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Article

# Seismic Response of (G+10) R.C.C Building with Floating Column In Different Zones

**Ms. V. Kavitha[1], G. Anil Kumar[2], Dr. P. Rohit[3]**

[1] Assist. Prof, Department of CIVIL, Siddhartha Institute of Technology & Sciences, Narapally village, Peerzadiguda, Hyderabad, Telangana 500088.
Email: vavillakavitha.civil@siddhartha.co.in
[2] PG Scholar, Department of CIVIL, Siddhartha Institute of Technology & Sciences, Narapally village, Peerzadiguda, Hyderabad, Telangana 500088.
Email: 24TQ1D2017@siddhartha.org.in
[3] Assist. Prof, Department of CIVIL, Siddhartha Institute of Technology & Sciences, Narapally village, Peerzadiguda, Hyderabad, Telangana 500088.
Email: dr.rohitpoleboyana@siddhartha.org.in

**Abstract:** In the current situation, majority of the buildings are usually erected on the steep ground owing to the limitations of the terrain. The behaviour of building on sloping ground during earthquake is dependent on distribution of stiffness and mass in vertical and horizontal plane, which are different in the case of building resting in sloping ground. Short columns are very stiff, and thus they absorb a lot of structural energy. Some of the manuals and regulations like the Earthquake regulations to this phenomenon require an additional attention to be paid to it. The building that was considered in this study has a G + 10 storeys reinforced concrete (RC) building with variable ground slope as 0 0, 5, 10, 15 and 20 without shear walls and with shear walls regular on plan and at corner as well. The constructions are planned according to the IS 456:2000 and subjected to the earthquake loads. Liner Static and Linear Dynamic analysis (Response Spectrum and Linear Time History analysis) has been done using structure analysis tool SAP 2000, on the modelling and analysis of the building. The primary purpose is to determine the behaviour of the building on sloping ground due to different height of column used in bottom storey and different location of shear walls and to investigate the effectiveness of shear wall on the sloping ground. The building models have been found to check performance of the building by studying the dynamic properties such as maximum forces in columns, Base shear, Roof displacement, Bending Moments and Fundamental natural periods. It is noted that step back buildings with shear walls which are symmetrically arranged in plan are observed to be more appropriate as compared to step back buildings which have shear walls arranged in peripheral corners and buildings which do not have shear wall.
**Keywords:** RC, G +10, Floating column, base shear, shear wall

## 1. INTRODUCTION

Earthquake refers to vibration of the earth surface that occurs after the sudden release of energy within the earth lithosphere and produces the seismic waves. In order to conduct the seismic analysis, one must have the knowledge of how buildings behave in case of an Earthquake. The step back buildings collapse during the occurrence of earthquakes as the column height differs. In order to enhance the performance of step back buildings, shear walls are also added at various points. Step back buildings on different slopes without shear walls and step back buildings on different slopes with shear walls are compared in this study and given symmetrically in the plan and shear walls in the peripheral corners respectively.

EARTHQUAKES

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An earthquake can be described as a wavelike motion caused by forces of unceasing inconsistency underneath the uppermost surface of the earth (the lithosphere) and running through the crust of the earth. It can also be explained as shaky motion, even violent motion of the earth surface due to discharge of energy in the earth crust. This energy may be triggered by the sudden dislocations of the segment of the crust, volcanic eruptions or even explosions that can be performed by people. However, the most devastating quakes occur as a result of dislocations of crust segments. During dislocation the vibrations are produced in the form of seismic waves. The current buildings that were formulated and developed based on previous code provisions, fail to meet the requirements of the current seismic code and design practices. It is thus necessary to protect unacceptable perils to property and life of occupants, which are established during future expecting earthquake. Hazard safety can be achieved through seismic assessment and performance as well as retrofitting the poor and weak structures of the existing buildings. The pace of framed buildings is catching up in sloppy locations especially in hills, due to the population growth and the value of the land. and therefore most of them are built upon slopes and curved grounds.

Inertia forces in constructions.

The shaking of the ground is caused by earthquake. At its base a building that is built upon it will have a motion. Based on the first law of motion by Newton, although the ground moves, the roof will be inclined to remain at the same position. But the fact that the walls and columns are attached to it, pulls the roof with them. This habit of still occupying the old school is what is referred to as inertia. The movement of the roof is not the same as that of the ground since the walls or the columns of the building are flexible. Take the case of a building whose roof is being supported on columns. Even the building is pushed back when the ground moves and the roof has a force, known as inertia force. Assuming that the roof is of mass m and accelerates with acceleration a, the acceleration accelerates the roof four times inertia force FI, which has opposite direction to the acceleration. It is evident that the greater the mass, the greater is the inertia force. Thus, light constructions can resist the earthquake vibration more.

Impact of Deformations in Structures.

The force that acts on the roof is the inertia force that is transferred to the ground through the columns, which impose forces in columns. Another way of understanding these forces that are produced in the columns is possible. The columns move relative to each other at the ends in the course of earthquake shaking. This movement is indicated by quantity ubetween the roof and the ground. However, with the free choice, columns would prefer returning to the rigid straight vertical position i.e. columns do not like deformations. In the straight vertical posture, there is no horizontal force of the earthquake passing through the columns. But when they must bend they acquire forces within themselves. The greater is the relative horizontal movement u of the column top and bottom, the greater this interior force in columns. In addition, the greater the rigidity of the columns (i.e. the larger the column size), the greater is this force. It is due to this that these internal forces in the columns are termed as stiffness forces. As a matter of fact, column stiffness is the product of column stiffness and relative displacement of column ends.

Forces to Foundations at Flow.

Horizontal inertia forces are produced at level of themass of the structure (which is normally at the floor levels) under horizontal shaking of the ground. These lateral forces of inertia are passed through the floor slab to the walls or columns, to the foundations and ultimately to the soil system below. Thus, all of these structural components (floor slabs, walls, columns, and foundations) and the interconnectedness between them should be designed in a way that these forces of inertia may be safely channeled through them. The most important aspects of the transfer of the inertia forces are walls or columns. However, when it comes to traditional construction, more care and attention is paid to floor slabs and beams during the design and construction, as compared to walls and columns. Walls are quite thin and in most cases of a fragile material such as masonry. They are weak in transmitting the horizontal inertia forces of earthquakes across their thickness. Masonry walls have been found to fail in numerous quakes of the past. In the same light, reinforced concrete columns, which are improperly built and constructed are catastrophic. The collapse of the columns in the ground storey led to many collapses of the buildings when there was the Bhuj (India) earthquake in 2001

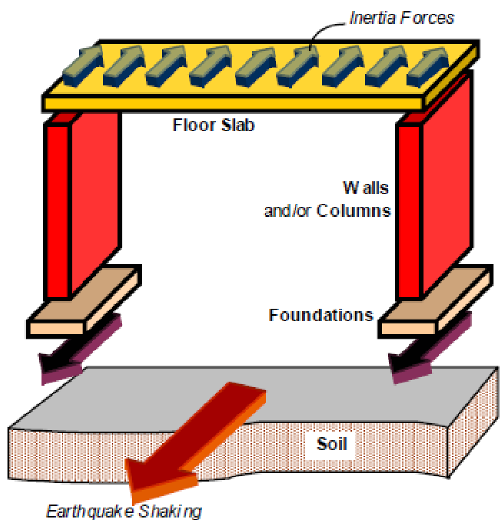


**Fig.1. Flow of seismic inertia forces through all structural components.**

## 2. SURVEY OF RESEARCH

Abrahamson, Michael Shi and Yang (2016) have researched to predict the Ground-Motion Prediction Equations to the Arias Intensity the NGA-West2 database to establish a new scaling model of Arias intensity at peak ground acceleration (PGA), spectral acceleration of T = 1 sec (SAT1), shear-wave velocity in the top 30 m (VS30), and magnitude. We used this conditional model plus each of five NGA-West2 ground-motion models of PGA and SAT1 to obtain five new equations of ground motion prediction (GMPEs) of the median and standard deviation of Arias intensity. All of these, these five GMPEs of Arias intensity, represent the more complicated ground-motion scaling effects present in a few of the NGA-West2 GMPEs, including hanging-wall effects, sediment-depth effects, soil nonlinearity effects and regionalization effects.

Nagarjuna and Patil (2015) have examined a G + 10 storeyed RCC structure that was built on a sloppy ground and had a slope of 10 o 40 o. It has been compared with the building on an equal ground (setback). The purpose of the study is to investigate the influence of different height of the column in bottom storey and the influence of shearwall at various position at the time of earthquake. Liner static analysis and response spectrum analyses were carried out in achieving the seismic analysis. The analyses indicated that stepback setback building format is applicable in construction of the building on sloping ground and shear wall located in the corner of the building.

Prasad Ramesh Vaidya (2015) investigated the seismic performance of shearwall building on sloping land. Four mathematical models have helped in the study of performance of building. Model one is of frame type structural system and other three models are of dual type (shearwall- frame interaction) structural system and three positions of shearwalls. It is noted that Short columns are the most essential member in the building on the sloping ground. In order to enjoy a good control over the forces like shear force, bending moment, etc, it is better to place the shear wall on the shorter wall of a column.

Keyvan and Mehrabpour (2014) have analysed short column behaviour of four story reinforced concrete building; which includes the analysis of simple 2-D frame of different floor height and different number of bays. It is noted that the shear increase has been noted to be very high in short columns than common columns and huge moment should be withstood by sloping lot structures. Non-linear static (Push-Over) analysis also indicated the increased stiffness of the structure.

The seismic response of hill slope buildings has been studied by Mohammad Umar Farooque Pateletal (2014). The step back building may be more susceptible to the seismic excitation. Through Equivalent statical analysis they discovered that the centre shearwall and corner shearwall buildings have 41.4% and 61.5% less displacement respectively and according to Response spectrum analysis; the buildings with shearwall have 23.6 and 38.1 less displacement respectively compared to the model with bare frame on sloping ground.

Ajay K and Pradeep K (2013) have conducted research on the behaviour of a G+3 building that has been set on different slope angles i.e., 15, 30, 45 and 60 degrees and compared with the same on the flat ground. It was noted that stiffer building is being realized as the slope angle is increasing. Two forms of analysis were done; these are lateral load analysis and incremental dynamic analysis. The first results observed were that the short columns were exposed to a higher force of shear. The study of the static behaviour is done by means of Finite element method and incremental dynamic analysis is done by Applied Element Method (AEM).

AS Patil and P D Kumbhar (2013) have done the nonlinear dynamic analysis of the ten storied RCC building taking into consideration the seismic intensity as they vary. On establishment of relationship between seismic intensities and seismic responses, five varying time histories have been taken into consideration with seismic intensities V, VI, VII, VIII, IX and X in the Intensity scale of Modified Mercalli (MMI). The study findings revealed comparable pattern of variations of Seismic responses of base shear and storey displacement with intensities V to X.

Similar to reinforced concrete (RC) beams and columns, RC shear walls also do much better when they are made to be ductile. General geometrical proportions of the wall, reinforcement types and quantity, and relationship to other elements that remain in the building assist in enhancing ductility of walls. The Indian Standard Ductile Detailing Code of RC (IS: 13920-1993) has given special design requirements of ductile detailing shear walls. The shear walls are oblong in cross-section i.e. one side of the cross-section is significantly imposing to the other. Rectangular cross-section is used but L and U-shaped cross-section is also practiced. The shear walls of the buildings are also made up of hollow RC shafts that have a thin wall around the elevator core, which should be exploited to withstand the forces caused by earthquakes. The walls to be provided with steel reinforcing bars in vertical and horizontal grids with a regular spacing. The wall vertical and horizontal reinforcement may lie in a single or two parallel layers referred to as curtains. Horizontal reinforcement must be held at the end of walls. The smallest thickness of the reinforcing steel that should be provided is 0.0025 of the cross-sectional area, both horizontally and vertically. This vertical reinforcement must be uniformly spread in the cross-section of the wall.

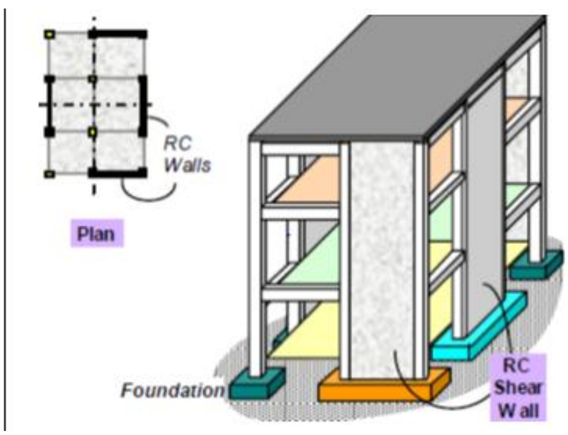


**Fig.3.1. Reinforced shear walls in buildings.**

Earthquake or seismic analysis is a subdivision of structural analysis that entails the calculation of the response of a structure that is excited by earthquakes. Once the structural model has been chosen, analysis can be conducted to establish the forces that are caused by seismic activities in the structures. The analysis can be conducted based on the external action, the behaviour of the structure or structural materials and the nature of structural model adopted. The process analysis may be categorized as linear static analysis, linear dynamic analysis, non- linear static analysis and non linear dynamic analysis. Response spectrum and linear time history are discussed in this chapter linear static analysis. These analysis models of the structure are created using the structural software SAP 2000 and the analysis is done using three analysis tools i.e. the linear static analysis, response spectrum analysis and the linear time history analysis. The earthquake resistance design of buildings entails the management of the damage to tolerable levels in the affordable price. The issue of earthquake resistant design is thus concerned with making sure that damages of buildings during earthquakes are of the acceptable type, and also, they are of the right locations and of the right proportions. Ductility is among the most crucial parameters that influence the building performance. Therefore, earthquake-resistant design aims at pre-determining the sites where the damage occurs and then giving good detailing where the damage occurs to give the building ductile behaviour.

Seismic codes are of a locality or a nation. In India, the primary code that offers a guideline on the calculation of seismic design force is the IS 1893(Part 1): 2002. This force relies on mass and the seismic coefficient of the structure and the latter in its turn relies on such characteristics of the structure as being in seismic zone or not, its importance, its stiffness, the soil where it is placed on, and its ductile properties. IS 1893(Part1):2002 concerns the examination of seismic loading on different structures and buildings. Type of analysis i.e. dynamic analysis or static analysis is done depending on the height of the building and the zone in which it belongs. Simple theory incorporates the idealization of entire structure to a lumped mass at every floor level. There are quite a number of ways of analyzing the earthquake of buildings; two of them are listed here:

1. Linear static analysis

2. Linear dynamic analysis

i.Response spectrum method.

ii.Linear Time history approach.

**3. LINEAR STATIC ANALYSIS**

In the corresponding statical approach, the lateral force which is equivalent to the design basis earthquake is added in a statical manner. The analysis of the equivalent lateral forces at every storey level is made at the design locations of centres of mass. It is at the design eccentricity of the point of calculation of centre of rigidity (or stiffness).

Vb = Ah W

DYNAMIC ANALYSIS:

Dynamic analysis will be executed to obtain the design seismic force and its distribution to various levels on the height of the building and to the various lateral load resisting elements, in the following buildings:

Regular buildings: Buildings more than 40m high in zone IV and V, more than 90m high in zone II and III.

Irregular buildings: Any framed building exceeding 12m heights in zone IV and V as well as exceeding 40m in height in the zone II and III.

## 4. EXPERIMENTAL ANALYSIS:

It is only occasionally that a single cantilever wall will be called upon to sustain the entire effect of the lateral load on a multistorey structure. More probably several such walls will share in the overall load resistance. Most multistorey buildings shear wal1s wi1l in an area that surrounds the service core and that the frame rigid joints are apt to bear the gravity load over the rest of the storey. The nature of the reaction of rigid jointed frames and cantilever shear walls to the lateral loads can be so significantly different, especially in the upper storeys, that unacceptable interaction may be guaranteed. These two categories of structures can be counterproductive and the exceptionally high ductility requirement can potentially lead to the procedure of achieving the final strength of the entire structure. The majority of the seismic codes suggest a similar static process to the design of ordinary buildings in which the design base shear is determined as a percentage of the seismic weight, depending on aspects of seismic zone, building significance, design ductility, basic natural period and soil **type.**

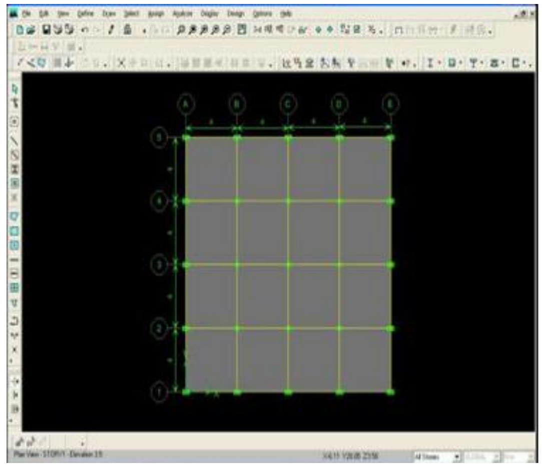

**Fig.4.1. Model of Building without shear wall**

In case the shear walls are robust, they will transmit the same horizontal forces to the subsequent element in the load path beneath the shear wall. These other parts to the load path can be other shear walls, floors, foundation walls, slabs or footings. Lateral stiffness is also offered by shear walls to avoid undue side-sway on the roof or floor above. The stiffness of the shear walls will ensure that the floor and roof framing members will not move out of their supports. Also the buildings with adequate stiffness will tend to have less non structural damage.

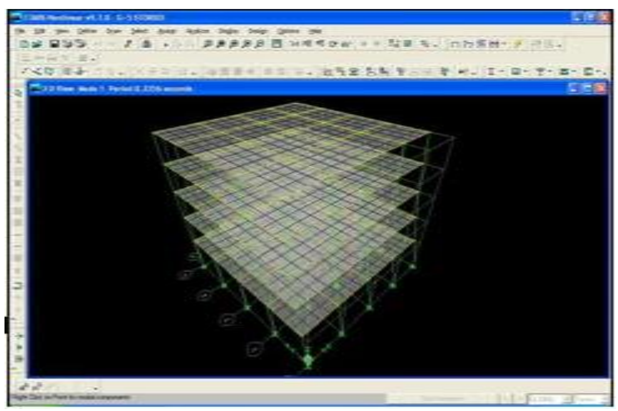

**Fig.4.2. Model I: Structure without shear wall.**

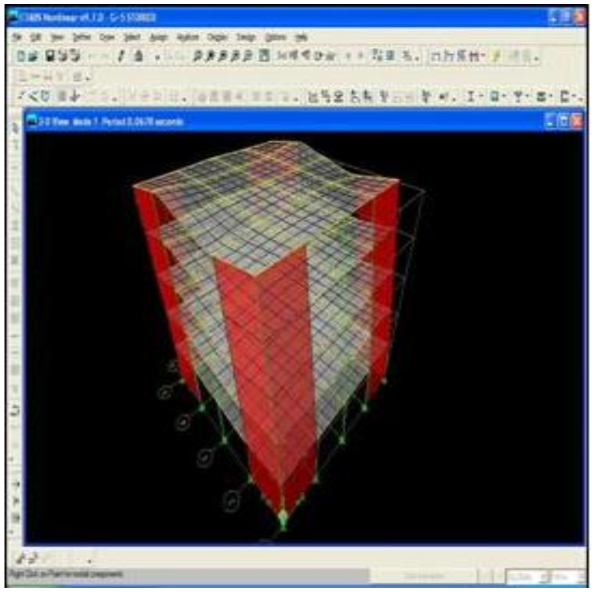

**Fig.4.3.Structure with L type shear wall.**

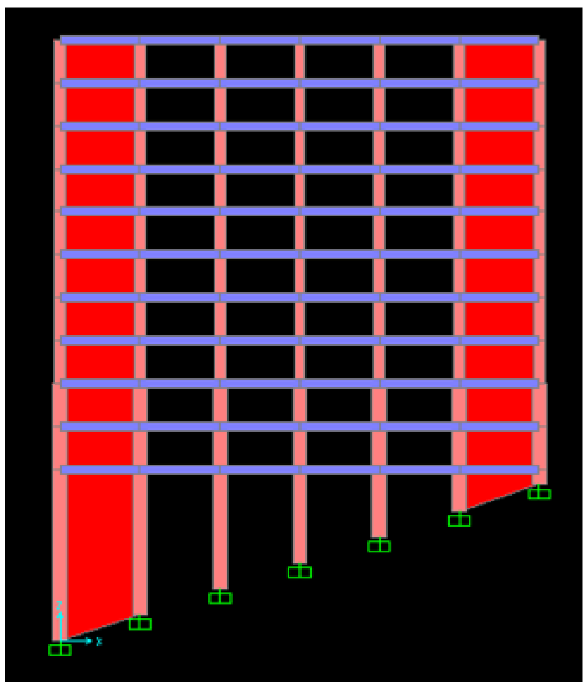

**Fig.4.4. Building model with shear walls provided at peripheral corners on 20º slope ground.**

The displacements of the building on flat ground and sloped ground have been determined to be relatively high. The displacements in the building are being reduced as the slope of the ground is increasing.

| Storey level | Step back building without providing shear walls(mm) | | | | |
|---|---|---|---|---|---|
| | 0° | 5° slope | 10° slope | 15° slope | 20° slope |
| 10 | 20.23 | 13.99 | 16.26 | 13.65 | 10.68 |
| 9 | 19.51 | 13.51 | 15.63 | 13.25 | 10.29 |
| 8 | 18.39 | 12.75 | 14.62 | 12.61 | 9.67 |
| 7 | 16.87 | 11.71 | 13.24 | 11.74 | 8.82 |
| 6 | 15.03 | 10.44 | 11.55 | 10.66 | 7.77 |
| 5 | 12.95 | 8.99 | 9.61 | 9.42 | 6.55 |
| 4 | 10.68 | 7.41 | 7.50 | 8.04 | 5.20 |
| 3 | 8.29 | 5.73 | 5.28 | 6.56 | 3.77 |
| 2 | 5.85 | 4.02 | 3.10 | 5.00 | 2.33 |
| 1 | 3.42 | 2.53 | 1.38 | 3.59 | 1.15 |
| 0 | 1.23 | 1.18 | 0.19 | 2.21 | 0.25 |

**Fig.4.7. Displacement for buildings without providing shear walls in X Direction.**

It is seen that construction on flat ground without shear walls are experiencing a comparatively high displacement compared to the shear walls that are placed elsewhere on the buildings. By offering shears walls symmetrically in plan, the displacements are minimized as compared to building where shear walls are offered at the peripheral corners.

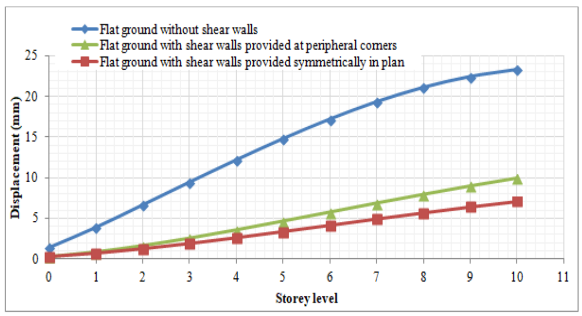


**Fig.4.8. Displacements in Y-direction of buildings resting on flat ground without shear wall and with shear wall.**

## 5. CONCLUSION:

The most important components of the building on the slope ground are short columns. In order to have a good control over the forces like shear force and bending moment, it is desirable to position the shear wall on the short column side. Vibration time of building with shear walls towards shorter column is found to be the least compared to any other location. The seismic performance of building on slopes is greatly enhanced by giving the shear walls various configurations as the storey displacement, storey drifts and bending moments reduces significantly in the building under the provision of shear walls. It is noticed that the displacements are becoming smaller as the shear walls are given symmetrically on the plan as well as the sloping angle is being steepened there is reduction in the displacements. The displacements of the Linear Static analysis are more in comparison to the displacements of the Response Spectrum analysis. The displacements of Linear Time History Analysis get increased significantly when compared with the Linear Static and Response Spectrum Analysis.

### REFERENCES

1. Alireza Mortezaei, Seismic behavior of flanged shear wall buildings to near fault earthquakes with forward directivity, Proc. 15 th World Conference on Earthquake Engineering, Lisboa, 2012.
2. Ashish S.Agrawal, S.D.Charkha, Effect of change in shear wall location on storey drift of multistorey building to lateral loads, International Journal of Engineering Research and Applications (IJERA) Vol. 2, Issue 3, 2012; 1786-1793.
3. Rahul Rana, Limin Jin and Atila Zekioglu, Pushover analysis of a 19 story concrete shear wall building, Proc. 13 th World Conference on Earthquake Engineering, Vancouver, B.C., Canada, 2004,133.
4. Ravikanth Chittiprolu, Ramancharla Pradeep Kumar, Significance of shear wall in the irregular structure of highrise, International journal of education and applied research (ijear), Vol 4, issue Spl-2, 2014, 2348-0033.
5. Effects of change in shear wall position on storey drift of multistory building under lateral load: Ashish S Agarwal, S D Charkha, (2012), Effect of change in shear wall position on storey drift of multistory building under lateral load:

International Journal of engineering Research and Applications (IJERA) ISSA: 2248- 9622 www.ijera.com Vol. 2, Issue 3, May-June 2012, pp.1786-1793
6. Configuration of Multi-Storey Building Subjected to Lateral Forces Ashraf M Siddique Z A and Javed M A, (2008), Asian Journal of Civil Engineering (Building and Housing), Vol. 9, No. 5, pp. 525-537.
7. The Rotation of asymmetric Plan Structures, Castillo R., Carr A.J. and Restrepo J. (2001), proceeding of NZSEE conference, Paper No. 4.08.01.
8. H.S.Vidyadhara.Sivanand.B, H.S.Vidyadhara, "Design of 3D RC frame on sloping ground, IJRET Essin: 2319-1163.pIISN: 2321-7308.
9. Dr. R.B.Khadinanaikar and Arif Masali- Seismic performance of buildings erected on sloping ground- A review IOSR Journal of Mechanical and Civil Engineering (ISOR-JMCE) e-IISN:2278-1684, p-IISN:2320-334X, Vol. 11, Issue 3 Ver. III (May-June, 2014), PP12-19.
10. Prasad Rames Vaidya- "Seismic Analysis of Building with Shearwall on Sloping Ground" International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (online) Vol.2, Issue 2, and pp: (53-60), Month: October 2014-March 2015.
11. Y.Sing&Phani Gade, D.H.Lang& E. Erudan -Seismic Behaviour Buildings Located on Slopes an Analytical Study and some observations of Sikkim Earthquake of September 18, 2011.
12. Dr.S.K. Dubey, P.D. Sangamnerkar -Seismic behaviour of asymmetric RC building International Journal Advanced Engineering Technology E-ISSN 1976-3945.
13. Aziminejad, A.S Moghadam and W.K.Tso -A new process of designing Multi-Storey asymmetric buildings, the 14th world conference on Earthquake Engineering, October 12-17, 2008, Beijing, China.
14. S K Hirde and N K Shelar -Effect of positioning of RC Shearwalls on Seismic performance of buildings resting on Plain and Sloping Ground International Journal of Current Engineering and Technology E-ISSN 2277-4106, P-ISSN 2347-5161, International Journal of Current Engineering and Technology, Vol.5, No.3 (June 2015).
15. Paulay T, and Priestley M.J.N.,Seismic Design of reinforced concrete and masonry buildings, John-Wiley Publisher, 1992.