STUDY ON THE OPTIMUM LOCATION OF RC WALL IN REINFORCED CONCRETE BUILDING

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Abstract - *RC wall is a wall consists of concrete and reinforcement without bricks. The vertical element of a seismic force resisting system that is designed to resist in-plane lateral forces, typically wind and seismic loads are known as RC wall. It is also known as Seismic Wall. Reinforced concrete wall is designed as a compression member. Reinforced concrete wall is used in case where beam is not provided and load from the slab is heavy or when the masonry wall thickness is restricted. It is highly suitable for seismic zone areas. Nowadays, it is mostly used in seismic areas than a brick wall. The aim of this project is to determine the optimum location for RC wall in multi-storey building. For this purpose, nine different models G+7 storied building each has been considered i.e. one model without RC wall and others eight with RC walls in different positions. Models are studied in all the eight positions for comparing storey displacement, storey drift, storey shear, storey overturning moment and storey stiffness with different positioning of RC walls. Earthquake load is calculated as per IS: 1893-2002 (Part-1), the various parameters like response reduction factor, importance factor, zone factor are taken from IS: 1893-2002 (Part-1) and are applied to a building located in Zone V. The buildings are modeled using software ETABS 2017 Nonlinear v 17.1.0.Providing RC walls at adequate locations substantially reduce the displacement and increase in stiffness due to earthquake. The model having RC wall in one storey, RC wall in two storey, RC wall in three storey and RC wall in four storey; RC wall in first storey, RC wall in first and second storey, RC wall in first, second and third storey and RC wall in first, second, third and fourth storey respectively have minimum displacement with higher stiffness. Hence accounting RC wall in a building will form an efficient lateral force resisting system.*

Key Words: **RC wall, Storey displacement, Storey drift, Storey Shear, Overturning moment, Storey Stiffness etc.**

1. INTRODUCTION

Reinforced concrete wall is designed as a compression member and used in case where beam is not provided and load from the slab is heavy or when the masonry wall thickness is restricted. Also, it is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength or ductility. RC wall systems are one of the most commonly used lateral load resisting systems in high rise buildings.

An introduction of RC wall represents a structurally efficient solution to stiffen a building, because the main function of a RC wall is to increase the rigidity for lateral load resistance. In modern tall buildings, RC walls are commonly used as a vertical structural element for resisting the lateral loads that may be induced by the effect of wind and earthquakes. RC wall has high in-plane stiffness and strength which can be used to simultaneously resist large horizontal loads and support gravity loads, which significantly reduce lateral sway of the building and thereby reduce damage to structure. RC walls are like vertically-oriented wide beams which transfer these horizontal forces to the next element in the load path. It is possible for a Reinforced concrete multi-storey building to resist both the vertical and horizontal load without considering a RC wall, but the problem is beam and column sizes are become quite heavy, steel quantity requirement is also in large amount thus there is lot of congestion takes place at joints and it is difficult to place and vibrate concrete.

When RC walls are situated in advantageous positions in the building, they can form an efficient lateral force resisting system by reducing lateral displacements under earthquake loads. Therefore it is very necessary to determine effective, efficient and ideal location of RC wall. It may be possible to decide the optimum or ideal location of RC wall in a building by comparing various parameters such as storey displacement, storey (or) base shear, storey drift and reinforcement requirement in columns etc of a building under lateral loads based on strategic positioning of shear wall. In our project some of the above parameters are being calculated by using software E-TABS 17.0.1.

1.1 Objective of the Study

The most important objectives of present study include:

- To analyze the multi-storey building with RC wall using Equivalent static method, Response spectrum method and Time History Analysis method.
- To determine the optimum location of RC wall in multi-storey building which are subjected to lateral loads.
- Different location of RC wall in RC building will be modeled in E-TABS software and the results in terms of storey displacement, storey drift, storey shear, overturning moment and storey stiffness is compared.
- To determine the stresses on the building due to earth pressure.

2. MODELLING AND ANALYSIS

2.1 Modeling of Structures

Member of the structure like beam, column and strut were modeled as frame element with prismatic section with specific defined material properties of concrete, steel and masonry. The foundation level was assumed fixed and meshing of the shell element i.e. slab and RC wall was done. Concrete grade of M20 and steel of grade Fe415 were assigned as material for beam, column, slab and M30 for the RC wall. Slab and RC wall were modeled as shell element with slab having rigid diaphragm in each story level. Each model was designed as per IS 1893:2002 load combinations for linear static, response spectrum method and time history analysis method with medium soil type and seismic zone of V.

For this study, a G+7 stories building with 3 meters height for each story, regular in plan is modeled. This building consists of five spans of 4.5 meter in X direction and in Y direction as shown in figure 4.1. The square plan of all buildings measures 22.5m x 22.5m. RC wall is modeled with varying RC wall in storey wise. ETABS 2017 version 17.0.1 is used for the analysis of the model.

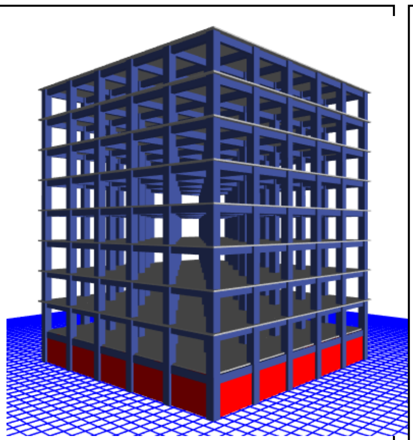

Figure 1:- Model 1 (3D View of the bare frame structure)

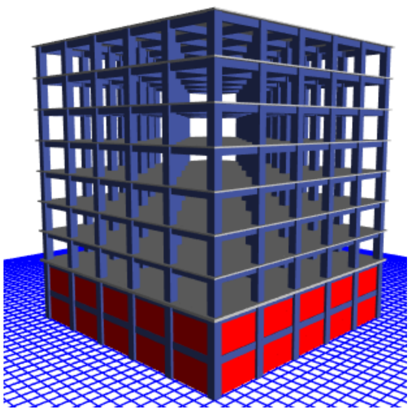

Figure 2:- Model 2 (3D View of the RC wall in first storey)

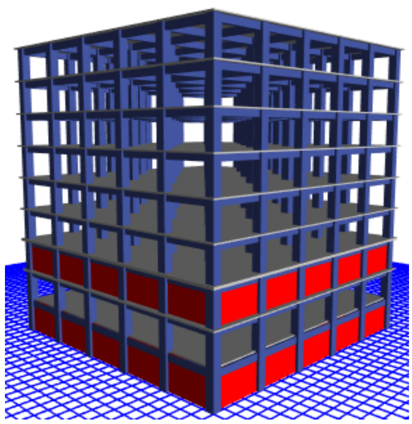

Figure 3:- Model 3 (3D View of the RC wall in second storey)

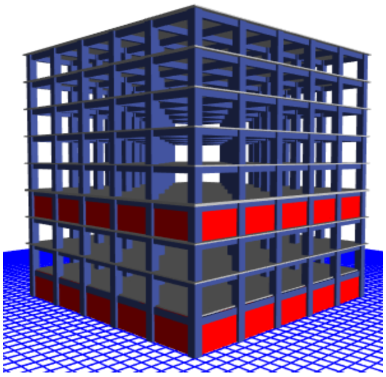

Figure 4:- Model 4 (3D View of the RC wall in third storey)

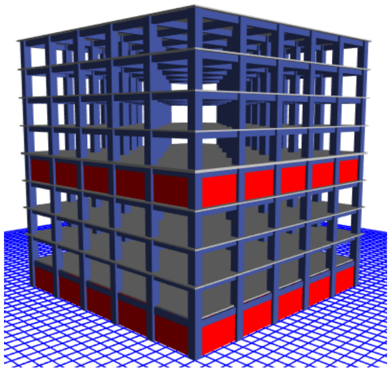

Figure 5:- Model 5 (3D View of the RC wall in fourth storey)

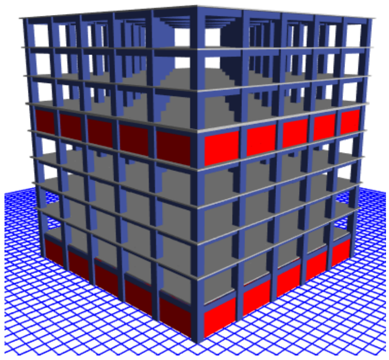

Figure 6:- Model 6 (3D View of the RC wall in fifth storey)

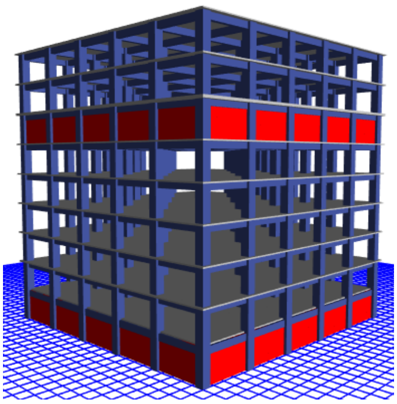

Figure 7:- Model 7 (3D View of the RC wall in sixth storey)

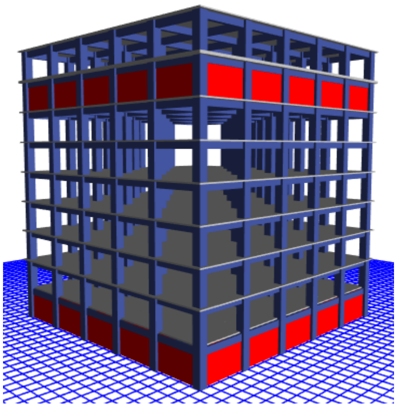

Figure 8:- Model 8 (3D View of the RC wall in seventh storey)

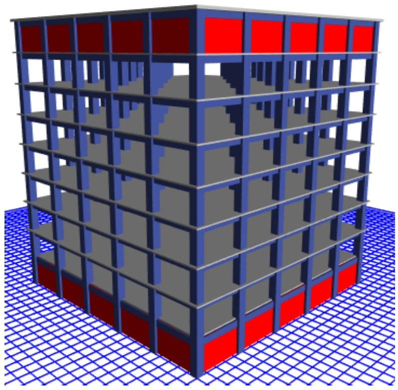

Figure 9:- Model 9 (3D View of the RC wall in eighth storey)

2.2 Load Calculations

The structure is subjected to three types of primary load as per the provision of IS Code of practice.

They are:

- Dead Load (From IS: 875-1987(Part I))
- Live load (From IS: 875-1987(Part II))
- Seismic Load (From IS: 1893-2002(part I))

2.3 Building Properties

Table -1: Material Properties

Parameters	Data	Units
Grade Of concrete, fck	M_{20}	MPa
Grade Of Steel	Fe 415	MPa
Specific Weight of RC	25	KN/m^3
Poisons Ratio of Concrete	0.2	
Modulus of Elasticity Concrete (M_{20})	22360.68	MPa
Floor Height	3	m
Impose Load	4	KN/m^2
Floor Finish Load	1	KN/m^2
RC wall and Basement Wall thickness	230	mm
Slab thickness	125 for 1^{st} to 7^{th} Storey	mm
	100 for 8^{th} Storey	mm
Size of Column	700x700	mm x mm
Size of Beam	600x350	mm x mm
Grade Of concrete, fck in RC wall and Basement Wall	M_{30}	MPa

2.4. Method of analysis

In the study, the analysis of the high rise structure is carried out for lateral loads using Equivalent Static Method, Response spectrum method and Time History analysis method.

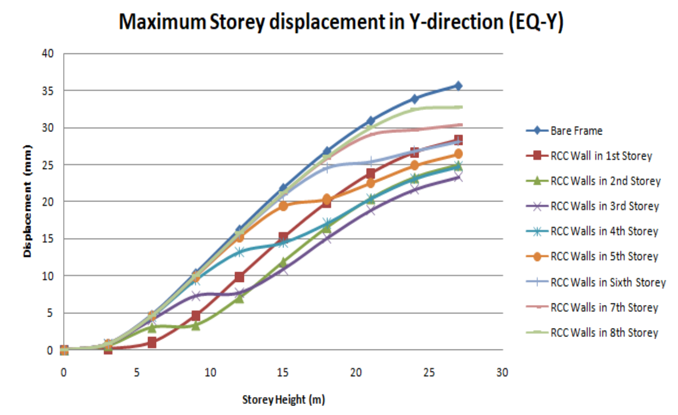

Chart 1:- Storey height level displacement in Y-direction (EQY) by Equivalent Static Method.

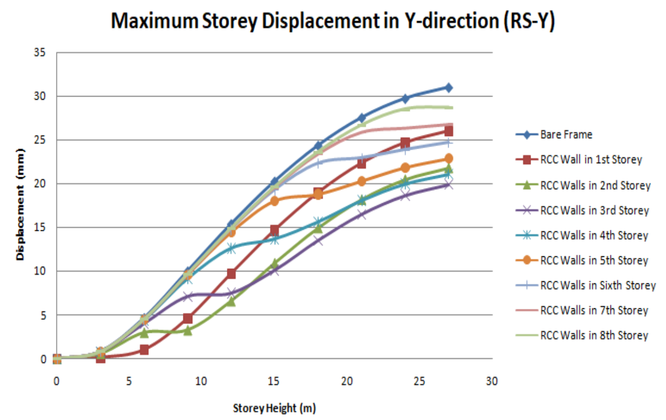

Chart 2:- Storey height level displacement in Y-direction (RS-Y of RSM) by Response Spectrum Method.

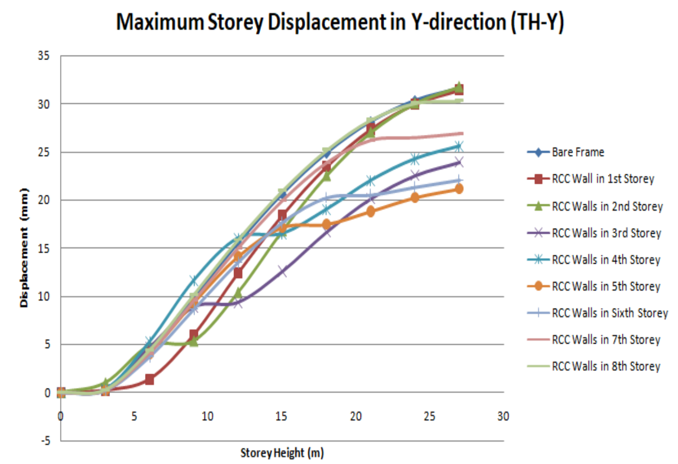

Chart 3:- Storey height level displacement in Y-direction (TH-Y) by Time History Analysis Method.

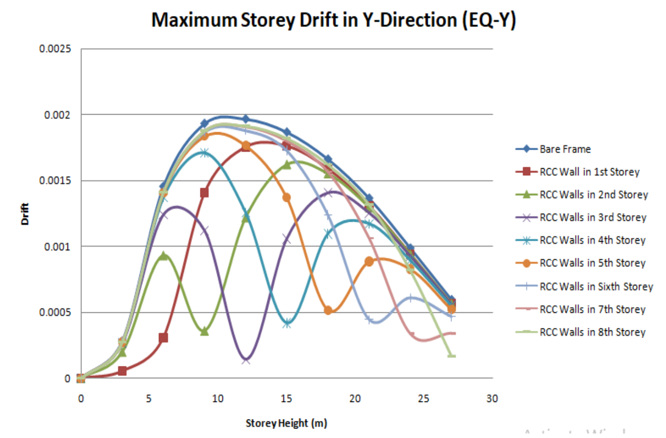

Chart 4:- Storey height level drift in Y-direction (EQY) by Equivalent Static Method.

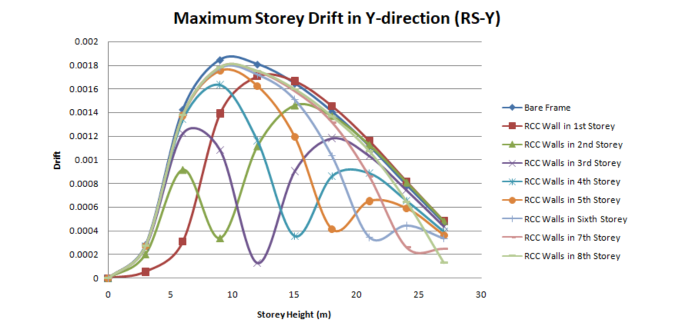

Chart 5:- Storey height level drift in Y-direction (RS-Y of RSM) by Response Spectrum Method.

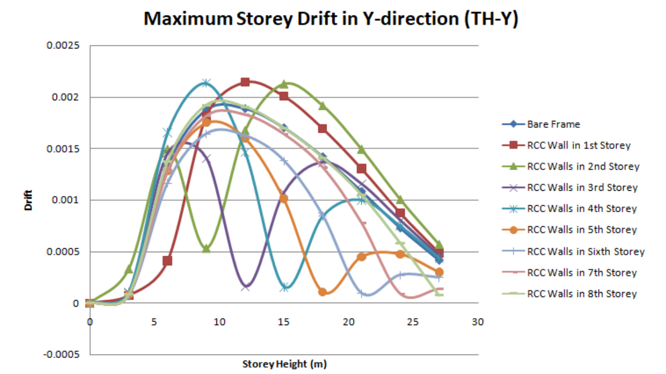

Chart 6:- Storey height level drift in Y-direction (TH-Y) by Time History Analysis Method.

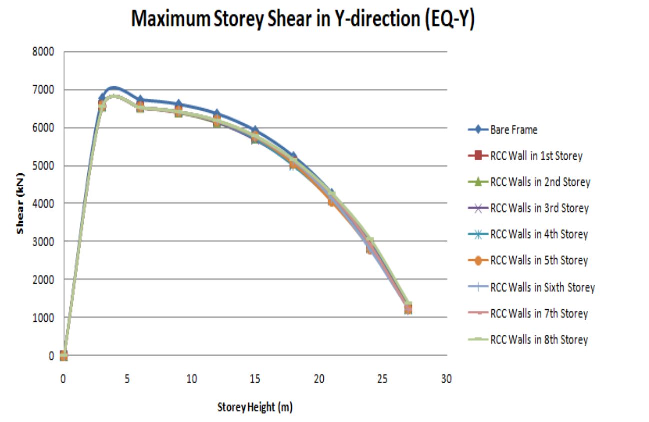

Chart 7:- Storey height level shear in Y-direction (EQY) by Equivalent Static Method.

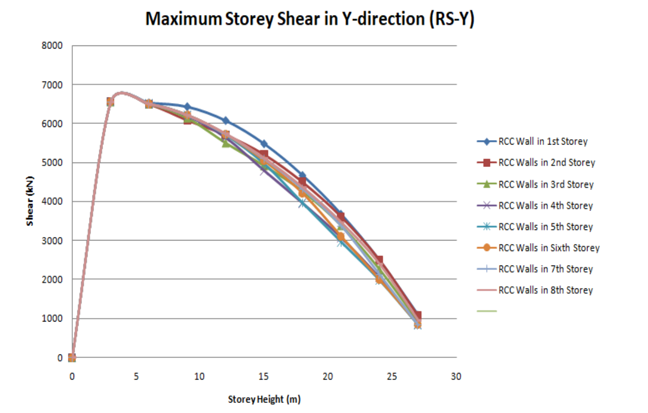

Chart 8:- Storey height level shear in Y-direction (RS-Y of RSM) by Response Spectrum Method.

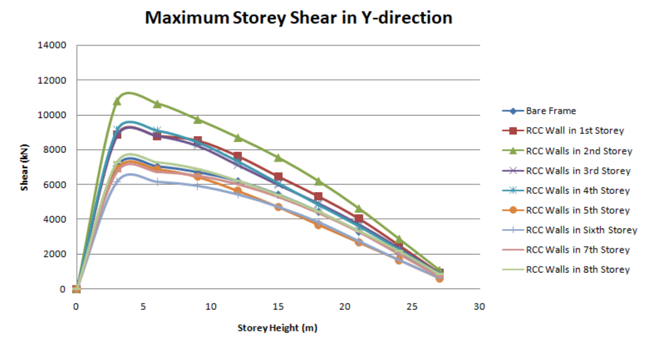

Chart 9:- Storey height level shear in Y-direction (TH-Y) by Time History Analysis Method.

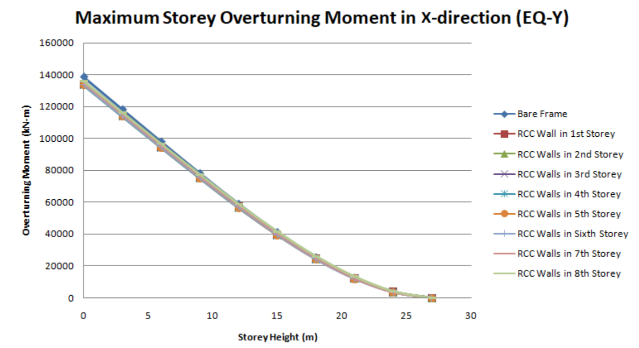

Chart 10:- Storey height level Overturning moment in Y-direction (EQY) by Equivalent Static Method.

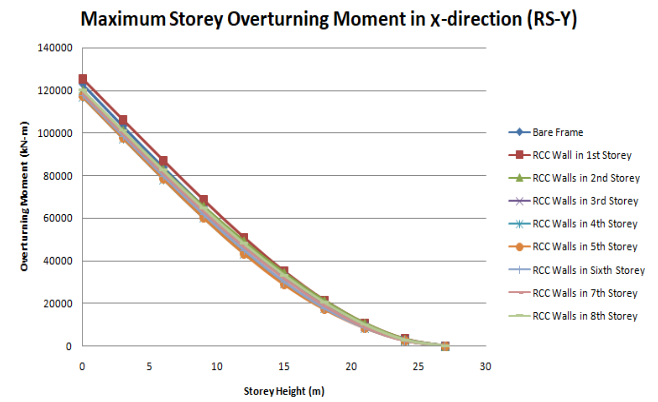

Chart 11:- Storey height level Overturning moment in Y-direction (RS-Y of RSM) by Response Spectrum Method.

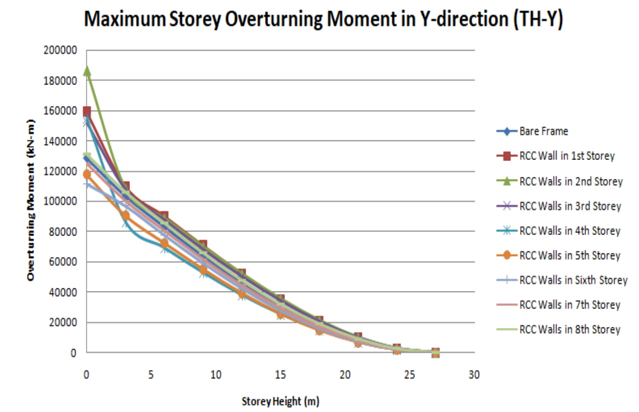

Chart 12:- Storey height level Overturning moment in Y-direction (TH-Y) by Time History Analysis Method.

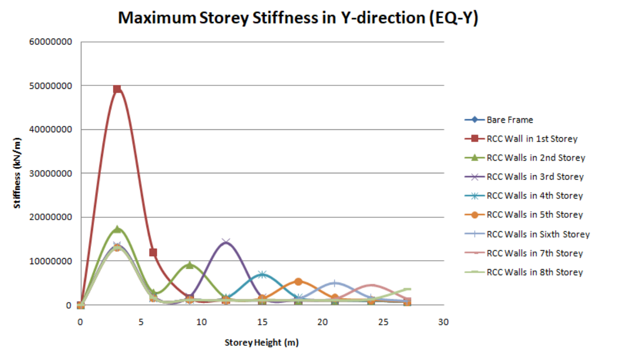

Chart 13:- Storey height level stiffness in Y-direction (EQY) by Equivalent Static Method.

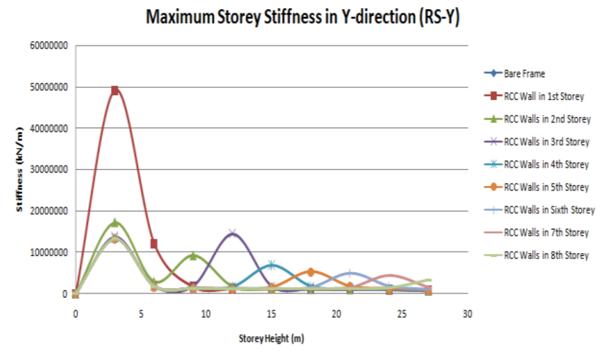

Chart 14:- Storey height level stiffness in Y-direction (RS-Y of RSM) by Response Spectrum Method.

2.5. Stress analysis due to Earth pressure

Table 2:- Stress analysis of Structure with different location of RC Wall

Positioning of RC Wall in		S max (MPa)	C0-ordinate	S min (MPa)	Co-ordinate
Bare frame	Max	0.8	[0,15.75,0]	0.18	[0,2.25,1.5]
	Min	0.07	[0,22.5,0]	-0.13	[0,13.5,0.75]
First Storey	Max	0.8	[11.25,22.5,0]	0.16	[2.25,0,1.5]
	Min	-0.03	[13.5,13.5,3]	-0.13	[0,18,0.75]
Second Storey	Max	0.82	[11.25,22.5,0]	0.17	[0,2.25,1.5]
	Min	-0.03	[9,9,3]	-0.13	[18,22.5,0.75]
Third Storey	Max	0.8	[6.75,0,0]	0.18	[22.5,2.25,1.5]
	Min	0	[11.25,22.95,21]	-0.13	[0,13.5,0.75]
Four Storey	Max	0.8	[6.75,0,0]	0.18	[22.5,2.25,1.5]
	Min	0	[11.25,23.1,21]	-0.13	[22.5,13.5,0.75]
Fifth Storey	Max	0.8	[15.75,0,0]	0.18	[22.5,2.25,1.5]
	Min	0	[11.25,22.95,18]	-0.13	[0,13.5,0.75]
Sixth Storey	Max	0.8	[15.75,22.5,0]	0.18	[22.5,20.25,1.5]
	Min	0	[0,4.5,18]	-0.13	[22.5,13.5,0.75]
Seventh Storey	Max	0.8	[15.75,22.5,0]	0.18	[22.5,2.25,1.5]
	Min	0	[0,18,21]	-0.13	[0,13.5,0.75]
Eight Storey	Max	0.8	[6.75,22.5,0]	0.18	[0,2.25,1.5]
	Min	0	[22.5,12.375,25.5]	-0.13	[0,13.5,0.75]

3. CONCLUSIONS

After Equivalent Static Analysis, Response Spectrum Analysis and Time History Analysis of eight storied structures using earthquake loading according to IS 1893:2002 by locating RC walls at different position, the following conclusions can be drawn.

- When we look towards the model having RC wall in each storey, RC wall in first Storey have minimum displacement with higher stiffness. So, this position of RC wall in a structure is optimum location.
- When we look towards the chart for the value of storey displacement, storey drift and storey shear, Equivalent Static method gives the higher value than Time History Analysis method and Response Spectrum method.
  i.e. Equivalent Static method >Time History Analysis method >Response Spectrum method.
- The maximum stress (Smax) is at second storey with the value of 0.82 MPa at co-ordinate [11.25, 22.5, 0] and minimum stress (Smin) is at first storey with the value of 0.16 MPa at co-ordinate [2.25, 0, 1.5].
- Also we can conclude that, when the storey height increases displacement increases but in case of rest of other parameters storey height is inversely proportional to storey drift, storey shear, overturning moment and stiffness.

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