Comparative Study Probabilistic Seismic Risk Assessment for Regular and Irregular RCC Buildings

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Abstract. In the study numerous buildings exhibit irregularities of their architectural plans, a feature that could render them susceptible to excessive seismic activities in the future. The purpose of this paper is to evaluate the seismic vulnerability and response of regular and irregular shaped multi-storey building of identical weight in context. Both static and dynamic (response spectrum) analysis has been done to observe the influence of shape of a building on its responses to various loading. G+12 storied regular (rectangular) and irregular shaped buildings have been modeled using program staad pro for seismic zone III. Impact of wind and static load on exclusive formed shape along with dynamic response spectrum has been meticulously analyzed considering the mass of each shaped is identical. A comparative analysis of the center of mass and maximum displacement overstorey of variously shaped buildings under static loading and dynamic response spectrum has been conducted. All form buildings react nearly in sync if the total mass fluctuates only little. But as the end result indicates, a structure's irregular dimensions are what expose it to its vulnerable direction. It is possible to build an irregularly shaped structure that might act more like a rectangular building while keeping the total mass the same.

Keyword-: maximum displacement, regular shape, irregular shape, wind load, muilty storey building.

1 Introduction

Buildings, intricate assemblies of roofs and walls with numerous configurations and dimensions, serve as several functions starting from sheltering towards weather conditions to

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offering residing and operating areas, safety, and privacy starting from modest dwellings to towering skyscrapers, buildings cater to numerous needs across different scales [1]. To address the challenges posed by way of irregularities in land availability, in particular in densely populated city areas, high-rise structures with irregular cross-sectional shapes have emerged as a feasible solution. but, the construction of such high-rise buildings presents particular challenges, especially regarding wind results, as traditional wind information might not be simply available or relevant [2-3]. Whilst international standards exist for designing tall buildings with regular shapes, they frequently overlook the complexities associated with irregular structures, leaving designers to navigate uncharted territory. Utilizing advanced software program like Staad.pro, structural engineers undertake the intricate undertaking of designing buildings with irregular geometries [4]. It's recognized that buildings with simple and normal geometries normally exhibit higher seismic performance and withstand wind loads more successfully due to the uniform distribution of mass and stiffness. Conversely, irregular structures present an impressive assignment [5-6]. Their non-uniform distribution of mass and stiffness complicates wind response prediction and structural design, making it hard for engineers to ensure ultimate performance. Despite advancements, it's impractical to standardize all structures to stick to normal geometries [7]. Subsequently, while efforts are made to decorate the wind response of irregular buildings, designers must refrain from attributing structural collapses totally to irregularities [8]. Instead, they need to give attention on growing appropriate treatments and strategies to mitigate wind-triggered stresses. Studies by various researchers concentrate on analysing the wind demands on vertical irregular strengthened concrete buildings throughout different wind zones in India [9]. This includes studying numerous strategies to assess wind masses, considering standards such as IS-875 and IS-1893. Publish-analysis, parameters along with maximum shear forces, bending moments, and storey displacements are computed and compared throughout special scenarios, encompassing each regular and irregular configuration [10]. An important problem stemming from the rapid urbanization and industrialization, which sees a significant part of the population gravitating toward urban centres. ensuring the structural stability of buildings in such contexts turns into paramount, in particular considering the want to withstand lateral loads induced by earthquakes and wind along gravity loads [11]. Consequently, it becomes imperative for structures to possess good enough energy and stiffness to face up to those numerous forces. advancements in design and analysis, facilitated by using the accessibility of computer systems and specialised software applications, have made the undertaking more feasible and fee-effective [12]. In this take a look at, the design of multi-storeyed buildings is undertaken utilizing the Staad pro v8i software [13]. The focus lies on analysing 3 distinct models of irregular multi-storey buildings, each comprising ten floors with a floor height of three meters. These models are characterized by a reaction factor of five, a significance component of 1.2, medium soil type, and shape kind 1, incorporating a damping ratio of 5% [14]. The analysis consists of various loads, consisting of dead load in accordance with IS 875 part 1, live load as per IS 875 part 2, and seismic load following IS 1893 part 1 standards. The beams, columns, and slabs are individually designed inside the software environment to make sure comprehensive analysis and assessment of the structural integrity [15]. Subsequently, the results obtained from the analysis of the three models are as compared based totally on parameters which includes storey drift and displacement. Through this comparative assessment, insights into the performance of each version under dynamic loading conditions are gleaned, shedding light on their respective strengths and weaknesses in terms of structural stability and resilience [16]. The seismic overall performance of multi-storey framed buildings hinges on the careful distribution of mass, stiffness, and strength throughout each horizontal and vertical planes. Throughout seismic activities, damage normally originates at points of structural vulnerability within the lateral load resisting frames. These weaknesses may additionally stem from disparities in stiffness, strength, or mass between adjacent storeys, frequently connected to abrupt adjustments in frame geometry along the building's height. Vertical geometric irregularities, characterised by using unexpected height drops, are a common shape of such discontinuities [17]. This study investigates the performance and behavior of each regular and vertically irregular strengthened concrete (RCC) framed structures under seismic loading conditions. Five constructing geometries are examined, inclusive of one regular frame and 4 irregular frames [18]. A comprehensive comparative analysis is conducted, considering variations in building top and bay configuration. Using Staad.pro V8i software program, all building frames are meticulously modelled and analyzed. Numerous seismic responses along with shear force, bending moment, storey drift, and displacement are assessed according with IS 1893:2002-part (1) suggestions [19]. Seismic sector III and medium soil strata are assumed for all cases, ensuring consistency in the course of analyses. Thru this research, changes in seismic reaction during exclusive heights are found and analyzed, presenting precious insights into the impact of geometric irregularities on structural behaviour. By means of systematically comparing various configurations, this study contributes to a deeper knowledge of the seismic overall performance of multi-storey framed buildings and informs design practices aimed at improving structural resilience and protection in earthquake-prone regions [20-24].

2 Methodology

An RCC framed structure accommodates a cohesive assembly of slabs, beams, columns, and foundation additives interconnected to shape a unified system [25]. The burden transfer mechanism inside those structures is elaborate, starting from the slabs moving loads to beams, which then bring the loads to the columns. Ultimately, the columns distribute the loads to the foundation, which subsequently transfers them to the underlying soil [26-29]. This structural analysis study makes a speciality of investigating the impact of building irregularities on seismic performance throughout numerous seismic zones [30]. In particular, the study aims to offer a comparative evaluation of ordinary and irregular building's interior specific seismic zones. The primary purpose of this examine is to behavior a comparative evaluation of a G+12 storey structure beneath seismic loading situations, considering both regular and irregular configurations [31]. By using analysing the structural reaction of buildings with numerous tiers of geometric irregularities at some point of different seismic zones, insights into their respective seismic vulnerabilities and average performance characteristics can be received [32-35]. Through meticulous evaluation and assessment, this study endeavours to contribute to the records of how structural irregularities have an effect at the seismic behaviour of buildings, thereby informing future design practices and techniques aimed towards enhancing structural resilience and mitigating seismic risks in several geographical contexts [36].

2.1 Building analyzing G+12 structures, both regular and irregular, within zone III

On this analysis, we focus on studying the seismic response of a G+12 RCC multi-storey framed building to gain insights into its realistic conduct under seismic loading situations, considering each regular and irregular configurations inside seismic sector III [37]. The structural models of each regular and irregular buildings are meticulously built using wind load evaluation with constant guide within Staad pro software program. The constructing specifications include a standard floor height of three meters and a plinth height additionally set at 3 meters. The structural substances applied consist of concrete with a grade of M30 and steel of grade Fe415 [38-42]. These materials have been chosen to offer sufficient durability and strength to effectively withstand seismic forces. The objective is to analyse higher design practices and strategies for seismic resilience in earthquake-prone regions in order to investigate how differences in building geometry and structural imperfections affect the seismic response of multi-story buildings which is the key aspect of this comprehensive analysis [43].

Table 1: Details of geometric for G+12 building

Geometrical details	
Particulars of Item	Properties
Number of Storey	G+12
Total height of Structure	40m
Typical Storey height	3m
Bottom Storey Height	3m
Floor Diaphragm	Rigid
Number of bays along length	8
Number of bays along width	6
Spacing of bays along length	3m
Spacing of bays along width	3m
Beam Size	450x600mm
Beam Shape	Rectangular
Column Size	700x700mm
Column Shape	Rectangular
Slab Depth	150mm
Yield strength of distribution bar (fysec)	Fe415

This Table 1 presents a synthesis of studies papers authored through numerous contributors, focusing at the evaluation of multi-storey high-rise structures under seismic loads, mainly inside sector III. Staad pro software program offers a convenient modeling feature known as quick Template, which simplifies the procedure of defining the structure's bays inside the X, Y, and Z directions [44]. On this particular look at, the structure is configured with 8 bays in the X direction and 6 bays in the Y direction, with a uniform spacing of 3 meters, ensuring symmetrical modeling. The building under consideration is a G+12 storey structure, with a standard storey top of 3 meters and a bottom storey height of 4 meters. To establish the structural properties within Staad-pro, the general-assets command is utilized to define the properties according to the size requirements of the building. Subsequently, beams and columns are generated based totally at the assigned properties. Section properties for beams, columns, and slabs are meticulously defined. In this observe, beams are sized at 450x600mm, columns at 700x700mm, and slabs at a thickness of 150mm. those specifications are critical for accurately representing the structural factors in the analysis version, facilitating a comprehensive evaluation of the building's response to seismic loads.

3 Result and Discussion

The comparative research explores the effect of regular and irregular building configurations throughout various wind zones on high-rise structures. Located within seismic zone III, the study specializes in analysing the outcomes and discussing the outcomes of RCC framed structures affected by each regular and irregular constructing forms. Specifically, the examination aims to evaluate the repercussions of these configurations on a G+12 storey building within seismic zone III. Conducting seismic load evaluation forms the crux of this study, with specific emphasis on evaluating storey displacement and bending moment. The obtained results are meticulously tabulated to facilitate thorough examination. Ultimately, the findings from the evaluation are presented under, observed by a comprehensive comparative study delineating the observed variations among regular and irregular constructing configurations. Through this rigorous analysis and comparison, insights into the structural reaction of high-rise buildings to seismic loads, below varying geometric configurations, are gleaned. This endeavour contributes to a deeper understanding of the dynamic behaviour of structures in seismic-prone areas, aiding in the components of informed design techniques for enhancing structural resilience and mitigating capability risks.

Table 2: Results of storey displacement for G+12 RCC building for regular building in zone III

Storey	Height in Meter	Storey Displacement in mm
13	40.00	18.293
12	37.00	17.772
11	34.00	17.039
10	31.00	16.087
9	28.00	14.941
8	25.00	13.626
7	22.00	12.159
6	19.00	10.552
5	16.00	8.811
4	13.00	6.945
3	10.00	4.977
2	7.00	2.966
1	4.00	1.086
BASE	0.00	0.00

The Table 2 provides data concerning the storey height of a building, measured in meters, along with the corresponding storey displacement, measured in millimetres. Each row in the table represents a selected storey of the building, with the storey number listed on the leftmost column. The "Storey height in Meter" column indicates the vertical distance from the base of the building to the respective storey, while the "Storey Displacement in mm" column denotes the amount of lateral displacement experienced by using every storey during a seismic event. For instance, the data indicates that the topmost storey (Storey 13) has a height of 40 meters and experiences a displacement of 18.293 millimetres. As we move downwards through the storeys, both the storey height and the corresponding displacement decrease gradually.

Table 3: Results of bending moment for G+12 RCC building for regular building in zone III

S. No	Beam	Max Bending Moment in KN-m
1	1	292.4
2	6	163.5
3	11	144.2
4	16	135.5
5	21	127.9

The Table 3 presented in the table pertains to the maximum bending moments experienced by beams within a building structure. Each row represents a specific beam, identified by its corresponding number in the first column. The "Max Bending Moment in KN-m" column indicates the maximum magnitude of the bending moment, measured in kilonewton-meters

(KN-m) that each beam is subjected to during structural loading conditions. For instance, the first row indicates that Beam 1 experiences a maximum bending moment of 292.4 KN-m. Similarly, the subsequent rows provide the maximum bending moments experienced by Beams 6, 11, 16, and 21, which are 163.5 KN-m, 144.2 KN-m, 135.5 KN-m, and 127.9 KN-m, respectively.

Table 4: Results of storey displacement for G+12 RCC building for irregular building in zone III

Storey	Height in Meter	Storey Displacement in mm
13	40.00	22.4
12	37.00	21.8
11	34.00	21.1
10	31.00	20.2
9	28.00	18.8
8	25.00	16.4
7	22.00	15.1
6	19.00	12.8
5	16.00	10.2
4	13.00	7.6
3	10.00	4.9
2	7.00	2.8
1	4.00	1.2
BASE	0.00	0.00

The presented Table 4 contains data regarding the storey height of a building, measured in meters, alongside the corresponding storey displacement, measured in millimetres. Each row in the table represents a specific storey of the building, with the storey number listed on the leftmost column. The "Storey Height in Meter" column indicates the vertical distance from the base of the building to the respective storey. For example, the topmost storey (Storey 13) has a height of 40 meters, while the base of the building (labeled as "BASE") is at a height of 0 meters. The "Storey Displacement in mm" column denotes the amount of lateral displacement experienced by each storey during a seismic event. For instance, Storey 13 experiences a displacement of 22.4 millimetres.

Table 5. Results of bending moment for G+12 RCC building for irregular building in zone III

S. No	Beam	Max Bending Moment in KN-m
1	1	321.5
2	6	185.9
3	11	156.3
4	16	145.7
5	21	138.4

The provided data in Table 5 represents the maximum bending moments experienced by beams within a building structure, measured in kilonewton-meters (KN-m). Each row in the table 5 corresponds to a specific beam, identified by its respective number listed in the first column. For instance, Beam 1 is subjected to a maximum bending moment of 321.5 KN-m, Beam 6 experiences a maximum bending moment of 185.9 KN-m, Beam 11 encounters a maximum bending moment of 156.3 KN-m, Beam 16 undergoes a maximum bending moment of 145.7 KN-m, and Beam 21 faces a maximum bending moment of 138.4 KN-m.

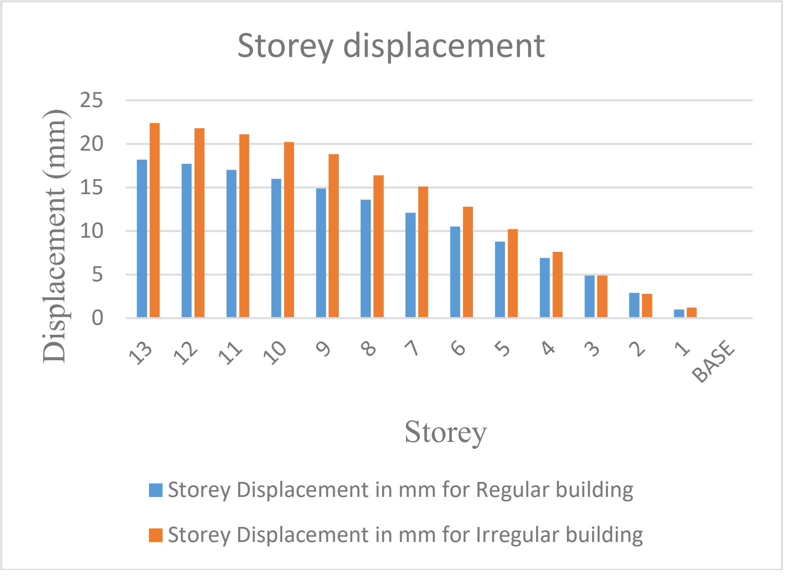

Fig. 1: Comparatively results of storey displacement for regular and irregular building

The provided Fig. 1 presents data comparing the storey displacement in millimetres for both regular and irregular buildings across different storeys. For instance, at the topmost storey (Storey 13), the regular building experiences a displacement of 18.2 millimetres, whereas the irregular building experiences a slightly higher displacement of 22.4 millimetres. These data are essential for understanding how structural irregularities impact the dynamic behaviour of buildings during seismic events. By comparing the storey displacement between regular and irregular buildings, engineers can benefit insights into the structural performance and vulnerability of different building configurations, aiding within the development of effective design strategies for enhancing structural resilience and mitigating ability risks.

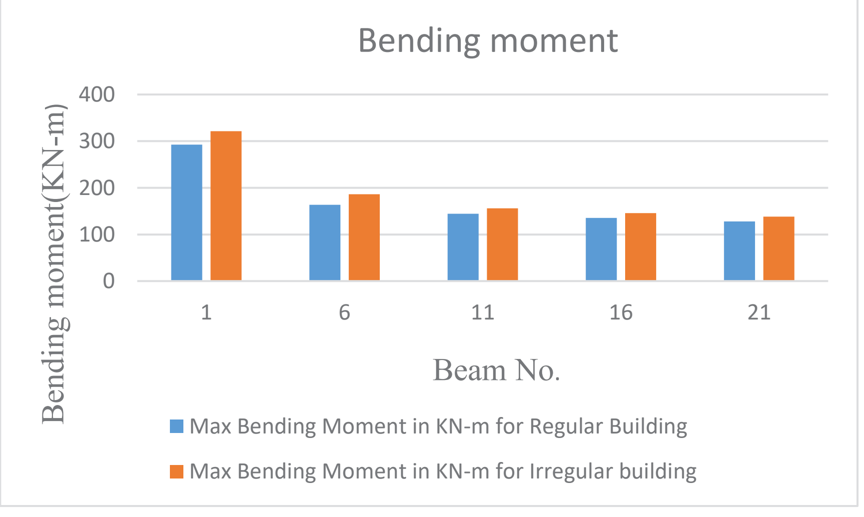

Fig. 2. Comparatively results of bending moment for regular and irregular building

The provided Fig. 2 presents a comparative evaluation of the maximum bending moments experienced by using beams in each regular and irregular buildings. The maximum bending moments for beams 6, 11, 16, and 21 are in comparison among the regular and irregular buildings, revealing potential variations in structural normal performance between the two building configurations. This comparative assessment is crucial for understanding how structural irregularities have an effect on the distribution of bending stresses inside buildings. Through comparing the maximum bending moments amongst regular and irregular buildings, engineers can investigate the structural integrity and resilience of numerous constructing configurations, informing design selections aimed toward enhancing structural safety and performance.

5 Conclusion

The impact of seismic activity on multi-storey reinforced concrete building frames is investigated, focusing on structures with both regular and irregular shapes inside seismic region III. The examine underscores the significance of considering both structural form and seismic region characteristics in the design and analysis of multi-storey reinforced concrete buildings, ultimately contributing to more strong and resilient structural solutions in earthquake-susceptible areas. The study examines versions in seismic responses, including bending moments and storey displacement, throughout amazing seismic zones. Especially, the effects for a G+12 storey building are mentioned inside the results segment, main to the following conclusions:

- The structural behavior of both regular and irregular buildings is done by analysing the maximum bending moments experienced through beams and comparing storey displacements, this will give engineers a deeper information of the way structural irregularities impact building's overall performance.
- The seismic response of multi-storey reinforced concrete buildings is inspired by using approach of different shape and the seismic vicinity in which it is positioned. The irregular building consistently exhibits higher displacements across various storeys compared to the regular building. At Storey 13, the irregular constructing shows a displacement of 22.4 mm, whilst the regular building statistics 18.293 mm.
- Irregular buildings demonstrate higher maximum bending moments across different beam numbers as compared to regular buildings. As an example, in the irregular building experiences a maximum bending moment of 321.5 kN-m, surpassing the292.4 kN-m recorded within the regular building.
- Differences in storey displacement and maximum bending moments indicate distinct structural behaviours among regular and irregular structures. The irregular building's higher displacements and bending moments advise potential vulnerabilities for seismic or dynamic loads.
- Buildings with irregular shapes exhibit distinct seismic behaviour in comparison to those with regular shapes, highlighting the importance of considering structural irregularities in seismic design.

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