were drawn:

- Based on the findings, it is evident that resisting lateral stresses acting on a building without a shear wall is very difficult.
- Model 4 is preferable to the other three since it results in the least amount of drift and displacement between floors.
- Also, we found that the response spectra were more effective than the corresponding static methods.
- When shear walls were included, the forces and moments, which had been at their highest in the no-walls model, dropped down dramatically.
- Model 2 has the least amount of base shear (23.13%) compared to the other models, while Model 1 has the most (56.93%).
- The foregoing findings indicate that, among the several models considered, model 4 (LCW & SW at corner) is the most appropriate and secure.

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