International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 02 | Feb 2021 www.irjet.net p-ISSN: 2395-0072

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

Bibek Baral[1], Chhabiraj Ghimire[2]

[1]Consultant, Sunrise Engineering Consultancy Services, Gandaki, Nepal
[2]Lecturer, School of Engineering, Pokhara University, Gandaki, Nepal

---***---

Abstract - *Shear wall system is one of the most commonly used lateral-load resisting technique for high-rise buildings. Shear walls have very high in-plane strength and stiffness, which can be used simultaneously for resisting large horizontal and gravity loads. In tall buildings, it is very important to ensure adequate lateral stiffness to resist lateral load. The aim of this project is to determine the solution for Shear wall location in multi-storey building. For this purpose, G+7 storied building with Shear wall in six different positions has been considered i.e. one model is bare frame in each location of Shear and rest of others with Shear walls in different positions. Models are studied in all positions for comparing storey displacement, storey drift, storey Shear, storey overturning moment and storey stiffness with different positioning of Shear wall. 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.Among the various location of Shear wall, Shear wall in interior core yields minimum displacement with maximum stiffness. Hence, accounting Shear wall in a building will form an efficient lateral force resisting system*

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

1. INTRODUCTION

Shear 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. Shear wall systems are one of the most commonly used lateral load resisting systems in high rise buildings.

An introduction of shear wall represents a structurally efficient solution to stiffen a building, because the main function of a shear wall is to increase the rigidity for lateral load resistance. In modern tall buildings, shear 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. Shear 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. Shear 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 shear 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 shear 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 shear wall. It may be possible to decide the optimum or ideal location of shear 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 shear wall using Equivalent static method, Response spectrum method and Time History Analysis method.
- To determine the optimum location of shear wall in multi-storey building which are subjected to lateral loads.
- Different location of shear 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 shear wall was done. Concrete grade of M20 and steel of grade Fe415 were assigned as material for beam, column, slab and M30 for the shear wall. Slab and shear 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. Shear wall is modeled with varying shear wall in storey wise. ETABS 2017 version 17.0.1 is used for the analysis of the model.

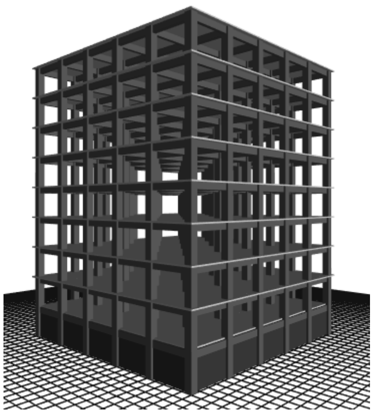

Figure 1:- Model 1 (3D View of the bare frame structure)

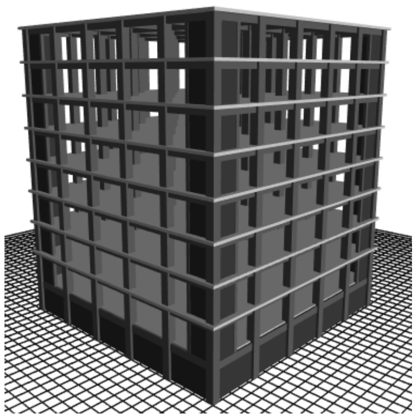

Figure 2:- Model 2 (3D View of the shear wall in four corners)

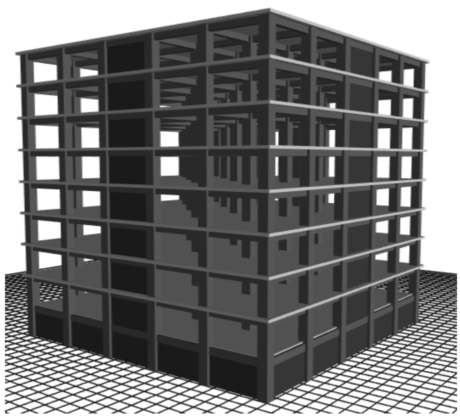

Figure 3:- Model 3 (3D View of the shear wall in the middle of four outermost sides)

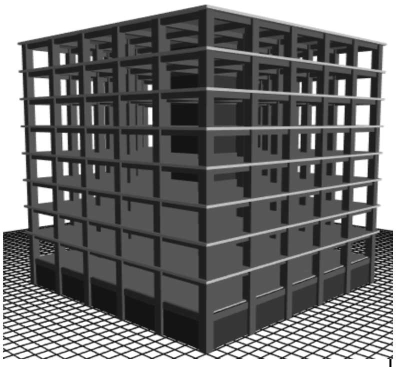
Figure 4:- Model 4 (3D View of the shear wall in interior core)

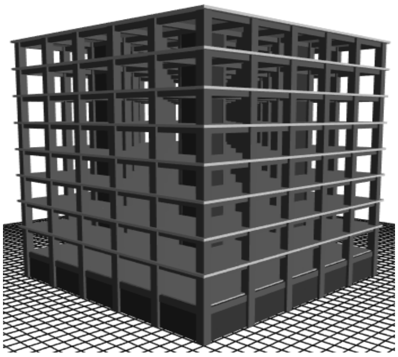
Figure 5:- Model 5 (3D View of the shear wall in between interior and exterior core)

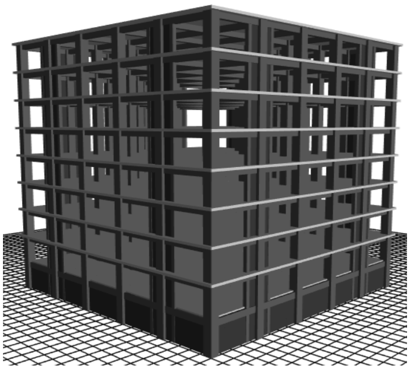
Figure 6:- Model 6 (3D View of the shear wall in the direction parallel to both X and Y-axis

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 RCC	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
Shear wall and Basement Wall thickness	230	mm
Slab thickness	125 for 1st to 7th Storey	mm
	100 for 8th Storey	mm
Size of Column	700x700	mm x mm
Size of Beam	600x350	mm x mm
Grade Of concrete, fck in 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.

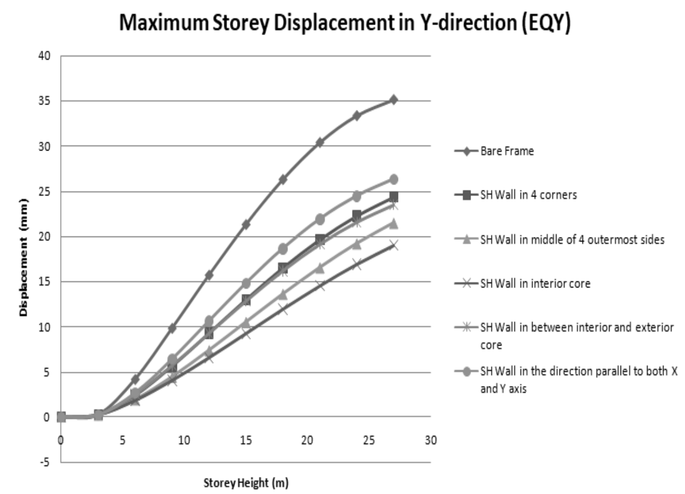

Chart 1:- Storey height level displacement in Y-direction (EQY) by Equivalent Static Method.

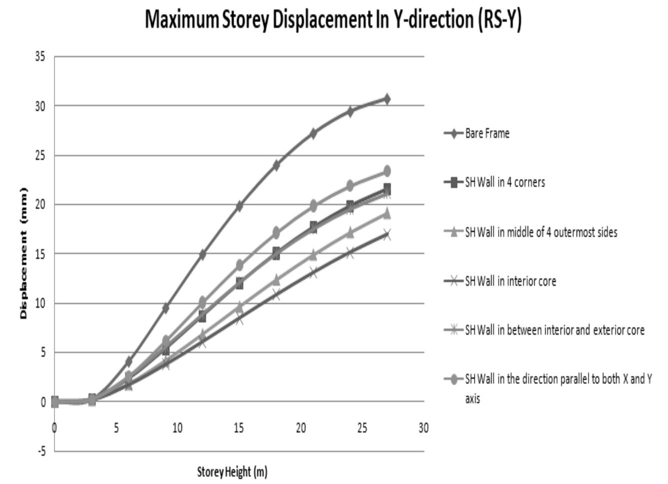

Chart 2:- Storey height level displacement in Y-direction (RS-Y of RSM) by Response Spectrum Method.

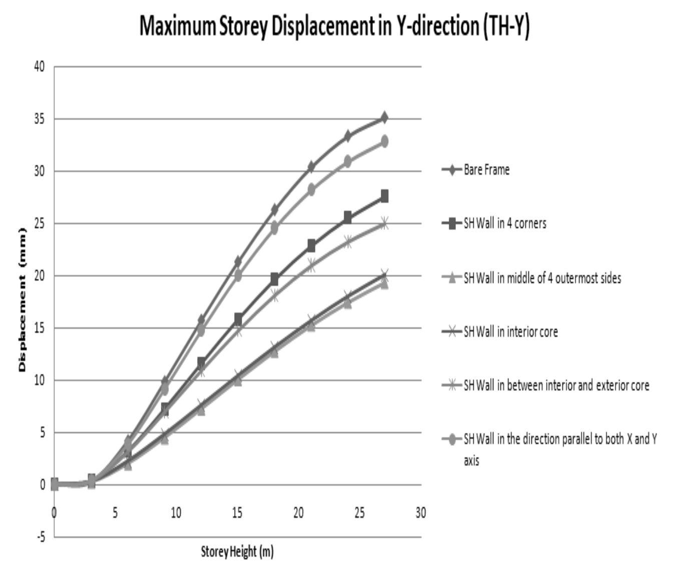

Chart 3:- Storey height level displacement in Y-direction (TH-Y) by Time History Analysis Method.

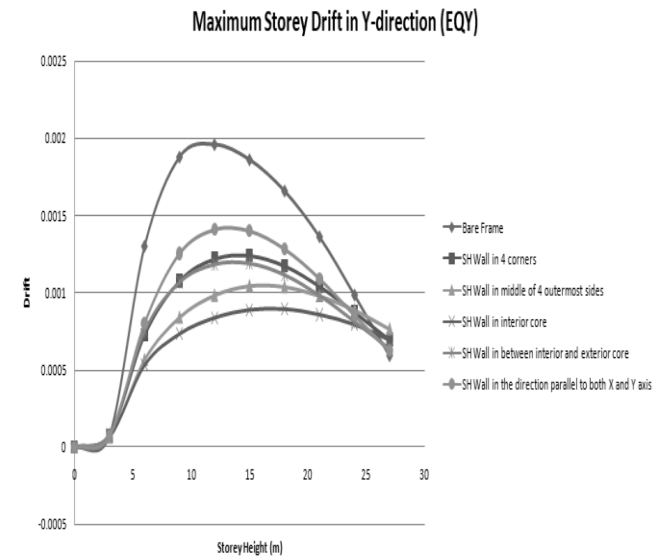

Chart 4:- Storey height level drift in Y-direction (EQY) by Equivalent Static Method.

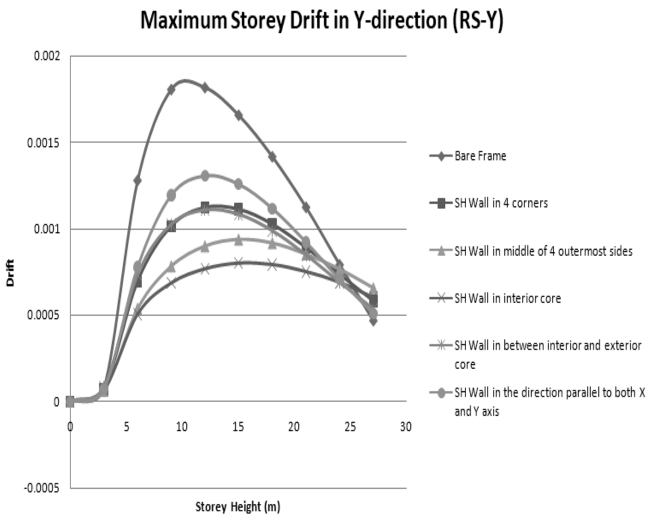

Chart 5:- Storey height level drift in Y-direction (RS-Y of RSM) by Response Spectrum Method.

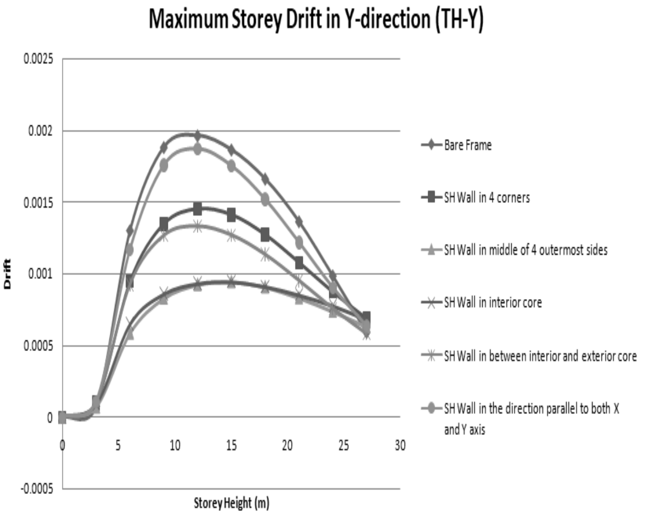

Chart 6:- Storey height level drift in Y-direction (TH-Y) by Time History Analysis Method.

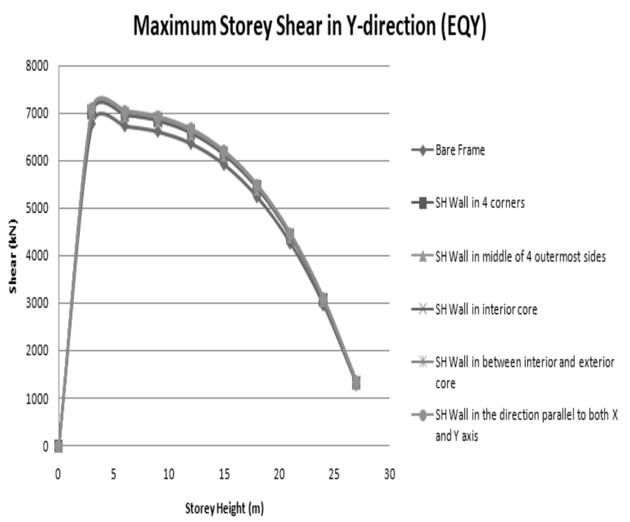

Chart 7:- Storey height level Shear in Y-direction (EQY) by Equivalent Static Method.

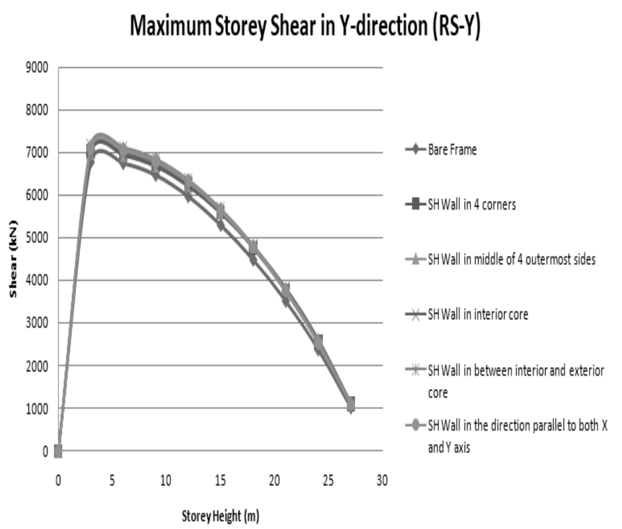

Chart 8:- Storey height level Shear in Y-direction (RS-Y of RSM) by Response Spectrum Method.

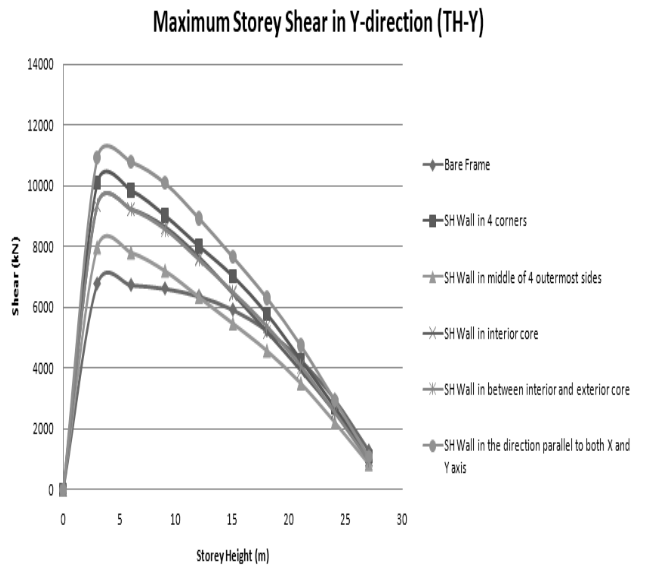

Chart 9:- Storey height level Shear in Y-direction (TH-Y) by Time History Analysis Method.

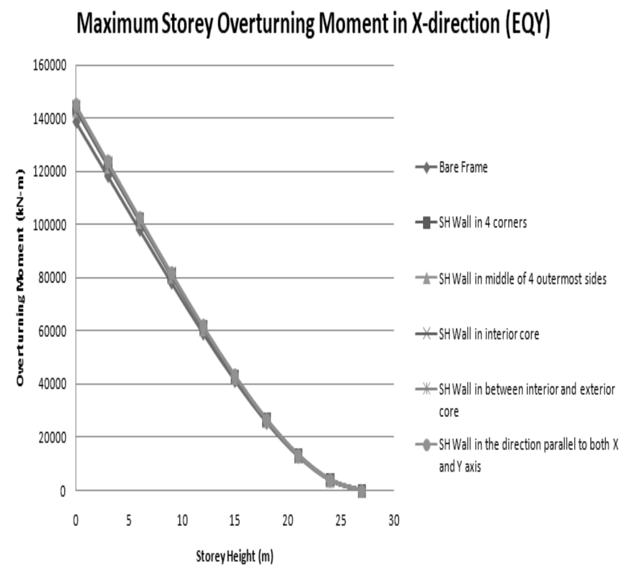

Chart 10:- Storey height level Overturning moment in Y-direction (EQY) by Equivalent Static Method.

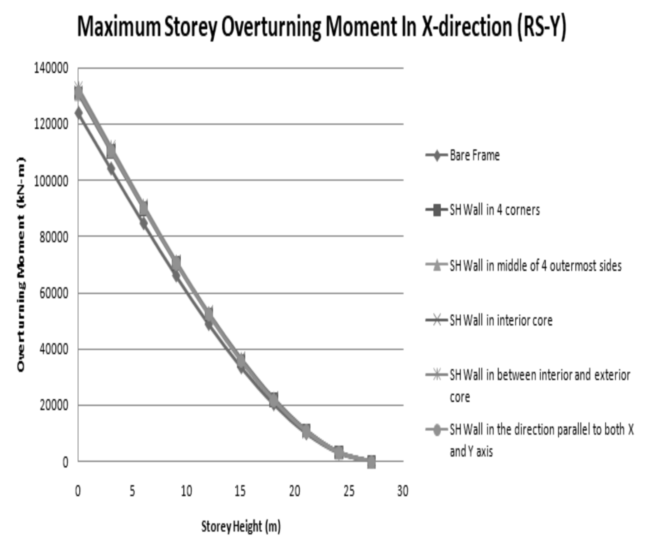

Chart 11:- Storey height level Overturning moment in Y-direction (RS-Y of RSM) by Response Spectrum

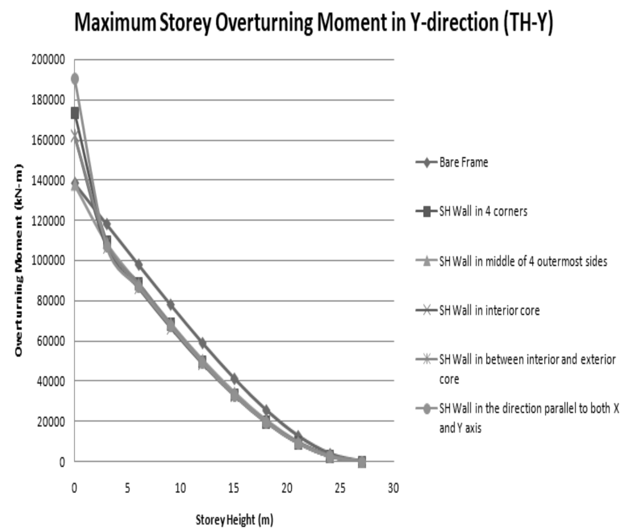

Chart 12:- Storey height level Overturning moment in Y-direction (TH-Y) by Time History Analysis Method.

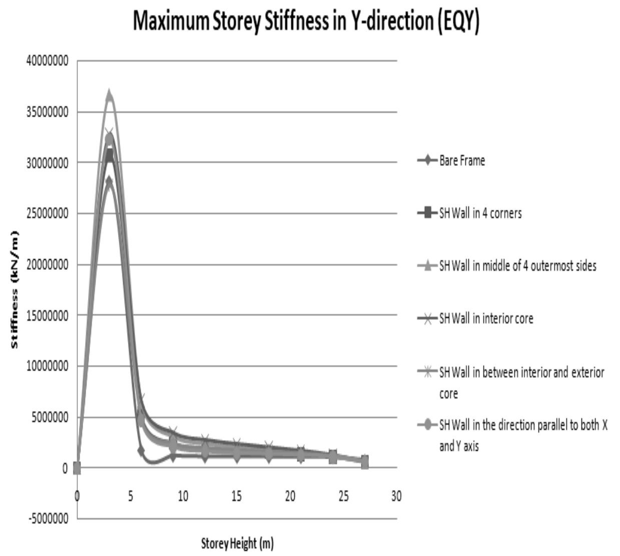

Chart 13:- Storey height level Stiffness in Y-direction (EQY) by Equivalent Static Method.

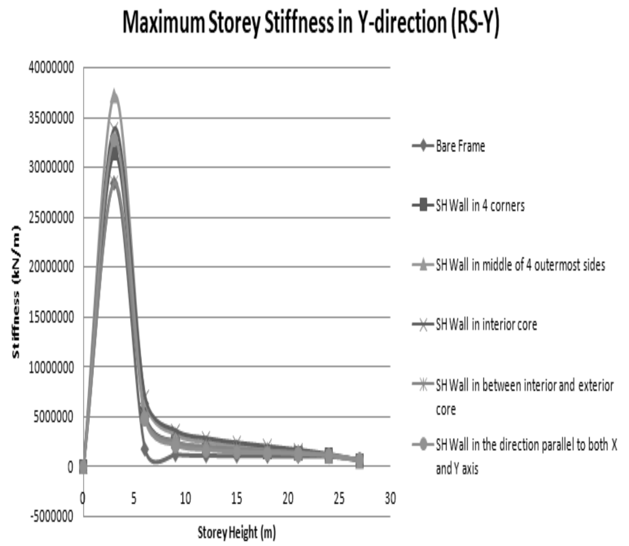

Chart 14:- Storey height level Stiffness in Y-direction

2.5. Stress analysis due to Earth pressure

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

Positioning of SHEAR 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 Shear walls at different position, the following conclusions can be drawn.

- From the above analysis, it is observed that shear wall placed at interior core shows better response with less displacement and higher stiffness than that of shear wall placed at four corners and by sides. It is clear that by providing shear walls about 20% of the side length at central core, we can decrease the top displacement by 51.42% and increase of storey stiffness by 76.71% than the structures without shear walls. The displacement is less in such model is due to box action where all the walls are interconnected and resist the force by each other. Model with shear wall at the central core gives good ductile character than rest of other five models considered. So, shear wall placed at interior core is the optimum location.
- Storey drift is minimum at centrally located shear wall building. It is clear that by providing shear walls in interior core, we can decrease the storey drift by 42.1% than the structures without shear walls.
- It is observed that placing shear walls away from the center of gravity resulted in increase in most of member forces and overturning moment. Overturning moment is increased by 10% when shear wall is placed away from center of gravity.
- 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].

ACKNOWLEDGEMENT

I extend my sincerest gratitude to my parents, my friends, my corresponding author and my well wishers who had constantly encouraged me and helped me in all situations whenever needed during this research completion. A special thanks to Faculties of Science and Technology, School Of Engineering families for their kind support.

REFERENCES

[1] M. Kondapalli (2018), "Optimum Location of a Shear wall in a RC Building". International Journal of Scientific and Engineering Research, Volume 9, Issue 7, July-2018 ISSN 2229-55

[2] T. Magendra, A. Titiksh and A. Qureshi (2016), "Optimum Positioning of Shear Walls in Multistorey Buildings". International Journal of Trend in Research and Development, Volume 3(3), ISSN: 2394-9333.May-Jun 2016.

[3] S. Anshumn, D. Bhunia, B. Rmjiyani (2011), "Solution of Shear wall location in Multi-storey building." International Journal of Civil Engineering Vol. 9, No.2Pages 493-506.

[4] A. Chandiwala (2012), "Earthquake Analysis of Building Configuration with Different Position of Shear Wall", International Journal of Emerging Technology and Advanced Engineering ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 2, Issue 12, December 2012, Adhoc Lecturer in Sarvajanik College of Engineering & Technology, Athvalines, Surat, Gujarat, India.

[5] A. Karnale and D. Shinde (2015), "Comparative Seismic Analysis of High Rise and Low Rise SHEAR Building with Shear Wall", International Journal of Innovative Research in Science, Engineering and Technology, September 2015.

[6] C. Qin and Q. Jiaru (2002), "Static inelastic analysis of RC Shear walls", department of civil engineering, Tsinghua University, Beijing 100084, China.

[7] IS. 456-2000, Indian standard Plain and Reinforced Concrete code of practice, Bureau of Indian standards, New Delhi.

[8] IS 1893 (Part 1): (2002) Indian Standard Criteria for Earthquake Resistant Design of Structures General Provisions and Buildings.

[9] B. Kameshwari, G. Elangovan & G. Vaisakh (2011). "Dynamics Response of High Rise Structures under the Influence of Discrete Staggered Shear Walls". International Journal of Engineering Science and Technology.

[10] M. Aainawala, P. Pajgade (2014). "Design of multistoried R.C.C buildings with and without Shear walls". International Journal of Engineering Sciences and Research Technology.

[11] P. Chandurkar, P. Pajgade (2013). "Seismic analysis of SHEAR building with and without Shear wall". International Journal of Modern Engineering Research.

[12] S. Bhat, A. Rao. "Earthquake Behavior of Buildings with and Without Shear Walls". IOSR Journal of Mechanical and Civil Engineering.

[13] S. Kamal, M. Azam, V. Hosur (2013) "Seismic Performance Evaluation of Multistoried RC framed buildings with Shear wall". International Journal of Scientific & Engineering Research.

[14] M. Atif, L. Vairagade, V. Nair (2015). "Comparative study on seismic analysis of multistorey building stiffened with bracing and Shear wall".

[15] P. Agarwal and M. Shrikhande (2006) "Earthquake Resistant design of structures". Prentice hall of India Pvt.Ltd.India.

[16] FEMA 273, Seismic rehabilitation guidelines, Systematic Rehabilitation, Chapter 7, Clause 7.3.2.1, 1997.

[17] IS 875:1987, code of practice for design load for buildings and structures (Part 2). Bureau of Indian Standards, New Delhi. IS 13920:1993, Ductile Detailing of reinforced concrete structures subjected to seismic force. Bureau of Indian Standards, New Delhi.

[18] V. Bertero and E. Popov. "Seismic behavior of ductile moment resisting reinforced concrete." ACI publication SP-53, American Concrete Institute Detroit, 1977.

[19] T. Paulay and M. Priestly (1992),"Seismic design of reinforced concrete and masonry buildings" (John Wiley and Sons, Inc.USA).

BIOGRAPHIES

Consultant, Sunrise Engineering Consultancy Services.

Lecturer, School Of Engineering, Pokhara University.