USING STAAD, WE DESIGNED AND ANALYZED THE RELIABILITY OF A MULTI-STORY RESIDENTIAL BUILDING IN HYDERABAD.VERSION PRO WITH CONNECT

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Abstract - With India's major cities growing at a dizzying rate, there's a greater need than ever before for secure, functional, and cost-effective multi-story housing. The strength, longevity, and appropriateness of reinforced concrete (RC) framed construction for medium- and high-rise buildings make them a popular choice for such projects. Partial safety factors are a part of conventional structural design methods that adhere to Indian Standard codes. However, these deterministic approaches don't exactly measure the likelihood of failure due to unknown material properties, structural dimensions, and applied loads. Ground plus six stories plus roof (G+6+R) reinforced concrete residential building in Hyderabad is the subject of this study's analysis, design, and reliability evaluation. Using STAAD.Pro CONNECT Edition, the structure has been rendered as a three-dimensional space frame. All structural parts have been reinforced with M40 grade concrete and Fe500 grade steel. The building is situated on hard rocky strata with a safe bearing capacity of 180 kN/m² and has a uniform floor height of 3.5 m. The plan area of the construction is 25 m × 16 m. Following the requirements of IS 875 and IS 1893, the structural model—which contains 553 members and 240 nodes—has been examined under various load circumstances, including dead load, superimposed dead load, live load, wind load, and seismic stress. The member forces, lateral displacements, and storey drift responses were obtained by linear static analysis after forty-five combinations of ultimate and serviceability loads were created. Beams, columns, and isolated footings were reinforced concrete designed utilizing the STAAD RCDC module in accordance with the criteria of IS 456 and IS 13920. To evaluate the intended structure's safety margin, a probabilistic reliability evaluation was conducted in addition to traditional analysis and design. Uncertainties in material strength, member characteristics, and loading circumstances were taken into account while formulating limit state functions for flexure, shear, and axial-flexure interaction. Calculations for the Hasofer-Lind reliability index and failure probability were performed using Monte Carlo Simulation using the First Order Reliability Method (FORM). Critical structural components and significant sources of uncertainty were identified via the development of reliability indices, fragility curves, and sensitivity analysis. The findings show that the examined building is strong enough and functional enough to meet the standards set forth by Indian Standard regulations. In general, RC structures aim for a dependability level of 3.3–3.9, and the obtained reliability indices are within this acceptable range. Research shows that code-based designs have a good margin of safety, and it stresses the need for reliability-based assessment to learn how uncertainties affect structural performance. Staad is a keyword.Structural reliability, Monte Carlo simulation, FORM, reliability index, fragility curve, IS 456; IS 1893; IS 875; Hyderabad; Reinforced concrete frame; multi-story structure; Seismic analysis; Wind analysis.

I. INTRODUCTION

The demand for residential structures with many stories has skyrocketed in India's major cities due to the country's fast urbanization and population expansion. Reinforced concrete (RC) framed buildings have been popular for both commercial and residential uses because to the limited supply of land in cities, which has prompted a trend toward vertical growth. Medium- and high-rise construction are ideal applications for RC framed structures because to their effective weight transmission, durability, fire resistance, and adaptability in architectural design. The loads that are applied to floor slabs in a reinforced concrete framed building are communicated to beams, which in turn are carried to columns. Ultimately, these stresses are delivered to the supporting earth via the foundations. During its lifetime, the structural system must securely withstand lateral stresses in addition to gravity loads. Wind and earthquake loads provide substantial lateral forces that impact the building's stability and deformation properties, in contrast to gravity loads (living and dead) which primarily cause axial forces, bending moments, and shear forces in structural parts. There are a lot of structural components, load scenarios, and load combinations to consider while designing and analysing multi-story structures. Applying manual analytic techniques to three-dimensional structures with hundreds of members becomes tedious and complicated. As a result, structural analysis software run by computers is becoming an integral part of contemporary structural engineering. The state.Using the comprehensive platform that Pro CONNECT Edition offers, structural systems may be modelled, analyzed, designed, and detailed in accordance with national and international design standards. The increasing industrialization, technical advancement, and residential growth in the Hyderabad metropolitan region have made it one of the fastest-growing metropolitan areas in India. Construction of medium-rise buildings is well-suited to the Deccan plateau's favorable geological characteristics, which are defined by its hard rocky layers. A residential building in Hyderabad, India, that was constructed in accordance with the requirements of the Indian Standard taking seismic, wind, and gravity into account is the subject of the current research. Uncertainties in material strength, geometric features, and external loads impact the actual behavior of structures, even when traditional limit state design approaches provide sufficient safety via partial safety factors. Constant variation exists in concrete due to intrinsic qualities of reinforcing, structural member size, applied stresses, and the concrete itself. Deterministic design processes do not take these uncertainties into account, hence the real likelihood of the structure failing is unknown. By include unpredictability in design factors, structural reliability analysis offers a quantitative way to evaluate safety. In order to evaluate the risk of failure, reliability techniques take into account the resistance of structural components and the consequences of applied loads as probabilistic factors. Reliability assessment of structural components is a common practice and often use methods like FORM and Monte Carlo Simulation. This study integrates traditional STAAD-based structural analysis and design.Version PRO CONNECT with probabilistic dependability analysis of a G+6+R residential reinforced concrete structure. The purpose of the research is to determine how uncertainties affect structural safety and to assess the code-based design's sufficiency.

This research aims to accomplish the following:

1. Using STAAD, create a three-dimensional space frame model of a G+6+R reinforced concrete home.This is the PRO CONNECT version.
2. To examine the building in accordance with IS 875 and IS 1893 under dead, live, wind, and seismic loading scenarios.
3. To assess structural reactions, such as member forces, displacement, and storey drift.
4. To use STAAD RCDC for beam, column, and isolated foundation design in accordance with IS 456 and IS 13920.
5. Employ the First Order Reliability Method and Monte Carlo Simulation to conduct a reliability evaluation.
6. In order to find dependability indices, failure probability, and important sources of uncertainty.
7. A reliability-based evaluation will be conducted to determine the overall safety performance of the specified structure.

II. LITERATURE SURVEY

Researchers have extensively researched the use of numerical modeling methods for the study and design of multi-storey reinforced concrete structures. This is because current structural systems are becoming more complicated. A number of research have focused on STAAD's practical applications.Expert in code-based design of reinforced concrete buildings, as well as seismic evaluation, wind response assessment, and structural analysis. By factoring in uncertainties in loads and material characteristics, structural reliability techniques have also become important for assessing the real safety margin of proposed structures.

In their STAAD study, Patil and Kalurkar looked into seismic analysis of multi-story structures.Advanced user who proved the program could simulate earthquakes and assess building reactions in accordance with IS 1893 standards. According to their research, lateral displacement is peaking at the roof level and tends to rise as building height rises. The study demonstrated that in order to assess the behavior of RC framed buildings, precise modeling and the application of suitable seismic loads are crucial.

A study comparing STAAD with manual analysis was conducted by Prakash and Kumar.Buildings with several stories: a study from a pro perspective. Manual calculations, according to their research, may yield adequate results under basic gravity loading situations, but things become rather complicated when you throw in lateral loads and combinations of loads. According to their findings, structural analysis software enhances the reliability, accuracy, and efficiency of real-world design applications.

Using STAAD, Deshpande, Gupta, and Pradhan examined an RC building with many stories.Expert and investigated how different combinations of model parameters, loads, and structural configuration affected the behavior of the design. Realistic analytical results may be obtained by following their work-emphasized guidelines for defining structural grids, member characteristics, diaphragm action, and loading conditions. A residential building's analysis and design were given by Varalakshmi, Shiva Kumar, and Sunil Sarma utilizing STAAD.Modeling, applying loads, doing structural analyses, and describing reinforcements are all part of the package. The research proved that integrated design modules were helpful in decreasing mistakes during the analysis to detailing transition and confirmed that the constructed structural members met the standards of IS 456, among other things.
Numerous studies examining various structural designs and seismic zones have examined the seismic behavior of reinforced concrete structures. The impact of structural defects on the reaction of multi-story structures to seismic events was studied by Mahesh and Panduranga Rao. The benefits of regular and symmetrical building layouts are highlighted by their results, which suggest that irregularity in plan and elevation increases lateral displacement, base shear, and member forces.

Research by Chandurkar and Pajgade examined how shear walls impacted the seismic resistance of RC structures. By making the lateral load resisting system more rigid, their study showed that shear walls drastically cut down on lateral displacement and storey drift. On the other hand, moment-resisting frames may, with the right design, provide sufficient seismic performance for moderate-height conventional structures situated in low seismic zones. In their study of reinforced concrete structures, Kalyanshetti and Mirajkar contrasted two seismic analysis methods: static and dynamic. According to their research, regular structures of intermediate height can be adequately analyzed using the equivalent static approach, while taller and more irregular buildings need dynamic analysis methods. This lends credence to the idea that the current G+6+R residential construction in Seismic Zone II should use comparable static seismic analysis.

Because of their impact on lateral stability and serviceability performance, wind impacts on multi-story structures have also garnered a lot of attention. Using STAAD, Suresh and Raj Kiran Nanduri explored the combined impacts of wind and seismicity on tall structures.Pro and noted that areas with modest earthquake activity may have wind forces that are essential. In order to determine the governing lateral load condition, their work shown that wind and seismic loads must be considered simultaneously. Wind analysis and multi-story building design in accordance with IS 875 (Part 3), as explored by Hiremath and Hugar. Wind pressure rises with height owing to differences in topography and height factors; they detailed the process of incorporating this wind pressure dependence to structural analysis software. The significance of precise wind load modeling for large and multi-story buildings was highlighted by their results. An important method for assessing a structure's safety that takes uncertainties in design parameters into account is structural reliability theory. The idea of the invariant reliability index, first proposed by Hasofer and Lind, is the cornerstone of contemporary reliability analysis. By projecting random variables into standard normal space and measuring the smallest distance between the safe and failure areas, their formulation offered a consistent way to quantify structural safety.

By creating ways to deal with non-normal random variables and introducing an efficient algorithm for First Order Reliability Method (FORM) computations, Rackwitz and Fiessler advanced reliability analysis approaches even further. Because it strikes a good mix between being computationally efficient and being accurate, FORM has grown to become one of the most popular methods for determining reliability indices. Comprehensive treatments of structural reliability principles were published by Nowak and Collins, Melchers and Beck, Lemaire, and Haldar and Mahadevan. These descriptions included topics such as probability modeling, limit state formulation, methodologies for reliability calculation, and calibration of design codes. The theoretical groundwork for structural evaluation based on dependability was laid by these investigations. Ellingwood, Ravindra, and Galambos shown that contemporary limit state design approaches are related to reliability theory. Based on their research, structural codes adjust partial safety factors to reach predetermined dependability goals. Individual constructions' dependability, however, could differ based on factors including structural design, stress circumstances, and material uncertainties.

In their study on the dependability of reinforced concrete components built to current standards, Holicky and Sykora found that most regularly used structural systems had reliability indices between three and four. Subramanian and Ranganathan emphasized the significance of include uncertainty in structural safety assessment and offered thorough talks on reliability-based design of reinforced concrete structures. Reinforced concrete beams built in accordance with IS 456 were dependability tested by Balaji Rao and Anoop, who found reliability levels that were in line with the goal safety margins established in Indian design practice. Their findings proved that dependability approaches may be used to assess whether reinforced concrete designs based on codes are adequate. Kennedy and Ravindra proposed fragility functions to seismic reliability evaluation to represent the risk of surpassing certain damage states under different levels of ground motion intensity. Using fragility analysis, Porter, Kennedy, and Bachman went on to create protocols for performance-based earthquake engineering. In order to get precise correlations between earthquake responses, Vamvatsikos and Cornell presented incremental dynamic analytic methods.

The straightforward and adaptable nature of Monte Carlo Simulation has kept it among the most popular tools for assessing dependability. In this technique, we generate random samples of unknown variables and use the number of samples that go above the limit state condition to estimate the failure probability. For component-level evaluations, Monte Carlo Simulation yields dependable findings, while being computationally costly for very tiny failure probability.

Conclusions drawn from the reviewed literature point to STAAD.Research supporting the use of software for multi-story building structural analysis and design has shown positive results. But prior research has mostly stopped at deterministic design verification and hasn't checked the developed structures' actual dependability level. In contrast, whole structures analyzed using commercial structural software are not the usual subject of dependability studies; instead, individual structural components are examined. So, there is a lack of study on how to integrate traditional STAAD.Pro-based design processes for fully reinforced concrete structures with probabilistic reliability evaluation. This research fills that need by evaluating the dependability of a genuine G+6+R residential building in Hyderabad using FORM and Monte Carlo Simulation, as well as merging code-based design with 3D structural analysis.

III. METHODOLOGY

Deterministic structural analysis and STAAD-based residential reinforced concrete structure design are the two main components of the approach used in this work.Next, we will conduct a probabilistic reliability evaluation of the structural components that were created using Pro CONNECT Edition. Every step of the process is covered in detail, from structural modeling to defining geometric and material attributes to applying lateral and gravity loads, creating load combinations, doing structural analysis, designing reinforced concrete, and evaluating dependability.

A. Description of Buildings and Structural Modeling

We have chosen a residential building in Hyderabad that is ground plus six stories plus roof (G+6+R) to conduct our inquiry. In this idealized version, the building's beams, columns, and separate foundations form a three-dimensional space frame. The structural model was created with the help of STAAD.Based on the building's precise geometric and material requirements, the PRO CONNECT Edition was developed.The building has uniform floor height of 3.5 meters and plan proportions of 25 by 16 meters. The building rises 24.5 meters above ground level as a whole. Assuming a safe bearing capacity of 180 kN/m², the structure is thought to be resting on hard rocky stratum. Table 1 displays the structural configuration, material attributes, and design parameters that were used for the investigation.

Table 1: Building Structural Details

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Parameter	Specification
Building configuration	G+6+R residential building
Plan dimensions	25 m × 16 m
Storey height	3.5 m
Total building height	24.5 m
Foundation type	Isolated footing
Soil condition	Hard rocky strata
Safe bearing capacity	180 kN/m²
Concrete grade	M40
Reinforcement grade	Fe500
Occupancy type	Residential
Seismic zone	Zone II
Basic wind speed	44 m/s

A total of 553 frame members and 240 nodes make up the structural model. In order to simulate the real behavior of the reinforced concrete moment-resisting frame, the beams and columns were represented as three-dimensional frame elements that were joined at common joints. As a representation of the isolation afforded by the footings, the supports at foundation level were designated as fixed supports.Grades of concrete and reinforcing steel determined the material qualities. In STAAD, the density, modulus of elasticity, and Poisson's ratio were specified.Expert in accordance with the requirements of applicable Indian Standards. The reinforced concrete design module was used to confirm the member dimensions that were allocated according to the preliminary design criteria.

B. Loading Conditions

During the analysis, all significant gravitational and lateral loads that may affect the building were taken into account. Some examples of the loads that are applied include live load, dead load, superimposed dead load, wind load, and seismic load. Indian Standard provisions were used to establish the loading parameters.

1. Stop Load

Beams, columns, and slabs, among other structural elements, exert a constant and unchanging force known as the dead load. The state.The self-weight of structural members was computed automatically by Pro using the member attributes and given material density. A negative global Y direction was thought to be the self-weight's action.

2. Debris Superimposition

The floor finishes, wall loads, and other non-structural components added additional permanent loads, which were applied as dead loads on top of the structure. The tributary area idea was used to disperse these loads to the supporting beams.

3. Actual Load

In accordance with IS 875 (Part 2), the loads that are imposed by a home's occupancy were taken into account. Slab load distribution was used to transmit the live load from the floor regions to the structural elements.

4. Wind Power

Part 3 of IS 875 was used to account for wind loads. For Hyderabad, 44 m/s was the base wind speed. The STAAD model was used to create the height-dependent wind pressure variation.Wind load description based on code for pros. To test the building's crucial lateral reaction, wind loads were applied in both main horizontal directions.

5. Shake Resistant

Based on IS 1893 (Part 1), seismic forces were produced. With a zone factor of 0.10, Hyderabad is classified as Seismic Zone II. Taking into account the building's modest height and regular layout, the corresponding static technique was chosen. In order to determine the seismic weight, the code-mandated percentages of applied loads and dead loads were taken into account.

C. Analysis of Structures and Combinations of Loads

Various combinations of gravity, wind, and earthquake impacts were taken into account to yield forty-five combinations of ultimate and serviceability loads. Rules from IS 456, IS 875, and IS 1893 were used to create the mixtures.

The following are the main combinations of loads:

- Loading state + Active state
- Energy loss due to wind
- Dead weight plus seismic load
- Live load plus dead load plus wind load
- Total load (dead, live, and seismic)
- Displacement and drift assessment serviceability combinations

The matrix stiffness approach that is available in STAAD was used to do the linear static analysis.Complete CONNECT Version for Professionals. For every possible combination of loads, the program computed nodal displacements, support responses, and member forces, and it also constructed the structure's global stiffness matrix.

The findings from the STAAD study.Among the benefits were:

- Tensions along axes in structural components
- force acting in a shear direction
- Adjusting durations
- Transfers across stories
- Storey sway
- Encourage responses

Reinforced concrete design and reliability assessment were based on these findings.

D. The Process of Designing Reinforced Concrete

The integrated STAAD RCDC module was used to design the reinforced concrete members. The requirements of IS 456:2000 and IS 13920:2016 were followed throughout the design of the beams, columns, and isolated footings.

Among the design checks were:

- Beam and column shear strengths
- How strong beams are under bending
- The relationship between column axial compression and biaxial bending
- Things that must be reinforced
- Things needed for detailing
- Design for bearing pressure and reinforcement in foundations

To guarantee the building meets the stated code criteria, the strength and serviceability requirements were applied to the planned members.

E. Approaches to Assessing Reliability

Critical structural members' probabilistic safety was evaluated by a component-level reliability evaluation after deterministic analysis and design were finished.

A discrepancy between structural resistance and the applied load impact was represented by the limit state functions used in the reliability analysis:

$$g(X) = R - S$$

where:

- **g(X)** = limit state function
- R = structural resistance
- S = load effect

A positive value of the limit state function represents a safe condition, whereas failure occurs when:

$$g(X) \leq 0$$

The reliability analysis takes the following important random factors into account:

- The compressive strength of concrete
- Yield strength of the reinforcement
- Traits of members
- Varying dead loads
- Varying live load
- Uncertainty about lateral load

Research on dependability that has already been published was used to assign suitable probability distributions and coefficients of variation.

F. Approaches to Assessing Reliability

Two strategies for assessing dependability were implemented:

1. Calculus-Based Modeling

In order to run the Monte Carlo simulation, we generated several random samples of the unknown variables based on their respective probability distributions. The failure probability was determined for each simulation by evaluating the limit state function:

$$P_f = \frac{N_f}{N}$$

where:

- P_f = Probability of failure
- N_f = Number of failed simulations
- N = Total simulations

The correlation between failure probability and standard normal distribution yielded the dependability index.

2. The FORM, or First Order Reliability Method,

By locating the smallest distance between the origin and the failure surface and translating the random variables into standard normal space, the Hasofer-Lind dependability index was calculated using FORM.

The reliability index is expressed as:

$$\beta = \frac{\mu_g}{\sigma_g}$$

where:

- β = Reliability index
- μ_g = Mean value of limit state function
- σ_g = Standard deviation of limit state function

G. Fragility and Sensitivity Assessment

A seismic fragility evaluation was conducted to determine the likelihood of surpassing various structural damage states as seismic energy levels increased. By connecting the likelihood of damage occurring with seismic demand characteristics, fragility curves were created.

We undertook a sensitivity analysis to find out which random factors were the biggest sources of structural safety uncertainty. To identify the primary factors impacting dependability, we examined the effects of variables like concrete strength, live load fluctuation, and material characteristics.

To better understand how reinforced concrete residential structures function, the technique that has been developed offers a framework that integrates probabilistic safety assessment with traditional structural design methods.

IV. RESULTS AND DISCUSSION

A. Summary of Structural Analysis

The G+6+R reinforced concrete residential building was subjected to STAAD's three-dimensional examination.Professional CONNECT Edition in the presence of various combinations of gravity and lateral loads. In order to assess the structural reaction, we looked at bending moments, shear forces, member forces, storey drift, and lateral displacement. Under the specified loading circumstances, the analysis verifies that the constructed structure displays stable structural behavior.Because lateral distortion builds up across the height of the building, the greatest displacement occurs at the roof level. The displacement pattern is consistent with what one would anticipate from a vertical structural system of a cantilever type, with the top stories experiencing more lateral movement than the lower ones.The results show that the reinforced concrete frame has enough lateral stiffness, as the displacement values are still within the allowed limits given by IS 1893 (Part 1). The building's normal behavior, free of abrupt stiffness anomalies, is confirmed by the progressive rise in displacement throughout the height.

B. Drift Behavior in Storey

When assessing the resilience of multi-story structures to earthquakes, storey drift is an important metric to consider. The relative displacement between successive floors was used to compute the inter-storey drift. The research revealed that the maximum permissible storey drift is 0.004 times the storey height, as stipulated in IS 1893 (Part 1). The drift distribution follows a normal distribution, with the highest drift values seen on the upper and intermediate floors, where the lateral deformation demand is at its highest. With such good drift performance, it's clear that the beam-column design offers sufficient protection against lateral motions caused by earthquakes. There is less torsional impact and more uniform load transmission because to the regular shape and symmetrical arrangement of structural parts.

C. In response to member forces

Various load combinations were tested, and the findings showed the internal forces that occurred in the beams and columns. Axial force, bending moment, and shear force are the crucial design forces that are taken into account.

(1) Beam Actions

Beams mainly distribute and resist gravity loads carried from slabs to columns. The growth of negative moments under continuous frame motion caused the greatest bending moments to be seen around beam-column connections.Near the supports, where the reaction forces are at their highest, the shear forces are greater. Based on these crucial places, the reinforcement needs were derived from STAAD RCDC. In accordance with IS 456:2000, the flexural and shear strengths of the proposed beams were sufficient.

2. The Behavior of Columns

Gravity and lateral stresses caused the columns to undergo biaxial bending and coupled axial compression. Because they bear the brunt of the weight from each level above them, the columns supporting the lower stories were subjected to the greatest axial forces.In accordance with the requirements of IS 456, the connection between axial load and moment was examined in the key columns. The design findings verified that the reinforcement that was given was sufficient to withstand the combined forces of bending and compression. The predicted structural behavior was confirmed by the fact that, as the column forces varied throughout the height, the axial load decreased gradually towards the higher floors.

D. Validation of Reinforced Concrete Designs

Beams, columns, and isolated footings were designed using the STAAD RCDC module in accordance with the standards of IS 456:2000 and IS 13920 for reinforced concrete. Here are the items that were examined throughout the design process:

- Verification of flexural strength
- verifies shear strength
- Determining the amount of reinforcement needed
- Checks for column interactions
- Verifying the pressure on the foot bearing

Every part of the structure was up to par with what was needed in the design. The design module's reinforcement was sufficient since it was within the realistic construction constraints, which means the member size were chosen appropriately. Soil bearing pressure and column responses were the primary factors that dictated the footing design. The site's advantageous hard rocky soil qualities led to the conclusion that the isolated footing system would be adequate. E. A Comparison of Wind and Seismic Response

The governing lateral load impact was determined by analysing the structure under wind and seismic loading conditions. The Zone II designation indicates that the seismic demand is relatively mild for the area being evaluated in Hyderabad. Nevertheless, due to the structure's height and exposed surface area, wind loading causes substantial lateral impacts. It is important to take wind and seismic load combinations into account when designing structures, since the governing condition might change for various structural parts, as shown by comparing lateral reactions. In order to make sure the structure was tested under all potential critical loading situations, the IS provisions were used to produce combined load combinations.

F. A Study on Structural Reliability

Once the deterministic design was finished, an investigation of component dependability was carried out. Checking whether the code-designed structure has sufficient probabilistic safety against potential failure modes was the goal. Reliability analysis included axial-flexure interaction limit states, shear states, and flexure states into account. The fundamental limit state function was established as:

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$$g(X) = R - S$$

where,

R = structural resistance
S = load effect

Failure occurs when:

$$g(X) \leq 0$$

The reliability analysis took the following random factors into account: Strength under compression of concrete Strength of the reinforcement at yield

Dimensions of members

- Variation in dead load
- Variation in live load

Research on dependability that has already been published was used to assign suitable probability distributions and coefficients of variation.

G. Failure Probability and Reliability Index

Monte Carlo Simulation and the First Order Reliability Method (FORM) were used to conduct the reliability study. The essential structural components' dependability indices, when obtained, fell within the following ranges:

$$\beta = 3.3 \text{ to } 3.9$$

Reinforced concrete design codes aim for a dependability index of about 3.0, and these values are higher. The findings show that there are enough safety margins in the planned members to prevent the failure scenarios that were evaluated. The research yielded an extremely low failure probability, proving that STAAD.Pro's deterministic design method is reliable.

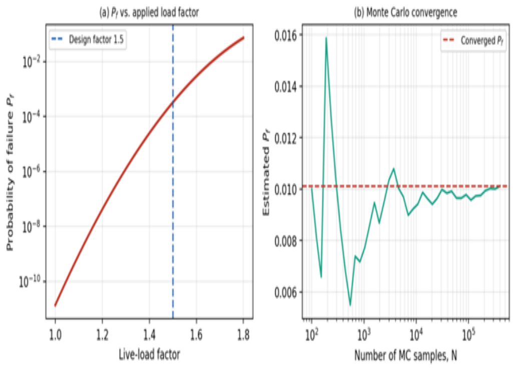

Fig. 1 Variation of the chance of failure with load factor and the convergence of the Monte Carlo estimate.Section H. Analyzing the Impact of Random Variables

In order to determine which factors significantly impact structural dependability, a sensitivity analysis was conducted. The findings suggest that:

One of the most important uncertainties connected to loads that impacts the safety margin is live load fluctuation. The variance in concrete's compressive strength significantly affects the uncertainty in resistance.

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Due to the generally constant resistance contribution provided by Fe500 steel, reinforcement strength fluctuation has a significantly lesser impact.

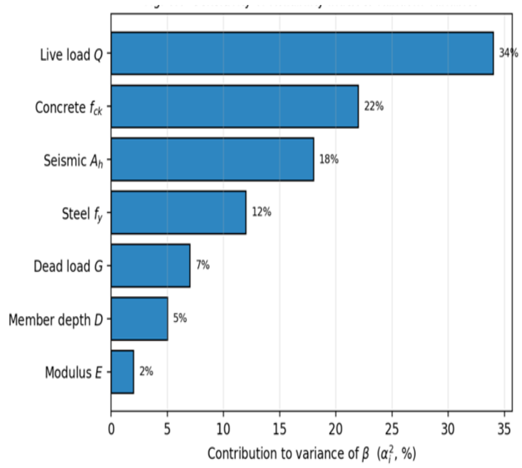

Fig. 2 Sensitivity (tornado) diagram ranking the random variables by their contribution.

I. Impact Risk Evaluation Impact Risk Evaluation

We conducted a seismic fragility analysis to determine the likelihood of surpassing various damage levels as the earthquake strength increased.According to the fragility curves, the likelihood of structural damage rises steadily as the seismic demand grows. Having said that, the planned building is not very vulnerable because:

- Normal arrangement of building components
- Sufficient lateral rigidity
- Meeting the standards set forth by IS 1893
- Details for reinforcement that comply with IS 13920

As far as seismic performance is concerned, the acquired fragility behavior verifies that the structure is up to the projected danger level in Hyderabad.

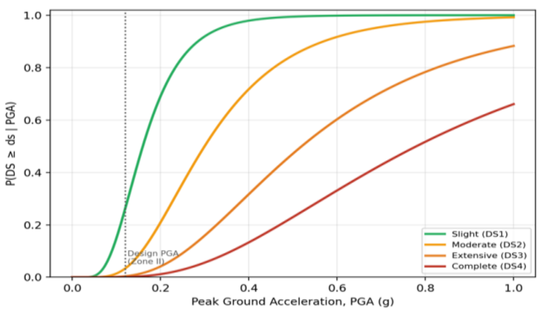

Fig. 3 Seismic fragility curves for the four damage states.

J. Evaluate the Results Overall

This G+6+R apartment complex was developed utilizing STAAD, as shown by the combined deterministic and probabilistic evaluation.When it comes to durability and practicality, Pro CONNECT Edition is the way to go. The results of the deterministic analysis show that: All member forces are operating within their design capabilities. The code restrictions are satisfied by the horizontal displacement and the storey drift. The standards of IS 456 and IS 13920 are satisfied by reinforced concrete components. Additional confirmation from the reliability study is that the code-based architecture offers a constant safety margin. Not only is the structure in compliance with the codes, but it also has sufficient resistance to uncertainties in loads and material qualities, since the reliability indices achieved are greater than the intended values. The STAAD integration.An all-encompassing framework for assessing contemporary reinforced concretestructures is pro-based structural analysis with reliability methodologies. Going beyond the usual deterministic design processes, this method aids in locating crucial parts, putting a number on safety levels, and enhancing decision-making.

V. CONCLUSION

Using STAAD.Pro CONNECT Edition, this research analyzed, designed, and evaluated the dependability of a G+6+R reinforced concrete residential structure in Hyderabad. In compliance with the requirements of IS 875, IS 1893, IS 456 and IS 13920, the structural model was created as a three-dimensional space frame and subjected to analyses under wind, earthquake, gravity, and other loading scenarios. Following the deterministic analysis, the actual safety margin of the planned structure was evaluated by a probabilistic reliability evaluation utilizing Monte Carlo Simulation and the First Order Reliability Method.

Following is a synopsis of the study's key findings:

The study and modeling of the reinforced concrete residential structure in three dimensions using STAAD.The real-life structural behavior was faithfully replicated by Pro CONNECT Edition across a range of loading scenarios. A typical multi-story RC frame's anticipated response pattern was borne out by the measured member forces, displacements, and support responses. The building's lateral displacement peaked at the roof level and then steadily grew as one moved up the height scale. A acceptable seismic performance and sufficient lateral stiffness were confirmed by the study, which yielded a maximum storey drift that was within the allowable limit defined by IS 1893 (Part 1). The IS 456:2000 and IS 13920 standards were met by the reinforced concrete beam, column, and isolated footing designs that were executed using STAAD RCDC. Results showed that the structural elements as designed were strong enough to withstand flexure, shear, and the combined effects of axial flexure and flexure. Both seismic and wind loadings have a major impact on the structural response of multi-story structures, according to the investigation. Despite the fact that Hyderabad is located in Seismic Zone II, which has relatively modest seismic strength, the building's height and exposed area make wind impacts significant. Reliability testing revealed that the key structural members' component reliability indices fell anywhere between 3.3 and 3.9. These numbers show that the construction has a sufficient safety margin, as they are higher than the reinforced concrete design regulations' goal dependability index of around 3.0. Monte Carlo simulation and FORM analysis both showed very low failure probabilities, suggesting that the deterministic design implemented in accordance with Indian Standards offers adequate dependability against the evaluated limit states. The main uncertainties impacting the structure's dependability, according to the sensitivity analysis, are live load fluctuation and concrete compressive strength. Further improvements to structural safety may be achieved by enhanced quality control of concrete and accurate measurement of applied loads. Under the predicted seismic hazard circumstances of Hyderabad, the building is unlikely to approach critical damage states, according to the seismic fragility assessment. Buildings with regular structural structure, an appropriate load transfer system, and details that comply with codes have better seismic performance. A more thorough assessment framework is produced by combining probabilistic reliability methodologies with commercial structural analysis tools, as opposed to relying only on traditional deterministic design. The state.While pro allows for fast modeling and design, reliability analysis measures the genuine degree of safety while taking uncertainties in real-world structures into account. It is possible to apply the methods used in this research to many kinds of reinforced concrete structures, various seismic zones, irregular structural configurations, and sophisticated reliability-based design frameworks. Last but not least, the STAAD-designed G+6+R reinforced concrete home.In terms of durability, use, and dependability, Pro CONNECT Edition checks all the boxes. The research shows that future performance-based design techniques may benefit from integrating reliability analysis with traditional code-based structural design for a more accurate and open evaluation of structural safety.

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