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ANALYSIS OF REGULAR AND IRREGULAR BUILDINGS IN ETABS WITH IRREGULAR FOUNDATIONS (STEPPED FOUNDATION)

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Abstract - *Structures being constructed are governing the architectural and structural requirements, in different types of terrains resulting in irregular phenomena in structural systems such as stiffness, mass, strength, torsional, vertical, and floating columns. These types of irregularities attract large sections and design forces which are unavoidable and special care should be taken to make the structure resist the changes in the load path, pattern, and stress reversal mechanism due to lateral and vertical loads. Foundation irregularities are being showing the significance because they are being constructed on hill slopes and large level difference sites extended up to square kilometres, the study on foundation and structural irregularities has a lot of scope for understanding the behaviour hence it is considered as a case study in this project.*

In the present study G+9 structures are modelled in different seismic and wind zones across India as per the Indian standard codes IS: 1893-2016 and IS: 875-2015 namely the seismic zones considered are Zone-II, Zone-III, Zone-IV and Zone-V and wind zones are having wind speeds of 33m/s, 39m/s, 44m/s, 47m/s, 50m/s and 55m/s all the structures were modelled in seismic and design software ETABS residential structures having floor to floor height of 3m and assumed the supports are to be fixed, considering the material grades of concrete and steel considered are M30 and Fe500. Different structural configurations are considered on sloping grounds with regular frame with regular base, regular frame with irregular base, irregular frame with regular base, irregular frame with irregular base.

Keywords: *Irregularities, ETABS, Regular frame, irregular frame, M30, FE500.*

1 INTRODUCTION

1.1 Sloping grounds

Due to rapid urbanization and development of high strength material and construction activities and based on the architectural appearances the structures are being built irregular in manner and the construction activities happening on the hilly grounds resulting in the irregular foundation levels for different footings which resulting in irregular behavior when subjected to seismic and wind loadings, structures built on sloping grounds are attracted for more forces, the variation of the footing levels results variation of column heights.

Due to these adverse effects the stiffness, flexibility and force behavior changes and the long and short effects come into picture and these phenomena increase with the increase in the seismic and wind zones. Columns are generally designed for the vertical loading and under the horizontal force, they are heavily damaged. The dynamic behavior and properties of the structures defer greatly when compared to the regular structures with base regular, rapid population growth have increased in the population of hilly area.

1.2 Earthquake effects on structures

An earthquake deal with the understanding of seismic wave's formation and capturing the sources producing them. It is a rapid shake of top and bottom layers of the earth. "It is a wave phenomenon with a train of oscillating waves radiating from an underground centre and follows the laws of simple harmonic motion (SHM)"

1.3 Causes of earthquake

The earth is made of 4 parts as shown. The outer core is liquid, while the inner core is solid. The outer core is liquid and the inner core is solid.The crust is a thin layer, rocky and brittle in nature, so that when it fractures under stress earthquakes are produced.

The most important processes such as volcanism and seismic activity is believed to originate in the mantle, because of temperature variation.

The main sources of earthquakes are

1. Tectonic earthquakes
2. Volcanic earthquakes
3. rock faults
4. Controlled sources
5. reservoir earthquakes

All the major earthquakes are caused by plate tectonics as shown below. Plate tectonics is a starting point for understanding the forces within the earth that cause earthquakes.

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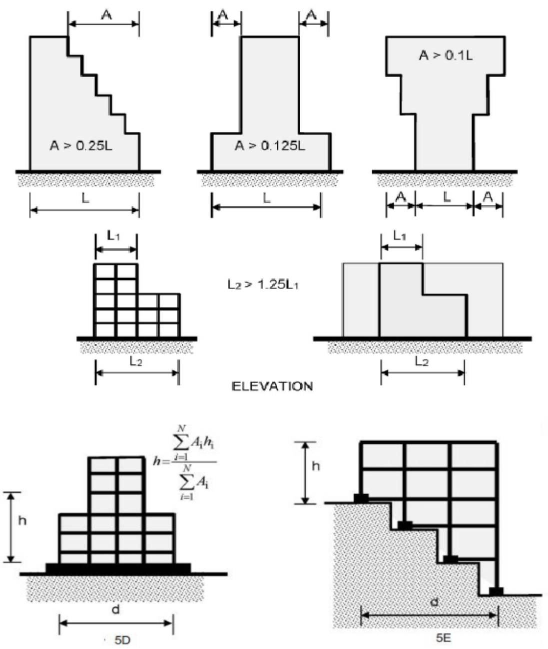
Types of irregularities:



1.4 Seismic Data as Per Is 1893(Part 1): 2016 Code

Based on magnitude of the earthquake India is classified into four zones (II, III, IV, and V)

Table 1.1: Seismic zone factor based on intensity

Seismic intensity	Seismic zone	Zone factor, Z
Low	II	0.1
Moderate	III	0.16
Severe	IV	0.24
Very severe	V	0.36

1.5 ETABS Software

- ETABS stands for extended three-dimensional advanced building systems.
- ETABS is finite element software used for analysis and design of concrete and steel structures.
- ETABS supports wind and seismic loadings, and also different load cases and combinations.
- ETABS is been utilized for analysis of elastic and inelastic behavior of structures with irregularities and mass concentrations.

2 LITERATURE REVIEW

Mojahid Islam, Siddharth Pastariya, "Analysis of building on Sloping Ground subjected to Seismic Forces", building is analyzed for four different slopes 10˚, 20˚, 30˚ and 40˚ along with a regular building restedon flat terrain and concluded that In this research study various cases are analyzed as perIS 1893:2016 (part-1) by response spectrum method for seismic zone V against all constraints as mentioned in theobjectives. Dynamic analysis was performed againstvarious seismic parameters for multiple load combination for all the models consist of structure on normal ground,step back configuration and step back & setbackConfiguration.

Suraj Harish V, Muthanand P, RajendraPrasath C, "Performance Analysis of Braced Reinforced Concrete Building in Sloped Terrain", study is on generating a 3D analytical model of multi-storey buildings analyzed using structural analysis tool 'ETABS" to study the effect of varying height of columns due to sloping ground and the effect of bracing at different positions in a different configuration of the building during an earthquake. The performance of step back building and set step back building proves more effective in seismic zone than normal configuration building. Bracing placed in lateral direction resist more effect to the building than the other position where the bracing are placed. Bracing which is configured like X prove more resistance towards lateral loads and effect to the structure than the other bracing.

Anjeet Singh Chauhan and Rajiv Banerjee, "seismic response of irregular building on sloping ground", on a G+10 RCC Stepback building having each storey of height 3.6m with a horizontal angle of inclination 20°, 30°, 40°, and 45° on the sloping ground is analyzed in seismic zone V by Response Spectrum method analysis and modeling of the Stepback building are carried out by Etabs software as per IS 1893:2016. Based on the dynamic analysis of the different type of irregularity with G+10 stepback building on sloping ground, the following are the conclusion. As the angle of slope increase then every Model frames of Mode period, Base shear, Storey displacement, and storey drift values increases in both directions, but in the case of storey shear, its values decrease in both directions of each Model frames as the angle of slope increases. The stepback bear frames with Diaphragm irregularity are less vulnerable and suitable on the sloping ground during the seismic excitation due to less seismic weight and fewer values of dynamic response as compare to other models.

Paresh G. Mistry, Hemal J. Shah, "Seismic Analysis of Building on Sloping Ground Considering Bi-Directional Earthquake", Building on a plain ground, Step back building and Set back with step back building have been considered. Dynamic analysis of building on a plain ground, Set back with step back building and Step back building will be carried out in SAP 2000 software and found that In response spectrum analysis, Axial force is almost same in all three types of building but moment increase 63 % and 5 % in stepback building compare to

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building on plain ground and setback with stepback building respectively. The values of base shear are higher for time history analysis compare to response spectrum analysis. The values of axial force and moments are higher for time history analysis compare to response spectrum analysis. In most of cases critical angles are different from 0^0 and 90^0. It is not possible to decide the angle of application of earthquake which gives peak response because we are getting different angles for various peak responses such as Base shear, Axial force and moments for column. The columns near ground attract higher moments so design should be properly done to resist that much high moment.

MdZaid, Hafiz Ashraf Alam, Khan Imran, Mohammed Ibrahim Gori, Saddam Hussain, HuzefaShaikh, "Critical Analysis of Regular Building on Sloping Ground Amlibari, Nandurbar (Maharashtra)", The structures aregenerally constructed on level ground; however, due to scarcity of level grounds the construction activities have beenstarted on sloping grounds. There are two types of configuration of building on sloping ground, the one is stepback and the other is step back setback. In this study, G+4 storey's RCC building and the ground slope is 140. Acomparison has been made with the building resting on level ground. The modelling and analysis of the building has been done by using structure analysis tool STAAD-PRO (v8i, and found that The critical axial force in columns increases as slopeincreases.Shear force is found maximum in column of shorterLength at front side of earthquake direction. Torsion is very critical in higher slopes in the frontdirection when the Earthquake force is consideredFrom hill to ground. At the middle column the torsion is critical atvarious floor levels and for back side column thetorsion is normally critical at higher floor levels.When the torsion is considered in Z direction thetorsion pattern is erratic in all columns howevercolumn placed in middle are subjected to higher level of torsion than that of lower level of floor.

NarendraTak, Ankit Pal, Mayank Choudhary, "Review on Analysis of Tower on Building with Sloping Ground", Therefore the seismic and wind analysis on building towers plays an important role in the construction of tower on building on sloping ground surface. By using Staad-pro software seismic and wind load is analysed make the structure safe against earthquake and heavy wind. Modelling through this software's helps to find strength of the structure against lateral and vertical loads. Analysis result shows the safety of the structure against lateral and vertical loads. If the structure is situated on steep or sloping ground the analysis of the structure is more important. After reading all of the research we can conclude that Tower on building saves the extra land cost and if the analysis and modelling of the structure is accurate we can easily find out the safety of the structure against lateral loads and against sliding.

Sachin Kumar Dangi, and Saleem Akhtar, "Seismic Analysis of a RC Building on Sloping Ground with Shear Wall at Different Positions", and observed that the position of the shear wall at corner is the optimum position for countering axial loads. Maximum shear force and maximum bending moment increase significantly for slopingground at 45° slope. It is observed that, axial force increases in the buildings with shear wall. Base shear is found maximum in the building with shear wall, due to dead load of the shear wall.

B.G. Birajdar, S.S. Nalawade, "seismic analysis of buildings resting on sloping ground", and concluded that**.** The performance of STEP back building during seismic excitation could prove morevulnerable than other configurations of buildings. The development of torsional moments in Step back buildings is higher than that in the Stepback set back buildings. Hence, Step back Set back buildings are found to be less vulnerablethan Step back building against seismic ground motion. In Step back buildings and Step back-Set back buildings, it is observed that extreme leftcolumn at ground level, which are short, are the worst affected. Special attention should begiven to these columns in design and detailing.

Subodhkumar V. Dhoke, Mohd. Abdul Rehman, "Seismic Response of Stepped Setback Building Stiffened with Reinforced Concrete Shear walls and Braces", and It is observed that there is significant reduction in the member forces, and lateral drift demand, and hence the

Performance of members in setback level gets improved if the described improving measures are used. Shear wall and cross bracings are found to be very effective in reducing the forces in the columns. Use of straight type of shear wall at external peripheral frame in setback building considerably reduces the forces in members at the setback level. Shear walls are found to be very effective in reducing the lateral displacements in setback buildings than bracings. However use of bracing reduces forces in columns more than using shear walls. This is due to reduction in effect of vertical irregularity in setback building.

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Saurav Kumar Verma, Hrishikesh Dubey, "Seismic Performance of Buildings with Various Configurations in Hilly Regions", The addition of shear walls increases base shear for all models, which is related to the increased seismic weight of the building. When structures are subjected to lateral stresses, the presence of a shear wall affects the overall behaviour of the structures. Displacement and storey drift are much minimised due to shear walls contribution. In regular type building without any setback on sloping ground, with incorporation of shear walls at various locations reduction is found in lateral displacement up to 3-5times. A dual-type structural system with properly placed shear walls is more effective than a moment-resisting frame system in resisting earthquake stresses and can be employed efficiently for structures on slopes.

Chaitrali Arvind Deshpande, P. M. Mohite, "Effect of Sloping Ground on Step- Back And

Setback Configurations of R.C.C.Frame Building", As the slope of ground increases base shear, top storey displacement and time period decreases mildly. Time period of stepback building resting on plain ground increases by 5 % than that of stepback-setback building and for sloping ground it is 6.1 %. Time period of building resting on sloping ground is increased by 28.9% than building resting on plain ground Top storey displacement of setback-stepback building is less than that of stepback building. Use of bottom ties gives effective response of hilly building.

3 MODELING OF STRUCTURES

A residential structure consisting of ground and nine upper stories are considered for analysis in ETABS, live loads are considered as per IS: 875-2(1987). The plan dimension is considered length as 60m and considered width as 30m.

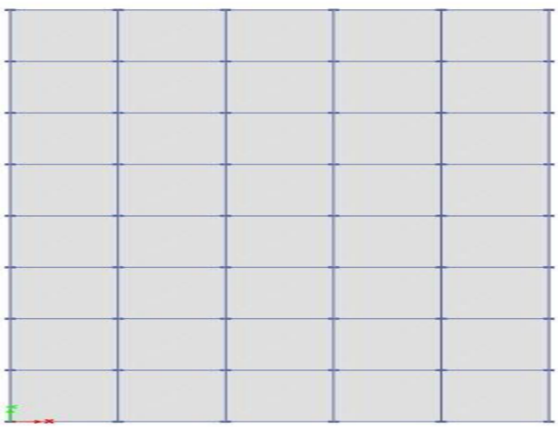


Fig 3.1 : Plan of structure

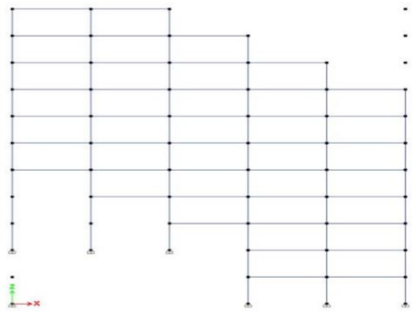


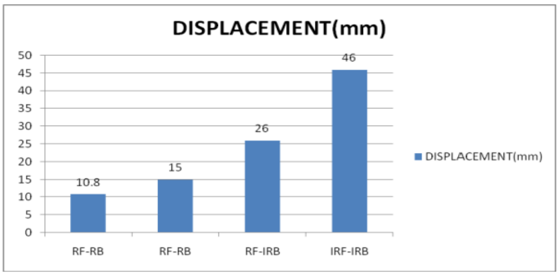
Fig 3.6 : Elevation along width of Irregular Frame and Irregular Base structure

Table3.1: Design Data of Structures

Grade of concrete	M30
Grade of steel	Fe 500
Seismic zones	IS: 1893
Wind speeds	IS: 875
Beam size	230x450
Column size	300x600
Slab thickness	200mm
Wall thickness	230mm
Floor height	3m
Floors data	G+9
Type	Regular, irregular
Occupancy	Residential
Base	Fixed

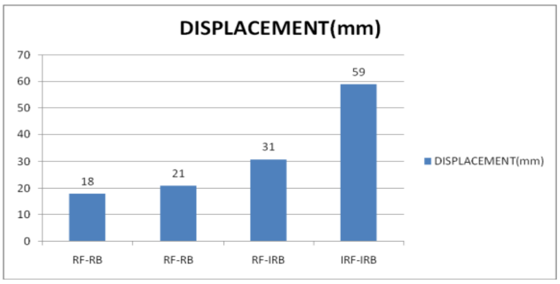
4 RESULTS:

- ZONE II

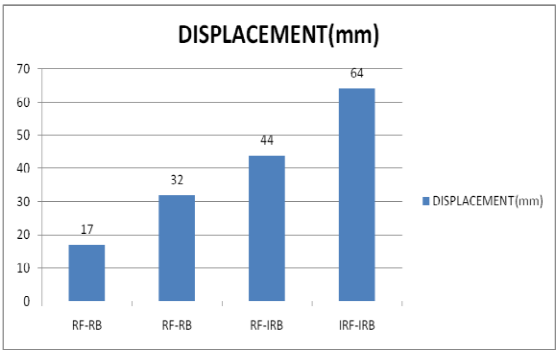


◉ Displacement results for Zone-II all structures

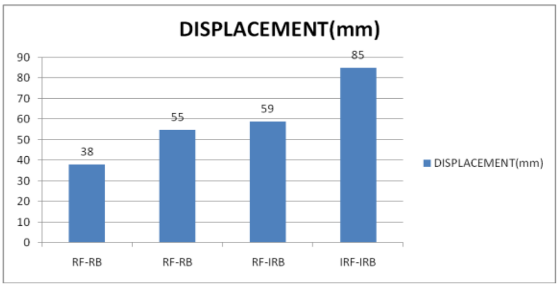
- ZONE III



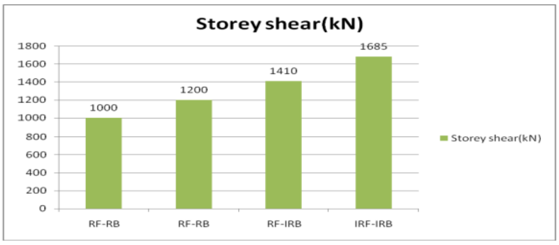
- ZONE IV



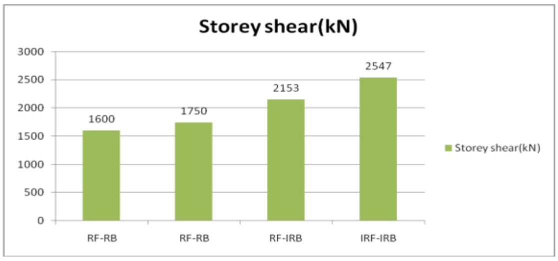
- ZONE V



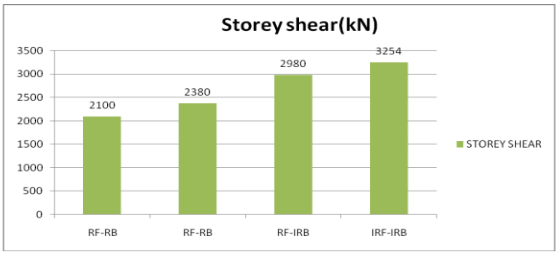
- ZONE II



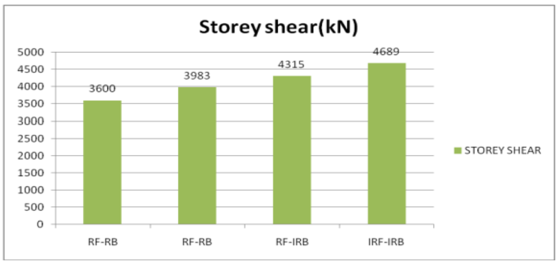
- ZONE III



- ZONE IV



- ZONE V



5 CONCLUSIONS

The results so obtained are shown in terms of graphs and tables for seismic and wind results as per IS: 1893-2016 and IS: 875-2015 respectively, seismic zones considered are Zone-II, Zone-III, Zone-IV and Zone-V and wind speeds considered are 33m/s, 39m/s, 43m/s, 47m/s, 50m/s and 55m/s. all the structures are modelled and analysed in software ETABS. In this project work structure considered are

Structure1: RF-RB: Regular Frame Structure with Regular Base

Structure2: RF-IRB: Regular Frame Structure with Irregular Base

Structure3: IRF-RB: Irregular Frame Structure with Regular Base

Structure4: IRF-IRB: Irregular Frame Structure with Irregular Base

1. It is observed that the stress resultants are increased with the increase in seismic zone and wind speed on the structures.
2. Seismic and wind forces have shown significant effects on Irregular structures in two orthogonal directions.
3. Irregular structures are not advisable in the higher seismic zones and in localities in areas were subjected to higher wind speeds.
4. Irregular frame and irregular base structures are severely affected when compared to other structures.
5. Displacements and storey shears are increased with the increase in the seismic zone from zone-II, zone-III, zone-IVand zone-V.
6. Displacements are increased by 44.73%, 55.26% and 123.68% in seismic zone V for RF-IRB, IRF-RB and IRF-IRB when compared with RF-RB.
7. Storey shears are increased by 10.63%, 19.86% and 30.25% in seismic zone V for RF-IRB, IRF-RB and IRF-IRB when compared with RF-RB.
8. Auto lateral load, overturning moment and storey shear are increased with increase in wind speed from 33m/s, 39m/s,43m/s,47m/s,50m/s and 55m/s.
9. Auto lateral load are increased by 12.96%, 22.22% and 31.11% at wind speed 55m/s for RF-IRB, IRF-RB and IRF-IRB when compared with RF-RB.
10. Overturning momentis increased by 5.45%, 18.18% and 61.81% at wind speed 55m/s for RF-IRB, IRF-RB and IRF-IRB when compared with RF-RB.
11. Storey shear is increased by 4.53%, 15.83% and 22.46% at wind speed 55m/s for RF-IRB, IRF-RB and IRF-IRB when compared with RF-RB.

REFERENCES

[1] Mojahid Islam1, SiddharthPastariya 2 "Analysis of building on Sloping Ground subjected to Seismic Forces" International Journal of Advanced Engineering Research

and Science (IJAERS) [Vol-7, Issue-1, Jan- 2020] ISSN: 2349-6495(P) | 2456-1908(O).

[2] Suraj Harish V, Muthanand P, RajendraPrasath C "Performance Analysis of Braced Reinforced Concrete Building in Sloped Terrain" International Journal of Engineering and Advanced Technology (IJEAT), ISSN: 2249 – 8958 (Online), Volume-9 Issue-4, April 2020.

[3] Anjeet Singh Chauhan, Rajiv Banerjee "Seismic Response Of Irregular Building On Sloping Ground" International Journal of Advanced Research in Engineering and Technology (IJARET) Volume 12, Issue 5, May 2021, pp. 181-202, Article ID: IJARET_12_05_017, ISSN Print: 0976-6480 and ISSN Online: 0976-6499.

[4] Paresh G. Mistry1, Hemal J. Shah2 "Seismic Analysis of Building on Sloping Ground Considering Bi-Directional Earthquake" International Journal of Scientific Development and Research (IJSDR) ISSN: 2455-2631, April 2016 IJSDR | Volume 1, Issue 4.

[5] Md Zaid1, Hafiz Ashraf Alam2, Khan Imran3, Mohammed Ibrahim Gori4, Saddam Hussain5, Huzefa Shaikh6 "Critical Analysis of Regular Building on Sloping Ground Amlibari, Nandurbar (Maharashtra)" International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, p-ISSN: 2395-0072 Volume: 06 Issue: 04 | Apr 2019.

[6] Narendra Tak1, Ankit Pal2, Mayank Choudhary3" A Review on Analysis of Tower on Building with Sloping Ground" International Journal of Advanced Engineering Research and Science (IJAERS) [Vol-7, Issue-2, Feb- 2020, ISSN: 2349-6495(P) | 2456-1908(O).

[7] Sachin Kumar Dangi, and Saleem Akhtar "Seismic Analysis of a RC Building on Sloping Ground with Shear Wall at Different Positions" Proceedings of the International Conference on Sustainable Materials and Structures for Civil Infrastructures (SMSCI2019) AIP Conf. Proc. 2158, 020030-1–020030-10.

[8] B.G. Birajdar1, S.S. Nalawade2. "Seismic analysis of buildings resting on sloping Ground" 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004.

[9] Subodhkumar V. Dhoke1, Mohd. Abdul Rehman2 "Seismic Response of Stepped Setback Building Stiffened with Reinforced ConcreteShear walls and Braces" International Journal of Innovative Research in Science, Engineering and Technology, ISSN(Online): 2319-8753, Vol. 7, Issue 4, April 2018.

[10] Saurav Kumar Verma, Hrishikesh Dubey "Seismic Performance of Buildings with Various Configurations in Hilly Regions", Civil Engineering and Architecture 9(7): 2205-2236, 2021, DOI: 10.13189/cea.2021.090710.

[11] Miss. Chaitrali Arvind Deshpande, Prof. P. M. Mohite, "Effect of Sloping Ground on Step- Back And Setback Configurations of R.C.C.Frame Building", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 3 Issue 10, October- 2014.

[12] IS 1893:2016,"Criteria for earthquake resistant design of structures", Bureau of Indian Standards, New Delhi, India.

[13] IS 1893(Part1):2002,"Criteria for earthquake resistant design of structures -General provisions and buildings", Bureau of Indian Standards, New Delhi, India.

[14] IS 456: 2000,"Plain reinforced concrete-code of practice", Bureau of Indian Standards, New Delhi, India.

[15] IS 875-3, "IS 875-3 (1987): Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Part 3: Wind Loads [CED 37: Structural Safety], Bureau of Indian Standards, New Delhi, India.