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Comparative study of RC Flat Slab & Shear wall with Conventional Framed Structure in High Rise Building

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***Abstract** Tall buildings are being increasingly designed with structural system comprising of flat slab and shear wall core with or without perimeter beams. The behavior of this system under lateral loads is dependent on numerous parameters such as the height of the building, floor plate size, location of the shear wall core, flat slab spans and others. This paper studies the effect of RC flat slab with shear wall at different location for various heights of building. Shear wall with flat slab gives stability to structure as well as it improves lateral load resistance. The effectiveness of RC flat slab and shear wall building is studied with the help of three different models. Model one is a conventional building with regular slabs, beams & column framing. Model two is conventional building with various shear wall location and model three with flat slab and shear wall. Time history analysis is carried out for the structure using ETABs software.*

Keywords Conventional building, flat slab, shear wall, time history, storey drift, lateral displacement.

1. Introduction

One of the most common floor systems for the construction practice in many earthquake vulnerable parts of the world is the reinforced concrete flat slab. Flat slab construction possesses major and various advantages over conventional slab-beam-column construction. The flat slab system's structural efficiency is often hindered by occasionally poor performance under earthquake loading due to inherent insufficient lateral resistance. This undesirable behavior is mainly due to the absence of deep beams and/or shear walls in the flat slab system which generally gives rise to excessive lateral deformations. Hence, it becomes more important to give further attention to the study of this structurally appealing system. Shear walls are vertical elements of horizontal force resisting system. Shear walls are usually provided between columns, stairwells, lift wells, toilets, and utility shafts. When walls are situated in advantageous positions in a building, they can be very efficient in restating lateral loads originating from wind or earthquakes, large portion of the lateral loads on the buildings and horizontal shear force resulting from the load are often assigned to structural elements they have been called shear wall. RC buildings with shear wall also have columns; these columns primarily carry gravity loads. This paper investigates the comparison of conventional reinforced concrete building system i.e. slab, beam & column to the flat slab and shear wall building. These results are compared for different heights of building.

Mohamed Abdel et al. [1] studied the base shear ratio, period of vibration and displacement for six and ten storey building using Etabs. All models were studied using various shear wall locations and they identified that an appropriate FE model of SW dominant flat-plate R/C buildings, which can be used to study its dynamic behavior.

Kim et al. [2] proposed an efficient method for a three dimensional analysis of a high-rise building structure with shear walls. Three-dimensional super elements for walls and floor slabs were developed and a substructure was formed by assembling the super elements to reduce the time required for the modeling and analysis. Static and dynamic analyses of example structures with various types of opening were performed to verify the efficiency and accuracy of the proposed method. They concluded that the proposed method is very useful for an efficient and accurate analysis of high-rise building structures with significantly reduced computational time and memory.

Aksogan et al. [3] studied the forced vibration analysis of a multi-bay coupled shear wall on an elastic foundation. Their analysis considers shear walls with a finite number of stiffening beams, the properties of which vary from span to span and/or from section to section in the vertical direction. They employed continuous connection method (CCM) to find the structure stiffness matrix. The structure mass matrix was found with the lumped mass assumption. A time-history analysis was carried out using the Newmark numerical integration method to obtain the response. The response obtained by the present method was then compared with those obtained using SAP2000 structural analysis program. They found a good match between the results of present method and the results of the SAP2000 program. Tuken [4] proposed an analytical method to determine the sway of a mixed structure (frame + shear wall) subject to seismic forces. The validity of the analytical method was tested on 3-D buildings of different heights. He also obtained the sway response using SAP2000 and found that the sway results obtained by the analytical method matches well with the results of SAP2000.

Fayazuddin Ahmed Syed et al. [5] proposed a flat plate floor system with and without shear wall, the Shear walls with flat plates contribute towards reducing the column axial force even in the middle frame region also. In the case of other building frames there is similar reduction in column axial force when wind is acting.

Husam Omar, Glenn Morris [6] they studied a review about a procedure which is described for performing a linear structural analysis of laterally loaded three-dimensional flat plate structures, with or without shear walls.

H.S. Kim, D.G. Lee [7] they studied a review about the Flat Plate system which has been adopted in many buildings constructed recently due to the advantage of reduced floor heights to meet the economical and architectural demands.

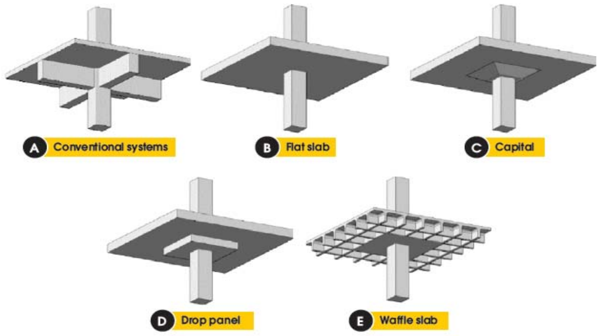

Figure1. System of Reinforced concrete slab

2. General Principle of Time History

It is an analysis of the dynamic response of the structures at each increment of time, when its base is subjected to a specific ground motion time history. In this method, the structure is subjected to real ground motion records. This makes this analysis method quite different from all of the other approximate analysis methods as the inertial forces are directly determined from these ground motions or in forces are calculated as function of time, considering dynamic properties of building structure.

Total two numbers of earthquake records were used; the maximum PGA on the basis of acceleration gravity for Imperial Valley (El Centro) (1979) and Kern city (1952) are 0.314 and 0.275 respectively. Acceleration component and properties of earthquake is shown in figure 2 and table 1.

Table 1 Properties of earthquake records

Record	Imperial valley (1979)	Kern city (1952)
Station	EC meloland overpass	Taft Lincoln tunnel
PGA(g)	0.348	0.275
Magnitude	6.5	7.5

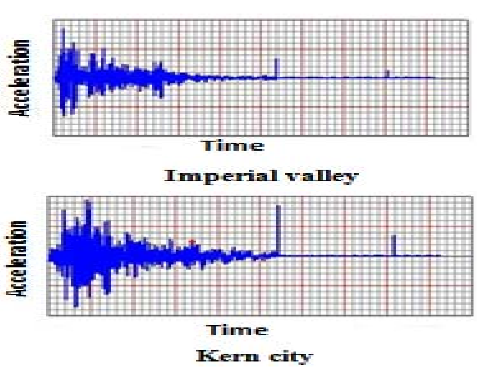

Figure2. Acceleration component of earthquake

3. Modeling of Structure

3.1. Analytical Analysis

The main objective of t nventional structure i.e. slab, beam and column, shear wall and he analysis is to study the different forces acting on a building. The analysis is carried out in ETAB software. Results of co R.C flat slab structure for different heights are modeled for the different combinations of static loading, time history analysis. The comparison is made between the conventional structure with flat slab and shear wall.

3.2. Assumptions

The following are the assumptions made:

The heights of the buildings are kept as 32.5 m and 39.5 m from ground these buildings are of 9-storey and 11-storey respectively. The height of one floor is of 3.6m each. In this way 20 numbers of total models are analyzed.

3.3. Group Properties

The different components of conventional R.C.C structure, flat slab and shear wall are as follows:

Grade of concrete M25
Columns of the building is of 230mm x 600mm,
Beam size of the building is of 230mm x 450mm,
Slab thickness of the building is of 150mm,
Flat slab thickness 250mm, shear wall thickness 250mm,
Size of drop 5000mm x 50000mm x 300mm

3.4. Description of Loading

The loading of the buildings is considered as per following calculations

1. Dead Loads

i. Wall load with 150mm thickness = 24 x (3.6-0.45) x 0.15 = 11.34kN

ii. Wall load with 230mm thickness = 20 x 3.15 x 0.23 = 15.73kN

iii. Weight of the slab having thickness 150mm = 25 x 0.150 = 3.75kN/m

iv. Weight of the slab having thickness 300mm = 25 x 0.3 = 4.05kN/m

v. Self weight of building is automatically considered by the ETAB software.

2. Live Loads

The live load of 4kN/m2 is considered on the buildings.

3.5. Loading Combination

The different loading combinations for the analysis of the building and tower considered are shown in Table 2

3.6. Types of cases used for analysis of structures

There are different cases considered for analysis of 9 and 11 storey structures.

1. Performance of conventional structure.
2. Performance of conventional structure with various shear wall location.
3. Performance of flat slab with various shear wall location.

Table 2: Different Loading Combinations for Analysis

Sr.	Load Combinations
1	1.5 (DL + LL)
2	1.2 (DL + LL + WLX)
3	1.2(DL + LL + WLZ)
4	1.2(DL + LL - WLX)
5	1.2(DL + LL - WLZ)
6	1.5(DL + WLX)
7	1.5(DL + WLZ)
8	1.5(DL - WLX)
9	1.5(DL - WLZ)
10	0.9DL + 1.5WLX
11	0.9DL + 1.5WLZ
12	0.9DL - 1.5WLX
13	0.9DL - 1.5WLZ

Figure3.A. Building with conventional beam, slab and column **z**

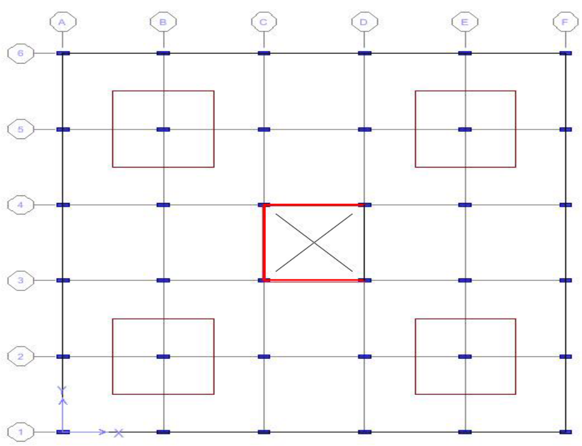

Figure3.B. Building with C type shear wall with flat slab

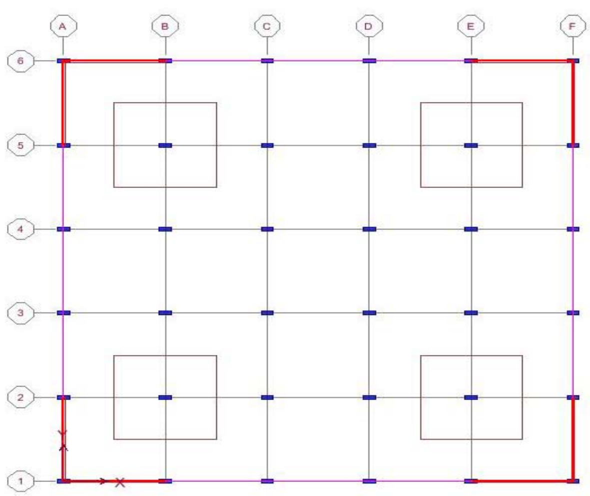

Figure3.C. Building with L type shear wall with flat slab

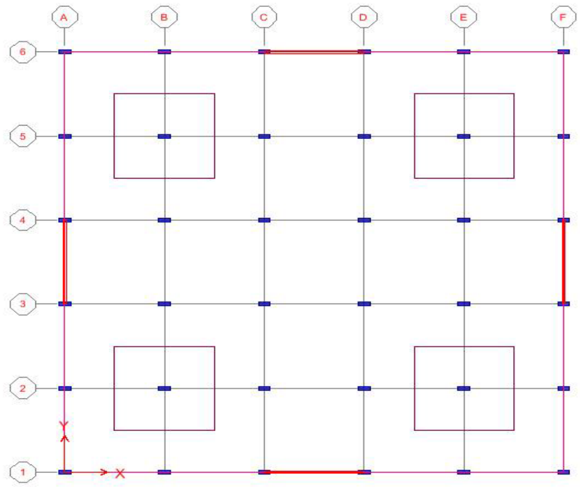

Figure3.D. Building with shear wall along periphery with flat slab

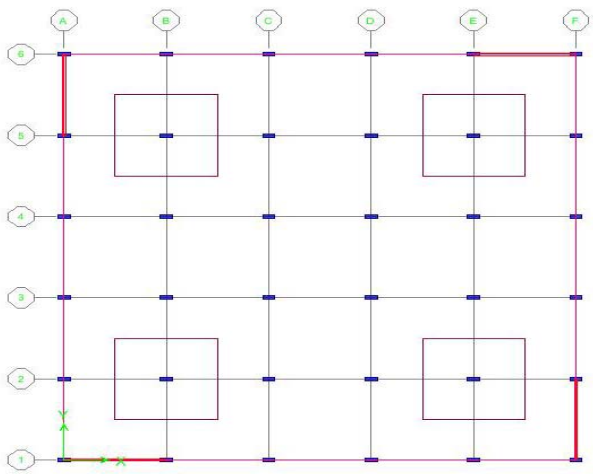

Figure3.E. Building with non parallel shear wall along periphery with flat slab

4. Results and Discussion

4.1 Time History analysis

In this study, G+9 and G+11 RC structures with conventional and flat slab along with variation of different location of shear walls has been considered. Seismic responses including displacements, time period and base shear were assessed under two earthquake records.

The seismic responses of all these models have been determined using time history analysis. The time history records are shown in the figure below i.e. figure 4.A to 4.G, and the obtained results are summarized as follows.

1. The critical response depends on the earthquake characteristics and particularly frequency content of earthquake records.
2. It is observed that the displacements for models with shear wall are less than the models without shear wall.
3. Provision of flat slab increases the value of base shear than conventional slab.
4. Considering shear wall location C-type and L-type and periphery shear wall increases the base shear.
5. Considering among the same model i.e. shear wall

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and another shear wall with flat slab, it is observed that provision of flat slab increases the displacement in some cases but in most of the cases displacement decreases due to provision of shear wall and flat slab than in case of conventional slab.

6. Base shear goes on increasing with provision of flat slab and shear wall than conventional slab.

7. Base shear and displacements are directly proportional to the height of the structure.

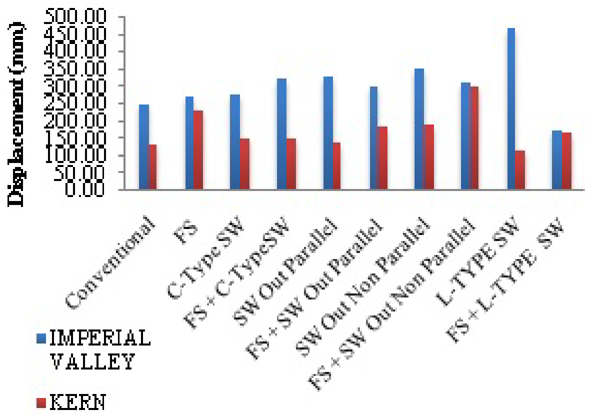

Figure4.A. Displacement graph for different G+9 models

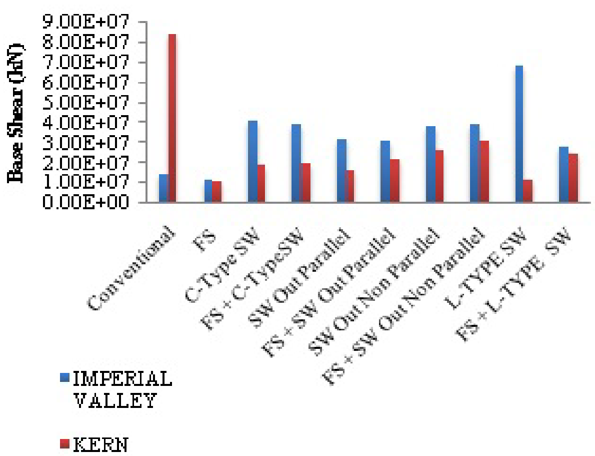

Figure4.B. Base Shear graph for different G+9 models

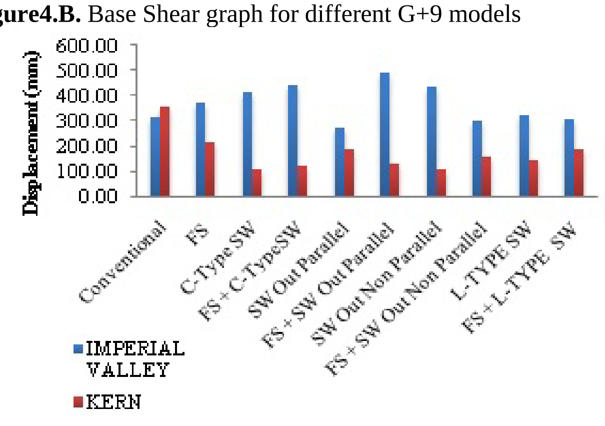

Figure4.C. Displacement graph for different G+11 models

8. There is sudden change in displacement values for Imperial Valley earthquake. All the models shows maximum displacement for imperial valley earthquake data and minimum responses for kern earthquake data for all variations of shear wall and flat slab.

9. Considering C shaped shear wall it is observed that structure undergoes in torsion for mode 1 as shown in figure4.G.

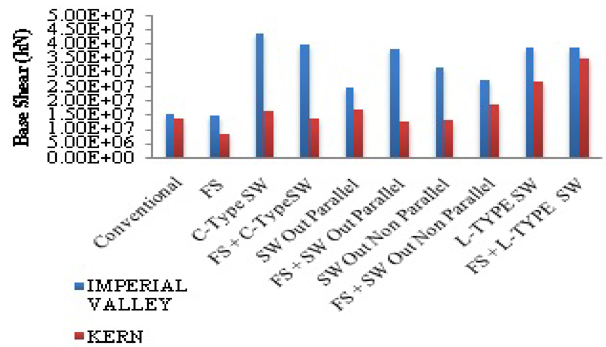

Figure4.D. Base Shear graph for different G+11 models

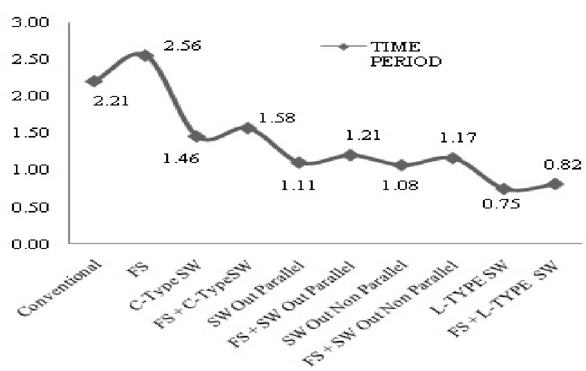

Figure4.E. Time Period variation for different G+9 models

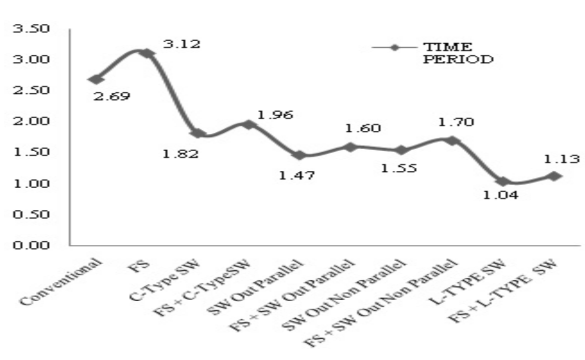

Figure4.F. Time Period variation for different G+11 models

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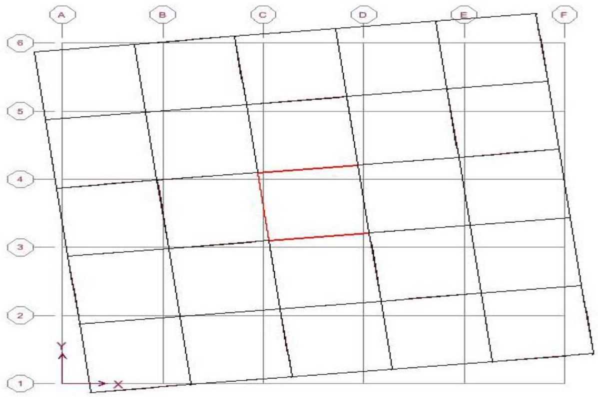

Figure4.G. Torsional mode for C-shape shear wall with and without flat slab

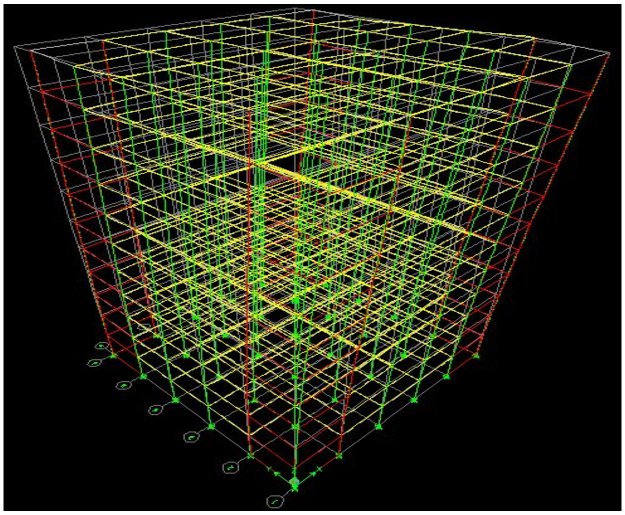

Figure4.H. Lateral displacement for L-shaped shear wall with and without flat slab

5. Conclusion

This paper represents the summary of the study, for conventional R.C.C. structure and Flat slab structure along with different location of shear wall, on the basis of results following conclusion have been drawn.

1. The natural time period increases as the height of structure increases irrespective of type of structure. However, the time period is same for flat slab structure and flat slab with shear wall.
2. In comparison of the conventional structure to flat slab structure, the time period is more for conventional structure than flat slab structure because of monolithic construction.
3. Base shear increases with the height of the structure. Base shear of conventional R.C.C. structure is less than flat slab structure.
4. Displacement increases in case of flat slab structure than conventional structure but displacement decreases in case of structure along with flat slab with shear wall.
5. As a result structure with flat slab and shear wall sustain additional and maximum load as redistribution reduces as the number of member reduces in selected lateral load resisting system.

References

i. Mohamed Abdel-Basset Abdo, Modeling of shear-wall dominant symmetrical flat-plate reinforced concrete buildings. International Journal of Advanced Structural Engineering 2012.

ii. Kim, H., Lee, D., Kim, C.K. Efficient three-dimensional seismic analysis of a high-rise building structure with shear walls. Engineering Structure 27(6), 963–976 (2005)

iii. Aksogan, O., Bikce, M., Emsen, E., Arslan, H.M., A simplified dynamic analysis of multi-bay stiffened coupled shear walls. Advance Engineering. Software 38, 552–560 (2007)

iv. Tuken A., Analysis and assessment of seismic drift of reinforced concrete mixed (shear wall-frame) structures. Technology 7(4), 523–532 (2004)

v. Fayazuddin Ahmed Syed, B. Dean Kumar, Y. Chandrasekhar, B.L.P. Swami. Comparative Analysis of Flat Plate Multistoried Frames With and Without Shear Walls under Wind Loads. International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-2, Issue-1, October 2012.

vi. Husam Omar, Glenn Morris, Analysis of laterally loaded flat-plate structures, Canadian Journal of structural engineering, Vol.18, No.1, 1991, pp.109-117.

vii. H.S.Kim, D.G.Lee, Efficient Analysis of Flat Plate Structures subjected to Lateral Loads, Science Direct, Engineering Structures Journal, Vol.27, Issue.2, January 2005, pp 251-263.

viii. Sejal Bhagat, Optimization of a Multistorey Building by Optimum Positioning of Shear Wall. International Journal of Research in Engineering and Technology (IJRET) eISSN: 2319 – 1163, Volume-3, Issue-1, January 2014.

ix. P. P. Chandurkar, P. S. Pajgade. Seismic Analysis of RCC Building with and without Shear Wall. International Journal of Modern Engineering Research (IJMER) ISSN: 2249–6645, Volume-3, Issue-3, June 2013.

x. Varsha Harne, Comparative Study of Strength of RC Shear Wall at different Location on Multi-storied Residential Building. International Journal of Civil Engineering Research (IJCER) ISSN: 2278–3652, Volume-5, Issue-4, 2014.

xi. Alfa Rasikan, M. G. Rajendra. Wind Behaviour of Buildings with and without Shear Wall. International Journal of Engineering Research and Applications (IJERA) ISSN: 2248–9622, Volume-3, Issue-2, March 2014.

xii. Bhavin Ramjiyani, Dipendu Bhunia. Solution of Shear Wall Location in Multi-Storey Building. International Journal of Civil and Structural Engineering (IJCSE) ISSN: 0976–4399, Volume-2, Issue-2, September 2011.

xiii. Haroon Tamboli, Umesh Karadi. Seismic Analysis of RC Frame Structure with and without Masonary Infill Walls. International Journal of Natural Research (IJNR) ISSN: 0976–0997, Volume-3, Issue-14, October 2012.

xiv. P. V. Chaudary, S.M. Pandian. A Comparative Study of RCC Structure with and Without Shear Wall. International Journal of Scientific Research and Development (IJSRD) ISSN: 0976–0997, Volume-3, Issue-14, October 2012.

xv. Shahzad Jamil Sardar, U. N. Karadi. Effect of Change in Shear Wall Location on Storey Drift of Multistorey Building Subjected to Lateral Loads. International Journal of Innovative Research in Science (IJIRS) ISSN: 2319-8753, Volume-2, Issue-9, September 2013.

xvi. George E. Lelekakasis, Athina T. Birda. Application of Flat Slab R/C Structures in Seismic Regions.

xvii. Bryan Stafford Smith and Alex Coull. Tall Building Structure Analysis and Design. A Wiley-intersceince Publication, New York-1991.