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Behaviour of Multistorey Building under the Effect of Wind and Earthquake for Different Configuration of Shear Wall

Aneeket T. Patil[1] and Sachin B. Kadam[2]

[1]S.Y. MTech, Walchand College of Engineering, Sangli
[2]Walchand College of Engineering, Sangli
E-mail: [1]patilaneeket@gmail.com, [2]sachin.kadam@walchandsangli.ac.in

Abstract—*As the world move towards the implementation of performance based engineering philosophies in seismic design of civil engineering structures; structural engineer appeals nonlinear analysis for the design of tall structures. India is projected to be the world's most populous country by 2022, surpassing China, its population reaching 1.6 billion by 2050. So to accommodate large number of population in the urban area as there is not enough space available on the horizontal ground, there is need to expand vertically. So the analysis and design of high-rise buildings for lateral load such as wind load and earthquake are the challenges to structural engineering committee. Generally shear wall has been proved one of the best lateral load resisting system having very high in-plane stiffness and strength, to resist large horizontal loads and support gravity loads, making them quite beneficial in seismic performance of buildings.*

However, there is need of study to locate shear wall at appropriate location in multistory building and its effect on performance against earthquakes and wind. It is not much discussed in the literatures. So there is need of indepth study for different configuration of shear walls in multistorey building and its analysis for wind and earthquake effect.

This paper address at designing and modelling of multistorey building for different configuration in terms of height and location of shear wall using ETABS. Linear and non-linear analysis of different modelled buildings and to compare the results with respect to base shear and displacement to find best suitable configuration of building for different location of shear walls in multistorey building.

Keywords*: High-rise buildings, shear walls, seismic and wind load, base shear, displacement.*

1. INTRODUCTION

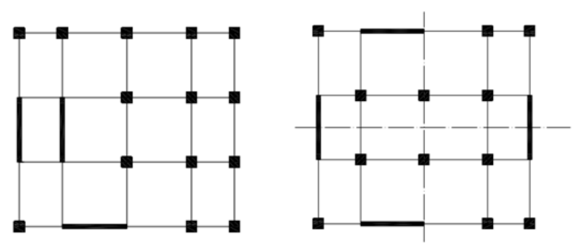
A large portion approximately 59% of Indian land is susceptible to damaging levels of seismic hazards due to earthquakes, floods, cyclones, landslides, etc. Population of India is increasing at alarming rate. This large population not only needs job but also needs housing and infrastructure facilities. With the advent of Industrial policy most industries are coming in middle level cities and large cities. Hence, large population is migrating to these cities. Medium or High rise is the only answer to this urbanization. Land is becoming scarce and therefore, there is the urgent need to build multistorey structures in greater number in these cities. At present these cities are expanding horizontally in mix manners but with the scarcity of land there is need for vertical expansion. Hence, the concept of multistoried buildings or high rise buildings comes into existence.

The response of structures under wind and earthquake effects becomes crucial issues in design where the researchers are working globally and finding effective disaster mitigating techniques so that the structures remain in acceptable function during disaster. In case of low-rise buildings effects of earthquake and wind are not so important during designing. But as height of buildings goes on increasing, the effects of both earthquakes and wind increases. Therefore, it is essential to consider effects of lateral loads induced from earthquakes and wind. In present study, buildings with different heights are modelled to know the effects of height on performance of building under wind and earthquake forces so as to check the performance of high rise buildings under earthquake forces and wind forces.

As part of study, initially efforts have been made to study twelve storey framed structure subjected to a variety of earthquake excitations. This study concluded that the maximum inter storey drifts due to the design earthquake are not greater than 0.01 of the storey height and suggested that for inelastic frames, increasing the strength, rather than stiffness offers the most effective means of controlling the increase in displacements and later on it was extended for high rise buildings with same configuration in plan but variation in heights [1]. Also the study of behaviour of multistorey building with openings for different terrain conditions and velocity of wind, to obtain significant relations of moments, forces and displacement with wind speeds was carried out [2]. The multistorey buildings situated in wind zone VI and seismic zone V of India was studied for the severity of wind forces against seismic forces [3].

1.1 Shear wall

The various studies made over worldwide have proved shear wall as one of the most preferred lateral load-resisting systems [4-6-7]. Arrangement of plan by coinciding centroid and mass center of the building is the ideal configuration for a structure. So in order to avoid torsional movement in the building, there should be symmetrical placement of shear wall. 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 which cause the failure of structure. Shear walls of varying cross sections i.e. rectangular shapes to more irregular cores such as channel, T, L, barbell shape, box etc. can be used.



(a) **(b)**

Fig. 1.1 Unsymmetrical and Symmetrical placing of shear wall

The size and location of openings may vary from architectural and functional point of view. It has been proven that this system provides efficient structural system for multistorey building in the range of 30-35 storeys by Marsono and Subedi [5].

The displacement and base shear of the multistorey structure for different configurations of shear wall only for seismic forces was studied and was compared with that of bare frame [6]. The different position of shear walls can reduce the top story drift of the structure [7]. To determine the strength of RC shear wall of a multistoried building by changing shear wall location, three different cases of shear wall position for a six storey building was analyzed. Also different load combinations applied on the structure can be used to determine deflection, shear force and bending moment [8]. The analysis on three different models, one with bare frame and other two for parallel and non-parallel shear wall system was done. It was observed that the lateral displacement and the storey drift for the structure with parallel shear wall (PSW) was less compared to the other two structures. From the analysis carried out, it was concluded that the structure with PSW is much efficient than the other two structures i.e., non-parallel shear wall (NPSW) and without shear wall (WSW) during lateral force [9].

Although past researchers have studied different configuration of shear wall, some drawbacks remain to be solved. One of them is indepth study for different configuration of shear wall in multistorey structure and its analysis for wind and earthquake effect.

1.2 Analysis of Tall structures:

Designing and analysis of tall structure is very challenging task for structural engineer. Different structural components like beam, column, slab, etc. are to be designed by considering loads coming on that component. In this study, effort has been made to calculate sizes of different structural components by considering dead and live load acting on it and have been checked for gravity loading.

Analysing and designing of tall buildings for nonlinear dynamic forces is a time-consuming process and requires additional input related to mass of structure, and an understanding of structural dynamics for interpretation of analytical results. On the other hand, for nonlinear static analysis there is availability of affordable computers and specialized programs which can be used easily for the analysis purpose. Nonlinear static analysis is also known as pushover analysis. This type of analysis enables weakness in the structure to be identified. The decision to retrofit can be taken in such studies. As shown in Fig. 1.2, five points labelled A, B, C, D, and E are used to define the force deflection behaviour and three points labelled Immediate Occupancy (IO), Life Safety (LS) and Collapse Prevention (CP) are used to define the acceptance criteria for the hinge as per [15]. The range AB is elastic range, IO, LS and CP stand for Immediate Occupancy, Life Safety and Collapse Prevention respectively.

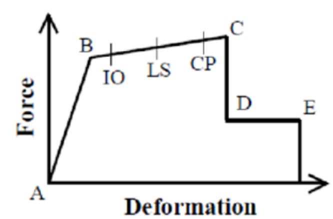


Fig. 1.2 Nonlinear Static analysis curve (ASCE 41-06, 2007)

1.3 Scope and Methodology of the study:

In the present paper, an attempt is made to study and compare the effects of wind and earthquake on a multistorey building for different configuration of shear walls by changing their location using Extended Three-dimensional Analysis of Building Systems (ETABS). Further the non-linear analysis will be carried out for the respective structure to compare the effect of wind and earthquake for different configuration of shear wall.

2. MODELLING OF MULTISTOREY BUILDING

In order to evaluate the seismic response of multistorey building with rigid floor diaphragms using dynamic (Response spectra and Pushover) analysis procedures, sample building is adopted. For validation purpose, G+10 building was considered. Time period and base shear for the building was calculated manually by using equations given in IS 1893 (Part I): 2007.

Time period = $0.075h^{0.75}$ .... (1)

Base shear (V_b) = $\frac{Z}{2}\times\frac{I}{R}\times\frac{S_a}{g}\times W$ .... (2)

The same building was modelled by using ETABS software. Values obtained from both manual calculations and software were nearly same. Thus, case study can be formulated based on the results obtained for G+10 building

2.1 Problem formulation:

Different models with varying storey heights along with different configuration of shear walls have been considered with 30mX30m plan. The floor to floor height for each model is considered as 3.5 meters. The buildings are considered to be fixed at the base, situated in seismic zone V and designed in compliance to the Indian Code of Practice for Earthquake Resistant Design of Structures [14]. The same buildings have been modelled using ETABS 2015. Models are studied for comparing lateral displacement and base shear. For all models in this study the basic inputs adopted are given in table 1.

Model I: Framed building.

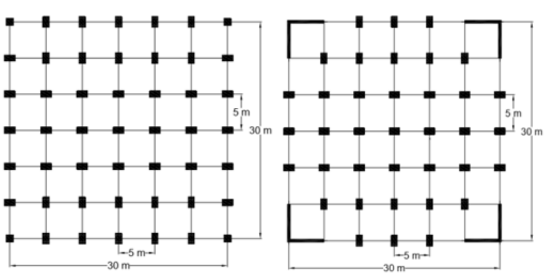
Model II: The building with shear walls at corners.

Model III: The building with shear walls at periphery.

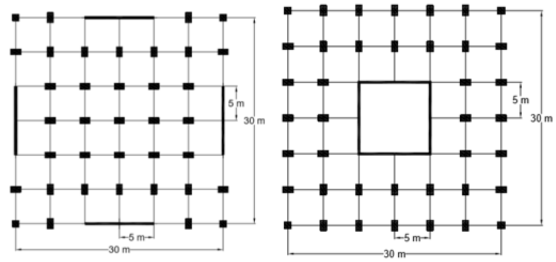
Model IV: The building with shear wall at center.

Table 1: Details of the building considered is this study

Sr. No.	Particulars	Size/Value
1.	Floor to Floor Height	3500 mm
2.	Thickness of slab	150 mm
3.	Thickness of Wall	230 mm
4.	Thickness of shear wall	250 mm
5.	Live Load	3 kN/m^2
6.	Floor Finish	1 kN/m^2
7.	Zone factor (Z)	0.36
8.	Importance factor (I)	1
9.	Response reduction factor (R)	5

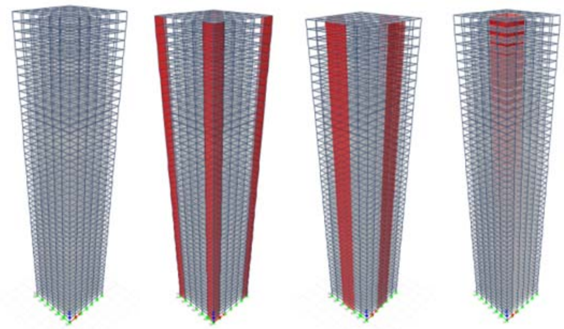


(a) Model I (b) Model II



(c) Model III (d) Model IV

Fig. 2.1 Plan views of different models considered under present study



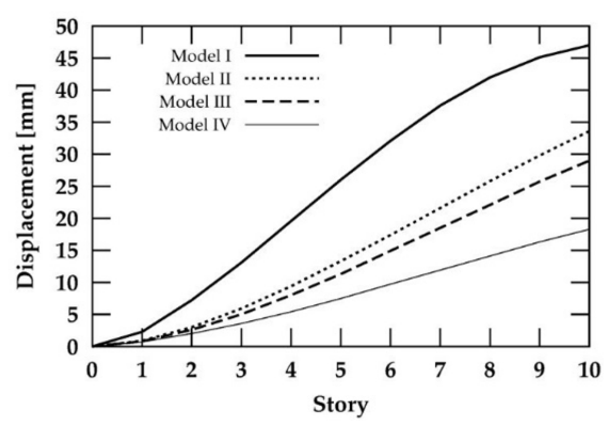
Model I Model II Model III Model IV

Fig. 2.2 Snapshots of 3-Dimensional models from ETABS

3. RESULTS AND DISCUSSION

The variation of storey shear and storey displacement are evaluated for all the models. Comparison of results obtained from earthquake analysis with wind analysis is shown in following figures.

EARTHQUAKE



WIND

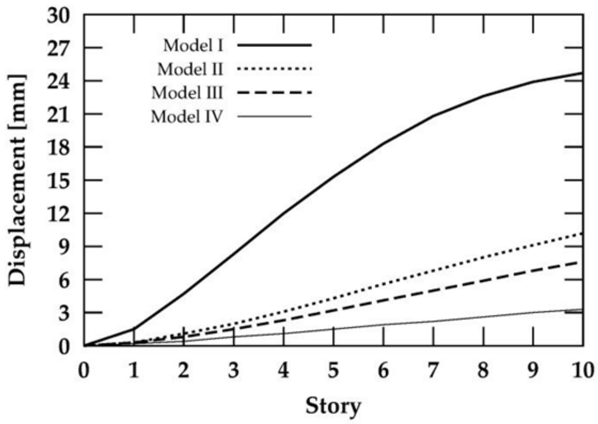
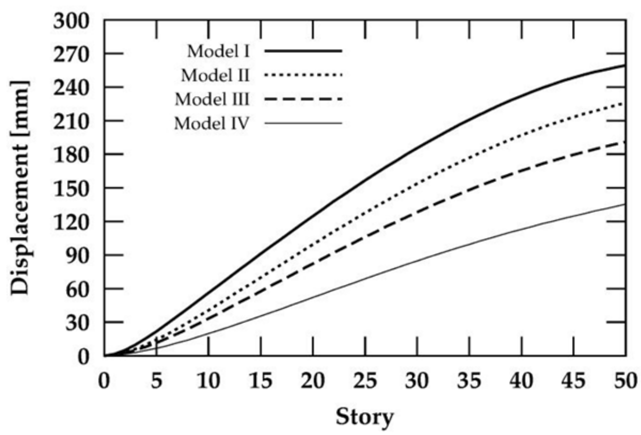


Fig. 3.1 Comparison of displacement for all models for seismic and wind analysis (10-storey building)

EARTHQUAKE



WIND

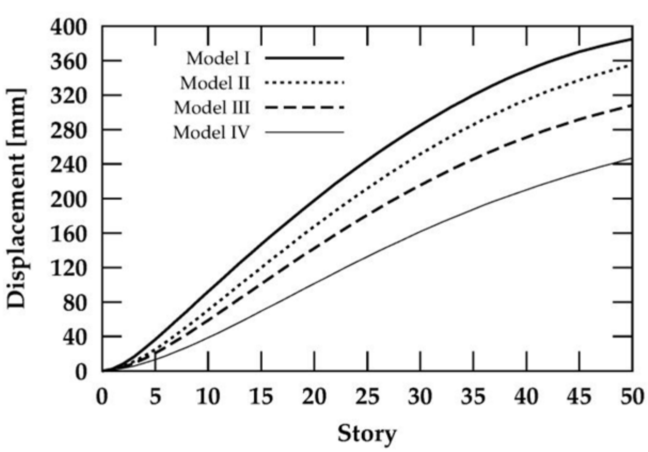


Fig. 3.2 Comparison of displacement for all models for seismic and wind analysis (50-storey building)

From figures 3.1 and 3.2, it can be observed that for Model I i.e. without shear walls, displacement is maximum compared to other models for both seismic as well as wind analysis. For Model II and Model III, there is not much difference in displacement values. And there is least displacement for Model IV. Thus, it can be concluded that location of shear walls at the core of the building can reduce displacement to much greater extent.

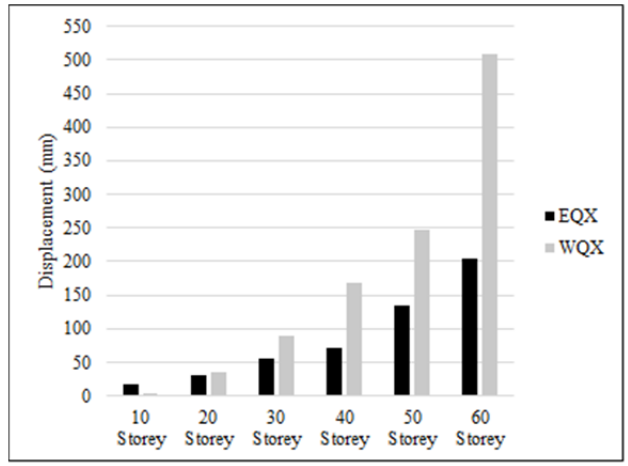
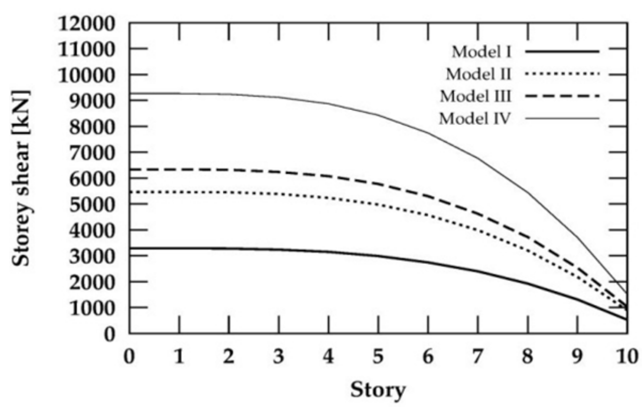


Fig. 3.3 Comparison of displacement for earthquake and wind loading for different storey buildings

The Fig. 3.3 shows that earthquake is more dominant compared to wind upto 10 storey and above 10 storey, wind is getting more dominant.

EARTHQUAKE



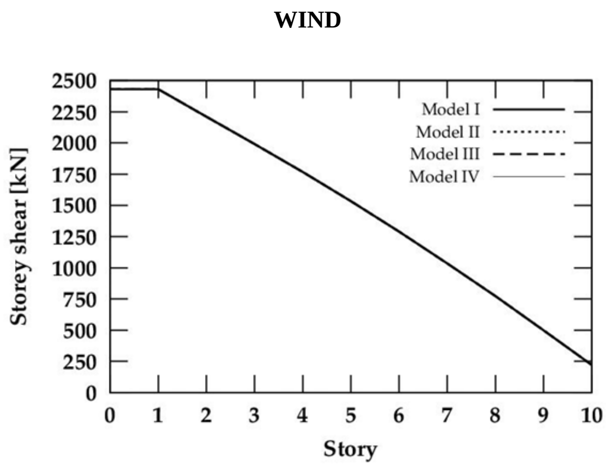


Fig. 3.4 Graphical representation of storey vs. base shear for all models for both seismic and wind analysis (10-storey building)

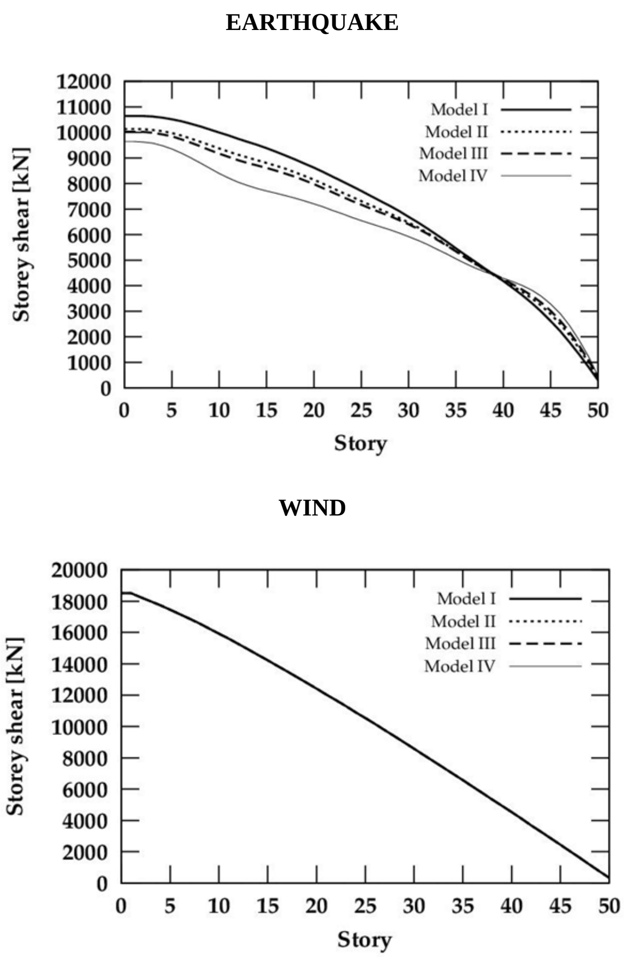


Fig. 3.5 Graphical representation of storey vs. base shear for all models for both seismic and wind analysis (50-storey building)

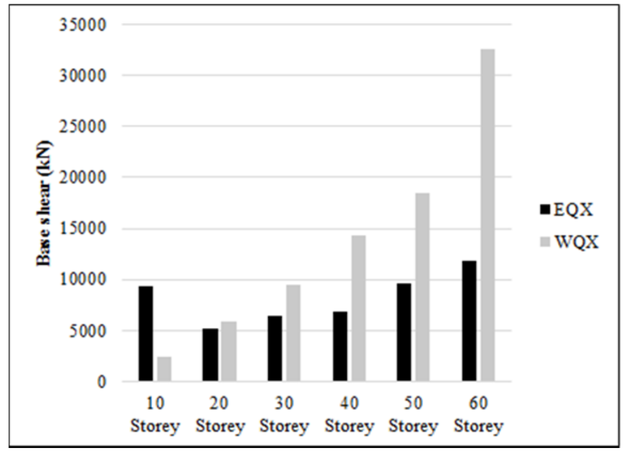


Fig. 3.6 Comparison of base shear for earthquake and wind loading for different storey buildings

From figures 3.4,3.5 and 3.6, we can conclude that base shear is increasing from top story to bottom story. Base shear for different stories are shown in Fig. 3.6. It shows that for 10-storey structure, base shear for earthquake loading is higher than wind loading whereas for remaining stories base shear for earthquake loading is much lesser than wind loading.

In case of wind loading, base shear is not dependant on the stiffness, time period of the building. Base shear is just the summation of the forces at the base and it will not change whether shear wall is placed or not. Therefore, in above figures for wind loading, base shear is not changing for different models of same storey.

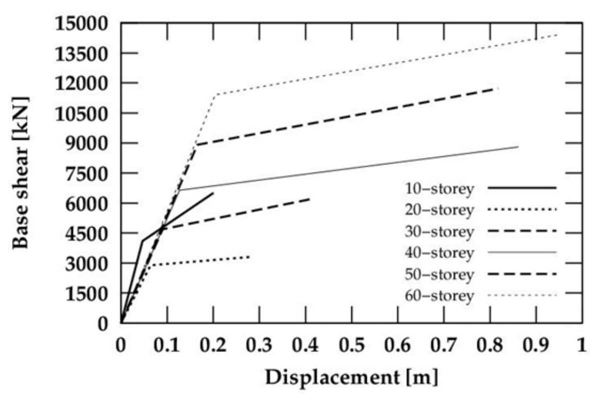


Fig. 3.7 Bilineared Nonlinear static curves for different storey buildings

Pushover analysis is carried to calculate the yeild and ultimate point of the structure. For comparison purpose, the pushover curves have been converted to its equivalent bilinear form as shown in Fig. 3.7. The Fig. shows that the performance of 10 storey building is better than 20 storey building since the ultimate point of 10 storey building is higher than that of 20 storey building.

4. CONCLUSION

From the above graphs it is observed that shear wall affects the structural behaviour of multistorey building under earthquake and wind excitation.

- The top displacement of the structure in case of either wind or earthquake loading can be reduced by placing shear wall at the core of the structure.
- It is observed that base shear and top displacement is less in case of wind analysis for G+10 structure whereas for G+20, G+30, G+40, G+50 and G+60 structure, it is more in case of wind analysis.
- As height of the structure goes on increasing, wind effect is more dominant than earthquake. Hence, for G+20, G+30, G+40, G+50 and G+60 structure, earthquake loading is less effective compared to wind loading.
- Hence the severity of wind forces increases from medium rise to high rise building than that of earthquake forces. Building should be design for more severe load to achieve safer design under both earthquake and wind excitation.

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REFERENCES

[1] Carr A. and Moss P., "The Effects of Large Displacements on the Earthquake Response of Tall Structures", Senior Lecturer, Department of Civil Engineering, University of Canterbury, Christchurch, New Zealand, (1999)

[2] Ambadkar S. and Bawner V., "Behaviour of multistoried building under the effect of wind load", *International Journal of Applied Sciences and Engineering Research,* vol. 1(2012).

[3] Hirde S. and Magadum V., "Severity of Earthquake Forces against Wind Forces for Multistorey RCC Building", *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)* pp. 71-75 (2014).

[4] Murthy C. Internet site for "Why are Buildings with Shear Walls preferred in Seismic Regions?", http://www.iitk.ac.in/nicee/EQTips/EQTip23.pdf (2012).

[5] Marsono and Subedi., "The Structural Design of Tall Buildings". Volume 8, Issue2, pages 117-143, (1999)

[6] Bhat S., Shenoy P., Rao A., "Earthquake Behaviour Of Buildings With And Without Shear Walls", *Journal of Mechanical and Civil Engineering (IOSR-JMCE)* (2003).

[7] Firoozabad E., Rao R. and Bagheri B., "Effect of Shear Wall Configuration on Seismic Performance of Building", *Proc. of International Conference on Advances in Civil Engineering and Association of Civil and Environmental Engineering* (2012).

[8] Harne V., "Comparative Study of Strength of RC Shear Wall at Different Location on Multi-storied Residential Building", *International Journal of Civil Engineering Research*, vol. 5, pp. 391-400 (2014).

[9] Santhosh M. and Pradeep S., "Seismic Analysis and Design of Multi Storey Building with Non Parallel Shear Wall System", *International Journal of Engineering and Management Research*, vol. 4, pp. 157-160 (2014).

[10] Gunel H. and Ilgen E., "A Proposal for the Classification of Structural Systems of Tall Buildings", *Science Direct* (2007).

[11] Reddy A. and Fernandes R., "Seismic analysis of RC regular and irregular frame structures", *International Research Journal of Engineering and Technology (IRJET)*, volume. 02, issue 05 (2015)

[12] Rasikan A. and Rajendran M., "Wind Behavior of Buildings with and without Shear Wall", *International Journal of Engineering Research and Applications (IJERA)* vol. 3, pp. 480-485(2013).

[13] Oni P. and Vanakudre S., "Performance Based Evaluation of Shear Walled RCC Building by Pushover Analysis", *International Journal of Modern Engineering Research (IJMER)*, vol. 3, Issue. 4, pp-2522-2525 (2013).

[14] IS 1893 Part-I (2002), "Indian Standard Criteria for Earthquake Resistant Design of Structures", Bureau of Indian Standards, New Delhi, India (2002).

[15] ASCE 41-06 (2007), "Seismic Rehabilitation of Existing Buildings", American Society of Civil Engineers, Virginia, USA (2007).

[16] ETABS 2015 "Extended Three-dimensional Analysis of Building Systems", Computer and Structures Inc., Berkeley, CA 94704, USA.