Seismic Analysis of different Shapes of building (G+5) on plain terrain and slope terrain

Ankit Yogi[1],Vinod Kumar Modi [2]
M.Tech scholar,Department of Civil Engineering,KITE, Jaipur
yogiankit94@gmail.com
Associate Professor, Department of Civil Engineering,KITE, Jaipur

Abstract: A lot of RCC structures in seismic zones are unable to withstand earthquakes as a result of rapid expansion in urbanization and the development of more of high rising buildings. Buildings on sloping ground present unique challenges compared to those on flat terrain. Their irregular and asymmetrical designs, necessary for adapting to the slope, can create structural vulnerabilities. On the sloped terrain, buildings often require columns of varying heights to accommodate the gradient, leading to uneven weight distribution and increased stress on certain parts of the structure. The present scenario, buildings are constructed of irregular plans on different terrain and shape due to less availability of space, economic feasibility, and other factors. This work aims to be studying the many building's irregularities along with L- shape, O-shape, H-shape & rectangular shape on different terrain and their behavior during seismic forces. Buildings models are analyzed by Etabs 18 software. The aim is to conduct response spectrum analysis (RSA) on vertically uneven buildings on different terrain based on IS 1893(part 1)-2016. This study focusses on learning the various parameter like base shear, storey drift, and vertical geometry irregularity to be analyzed for seismic force. The adoption of base isolation strategies has become increasingly popular as an effective means of protecting buildings from earthquake threats. This technique involves creating a separation between a building's structure and the ground motion, allowing the building to move independently during seismic events.The purpose of the study is to show comparative analysis of symmetric buildings and asymmetric buildings of G+5 height in slope terrain and flat terrain. Five storey structures are analyzed here. Space frames constructed from reinforced concrete can effectively withstand tremors or earthquakes, thanks to a non-linear analysis of past seismic events. By the help of ETABS version 18 non-linear software (developed by CSI Ltd), the building is evaluated in accordance with the seismic code IS-1893: 2016.The increasing urbanization and proliferation of high-rise structures in seismic zones have raised critical concerns about the structural integrity of buildings during seismic events. This study delves into the seismic analysis of buildings with various shapes situated on both plain and sloping terrains. Through this study, insights into the seismic performance of irregular structures on both sloping and plain terrains are gained, shedding light on the effectiveness of base isolation strategies in safeguarding these structures against seismic threats.

Keywords: Irregularity, Sloping terrain, Geometry structure shape, dissipation of energy, Size, Response spectrum analysis (RSA) etc.

1. INTRODUCTION

A natural earthquake occurs when the earth's crust trembles or moves abruptly. Shock waves from nuclear testing, bombs, and other man-made explosions are not included in the definition of a natural shock wave. We live on a planet made up of plates. A rift is a junction between two plates. According to the Indian context, that rift extends from Himachal Pradesh through Uttaranchal, Bihar, Assam, & Burma. In Indonesia, that plate descends via the Andaman-Nicobar Islands & the Bay of Bengal. Earthquakes occur when the rocks are subjected to stress due to the movement of the plate. People do not die in earthquakes, but buildings do. In designing a safe structure, it is up to a structural engineer to determine the parameters based on past experiences and to plan for potential hazards in the future. Engineers can now model, analyze, and painstakingly show the performance of earthquake-exposed buildings on a computer using finite element computer technology/software. One would never have imagined that Civil Engineering research had reached such far-reaching horizons. Technology developed in the preceding few eras have saved a lot of human effort and time for structural engineers. Codes stipulate that buildings be designed to resist a specific level of ground acceleration, the magnitude of which varies with the seismic risk. Buildings repeatedly have some yielding as a aftermath of the tremendous stresses transferred to them during an earthquake. The reason of earthquake engineering is to reduce casualties caused by the collapse of weak buildings. When architects in the past attempted to plan buildings to resist earthquake-induced stresses, the result was fragile constructions with plenty of unnecessary, expensive materials. The introduction of limit states was a game-changer for the development of methods. Performance-based designs, made possible by limit state techniques, are slimmer in profile, cheaper to build, & take less time to put together than their bulkier, less efficient predecessors. Due to ductility's ability to dissipate earthquake energy, the designers had ample time to evaluate the structures' performance while designing and monitoring them. Modeling the structure mathematically can provide insight into its performance under loading. You can do this with any structural modeling, analysis, or design software available on the market. Engineers in this field must be able to anticipate how a building will respond to a certain set of loads, as well as a specified degree of security. An earthquake design method consists of two phases. All seismic performance goals, including serviceability, life safety, and collapse avoidance, must be taken into consideration while designing an efficient structural system. In order to create a framework that not only satisfies seismic performance requirements but also takes into consideration the constraints set by the owner, the architect, and other professionals involved in the building and design of a structure, the engineer must exercise creativity. Instead than using strict mathematical rules, this method of development depends on human judgment, experience, and knowledge of seismic behavior. Fundamental knowing of ground motion & inelastic and elastic dynamic response attributes are suitable starting points for the configuration and approximate sizing of an efficient structural system. To analyze structures and evaluate their performance under given loads, there are lot of techniques available, but the most accurate is response spectrum analysis. Other conventional methods have been developed for structures with less importance or seismic hazard, like Non-Linear Static Methods (NSPs) and Linear Dynamic Methods (LDMs). There's no guarantee that these procedures will give you accurate results. It is essential to predict how a structure will respond to a specific load when designing a structure. Based on the codes and previous experiences, we have an in-depth understanding of the various load types & their intensities, as well as how they interact with various building types and site circumstances. Engineers choose study method based on the accuracy of the work required. An accurate method for predicting seismic demand and evaluating structural performance is response spectrum analysis. Using this technique requires choosing a suitable collection of ground movements, precise site circumstances, and a mathematical toolset to interpret the data, all of which add up to a significant computing burden. Although it is not the only way of analysis, it is often regarded as the most thorough and accurate. There are a number of simple techniques that may be utilized to lessen the effects of earthquakes and wind loads on buildings. Changes in rigidity, mass, damping, or form, in addition to the application of active or passive counterforces, all fall under this category of ideas. As of yet, a number of different techniques for controlling the structure have been implemented effectively. There are a number of suggested approaches that have the potential to increase productivity and the usefulness of existing apps. There has been a lot of effort put into studying and creating structural control devices in recent years. Furthermore, the past two decades have seen significant work put forward toward developing structural control as an implementable technology. Structural control is now generally acknowledged as a crucial aspect of the design of major building projects like hospitals. Retrofitting for wind and earthquake resilience is another common use. However, most current and future plans rely on passively tuning mass or isolating techniques. An elastic theoretical model was postulated in the beginning phases of study. Nonlinear responses to large-magnitude earthquakes, however, are inelastic. To analyze the seismically excited building's physical damage and large motion hysteretic damping process in a linear manner, a numerical analysis has been conducted. Nonlinear evaluation models are therefore useful for illustrating the salient structure dynamics and presenting appropriate evaluation criteria and control constraints. Numerous contemporary structures, some as tall as 10 storey, were demolished in the Kutch Earthquake that hit Gujarat, India on January 26, 2001. This earthquake has prompted inquiries on our standard operating procedures, codes, materials, and training of civil architects and engineers. The post-yield reaction under dynamic loading is one of the most significant responses, yet it was often neglected in structures subjected to lateral seismic study. Seismic control techniques, such as foundation isolation, must be used to manage the building's reaction. The structure's response after yielding is best understood via a non-linear historical analysis. Knowing how Seismic Control Devices such as Base Isolator effect the Structure during an earthquake is made easier with the use of Earthquake Ground Acceleration Loading Analysis.

2. LITERATURE REVIEW

S. Sivakumar,R. Shobana,E.Aarthy, S.Thenmozhi(2023)[1] "The primarygoalisto constructastructure thatcansurvivesignificantearthquakesthatma yoccur over the building's lifespanwithoutsufferingdamage.Thestudy,t he seismic analysisof RCbuildings,was conductedusingtheresponsespectrumapproa ch.TheETABsoftwarewasutilizedtodostruct ural analysisbasedontheIScodeforthisinvestigatio n.ThegroundG+9buildingandthe structure in seismiczoneIIIwereassessedbythestudy. Structure that establishes the project's maximum land displacement cost, time frame, and primary escape.The top stroey has the largest movement values in both the X and Y axes. The movement of the structures G +10 and G +25's layers is 22% and 26% less in the dynamic analysis than it is in the static analysis. This study concludes that in order to analyse using the response spectrum method in ETABS, the fundamental requirements of an above-ground reinforced concrete structure had to be understood.

Chakaravarthi A.V.Deepan,PrasathK.Jeeva,etal.(2021)[2] “This design project presents anin-depthknowledgeofapartmentbuildingplanni ng,researchanddevelopment.Fromthisstudy itwasconcludedthatTheapartmentisdesigned andconstructedinsuchawaythatitperformsthe functions for which it is designed for land scarcity. The basic principles of framed buildings are applied in the project work. Various design methodologies especially those going around the planning of apartmentsbuildingwerelearntbyus.Theseco nceptswillimproveourknowledgeon analysis and design and guide us in the futurein taking up any design project.”

Fahim Sadek, BijanMohraj, Andrew W Taylor, andRiley MChung (2021)[3]Methods for determiningthe TMD parametersthatprovide thegreatestdecrease inthestructural responseto seismic loads areintroduced.Theselectionoftheoptimalparamet ers isbasedonacriteria that requiresequal&largemodaldampingin first2modesofvibrationforagivenmassratio.Usin g thesecharacteristics,wecomputedhowanumberof single-andmulti-DOFTMDstructureswould reacttoa varietyof seismicexcitations.The authorsdeterminedthatfollowingtherecommende d procedure considerablymitigates the effects of displacement & acceleration.

RomyMohanandC Prabha(2020)[4] Analysisof non-linear time historiesof three-dimensionalstructureswithsixkindsofshearwalls ofvaryingshapeswascarriedoutfor the seismic zone-vinIndia.The structural reactionof shear wallwereanalyzed,andthe impactof varyingbuildingheightswasalsoinvestigated.RS A&ESA werealsocompared.Inconclusion, the equivalent statictechnique may beutilizedforsymmetric buildings to aheightof 25m,whileRSAmustbeemployedfortallerandless symmetricalstructures.Duetomaterialnon-linearity& p-delta effectspresentinactual structures, response spectruman alysisis requiredtocorrectly anticipatestructuralresponse. Themostefficientshearwallmodelwasasquare one,whereasthe least efficient was an L-shaped one.

UikeySangeeta,SatbhaiyaRahul,(2020)[5] In this study, the software's accuracy was verified manually and through frame analysis using the results we obtained. The outcomes turned out to be incredibly accurate and precise. A G+4, G+9, G+14, and G+19 storey building was examined for every potential load combination (dead, live, wind, and seismic loads) during the analysis and design process. With STAAD Pro's extremely intuitive and interactive UI, users can control load values and dimensions by just drawing the frame.This study led to the conclusion that, in the case of the G+4 RC frame, the maximum storey drift in soft soil continuing from zone-II to zone-III is 37.74%. The G+9 RC frame illustrates that the maximum storey drift in medium soil, continuing from zone-II to zone-III, is 37.44%. The G+14 RC frame illustrates that the maximum storey drift in hard soil continues from zone-II to zone-III, at 41.97%. The G+19 RC frame illustrates that the maximum storey drift in medium soil, continuing from zone II to zone III, is 47.29%. The G+4 RC frame illustrates that the maximum deflection in medium soil, continuing from zone II to zone III, is 37.478%. The maximum deflection in the G+9 RC frame is 37.49%, which is also the case in medium soil moving from zone II to zone III.

V S Satheesh,et al.(2020)[6] **“**In accordance with IS:1893-2002 and IS:875-2015 Part 3 recommendations, the wind and seismic loads for a residential building are estimated in this project. Every horizontal member's short-term deflection, according to the study, is within 20 mm. The building's structural elements are secure against shear and flexure. The structure uses a reasonable quantity of steel. The suggested element sizes are appropriate for use in the structure, as confirmed by the analysis results obtained using the Kanis method and STAAD Pro, which do not significantly differ from one another.”

TripathiMohit,Singh S.K. (2020)[7] “This review paper uses STAAD Pro to analyse and design a multi-story residential building from various angles. Both static and dynamic loads were addressed in the analysis and design, which were carried out in compliance with standard specifications. The dimensions of the structural members were established, and different loads—such as dead, live, and wind loads—were applied. The safety of beams, columns, and slabs was confirmed by the results of their evaluation for shear and deflection. After a combination of theoretical and practical methods were used, it was determined that practical work provides a deeper understanding than just theoretical study.”

MeshramKomalS.etal., (2019)[8]**“**The seismic analysis and design of a G+7 RCC building in India's Zone-II are the main topics of this study report. Seismic assessment of a G+7 story residential building is part of the project. Designs for the beams, columns, slabs, and footings were obtained, and dead and live loads were applied. According to the study's findings, nodal deflections against lateral forces can be computed to determine the necessary reinforcement for any concrete section based on its loading. Both static and dynamic analyses of the structure produced accurate and important results.”

BarkhaVerma,AnuragWahane(2019)[9] **“**Using the most recent version of STAAD Pro software, the study intends to examine and contrast the seismic response of a G+9 storey RCC frame structure in Seismic Zone V under various soil conditions (hard, medium, and soft). Models M1, M2, and M3 all have the same structural and seismic parameters; the soil type is the only difference. The Equivalent Static method is used in STAAD Pro V8i to analyse seismic data for all three models. In terms of maximum storey displacement, compressive stress in columns, and the quantity of steel needed, the study looks at the responses of the models. Evaluating the three models' stability in various soil scenarios is the goal.”

DarioDe Domenico, Giuseppe Ricciardi(2019)[10] An earthquake-resistant design case study for a reinforced concrete frame structure is presented in this article. A new method is investigated to improve the building's seismic performance: base isolation combined with a Tuned Mass Damper (TMD) placed below the isolation level in the basement. To provide seismic base isolation, low-damping rubber isolators are positioned strategically around the perimeter beneath the first floor. Usually placed at the center of the building is a large-mass TMD, which is essentially a box filled with large aggregate concrete. The TMD consists of a box that is installed in the basement that houses a spring and a damper. An additional set of lead-core rubber isolators connects the box to the base isolation system. The TMD box is separated from the floor by means of flat sliding mechanisms with low friction. The process of minimizing an objective function obtained from a stochastic dynamic analysis of a simplified three-degree-of-freedom system comprising the main structure, base isolation, and TMD determines the optimal design parameters for the auxiliary TMD isolators. The displacement of the main structure from the ground, displacements between stories, total acceleration, and an energy-based indicator are the four objective functions that are taken into consideration. Nonlinear time-history studies show the effectiveness of this novel model and its corresponding optimization process—applied for the first time to a real-world example—using generated accelerograms consistent with the response spectrum of the project location. The building's seismic performance is summed up by a number of response indicators, all of which demonstrate how well this structural system performs in comparison to fixed-base buildings and traditional base isolation techniques.

AmerHassan, ShilpaPal(2018)[11]**“**This paper presents response spectrum analyses to investigate the effect of soil conditions under a base-isolated structure using Etabs-2015 software. In accordance with the seismic provisions of the Indian Standard Code, the study takes into account the effects of soil flexibility to evaluate variations in spectral acceleration, storey shear, storey displacements, storey drifts, and storey shear. Based on the findings, base-isolated buildings can be constructed on hard and medium soils. The paper also provides analysis and design considerations for conventional and base-isolated structures to aid designers in their understanding at the initial design stage."

KumarK.Prabinetal., (2018)[12]**"**AutoCAD was first used for the project's planning. The structural analysis was carried out using STAAD.Pro, an intuitive piece of software that makes it simple to draw the frame and enter load values and dimensions. Manual load calculations were also done. The structure was subjected to wind loads, dead loads, and imposed loads. The limit state method was used to conduct the analysis in STAAD.Pro. According to the study's findings, STAAD.Pro can accurately determine how much reinforcement is needed for any concrete section. The analysis took into account a number of structural actions on the members, including torsion, flexure, and axial loads. The purpose of shear reinforcement was to withstand torsional moments in addition to shear forces. Columns were designed for axial forces and biaxial bending at their ends, whereas beams were designed for flexure, shear, and torsion. The IS: 456-2000 standards are followed in the building design."

R.Sanjaynathet al., ((2018)[13] **"**This project's main goal is to use STAAD.Pro to analyse and design a G+20 multistory building. During the design phase, STAAD.Pro software is used to analyse the structure and perform manual load calculations. The project adheres to IS 456-2000, SP16, and NBC codes, among others. M30 concrete mix is utilised, and grade Fe415 steel is used for each member. According to the study's findings, the G+20 multi-story residential building's planning, analysis, and design were successfully finished. Using STAAD.Pro, the analysis and design took into account both static and dynamic loads while adhering to standard specifications. The dimensions of the structural members were established, and loads including dead, live, and wind loads were applied. Additionally, shear and deflection tests for slabs, columns, and beams were performed."

3. METHODOLOGYANDBUILDINGDESCRIPTION

The RSA uses dynamic inelastic investigation to envisage how fit a structure will hold up under a variability of earthquake scenarios by assessing its deformation and strength needs for design earthquakes and contrasting those figures with those of comparable buildings that have already undergone base isolator and tuned mass damper retrofits. Elements' global and inter-storey displacements, as well as their elastic deformations, deformations among elements, & element as well as connection forces, are evaluated. By analysing the inelastic deformation time history, seismic forces and deformation demand can be roughly predicted. This will permit us to take into regard the redistribution of internal forces caused by the application of inertia forces outside the elastic range of the structure. Unlike the still-questionable accuracy of linear dynamic and elastic analysis, the RSA is expected to provide information on a range of response properties. Examining the structural system, all connections, the stiff nonstructural parts of significant strength, and the foundation system will validate the fullness and sufficiency of the load route. RSA may be the only earthquake replication approach competent of realistically recreating the behavior of buildings under realistic earthquake loads. There is a large amount of extra analysis work required to reap the advantages, including incorporate all essential parts, modeling their inelastic load features, and doing incremental inelastic evaluations, ideally utilizing 3D analytical models. At present, convenient methodical tools that are up to the task are either unavailable or very inconvenient to use. ATC-40, FEMA 273, and FEMA 356 documents, which are regarded as the "gold standard" of seismic analysis globally, govern RSA in contrast to linear seismic static analysis, linear seismic dynamic analysis, and non-linear static analysis, each of which has its own code. The RSA demonstrates that the response is calculated at every phase of earthquake loading, causing the structure to progress into inelastic deformation. Structures designed in the past aimed to resist earthquake-induced forces, resulting in brittle structures with heavy sections and therefore a high construction cost. Design processes advanced greatly thanks to the introduction of the idea of limit states. Limit-state approaches led to the establishment of performance-based engineering practices and the construction of buildings with thinner members, cheaper construction costs, and shorter construction times. Because ductility was designed to disperse seismic energy emitted by earthquakes, it gave designers sufficient leeway to assess and monitor the buildings' performance. Predictions about the design of structures can be made by developing a mathematical model of the structure with the performance under loading in mind. Any structural modelling, analysis, or design program that is sold commercially will work. It is essential for a structural engineer to be able to predict how a structure will react to a specific set of loads and assurance level. The most accurate technique for examining the structures and evaluating how well they function under the given stress is response spectrum analysis. Non-linear static approaches (NSPs) have been developed for less critical or seismically risky buildings. The process of response spectrum analysis is iterative, involving the assessment of loading and response history at various Δt -steps over the course of some period of time. The response is calculated for each step by considering the loading history over the gap and the starting situation at start of the step. Through the systematic modification of one or more structural parameters (e.g., stiffness), non-linear performance can be easily considered with this procedure. That's why it's the best option for dealing with non-linear situations, out of all the alternatives. Response spectrum analysis may be thought of as a way to foretell the requirements for seismic force and deformation. When the structural system is exposed to inertia forces which cannot be sustained inside structural elastic range of motion, this method provides an approximation of the causing relocation of internal forces. RSA is envisioned as a tool that will provide details about various response features which are obscure through linear elastic & linear dynamic analysis. Validating a full and adequate load route, and therefore the correctness of this computation, remain open questions. Included are all joints, all stiff non-structural parts, all structural parts, and the underpinnings. RSA is your greatest bet if you want to know how a building would respond to a real earthquake. It is necessary to integrate all components, model their inelastic load-deformation characteristics, and carry out incremental inelastic assessments, preferably utilizing 3D analytical model, in order to reap these advantages. Currently, with very few exceptions, suitable analytical tools cannot be used for this purpose. Like linear seismic static analysis & linear seismic dynamic investigation, which all nations have their own codes, and nonlinear static analysis, that is followed internationally in the form of ATC-40, FEMA 273, and FEMA 356, there isn't a code or study document accessible for RSA. During earthquake loading, RSA computes responses at several time steps, and while the loading continues, the structure deforms in elastically. Based on the scoring system, it is always necessary to employ complex and time-consuming techniques to ascertain the vulnerability of buildings. Techniques requiring more in-depth research and sophisticated models are more time-consuming and should only be applied after a building has been evaluated in several stages as potentially dangerous. It is not appropriate for earthquake scenario projects where a large number of buildings need to be assessed. Outlining the main analytical steps in brief is required in order to create simple, effective techniques based on these ideas. There are two types of analyses: linear and nonlinear. In linear static analysis technique, the structure is treated as a SDOF system with linear elastic rigidity & viscous damping equivalent. To generate the same stresses, the seismic effect is based on a viscosity as Earthquake it depicts. By estimating the building's first fundamental frequency utilizing empirical relations or Rayleigh technique, we can calculate the spectral acceleration, which when multiplied by body's mass, gives us an estimate of the corresponding laterally strong strength. The equations include not just second-order effects and stiffness degradation, and also force reduction owing to anticipated inelastic behavior. Using linear elastic analysis, we can determine the internal displacements and forces caused by the lateral force's dissemination along the construction's height.

4. MODELING

The lateral load analysis is done using the E-TABS software, which is also used to create 3D models. The lateral loads that must be applied to the buildings in the form earthquake loads are based on Indian specifications. Every seismic zone has a study conducted in accordance with IS456:2000 (Deadload, Liveload), and IS1893:2002. (Earthquake load).The model data of structures are given below:

Table 4.2: General Data of G+5 building

S. No.	Description	Info	Remarks
1	Plan size	24 x24 m	-------
2	Building heights	15m	-------
3	Number of the Storey above ground level	G+5	-------
4	Type of Structure	L, H, O &	-------
5	Type of building	Irregular frame	IS-1893:2016
6	Software used	ETABS 2018	-------

Table4.1: Detailofmodels

1	Model1 –G+5 NormalBuilding with and without baseisolation (Rectangularshape)
2	Model2 – G+5 NormalBuilding with and without baseisolation (L-shape)
3	Model3– G+5 NormalBuilding with and withoutbaseisolation (H-Shape)
4	Model4 – G+5 NormalBuilding with and without baseisolation (O-shape)
5	Model5– G+5 SlopeBuilding with and withoutbaseisolation (Rectangular shape)
6	Model6 – G+5 SlopeBuilding with and withoutbaseisolation (H-shape)
7	Model7– G+5 Slope Building with and without baseisolation (L-Shape)
8	Model8 – G+5 SlopeBuilding with and withoutbaseisolation (O-shape)

Fig.1:Planviewofslab

Fig4.1: Plan for rectangular shape of G+5 storey building

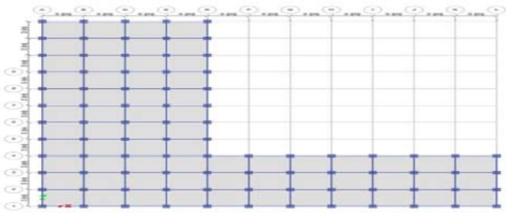


Figure 4.3: plan view of 5 stories L-Shape building

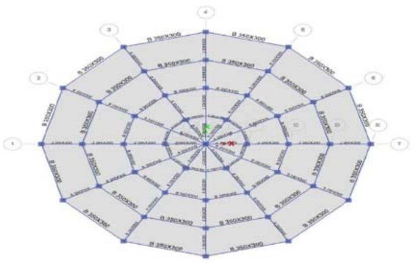


Figure 4.7: Plan view of 5 stories O-Shape building with and without base isolation

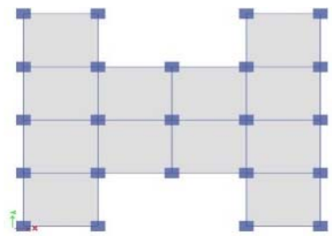


Figure 4.5: Plan view of 5 stories H-Shape building with and without base isolation

5. RESULTS

The lateral forces acting on the structure such as earthquake forces produce as way movement of the building as a result the structure produces lateral displacement of the building.

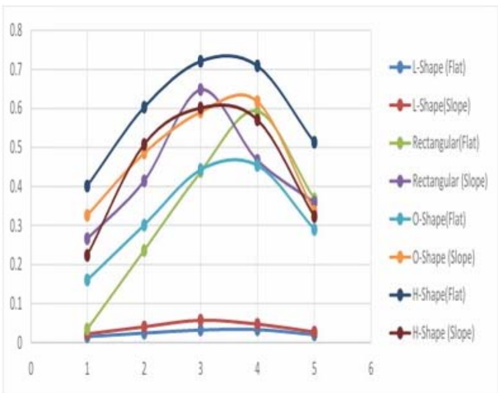


Fig. 5.11.1 Plot between Storey and inter storey drift for different shapes due to EQ-X in X-direction

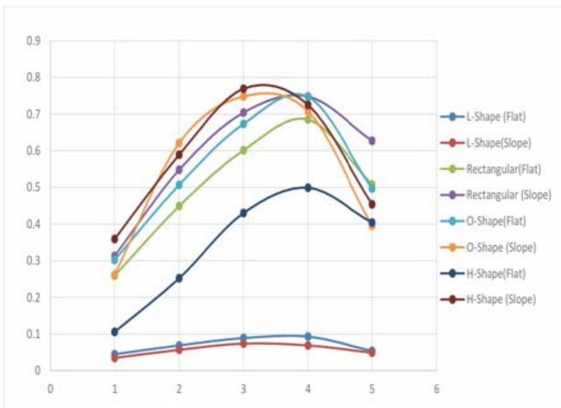
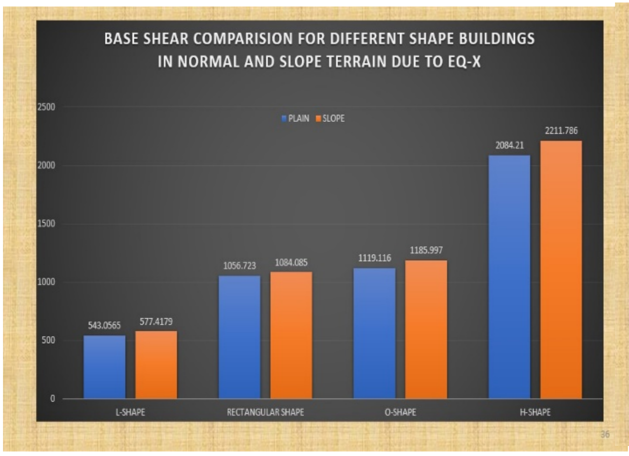
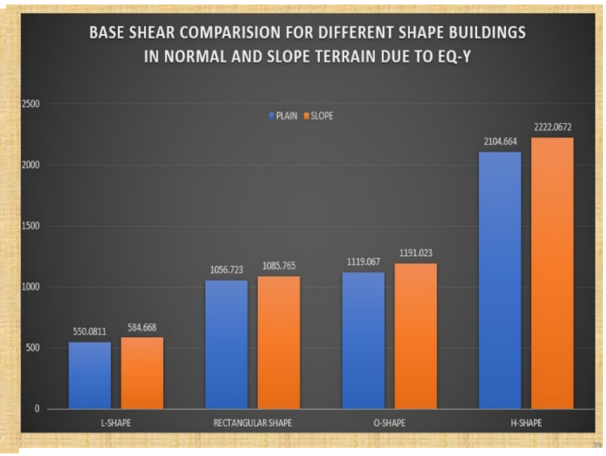


Fig. 5.11.2 Plot between Storey and inter storey drift for different shapes due to EQ-X in Y-direction





6. CONCLUSION

As per overall study it is conclude that Asymmetric buildings are more susceptible to seismic damage compared to symmetric ones. This is due to the uneven distribution of seismic forces and torsional effects, which can lead to greater base shear and inter storey drift and structural stress. And Buildings on slopes steeper than 15 degrees are particularly vulnerable during seismic events. The inclination of the terrain can amplify seismic forces and cause additional challenges such as slope instability and uneven settlement. Implement advanced reinforcement techniques and bracing systems to mitigate torsional effects and improve stability.

- Inter-story drift of L-Shape, Rectangular Shape, O-Shape and H-shape building due to EQ-X has decreased comparatively for flat and slope roof.
- Inter-story drift of L-Shape, Rectangular Shape, O-Shape and H-shape building due to EQ-Y has decreased comparatively for flat and slope roof.
- Base shear of L-Shape, Rectangular Shape, O-Shape and H- building due to EQ-Y in comparison of flat and slope roof increased by 6.29%, 2.75%, 6.43%, and 5.58%.e to EQ-Y has decreased comparatively for flat and slope roof.
- Base shear of L-Shape, Rectangular Shape, O-Shape and H- building due to EQ-X in comparison of flat and slope roof increased by 6.33%, 2.59%, 5.98%, and 6.12%.
- L-shaped Building produces maximum displacement from all the shapes i.e. H-shape, L-shaped and O-shaped and Rectangular Shape.
- Base shear is less in L-shape building in plain terrain as compare to other shape building i.e. H shape, L-shaped and O-shaped and Rectangular Shape. In L-shape building in normal terrain base shear is less so lateral force at base should be minimum as compare to other so member size required less.
- In O shaped building base shear is maximum in case of slope terrain so they required large member size to prevent from damage or safe against seismic activity. this type of building is not durable for slopy terrain or several preventions require which is costly.

7. FUTURESCOPE

There are few investigations to be performed for the study and are explained as below:

1. India consists of great arc of mountains which consists of Himalayas in its northern part which was formed by on-going tectonic collision of plates. Hence there is need of

study of seismic safety and the design of the structures on

2. To further investigate the impact of rotational loading upon structure, a non-linear time history analysis might be carried out for base rotation loading
3. In the current research work, Response spectrum has been conducted for G+5 building which can be extended for high rise buildings.
4. It would give people enough knowledge and assurance to choose which shapes structure should be construct for future construction in India. As a result, the study can be considered before designing a building.

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