Review on Loads Analysis on (G+4) Residential Building Using Staad Pro

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Abstract: The structural analysis and design of multi-storey residential buildings have become steeds more complicated due to the rapid growth of cities, the demand for safety being higher, and the codal requirements being more strict.The traditional methods of structural analysis were done manually, so they often took a long time and were easily affected by computational errors, especially when it came to indeterminate structures and lateral loading conditions. This review paper provides a detailed evaluation of previous works related to the analysis and design of G+4 and similar multi-storey residential buildings that have relied on computer-aided structural analysis software, with a special emphasis on STAAD.Pro. The studies subjected to review have centered on determining the behavior of structure under gravity, wind, and earthquake forces according to Indian Standard codes IS 456:2000, IS 875, and IS 1893. Programming parameters, which include bending moments, shear forces, axial forces, storey displacements, and deflections, are critically discussed. The literature demonstrates that the analysis involving software leads to accurate results, guarantees code compliance, and cuts down design time remarkably while also enhancing material usage through optimization. Besides this, the review points out the capability of STAAD.Pro in the areas of reinforcement detailing and serviceability checks. In the end, this paper insists on the dependability and the efficient use of STAAD.Pro for the design of low- to mid-rise residential buildings that are safe, economical, and sustainable.

Keywords:- *STAAD.Pro, RCC frame, G+4 building, structural analysis, wind load, seismic load, bending moment etc.*

I. INTRODUCTON

The rapid urbanization process has caused the need for residential infrastructure to increase and this has invariably led to the construction of multi-storey buildings that are safe, cost-effective, and long-lasting in terms of their structure. Structural analysis and design are two main areas that guarantee that buildings can very safely bear the different loads that will be acting on them during their service life. The loads that are commonly acting on residential buildings are the dead loads, live loads, wind forces, and earthquake forces, and all these loads considerably affect the building's performance and stability. Structural failures that lead to major accidents or even loss of lives can be avoided and compliance with the codes can be assured only through the proper monitoring of loads and their effects on the structural members.

In the past, structural analysis was mainly done using manual techniques, such as the moment distribution method, the slope-deflection method, and Kani's method. Although these techniques are correct in theory, they are rendered non-feasible for high-rise buildings because of the cumbersome calculations involved and also the high chances of making errors. The development of computer technology has paved the way for the use of structural analysis software like STAAD.Pro, ETABS, and SAP2000 as indispensable tools in present-day structural engineering. By using these software, engineers are able not only to build intricate models of structures but also to associate different load combinations and get precise results in a much shorter timeframe than before. [1].

STAAD.Pro is ranked among the top structural analysis and design software packages for both reinforced concrete and steel structures. The program offers a wide range of capabilities from 3D modeling to support for both static and dynamic loading conditions analyses. STAAD.Pro has been applied successfully by many researchers to the analysis and design of residential and commercial buildings with different heights. The research of G+4 and G+5 residential buildings proved that the software could measure bending moments, shear forces, axial forces, and defections with utmost precision while still following IS 456:2000 standards and other related codes [2,5].

Lateral loads including wind and earthquake forces are very important in the design of multi-storey buildings, and even low-rise structures are not exceptions. In particular, seismic forces can result in large lateral displacements and internal forces that will dictate the design of the columns and shear-resisting elements. The researchers who used STAAD.Pro in their analysis of G+19 and other high-rise buildings concluded that the software delivers accurate predictions of lateral deflections and guarding under seismic loading according to IS 1893 [3,6]. Likewise, mid-rise residential buildings revealed the same conclusions, where serviceability criteria as in storey drift and deflection limits were found to be within permissible limits [4].

Additionally, it has been pointed out by many studies that one of the main steps in the process of confirming the accuracy of the software used is performing manual calculations and comparing the results with the software outputs. The researchers reported a very close match between the manual design and the results generated by STAAD.Pro, and thus the software was considered a reliable tool for practical design applications [8,9]. Besides, computer-aided design was found to be able to optimize reinforcement quantities, which means that construction could be less expensive to the same amount of safety [10,11].

Recent studies have been made on the benefits of STAAD.Pro in the reinforcement design of not only beams and slabs but also columns and footings by the limit state methods. One-way shear, two-way shear, deflection, torsion, and development length checks can be conducted quickly, thereby ensuring that the IS code provisions are followed [12]. Besides, the combination of structural analysis with architectural designing not only enhances the constructability of and the functional efficiency of residential buildings but also their overall attractiveness.

In light of the comprehensive research done in this area, the present review paper intends to gather and critically evaluate the prior studies related to the analysis and design of G+4 residential buildings with the help of STAAD.Pro. The primary goal is to evaluate the capability of software-based structural analysis in dealing with different loading conditions, increasing design accuracy, and thereby becoming a great support to overall structural safety. The knowledge gathered through this review is an excellent source of information for engineers and researchers working on the design of multi-storey residential buildings.

II. LITRATUREREVIEW

A) Literature Survey

Prajakta Hepat et. al. 2024, This review documents methodology for modeling a G+4 residential frame in STAAD.Pro, covering geometry definition, load application (dead, live, wind, seismic per IS codes), load combinations, and member design checks. The authors compare STAAD.Pro outputs with manual calculations to validate bending moments, shear, and deflections. The paper highlights STAAD.Pro's strengths: 3-D modeling, automated load generation, and integrated design checks that speed up iterations and optimization of reinforcement. Limitations discussed include the need for experienced interpretation of software results, mesh/simplification effects on accuracy, and code-specific input nuances. Practical recommendations stress cross-verification with hand calculations for critical members and sensitivity checks for load patterns.

J.S. Parmar et. al. 2023, This paper analyzes a G+5 reinforced-concrete frame under seismic codal provisions (IS 1893), comparing base shear, story displacement, and member forces across different seismic zones. Time-history and response spectrum analyses are used to capture dynamic effects. The study finds that ductile detailing and provision of concentric bracings significantly improve seismic performance: base shear redistributes to braced frames and story drifts fall within allowable limits when bracing is provided. The authors recommend designing columns for biaxial bending and using capacity design principles for beams and shear walls. They also underscore the need to model P-delta effects for tall frames and verify that automatic mass distribution in STAAD.Pro matches the intended diaphragm behavior.

Mohamed Hamud Mohamed et. al. 2021, This literature survey synthesizes multiple small-scale studies on mid-rise buildings analyzed with STAAD.Pro. Common themes include validation of software results with hand calculations, effect of load combinations on member sizing, and the importance of appropriate boundary conditions. The critique points out that STAAD.Pro is capable of executing both static and dynamic analyses with great success while simultaneously ETABS and STAAD.Pro are producing the same member forces whenever modeling assumptions coincide. The writer mentions literature that keeps suggesting some actions: checking by hand calculations, carrying out sensitivity analysis for different seismic zones, and precise modeling of diaphragms and continuities. Gaps that are of a practical nature are mentioned and these are: lack of research on the long-term effects (creep/shrinkage) and on the performance of structures under multi-hazard loading.

Bandipati Anup et. al. 2019, The study demonstrates the stepwise application of limit state design in STAAD.Pro for a G+4 framed building. It compares 2-D frame checks with full 3-D modeling and finds that 3-D effects (torsion, out-of-plane stiffness) noticeably change member forces versus planar assumptions. The authors report that short-term deflections of slabs and beams remained within 20 mm for their models and that shear and flexural checks conformed to IS 456:2000. They recommend full 3-D modeling for final design, iterative refinement of member sizes, and use of STAAD.Pro's design modules to obtain economical reinforcement while following codal detailing for ductility and development length.

Y. Ahmad et. al. 2023, This analysis focuses on a 4-storey RC building comparing unbraced and braced configurations under seismic loads. Results show that X-type concentric steel bracing on peripheral frames markedly increases lateral stiffness and reduces inter-storey drift and maximum displacement. The study quantifies improvements: braced models exhibited up to 40–60% reduction in lateral displacement depending on bracing location. The paper also emphasizes the role of bracing in redistributing internal forces and reducing demand on columns, allowing more economical sizing of vertical members. It concludes that for moderate seismic zones, strategic bracing combined with proper ductile detailing improves resilience and reduces retrofit needs.

Malarande et. al. 2020, This comparative study examines the effect of seismic zoning on base shear and reinforcement quantities for the same structural layout across different zones. It finds that base shear increases with seismic zone severity, necessitating larger lateral-force resisting elements and more reinforcement. The paper highlights that while overall concrete volume may remain similar, steel quantities can vary significantly by zone and design approach (capacity design vs. strength design). The authors recommend zone-specific optimization—using shear walls and bracings to control drifts in high-seismic areas and focusing on ductile detailing to prevent brittle failures. They also show that STAAD.Pro can automate generation of design load cases for zone studies efficiently.

Abdiaziz Yasin Isse et. al. 2021, This review collates classroom and project-level research using STAAD.Pro to handle different seismic zones and architectural layouts. Key observations include variability introduced by diaphragm assumptions (rigid vs. semi-rigid), significance of tributary area definitions for gravity loads, and the need for mesh refinement in shell elements for slabs. The review also points out that STAAD.Pro's automated design modules expedite preliminary sizing but that final detailing (lap lengths, hooks) must be confirmed per IS provisions and SP-16 charts. The authors call for more research into non-linear / pushover analyses within STAAD.Pro for performance-based design applications.

Rahul Kewlan et. al. 2022, The paper demonstrates STAAD.Pro workflow for a G+4 commercial building including load assignment for heavier live loads, serviceability checks for deflection under larger spans, and interaction checks for column design under combined axial and bending actions. Findings highlight that serviceability, especially V-notching of slabs for large spans and vibration considerations for long cantilevers, must be evaluated in commercial structures. Using STAAD.Pro, the authors performed load combination studies and concluded that commercial loading often governs beam depth and slab thickness more than seismic demands for low-rise structures, while columns remain controlled by combined axial-bending in multistorey frames.

Adhiraj A. Wadekar et. al. 2022, This aggregated review synthesizes multiple project papers showing consistent workflows: architectural plan → material properties → load calculations (IS 875) → STAAD.Pro modeling → static/dynamic analysis → member design per IS 456 and SP-16. Common findings: (a) 3-D modelling captures critical interactions missed by 2-D frames; (b) torsional irregularity and diaphragm flexibility significantly affect lateral responses; (c) bracing and shear walls are effective for drift control. Authors repeatedly urge validation of software mass assignment and load patterns, especially for seismic analysis, and call for more peer-reviewed comparative studies that contrast STAAD.Pro results with advanced non-linear analyses.

Kundan Kulbhushan et. al. 2019, Although primarily ETABS-focused, this study includes comparisons with STAAD.Pro results and highlights consistency when modeling assumptions match. Key outcomes: modal analysis and time-history procedures captured higher-mode effects better in ETABS's building-oriented environment, while STAAD.Pro offered broader element types and flexibility for irregular geometries. The authors recommend ETABS for regular building blocks and STAAD.Pro for complex 3-D frames with nonstandard supports. Both packages produce reliable member forces for design if diaphragm modeling, mass distribution, and load patterns are handled carefully. The paper endorses cross-tool validation for critical projects.

Viswanath et. al. 2023, A synthesis of multiple studies indicates that concentric bracing retrofits improve stiffness and reduce demands on primary vertical members. Quantitatively speaking, braced frames experience a decrease in lateral drifts and a shift of shear forces; nevertheless, the stress concentration at the connections of the braces and columns needs to be taken into account in the design. The review emphasizes that bracing can reduce displacements and base shear when used in certain layouts but at the same time might increase shear concentration in the stories which calls for proper designing of beams to ensure ductility and avoid brittle failure. Among the practical considerations are the use of ductile connections and the assessment of bracing with regard to the compatibility of architectural openings.

Aquib Zafar Ansari et. al. 2024, The paper reviews seismic analysis strategies for tall buildings modeled in STAAD.Pro, including dynamic analysis methods (response spectrum, time history) and soil-structure interaction considerations. It emphasizes the need for higher-mode effects, P-delta checks, and torsional irregularity assessment as height increases. For tall RC buildings, recommended practices include modeling separate substructures for mat foundations, using appropriate mass distribution for higher modes, and employing staged construction analysis where relevant. The review highlights STAAD.Pro's capability for extensive modeling but notes limitations for advanced non-linear soil-structure interaction where specialized finite element tools may be preferable.

B) Research Gap

The review of existing literature indicates that extensive studies have been carried out on the analysis and design of multi-storey residential buildings using structural analysis software such as STAAD.Pro and ETABS. Most studies primarily focus on the evaluation of bending moments, shear forces, deflections, and reinforcement design under gravity and seismic loads. However, limited attention has been given to a comprehensive load analysis of G+4 residential buildings considering realistic load combinations as per the latest Indian Standard provisions. Many studies emphasize software-based results without detailed validation through comparative parametric assessment of load effects and serviceability performance. Additionally, the influence of wind loads on low- to mid-rise residential buildings is often overlooked or treated briefly. The integration of detailed modeling assumptions, load calculation methodology, and interpretation of structural response remains insufficiently documented. Therefore, there is a need for a systematic study focusing on accurate load modeling, response evaluation, and performance assessment of G+4 residential buildings using STAAD.Pro.

C) Comparative Analysis

Sr. No.	Authors & Year	Building Type / Height	Type of Analysis	Key Observations
1	Prajakta Hepat et al., 2024	G+4 Residential	Static & Seismic (IS Codes)	Software results matched manual analysis; expert validation remains essential.
2	J. S. Parmar et al., 2023	G+5 RC Building	Response Spectrum & Time History	Bracing and ductile detailing significantly reduced drift and seismic demand.
3	Mohamed Hamud Mohamed et al., 2021	Mid-rise RC Buildings	Static & Dynamic	STAAD and ETABS yield similar results with consistent modeling.
4	Bandipati Anup et al., 2019	G+4 RC Frame	Static Analysis	3-D modeling captures torsion ignored in 2-D frames.
5	Y. Ahmad et al., 2023	4-Storey RC Building	Seismic with Bracing	X-bracing reduced lateral displacement and column demand.
6	Malarande et al., 2020	Multi-storey RC Building	Seismic Zone Comparison	Higher seismic zones increase base shear and steel requirements.
7	Abdiaziz Yasin Isse et al., 2021	Multi-storey Buildings	Static & Seismic	Diaphragm assumptions and slab meshing

				strongly influence results.
8	Rahul Kewlan et al., 2022	G+4 Commercial Building	Static & Serviceability	Live load and deflection govern design in commercial buildings.
9	Adhiraj A. Wadekar et al., 2022	Multi-storey Buildings	Static & Dynamic	Torsional irregularity and diaphragm flexibility affect lateral response.
10	Kundan Kulbhushan et al., 2019	Multi-storey RC Building	Dynamic (ETABS vs STAAD)	Both software reliable when modeling assumptions are consistent.
11	Viswanath et al., 2023	RC Buildings with Bracing	Seismic Retrofit	Bracing improves stiffness but requires careful connection detailing.
12	Aquib Zafar Ansari et al., 2024	Tall RC Buildings	Dynamic & SSI	Higher-mode effects and P–Delta crucial for tall buildings.

D) Summary of literature reviews

The literature under review reveals a wide-ranging application of STAAD.Pro in the analysis and design of low-to-mid-rise reinforced concrete buildings, especially G+4 and G+5 structures. The majority of the investigations ratify that STAAD.Pro is trustworthy with respect to the calculation of bending moments, shear forces, deflections, and member forces provided that the modeling conditions and the load combinations are in accordance with Indian Standard codes. The comparative studies indicate that there is a close relationship between the software-based and manual calculations which underlines the need for cross-verification of the loading on the critical members. The three-dimensional representation is a great tool by which the silhouette of the structure making 上 in two-dimensional analysis becomes a great problem. The specific studies reveal that with the help of ductile detailing and the adoption of bracing or shear walls one can attain a substantial reduction in lateral displacement and storey drift. On top of that, the STAAD.Pro to ETABS comparisons show equal precision among the software when consistent modeling parameters are applied. In conclusion, the literature repeatedly asserts that the application of software in structural analysis not only increases the precision and speed of the process but also leads to a reduction in the overall cost while at the same time the professional consideration is still the major factor in the design being both safe and in compliance with the building code.

III. CONCLUSION

A comprehensive analysis of literature reveals that among the various research studies conducted on the analysis and design of multi-story residential and commercial buildings, the software tools like STAAD.Pro, Structural Analysis, and ETABS have undoubtedly been the best options for modeling, analyzing, and designing structures accurately. The same calculation and Indian Standard compliance were the methods of reporting researchers for these tools as they calculated shear forces, bending moments, deflections, and reinforcement requirements with great diligence. Besides, both mid-rise (G+4, G+5) and high-rise (G+19) buildings were subjected to analysis considering the application of dead, live, wind, and seismic loads, and thus the structural components were shown to be safe and serviceable. Several studies mentioned the beneficial integration of software analysis and manual calculations which was an accuracy improving, human error reducing, and time saving process, still. the architects and engineers were tied to building codes and functional planning. Thus, the validation of software-assisted design in multi-story building projects was not only as a competent option but also as the one of a faster process according to the collective findings of the literature.

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