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Comparative Study of Multi-Storey Building Due to the Change in Location of the Shear Wall under Dynamic Loading

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ABSTRACT: This study investigates the seismic behaviour of a multi-storey building subjected to the relocation of reinforced concrete (RC) shear walls. Seismic events pose significant threats to the structural integrity of buildings, and the placement of shear walls plays a critical role in mitigating these risks. By analysing the effects of relocating RC shear walls, this research aims to provide insights into enhancing the seismic performance of multi-storey structures. The methodology involves conducting finite element analysis (FEA) simulations using Extended Three-Dimensional Analysis of Building System (ETABS). A typical multi-storey building model is established, incorporating various parameters such as building geometry, material properties, and seismic loading conditions based on IS 1893: PART 1: 2016. The findings of this research contribute to understanding the influence of RC shear wall location on the seismic behaviour of multi-storey buildings. Insights gained from the analysis can inform structural engineers and architects in optimizing building designs for enhanced seismic resilience. By strategically positioning RC shear walls, structural vulnerabilities can be minimized, leading to safer and more resilient structures in earthquake-prone regions. Overall, this study underscores the importance of considering the effects of shear wall location in seismic design practices, emphasizing the need for meticulous analysis and optimization strategies to enhance the structural performance and safety of multi-storey buildings against seismic hazards.

KEYWORDS: Shear wall, E-TABS, Static Analysis, Dynamic Analysis, Storey shear, Storey Acceleration

I. INTRODUCTION

Earthquakes result from the sudden movement of tectonic plates in the earth's crust. The movement takes place at fault lines, and the energy released is transmitted through the earth in the form of waves that causes ground motion many miles from the epicentre. Hence it is essential to analyze and design buildings such that they are safe, serviceable and economical. Thus, the effect of lateral loads like wind loads, earthquake force and blast force etc., are attaining increasing importance and almost every designer is faced with the problem of providing adequate strength and stability against lateral loads. In general, a shear wall building, and for that matter any other structure, is designed to satisfy certain basic structural and functional requirements. The structural requirements are:

i) Strength ii) Stiffness iii) Stability

II. OBJECTIVE

- To study the performance of buildings with bare frame and different location of shear wall in Special Moment - Resisting Frame (SMRF).
- To study the seismic behaviour of buildings using Equivalent static force method and Response spectrum method.
- To evaluate the effect of shear wall with different location on the seismic performance of G+9 storey buildings located in zone- V.

III. METHODOLOGY

The building resting on the ground starts vibrating when an earthquake occurs. Because it induces inertia forces on the building. So, in order to find out these forces and behaviour of the structure during the activity, several researches have been conducted all over the world. This research involves the various analysis techniques to determine the lateral forces ranging from purely linear to non-linear inelastic analysis. In India the Standardized method of analysis is followed by using a code – IS1893 (Part 1):2002 – “Criteria for Earthquake resistant design of structures”.

1. Linear Static Analysis Or Equivalent Static Analysis

Design horizontal seismic coefficient depends on the zone factor of the site, importance of the structure, response reduction factor of the lateral load resisting elements and the fundamental period of the structure.

2. Response spectrum method (RSM)

A response spectrum is simply a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency that are forced into motion by the same base vibration or shock. The resulting plot can then be used to pick off the response of any linear system, given its natural frequency of oscillation. One such use is in assessing the peak response of buildings to earthquakes.

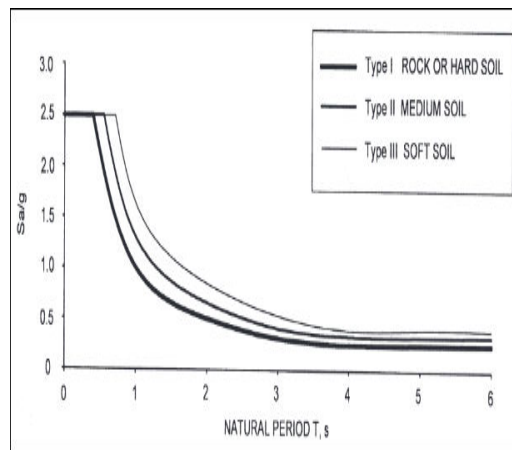


Fig 1. Design Acceleration Coefficients (Sa/g) (Corresponding to 5% damping): Spectra for Equivalent Static Method

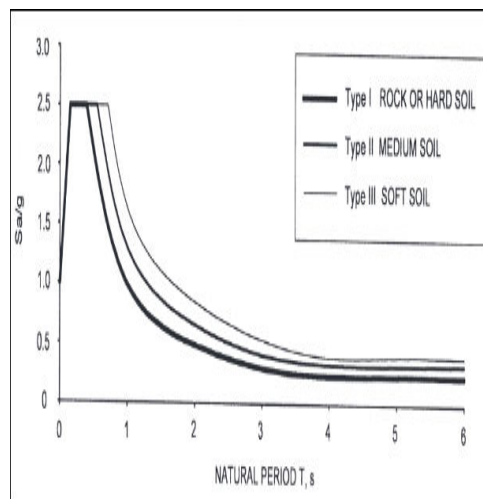


Fig 2. Design Acceleration Coefficients (Sa/g) (Corresponding to 5% damping): Spectra for Response Spectrum Method

IV. EXPERIMENTAL RESULTS

Effectiveness of changing reinforced concrete shear wall location on multi-storey building in SMRF has been studied with the help of five different models. Model one is bare frame structural system and other four models are dual type structural system subjected to earthquake loads on with were compared using the results of analysis. The response quantities that are considered in the comparison are displacement, storey shear, base shear and acceleration.

3. Storey Displacement

No. of storeys	Displacement(mm) along X-X direction				
	Model 1	Model 2	Model 3	Model 4	Model 5
Storey 15	85.7	41.4	22.3	39.4	70.1
Storey 14	83.4	38.2	20.5	36.4	65
Storey 13	80.2	34.9	18.7	33.1	59.7
Storey 12	76	31.6	16.8	29.8	54.3
Storey 11	71.1	28.2	14.9	26.5	48.7
Storey 10	65.5	24.7	13.1	23.1	43
Storey 9	59.2	21.3	11.2	19.8	37.1
Storey 8	52.6	17.9	9.4	16.6	31.4
Storey 7	45.5	14.6	7.6	13.5	25.7
Storey 6	38.3	11.4	6	10.5	20.2
Storey 5	30.9	8.5	4.4	7.8	15
Storey 4	23.4	5.9	3.1	5.4	10.4
Storey 3	16	3.6	1.9	3.3	6.4
Storey 2	9	1.8	1	1.7	3.2
Storey 1	3	0.6	0.3	0.6	0.9

Fig.3. Comparison of Storey Displacement for different models along X-X direction in mm

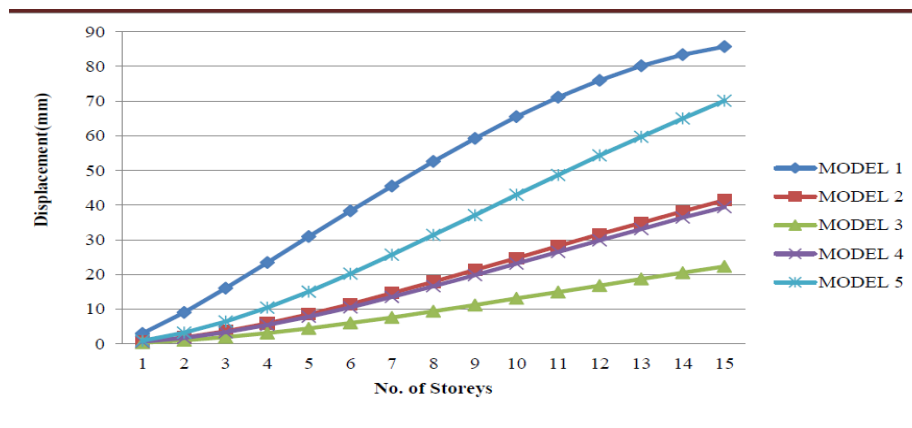


Fig.4. Comparison of displacement (mm) for different models along X-X direction

No of storeys	Displacement(mm) along Y-Y direction				
	Model 1	Model 2	Model 3	Model 4	Model 5
Storey 15	82.4	30	29.4	42.9	34.9
Storey 14	80	27.5	27.2	39.8	32.1
Storey 13	76.9	24.9	24.9	36.5	29.2
Storey 12	72.9	22.4	22.6	33.1	26.2
Storey 11	68.1	19.8	20.2	29.7	23.3
Storey 10	62.6	17.3	17.8	26.1	20.3
Storey 9	56.6	14.7	15.4	22.6	17.4
Storey 8	50.2	12.3	13	19.1	14.5
Storey 7	43.5	9.9	10.6	15.6	11.8
Storey 6	36.6	7.7	8.4	12.3	9.2
Storey 5	29.5	5.7	6.3	9.2	6.8
Storey 4	22.5	3.9	4.4	6.4	4.7
Storey 3	15.5	2.4	2.7	4	2.9
Storey 2	8.8	1.2	1.4	2.1	1.4
Storey 1	3	0.4	0.4	0.7	0.5

Fig.5. Comparison of Storey Displacement for different models along Y-Y direction in mm

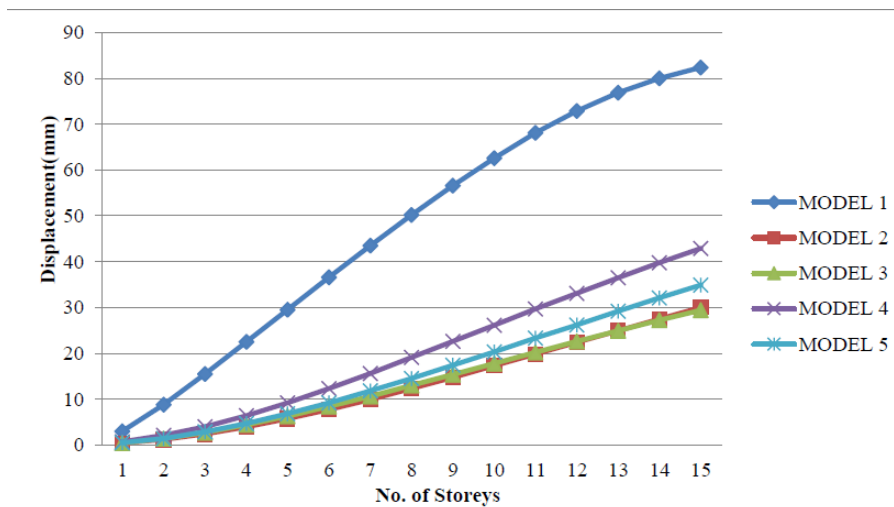


Fig.6. Comparison of displacement (mm) for different models along Y-Y direction

4. Storey Shear

No of storeys	Storey Shear(kN) along X-X direction				
	Model 1	Model 2	Model 3	Model 4	Model 5
Storey 15	352.16	439.52	423.22	448.62	444.87
Storey 14	698.95	1023.02	1015.86	971.26	983.94
Storey 13	997.96	1527.53	1528.57	1422.68	1449.72
Storey 12	1252.73	1958.79	1967.13	1808.09	1847.55
Storey 11	1466.82	2322.57	2337.36	2132.72	2182.80
Storey 10	1643.75	2624.59	2645.03	2401.79	2460.83
Storey 9	1787.06	2870.61	2895.94	2620.50	2686.99
Storey 8	1900.29	3066.39	3095.90	2794.09	2866.65
Storey 7	1986.99	3217.66	3250.68	2927.76	3005.15
Storey 6	2050.68	3330.18	3366.09	3026.74	3107.87
Storey 5	2094.92	3409.69	3447.93	3096.24	3180.15
Storey 4	2123.22	3461.94	3501.98	3141.48	3227.35
Storey 3	2139.15	3492.68	3534.04	3167.69	3254.84
Storey 2	2146.23	3507.66	3549.90	3180.07	3267.97
Storey 1	2147.99	3512.62	3555.36	3183.84	3272.09

Fig.7. Comparison of Storey Shear for different models along X-X direction in kN

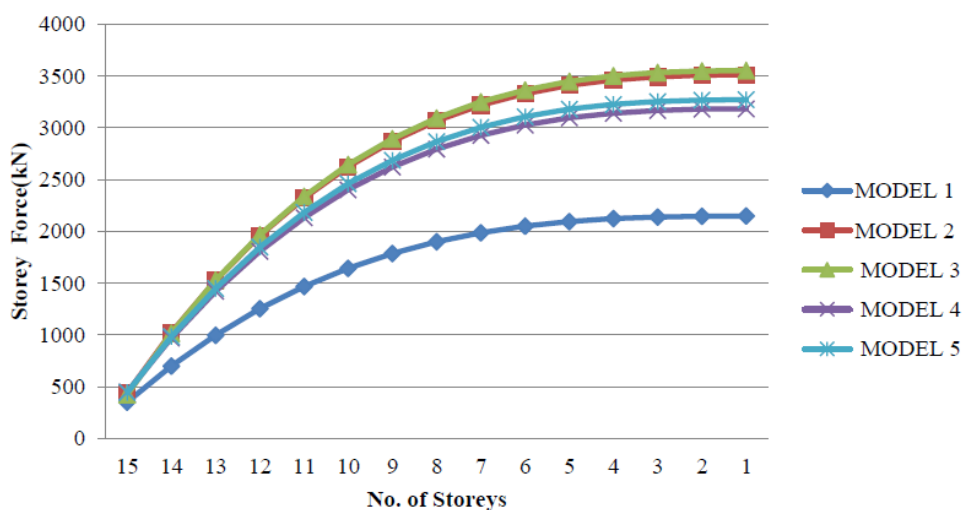


Fig.8. Comparison of Storey Shear for different models along X-X direction in kN.

No of storeys	Storey Shear(kN) along Y-Y direction				
	Model 1	Model 2	Model 3	Model 4	Model 5
Storey 15	352.16	461.28	444.17	470.83	466.90
Storey 14	698.95	1073.67	1066.15	1019.34	1032.65
Storey 13	997.96	1603.15	1604.24	1493.11	1521.48
Storey 12	1252.73	2055.76	2064.52	1897.60	1939.01
Storey 11	1466.82	2437.54	2453.07	2238.31	2290.86
Storey 10	1643.75	2754.52	2775.97	2520.69	2582.65
Storey 9	1787.06	3012.72	3039.31	2750.23	2820.01
Storey 8	1900.29	3218.19	3249.16	2932.41	3008.56
Storey 7	1986.99	3376.95	3411.61	3072.70	3153.92
Storey 6	2050.68	3495.04	3532.73	3176.58	3261.72
Storey 5	2094.92	3578.48	3618.62	3249.52	3337.58
Storey 4	2123.22	3633.32	3675.34	3297.00	3387.12
Storey 3	2139.15	3665.58	3708.99	3324.50	3415.97
Storey 2	2146.23	3681.30	3725.64	3337.50	3429.75
Storey 1	2147.99	3686.51	3731.37	3341.46	3434.08

Fig.9. Comparison of storey shear for different models along Y-Y direction in Kn

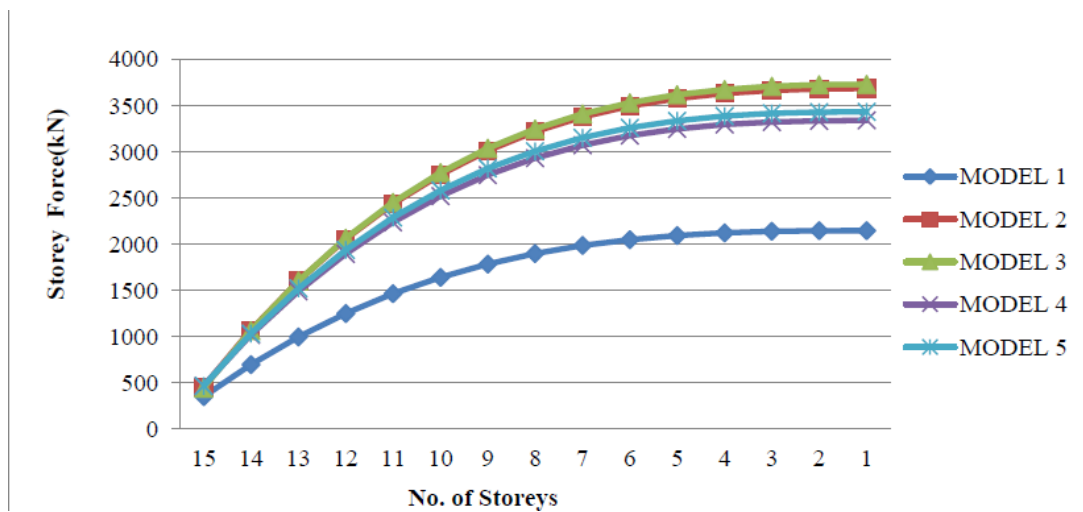


Fig.10 Comparison of storey shear for different models along Y-Y direction in kN

V. CONCLUSION

The seismic analysis of RC frame structure is done by both static and dynamic analysis to determine and compare the displacement, base shear, storey shear and acceleration. Based on the studies carried out the following conclusion may be drawn.

STOREY DISPLACEMENT - Model-I (Bare frame without shear wall) shows a maximum storey displacement of 85.7mm, whereas Model-III (Dual type structural system with Channel shape of shear wall) is having minimum storey displacement of 22.3mm along X-X direction. Model-II, Model-III, Model-IV and Model-V are having less storey displacement of 51.7%, 73.9%, 54.02% and 18.2% respectively when compared to Model-I in 15th Storey along X-X direction.

STOREY SHEAR - Storey shear goes on decreases with increases in number of storeys or storey level. The frame type structural system become economical as compared to dual type structural system can be used for economical building situated in seismic zone-V.

BASE SHEAR - It has been found that the maximum base shear in Model-III (Dual type structural system with Channel shape of shear wall) along longitudinal and transverse direction as compared to other models. Also, it has been found that Model-I (Bare frame without shear wall) shows lesser base shear as compared to other models in both the direction.

STOREY ACCELERATION - Model-I (Bare frame without shear wall) shows less storey acceleration compare to all other models. It has been found that Model-II, Model-III, Model-IV and Model-V are having more storey acceleration of 39.83%, 22.88%, 34.74% and 55.93% respectively when compared to Model-I along X-X direction.

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