Seismic Performance of Flat slab Multistory Building with Varying Span A Review Paper

[1]Minakshi Mawle, [2]Mayur Singi
[1]PG Scholar, [2]Assitant Professor
[12] Civil Engineering Department, BMCT College, Indore, India.

Abstract: – The necessity of a large headroom is now the essential point of view for any architecture and for that, the only way to solve this as per the structural point of view is to provide a flat slab. The elimination of the beam could show the drastic effect in a different component of the structure. It has been examining from various findings that the stresses generated in the flat slab analysis, its intensity should lessen in order to provide stability to the structure. In this paper we take four cases i.e simple flat slab providing shear wall at lift core, simple flat slab providing shear wall at lift core and at highly stressed section location, flat slab with drop providing shear wall at lift core and flat slab with drop providing shear wall at lift core and at highly stressed section on 12 storied residential building located at Seismic Zone four and vary the flat slab panel L/B ratio from 0.2 , 0.8, 1.2,1.5 and 2. Using dynamic analysis method with the help of STAAD Pro V8i, to evaluate analysis parameters such as Node Displacement, Shear forces in the column, Compressive and tensile stresses, storey drift, von mis stress along with principle stress values, find out the optimum case of structure from this analysis.

Index Terms **– Flat slab, Shear wall, Dynamic Analysis, Stresses on flat slab.**

I. INTRODUCTION

The necessity of a large headroom is now the essential point of view for any architecture and for that, the only way to solve this as per the structural point of view is to provide a flat slab. The elimination of the beam could show the drastic effect in a different component of the structure. It has been examining from various findings that the stresses generated in the flat slab analysis, its intensity should minimize in order to provide stability to the structure. Flat Slab and shear wall are two different components which are used in building structure. Generally flat slab and shear wall are different types and it will be used according to loading condition. In a multistoried building where building construction cost is very high flat slab can be used to decrease its overall construction cost. The shear wall also be provided where lateral force is imminent in structure and when the amount of lateral loading is very high, then take, different type of shear wall according to its requirement. Flat slab is used with its different type in a multistoried building according to its loading conditions. Flat slab is generally four types which are simple flat slab, flat slab with drop, flat slab with column head and flat slab with drop and column head. In this study we will be take four cases first simple flat slab having shear wall at lift core, simple flat slab having shear wall at lift core and at highly stressed section, flat slab with drop having shear wall at lift core and flat slab with drop having shear wall at lift core and at highly stressed section on 12 storied residential building located at Seismic Zone **four**. Using dynamic analysis method with the help **of STAAD** Pro V8i, to evaluate analysis parameters such as Node Displacement, Shear forces in the column, Compressive and tensile stresses, storey drift, von mis stress along with principle stress values, find out the optimum case of structure from this analysis.

II. CONTRIBUTION OF RESEARCHERS IN FIELD OF FLAT SLAB IRREGULAR BUILDING

To analyses and design of flat slab for a different shape such as rectangular and square with and without the drop, pushover analysis (statics analysis) and earthquake analysis (seismic co-efficient method) with the help of ETABS software. After the evaluation of the result, the maximum strip moment was almost same for rectangular and square slab and the value of base shear was higher in square flat slab without the drop. The storey displacement seems to be higher in rectangular slab and the storey drift value for rectangular and square was also the same, the natural period value was almost the same for both shapes. Kaulkhere R.V, Prof. G.N Shete, (2017).[1]

In this work, to analyze and model of G+3 regular frame structure with shear wall and G+3 flat slab with the shear wall in Seismic Zone 3 done with SAP-2000. The plan area is (24 x 24) m, the height of plinth 1.8 m and floor height is 3.6 m. After the result comparison regular frame building has better performance as compared to the flat slab. To enhance the performance of flat slab building, shear wall can be provided. Mohammed Imran, M. Visweswara Rao, Dr. Jammi Ashok. (2017).[2]

Authors investigated that response of mass irregular structure need to be studied for the earthquake scenario. In this paper researcher affect RCC framed structure in both regular and mass irregular manner with different analysis methods. Salunkhe and Kanase (2017). [3]

The effect of infill and mass irregularity on a different floor in RC buildings. The results were concluded that the brick infill enhances the seismic performance of the RC buildings and poor seismic responses were shown by the mass irregular building, therefore it should be avoided in the seismically vulnerable regions. Sayyed (2017). [4]

the Flat-slab building structures possess major advantages over traditional slab-beam-column structures because of the free design of space, shorter construction time, architectural –functional and economical aspects. Because of the absence of deep beams and shear walls, the flat-slab structural system is significantly more flexible for lateral loads then traditional RC frame system and that make the system more vulnerable under seismic events. The critical moment in the design of these systems is the slab-column connection, i.e., the shear force in the slab at the connection, which should retain its bearing capacity even at maximal displacements. The behaviour of flat slab building during an earthquake depends critically on 'Building Configuration'. This fact has resulted in to ensure safety against earthquake forces of tall structures hence, there's got to determine seismic responses of such building for designing earthquake-resistant structures. Response spectrographic analysis is one among the important techniques for structural seismic analysis. In the present work, dynamic analysis of 15 models of multi-storied RCC Flat slab structure is administered by response spectroscopic analysis. Renuka Ramteke (2017) [5]

Analyse R.C structures (regular and irregular structure) with the and without shear wall by response spectrum analysis and wind analysis using CYPE software. A parameter such as time period, the centre of mass and centre of stiffness, base shear, mode shapes and drifts are calculated and compared. Comparing the amount of analysis of various models is additionally done. The model analysis is conducted to know the response of a structure with a shear wall. (Sharma Prabesh., D.R Rajendra. S, Vanisree C.N. 2016).[6]

The lateral behaviour of the multi-storey building designed according to the IS-456 and IS-1893 part-I is evaluated using dynamic analysis of framed structures using Response Spectrum Method. The inadequacies of multi-storied frame shear wall building are discussed comparing the lateral behaviour, building drift, axial force, and seismic base shear. Two important parameters of zone factor and Soil-structure interaction (SSI), which influence the lateral behaviour of the building is also considered in this study. Software STAAD-ProV8i is used for this purpose. In this study variety of stories, zone factor and soil condition are varying parameters. (Chouhan Maikesh., Ravi Kumar Makode,2016).[7]

Comparison of flat slabs and grid slabs and compare them with normal slab using STAAD pro, to get the optimum design. The design involves load calculations and analysing the whole structure by STAAD pro. The design methods used in STAAD pro analysis are Limit State Design conforms to an Indian Standard Code of Practice. STAAD pro options a progressive computer program, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis design to visualization and result verification, STAAD pro is that the professional's choice. STAAD pro has a very interactive user interface which allows the users to draw the frame and load the input values and dimensions. Then consistent with the desired criteria allotted it analyses the structure and styles the members with reinforcement details for RCC frames. (Bhatia Navjot Kaur., Tushar Golait,2016).[8]

In this study, for the strengthening of flat slab against punching shear, the use of post-installed shear reinforcement after the completion of construction work. It is also known as post shear reinforcement, used to improvement of punching shear strength of flat slab. The critical shear crack theory has used to design the post-installed shear reinforcement. The main conclusion of this work was that the inclined shear reinforcement was simpler to enhance punching shear strength. M. K. Devtale, S. S. Sayyed, Y. U. Kaulkarni, P. G. Chandak (2016).[9]

highlighted the effect of mass irregularity on a different floor in RCC buildings with as Response Spectrum analysis using STAAD.Pro V8i software. In the project work, seismic analysis of RCC buildings with mass irregularity at different floor level was carried out. Models are compared with each other for response in terms of drift and deflection. Khan & Dhamge (2016).[10]

This paper represents the shear-wall frame behaviour in a multi-storey building subjected to wind loading. The different cases are prepared with a different configuration of the shear wall. Comparative graphical illustration totally different from various} models (cases) supported different parameters like lateral deformation, level drift index, most bending moment and shear forces are mentioned. Seismic analysis of G+15 building stiffened with bracings and shear wall. The performance of the building is analysed in Zone II, Zone III, Zone IV, and Zone V. The study includes underneath, standing the most thought issue that leads the structure to perform poorly throughout an earthquake, to attain their acceptable behaviour under future earthquakes. The analysed structure is symmetrical, G+15, standard RC moment-resting frame (OMRF). Modelling of the structure is completed as per standard professional. V8i software. The time period of the structure in both the direction is retrieved from the software and as per IS 1893(part 1):2002 seismic analysis has undergone. The Lateral seismic forces of RC frame are carried out using the linear static method as per IS 1893(part 1): 2002 for different earthquake zones. The scope of gift work is to know that the structures got to have appropriate Earthquake resisting options to soundly resist massive lateral forces that are obligatory on them during the Earthquake. Shear walls are efficient, both in terms of construction cost and effectiveness in minimizing earthquake damage within the structure. Also, the braced frames can absorb a great degree of energy exerted by an earthquake. The results of the performance and the analysis of the models are then graphically represented and in tabular form and is compared for determining the best performance of building against lateral stiffness by the arrangement of three different types of bracings with three different orientation of bracings and shear wall. A comparative analysis is completed in terms of Base shear, Displacement, Axial load, Moments in Y and Z direction in columns and shear forces, maximum bending moments, max Torsion in beams. (Mohd Atif., Prof. Laxmikant Vairagade., Vikrant Nair., 2015).[11]

The work is done in this kind of approach, the analysis of flat slab in earthquake loading condition has drawn out. In this research, the flat slab is designed with the help of direct design method, equivalent frame method (for gravity load only) and finite element method (for irregular geometry and irregular layout). Contrasting the result, it has been found that in IS Code 456-2000, there aren't any provisions related to the flat slab for seismic loading, it is only based on the gravity loading conditions. If the designing has not done properly, then cracks are evolved near the support which concluding the drastic results when any structure considered during construction. P. Srinivasulu, A. Dattatreya Kumar. (2015).[12]

The important objective of earthquake engineers is to style and build a structure in such how that damage to the structure and its structural component during the earthquake is minimized. This report aims towards the dynamic analysis of a multi-storey RCC building with symmetrical configuration. For the analysis purpose model of ten storey's RCC with the asymmetrical floor plan is considered. The analysis is carried by exploitation finite element based mostly computer code SAP 2000. Various response parameters like lateral force, base shear, story drift, story shear can be determined. For dynamic analysis time, history method or response spectra method are often used. The time-history analysis is a step-by-step analysis of the dynamical response of a structure to a specified loading that may vary with time. The analysis may be linear or non-linear. The dynamic analysis may be performed for symmetrical yet as unsymmetrical building. The dynamic analysis may be within the form of nonlinear dynamic time history analysis. In this paper, a nonlinear time history analysis is performed on a ten storey RCC building frame considering time history of El Centro earthquake 1940 using SAP2000. The main parameters of the seismic analysis of structures ar load-carrying capability, ductility, stiffness, damping and mass. The various response parameters like base shear, level drift, level displacements etc are calculated. The storey drift calculated is compared with the minimum requirement of storey drift as per IS 1893:2002. Akil Ahmad., (2015).[13]

In this work, the discovery of the actual performance of R.C.C. flat slab building under earthquake loading has been done. It was determined that due to seismic loading, the effect on the flat slab in terms of storey displacement, frequency, base shear, storey level acceleration and also the effect of punching shear in all types of flat slab i.e. flat slab not including drop, flat slab with drop, flat slab with only shear wall, flat slab with drop and shear wall have also concluded. The response spectrum method is used with the help of ETABS software. After the result was compared, the fundamental mode of frequency is 20% increase in a flat slab with a drop and to enhance stiffness property with the shear wall the value was increased with 96%. The value of fundamental frequency was high on the bottom floor and less at the top floor and the value of the fundamental time period increased on the top floor to the bottom floor. The storey shear value seems comparatively high on the bottom floor and less at the top floor. Hence concluding this, the flat slab with drop and shear wall is a better option to overcome the displacement in the X direction, also base shear increased when weight increases. If the drop has provided in the interior panel then punching shear gets reduced by 25%. R. S. More, V. S. Sawant. (2015).[14]

The non-linear analysis of frame for various positions of shear wall up a building frame. In this present study, the focus is to identify the effective location of the shear wall in a multi-storey building. Considering model, one is the bare

frame structural system and the other three models are the dual-type structural system. An earthquake load is applied to a building of eight stories is in zone II, zone III, zone IV and zone V as per Code Provision IS1893-2002. The analysis has been distributed exploitation ETABS software package. Pushover curves are developed and compared for varied models. It has been observed that structure with shear wall at the appropriate location is more significant in case of displacement and base shear. Mr.K.LovaRaju., Dr.K.V.G.D.Balaji., (2015).[15]

The performance of a structural system is often evaluated resorting to non-linear static analysis. This involves the estimation of the structural strength and deformation demands and the comparison with the out their capacities at desired performance levels. This study aims at evaluating and comparing the response of thirty reinforced concrete buildings, systems with different with and without infill materials using methodology namely the ones described by the FEMA-273 using nonlinear static procedures, with described acceptance criteria. The methodology is applied to a 4 and 10 storey frames system with and without vertical irregularity, both designed as per the IS 456-2000 and IS 1893-2002 (Part I) in the context of Performance-Based Seismic Design procedures. Nonlinear Static Pushover Analysis of G+3 medium rises and G+9 high rises RCC residential building frame which is to be designed by Conventional Design Methodology. A Non-linear Static Analysis (Pushover Analysis) had been used to obtain the inelastic deformation capability of the frame. It was found that Ferro cement infilled irregular model 4 (300%) high rises building decrease in deformation or displacement of the building as it's stiffer than other buildings. Himaja G.V. Sai., Ashwini.L.K., N. Jayaramappa., (2015) [16]

The improvement location of shear walls in a symmetrical high-rise building. Position of shear walls in symmetrical buildings has due considerations. In symmetrical buildings, the centre of gravity and centre of rigidity coincide, in order that the shear walls are placed symmetrically over the outer edges or inner edges (like box shape). So, it's terribly necessary to seek out the economical and ideal location of shear walls in symmetrical buildings to attenuate the torsion impact. In this work, a high rise building with completely different places of shear walls is considered for analysis. The multi-storey building with 14 stories is analysed for its displacement, strength and stability using ETABS-2013 software. For the analysis of the building for seismic loading with two different Zones (Zone-II & Zone-V) is considered with soil I & soil III types. The analysis of the building is done by using an equivalent static method and a dynamic method. The results from the analysis obtained from both the methods are presented in tabular form and the results are compared using the graphical form. N. Janardhana Reddy., D. Gose Peera., T. Anil Kumar Reddy (2015) [17]

Seismic performance evaluation of the behaviour of frame-wall irregularity on established existing concrete (RC) structures that were subjected to the 1999 Kocaeli Earthquake in Turkey. In explicit, reference is formed to the nonlinear static analysis and nonlinear dynamic analysis of ferroconcrete (RC) structures containing shear walls. The layered shell model has been chosen due to its advantages. The damage observed after reconnaissance studies have been captured using the 3D model. Ali Koçak, Başak Zengin, Fethi Kadioğlu (2014) [18]

The effect of with and without the shear wall of flat slab building on the seismic behaviour of high rise building with different position of shear wall studied. For that, 15 story models are selected. To study the effect of different location of the shear wall on high rise structure, linear dynamic analysis (Response spectrum analysis) in software ETABs is carried out. Seismic parameters like period of time, base shear, storey displacement and storey drift are verified. Anuja Walvekar, H.S.Jadhav (2015).[19]

The effect of RC flat slab with shear wall at a different location for various heights of the building. Shear wall with flat slab provides stability to structure further because 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 a 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. (Patwari K. G. L. G. Kalurkar 2016), As per IS code 1893:2002 analysis carried out by considering regular and irregular buildings with brick infill and modified building with strong column and shear wall at the corner of the soft storey. For linear and nonlinear analysis five, 10, and 15 storey buildings modelled by using ETABS software considering Response reduction factor, Importance factor, Zone factor, damping ratio, loads as per code Lateral displacement, base shear and hinge reactions were obtained consistent with code provision. Ravindra B N, Mallikarjun S. Bhandiwad (2015).[20]

The opening in Shear walls is generally located at the sides of buildings or arranged in the form of the core that houses stairs and lifts. Due to practical necessities like doors, windows, and alternative openings, a shear shut in a building contains several openings. The size and location of openings may vary from an architectural and functional point of view. In most of the apartment building, size and location of openings in the shear wall are made without considering its effect on the structural behaviour of the building. This study is administered on 6- story frame-shear wall buildings, using linear elastic analysis with the assistance of finite element software, STAAD PRO under earthquake loads in equivalent static analysis. The results reveal that stiffness, as well as seismic responses of structures, is affected by the size of the openings as well as their locations in the shear wall. It is also explored that top lateral drift of the system can also be reduced thickening the element in the model around the opening of the shear wall. (Bhruguli H. Gandhi 2015).[21]

Reddy and Fernandez R.J (2015) conducted an analytical study for regular and irregular buildings to analyse the response of buildings in seismic zone V.15 storey building is considered and ETABS software is used to model and simulate building response. The analysis is performed for static and dynamic methods of analysis. Paper concluded behaviour of irregular structures as compared to the regular structure.[22]

Mukundan (2015) found shear wall provision in the building has been effective and economical. A 10-storey building in Zone IV is tested to reduce the effect of an earthquake using reinforced concrete shear walls in the building. The results are presented after analysing model using ETABS software and RSA method is used. Researchers also studied results in varying thickness of shear walls. It is concluded that shear walls are more resistant to lateral loads in regular/Irregular structure and for safer design, the thickness of the shear wall should range between 150mm to 400mm. [23]

Sagar et al. (2015) analysed the performance on various sort of irregularity Considered i.e.(a) Horizontal Irregularity. Plan irregularity (b) Vertical Irregularity. Mass Irregularity. To achieve the objective of the project Time history Analysis & Response spectrum analysis method was carried out.[24]

The effects of openings in the shear wall on the seismic response of structures. For parametric study 6 and 12 storied 7x3 bays apartment buildings with the typical floor plan of 35mx15m and floor height of 3m with different openings size and location in shear walls were modelled in STAAD Pro. An equivalent static analysis for three-dimensional models of the buildings was performed as per IS 1893 (part 1): 2002. Seismic responses of the analysed structures were compared. The results reveal that for gap space < 2 hundredths, the stiffness of the system is additionally littered with the scale of openings than its arrangement. However, for gap space >20%, the stiffness of the system is considerably littered with openings configuration in shear walls. (Vishal A. Itware., Dr Uttam B. Kalwane 2015).[25]

III. GAP IN RESEARCH REVIEW AND OBJECTIVE OF NEW RESEARCH

- Based on the survey of available literature following gaps in the research are identifying.

1. The dynamic analysis of various structures has been assessed but as far as the RC flat slab with varying span are concerned no work has been reported.
2. There are very few researches works available for varying flat slab span in highly seismic zone.

- Based on above-mentioned gaps following the objectives of the research are being investigated:

1. To study the stresses like principal stresses, von Mis stresses in Flat slab for zone four for medium soil, by changing the position of shear wall core with the help of dynamic analysis.
2. Also study the Storey shear and storey drift in structure for seismic zone four for medium soil, flat slab structure with the help of dynamic analysis.

IV. CONCLUSION

1. From the research, we understand approximately the contribution of different researches inside the area of the flat slab system, a gap in the research and objective of the studies to be carried out.
2. These contributions help to visualize the hassle faced by way of RC flat slab from a new perspective.
3. By evaluating the overall performance of flat slab constructing with exclusive seismic area its enhanced financial element may be completed.
4. which shall result in the path of the layout of secure stronger and greater comparatively cheap shape.

REFERENCES

1. Kaulkhere R.V, Prof. G.N Shete, (2017) "Analysis and Design of Flat Slab with Various Shapes", *International Journal of Scientific Development and Research*, Vol. 2, pp. 538-544, Issue No.5, May 2017.
2. Mohammed Imran, M. Visweswara Rao, Dr. Jammi Ashok, (2017) "A Comparative Study of Flat Slab Vs Post Tensioned Flat Slab", *International Journal for Scientific Research & Development,* Vol. 5, pp. 979-982, Issue No.9, 2017.
3. Salunkhe, U., and Kanase, J.S., (2017). "Seismic Demand of Framed Structure with Mass Irregularity International Journal of Science." *Engineering and Technology Research* (IJSETR) 6(1)
4. Sayyed O., Kushwah S.S., Rawat A., (2017). "Effect of Infill and Mass Irregularity on RC Building under Seismic Loading." *International Research Journal of Engineering and Technology* (IRJET) 04 (2)
5. Renuka Ramteke, (2017) "Parametric study of multistoried R.C.C. flat slab structure under seismic effect having different plan aspect ratio and slenderness ratio" *International Journal of Trend in Scientific Research and Development*, Vol. 1(4), pp. 210-220.
6. Prabesh Sharma., D.R Rajendra. S, Vanisree C.N. (2016). "Scrutinizing the Structural Response of Regular and Irregular Structure (With and Without Shear Wall) Subjected to Seismic and Wind Loading." *International Journal on Recent and Innovation Trends in Computing and Communication*, 4(3), 353 – 359.
7. Maikesh Chouhan., Ravi Kumar Makode (2016). "Dynamic Analysis of Multi-Storeyed Frame-Shear Wall Building Considering SSI." *Int. Journal of Engineering Research and Application*, 6(8) part-I, 31-35.
8. Navjot Kaur Bhatia., Tushar Golait, (2016). "Studying the Response of Flat Slabs & Grid Slabs Systems in Conventional RCC Buildings." *International Journal of Trend in Research and Development*,3(3), 334-337.
9. M. K. Devtale, S. S. Sayyed, Y. U. Kaulkarni, P. G. Chandak,(2016) "Comparison of Seismic Response Between Flat Slab Building and Regular Frame Building", *International Journal of Advancement in Engineering Technology, Management & Applied Science*, Vol. 3, pp. 104-111, Issue No.6, June 2016.
10. Khan, P. I., and Dhamge, N.R., (2016). "Seismic analysis of multistoried rcc building due to mass irregularity." *IJEDR* 4(3)
11. Mohd Atif., Prof. Laxmikant Vairagade., Vikrant Nair., (2015). "Comparative Study on Seismic Analysis of Multi-storey Building Stiffened with Bracing and Shear Wall." *International Research Journal of Engineering and Technology* (IRJET), 2(5), 1158-1170.

12. P. Srinivasulu, A. Dattatreya Kumar, "Behavior of RCC Flat Slab Structures Under Earthquake Loading," *International Journal of Engineering & Science Research*, Vol.5, pp.821-829, Issue No.7, July 2015.
13. Akil Ahmed (2015). "Dynamic Analysis of Multi-storey RCC Building Frames." *International Conference on Inter Disciplinary Research in Engineering and Technology, 89-94.*
14. R. S. More, V. S. Sawant, "Analysis of Flat Slab. (2015) *International Journal of Science and Research*, Vol. 4, pp. 98-101, Issue 07, July 2015.
15. Mr.K.LovaRaju., Dr.K.V.G.D.Balaji., (2015). "Effective location of shear wall on performance of building frame subjected to earthquake load." *International Advanced Research Journal in Science, Engineering and Technology*. 2(1), 33-36
16. G.V. Sai Himaja., Ashwini.L.K., N. Jayaramappa., (2015). "Comparative Study on Non-Linear Analysis of Infilled Frames for Vertically Irregular Buildings." *International Journal of Engineering Science Invention*. 4(6) 42-51.
17. N. Janardhana Reddy., D. Gose Peera., T. Anil Kumar Reddy (2015) "Seismic Analysis of Multi-Storied Building with Shear Walls Using ETABS-2013" International Journal of Science and Research (IJSR) ,4(11), 1030-1040.
18. Ali Koçak, Başak Zengin, Fethi Kadioğlu (2014) "Performance Assessment Of Irregular Rc Buildings With Shear Walls After Earthquake" *http://dx.doi.org/10.1016/j.engfailanal.2015.05.016*
19. Anuja Walvekar, H.S.Jadhav (2015) "Parametric Study Of Flat Slab Building With And Without Shear Wall To Seismic Performance" *International Journal of Research in Engineering and Technology*. 4(4),601-607.
20. Ravindra B N, Mallikarjun S. Bhandiwad (2015) "Dynamic Analysis of Soft Storey Building with Flat Slab" *International Research Journal of Engineering and Technology* (IRJET), 2(4), 1644-1648.
21. Bhruguli H. Gandhi "Effect of Opening on Behaviour Of Shear Wall" *International Journal for Technological Research In Engineering*, 4(3) 875-878.
22. Reddy A., Fernandez R.J., (2015). "Seismic analysis of RC regular and irregular frame structures." *International Research Journal of Engineering and Technology* (IRJET), 02(5)
23. Mukundan H., and Manivel S., (2015). "Effect of Vertical Stiffness Irregularity on Multi- Storey Shear Wall-framed Structures using Response Spectrum Analysis*", International Journal of Innovative Research in Science, Engineering and Technology*, 4(3)
24. Sagar, Patil B., Prof. Katti Gururaj B., (2015) "Study of Behaviour of Plan & Vertical Irregularity by Seismic Analysis." *International Journal for Scientific Research & Development (IJSRD)*, 03(4)
25. Vishal A. Itware., Dr. Uttam B. Kalwane (2015) "Effects of Openings in Shear Wall on Seismic Response of Structure" *Int. Journal of Engineering Research and Applications* 5(7) 41-45.