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TO STUDY THE PERFORMANCE OF HIGH-RISE BUILDING UNDER LATERAL LOAD WITH BARE FRAME AND SHEAR WALL WITH OPENINGS

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Abstract - *The usefulness of shear walls in the structural planning of multi-storey buildings has long been recognized. When walls are situated in advantageous positions in a building, they can be very efficient in resisting lateral loads originating from wind or earthquakes. Incorporation of shear wall has become inevitable in multi-storey building to resist lateral forces. In the present study, 15 storey building (45m) have been modeled using software package ETABS 2015 for earthquake Zone V in India based on the soil type III(Soft) and Reduction factor (R)=5 (special RC moment-resisting frame) is considered. The analysis of the building is carried for most suited location of shear walls then the best and effective location of shear wall is provided with different sizes of openings. To evaluate above using equivalent static method and response spectrum method of analysis carried out for different load combination as per IS: 1893:2002. Estimation of structural response such as storey displacements, Base shear and storey drift is considered.*

***Key Words*:** **Bare frame, shear wall, Top storey displacement, storey drift, Base shear, ETABS-2015.**

1. INTRODUCTION

Tall buildings are defined as virtue of its height (more than 30 m), is affected by lateral forces due to wind or earthquake or both to an extent that they play an important role in the structural design. Adequate stiffness is to be ensured in tall buildings for resistance to lateral loads induced by wind or seismic events. Reinforced concrete shear walls are designed for buildings located in seismic areas, because of their high bearing capacity, high ductility and rigidity. In high rise buildings, beam and column dimensions work out large and reinforcement at the beam-column joints are quite heavy, so that, there is a lot of clogging at these joints and it is difficult to place and vibrate concrete at these places which does not contribute to the safety of buildings. These practical difficulties call for introduction of shear walls in High rise buildings.

Developments in the design of tall building frames have emphasized the importance of limiting the sideway under the action of lateral loads. Some of the lateral load resistant structures used in practice are given in Fig 1. Diagonal bracing may be conveniently adopted in steel frames as shown in Fig 1(a). In reinforced concrete frames such diagonal bracing is impracticable, however in such buildings lateral sway restricted by providing rigid joints, Fig 1(b). Relaying only on rigid joints make it virtually impossible to achieve economy in the design of columns. Provision of reinforced concrete shear walls in the plane of the load at selected positions of tall buildings, as shown in Fig 1(c) is the modern trend of construction in order to limit the lateral sway and achieve economy in the designs.

However, the ever increasing cost of steel and cement make such structures quite expensive. This lead one to think of alternative means and one such is the possibility of utilizing the generally not considered structural stiffness and strength of masonry walls which have to be provided for functional reasons in a building along with reinforced concrete frames as shown in Fig 1(d).

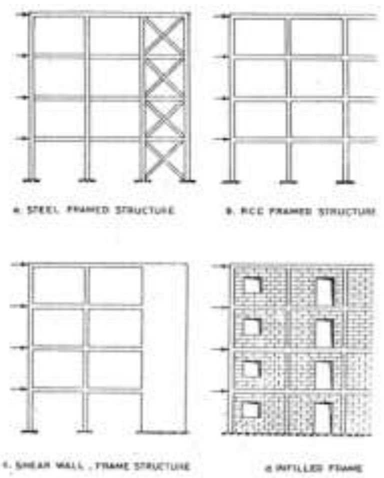


Fig-1: Lateral load resisting structures

1.1 BARE FRAME SYSTEM

Rigid frame systems, also called moment frame systems shown in fig-2, are rectilinear assemblage of beams and columns with the beams rigidly connected to the columns. Resistance to lateral force is provided primarily by rigid frame action that is, by the development of bending moment and shear force in the frame members and joints.

The structural stiffness of rigid frames is directly proportional to the cross-sectional dimensions and bending rigidity of the beams and columns, and inversely proportional to their length and spacing. In this system, columns are placed in locations that least restricts architectural planning. At the same time, columns should be of sufficient length to provide minimum story depth. To obtain effective rigid frame behavior, it is necessary to have closely spaced columns, and for the beams connecting them to be sufficiently deep.

For buildings constructed in regions of high seismic activity the details of the connections between structural elements are very important because of the need for ductile behavior in the rigid frame due to the large lateral drift during severe earthquakes (ductility is the ability to deform without a significant reduction in strength). In rigid frame systems ductility is achieved by the formation of plastic hinges in the columns and beams.

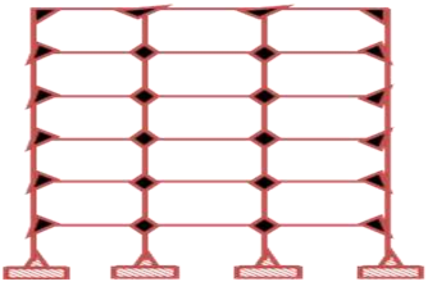
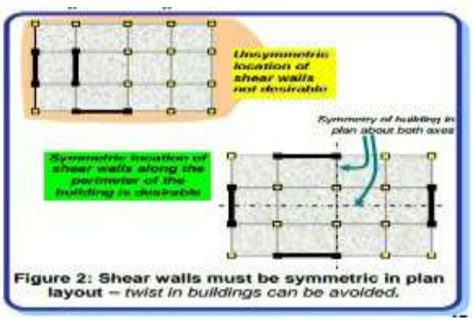


Fig-2: Bare frame system

1.2 SHEAR WALL SYATEM SYSTEM

Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm in high rise buildings. The overwhelming success of buildings with shear walls in resisting strong earthquakes is summarized in the quote, "We cannot afford to build concrete buildings meant to resist severe earthquakes without shear walls." RC shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. Since shear walls carry large horizontal earthquake forces, the overturning effects on them are large. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings. They could be placed symmetrically along one or both directions in plan. Shear walls are more effective when located along exterior perimeter of the building shown in fig-3 such a layout increases resistance of the building to twisting.



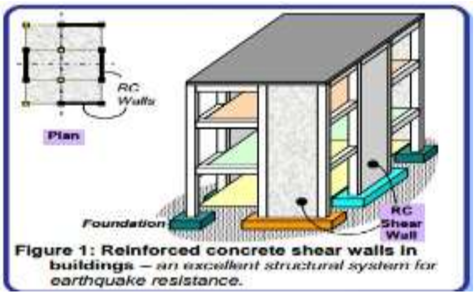


Fig-3: Location of Shear walls in RC buildings

2. METHODOLOGY

EQUIVALENT STATIC ANALYSIS: The equivalent static method of finding lateral forces is also known as the static method or the seismic coefficient method. This method is the simplest one and it requires less computational attempt and is based on formulae given in the code of practice. In all the methods of analyzing a multi storey buildings recommended in the code, the structure is treated as discrete system having concentrated masses at floor levels which comprise the weight of columns and walls in any storey should be equally distributed to the floors above and below the storey. In addition, the suitable amount of imposed load at this floor is also lumped with it. It is also assumed that the structure flexible and will deflect with respect to the position of foundation; the lumped mass system reduces to the solution of a system of second order differential equations. These equations are formed by distribution of mass and stiffness in a structure, together with its damping characteristics of the ground motion.

RESPONSE SPECTRUM ANALYSIS (RSA): The word spectrum in engineering conveys the idea that the response of buildings having a broad range of periods is summarized in a single graph. This method shall be performed using the design spectrum specified in code or by a site-specific design spectrum for a structure prepared at a project site. The values of damping for building may be taken as 2 and 5 percent of the critical, for the purposes of dynamic of steel and reinforce concrete buildings, respectively. For most buildings, inelastic response can be expected to occur during a major earthquake, implying that an inelastic analysis is more proper for design. However, in spite of the availability of nonlinear inelastic programs, they are not used in typical design practice because:

1) Their proper use requires knowledge of their inner workings and theories, Design criteria.

2) Result produced is difficult to interpret and apply to traditional design criteria, and

3) The necessary computations are expensive.

Therefore, analysis in practice typically use linear elastic procedures based on the response spectrum analysis. The response spectrum analysis is the preferred analysis because it is easier to use.

An effort is made to estimate Top storey displacement, storey drift and base shear for 15 storey building under Zone V and soil type III.

TOP STOREY DISPLACEMENT

Storey displacement is the lateral displacement of the storey relative to the base. The permissible limit for roof displacement is H/500, where H - height of the building from base.

STOREY DRIFT

Storey drift can be defined as the lateral displacement of one level to the level above or below it. The storey drift in any storey shall not exceed 0.004 times the storey height. Maximum drift permitted =0.004 x 3 = 0.012m.

BASE SHEAR

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. It mainly depends on the soil conditions at the site.

3. MODELLING OF REINFORCED CONCRETE BUILDING

Modeling of RC buildings describes the structural configuration of different structural system. Frame selected for analysis is symmetrical in plan of 42x42m with Centre to Centre column spacing is 6m and 7 bays each along both X and Y direction. Different structural system is introduced in order to minimize the top storey displacement, storey drift for 15 storey building. The material properties like concrete and rebar remains the same for all the stories. The sectional properties of column and beam are taken as 900x900mm and 450x600mm in order to obtain optimum design force. The floor to floor height is considered as 3m each. The thickness of Slab, Masonry wall and Shear wall is assumed as 150mm, 200mm and 300mm. The building is subjected to gravity and lateral load. Wall load of 9.6kN/m on floor throughout beam length, floor finish of 1.5kN/m^2 and live load of 2kN/m^2 except roof, at roof wall load of 4.8kN/m as parapet wall, floor finish of 3kN/m^2 and live load of 1.5kN/m^2. Seismic loading as per IS1893 (part1) – 2002, seismic zone considered is V at soil type III (soft soil).Natural time period of vibration by empirical expression as per IS1893 (part-1) – 2002 for 15 storey building is 0.625 sec respectively and the response reduction factor is considered is R=5(special moment resisting frame). The results are extracted for the maximum load combination of 1.5(DL±SDL±EQx , EQy) and the models are checked for design where percentage of reinforcement is under 4%.

3.1 METHOD OF ANALYSIS

Generally following four types of analysis are used for seismic design and performance of buildings, linear equivalent static analysis, linear response spectrum analysis, nonlinear static pushover analysis and nonlinear time history analysis. In present study, Equivalent static analysis and response spectrum analysis are used. Dynamic analysis are performed as per clause no 7.8.1 (a), IS1893 – 2002. Response of building from earthquake considered by load combination as per IS456: 2000, Table 18. Modeling and analysis are carried out by ETABS-2015 software.

3.2 MODEL DETAILS

MODEL 1: Bare frame

MODEL 2: Shear wall at centers along outer periphery

MODEL 3: Shear wall at all four corners of the building

MODEL 4: Combination of shear wall at centers and corners

MODEL 5: Shear wall as a core at centre of the building

MODEL 6: Shear wall at all four corners up to 12m

3.3 CONCLUDING THE BEST MODEL TO PROVIDE OPENINGS

EQUIVALENT STATIC ANALYSIS			
MODELS	**TOP STOREY DISPLACEMENT(mm)**	**STOREY DRIFT (m)**	**BASE SHEAR (kN)**
MODEL 1	226.3	0.00662	32385.66
MODEL 2	161.3	0.00448	32603.64
MODEL 3	118.2	0.00308	32821.62
MODEL 4	101.7	0.00262	33039.60
MODEL 5	142.3	0.00382	32330.15
MODEL 6	46.6	0.00122	33257.57

Table-1 Results obtained by Equivalent static analysis

RESPONSE SPECTRUM ANALYSIS			
MODELS	**TOP STOREY DISPLACEMENT (mm)**	**STOREY DRIFT (m)**	**BASE SHEAR (kN)**
MODEL 1	183.5	0.00551	32385.55
MODEL 2	130.5	0.00369	32603.67
MODEL 3	96.8	0.00256	32821.70
MODEL 4	84.3	0.00220	33039.56
MODEL 5	115.6	0.00315	32330.17
MODEL 6	40.5	0.00103	33322.43

Table-2: Results obtained by Response spectrum analysis

From the above table 1 and 2 under all parameters, model 6 is considered as the best and effective model to provide different sizes of openings.

3.4 ELEVATION AND 3D MODEL OF BUILDING WITH OPENINGS

MODEL 7: Shear wall with opening of 5x2 m

MODEL 8: Shear wall with opening of 4x2 m

MODEL 9: Shear wall with opening of 3x2 m

MODEL 10: Shear wall with opening of 2x2 m

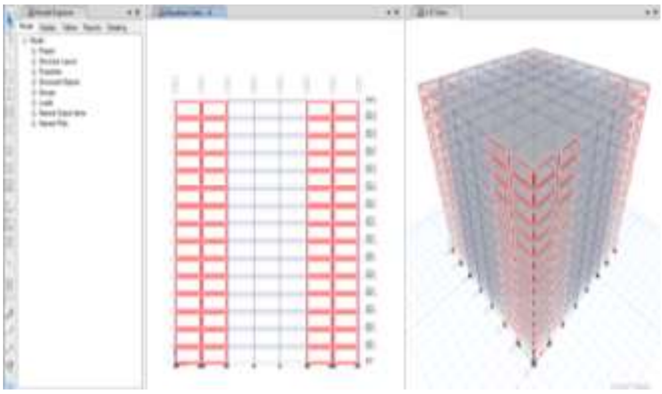


Fig-4: Opening of 5x2 m

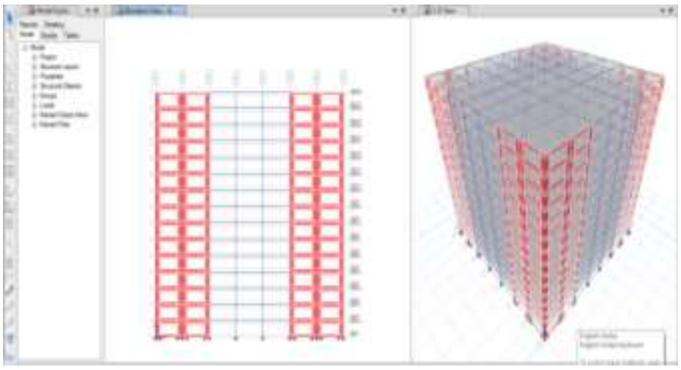


Fig-5: Opening of 4x2 m

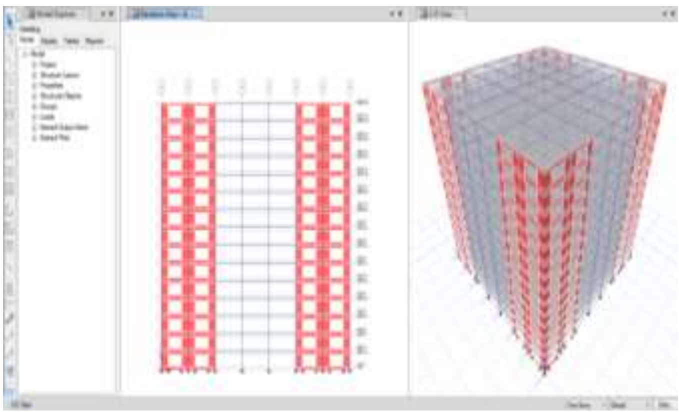


Fig-6: Opening of 3x2 m

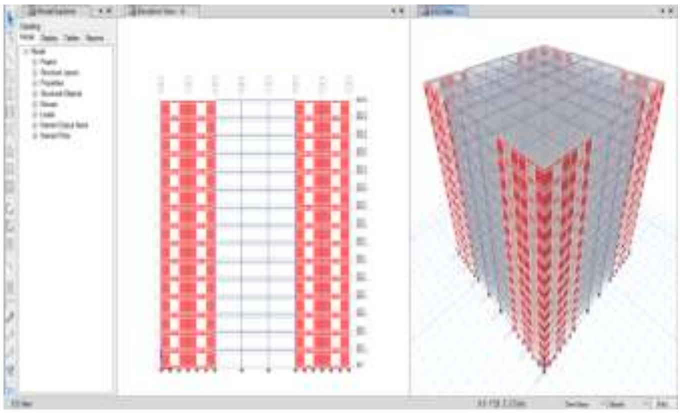


Fig-7: Opening of 2x2 m

4. RESULTS

The analysis of all the models considered are carried out by both Equivalent Static Method and Response Spectrum Method of analysis and the results are obtained for the parameters like Storey displacement, Storey drift and Base shear with respect to storey level as shown below

EQUIVALENT STATIC ANALYSIS			
MODELS	**TOP STOREY DISPLACEMENT (mm)**	**STOREY DRIFT (m)**	**BASE SHEAR (kN)**
MODEL 7	158.3	0.004531	31707.56
MODEL 8	129.8	0.003676	32024.04
MODEL 9	100.6	0.002797	32351.99
MODEL10	72.8	0.001948	32671.85

Table-3: Results obtained by Equivalent static analysis

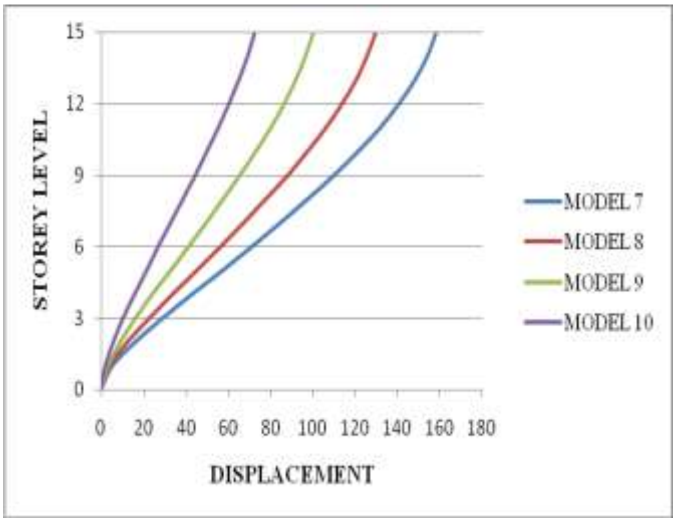


Chart1: Variation of Top storey displacement for ESA

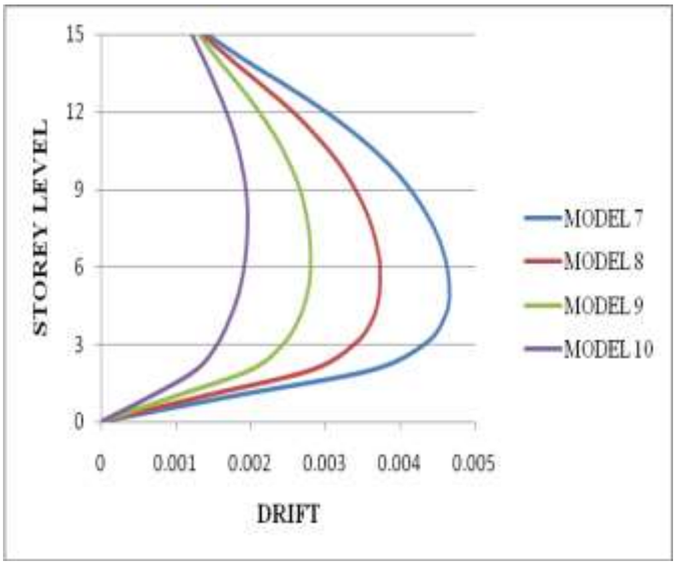


Chart-2: Variation of storey drift for ESA

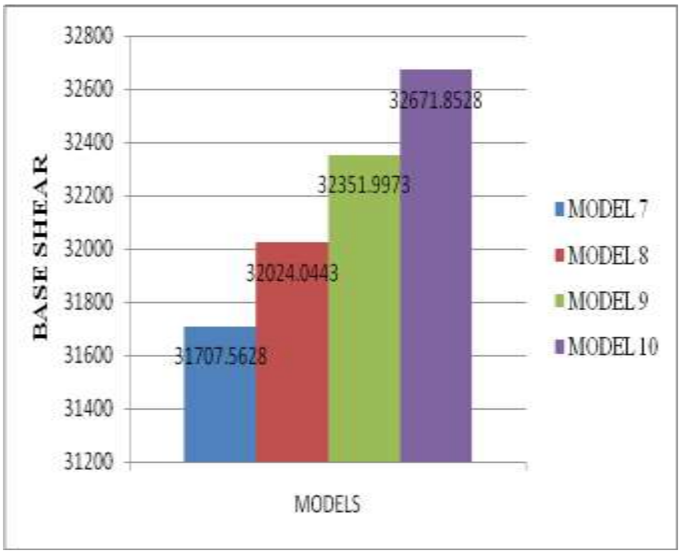


Chart-3: Variation of Base shear for EAS

RESPONSE SPECTRUM ANALYSIS			
MODELS	STOREY DISPLACEMENT (mm)	STOREY DRIFT (m)	BASE SHEAR (Kn)
MODEL 7	130.5	0.003827	31707.56
MODEL 8	107.7	0.003122	32024.04
MODEL 9	84.2	0.002391	32351.99
MODEL10	61.6	0.001675	32671.85

Table-4: Results obtained by Response spectrum analysis

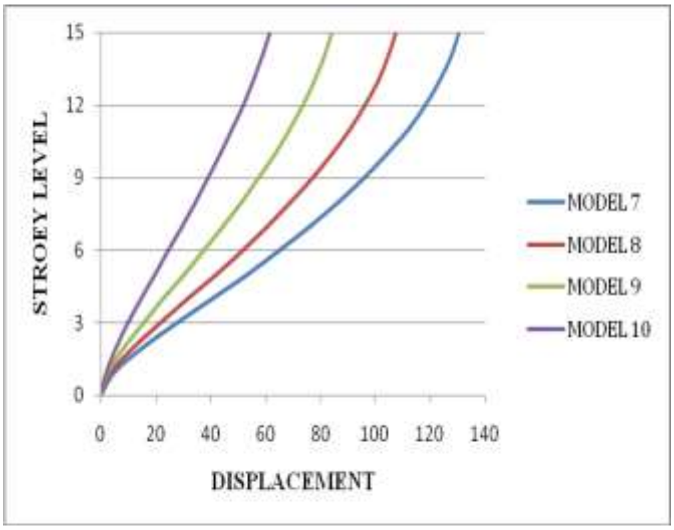


Chart-4: Variation of Top storey displacement for RSA

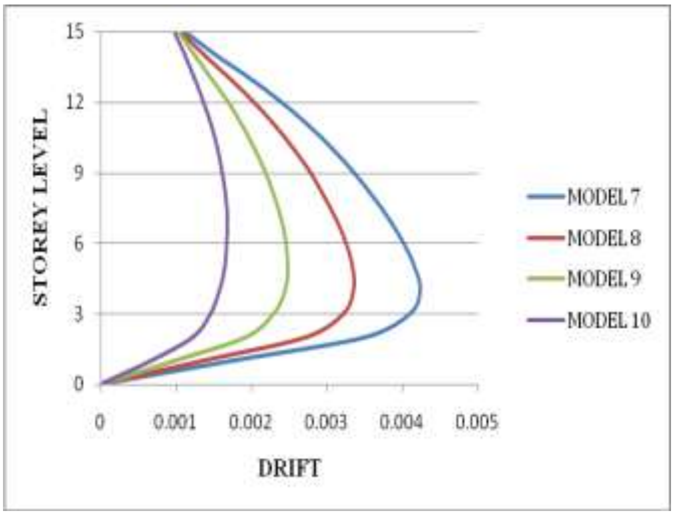


Chart-5: Variation of storey drift for RSA

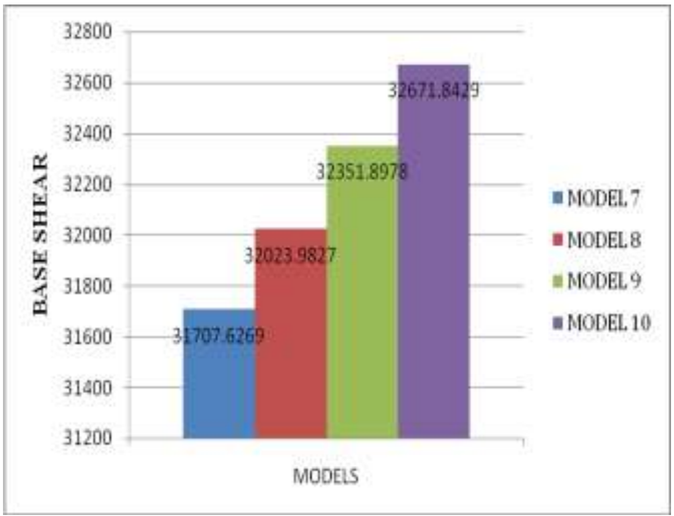


Chart-6: Variation of Base shear for RSA

5. CONCLUSION

In this paper various parameters like Base shear, Top Storey displacement and Storey drift in high rise building have been discussed. The following conclusions can be made from the studies,

1. The location of shear wall in the outermost perimeter considerably reduces the effect of storey displacement and storey drift.

2. Among all models, the MODEL 6 shows the better performance in terms of maximum Top storey displacement and storey drift, due to its increased stiffness and stability.

3. Here in MODEL 6, the extra 6m (one bay) of shear wall is increased at the corners in order to obtain the storey displacement within the permissible value. Therefore it is selected as best model to provide different sizes of openings.

4. After introducing the shear wall to MODEL 6, the parameters like Top storey displacement and storey drift are reduced up to 79% and 40% when compared with bare frame.

5. After providing different sizes of openings, it is observed that the maximum size of opening that can be provided is 2x2m to maintain the Top storey displacement well within the limiting value.

6. It is also observed that Top storey displacement and drift are increased up to 36% and 12% when compared between MODEL 6 and MODEL 10, but still the structure is safe under permissible limit.

7. Reduction of Top storey displacement and drift due to introduction of shear wall in the buildings , which makes the structure to behave as ideally stiff and also the risk of damaging structural elements is minimized.

8. By comparing between Equivalent Static analysis and Response spectrum analysis, the base shear remains the same, where as Top storey displacement and drift reduces up to 20% in Response spectrum analysis to that of Equivalent Static analysis.

REFERANCES

[1] N. Janardhan Reddy, D. Gose Peera, T. Anil kumar reddy (2015) “Seismic analysis of multi-storied building with shear walls using ETABS-2013”: International journal of science and research. Volume 4, issue 11.

[2] Mahdi hosseini, Proff. N.V. Ramana rao (2016) “Earthquake analysis of high rise buildings with shear walls at centre core and centre of each side of the external perimeter with opening”: International journal of science and research. Volume 5, issue 12.

[3] Reshma chavan, Proff. Ashok kankuntla, Proff. Prakarsh sangave (2016) “Effects of openings in shear wall”: Journal of mechanical and civil Engineering, Volume 13, issue 1.

[4] IS:1893(part 1) – 2002 criteria for earthquake resistant design of structures.

[5] Shahzad jamil sardar, Proff. Umesh .N. karadi (2013) “Effect of change in shear wall location on storey drift of multi-storey building subjected to lateral loads”: International journal of innovative research in science. Volume 2, issue 9.

[6] P.V.Sumanth chowdary, Senthil pandian.M (2014) “A comparative study on RCC structure with and without shear wall”: International journal for scientific research and development. Volume 2, issue 2.

[7] IS13920: 1993 Ductile detailing of reinforced concrete structures subjected to seismic forces – code of practice.

[8] IS: 875 (Part 1&2) 1987(Incorporating IS: 1911-1967) “Code of Practice for Design loads for Buildings and Structures”, BIS, New Delhi.

[9] IS: 456:2000 *(Fourth Revision)*“Plain and Reinforced Concrete - Code of practice”, BIS, New Delhi

[10] Suraj sangtiani, simon J, satyanayana J, dheeraj sangtiani (2017) “Performance of tall building under lateral loads with different type of structural system”: International journal of civil engineering and technology. Volume 8, issue 3, pp 1014-1022.