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Seismic Analysis of Irregular Building on Hilly Area

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Abstract

The RC buildings' construction has increased in the preferred location of north & eastern hilly areas during the last few decades due to population increase, urbanization, and tourists. The buildings located in the hilly areas are more susceptible to seismic loading as compared to the location of the flat surface building. The shape of the building on the sloping ground differs from the flat surface situated buildings. So, the construction of the building in hilly areas is irregular both vertically & horizontally, thus this type of building is susceptible to severe damage when applied to the seismic condition. The columns of the base storey have unequal height due to sloping ground. In this study, the behavior of a 10-storey stepback building with mass and diaphragm irregularity on the sloping ground is analyzed in seismic zone V by Response Spectrum. The analysis of the building is carried out by Etabs software as per IS 1893:2016 to compare the building based on their dynamic response and also identify the vulnerability frame in the sloping ground.

Keywords

Seismic Analysis, Response Spectrum Method, Stepback building, Mass Irregularity, Diaphragm irregularity, Sloping Ground, Seismic Zone V, IS 1893:2016 & IS 456:2000, bare frame, CSI ETABS vi 18 software.

1. Introduction

The multistoried RC mounted buildings are prevalent in alpine regions as a consequence of increasing the ground cast in metropolitan zones. Consequently, there are many people constructing on alpine inclines. Setback building frames are regular over level lands considering that step back construction frameworks are also common on slanted land. Combinations of setback and step back structures are likewise popular on tilting land. Structures in alpine regions are unusual and consequently, it is subjected to intense twisting in supplement to lateral forces under the act of seismic activity powers. Various structures on alpine regions are strengthened by columns of distinct elevations. Construction loads transferred at the base level to an inclined plane

generate the trouble of slope uncertainty and might consequence in the fall of structure. The soil report is non-consistent on the inclined planes and causes in the complete ruin of the construction. Seismic activity is the extremely catastrophic due to its foreseeability and the enormous energy of destruction. Construction buildings crisis for the period of acute seismic activities and create straight harm to human being lives [26], [27].

2. Literature Survey

After surveying various research papers which has been related to irregular building in slop ground, the short explanation about its approach, methodology and conclusions has discussed.

- **B.G. Birajdar & S.S. Nalawade (2004) [1]-** Seismic study was carried out on 24 RCC vertical abnormality frames with three distinct structures: step back construction, step back-setback construction, and setback construction, in this paper. The response spectrum methodology has been used to conduct a 3-D study. The three configurations of building is compared on the basis of the performance of dynamic response results. The results reveal that step back-setback construction frames are better suited to sloping terrain.
- **Pradip Sarkar et.al (2010) [2]-** In this paper, it was mainly focused on the dynamic response result as fundamental period which is incapable to represent the appropriate value of the time interval at the sloping ground that is given Empirical formula in IS: 1893-2002. The seismic stress on 78 vertical irregulars ranging in height from 6 to 18 stories was studied, and a proposed equation for fundamental time periods was given as a function of the regularity index. This has only been used on a variety of stepped unconventional designs.
- **Y. Singh & Phani Gade (2012) [3]-** To estimate the seismic actions of alpine buildings, analytical research was conducted on 3 to 10-story RC frame constructions. The buildings were analyzed for Seismic Zone IV as per Indian Code. In accordance with the basic duration of vibration, a sequence of column shear, inter-storey drift, and plastic hinge formation pattern, the dynamic response of irregular buildings on sloping ground is compared to conventional constructions on level terrain. Using linear and non-linear duration history approaches, the seismic motion of two scenarios of tilting land constructions is investigated. The conclusions of the scientific investigation are backed up by the harm being observed in precisely the same manner that the scientific analysis predicted.
- **Ravikumar C M, et.al (2012) [4]-** In this paper, the seismic analysis was performed on 3 storey with vertical and diaphragm discontinuity irregularity building on sloping ground. The analysis was performed on Etabs by using different method i.e. Equivalent static method, RSA & Pushover analysis using IS1893:2002 code. The performance was studied in terms of dynamic response and compare the model to the flat terrain and sloping terrain. The performances of all the models on based of result except sloping ground building are lies in between life safety. This demonstrates that structures built on hilly terrain are more susceptible to disasters than the other scenarios.
- **A.R. Vijaya Narayanan, et.al (2012) [5]-** Two steep back structures A and B (of the similar width and along street side) having four storeys beneath and three storeys above earth's surface, however with differing constraints at the foot of pillars, were investigated in this research. Besides the highest valley-side pillar, Construction A has permanent pillar bases while Construction B has roller pillar bases. The findings of nonlinear assessments conducted on construction on steep hilly terrain using two categories of pillar base connections to the land are presented in this study. Robust seismic disturbance makes RC constructions with huge design sizes insecure. For development alongside severe alpine slopes, only compact design structures are best.
- **Shaikh Abdul Aijaj Abdul Rahman & Girish Deshmukh (2013) [6]-** The seismic analysis performed on G+10 vertical irregular building of two frame with similar dimension but having the stiffness irregular in 2nd frame. The dynamic

analysis is analysed by Etabs software as per IS: 18931-2002. The dynamic response result to compare both frames. On the corresponding storey heights, the frame-1 (vertically erratic) produces the lowest storey drifts, whereas the structure with stiffness inconsistency on vertically erratic construction (frame-2) generates the first and most storey drift.

- **Adrian Fredrick C. Dya & Andres Winston C. Oretaa (2015) [7]-** In this study, the seismic analysis of low-rise 5 storey irregular building analyzed by the structural software of SAP2000. The Static displacement evaluation method is used to do the active analysis. On the basis of the examination of soft-story structure simulation result, it is clear that the fundamental reason for soft-story framed structures being far more seismically active is the localisation of tectonic stresses.
- **A. S. Swathi, et.al. (2015) [8]-** The tectonic actions of 5 storey constructions with open ground soft storey asymmetrical construction laying on 30 degrees tilting floor is analyzed by SAP-2000 software as per IS;1893-2002 with the help of Pushover analysis method. The performance building based on dynamic response results of open ground storey buildings is very less. The performance of building frames is enhanced by the augmentation of a shear wall.
- **Behzad Fatahi, et.al. (2016) [9]-** In this paper, the seismic analysis performed on a 15-storey moment-resisting structure which is stable on a 30m thick clay deposit and near 2m high shallow slope. The dynamic analysis is done by time history analysis method by using SAP2000 Software tools. When the structure was built nearer to the hillside, the steep downhill grew increasingly sensitive to destabilization and huge deformation concerns, as predicted by tectonic terrain stability study.
- **P. Manjunath et.al. (2016) [10]**- The seismic analysis performed on 10 storey vertical irregular with construction on a flat slab on flat and various oblique surface beneath the tectonic region. Seismic analysis is done by RAS method with analyzed by Etabs 2015 software and compare the dynamic response with plain and sloping ground.
- **Likhitharadhya Y R(2016) [11]-** The tectonic evaluation for this research was performed on a G+10 storey RC structure with level terrain and inclined ground ranging from 100 to 300 degrees. The ETABs 2015 software programme was used to construct and analyse the RC construction design in order to investigate the impact of altering column elevations in the base level at various points during the seismic activity. The tectonic assessment was conducted out using response spectrum studies in accordance with IS: 1893 (part 1): 2002. In the manner of topmost storey acceleration, storey displacement, mode period, and base shear, the transient response outcomes were derived from the frame structure assessment to the evaluation between plain and inclined terrain structural systems. The transient response data reflects that the small heighted column is more damaged by the seismic activity.
- **Zaid Mohammad, et.al. (2017) [12]-** In this work, Etabs software was used to create and assess 18 models of two distinct arrangement SB & SBSB structures. The structure is vertically uneven, with varying heights and lengths. The Response Spectrum Method is used to examine the entire design on a 26-degree hilly terrain. The vibrant features extracted from observations have been evaluated by comparing within the regarded structures of slanting floor structures in aspects of shear forces stimulated in the sections at ground levels, storey drifts, essential time periods, maximum peak storey displacements, and storey shear in structures, and presented in the context of shear forces stimulated in the sections at base of the structure. When it comes to seismic loads, SBSB structures outperform step-back structures.
- **Rahul Ghosh & Rama Debbarma (2017) [13]-** The tectonic behavior of setback buildings lying on flat terrain as well as steep terrain with soft storey configuration was evaluated in this research. Optimum reactions for open terrain storeyed setback buildings have been documented using three different methods: equivalent linear force technique, time history technique, and response spectrum approach. Three mitigation approaches have been used to attenuate the soft storey impact and the severe reactions: infill wall, shear wall, and RCFSTC.
- **Oman Sayyed, et.al. (2017) [14]-** The seismic performance & behaviour of 8 models of G+10 regular and vertical with soft irregular building is analysed by Response spectrum analysis method with the help of Etabs 2015software.By the

different seismic response to compare the regular and irregular building. In the case of rigidity irregular structures, the storey drift and displacement are greater than normal structures.

- **Ravindra Navale, et.al. (2017) [15]-** The seismic analysis of G+5 vertical irregular RC building in the 2D frame at different floor height and number of bays is analyzed by Etabs software. The seismic assessment is taken out by the response spectrum technique. The dynamic response result to compare the effect of the short column at the different number of the bays.
- **Shaikh Abdul Aijaj Abdul Rahman & Ansari Ubaidurrahman Salik (2018) [16]-** The tectonic response of G+10 storey of two frames having the same dimension with mass and the vertical irregular building was analyzed by dynamic technique and linear static technique with the help of Etabs software as per IS:1893-2002. On the corresponding storey levels, the dynamical response of the design frame-1 (vertically abnormal) creates the minimum storey drifts, whereas the structure with mass abnormality on vertically abnormal structure (frame-2) generates the most storey drifts. As a result, it is the most susceptible to harm.
- **Sachin Kumar gandi & Saleem Akhtar (2019) [17]-** The seismic analysis performed on 20 models of G+6 storey frame of the vertical irregular building (Step-back) with 3 distinct locations of the shear wall on various tilting terrain. Staad-Pro software is used to analyse frame construction. The shear wall's position at the perimeter is ideal for lateral load resistance, while its location at the corner is ideal for axial load resisting.
- **Ruoqiang Feng, et.al. (2019) [18]-** The study used numerical modelling to show the tectonic behaviour of G+4 multistory modular box structures. Structures were subjected to a modal analysis in both common and unusual tectonic activities. Abaqus software was used to analyze the 3-model of the modular box construction. To complete the model of the building, the analogous spring model was used to create a simplified model of a single container, and the shear behaviour of a single container was investigated. The stiffness and capacity of four categories of joints used in modular box construction were also evaluated. The findings demonstrate that the existing joints in multistory modular box constructions do not meet Chinese regulation, and new connections are necessary for complete implementation.
- **Kolasani Rajasekhar and Maganti Janardhana (2019) [19]-** The tectonic assessment was conducted on a 21-story RC building frame lying on hilliy terrain utilising linear dynamic and linear static analysis (RSA), in this article. The performance of RC framed structures lying on flat terrain and lying on hilly ground was compared in this work, which took into account the impact of infill wall stiffness.
- **G. Ajay Kumar and A. Gouthami (2019) [20]-** The tectonic study performed on the G+10 storey standard and vertical abnormal with and without a shear wall on a various sloping angle and surface land. The structure was modelled and analysed using linear static, RSA, and Time history assessment with SAP 2000 software, and the results of dynamic behavior with and without construction at various locations of the shear wall were compared.
- **Apurva Arjun Gaikwad & Dr. Atul B. Pujari (2019) [21]-** Response spectrum and time history techniques were used to examine the tectonic study done on high rise (G+15), mid-rise (G+10), and low rise (G+5) storeys on a flat and different angles of tilting ground constructions. Base shear, Storey displacement, Storey drift, Time period, and Modal participation variables are obtained and compared at various slopey angles using Etabs software.
- **Dr. K.B. Parikh & Jayant Shaligram (2019) [22]-** By using Time history evaluation technique, the design irregularity T and L shape G+4 either with or without OGS setback structure pillar by strengthened concrete-filled steel tube pillars (RCFST) lying on flat and 45-degree inclined ground were examined. Performance of both prototypes has been analyzed and compared to its results. RCFST pillars were installed in the open terrain storey to improve the plan uneven setback structure's effectiveness and reduces seismic risk.
- **Rayudu Jarapala & Kishore Chandra Biswal (2020) [23]-** In this paper, the seismic analysis performed on 10 models of vertical irregularity buildings & 4 to 8 number of storey buildings with Step back & Stepback-Setback buildings are

presented. It is analyzed by using SAP2000 software. The active reactions of the constructions under three different earthquakes as low, intermediate, and high-frequency. Dynamic analysis is done by the Time history method using IS 1893-2002. The regular index is ideal for analyzing the degree of abnormality in the SBSB and SB construction designs.

- **Mahdi Heshmati, et al. (2020) [24]-** The seismic performance of 6 models of 36 storey at various angles analyzed by Pushover & time history analysis method as per IS: 1893-2002. The dynamic analysis is accomplished on 3D software in order to evaluate energy overindulgence, inter-story drift fraction, hinges distribution and residual drift of structures. Diagrids structures achieved reasonably in MCE seismic activity movements and maximum of the average distortions were within the acceptable limit.
- **Shaik Akhil Ahamad & K.V. Pratap (2020) [25] -** In this research work, the use of Shear walls at various places in G+20 multistoried housing construction is studied to know the base shear, storey drift, highest permissible transposition and torsional abnormality. The assessment and modeling of the entire building are accomplished by utilizing Etabs 2015 by the RSA method at the different seismic zone as IS 1893 (Part-1) 2016. The active investigation is conducted on soft soil for an abnormal construct in proposal and match the three cases of shear wall with the different seismic zone. As per the observation the structure with shear edges located at four sides i.e. Case C had provided superior scores in terms of highest transposition, fundamental shear and storey drift.

3. Conclusion

After reviewing a lot of research papers that are based on the irregular building structure and sloping ground with various loading conditions. For further work in this direction irregular building with the various irregularity in the structure with the sloping ground would create various type of case model and using the response spectrum method & time history method to analyze to identify of Vulnerability frame.

The conclusion for the further work related to the irregular building on sloping ground are shown below: -

- A lot of work has been seen in various research papers, but none of the papers can show the various irregularity in the building frame for the earthquake analysis.
- For analysis, a structural tool such as Etabs 2018 could be used.
- Various types of irregularities such as vertical, mass, and diaphragm irregularities have taken in the building with the sloping ground which is not shown by various researchers.
- Response spectrum technique and Time history study approach might be to determine the seismic response over structural components.
- The building model will be analyzed in seismic zone IV & V.
- For different building models, determination of the dynamic response.
- After executing response spectrum & time history study, comparing all outcome parametric values and identify of Vulnerability frame.

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