

Evaluation of Structural Irregularities in H-Shaped RC High-Rise Building

Krishnendu M S

Student, M. Tech Structural Engineering:

Department of Civil Engineering

Rajadhani Institute of Engineering and Technology
Kerala, India

Sreelekshmi S

Assistant professor

Department of Civil Engineering

Rajadhani Institute of Engineering and Technology
Kerala, India

Abstract - Structural irregularities play an important role in the seismic response of Reinforced Concrete (RC) buildings, mostly in structures with complex geometries like H, T, U, I and L-Shaped plans. This study analyses Earthquake response of a G+7 H-shaped RC structure using Building Information Modelling (BIM) and ETABS. The model is created in Revit Structure and perform seismic analysis in ETABS based on seismic code IS 1893:2016 provisions. Type of structural irregularities such as Plan and vertical irregularities are identified and evaluated manually based on the code-based requirements. Various parameters like storey stiffness, displacement, drift and shear are evaluated. This investigation highlights the effect of irregularities on Response under seismic loading and the importance of proper evaluation during the design stage.

Keywords - Structural Irregularity; H-Shaped Building; Seismic Analysis; RC Buildings; ETABS; BIM; IS 1893:2016

1. INTRODUCTION

Earthquakes create dynamic forces that can seriously affect building stability, and have the potential for causing great damages in RC Buildings. The Structural response to earthquakes of a RC structure during seismic forces depends on its overall shape, size and geometry, in addition to how the earthquake forces are carried out to the ground. Modern construction practices widely adopt asymmetrical structural configuration to fulfill architectural and functional requirements. Buildings with T, I, L, U And H-Shaped configurations commonly used in modern construction, but they can cause significant structural irregularities which affects the Earthquake performance. Seismic code IS 1893:2016 is used to detect the structural irregularities. As per the guidelines given in IS 1893:2016, structural irregularities are grouped into plan and vertical types based on their behavior during seismic events, which can lead to uneven force distribution and torsional effects during earthquakes. These effects may increase the risk of damage and reduce structural stability of the building. Such irregular structures can be accurately modelled and analyzed by using BIM and ETABS. This study aims to evaluate the reaction to earthquake forces of a G+7 H-Shaped RC building and to find the irregularities based on IS 1893 guidelines. The seismic forces developed at different floor level levels in a building need to be brought down along the height to the ground by the shortest path, any deviation or uneven load distribution results in poor performance of the building.

Moreover, the existence of structural irregularities can mostly change the dynamic characteristics of a building, such as its natural frequency, mode shapes, and damping behavior. These changes can affect the seismic responses, particularly in higher modes, and leading to uneven concentration of stresses in critical regions like beam-column joints and re-entrant corners. So, proper design considerations, such as the inclusion of shear walls, bracings, and sufficient stiffness distribution, can help in mitigating these harmful effects. Therefore, a detailed seismic analysis considering codal provisions is essential for the safety, serviceability, and resilience of irregular RC structures under earthquake loading.

1.1 CHALLENGES CAUSED BY STRUCTURAL IRREGULARITIES

- Uneven load distribution
- Torsional effects
- Uneven stress concentrations
- Increased seismic vulnerability
- Complex design and analysis
- Difficulties in construction
- Higher cost and maintenance

2. OBJECTIVES

- To generate a G+7 H-shaped RC building using Revit Structure.
- To investigate the behavior of the structure using ETABS software under different load conditions
- To identify plan and vertical irregularities based on IS 1893:2016 code provisions.
- To study the building responses such as storey displacement, drift, stiffness, and base shear.
- To study the effect of structural irregularities on Earthquake analysis
- To understand the importance of proper structural design in irregular buildings.

3.METHODOLOGY

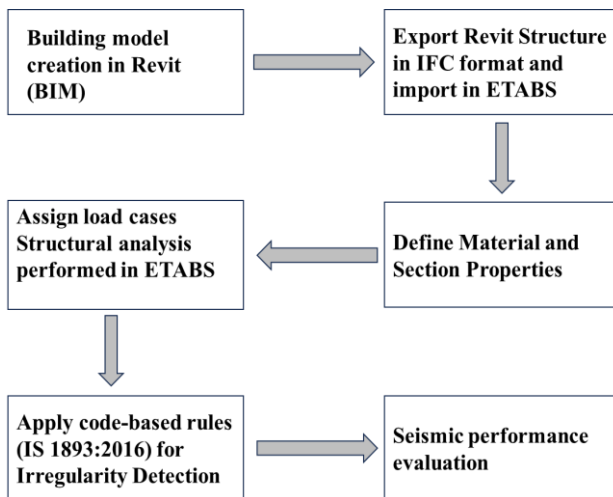


Chart 1: Methodology Workflow

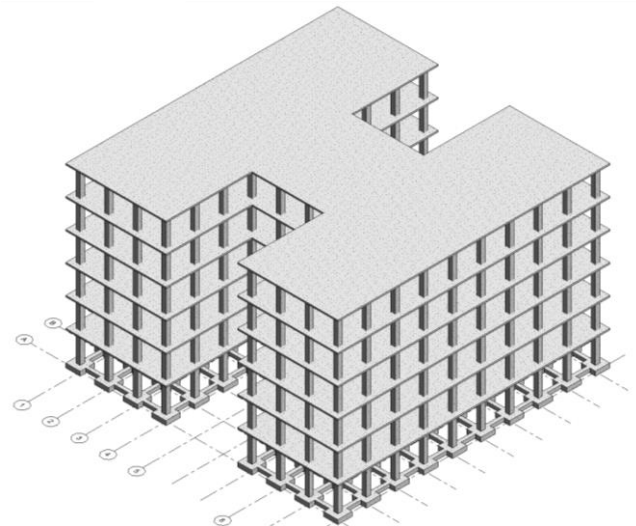


Fig 2: 3D plan layout

The H-shaped G+7 RC building is model is created using Autodesk Revit. Structural elements like beams, columns, slabs, and structural level levels are accurately defined.

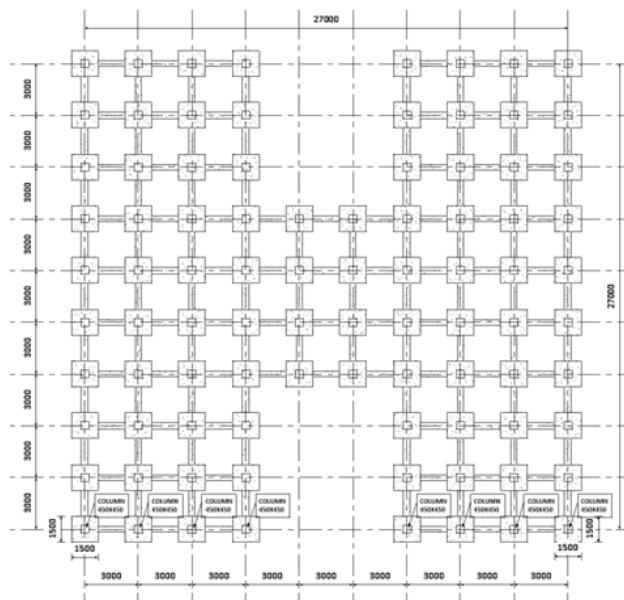


Fig 1: Plan layout of H-shaped structure

Table 1: H-shaped RC building model details

| Particulars | Data |
|--------------------------------|-----------------------|
| Type of structure | H-Shaped RCC building |
| Number of stories | 8 |
| Height of one floor | 3m |
| Total height of the building | 21.7m |
| Shape & Size of column | Rectangular 450X450 |
| Shape & Size of beams | Rectangular 350X350 |
| Length & Width of the building | 27 m x 27m |

Table 2: Material Properties

| Particulars | Data |
|--------------------------|-----------|
| Grade of concrete | M30 |
| Grade of steel | Fe500 |
| Grade of Rebar steel | Fe450 |
| Modulus of elasticity, E | 210000Mpa |
| Poisson's ratio | 0.3 |

Table 3: Load patterns as per IS 1893:2016

| Load Cases | |
|---------------------------|------|
| Dead load | DL |
| Live load | LL |
| Earthquake in X direction | EQ X |
| Earthquake in Y direction | EQ Y |

4. RESULTS

Structural analysis is performed to determine how the building responds to the assigned load cases. The software calculates forces, displacements, shear, drifts and other important parameters.

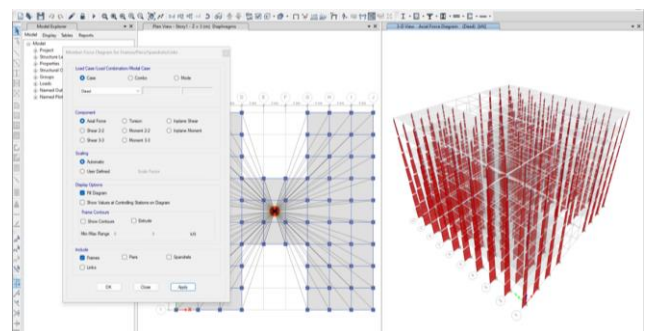


Fig 4: Axial force diagram for the building

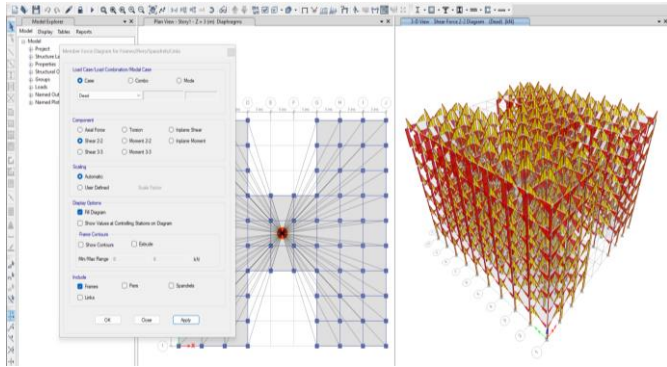


Fig 5: Shear force diagram for the building

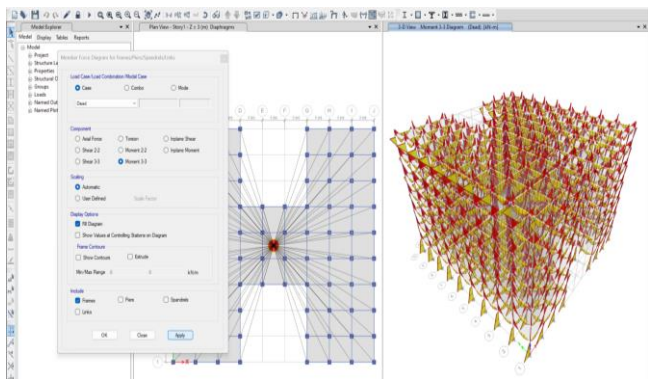


Fig 6: Bending moment diagram for the building

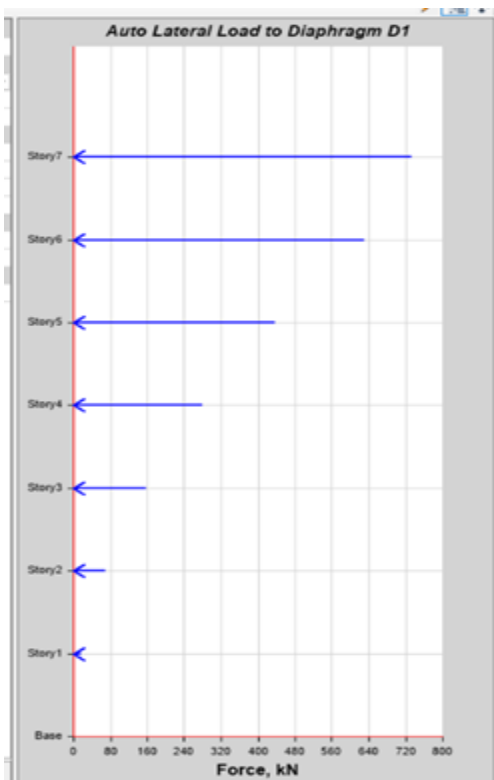


Fig 7: Auto Lateral Load under EQ X condition

Table 4: Auto Lateral Load under EQ X

| Storey | Elevation (m) | X direction | Y direction |
|----------|---------------|-------------|-------------|
| Storey 7 | 21 | 733.1084 | 0 |
| Storey 6 | 18 | 629.3654 | 0 |
| Storey 5 | 15 | 437.0593 | 0 |
| Storey 4 | 12 | 279.7179 | 0 |
| Storey 3 | 9 | 157.3413 | 0 |
| Storey 2 | 6 | 69.9295 | 0 |
| Storey 1 | 3 | 17.4824 | 0 |
| Base | 0 | 0 | 0 |

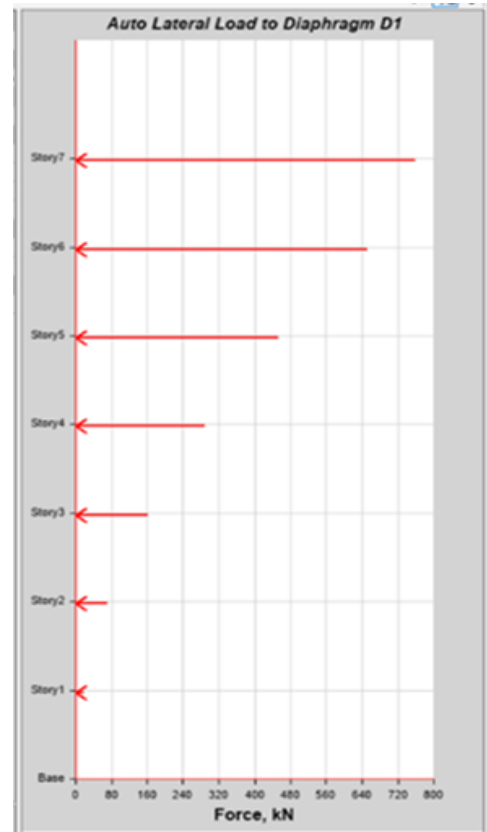


Fig 8: Auto Lateral Load under EQ Y condition

Table 5: Auto Lateral Load under EQ Y

| Storey | Elevation (m) | X direction | Y direction |
|----------|---------------|-------------|-------------|
| Storey 7 | 21 | 0 | 759.7501 |
| Storey 6 | 18 | 0 | 652.237 |
| Storey 5 | 15 | 0 | 552.9423 |
| Storey 4 | 12 | 0 | 289.8831 |
| Storey 3 | 9 | 0 | 163.0592 |
| Storey 2 | 6 | 0 | 72.4708 |
| Storey 1 | 3 | 0 | 18.1177 |
| Base | 0 | 0 | 0 |

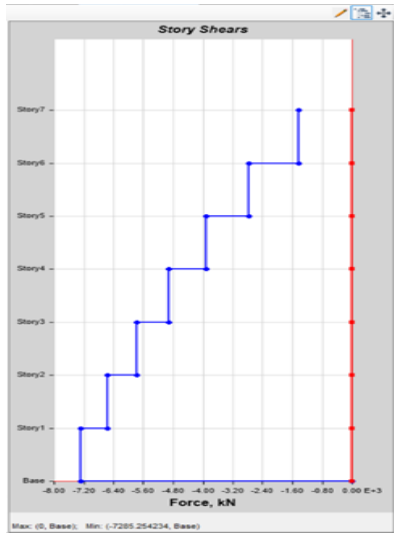


Fig 9: Storey Shear under EQ-X Load Conditions

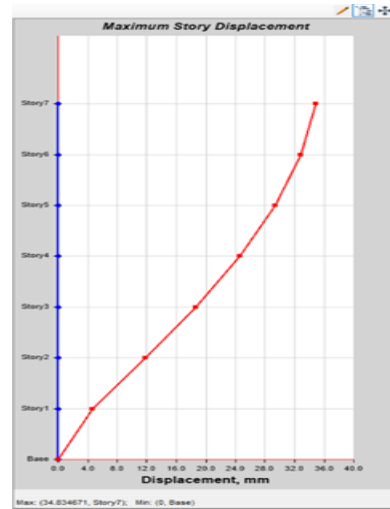


Fig 12: Storey Displacement under EQ-Y Load Conditions

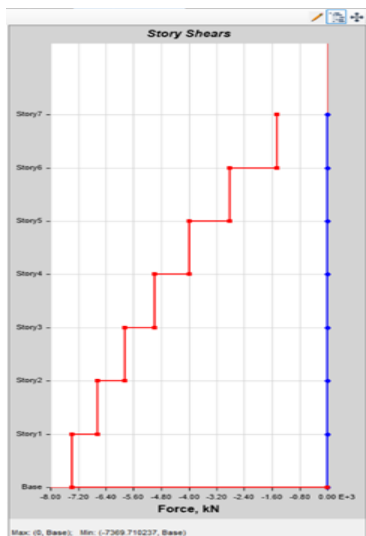


Fig 10: Storey Shear under EQ-Y Load Conditions

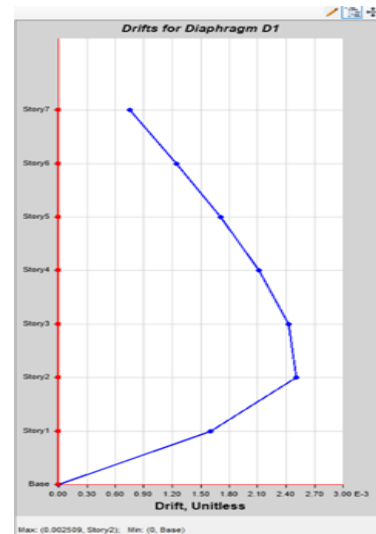


Fig 13: Storey Drift under EQ-X Load Conditions

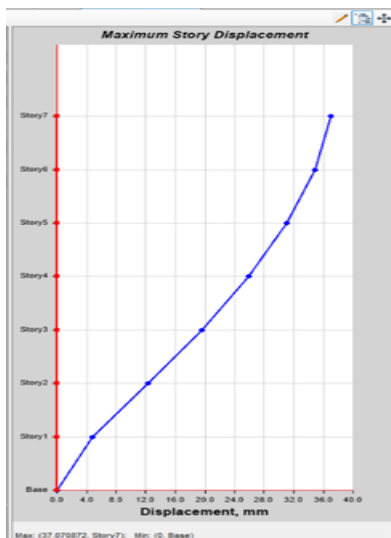


Fig 11: Storey Displacement under EQ-X Load Conditions

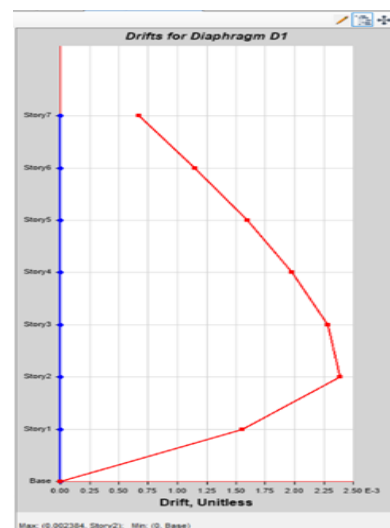


Fig 14: Storey Drift under EQ-Y Load Conditions

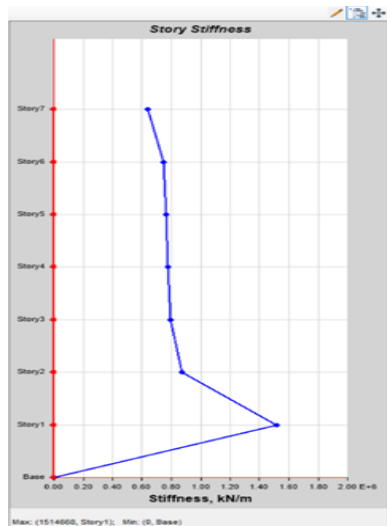


Fig 15: Storey Stiffness under EQ-X Load Conditions

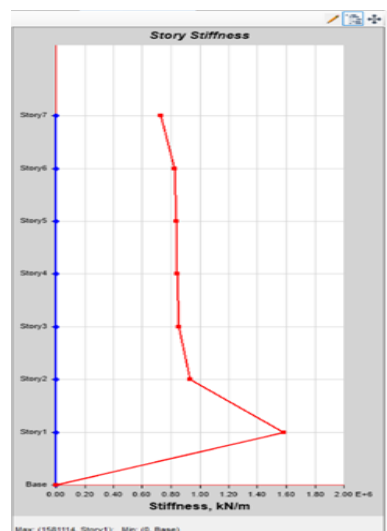


Fig 16: Storey Stiffness under EQ-Y Load Conditions

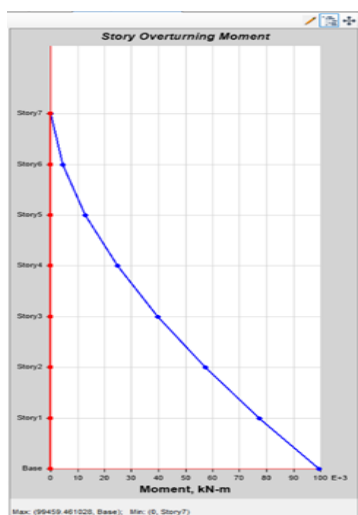


Fig 17: Storey Overturning Moment under EQ-X Load Conditions

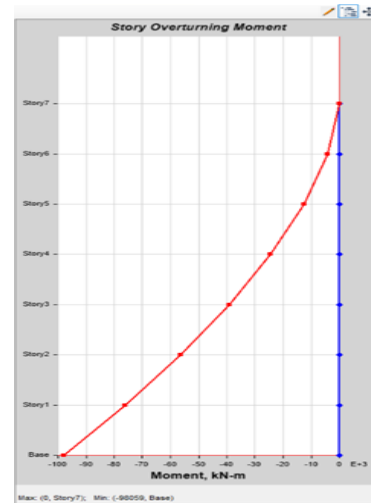


Fig 18: Storey Overturning Moment under EQ-Y Load Conditions

Structural analysis is performed to determine, how the building responds to the assigned load cases. The software calculates forces, stiffness, displacements, shear, drifts and other important parameters.

Table 6: Plan Irregularity detection

| Irregularity | IS 1893 Limit | Irregularity presence |
|-------------------------|---|-----------------------|
| Torsional Irregularity | Max storey displacement > 1.2 × average storey displacement | present |
| Re-entrant Corner | Projection > 15% of plan | present |
| Diaphragm Discontinuity | Opening >50% stiffness change | Not present |
| Out-of-Plane Offset | Elements not in same plane | Not present |
| Non-Parallel Systems | Not parallel to main axes | Not present |

Table 7: Vertical Irregularity detection

| Irregularity | IS 1893 Limit | Irregularity presence |
|--------------------------------------|--|-----------------------|
| Soft Storey (Stiffness Irregularity) | storey stiffness < 70% of storey above or < 80% of average 3 above | Not present |
| Mass Irregularity | storey masses > 200% of adjacent storey | Not present |
| Vertical Geometric Irregularity | Lateral system > 150% of adjacent | Not present |
| In-Plane Discontinuity | Columns/shear walls stop suddenly | Not present |
| Weak Storey (Strength Irregularity) | lateral strength < 80% of floor above | Not present |

CONCLUSION

The behavior during earthquakes of the G+7 H-shaped RC building shows that plan irregularities, such as torsional irregularity and re-entrant corner irregularity are present. However, there are no significant vertical irregularities in the structure.

These plan irregularities can affect vulnerability of the building's seismic performance during land shakes and to uneven force distribution. Therefore, it is very important to properly analyze and design to ensure the structural safety and improved seismic resilience.

FUTURE SCOPE

- Different seismic zones and soil conditions can be considered for a better comparison.
- Automation of code guidelines can be implemented for faster irregularity detection.

REFERENCES

- [1] Fousiya Zaker and Jesmi Thaha, Sharon Teressa Biju, Dony Stanly. "Study on Seismic Analysis of Multistorey RCC Building with Structural Irregularities", International Journal of Engineering Research & Technology, Vol 10, Issue 06, ISSN: 2278-0181, 2022
- [2] Tejram, Sakshi Sahu, Srishti Verma, "A Study on Soft Storey Irregularities in High-Rise Buildings Using Etabs Modeling", International Journal of Original Recent Advanced Research, Vol.02, Issue: 03, ISSN: 3048-5479, 2025
- [3] Radhakrishnan D,Arbaz Khan S, Boyaneni Dharani, S and Nayaz, S Rajesh, "Seismic Analysis of Vertical Irregular R.C.C Structure By Using ETABS Software", International Journal of Research and Analytical Reviews, Vol.10, Issue: 02, E-ISSN 2348-1269, P- ISSN 2349-5138, 2023
- [4] Mohamed Shajahan A, Kumaran S, Arivazhagan R and Dr. T. Ilango, "Analysis and Design of Multi-Storey Building Using Etabs", International Journal for Multidisciplinary Research, Vol.06, Issue: 02, E-ISSN, 2582-2160, 2024
- [5] Umer Bin Fayaz and Brahamjeet Singh, "A Study of Seismic Analysis of Building Using ETABS" International Journal of Innovative Research in Engineering and Management, Vol.06, Issue: 10, E-ISSN 2350-0557, 2023
- [6] S Abhishek, Manoj S K, Roopa B D, Bhagyashree M S and Guruprasad C H M, "Design and Analysis of Residential Building using E-TABS", International Research Journal of Engineering and Technology, Vol.05, Issue: 05, E-ISSN 2395-0056, P- ISSN 2395-0072, 2018
- [7] Albert Thomas, Anagha K M, Jishnu Prakash and Soniya John, "Analysis of Retrofitted building using ETABS" International Journal of Precious Engineering Research and Applications, Vol.07, Issue: 02, E-ISSN 2456-2734, 2022
- [8] Dr. B. H. Shinde, "Seismic Analysis of RCC Multistoried Building by IS 1893:2016 and it's Comparison with IS 1893:2002 ", International Journal for Multidisciplinary Research, Vol.17, Issue: 01, E-ISSN 2278-1684, P- ISSN 2320-334X, 2020
- [9] Pankaj Subhash Gawande and Dr. Pankaj Singh, "Comparative Study of Building structure by IS 1893:2016 with IS 1893:2002 with Plan Irregularity", International Journal for Multidisciplinary Research, Vol.07, Issue: 03, E-ISSN, 2394-9333, 2020