JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

PERFORMANCE EVALUATION OF MULTISTORIED BUILDING WITH SPECIAL SHEAR WALLS

[1]Chetan Konapure, [2]Sandhya Vadnal,
[1]Assistant Professor, [2]PG Student,
Of Civil Engineering Department,
[1]Walchand Institute of Technology, Solapur, India

Abstract: Shear walls are constructed to counter the effects of lateral load acting on a structure. A dual system is a structural system in which complete frame provides support for gravity loads, and resistance to lateral loads. As per IS 13920: 2016, use of special shear walls in buildings is in preliminary stage. Application of special shear walls will be admissible to decide the structural system for the buildings. In this paper, seismic analysis has been performed using response spectrum method for different model of structures as per IS 13920:2016, that is special shear walls. There are three types in special shear walls such as squat wall, intermediate wall and slender wall. These three types are used in evaluating the seismic performance of rectangular buildings with application software. These three types are decided based on h_w/L_w ratio of wall so the walls with different h_w/L_w ratios are provided and the seismic performance of rectangular building is evaluated. The results of displacement, storey drift, storey shear and time period are observed and compared. Based on the analysis of the models with different location of shear walls, the performance is evaluated. The type of shear wall and location of shear wall are playing key role in the seismic performance of building. The most feasible type and location of shear wall in rectangular building is the research outcome of this paper.

***Index Terms* - "Dual System", "Special Shear Wall", "Response Spectrum Method", "Squat Wall", "Intermediate Wall", "Slender Wall".**

I. INTRODUCTION

The shear walls and core walls are frequently used horizontal load opposing components in mid-rise to high-rise reinforced concrete buildings. The thickness of the shear wall should be as low as 150mm, or as high as 300mm in high rise buildings. Special shear walls are the types of shear walls newly introduced in IS 13920: 2016 code and this concept can be extended for the research. A dual system is a structural system in which an essentially complete frame provides support for gravity loads, and resistance to lateral loads is provided by a specially detailed moment-resisting frame and shear walls or braced frames. Both shear walls and frames participate in resisting the lateral loads resulting from earthquakes. As per IS 1893 (Part 1): 2016, Buildings with dual system consist of moment resisting frames and structural walls (or moment resisting frames and bracings) such that both of the following conditions are valid:

- Two systems are designed to resist total design lateral force in proportion to their lateral stiffness, considering interaction of two systems at all floor levels;
- Moment resisting frames are designed to resist independently at least 25 percent of the design base shear.

II. PROBLEM FORMULATION

2.1 Type of Building

1. Modelling of the ten storey buildings with core wall and shear wall at exterior frames in ETABS
2. Calculating the length of shear walls for special shear walls by considering height by length ratio as per I.S. 13920:2016
3. Analysing the building using Response Spectrum Analysis.
4. Comparing the results of building models for rectangular building (l/w ratio=1.8).

In this study, various models are considered to perform the seismic analysis for rectangular shape structures. All the models having 10 stories and height of each storey was 3.2 m. The models are in rectangular plan of 20m x 36m with 5 bays on one side and 9 bays on other side. In all the models the lateral loads are resisted by shear walls at exterior frames and core walls at the center of the building.

Table 1 Material and Section Properties considered for Building

Material Properties	Section Properties	Loads on Building
1. Grade of Concrete = M25 2. Grade of Steel = Fe500 3. Young's modulus of steel = 2x10^2 MPa 4. Young's modulus of concrete = 25000MPa	1. Size of Beam = 350mm x 450mm 2. Size of Rectangular column = 450mm x 680 mm 3. Thickness of slab = 150mm 4. Thickness of masonry wall = 230mm 5. Thickness of shear wall = 150mm, 200mm, 250mm, 300mm	1. Live load = 2 kN/m^2 2. Floor finisher = 1 kN/m^2 3. Wall load = 12.65 kN/m 4. Seismic zone = III 5. Soil type = 1 6. Importance factor = 1 7. Response Reduction factor = 5 8. Damping percentage = 5%

2.2 Model Preparation

Initially rectangular shape buildings are modelled in application software by providing length of shear walls as per I.S. 13920:2016 by calculating the length of shear wall from h_w/L_w ratio for squat wall, intermediate wall and slender wall on different location in building models. The location of shear walls for building considered are, at center of periphery, at corner of periphery, along length of building and along width of building.

The types of shear wall as per I.S. 13920:2016 are the Special shear walls shall be classified as squat, intermediate and slender depending on the overall height 'h_w' to length 'L_w' ratio as,

1. Squat Wall
   If $h_w/L_w < 1$, it is called as squat wall.
2. Intermediate Wall
   If h_w/L_w is between 1 to 2, it is called as Intermediate Wall.
3. Slender Wall
   If $h_w/L_w > 2$, it is called as slender wall.

Table 2 Details of Special Shear Walls Provided in the Building

Type of shear wall	Squat Wall	Squat Wall	Intermediate Wall	Intermediate Wall	Slender Wall	Slender Wall
Length of shear wall	8m	4m	2m	1.6m	1.3m	1m
Ratio(h_w/L_w)	0.4	0.8	1.6	2	2.46	3.2
Percentage of shear wall provided	30%	15%	7.5%	6.15%	5%	3.8%

Basic Plans of Rectangular Building with different location of Shear Walls

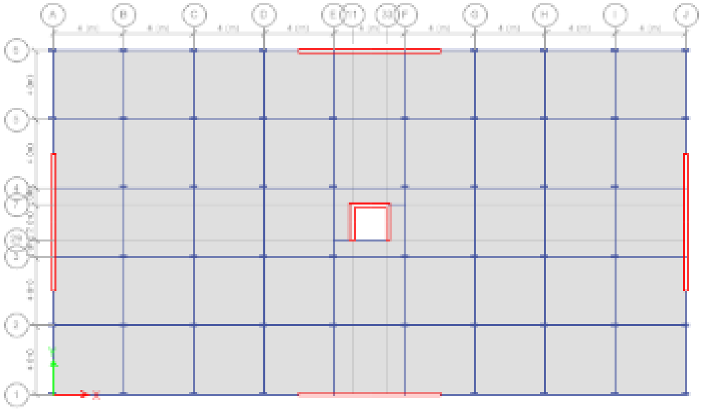

Figure 1

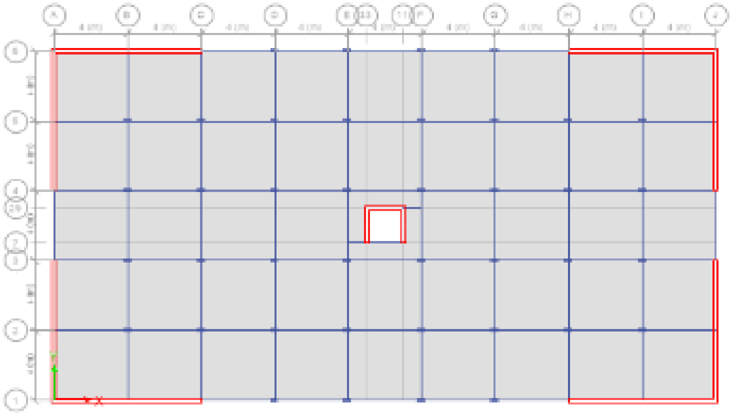

Figure 2

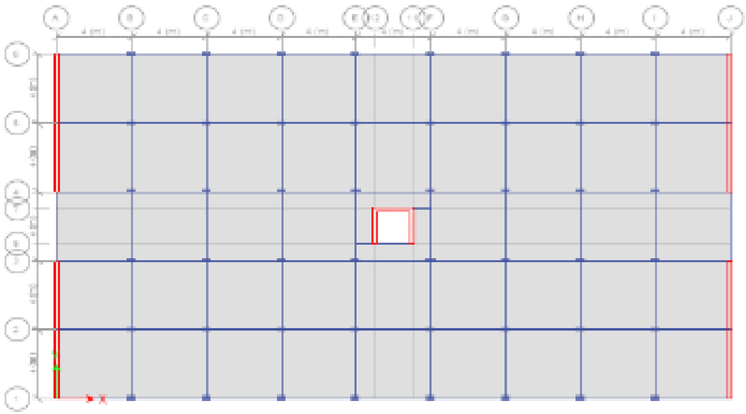

Figure 3

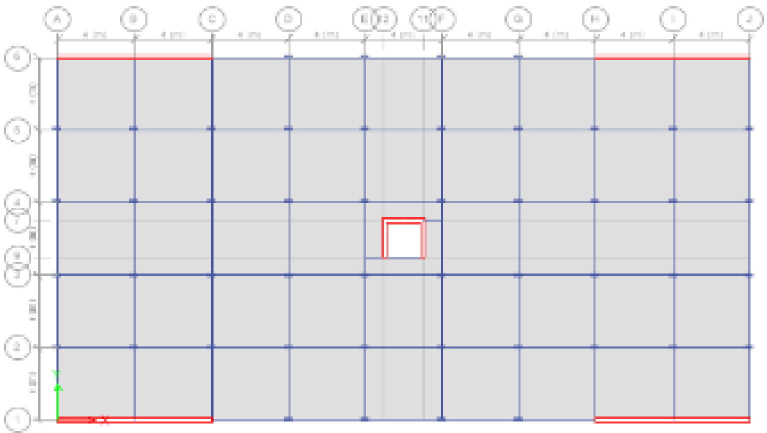

Figure 4

Model 1 to 4 – 8m shear walls with above 4 basic plans
Model 5 to 8 – 4m shear walls with above 4 basic plans
Model 9 to 12 – 2m shear walls with above 4 basic plans
Model 13 to 16 – 1.6m shear walls with above 4 basic plans

Model 17 to 20 – 1.3m shear walls with above 4 basic plans
Model 21 to 24 – 1m shear walls with above 4 basic plans

III. RESULTS AND DISCUSSION

All the models are analyzed with response spectrum analysis in ETAB software. The analytical results for displacement, storey drift, storey shear and time period are tabulated below. The comparison is made with the graphical representation.

Table 3 Dynamic Parameters for the Different Models

Model	Displacement (mm)		Storey Drift		Storey Shear (kN)		Time Period (sec)	Extreme Fibre Compressive Stress (N/mm^2)
No.	X	Y	X	Y	X	Y		
1	4.31	4.86	0.000154	0.000178	795.93	890.58	0.827	7.88
2	3.29	3.29	0.000116	0.000118	1243.93	1243.93	0.54	5.95
3	6.21	4.04	0.000285	0.000146	613.4	931.35	1.147	7.17
4	4.03	8.17	0.000145	0.000313	929.04	488.97	1.46	7.16
5	5.74	7.13	0.000206	0.00026	639.94	556.85	1.235	11.44
6	5.12	6.01	0.000158	0.000223	754.85	671.56	1.026	6.75
7	6.38	6.89	0.000276	0.000251	586.73	581.04	1.179	7.8
8	5.63	8.21	0.000203	0.000318	663.12	469.48	1.458	7.8
9	6.42	8.07	0.000242	0.000302	574.22	470.84	1.418	10.05
10	5.79	7.33	0.000209	0.000272	644.75	553.49	1.266	9.02
11	6.32	8.57	0.000271	0.00032	572.91	508.83	1.321	9.72
12	6.06	8.28	0.000218	0.000323	609.37	459.38	1.463	9.43
13	5.94	7.68	0.000229	0.000291	611.36	508.11	1.335	10.85
14	5.85	7.65	0.000213	0.000284	621.07	521.33	1.325	9.52
15	6.43	7.91	0.000268	0.000298	572.38	488.71	1.375	10.09
16	6.18	8.28	0.000231	0.000323	596.98	457.59	1.461	9.73
17	6.3	7.94	0.000256	0.000295	591.39	483.72	1.396	11.73
18	6.02	7.82	0.000229	0.000293	605.24	499.26	1.363	10.12
19	6.48	7.97	0.000268	0.000303	571.41	476.75	1.397	12.49
20	6.26	8.3	0.000243	0.000324	589.11	455.45	1.463	10.15
21	6.1	7.87	0.000225	0.000297	589.22	499.34	1.347	13.11
22	6.24	7.95	0.000243	0.0003	592.89	480.92	1.396	11.05
23	6.52	8.06	0.000268	0.000308	568.67	468.18	1.416	11.52
24	6.33	8.32	0.000252	0.000326	582.14	452.77	1.466	10.92

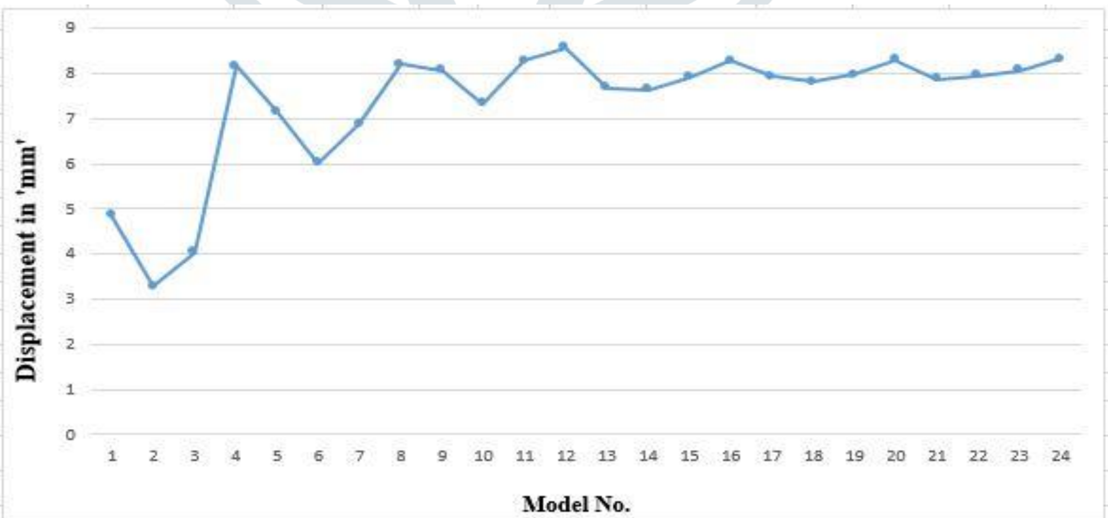

Figure 5 Maximum Displacement (mm)

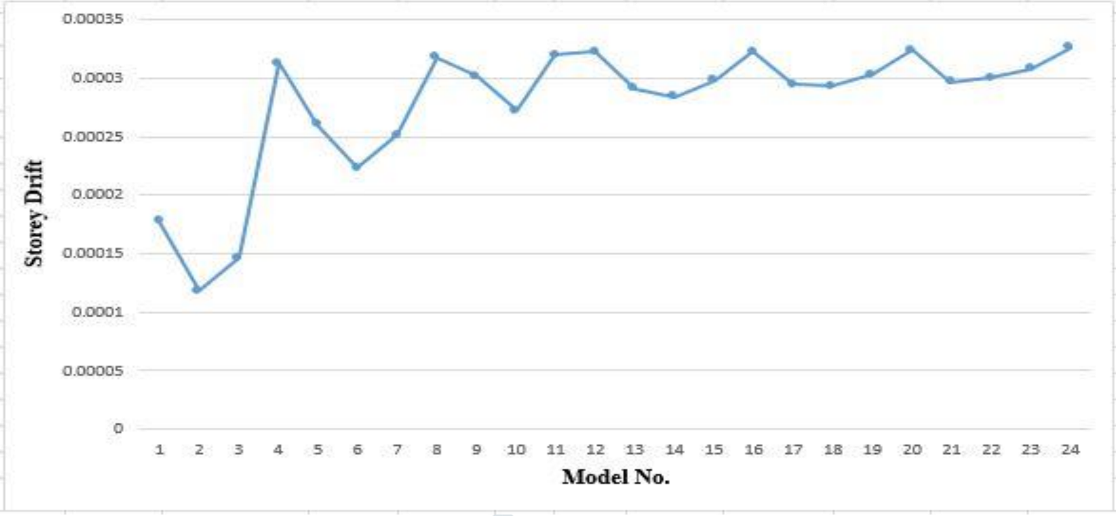

Figure 6 Maximum Storey Drift

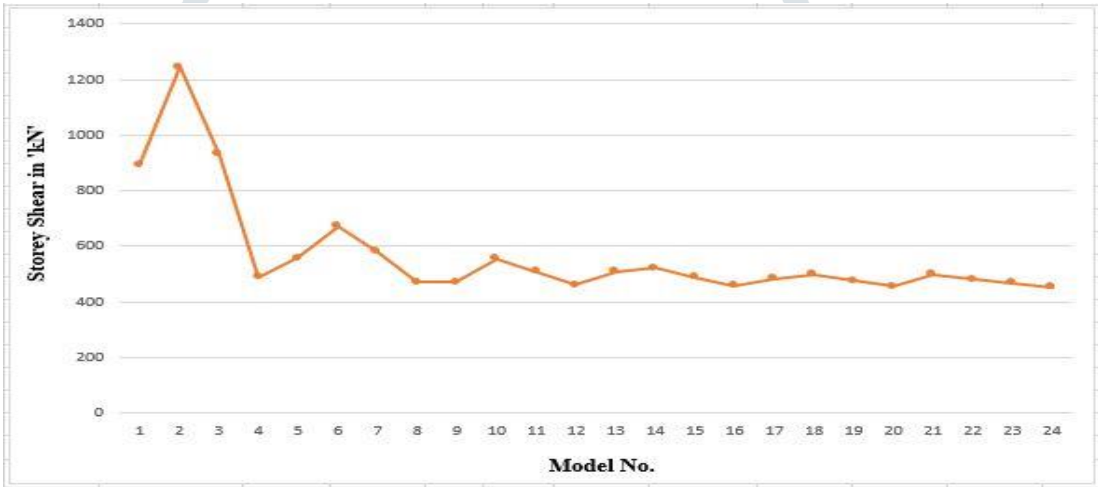

Figure 7 Maximum Storey Shear (kN)

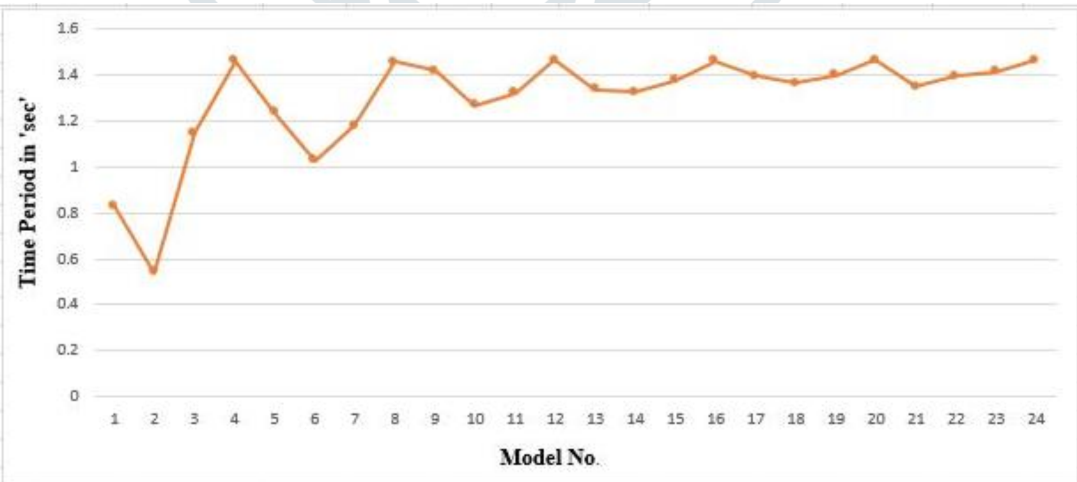

Figure 8 Time Period (sec)

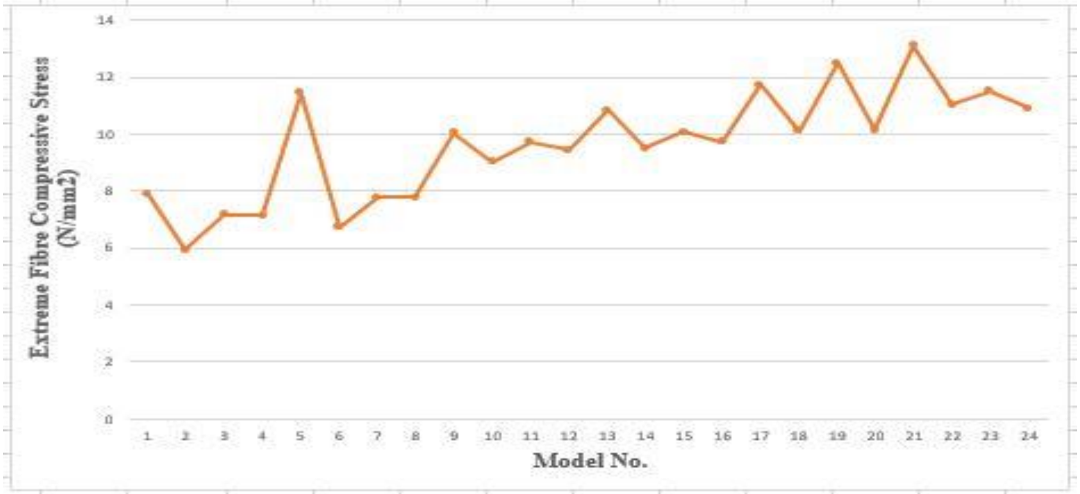

Figure 9 Extreme Fibre Compressive Stress (N/mm^2)

- The lowest displacement is observed for model 2 in which 8m squat walls are provided at corners of the building. The highest displacement is observed for model no. 4, 8, 12, 16, and 20 in which shear walls are provided along length. The fall in the displacement values is observed for model no. 2, 6, 10, and 14 which reveals that the squat shear walls and intermediate shear walls shall be provided at corners.
- The rise in drift values is observed for model no. 4, 8, 12, 16, and 20 in which shear walls are provided along length. The fall in the drift values is observed for model no. 2, 6, 10 and 14 which reveals that the squat shear walls and intermediate shear walls shall be provided at corners.
- The fall in storey shear values is observed for model no. 4, 8, 12, 16, and 20 in which shear walls are provided along length. The rise in the storey shear values is observed for model no. 2, 6, 10 and 14 which reveals that the squat shear walls and intermediate shear walls shall be provided at corners.
- The longer time period is observed for model no. 4, 8 and 12 because of lower stiffness along width. The time period values suddenly dropped for model no. 2, 6 and 10 because of higher stiffness.
- The extreme fibre compressive stress in the wall exceeds the permissible stress 0.2fck for all the models.

3.1 Buildings with Shear Walls at Corners

From the results and discussion made above it can be revealed that the models of the buildings with shear walls at corners gives better performance in all the dynamic parameters irrespective of type of special shear walls. An attempt is made for the extreme fibre compressive stress to be lowered within the permissible limit 0.2fck.

The models of building with shear walls at corners with squat, intermediate and slender shear walls are redesigned by varying thickness of shear wall. Following are the models considered

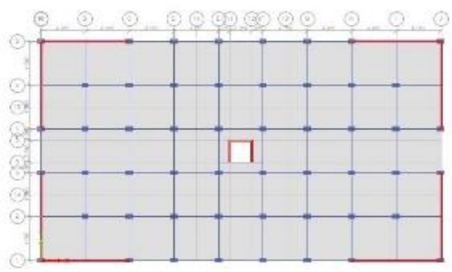

Figure 10 Model 5 (building with shear wall 57% of periphery)

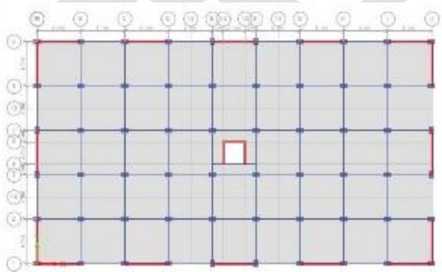

Figure 11 Model 6 (building with shear wall 57% of periphery)

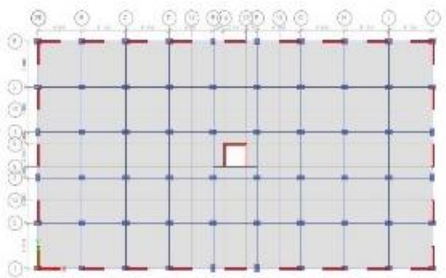

Figure 12 Model 7 (building with shear wall 50% of periphery)

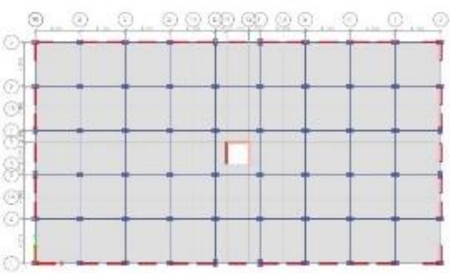

Figure 13 Model 8 (building with shear wall 57% of periphery)

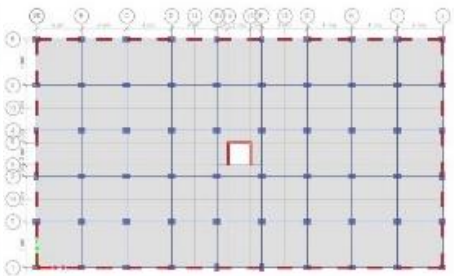

Figure 14 Model 9 (building with shear wall 57% of periphery)

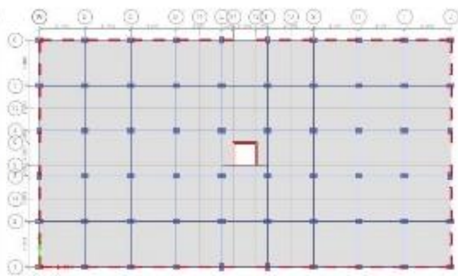

Figure 15 Model 10 (building with shear wall 50% of periphery)

Table 4 Dynamic Parameters with Permissible Compressive Stress in Squat, Intermediate and slender wall for the Buildings with Shear walls at corners

Designation of Model	Shear Wall Thickness (mm)	Displacement (mm)	Storey Drift	Storey Shear (kN)	Time Period (sec)	Extreme Fibre Compressive Stress (N/mm²)
Squat Wall (SW = 8m) (Model No. 2)	150mm upto 1st Floor 200mm above Ground Level 250mm below Ground Level	2.95	0.000109	1626.29	0.493	3.79
Squat Wall (SW = 4m) (Model No. 6)	150mm upto 2nd Floor 200mm above Ground Level 250mm below Ground Level	4.03	0.000149	1193.2	0.694	4.33
Intermediate Wall (IW = 2m) (Model No. 10)	150mm upto 3rd Floor 200mm For 2nd And First Floor 250mm above Ground Level 300mm below Ground Level	3.89	0.000155	1227.94	0.717	4.37
Intermediate Wall (IW = 1.6m) (Model No. 14)	150mm upto 3rd Floor 200mm For 2nd And First Floor 250mm above Ground Level 300mm below Ground Level	3.32	0.000131	1380.36	0.61	4.35
Slender Wall (SW = 1.3m) (Model No. 18)	150mm upto 3rd Floor 200mm For 2nd Floor 250mm For 1st Floor 300mm above Ground Level and below Ground Level	3.31	0.000135	1388.94	0.615	5.51
Slender Wall (SW = 1m) (Model No. 22)	150mm upto 4th Floor 200mm For 3rd Floor 250mm For 2nd And 1st Floor 300mm above Ground Level and below Ground Level	3.34	0.000128	1430.72	0.616	6.08

Figure 16 Maximum Displacement (mm)

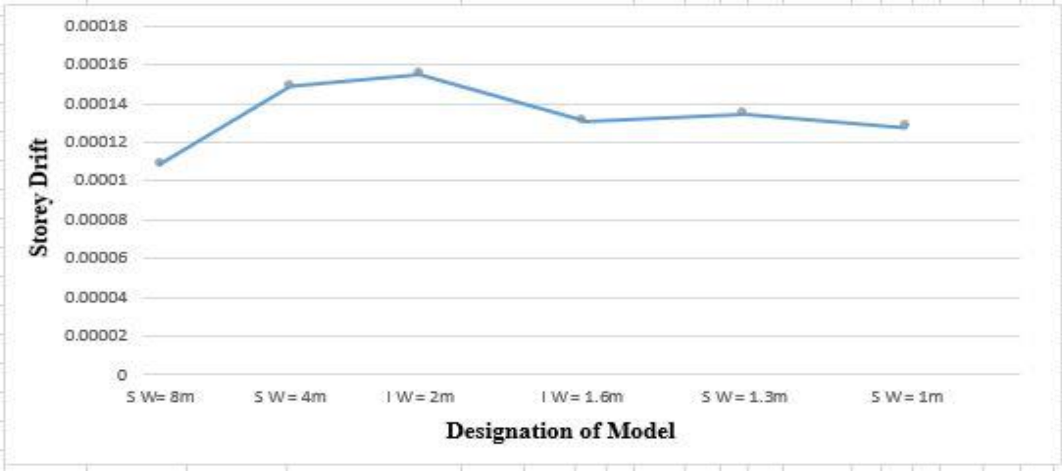

Figure 17 Maximum Storey Drift

Figure 18 Maximum Storey Shear (kN)

Figure 19 Time Period (sec)

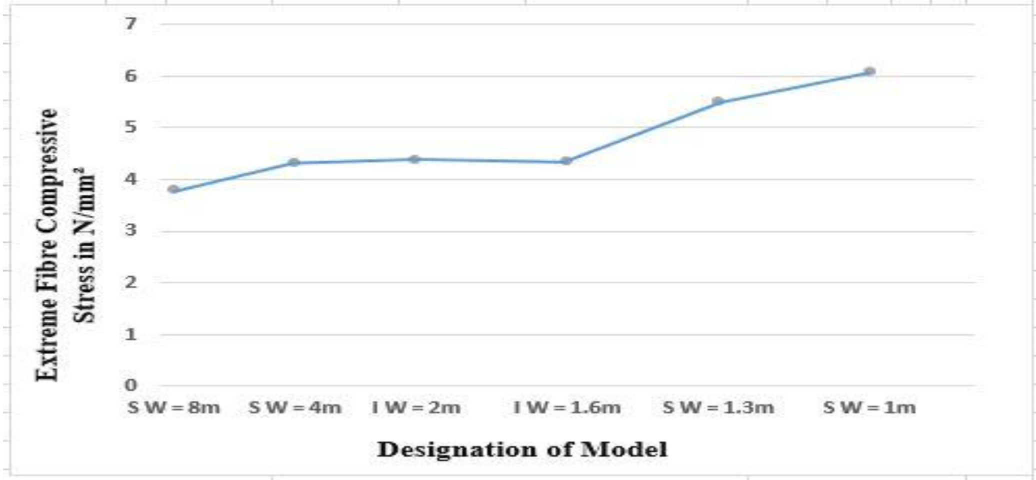

Figure 20 Extreme Fibre Compressive Stress (N/mm^2)

- Various models with thicknesses of shear wall 200mm, 250mm and 300mm have tried. However slender wall with 300mm thickness of wall is not passing the criteria of permissible compressive stress.
- Squat and intermediate walls have passed the criteria of permissible compressive stress with reducing thickness of shear wall from base. The uniform thickness of shear wall throughout height of building has not been proved the admissible solution for present building configuration.

IV. CONCLUSIONS

Various models with different shear wall locations have analyzed and the results of dynamic parameters have compared. Following are the conclusions:

- The configuration of building with corner shear walls have given better seismic performance for squat, intermediate and slender walls.
- Slender wall is not suitable for present building configuration from extreme fibre compressive stress point of view.
- The building with squat and intermediate shear walls have performed better from dynamic parameters as well as extreme fibre compressive stress aspect.
- For the present building the intermediate wall with length of 1.6m provided at corners (model 14) proved most economical alternative.
- However the thickness of shear wall cannot be kept uniform throughout the height of building. Moreover the thickness of shear wall shall be varied at different storey level.

REFERENCES

[1] N. Vinay Kumar, D. Arul Prakash, "Seismic Performance of a Reinforced Concrete Multi-storey Building having Circular Shear Wall and square Shear Wall at Core of the Building", Int. j. IJCIET, Vol -8, Issue 3, March 2017, pp. 928-941, Article ID: IJCIET_08_03_093.

[2] Mahapara Firdous, Sakshi Gupta, "A Critical Evaluation of the effect of Soft Storey and Column Orientation on RC Buildings", Int. j. IJSTE, Vol. – 4 Issue 10, April 2017 ISSN: 2349-784X.

[3] S.V. Venkatesh, H. Sharada Bai, "Effect of Internal & External Shear Wall on Performance of Building Frame Subjected to Lateral Load", Int. j. ISSN 0974-5904, Vol. - 4, No. 06 SPL, October 2011, pp. 571-576.

[4] T. Shobha, S. Ananda Rao, "Design and Construction of Shear Walls", ISSN 2348-2370, Vol.08, Issue.08, July-2016, Pages: 1549-1558.

[5] Prof. Patil S.S., Sagare S.D., "Dynamic Analysis of Soft Story-High Rise Building with Shear Wall", Int. j. IJLTEMAS, Vol. VII, Issue IX, September 2018, ISSN 2278-2540.

[6] Sanjay G.K., Dr. B Shiva kumara Swamy, "Analysis of Soft Storey Effect at Different Levels in a Framed Structure with and without Shear Wall for Different Seismic Zone", Int. j. IRJET, Vol. 05, Issue 08, August 2018, e-ISSN: 2395-0056, p-ISSN: 2395-0072.

[7] K.G. Patwari, L.G. Kalurkar, "Comparative Study of RC Flat Slab & Shear Wall with Conventional Framed Structure in High Rise Building", int. j. IJER, Vol. -5, Issue: Special 3, pp: 612-616, ISSN: 2319-6890(online), 2347-5013(print), 27-28 Feb. 2016.

[8] M. Santhosh, S. Pradeep, "Seismic Analysis and Design of Multi Storey Building with Non Parallel Shear Wall System", int. j. IJEMR, Vol.-4, Issue-2, April-2014, ISSN No.: 2250-0758, Page No.: 157-160.

[9] Birat dev Bhatta, G. Vimalanandan, Dr. S. Senthilselvan, "Analytical Study on Effect of Curtailed Shear Wall on Seismic Performance of High Rise Building", Int.j.IJCIET, Vol.-8, Issue 2, February 2017, pp. 511-519 Article ID: IJCIET_08_02_053.

[10] Ms. Priyanka Soni, Mr. Purushottam Lal Tamrakar, Vikky Kumhar, "Structural Analysis of Multistory Building of Different Shear Walls Location and Heights", Int. j. IJETT, Vol. 32 No-1, February 2016.

[11] N. Saravanan, Dr. T. Kavitha, "Study on Optimum Location of R.C. Shear Wall in a High Rise Soft Storey Structure Subjected to Seismic Force", Int. j. IJRASET, ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429, Vol.-8, Issue VI, June 2020.

[12] IS 1893(Part 1):2016 "Criteria for Earthquake Resistant Design of Structures" BIS, New Delhi

[13] IS 13920:2016 "Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces – Code of Practice