International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 10 | October - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Study on Horizontal and Vertical Irregularities in Structures Under Seismic Load – A Review

Lavanya S.R[1] and K. Sumangala [2]

[1]Post Graduate student, Department of Civil Engineering, Government College of Engineering Tirunelveli, Tamil Nadu, India.

[2]Assistant Professor, Department of Civil Engineering, Government College of Engineering Tirunelveli, Tamil Nadu, India.

Abstract - An increase in population has led more often towards vertical development rather than horizontal development, because of this the demand for multi-storied buildings has increased and they constitute about 60-70% of the urban infrastructure. In the present time, the analysis of civil structures is generally carried out by various design software. Now a day's irregular structures contribute a large portion of urban infrastructure. Irregular structures have certain physical discontinuities either in plan or in elevation or both which affect the performance of the structure subjected to lateral loads. This work reviews the analysis done by various researchers in multi storey reinforced concrete structures subjected to seismic load.

Key Words**:** ETABS, Seismic Load, Multi Storey buildings, vertical and horizontal Irregularity.

1. INTRODUCTION

Disasters are serious disruptions to the functioning of a community that exceed its capacity to cope using its own resources. Disasters can be caused by natural, man-made and technological hazards, as well as various factors that influence the exposure and vulnerability of a community. A sudden-onset disaster is one triggered by a hazardous event that emerges quickly or unexpectedly. Sudden-onset disasters could be associated with, e.g., earthquake. Disasters can be caused by natural, man-made and technological hazards, as well as various factors that influence the exposure and vulnerability of a community. When internal load bearing structural elements fail, a building will collapse into itself and exterior walls are pulled into the falling structure. This scenario may be caused by construction activity, an earthquake, or fire, and may result in a dense debris field with a small footprint. Structural failure occurs because of forces acting on the structure. These can be static forces (stationary forces) due to the structure's own weight or the load that it is carrying or dynamic forces (moving forces) produced by the wind waves, vehicles, people, etc. Irregular structures contribute a large portion of urban infrastructure. Irregular structures have certain physical discontinuities either in plan or in elevation or both which affect the performance of the structure subjected to lateral loads. Disaster areas affect the population living in the community by dramatic increase in expense, loss of energy, food and services. The objective of this study is to review works of various researchers with the analysis of a multi storey reinforced concrete structures subjected to seismic load on the plan layout includes of both X and Y directions of irregular building, using ETABS software.

2. VERTICAL IRREGULARITY

Mohod and Karwa (2014) in this paper, the authors made an effort to understand the earthquake response of irregular structures. Critical setback ratio RA=0.25 and RH=6/5 shows the variation in storey drift which signifies the jumping of the forces due to unequal distribution of mass along the plan as well as along the height. The optimum value of critical setback ratio for RA and RH come out to be RA=0.75 and RH=6/5. The irregular structures have to be treated with proper understanding and revision of seismic code provisions. Geometric vertical irregularities seems to be important to stipulate more restrictive limits.

Pradeep et al., (2014) studied the seismic behaviour of reinforced concrete framed structures with varying height of column within storey. They have created the model for frames on plain ground as well as for slope terrain. All models are modelled with the help of ANSYS. The results show that the short column in the ground storey fails very on a sloping terrain. Shear cracks also found on the beam column joint of column.

Pushkar and Rahul (2017) studied about considering a type of irregular structure during earthquake. Results obtained from the analysis shows that storey stiffness increases up to certain storey and then it starts to decrease. Storey shear inversely varies with increase in storey height of the structure.

Inel and Ozmen (2008) made investigations on soft storey behavior due to increased storey height with absence of infill amount at ground storey. Evaluating displacement capacity and drift demands, soft storey due to increased height and due to lack of infill walls have close values to each other. Soft storey may arise because of abrupt changes in amount of infill walls which are not thought to be a part of structural system. Also, soft storey due to both increased height and lack of infill wall at ground storey is the most detrimental case in view of drift capacities and demands of the structure.

Imranullahkhan et al., (2017) made this study to understand irregularity and to analyze this building under earthquake forces. The high rise buildings in plan of L-shape are analysed using response spectrum by the E-tabs analysis software. Storey drift response along the height of the building shows that the middle storeys are more affected than Lower and upper storeys. Displacements slowly increased from ground storey to top storey. Comparison of displacement is made in different zones of x-and y-directions.

Rana and Raheen (2015) has shown the behaviour of regular and vertical geometric irregular RCC framed structure under seismic motion. Five types of building geometry are considered: one regular and four irregular frames. A comparative study is made between height and bay wise. Frames are modelled and analyzed in software StaadPro V8i. The amount of setback increases the shear force and bending. The variation of critical shear force from regular to vertical geometric irregular is too high.

Gokdemir et al. (2013) in this paper, studied the effects of torsional irregularity on structures.

Eccentricity occurs between center of mass and center of rigidity which causes torsion and bending in structures. The magnitude of torsional moment is the function of eccentricity ratio. Under more torsion, structural elements may reach to their torsional moment capacity or the whole structure may be forced to deflect more than its lateral deflection limit. So, torsional irregularity may cause failure of any structural system.

Mario et al. (2006) examined the effects of the over strength in element cross-sections on the seismic behaviour of multi-storey asymmetric buildings. Torsional provisions, which aim at reducing ductility demands of single-storey asymmetric systems to those of the corresponding torsionally balanced systems, should be re-checked in light of the behaviour of realistic multi-storey buildings.

Abd-el-rahim and Farghaly (2010) in this the study evaluated the performance of gravity loaded irregular buildings in plan during earthquake. A time history analysis with a peak ground acceleration of 0.25g was carried out using software program SAP2000. From the result it is found that the induced base shear 90 degree to the earthquake direction is sensitive to the torsional eccentricity and increases by about 80%, 65%, and 40% of the base shear in earthquake direction for O, L, and U shape . The top displacements for O and L models are increased up to 1.9 time top displacement in I-model.

Hirde et al. (2016) made an attempt to study the building models with plan irregularities. In retrofitted building the hinges developed in beams are at Life safety which is acceptable criteria for the building. After retrofitting with X steel bracing it is observed that performance level of building is changed to life safety level from collapse level.

3. PLAN IRREGULARITY

Dhananjay (2017) analysed G+25 storey rectangular shape, L shape and I shape building using STADD pro software in zone III and zone IV for hard and medium soils. It was find out L shape had less bending moment and displacement in z direction when compared to x direction.

Guevara et al. (1992) focused on the effect of floor plan on the seismic behavior of structures. Study includes dynamic analysis of H, L and T shaped buildings. The paper suggests that buildings having H and L shaped plan should be divided into rectangular blocks separated by seismic joints.

Athanassiadou (2008) studied on high storey 2-dimensional plane frames with 2 and 4 large setbacks in the upper floors respectively. T his study it is find out that DCM frames are find to be strong and less ductile than the corresponding DCH ones. The high strength of the irregular frames was find to be similar to that of the regular building while DCH frames are found to dispose higher over strength than DCM ones.

Ahirwal et al. (2019) in this study made an attempt to know the difference in seismic response of 2 building with and without diaphragm discontinuity. Base shear for regular diaphragm building is higher than irregular diaphragm building. Due to the lower in floor area dead load of the regular structure is higher than irregular structure which leads to increase in base shear of regular diaphragm building. Joint displacement in regular diaphragm building is 15% more than irregular diaphragm building.

Rizwan and Peera (2015) in this paper considered four - 15 storied building of totally different shapes i.e, rectangular shape, L shape, H shape and C shape building. It was found out from results that more deformation in plan irregularity buildings than regular plan building.

Patil et al. (2019) this paper attempted to evaluate and compare seismic performance of G+14 Storey with 7 bays X 9 bays plan irregular and Regular building using ETABs 2015 software. From the analysis of ESA & RSA for both Plan Regular & Irregular Building, Storey Displacement &Storey drift is higher for Plan irregular building compare to plan regular building. In regular Building reduction in displacement and Storey drift is due to Infill action because of the lateral stiffness of frame. As the plan irregularity increase both.

Babu (2017) in this paper investigated the response of G+7 building structures by using STAAD PRO designing software. In this study of the G+7 building, seismic load dominates the wind load under the seismic zone –II. From this study it can be observed that, in the earthquake resistant design of G+7 RC framed building the steel quantity increased by 1.517% to the convention concrete design.

Momen et al. (2016) have studied the effect of seismic response of L shaped buildings. Equivalent static and response spectrum methods were performed using ETABS software. It is observed that response of L shaped building is higher than that the regular building frame due to torsion moment.

Upendra (2017), designed and analysed a G+12 storey building having rectangular shape, T shape, C shape and O shape using ETABS software. It was found that minimum drift in x direction was found to be more in C shape while in Y direction, O shape building was found to have less drift.

Naik and Shetty (2019) in their research paper modeled and analysed G+10 storied buildings of Rectangular shape, L shape and C shape structure using ETABS 2016 software. The storey shear values were less in L shape structure and C shape structure that shear force carrying capacity is less in these structures. The storey overturning moment is higher in rectangular shape which indicates that higher moment is required for overturning the storey. Rectangular shape is the best desired and L shape is the less desired shape for construction in seismic zone to construct the building.

ReenaSahu et al. (2017) made an attempt to know the difference between a building with diaphragm discontinuity and a building without diaphragm discontinuity. Models with a symmetrical opening in both directions expressed similar response for the parameters while models with change in the symmetry behaved differently. The increase in opening percentage increases the storey drift in the entire model. Shear force, bending moment and axial force obtained from the earthquake static analysis is more than compared to response spectrum.

Chandler and Hutchinson (1986) in this study made a detailed parametric study of the lateral and torsional moment response of a partially symmetric one storey building model. It is concluded that for particular value of the parameters defining the structural system, typical of the properties of many buildings, torsional coupling induces a significant amplification of earthquake forces which should be accounted for in their design of the building.

Mehana et al. (2019) studied the effect of the ratio Ω between (ωΘ) to (ωx) or (ωy), on torsional behaviour of the structure. A study is carried out using the ELF method applied to single storey building with one eccentricity by examining different values of Ω. Structures with ratio $\Omega > 1.0$ are torsional stiff and displacements values are not sensitive to the increment in eccentricity ratio. structures with ratio $\Omega < 1.0$ are torsional ,flexible and displacements values are sensitive to increases in eccentricity ratio, so the deformations are mainly torsionally twisting rather than transitional motion.

Hassballa et al. (2013) analysed the multistorey building by response spectrum method by using Etabs.Pro software. Upon analysis it is found that drift is obtained from this analysis is about 2 to 3 times the allowable drift which results in large displacement due to combination of static load and seismic load.

Uzun et al. (2018) studied about the number of storey with different locations of shear wall in plan. Earthquake analyzes of this building are made separately for the 3 different earthquake analysis methods defined in Turkish Earthquake. The coefficient of torsional irregularity increases as the number of storey decrease. The torsional irregularity coefficient increase about 60% in the EL method.

Ozmen et al. (2014) in this parametric study on 6 buildings with various shear wall position. Based on floor rotation, a torsional irregularity coefficient is proposed. According to their finding as the number of storey reduced, the torsional irregularity coefficient increases and the storey rotations occur for the top storey of the building.

4. COMBINED IRREGULARITIES

Soni (2015) studied of effect of irregularities in building and their consequence. In this study the author used the response spectrum method for the analysis of G+10 building. Structure with soft storey and heavy mass at top suffered maximum displacement. Storey drift is maximum, when heavy loaded.

Naveen et al. (2019) studied the seismic response of RC structures possessing various combination of irregularity. It is to observe that irregularity considerably affects the seismic response of the structure Out of various types of single irregularities analyzed, stiffness irregularity is found to have maximum influence Among the cases considered, combinations of irregulary in the building having configuration with heavy mass, stiffness and vertical geometric irregularities has maximum response.

Bansal and Gagandeep (2012) in this study carried out RSA and THA of vertically irregular RC building frames and to carry out the ductility based design using IS 13920. The storey shear force was found to be greater for the first storey and it decreases to minimum in the top storey in all cases. The mass irregular structures were observed to experience larger base shear than regular structures. The stiffness irregular structure experience lower base shear and has higher inter-storey drifts. Lower stiffness results in higher displacements to upper storeys. When THA was done for regular as well as stiffness irregular structure, it was found that displacements of upper storeys did not vary much from each other but as we moved down to lower storeys the displacement in case of soft storey are higher compare to other.

Sweetlin et al. (2016) in this study made a comparison of displacement between regular and irregular building. The displacement have direct co relation with mass of building so displacement in regular building is more than irregular building and storey drift is also more in regular building because they consider only the geometric irregular building.

Akhare and Maske (2015) in this work studied about the performance based seismic design of buildings with plan irregularity using Standard pushover analysis and Modal pushover analysis. Standard pushover analysis gives same results as Modal pushover analysis and THA for regular building, but for irregular buildings modal pushover analysis gives better results. It is also concluded that torsion produced in irregular buildings are almost 20% more than the regular building so it is necessary to take the effects due to torsion for irregular buildings.

Choudhary et al. (2018) in this study a difference between buildings with and without diaphragm discontinuity were analysed by ETABS. The models which have slab opening had lower storey displacement, storey drift, storey shear, modal period when compared to the regular building model. The study shows that variation in the slab thickness reduces the performance of the buildings during earthquakes. But the slab opening in a building having shear wall gives better performance during earthquakes.

Raj and Devi (2019) studied seismic performance of G+15 irregular buildings, modelled and analyzed for its seismic behavior using the software STAAD.Pro. The seismic response of stiffness irregular structure is far better than the vertical geometric irregular, and the re-entrant corner irregularity. The lateral displacement is found very high for re-entrant corner structure compared to other irregular structures. This occurs due to change in geometry of the structure are more and hence displacement is more. Re-entrant corner irregularity shows the worst seismic performance among the considered irregular structures.

5. METHOD OF ANALYSIS

Kulkarni and Tatikonda (2016) in this study used El Centro earthquake data. It is observed that the time period Vs displacement graphs obtained are similar to Time Vs acceleration graph obtained from earthquake data. when time period increases displacement of each floor increase in the building. As the height of structure increases time period increases which are in accordance with IS: 1893(Part 1): 2002 code.

Arvind and Fernandes (2015) worked on reinforced regular and reinforced irregular structures in zone IV and zone V. The results found out from the analysis included lesser storey displacement values in static analysis method as compared to dynamic analysis method.

Tremblay and Poncet (2005) in this study analysed 8 storey concentrically braced steel frame with different set back configuration obtain sudden reduce in plan dimensions and seismic weight along the height of the structure. The analysis of irregular structure could be improved by using the dynamic analysis method of structure.

Dubey et al. (2015) in this study on multi-storey irregular building with twenty storeys, modelled using software STAAD PRO for seismic zone in India. It is concluded that storey drift in time history analysis is 2 to 8% higher than RSA in both the regular and the irregular building. The base shear value in case of RSA is more as compared to Time history analysis. It depends on the frequency content of the earthquake observation. Time history method is better and more economical for designing of the structure.

6. CONCLUSION

Few works of the researchers were reviewed in this paper in the context of various types of irregularities provided in multi-storey buildings. It is summarized from the review that irregularity in building causes eccentricity between the building mass and stiffness center which gives rise to damage effect on building. The structure with plan and vertical irregularity structure are analysed. The moment of inertia has much importance in the stability of seismic resistant building. The lateral displacement is found very high for re-entrant corner structure compared to other irregular structures. This is due to change in geometry of the structure and the inertial forces are more and hence displacement is more. Re-entrant corner irregularity shows the worst seismic performance among the considered irregularities.

Rectangular shape is the best desired and L shape is the less desired shape for construction in seismic zone. The increase in opening percentage increases the storey drift in the entire model in case of diaphragm discontinuity. But the slab opening in a building having shear wall gives better performance during earthquakes.

REFFERENCE

1.Abd-el-rahim H.H.A., and Farghaly A., (2010) "Influence of Structural Irregularity in Plan Floor Shape on Seismic Response of Buildings", Journal of Engineering Sciences, Assiut University, Vol. 38, No.4, pp. 911-928

2.Ahirwal A., Kirti G., Vaibhav S., (2019) "Effect of Irregular Plan on Seismic Vulnerability of Reinforced Concrete Buildings", AIP Conference Proceedings, Vol. 2158, pp.1-5.

3. Akhare A.R., Maske A.A., (2015) "Performance Based Seismic Design of R.C.C. Buildings with Plan Irregularity", Journal of Civil Engineering and Environmental Technology, Vol. 2, No.10, pp. 1-6.

4. Al-Ali.A.A.K. and Krawinkler.H. (1998) "Effects of Vertical Irregularities on Seismic Behavior of Building Structures", The John A. Blume Earthquake Engineering Center, Stanford University, No.130, pp.1-396.

5. Arvind R., and Fernandes R.J. (2015) "Seismic Analysis of RC Regular and Irregular Frame Structures", International Journal of Engineering Research and Technology, Vol. 2, No.5, pp. 44-47.

6. Athanassiadou C. J. (2008), "Seismic performance of R/C plane frames irregular in elevation", Elsevier, Amsterdam, Vol. 30, No.5, pp. 1250-1261.

7. Avilaa.L, Vasconcelosb.G, Lourençob P.B. (2018) "Experimental Seismic Performance Assessment of Asymmetric Masonry Buildings" Engineering Structures, Elsevier vol 155,pp. 298–314.

8. Babu G.B. (2017), "Seismic Analysis and Design Of G+7 Residential Building Using Staadpro", International Journal Of Advance Research, Ideas And Innovations In Technology, Vol. 3, No.3, pp: 924-930.

9. Chandler A.M., and Hutchinson G.L., (1986) "Torsional Coupling Effects In The Earthquake Response of Asymmetric Buildings", Engineering Structures, Vol. 8, No.4, pp: 222-236.

10. Choudhary S., Arfath S., Ahmed M., Pasha N. (2018), "Comparative Study on Seismic Analysis of Multi Storey Building Having Diaphragm Discontinuity Using Etabs", International Journal of Research in Advent Technology, Vol. 6, No.5, pp.912-918.

11. Chunyu.T, Junjin.L, ZhangHong, Jinzhe.C (2012) "Experimental study on seismic behavior of an irregular high-rise building" 15th World Conference Earthquake Engineering, Vol. 26, pp. 20620-20629.

12. Dhananjay S., Bhaduria S.S. (2017), "Analysis of Multi-Storey RCC Frames of Regular And Irregular Plan Configuration Using Response Spectrum Method", SSRG International Journal of Civil Engineering, Vol. 4, No.6, pp.72-78.

13. Dubey S.K., Prakash S., Ankit A., (2015), "Dynamics Analysis of Structures Subjected To Earthquake Load", International Journal of Advance Engineering and Research Development Vol. 2, No.9, pp.11-19.

14. Dubule.S.C, Ainchwar.D (2018) "Seismic Analysis And Design of Vertically Irregular R.C. Building Frames" International Journal Of Advance Research In Science And Engineering, Vol. 7, No.4 , pp. 290-306.

15. Ferraioli.M (2015) "Case Study of Seismic Performance Assessment of Irregular RC Buildings: Hospital Structure of Avezzano (L"aquila, Italy)" Earthquake Engineering And Engineering Vibration, Vol.14, No.1, pp.141-156.

16. Gokdemir H., Ozbasaran H., Dogan M., Unluoglu E., Albayrak U. (2013), "Effects of Torsional Irregularity to Structures during Earthquake", Engineering Failure Analysis, Vol. 35, pp: 713–717.

17. Upendra K.R. and Arunakanthi E., (2017), "Dynamic Analysis of Multistorey Structure for Different Shapes", International Journal of Technical Innovation in Modern Engineering & Science, Vol. 3, No.12, pp. 8-17.

18. Harshita.R, Soundarya.A, Prathima.K, Guruprasad.Y (2014), "Seismic Analysis of Symmetric RC Frame Using RSM and THM", International Journal of Scientific Research and Education, vol.2, No.3, pp.483-499.

19. Hassaballa A.E., Fathelrahman M.A., Ismaeil M. A (2013), "Seismic Analysis of a Reinforced Concrete Building by Response Spectrum Method‟, IOSR Journal of Engineering", Vol. 3, No.9, pp: 01-09.
20. Hirde S.K. and Aher R.A. (2016), "Seismic Evaluation of Irregular Structures", International Journal of Current Engineering and Technology, Vol.6, No.5, pp.1665-1672.
21. Homaei.F, Shakib.H, Soltani.M (2017), "Probabilistic Seismic Performance Evaluation of Vertically Irregular Steel Building Considering Soil–Structure Interaction" International Journal of Civil Enggineering, Springer, Vol.4, No.15, pp.611-625.
22. Imranullahkhan, Satya R. (2017), "Seismic Analysis of Irregular L-Shape Building in Various Zones‟, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, No.8, pp.16529-16536.
23. Inel M., Ozmen.H.B., (2008), "Effect of Infill Walls On Soft Storey Behavior In Mid-Rise RC Building‟, Presented at the 14th World Conference of Earthquake Engineering, Beijing, China.
24. Kazantzi.A.K., Vamvatsikos.D.B, Lignos.D.G. (2014) "Seismic Performance of a Steel Moment-Resisting Frame Subject To Strength and Ductility Uncertainty" Engineering Structures, Elsiever, Vol.78, pp.69-77.
25. Magliulo.G and Ramasco.R (2008) "Seismic Perfomance of R/C Frames With Regular and Irregular Strength Vertical Distributions" The 14th World Conference On Earthquake Engineering Proceedings.
26. Mehana Md.S., Osama Md, Isam F. (2019), "Torsional Behaviour of Irregular Buildings with Single Eccentricity‟, IOP Conf. Series: Materials Science and Engineering, Vol.603, pp.1-10.
27. Soni A.G., Agarwal D.G., Pande A.M., (2015), "Effect of Irregularities in Buildings and their Consequences", International Journal of Modern Trends in Engineering and Research, Vol. 2, No.4, pp.14-21.
28. Moehle.J.P. and Alarcon.L.F. (1986). "Seismic Analysis Methods for Irregular Buildings", Journal of Structural Engineering, ASCE, Vol. 112, No. 1, pp. 35-52.
29. Mohamed.O.A. and Abbass.O.A. (2015), "Consideration of Torsional Irregularity in Modal Response Spectrum Analysis" Earthquake Resistant Engineering Structures X, Vol.152, pp.209-218.
30. Momen, M. M., Ahmed, Shehata., Abdel Raheem. E., Mohamed.M., Ahmed and Aly, G.A., Abdel, shafy, (2016), "Irregularity Effects on the Seismic Performance of L-shaped Multi-storey Buildings", Journal of Engineering Sciences, Vol. 44, No.5, pp.513-536.
31. Naveen S.E, Abrahamb, Kumari S D (2019), "Analysis of Irregular Structures under Earthquake Loads‟, Procedia Structural Integrity, Elsevier, Vol. 14, pp.806-819.
32. Neelavathi.S, Shwetha.K.G, and MaheshKumar C.L.(2019) "Torsional Behavior of Irregular RC Building under Static and Dynamic Loading" Materials Science Forum, Vol. 969, pp 247-252.
33. Ozmen G., Girgin K. and Durgun Y., (2014), "Torsional Irregularity in Multi-storey Structures‟, International Journal of Advanced Structural Engineering, Vol. 6, pp: 121-131.
34. Padol.S.R, and Talikoti.R.S. (2015) "Review Paper on Seismic Response of Multistoried RCC Building with Mass Irregularity" International Journal of Research in Engineering and Technology, Vol.4, No.3, pp.358-360.
35. Patil S., Matnalli P., Priyanka S V, Rooparani (2019), ‟Seismic Analysis Of Plan Regular And Irregular Buildings‟, International Research Journal of Engineering and Technology, Vol. 6, No.5, pp.1058-1063.
36. Pradeep S. and K. P. Jacob (2014), "Seismic Behaviour of Reinforced Concrete Framed Buildings with Columns of Different Heights within One Storey", International Journal of Civil Engineering and Technology, Vol. 8, No. 5, pp. 37–41.
37. Pushkar R. and Rahul C (2017), "Seismic Analysis of Multistoried Building For Different Plans Using ETABS 2015", International Research Journal of Engineering and Technology, Vol. 4, No.10, pp. 1101-1108.
38. Raj N., Devi N. (2019), "Seismic Analysis Of Regular And Irregular Multistorey Buildngs Using Staad.Pro", International Journal of Innovative Science and Research Technology, Vol. 4, No.4, pp.458-465.
39. Rana D., Raheem J. (2015), "Seismic Analysis

of Regular &Vertical Geometric Irregular RCC Framed Building”, International Research Journal of Engineering and Technology, Vol. 2, No.4, pp: 1396-1401.
40. Reena S. and Dwivedi R. (2017), “Seismic Analysis of RC Frame with Diaphragm Discontinuity”, IOSR Journal of Mechanical and Civil Engineering, Vol. 14, No.4, pp.36-
41. Rizwan Md.S and Peera D.G., (2015), “Dynamic Analysis of Multistorey Structure for Different Shapes”, International Journal of Innovative Research in Advanced Engineering, Vol. 2, No.8, pp. 85-91.
42. Sarno. L.Di, Elnashai.A.S, Nethercot.D.A. (2003), “Seismic Performance Assessment of Stainless Steel Frames” Journal of Constructional Steel Research, Elsiever Vol.59, pp. 1289–1319