iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 13 **Issue:** XI **Month of publication:** November 2025

**DOI:** https://doi.org/10.22214/ijraset.2025.75730

# Study on Response of Stiffness Irregular RC Framed Structures Subjected to Wind Loads

Potti Pushapanjali[1], Smt. B. Prudvi Rani[2]
[1]*Master of Technology in Structural Engineering*
[2]*Assistant Professor, M.Tech (Ph.D), Department of Civil Engineering, Sanketika Vidya Parishad Engineering College, (Affiliated to Andhra University, Visakhapatnam, A.P)*

***Abstract: Stiffness irregularities are among the most critical factors influencing the structural performance of reinforced concrete (RC) framed buildings under lateral loading. Abrupt reductions in stiffness—often resulting from weak storeys or sudden loss of lateral resistance—disrupt the uniform distribution of wind and seismic forces along the building height. This leads to stress concentration, localized deformations, and a significant increase in inter-storey drift, frequently culminating in soft-storey failures. In contrast, buildings with uniform stiffness exhibit more stable and predictable dynamic behaviour.***

***The present study investigates the wind response of RC framed buildings with stiffness irregularities and compares their performance with that of regular frames. A six-storey (G+5) RC frame is modelled and analysed for wind loads in accordance with IS 875 (Part 3): 2015, using ETABS. Key response parameters—including lateral displacement, storey drift, and base shear—are evaluated across different wind zones of India.***

***The results reveal that stiffness irregularities amplify inter-storey drift and shear concentration at specific levels, particularly in soft-storey and partially in filled configurations. These observations underscore the importance of incorporating stiffness discontinuities in wind design considerations to mitigate premature failures and ensure compliance with codal safety provisions.***

## I. INTRODUCTION

The behaviour of structures is significantly influenced by structural irregularities, particularly when subjected to wind loads. Wind exerts dynamic lateral forces that depend on the building's height, shape, stiffness, and mass distribution. In irregular buildings, discontinuities in the geometric configuration or the lateral force-resisting system can amplify these effects. Such irregularities may be vertical (e.g., setbacks, soft storeys, or abrupt changes in stiffness), plan-based (e.g., re-entrant corners, torsional asymmetry), or a combination of both, and they can substantially alter the wind-induced response.

Over recent decades, the study of structural performance under wind loads has gained increasing importance due to the rise of tall and complex buildings. Unlike gravity loads, wind loads are dynamic, fluctuating in direction and intensity, and can generate significant lateral sway, vibrations, and tensional motion. Irregular structures are especially susceptible, as discontinuities may lead to stress concentrations, amplified inter-storey drifts, excessive acceleration, and even serviceability or structural failures.

The catastrophic failures observed during severe wind events, such as cyclones and storms, underscore the necessity of adopting wind-resistant design principles in accordance with codal provisions (e.g., IS 875 Part 3–2015 in India). Engineers and architects are therefore tasked with designing structural systems that can safely resist wind-induced forces, control lateral displacements, minimize vibrations, and prevent failure. Enhancing the resilience of irregular structures against wind actions is a key concern in modern structural engineering practice.

### *A. Classification Of Structural Irregularities*

Building irregularities come in a variety of forms depending on where they exist and how they are constructed, but they can be broadly grouped into two categories.

1) Vertical Irregularities: These refers to an abrupt change in the properties of strength, stiffness, geometry, and mass that results in an uneven distribution of forces and deformation throughout the height of the building
2) Horizontal irregularities: These include large openings, re-entrant comer, and abrupt changes in torsion, diaphragm deformations, and stress concentration, as well as asymmetrical plan forms or discontinuities in the horizontal resisting parts.

*B. Plan Irregularities*

It describes "asymmetrical plan forms or discontinuities in horizontal resisting parts, such as wide apertures, re-entrant corners, and abrupt changes that generate torsion, diaphragm deformations, and stress concentration."

Buildings with irregular plane geometries may behave structurally poorly as a result of the following factors: Examples of time-dependent deformation include temperature differences, creep and shrinkage, various settlements, and various reactions to dynamic forces. As a result, some load-bearing system components could experience excessive strains. Re-entry corners irregularity, dimensions ratio irregularity, non-parallel system irregularity, and out of plane offset in this subject, irregularity refers to geometrical irregularities in the plan that are physically distinct from one another in behaviour and physics.

*1) Tensional Irregularity*

Torsion irregularity must be considered when floor diaphragms are stiff in their own plan in respect to the vertical structural elements that resist lateral stresses. When the greatest storey drift, calculated with design eccentricity, at one end of the structure transverse to an axis is larger than 1.2 times the average of the storey drifts at the two ends, torsion irregularity is said to exist.

Torsional irregularity is defined in the Indian Standards (IS 1893-Part-1-2016) Earthquake Code. A structure exhibits torsional irregular behaviour when: A floor's maximum horizontal displacement in the direction of lateral force is greater than 1.5 times greater than its minimum horizontal displacement in the same direction at the other end of the floor.

Every storey's maximum drift, including accidental torsion, at one end of the structure is limited to 20% of the average drift of the two ends of the building's storeys.

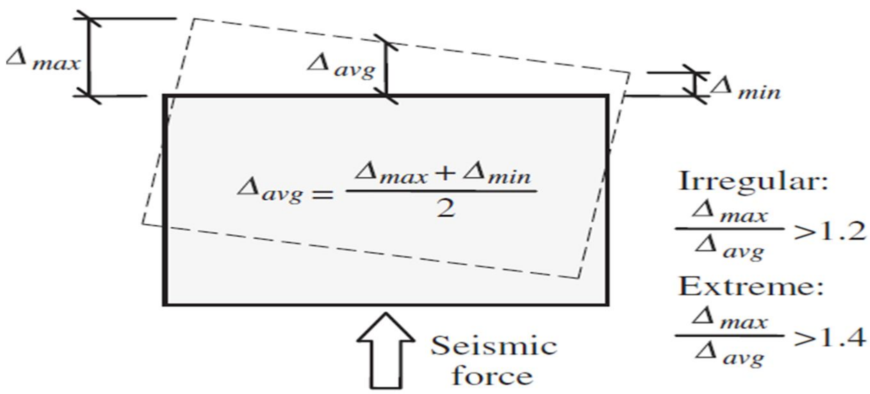



Fig. 1.1 Torsional irregularity

*2) Re-entrant Corners*

Re-entrants, a loss of continuity, or inside corners are frequently found in overall building layouts with a plan that resembles an L, T, H, or +. The occurrence of these shapes, or combinations of these shapes, is caused by a lack of tensile capability and force concentration. Re-entrant corners are found in the plan configurations of a structure and its lateral force resisting system when both projections of the structure beyond the re-entrant comer are greater than 15% of the plan dimension of the structure in the given direction.

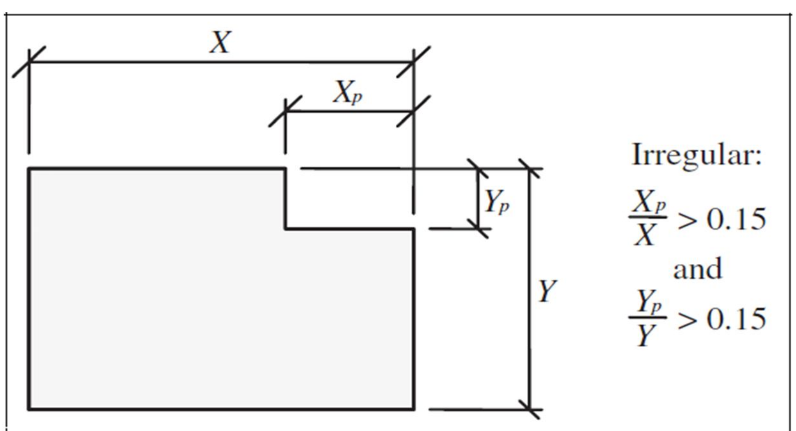



Fig. 1.2 Re-entrant irregularity

*3) Diaphragm Discontinuity*

A horizontal resistance element called the diaphragm is responsible for transferring forces from vertical resistance elements to horizontal resistance elements. Diaphragms that abruptly discontinue or vary in stiffness, such as those that have cut-out or open portions that are more than 50% of the total area of the diaphragm or that change in effective stiffness by more than 50% from one storey to the next. The margins of the diaphragm serve as a horizontal beam and as It goes without saying that a beam's ability to carry loads will be greatly reduced if a hole is cut into its tension flange.

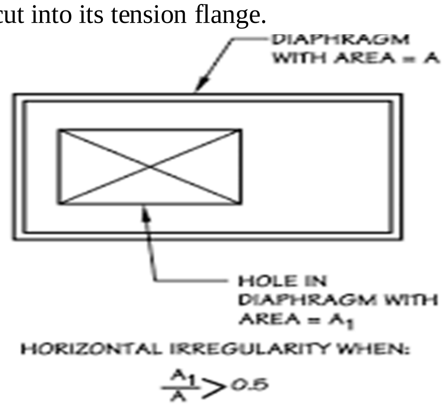



Fig. 1.3 Diaphragm Discontinuity

*4) Out of plane offsets Irregularity*

A lateral force resistance path that has discontinuities, such as offsets in the vertical elements A building's seismic safety is recognized to be compromised by out of plane offsets in vertical elements that are resisting lateral loads because they result in discontinuities of plane and detours in the load path. Out-of-plane offset in vertical elements is a term used to describe when structural walls or frames shift out of alignment in any level along a building's height.

The concept of a non-parallel system according to Indian Standards (IS 1893-Part-1-2016):

Discontinuities in a lateral force resistance route, such as out-of-plane offsets of vertical elements when structural walls or frames are moved out of plane in any Storey along the height of the building, are examples of irregularities.

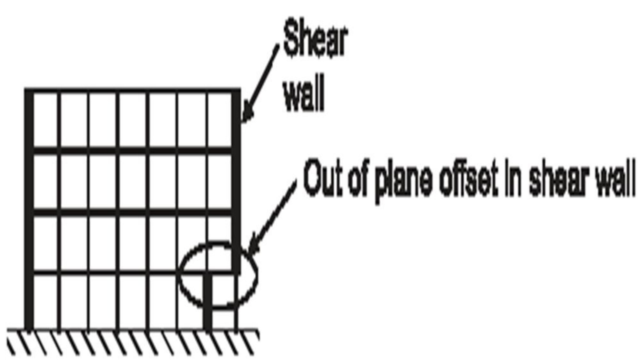



Fig. 1.4 Out of plane Offset Irregularity

*5) Non parallel Systems Irregularity*

The vertical elements resisting the lateral force are not symmetric about or parallel to the principal orthogonal axes or the vertical elements. Situations like this are common for architects. The likelihood of torsional forces under ground motion is increased by the fact that the centre of mass and the resistance do not coincide. This problem is often exacerbated in triangle- or wedge-shaped structures created by sharp roadway intersections. Torsion is more likely to occur since the building's narrower parts will be more flexible than its wider ones. The influence of torsion must be minimized or the torsional resistance of the narrow part of the building must be increased when designing these kinds of structures.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 13 Issue XI Nov 2025- Available at www.ijraset.com*

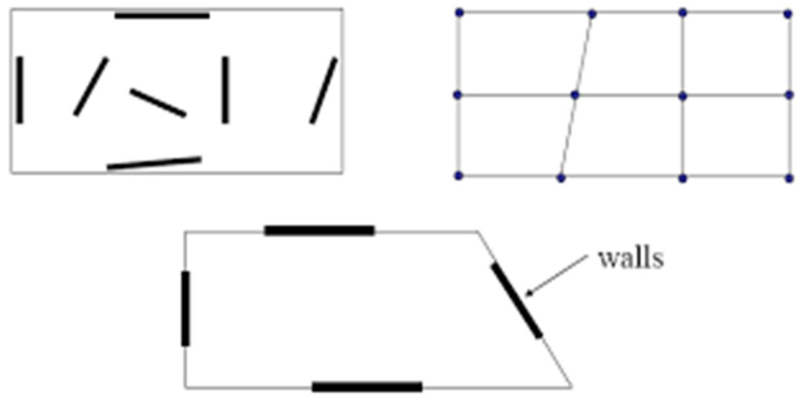



Fig. 1.5 Non-Parallel System Irregularity

*C. Vertical Irregularities*

The irregularities in the "load path or load transfer are one of the major contributors to structural damages in structures during strong earthquakes. The structure should contain a continuous load path for transfer of the seismic force, which develops due to acceleration of individual elements to the ground. Failure to provide adequate strength and toughness of individual elements in the system, or failure to connect individual elements, can result in distress or complete system collapse. As a result, all structural and non-structural elements must be sufficiently tied to the structural system, and the load path must be complete and sufficiently strong".

The general load path is as follows; earthquake forces originate in all elements of building and are delivered through structural connections to horizontal diaphragms. The diaphragms distribute these forces to vertical resisting components such as columns, shear walls, frames, and other vertical elements in the structural system, which transfer the forces on the foundation

Vertical irregularities are described by vertical discontinuities in geometry, mass distribution, rigidity, and strength. Setback buildings are a subset of vertically irregular buildings that have geometric discontinuities. Geometric Irregularity, on the other hand, introduces discontinuity in the vertical distribution of mass, stiffness, and strength.

Real structures are frequently irregular, as perfect regularity is an idealization that rarely occurs in practice. In the case of buildings, major seismic codes around the world distinguish between Irregularity in plan and Irregularity in elevation, but it must be understood that Irregularity in the structure is the result of a combination of both types. It can be seen that irregular structural configurations, either in plan or in elevation, were frequently identified as one of the major causes of collapse during previous earthquakes.

*1) Stiffness Irregularity (Soft Storey)*

The definition of earthquake in accordance with Indian Standards (IS 1893-Part-1-2016)

Stiffness irregularity: A "soft storey" is defined as "one in which the lateral stiffness is less than 70% of that in the storey above or less than 80% of the average lateral stiffness of the three stories above."

A storey is considered to be extreme soft if its lateral stiffness is less than 60% of the storey above it or less than 70% of the average stiffness of the three levels above. This category will include structures like those on stilts.

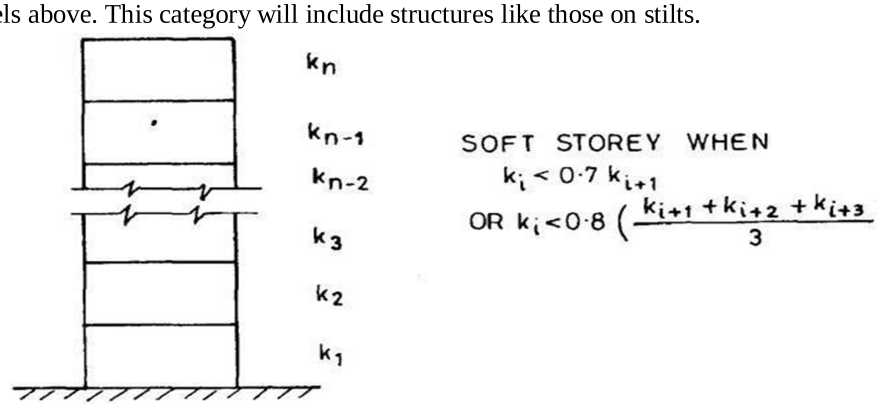



Fig. 1.6 Stiffness Irregularity

*2) Mass Irregularity*

When a storey's effective mass is more than a neighbouring storey's effective mass by more than 15%, there are mass irregularities. The real mass, which also includes the floor's dead weight and the actual weight of the equipment and the partition, is known as the effective mass. Overweight structures are more likely to collapse as a result of the P-effect, experience more lateral inertial forces, and have less ductility in their vertical load-resisting components.

There should be a minimum amount of effort put into avoiding massive plant rooms and enormous roofs. The use of dynamics analysis to examine the lateral force resisting elements in the presence of mass irregularities to provide a more accurate representation of the lateral load distribution of the base shear is beneficial.

The definition of the mass irregularity according to the Indian Standards (IS 1893-part-1-2016) earthquake code is: When a floor's seismic weight is greater than 150% of the floor below, mass irregularity is deemed to exist

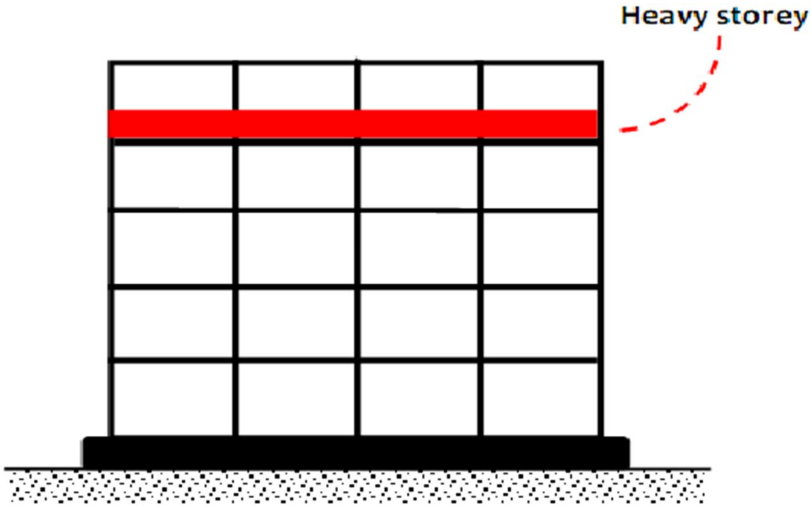



Fig. 1.7 Mass Irregularity

*3) Vertical Geometric Irregularity*

A geometric irregularity known as a vertical set back that occurs in a vertical plane. When the horizontal dimension of the lateral force resisting system in any storey exceeds 125% of that of a neighbouring storey, it is taken into consideration. A vertical re-entrant corner can also serve as a representation of the setback. Total seismic separation in the plan through separation section is the general solution to the setback issue, allowing each component of the building to vibrate separately. Perform a dynamic study on the component that resists lateral forces when the building is not divided.

The definition of vertical geometric irregularity according to Indian Standards (IS 1893-part-1-2016) earth quake code is:

"Vertical Geometric Irregularity shall be considered to exist where the horizontal dimension of the lateral force resisting in any storey is more than 125percent of that in its adjacent storey."

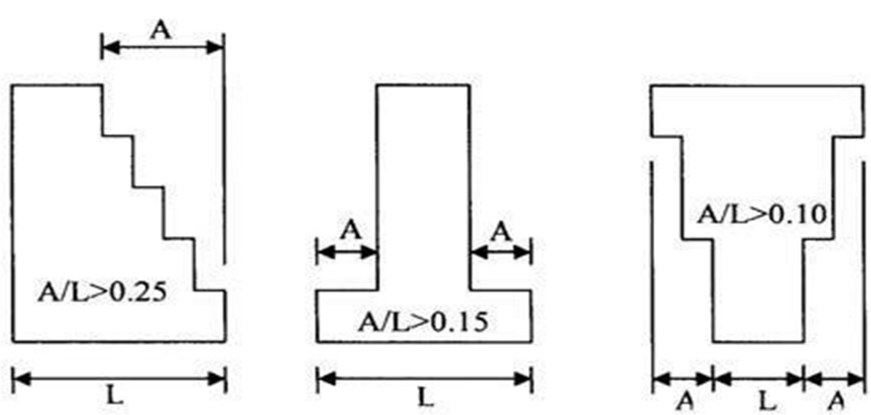



Fig. 1.8 Vertical Geometrical Irregularity

*4) In-plane discontinuity in vertical lateral force resisting Element*

As per the Indian Standards (IS 1893-Part-1-2016) earth quake code the definition of In-Plane Discontinuity in vertical elements resting lateral elements Irregularity:

"In-plane discontinuity in vertical lateral force-resting elements shall be considered to exit, when in plane off set of the lateral force resting elements in greater than 20 percent of the plan length of those elements".

The internal force of vertical-force-resisting components (columns, seismic walls, and seismic bracing) is transmitted downward via horizontal transmission components (beam and truss)

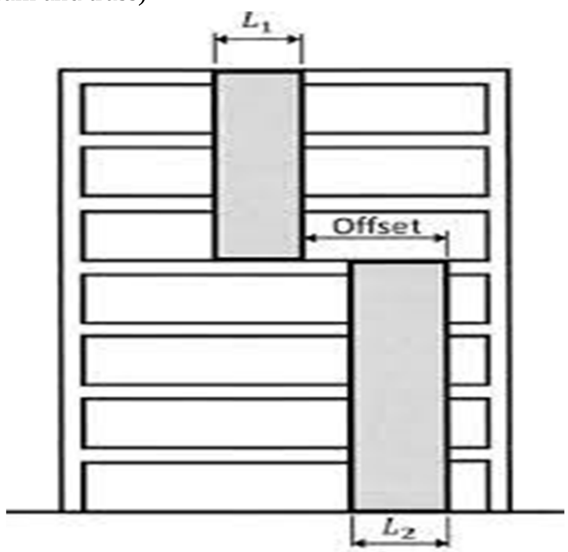



**Fig. 1.9** In plane Discontinuity Irregularity

*5) Discontinuity in Capacity (weak storey)*

A weak storey is one whose lateral strength is less than 80% that of the level above. The strength of any seismic force-resisting element that shares the storey shear in the given direction makes up the storey lateral strength. The storey lateral strength is the sum of the strengths of all seismic force resting elements that share the lateral storey shear in the considered direction.

These are classified in to two types

*a) Discontinuity in Lateral Strength-Weak Storey Irregularity*

It exists when the lateral strength of the storey is less than 80% of the strength of the storey above. The storey lateral strength is the sum of the lateral strengths of all seismic-resisting elements that share the storey shear for the considered direction.

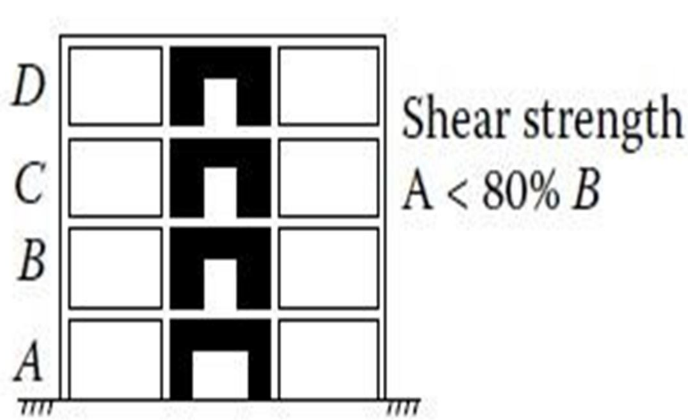



Fig.1.10 Discontinuity in Lateral Strength weak storey Irregularity

*b) Discontinuity in Lateral Strength-Extreme Weak Storey Irregularity*

Is defined to exist where "the storey lateral strength less than 65% of that in the storey above.

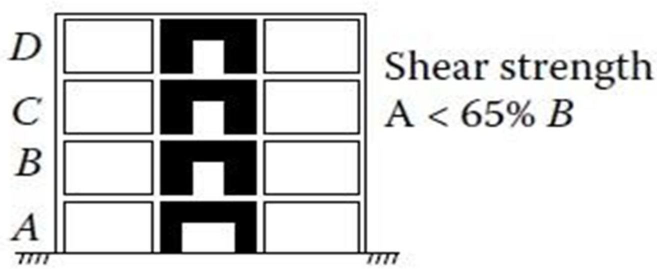



Fig. 1.11 Discontinuity in Lateral Strength Extreme weak storey Irregularity

*D. Objectives Of The Study*

Understanding the effect of stiffness irregularities on the wind performance of RC framed buildings is essential for ensuring safety and stability. When abrupt changes in stiffness occur due to weak storeys, or sudden reductions in lateral resistance, the distribution of wind forces across the height of the building becomes highly non-uniform. This leads to concentration of stresses and localized deformations, significantly altering the dynamic response compared to regular frames. In particular, stiffness irregularities intensify inter-storey drift, attract higher shear demands at critical levels, and increase the possibility of soft-storey failures.

Therefore, the present study is focused on evaluating and comparing the windperformance of regular and stiffness-irregular buildings under various windzones of India, considering critical response parameters such as lateral displacement, storey drift, and base shear.

The following are the objectives of the study:

1) To model and analyze stiffness irregular RC framed buildings with varying stiffness configurations using ETABS software.
2) To evaluate windresponse parameters such as base shear, story displacement, story drift, and fundamental time period.
3) To compare the wind performance of stiffness irregular buildings with that of regular (uniform stiffness) buildings under similar loading conditions.

*E. Scope Of The Study*

1) The study is limited to G + 5 Storied RC framed buildings as per IS 1893 (Part 1): 2016 provisions.
2) Both regular and stiffness irregular building models will be considered for comparative analysis.
3) The wind performance will be evaluated under linear static analysis using ETABS.
4) The study will focus on soft-story and partially infilled configurations to represent common real-world stiffness irregularities.

*F. Organization Of Dissertation*

The dissertation is organized into five chapters as outlined below:

1) Chapter 1: Provides an introduction to the study, highlighting different types of structural irregularities along with the objectives and scope of the present work.
2) Chapter 2: Reviews the relevant literature, summarizing the work of various researchers on the dynamic response of buildings.
3) Chapter 3: Explains the methodology adopted for the study, including modelling details, analysis procedures, and codal provisions followed.
4) Chapter 4: Presents the results of the analysis and discusses thewindresponse of the considered building models, with comparisons across different cases.
5) Chapter 5: Summarizes the key findings of the study and provides the conclusions drawn, along with possible recommendations for future research.

## II. LITERATURE REVIEW

*A. Overview*

The present chapter reviews the available literature related to the performance of both regular and irregular structures. It summarizes the major findings of earlier works, identifies gaps in existing research, and establishes the rationale for focusing on the present study, which primarily deals with vertical setback buildings and other forms of irregularities.

*B. Previous Studies*

Neha P. Modakwar et al. [1] studied the seismic behaviour of reinforced concrete buildings with both plan and vertical irregularities, focusing particularly on re-entrant corners and mass irregularity. The authors highlighted that such irregularities, though unavoidable in modern construction, play a critical role in amplifying seismic response. Using STAAD-Pro, they analysed G+4 and G+14 storey L-shaped and cross-shaped buildings with 5m × 5m frames to evaluate the torsional effects and additional shear forces induced by irregular configurations. Their findings revealed that re-entrant corner columns are especially vulnerable, experiencing significant variation in shear forces and moments, particularly in directions perpendicular to the earthquake loading. Moreover, torsional effects were found to be more pronounced when diaphragms were removed, necessitating the strengthening of re-entrant columns at lower and top floor levels. While torsional behaviour remained consistent across seismic zones, variations in axial forces and moments were evident at higher floors. The study concluded that diaphragm irregularities should be avoided and that proper stiffening of re-entrant corner columns is essential to enhance the seismic resilience of irregular buildings

Hemant B. Khamkar, Ganesh V. Tapkire, and S. M. Dumne[2] investigated the effects of structural irregularities on the seismic response of multi-storey reinforced concrete buildings, with emphasis on both plan and vertical irregularities. The study categorized irregularities into five types: plan, vertical, stiffness, mass, and combined irregularities, and analyzed their contribution to structural vulnerability. Using modelling and seismic analysis approaches, the authors evaluated key response parameters such as storey drift, lateral displacement, base shear, and torsional irregularity. Their findings indicated that plan irregularities like re-entrant corners and unsymmetrical shapes amplified torsional effects, while vertical irregularities such as soft storey and mass irregularity increased lateral displacements and storey drifts. Buildings with combined irregularities were identified as the most critical, exhibiting maximum instability under earthquake loading. The authors concluded that irregularities significantly amplify seismic demands compared to regular structures, thereby reducing safety margins. They emphasized the importance of designing irregular buildings with enhanced ductility, strict adherence to codal provisions, and appropriate strengthening measures to mitigate seismic risks

M. T. Raagavi and S. Sidhardhan [3] conducted a detailed study on the seismic performance of various irregular structures, emphasizing the impact of plan, vertical, mass, stiffness, and combined irregularities on structural safety. The paper reviewed different modelling and analysis approaches, including response spectrum analysis (RSA) and time history analysis (THA), and examined critical response parameters such as displacement, base shear, storey drift, and stiffness. The study highlighted that torsional coupling caused by eccentricity between the centre of mass and centre of stiffness significantly amplifies seismic forces, leading to potential structural damage. It was observed that structures with setbacks, soft storeys, or re-entrant corners are particularly vulnerable during seismic events due to stress concentration and uneven force distribution. Additionally, buildings with heavy mass at the top exhibited maximum displacements, while plan irregularity consistently led to higher storey drift compared to regular buildings. The authors concluded that irregularities induce damaging effects by altering stiffness and ductility demands, making such buildings more prone to failure under seismic loading. They stressed that time history analysis is more precise and reliable than RSA for seismic design, and recommended that irregular configurations should be carefully treated with enhanced ductility and code-based provisions to mitigate risks

Aditya Tambare et al. [4] studied the seismic analysis of plan irregular structures using ETABS software, focusing on the effect of different unsymmetrical plan configurations on building performance under earthquake loading. The research involved the analysis of G+5 and G+10 RC framed structures with irregular plans such as L-shape, C-shape, and T-shape, and compared them with a regular configuration using linear static analysis, response spectrum method, and time history method. The findings revealed that plan irregular structures exhibited greater lateral displacements and base shear compared to regular structures, due to torsional rotation induced by the eccentricity between the centre of mass and centre of rigidity. Among the irregular shapes, the L-shaped models recorded the highest displacements, whereas the T-shaped models showed relatively lower displacements despite higher irregularity. The study concluded that plan irregularities significantly amplify seismic demands and, therefore, each irregular configuration must be studied separately rather than adopting generalized assumptions. The authors emphasized the need for careful modelling, code-based provisions, and ductility considerations to ensure safety in irregular buildings.

Sanjay Sabu and SreerenchRaghavu [5] analyzed the seismic performance of irregular reinforced concrete structures using ETABS software, with a particular focus on the effects of vertical irregularities and sloping ground conditions. The study emphasized that irregularities in mass, stiffness, and geometry significantly influence dynamic response, often leading to early failures during earthquakes. A G+15 multi-storey RC frame structure was modelled for both flat and sloping ground conditions, and evaluated using response spectrum analysis as per IS 1893 provisions. Parameters such as storey displacement, storey drift, base shear, storey stiffness, and overturning moment were compared. Results revealed that structures on sloping ground experienced higher storey shear and reduced stiffness, though with slightly lower displacements than flat-ground models. Soft storey and weak storey effects were particularly critical in vertical irregular configurations. The authors concluded that irregular structures demand special design considerations, as conventional methods may underestimate dynamic forces. They recommended that ductility-based design approaches and appropriate strengthening measures are essential to ensure safety in seismically active regions

Shantnoo S. Girme and Atul B. Pujari [6] presented a review on the progressive collapse analysis (PCA) of reinforced concrete flat slab structures considering the effects of geometrical irregularities in both horizontal and vertical directions. The study highlighted that flat slab buildings are more prone to progressive collapse due to the absence of beams, which otherwise help redistribute loads after column failure. Using guidelines from the GSA (2016) and DoD (2009), the review examined various analytical methods such as linear static analysis and dynamic PCA under scenarios of column removal at different locations. Key response parameters included demand-capacity ratio (DCR), chord rotation, and vertical joint displacement. The review showed that irregular flat slab buildings exhibited higher vulnerability to progressive collapse, especially under corner column removal, compared to regular structures. The incorporation of perimeter beams and strengthening of critical columns was found to significantly enhance progressive collapse resistance by providing alternate load paths. Additionally, the study emphasized that the severity of collapse depends on the type, location, and degree of irregularity, with combined vertical and stiffness irregularities showing the most critical effects. The authors concluded that incorporating redundancy, ductility, and continuity in design can help irregular flat slab buildings develop alternative load paths and prevent catastrophic collapse under extreme loading

Gangotri Kinagi and Lokesh J. K. [7] presented a study on the seismic performance of reinforced concrete buildings with structural irregularities using ETABS V19. The authors emphasized that irregularities in plan, elevation, stiffness, and mass distribution are among the major causes of structural damage and collapse during earthquakes. A G+6 storey RC building (CV Raman Block, NMAM Institute of Technology, Nitte) was modelled with different irregular configurations, and the seismic response was evaluated through time history analysis and pushover analysis. The results revealed that irregular structures exhibit higher displacements, storey drifts, and torsional responses compared to regular buildings. Soft storey and mass irregularities were found to be the most critical, often leading to instability at lower levels. Time history analysis confirmed that nonlinear dynamic analysis provides the most realistic predictions of seismic performance, highlighting the need for proper strengthening and code-based provisions in irregular structures. The study concluded that avoiding diaphragm discontinuities, ensuring balanced stiffness and mass distribution, and adopting ductility-based design approaches are essential for improving the seismic resilience of irregular structures.

Abhijeet Dhalwar and S. P. Tak [8] carried out a seismic analysis of vertical irregular steel structures with different seismic resilience techniques to evaluate their effectiveness in mitigating earthquake-induced responses. A G+15 setback steel building was modelled using SAP2000 v23, and nonlinear time history analysis was performed considering Zone V earthquake data (Bhuj earthquake). Four models were compared: (i) a basic irregular structure without resilience, (ii) a structure with fluid viscous dampers, (iii) a structure with inverted V-bracing, and (iv) a structure with elastomer bearing base isolation. The results showed that the basic irregular model experienced the highest base shear, displacements, and storey drifts. Among the resilience techniques, base isolation proved to be the most effective, significantly reducing base shear, lateral displacements, and storey drifts, while fluid viscous dampers enhanced ductility by effectively dissipating seismic energy. In contrast, inverted V-bracing reduced base shear but led to higher bending moments and storey drifts. The study concluded that base isolation systems provide the highest seismic efficiency for vertical irregular steel structures located in high seismic zones, while damping and bracing systems can serve as supplementary strengthening strategies.

Aleena Sam and Mathews M. Paul [9] presented a review on the performance evaluation of irregular structures under seismic response considering soil-structure interaction (SSI). The study highlighted that past earthquakes, including the 2015 Nepal, 2017 Mexico City, and 2023 Turkey–Syria events, demonstrated the extreme vulnerabilities of asymmetrical and irregular buildings, especially when constructed on soft or loose soils. The authors emphasized that while seismic codes such as IS 1893 (Part 1):2002 allow irregularities with specific penalties; they often neglect the role of SSI, which can significantly influence seismic response. The review categorized irregularities into plan, vertical, stiffness, mass, torsional, and combined irregularities, noting that most structures in reality exhibit multiple irregularities simultaneously. Case studies and numerical models showed that torsional effects, soft storeys, re-entrant corners, setbacks, and floating columns amplify seismic demands, often resulting in greater storey drift, lateral displacements, and torsional moments compared to regular buildings. Importantly, the paper stressed that SSI often worsens seismic performance, contrary to earlier assumptions of beneficial damping effects, especially in soft soil conditions where bearing capacity failure, liquefaction, and pounding between adjacent buildings are more pronounced. The authors concluded that future seismic design must integrate SSI explicitly, with performance-based design guidelines, refined numerical models, and combined geotechnical–structural approaches to capture realistic seismic demands in irregular buildings.

Dasa Bhagirath and Odedra Chirag [10] investigated the seismic performance of irregular steel buildings using response spectrum analysis in ETABS, following IS 1893:2016 and IS 875:2015 provisions. Four different structural configurations—square, L-shape, T-shape, and C-shape—were modelled for an 18-storey steel building with varying bay distributions. The study considered multiple load combinations (dead, live, wind, and seismic) and evaluated design forces in beams and columns, maximum storey displacement, and storey drift. Comparative analysis revealed that the square-shaped building showed superior performance in resisting beam and column forces, while C-shape and T-shape structures performed better under response spectrum analysis, particularly in terms of storey displacement and drift. The L-shape model exhibited average performance across most parameters, highlighting the influence of plan irregularities on structural response. The authors concluded that square configurations are structurally efficient under static forces but less favorable under dynamic seismic excitations, while irregular shapes demand special attention in design to ensure seismic resilience.

Abhijeet Patil and Rushikesh Sutar [11] carried out a seismic analysis of multi-storey irregular RCC buildings incorporating steel cross-bracing systems to enhance lateral resistance against seismic and wind forces. Using ETABS 20 and linear static seismic analysis, the study focused on G+11 storey structures with plan irregularities (L-shaped, T-shaped, and C-shaped configurations) under seismic Zone V conditions. The analysis compared the response of braced and unbraced structures in terms of base shear, axial forces, bending moments, storey drifts, and lateral displacements. The findings revealed that T-shaped buildings exhibited the maximum displacement, followed by L-shaped, while C-shaped buildings showed the least displacement. The introduction of cross-bracing significantly improved structural performance, reducing lateral displacements by 38% in L-shaped, 45% in T-shaped, and 30% in C-shaped buildings. The study further highlighted that bracing not only minimized displacements but also optimized column forces and bending moments, thereby improving overall seismic resilience. The authors concluded that steel bracing is a cost-effective and efficient method for strengthening irregular RCC buildings, with T-shaped structures benefiting most from bracing interventions

Anuradha R. Babar and S. N. Patil [12] presented a comprehensive review on the seismic performance of multi-storied irregular steel buildings, focusing particularly on the role of base isolation and damping systems as mitigation strategies. The authors examined various structural irregularities—including plan, vertical, mass, stiffness, and torsional irregularities—and discussed their impact on stress distribution, dynamic response, and overall structural vulnerability under earthquake loading. Through the analysis of experimental studies, nonlinear time history analysis, finite element simulations, and real-world case studies, the review highlighted that irregular buildings suffer from amplified vibrations, torsional effects, and stress concentrations compared to regular configurations. Base isolation systems, such as lead rubber bearings (LRB), high damping rubber bearings (HDRB), and friction pendulum systems (FPS), were found to significantly reduce seismic forces transmitted to the superstructure by decoupling it from ground motion. Similarly, damping devices—including viscous dampers, friction dampers, tuned mass dampers (TMDs), and viscoelastic dampers—effectively dissipated seismic energy and minimized inter-story drifts. The authors also noted the potential of AI-based adaptive control systems and hybrid seismic mitigation strategies that combine isolation and damping mechanisms for enhanced resilience. Despite these advancements, the review stressed challenges such as high implementation costs, maintenance requirements, and gaps in design codes for irregular steel buildings. The study concluded that interdisciplinary research, integration of emerging materials, and adaptive real-time control systems are essential for achieving safer and more sustainable seismic performance in irregular steel structures.

Sanskriti Nagar and Mahroof Ahmed [13] investigated the seismic performance of reinforced concrete buildings with vertical irregularities, such as stiffness irregularities (soft storey), vertical geometric irregularities (setbacks), mass irregularities, and combined irregularities. Using SAP2000, a total of 19 structural models—both with and without infill walls—were analyzed under seismic loading as per IS 1893 (Part 1):2002 and IS 456:2000. The study employed linear static analysis, nonlinear pushover analysis, and response spectrum analysis to evaluate the structural response. The results indicated that vertical irregularities significantly affect structural integrity, with soft storey and setback conditions being the most detrimental, leading to higher displacements, reduced ductility, and premature hinge formations. In contrast, the presence of infill walls enhanced overall performance by increasing stiffness, reducing displacements by 25–40%, and delaying hinge formation, thereby improving collapse resistance. However, non-uniform distribution of infill walls could itself introduce irregularities. The authors concluded that buildings with combined irregularities performed the worst under seismic loading, while regular structures demonstrated better resistance. The study strongly emphasized the need for special seismic provisions in design codes for irregular buildings.

### *C. Need For The Present Study*

Studies consistently show that stiffness irregularities, such as soft storey or weak storey effects, amplify demands by increasing lateral displacement, storey drift, and torsional response. Since these irregularities are common in high-rise and open ground storey buildings, there is a strong need to analyse their behaviour in detail. Therefore, the present study emphasizes the impact of stiffness irregularities on structural performance, focusing on response parameters like base shear, drift, and displacements to support safer design strategies against wind loads.

## III. METHODOLOGY

The methodology adopted in this study is designed to evaluate the wind performance of reinforced concrete (RC) framed buildings with and without stiffnessirregularities. To capture these effects, a comparative analysis is carried out between a regular RC framed building and a setback frame.

Wind response of the structure is evaluated using the guidelines of IS 875:2015 (Part 3). ETABS software is employed to model and simulate the structural response under varying wind intensities corresponding to different Indian wind zones.

The wind performance of the frames is quantified through critical response parameters—lateral displacement, storey drift, and base shear—which collectively indicate the vulnerability of buildings to wind actions. By adopting this methodology, the study provides a systematic framework to assess how stiffness irregularities influence the behaviour and overall wind safety of RC framed structures.

### *A. Flow Chart*

The overall methodology adopted in this study is summarized in the flow chart shown in Figure 3.1. The process begins with the modelling of a reinforced concrete (RC) space frame, which is considered in two configurations: a regular RC framed building (RF) and a stiffness irregular RC framed building (SIF). Both building types are subjected to wind analysis under different wind zonesas per IS 875 (Part 3):2015.

The structural responses, including lateral displacement, storey drift, and base shear, are then evaluated and compared between the regular and stiffness irregular frames. This stepwise approach ensures a systematic assessment of how stiffness irregularities influence the performance of RC framed buildings under varying wind intensities.

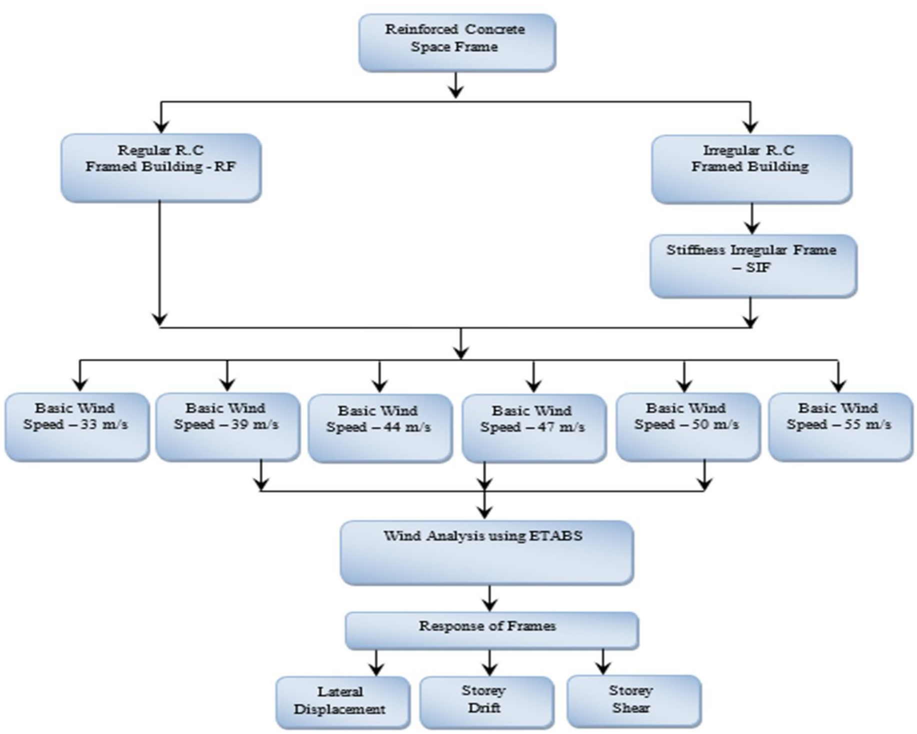


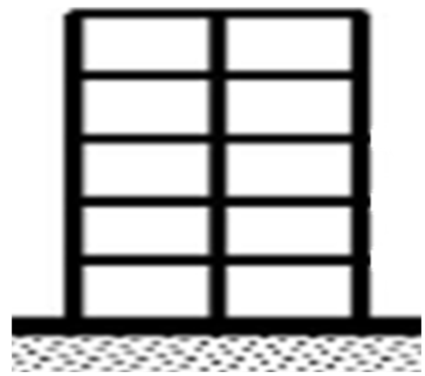
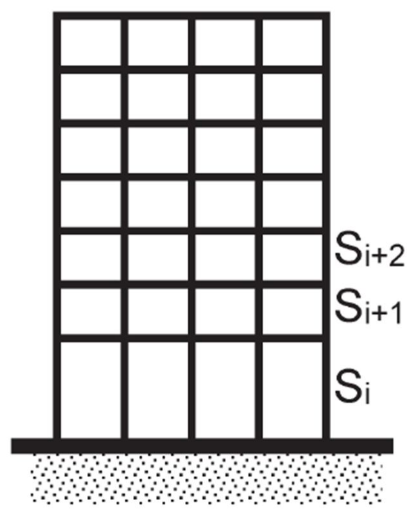

Fig. 3.1 Methodology Flow Chart

*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 13 Issue XI Nov 2025- Available at www.ijraset.com*

### *B. Case Studies*

Table 3.1 summarizes the different case studies considered in this work for wind analysis. Two categories of reinforced concrete space frames are analysed: a Regular Frame (RF) and a Stiffness Irregular Frame (SIF). Each frame type is evaluated under different wind intensitiesas per IS 875 (Part 3):2015.

Table 3.1 Details ofCase Studies

| Case No. | Frame Designation | Description of frame | Geometry of Frame |
|---|---|---|---|
| 1 | RF –33 m/s | Regular Space Frame – Basic Wind Speed – 33 m/s |  |
| 2 | RF –39 m/s | Regular Space Frame – Basic Wind Speed – 39 m/s | |
| 3 | RF –44 m/s | Regular Space Frame – Basic Wind Speed – 44 m/s | |
| 4 | RF –47 m/s | Regular Space Frame – Basic Wind Speed – 47 m/s | |
| 5 | RF –50 m/s | Regular Space Frame – Basic Wind Speed – 50 m/s | |
| 6 | RF –55 m/s | Regular Space Frame – Basic Wind Speed – 55 m/s | |
| 7 | SIF–33 m/s | Stiffness Irregular Frame – Basic Wind Speed – 33 m/s |   |
| 8 | SIF –39 m/s | Stiffness Irregular Frame – Basic Wind Speed – 39 m/s | |
| 9 | SIF –44 m/s | Stiffness Irregular Frame – Basic Wind Speed – 44 m/s | |
| 10 | SIF –47 m/s | Stiffness Irregular Frame – Basic Wind Speed – 47 m/s | |
| 11 | SIF –50 m/s | Stiffness Irregular Frame – Basic Wind Speed – 50 m/s | |
| 12 | SIF –55 m/s | Stiffness Irregular Frame – Basic Wind Speed – 55 m/s | |

### *C. Geometric Details of Models*

The geometric details of the considered building model are presented in Table 3.2, while Figure 3.2 and 3.3 illustrates the plan, elevation, and isometric views of the selected case studies adopted for the present work. Furthermore, the cross-sectional properties of various structural components, including beams, columns, and slabs, are provided in Table 3.3. Together, these details establish the fundamental modelling parameters required for the wind analysis.

Table 3.2 Geometric Details

| S.No. | Parameter | Dimensions |
|---|---|---|
| 1. | Typical Bay Dimensions | 5 m× 5 m |
| 2. | Storey Height | 4.4m – Stilt Floor<br>3.6m – Ground & 1$^{st}$ Floor 3.0m – 2$^{nd}$,3$^{rd}$& 4$^{th}$ Floor |
| 3. | Super Structure Height | 20.6 m |
| 4. | Depth of Foundation | 1.8 m |
| 5. | No. of Stories | 6 No's |

Table 3.3 Section Properties

| Structural Component | Dimensions |
|---|---|
| Slab | 150 mm |
| Beams | 300 mm × 450 mm |
| Columns | 375 mm × 375 mm |

*D. Material Properties*

The material properties adopted for modelling the reinforced concrete building are listed in Table 3.4. The table specifies the grade, characteristic strength, and Young's modulus of the materials considered, namely M30 concrete and Fe550 reinforcing steel, in accordance with IS codes. These values form the essential input parameters for the wind analysis and ensure realistic representation of structural behaviour.

Table 3.4 Material Properties

| Material | Grade of Material | Characteristic Strength (MPa) | Young's Modulus (MPa) |
|---|---|---|---|
| Concrete | M30 | 30 | 27386.13 |
| Steel-Rebar | Fe550 | 550 | $2 \times 10^5$ |

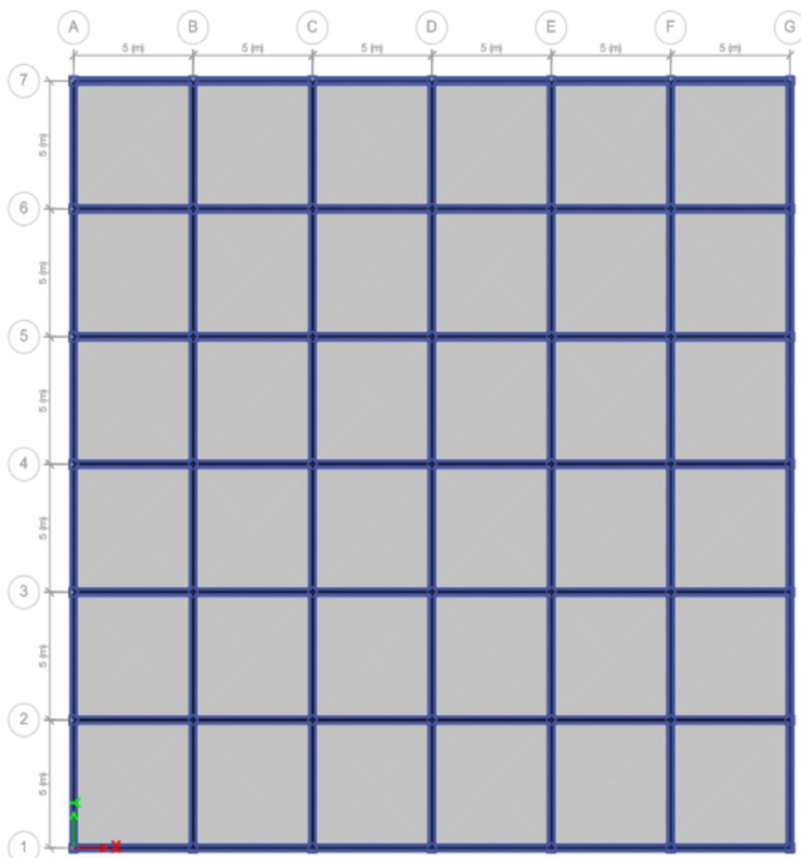



Fig. 3.2 (a) Plan of RF

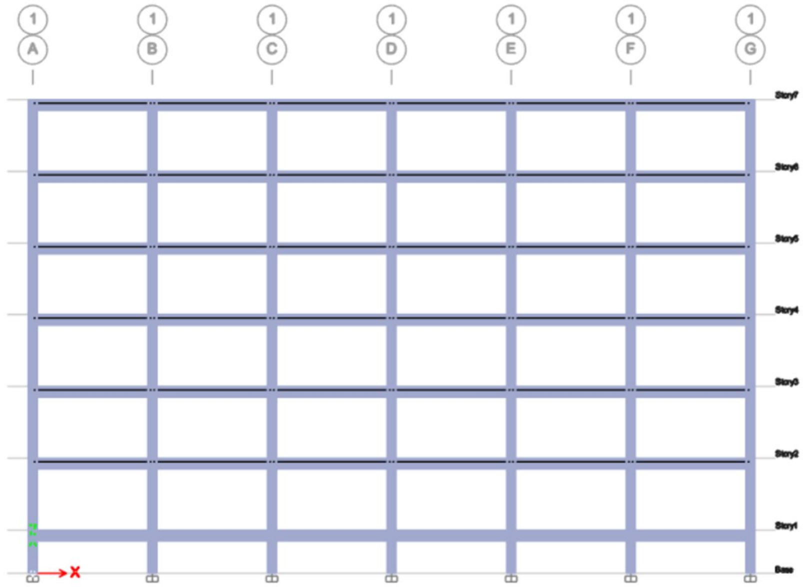



Fig. 3.2 (b) Elevation of RF

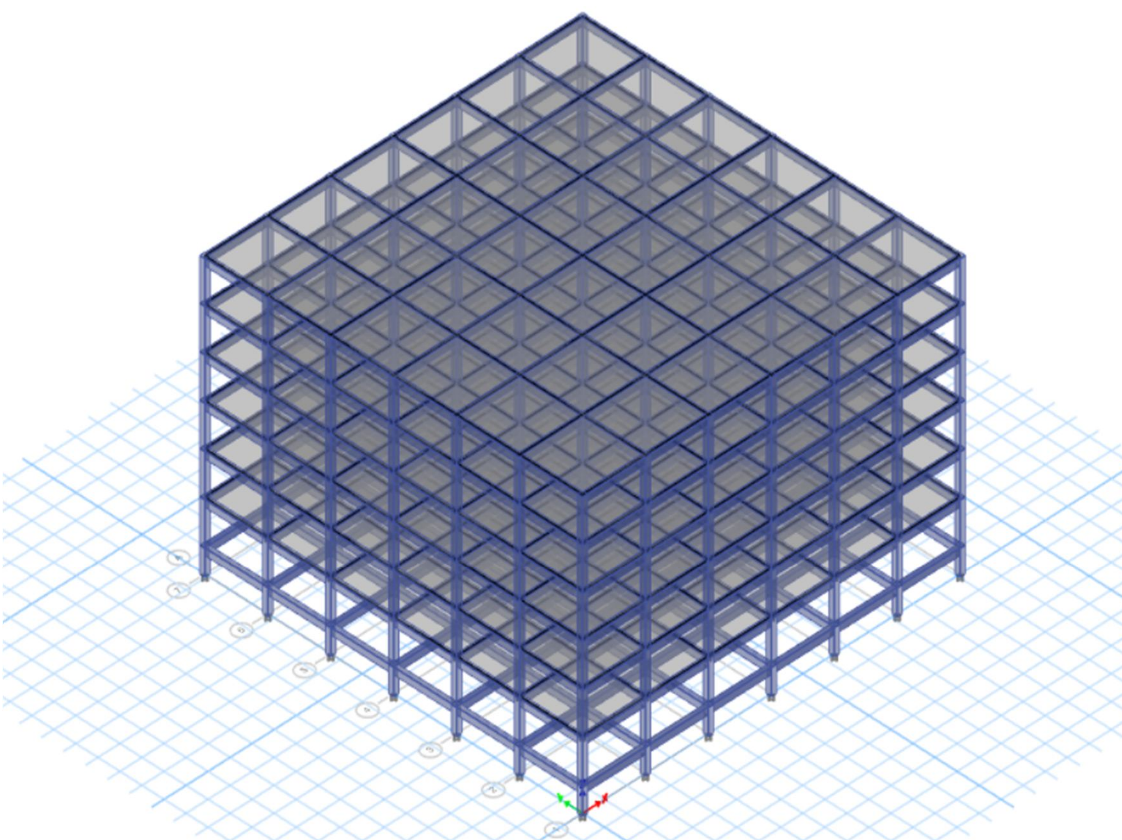


Fig. 3.2 (c) Isometric View of RF

Fig. 3.2 Geometric Views of Regular Frame - RF

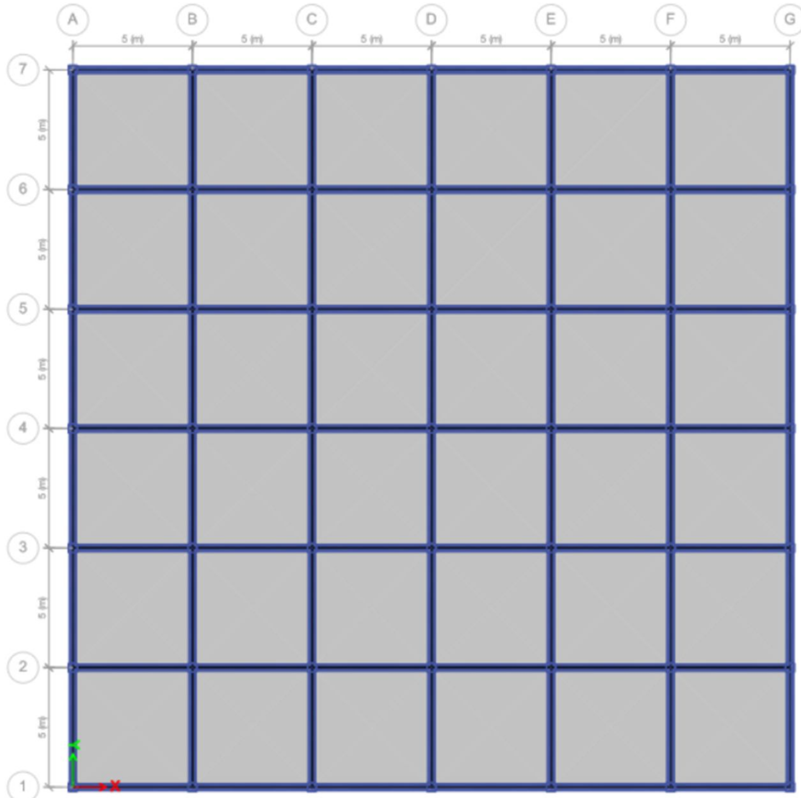



Fig. 3.3 (a) Plan of SIF

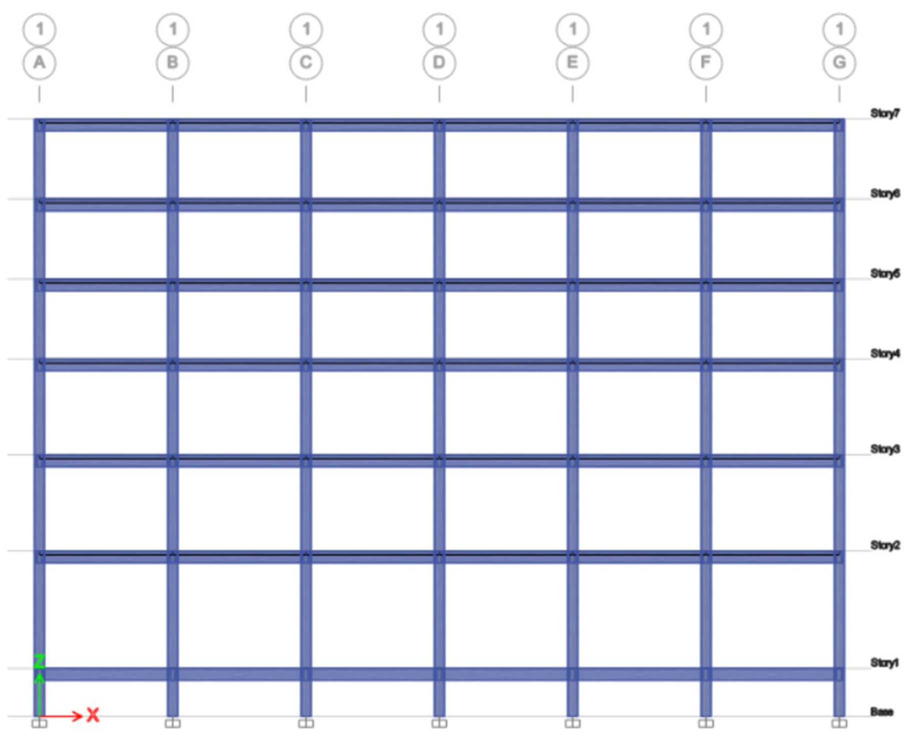



Fig. 3.3 (b) Elevation of SIF

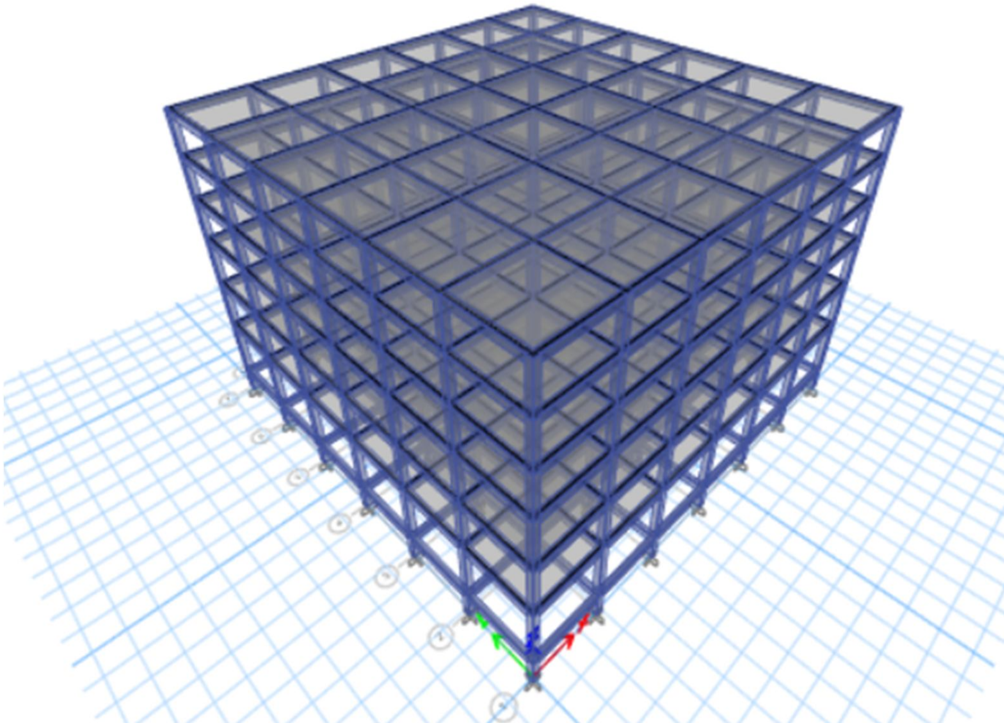


Fig. 3.3 (c) Isometric View of SIF

Fig. 3.3Geometric Views of Stiffness Irregular Frame - SIF

*E. Load Case Details*

*1) Dead and Live Loads*

In structural analysis and design, dead loads represent the permanent, immovable weights such as walls, slabs, and finishes, while live loads account for variable or transient actions like occupancy, furniture, and environmental usage. Both categories of loads are crucial in evaluating the wind performance of buildings, as they directly influence mass distribution and dynamic response.

In the present study, the intensity of dead and live loads is considered as per the provisions of IS 875 (Part 1 & Part 2), ensuring compliance with Indian codal standards. Table 3.5 summarizes the adopted values of wall load, parapet wall load, superimposed dead load on slabs, and live load, which serve as essential inputs for the wind analysis of the building models.

Table 3.5 Intensity of Dead and Live Loads

| S.No. | Type of Load | Intensity of Load |
|---|---|---|
| 1. | Wall Load | 12 kN/m |
| 2. | Parapet Wall Load | 3 kN/m |
| 3. | Super Imposed Dead Load on Slab | 2 kN/$m^2$ |
| 4. | Live Load | 4 kN/$m^2$ |

*2) Wind Loads*

Wind loads are a key input in lateral load analysis, as they represent the forces exerted on a structure due to wind pressure. In this study, wind forces are evaluated in accordance with the provisions of IS 875 (Part 3): 2015. The analysis is carried out for different wind zones of India, considering appropriate basic wind speeds and terrain conditions. The selected parameters include basic wind speed (Vb), risk coefficient (k1), terrain and height factor (k2), topography factor (k3), and pressure coefficient (Cp). These inputs are critical for accurately defining the wind demand on the structure. The adopted values are summarized in Table 3.6.

Table 3.6 Wind Load Parameters

| S.No. | Parameter | Value | Reference (IS 875 (Part 3):2015) |
|---|---|---|---|
| 1. | Basic Wind Speed | 33, 39, 44, 47, 50 and 55 m/sec | Figure 1 |
| 2. | Risk Coefficient – k1 | 1 (50 years Life Period) | Table 1 |
| 3. | Terrain Factor – k2 | 1 (Terrain – 2) | Table 2 |
| 4. | Topography Fator – k3 | 1 (Plain) | Clause 6.3.3.1 |
| 5. | Importance factor – k4 | 1 (Cyclonic Region) | Clause 6.3.4 |
| 6. | Cp | 1.2 | Figure 4 |

### *F. Wind Analysis*

In the present study, the wind behaviour of the building models is evaluated through static wind load analysis as per the provisions of IS 875 (Part 3): 2015. This method determines the lateral forces on the structure based on design wind pressures derived from basic wind speeds, exposure conditions, and building geometry. Unlike dynamic seismic methods, wind analysis typically considers steady-state wind pressures and suction effects acting on different faces of the building, making it a reliable approach for serviceability and strength assessment under wind loading.

The analysis is performed using ETABS, which is well-suited for modelling, analysing, and designing multi-storey RC frame structures. ETABS allows for automated calculation and application of wind loads as per codal provisions, accounting for terrain categories, building height, and pressure coefficients. This enables realistic estimation of critical wind response parameters such as lateral displacement, storey drift, and base shear, thereby facilitating a comparative assessment between regular frames (RF) and stiffness irregular frames (SIF).

## IV. RESULTS AND DISCUSSION

In this chapter, the wind performance of a six-storey reinforced concrete (RC) Stiffness Irregular Frame (SIF) is evaluated and compared with that of a Regular Frame (RF). The stiffness irregularity in the model is introduced through variation in storey heights: the stilt floor is 4.4 m, the ground and first floors are 3.6 m each, while the upper floors (2nd, 3rd, and 4th) are 3.0 m. This non-uniform storey height distribution creates vertical stiffness discontinuities, which disrupt the uniform transfer of lateral forces induced by wind. The analysis is carried out using ETABS in accordance with IS 875 (Part 3): 2015. Different wind zones across India are considered to capture the influence of increasing basic wind speeds on structural response. The critical response parameters—lateral displacement, storey drift, and base shear—are extracted and presented graphically for interpretation.

The comparative study between RF and SIF indicates that variation in storey stiffness leads to higher lateral displacements, sudden peaks in storey drift at transition floors, and an irregular distribution of shear forces along the building height. These effects become more pronounced in regions with higher design wind speeds, emphasizing the need to address stiffness irregularities in the design stage to ensure adequate wind resistance and serviceability performance.

### *A. Wind Response Of Regular Frame – RF*

The wind performance of the Regular Frame (RF) was studied under different wind zones of India, represented by basic wind speeds of 33 m/s, 39 m/s, 44 m/s, 47 m/s, 50 m/s, and 55 m/s. The response of the structure was evaluated in terms of lateral displacement, storey drift, and storey shear. The comparative results are discussed below.

1) Lateral Displacement: Figure 4.1 illustrates the variation of lateral displacement along the storey height for different wind zones. The displacement progressively increases with elevation and reaches its maximum at the roof level. At a basic wind speed of 33 m/s, the top-storey displacement is minimal, while at 55 m/s it becomes nearly 2.5 to 3 times higher. The percentage increase is approximately 30–35% from 33 m/s to 39 m/s, 40–45% from 39 m/s to 47 m/s, and 50–60% from 47 m/s to 55 m/s.
This smooth and uniform distribution indicates that the regular frame undergoes flexural deformation dominated by lateral bending without any abrupt changes along its height. Such behaviour is typical of a structurally regular system without vertical or horizontal irregularities.

2) Storey Drift:The storey drift profiles (Figure 4.2) exhibit a non-linear variation with maximum drift occurring at the mid to upper storeys. This is due to the cantilever-type behaviour of the structure under wind loading, where deformation accumulates with height. The drift magnitude increases consistently with higher basic wind speeds. Compared to the lowest zone (33 m/s), the peak drift at 55 m/s is nearly 2.5 times larger, with incremental increases of 30–45% between successive wind zones. Such increasing inter-storey drift highlights the importance of drift control measures, especially in tall structures subjected to strong wind forces, to prevent damage to non-structural components like partitions, cladding, and glazing.
3) Storey Shear: Figure 4.3 shows the storey shear distribution for all wind zones. As expected, the maximum shear is concentrated at the base, and it decreases progressively towards the upper storeys. With increasing wind speed, the base shear increases significantly—approximately 2.5 to 3 times from 33 m/s to 55 m/s. The incremental increase between successive wind zones is around 35–50%, closely following the increase in design wind pressures as per the codal provisions. The pattern confirms that the base region of the frame resists the largest portion of the wind-induced forces, necessitating adequate design of columns, shear walls, and foundation systems.
4) Overall Observations: The combined evaluation of lateral displacement, storey drift, and shear confirms the strong dependency of structural response on wind zone intensity. While lateral displacement and drift govern the serviceability and comfort criteria, storey shear governs the strength and stability requirements of the structural elements.

The percentage increases across all response parameters highlight the heightened vulnerability of frames in higher wind zones (50–55 m/s), requiring design provisions like increased lateral stiffness, and damping systems.

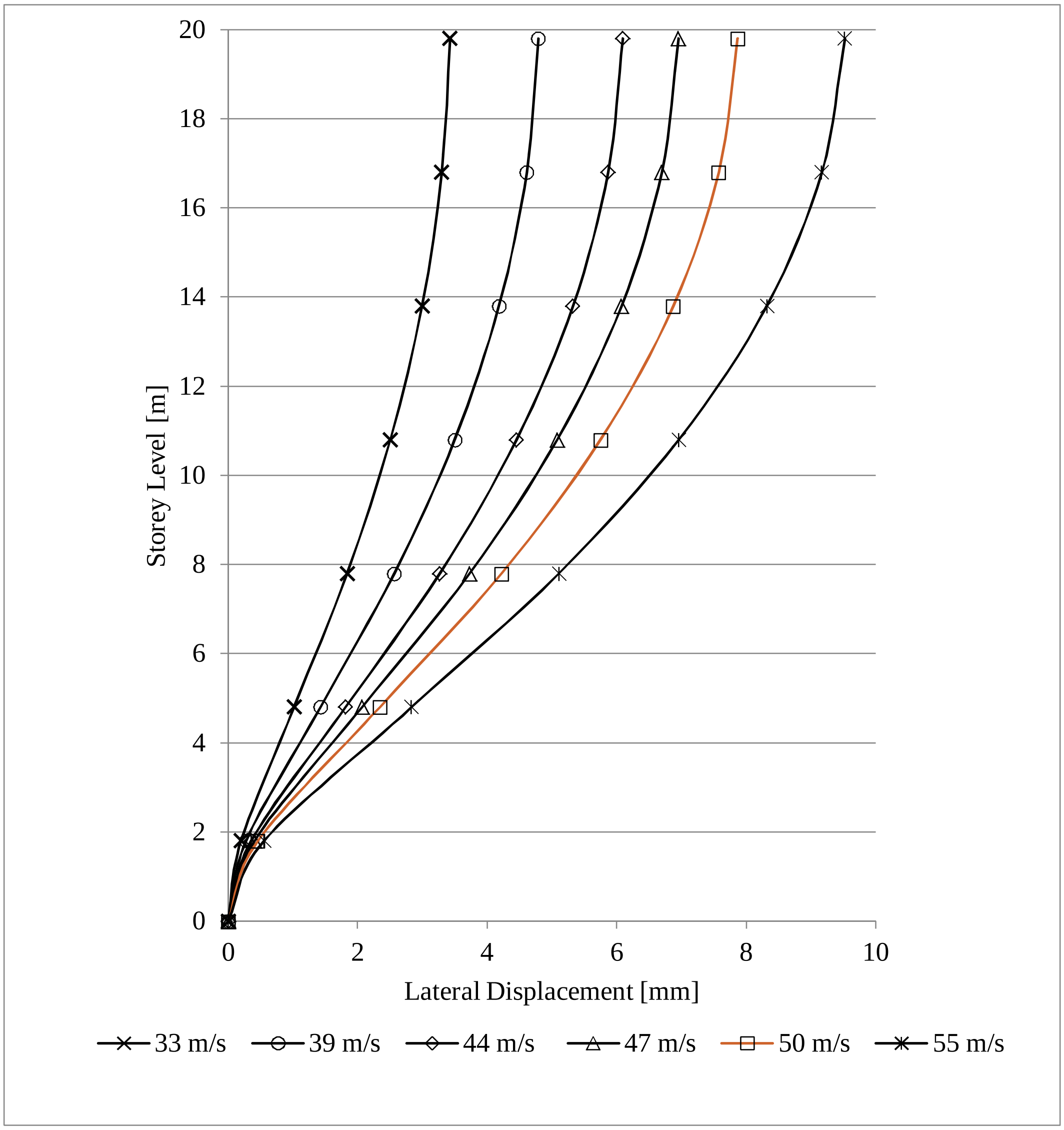



Fig. 4.1Wind Response (Lateral Displacement) of Regular Frame – RF at all Wind Zones in India

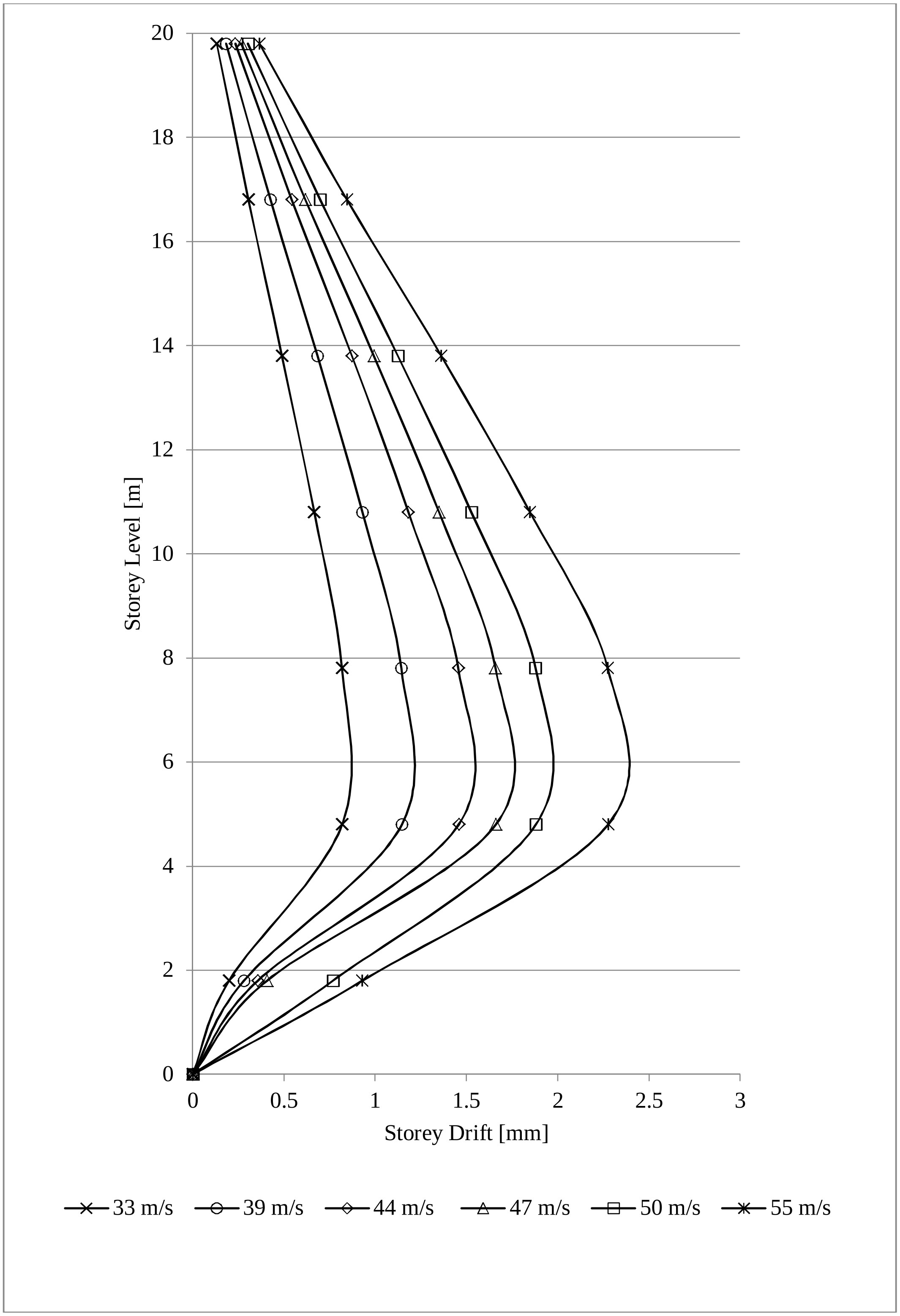



Fig. 4.2Wind Response (Storey Drift) of Regular Frame – RF at all Wind Zones in India

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 13 Issue XI Nov 2025- Available at www.ijraset.com*

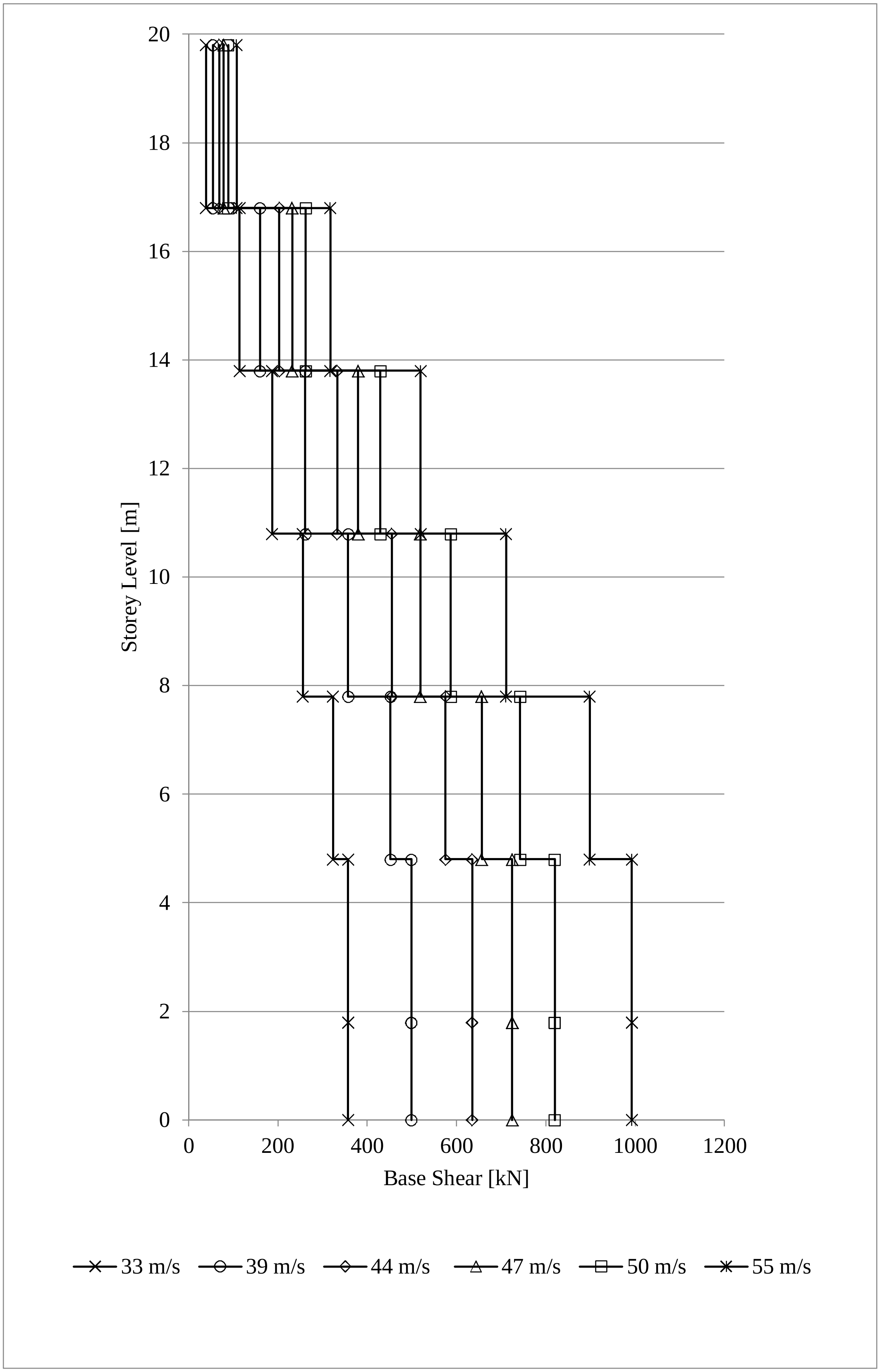



Fig. 4.3Wind Response (Storey Shear) of Regular Frame – RF at all Wind Zones in India

*B. Wind Response Of Stiffness Irregular Frame– SIF*

The wind performance of the Stiffness Irregular Frame (SIF) was evaluated for all wind zones in India to understand its behavior under varying wind intensities. The response parameters considered include lateral displacement, storey drift, and storey shear. The comparative observations are presented below.

*1)* Lateral Displacement: Figure 4.4 illustrates the variation of lateral displacement with storey height. As expected, the displacement gradually increases with height and reaches its peak at the top storey. In comparison to the lower wind zone (33 m/s), the displacement at the top storey for the highest wind zone (55 m/s) is nearly 2.5 to 3 times larger. The percentage increase is approximately 30–35% between 33 m/s and 39 m/s, 40–45% between 39 m/s and 47 m/s, and 50–60% between 47 m/s and 55 m/s. Unlike the regular frame, the displacement profile for the SIF is slightly non-uniform, with noticeable curvature changes at the levels where stiffness irregularity is introduced. This reflects concentration of lateral deformation at specific storeys, making these levels more susceptible to serviceability issues under strong winds.
*2)* Storey Drift: The storey drift distribution (Figure 4.5) exhibits a pronounced irregular pattern, with peak drift occurring at or just above the irregular storey levels. Compared to the base wind speed (33 m/s), the peak drift at 55 m/s increases by nearly 2.5 to 3 times, with incremental increases of 30–45% between successive wind zones. The drift profile is significantly less uniform than that of the regular frame, showing localized concentration of deformation near the stilt and lower storeys where the stiffness variation is introduced. This concentration of drift is critical because it can lead to higher non-structural damage, cladding failure, or serviceability problems, especially in high-wind regions.
*3)* Storey Shear: Figure 4.6 shows the distribution of storey shear along the height of the SIF. Similar to the regular frame, the maximum shear occurs at the base and decreases gradually upward. However, due to the irregularity, the shear distribution curve is not perfectly linear, showing distinct abrupt drops at the irregular levels. The base shear at 55 m/s is nearly 2.5 to 3 times greater than that at 33 m/s, with 35–50% increases between successive wind zones, reflecting the corresponding rise in wind pressure as per code.The shear force concentration at the base and irregular zones necessitates careful design of columns, transfer beams, and foundations to prevent overstressing.

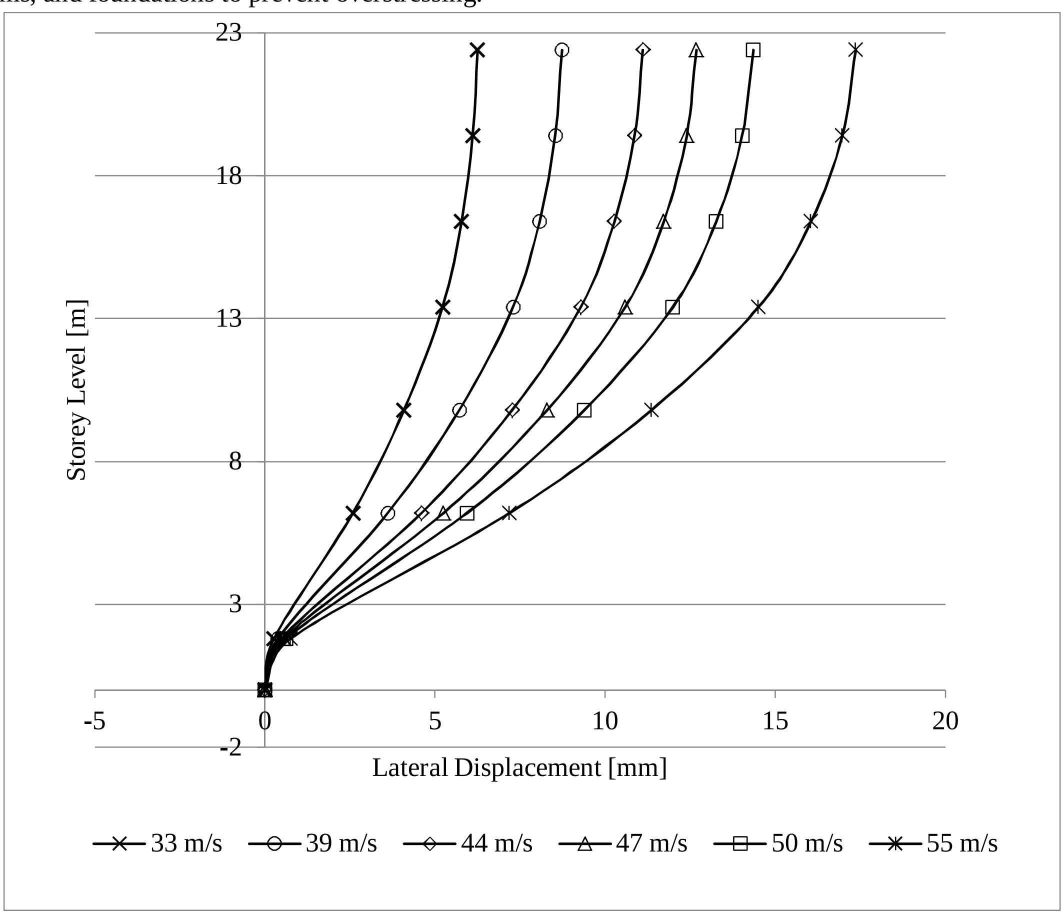



Fig. 4.4Wind Response (Lateral Displacement) of Stiffness Irregular Frame - SIF at all Wind Zones in India

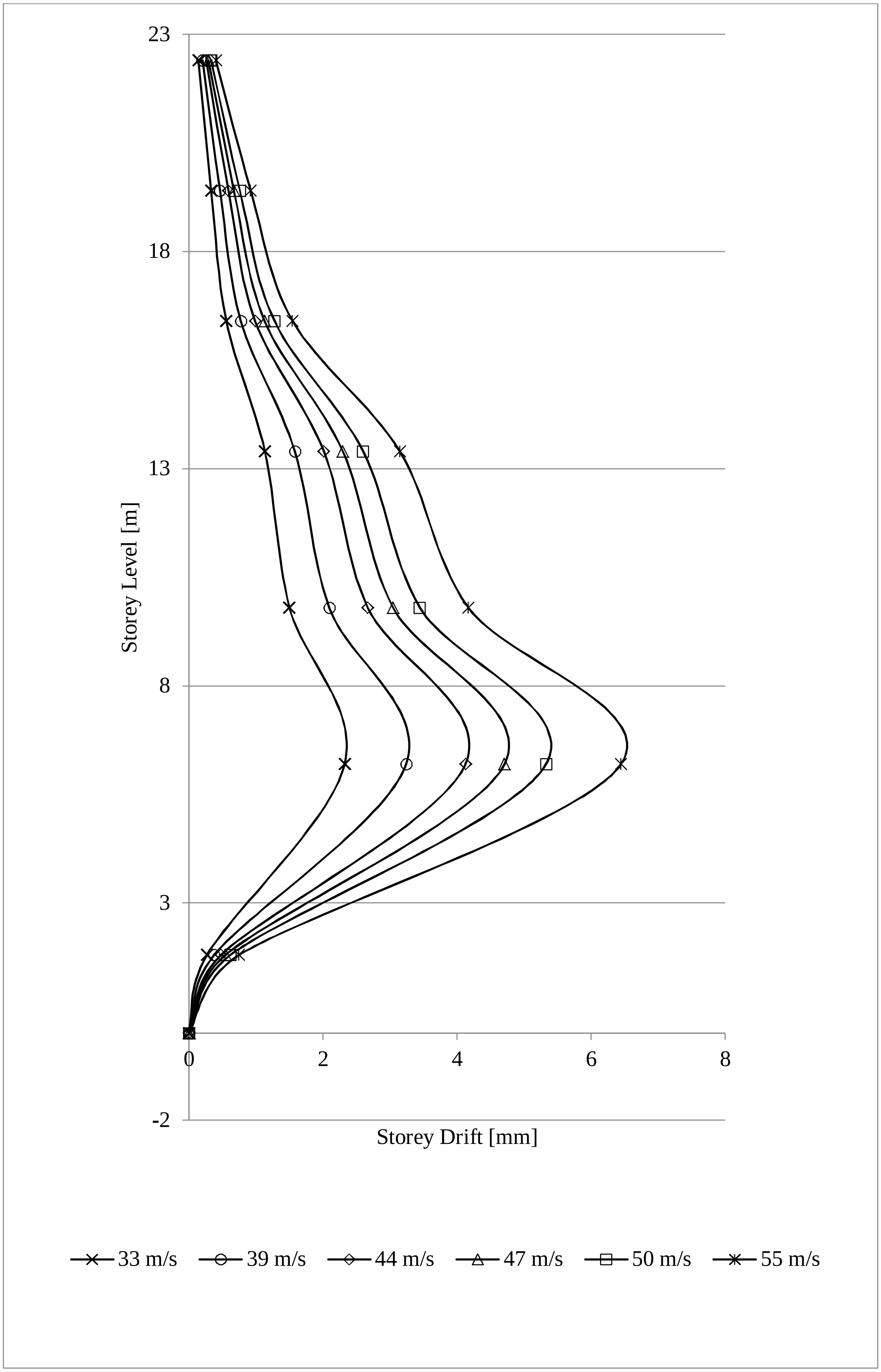



Fig. 4.5Wind Response (Storey Drift) of Stiffness Irregular Frame - SIFat all Wind Zones in India

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 13 Issue XI Nov 2025- Available at www.ijraset.com*

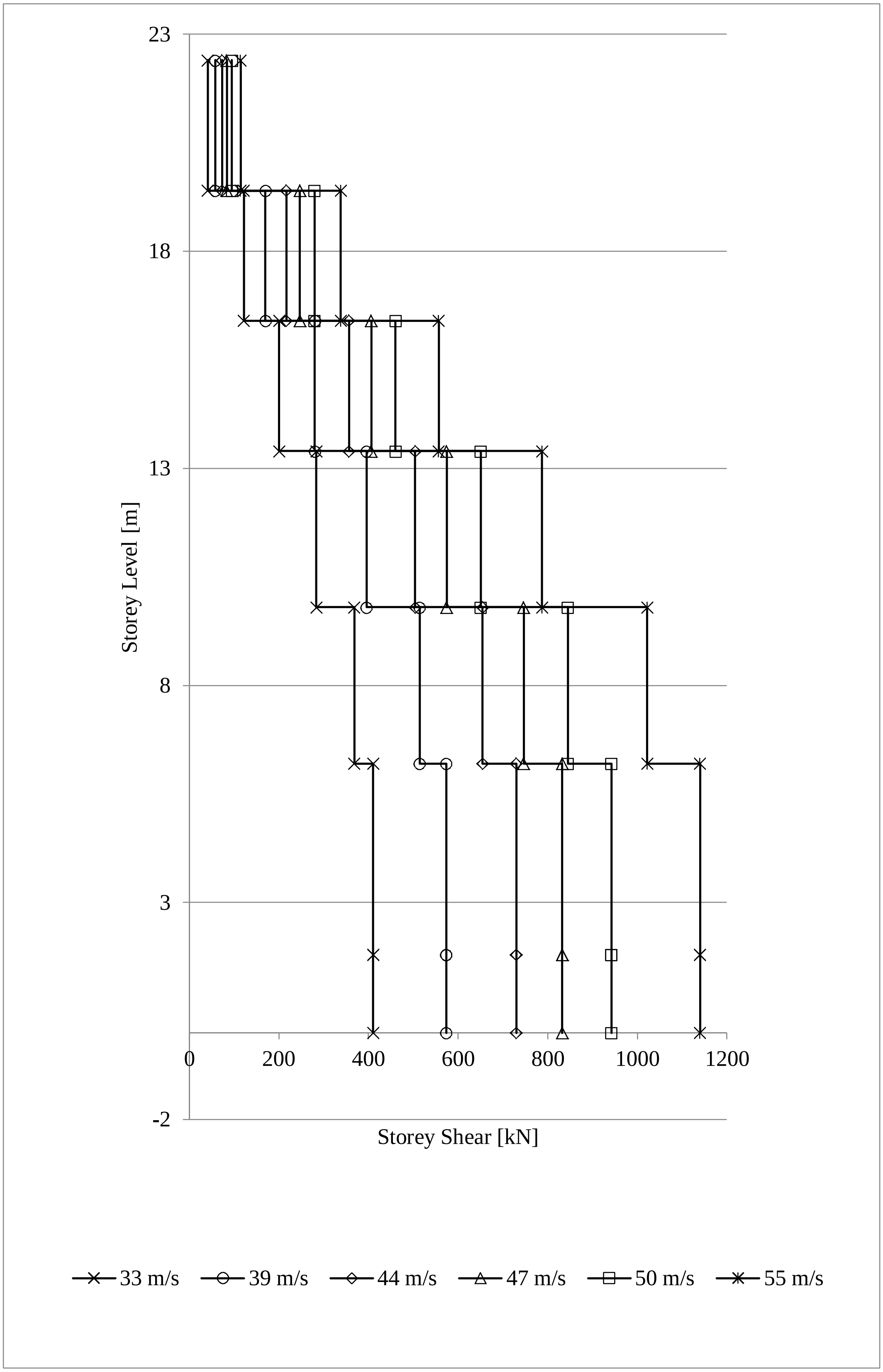



Fig. 4.6Wind Response (Storey Shear) of Stiffness Irregular Frame - SIFat all Wind Zones in India

### C. *Windresponse Of Regular (RF) And Stiffness Irregular (SIF) Frames Under Wind LOADS*

The wind performance of the Regular Frame (RF) and Stiffness Irregular Frame (SIF) was evaluated for different basic wind speeds as per the wind zones in India. The response is examined in terms of lateral displacement, storey drift, and storey shear, and the comparative behaviour between the two structural configurations is discussed below.

Lateral Displacement: Figure 4.7 illustrates the variation of lateral displacement with storey height for both RF and SIF. For all wind speeds, the displacement increases steadily with height, reaching its maximum at the roof level.

- For the Regular Frame, the displacement profile is smooth and parabolic, indicating uniform stiffness along the height.
- For the SIF, the displacement curve deviates from the regular trend, showing increased lateral deflections at and above the irregular storey level.

At the top storey, the lateral displacement for SIF at 55 m/s is approximately 2.5–3 times greater than that at 33 m/s, while for RF the increase is around 2–2.5 times. When comparing SIF and RF directly, the top storey displacement of SIF is 15–25% higher than RF at the same wind speed, emphasizing the magnifying effect of stiffness irregularity.

Storey Drift: The storey drift profiles shown in Figure 4.8 display significant differences between RF and SIF.

- The RF drift profile is fairly uniform and smooth, with peak drift occurring in the mid-height region.
- In contrast, the SIF exhibits a non-uniform and concentrated drift profile, with peak drift values shifting towards the irregular storey zone (lower–mid height), highlighting localized flexibility.

For increasing wind speeds, the drift grows proportionally. At 55 m/s, the peak storey drift in SIF is 30–40% higher than in RF, while both frames show a 2.5–3 times increase compared to 33 m/s wind speed. This clearly indicates that stiffness irregularity amplifies local deformations, which may lead to higher non-structural damage and serviceability concerns under strong winds.

Storey Shear: Figure 4.9 presents the variation of storey shear along the height. In both RF and SIF, maximum shear forces occur at the base, decreasing towards the top floors.

- For RF, the shear distribution is gradual, reflecting uniform load transfer.
- For SIF, there is a noticeable discontinuity and sudden drops at the irregular storey levels, indicating concentration of forces and abrupt stiffness changes.

The base shear for 55 m/s wind speed is approximately 2.5–3 times greater than that for 33 m/s in both frames, but the absolute value is higher for SIF due to increased displacement and load redistribution. On average, the base shear in SIF exceeds RF by 10–20% at higher wind speeds.

Overall Observations: The comparative assessment clearly reveals that stiffness irregularity intensifies wind-induced response in terms of displacement, drift, and shear. While both frames follow the expected trends with increasing wind speed, the magnitude and distribution of response differ significantly:

- RF shows uniform and predictable behaviour, suitable for straightforward wind-resistant design.
- SIF exhibits amplified and localized response, especially at and above the irregular storeys, requiring targeted strengthening and stiffness balancing.

This amplification effect becomes more pronounced at higher wind zones (≥ 47 m/s), which can compromise both serviceability (through increased drift) and structural safety (through increased shear demands).

Key Findings:

- Lateral displacement at 55 m/s is 2.5–3 times higher than at 33 m/s for both RF and SIF, with SIF showing 15–25% higher values than RF.
- Peak storey drift is localized near the irregular storey in SIF and 30–40% higher than RF at the same wind speed.
- Base shear in SIF is 10–20% higher than RF, with both frames showing 2.5–3× increase across wind zones.
- Stiffness irregularity magnifies structural response, necessitating careful detailing, bracing, or stiffening at critical zones.

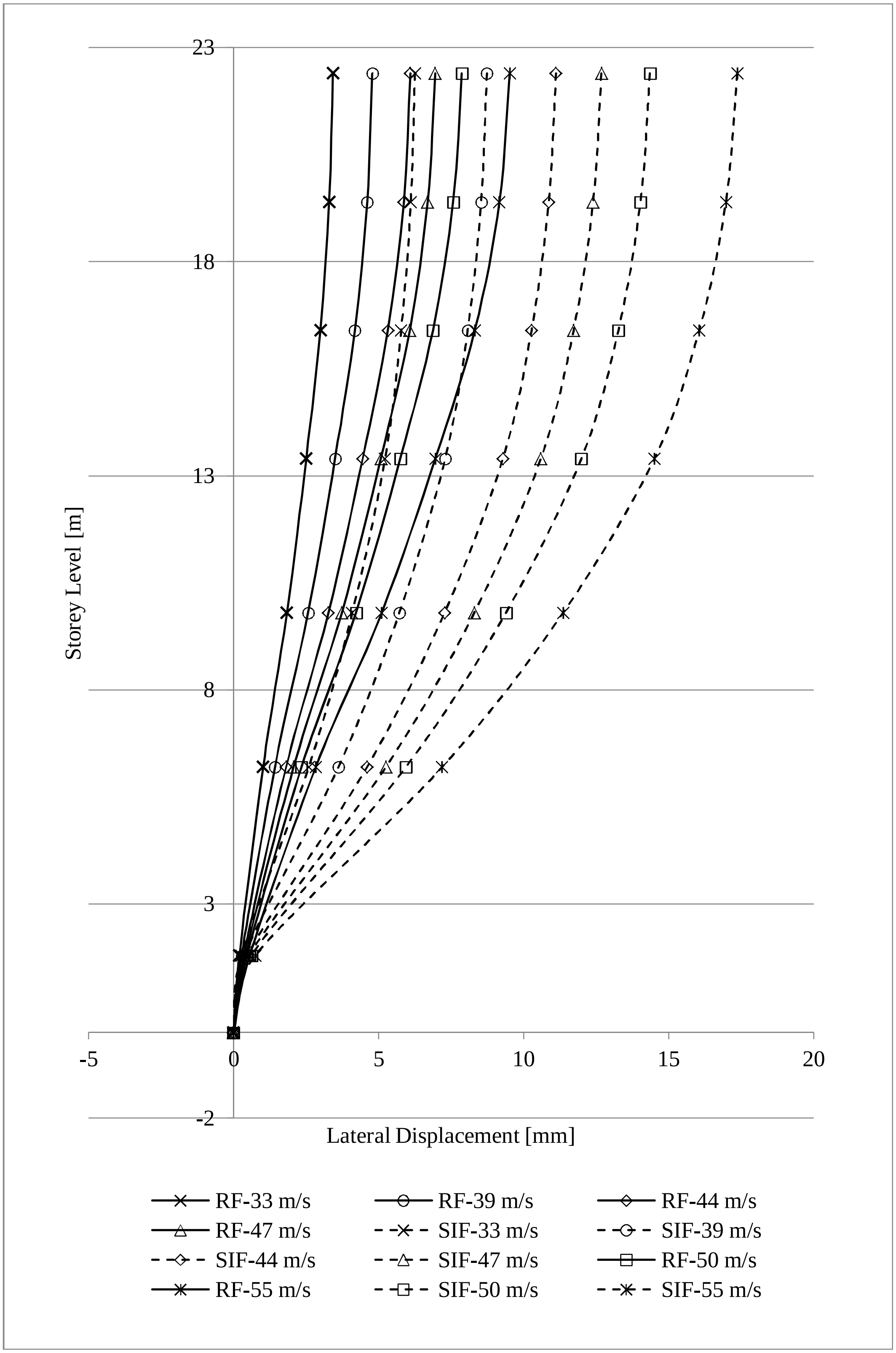



Fig. 4.7Lateral Displacement Response of Regular (RF) and Stiffness Irregular (SIF) Frames under Wind Loads

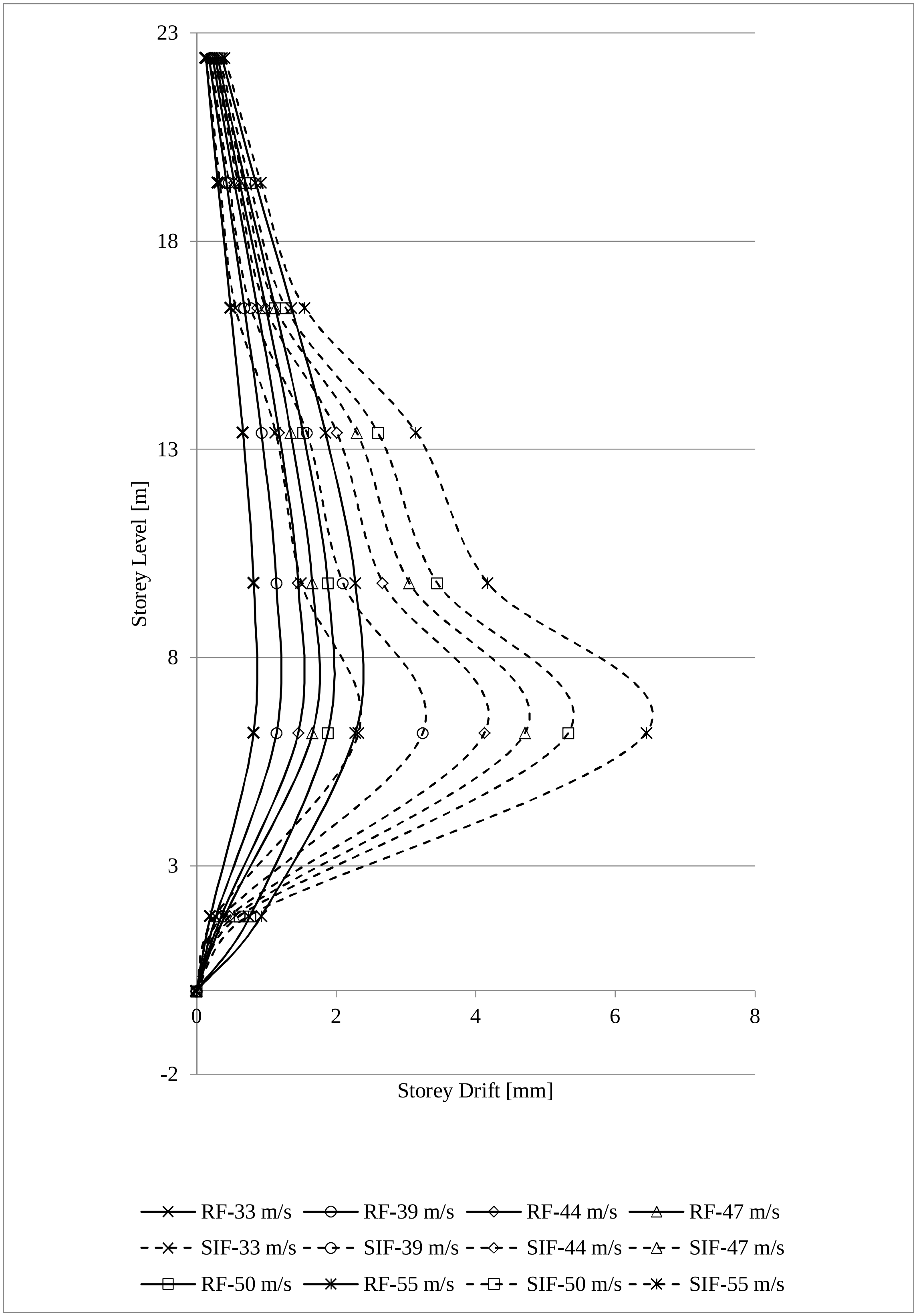



Fig. 4.8 Storey Drift Response of Regular (RF) and Stiffness Irregular (SIF) Frames under Wind Loads

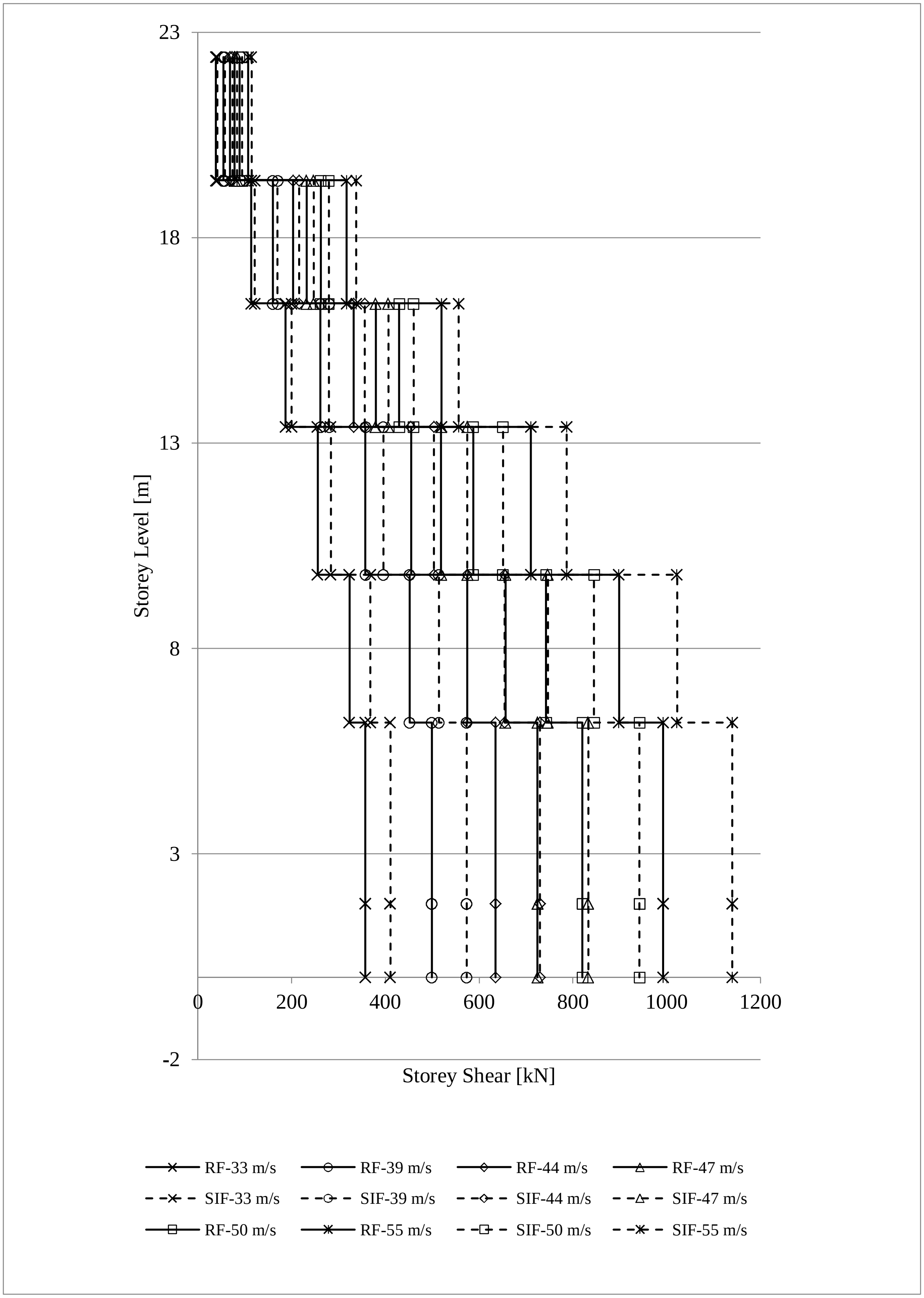



Fig. 4.9 Storey Shear Response of Regular (RF) and Stiffness Irregular (SIF) Frames under Wind Loads

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 13 Issue XI Nov 2025- Available at www.ijraset.com*

## V. CONCLUSIONS

The wind performance of Regular Frame (RF) and Stiffness Irregular Frame (SIF) buildings was evaluated. The primary conclusions drawn from the study are:

1) The SIF exhibits significantly higher roof displacement compared to RF, with top-storey displacements increasing by approximately 30–40% depending on the degree of irregularity. This indicates that stiffness discontinuity reduces global lateral stiffness, leading to larger deformations.
2) The lateral displacement profile of RF remains uniform and linear, whereas SIF shows pronounced deformation concentration at the irregular storey level. This soft-storey effect makes the structure more prone to localized damage.
3) The inter-storey drift in SIF is sharply peaked at the irregularity level, exceeding the corresponding drift values in RF by nearly 35–45%. Such concentrated drift demands enhanced ductile detailing and drift control strategies at the critical storey.
4) The storey drift distribution in RF is smooth and gradual, while SIF shows sudden drift spikes, indicating that irregularity disrupts energy dissipation and induces higher inelastic deformations in critical members.
5) The base shear demand in SIF is 20–25% higher than in RF, with abrupt shear variations above and below the discontinuity. This emphasizes the need for robust foundation systems and special detailing of columns and beams in the vicinity of the irregular storey.
6) Overall, SIF structures demonstrate greater wind vulnerability than RF. Stiffness discontinuity amplifies displacement, drift, and shear responses, particularly in higher wind zones. To ensure codal compliance and safety, design strategies must include stiffness balancing, drift limitation, and ductile detailing measures.

## VI. ACKNOWLEDGEMENT

While bringing out this dissertation to its final form, I came across a number of people whose contribution in various ways and they deserve special thanks. It is pleasure to convey my gratitude to all of them.

First and foremost, I would like to express my deepest gratitude to my project guide to Smt. B. Prudhvi Rani, Assistant professor, Department of civil engineering collage for her guidance and support. Her extreme energy and excellent skills have always been a constant source of motivation for me. The perfection that she brings to each and every piece of work that she does always inspire me to do things right at first time. She is great person and one of the best mentors, I always be thankful to her for encouragement, suggestions and support from an early stage of this dissertation.

I am very much thankful to the head of department of civil engineering of SVP Engineering College Dr. M. Madhuri, Associate Professor, for her kind support and cooperation that is difficult to express in words.

I am also thankful to the Principal of SVP Engineering College Sri Dr. K.Rama Krishna for his support and cooperation.

Finally, I am deeply indebted to my parents for their moral support and continuous encouragement while carrying out study.

## REFERENCES

[1] N. P. Modakwar, S. S. Meshram, and D. W. Gawatre, “Seismic Analysis of Structures with Irregularities,” IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Int. Conf. on Advances in Engineering & Technology (ICAET-2014), pp. 63–66, 2014.

[2] H. B. Khamkar, G. V. Tapkire, and S. M. Dumne, “Effects of Structural Irregularities on the Seismic Performance of Multi-Storey RC Buildings,” International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), vol. 5, no. 7, pp. 13615–13622, Jul. 2016.

[3] M. T. Raagavi and S. Sidhardhan, “A Study on Seismic Performance of Various Irregular Structures,” International Journal of Research in Engineering and Science (IJRES), vol. 9, no. 5, pp. 12–19, 2021.

[4] Tambare, O. Landge, P. Rakhunde, P. Raskar, and M. Deosarkar, “Study of Seismic Analysis of Plan Irregular Structures by Using ETABS Software,” Journal of Emerging Technologies and Innovative Research (JETIR), vol. 9, no. 5, pp. 111–115, May 2022.

[5] S. Sabu and S. Raghavu, “Analysis of Irregular Structures Using ETABS Software,” International Journal of Engineering Research & Technology (IJERT), vol. 10, no. 6, pp. 272–276, 2022.

[6] S. S. Girme and A. B. Pujari, “Review of Progressive Collapse Analysis of Reinforced Concrete Structures with Flat Slab Considering Effects of Geometrical (Horizontal and Vertical) Irregularities,” International Research Journal of Engineering and Technology (IRJET), vol. 9, no. 5, pp. 3526–3531, May 2022.

[7] G. Kinagi and L. J. K., “Seismic Analysis of Structure with Structural Irregularities,” International Advanced Research Journal in Science, Engineering and Technology (IARJSET), vol. 9, no. 6, pp. 844–854, Jun. 2022, doi: 10.17148/IARJSET.2022.96134.

[8] Dhalwar and S. P. Tak, “Seismic Analysis of Vertical Irregular Steel Structure with Seismic Resiliences,” International Journal of Creative Research Thoughts (IJCRT), vol. 10, no. 10, pp. 370–374, Oct. 2022.

[9] Sam and M. M. Paul, “Performance Evaluation of Irregular Structures Under Seismic Response Considering Soil-Structure Interaction: A Review,” International Journal of Engineering Research & Technology (IJERT), vol. 12, no. 5, pp. 678–684, May 2023.

[10] D. Bhagirath and O. Chirag, “Seismic Performance Analysis of Irregular Steel Building,” Journal of Emerging Technologies and Innovative Research (JETIR), vol. 11, no. 4, pp. 481–490, Apr. 2024.

[11] A. Patil and R. Sutar, “Seismic Analysis of Multi Storey Irregular RCC Buildings with Bracing System,” IRE Journals, vol. 8, no. 3, pp. 206–213, Sep. 2024.

[12] A. R. Babar and S. N. Patil, "Performance of Multi-Storied Irregular Steel Buildings: A Comprehensive Review of Dampers and Base Isolation Systems," International Journal for Multidisciplinary Research (IJFMR), vol. 7, no. 3, pp. 1–12, May–Jun. 2025.

[13] S. Nagar and M. Ahmed, "Investigating the Influence of Vertical Irregularities on Structural Integrity," International Journal of Advance Scientific Research and Engineering Trends, vol. 9, no. 9, pp. 21–31, Sep. 2025.

[14] Indian Standard Plain and Reinforced Concrete – Code of Practice (IS 456:2000), Bureau of Indian Standards, New Delhi, 2000.

[15] Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Part 1: Dead Loads – Unit Weights of Building Materials and Stored Materials (IS 875 Part 1:1987), Bureau of Indian Standards, New Delhi, 1987.

[16] Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Part 2: Imposed Loads (IS 875 Part 2:1987), Bureau of Indian Standards, New Delhi, 1987.

[17] Criteria for Earthquake Resistant Design of Structures (IS 1893:2016, Part 1 – General Provisions and Buildings), Bureau of Indian Standards, New Delhi, 2016.