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Comparative Analysis of Multi-Storeyed Reinforced Concrete Buildings Designed Manually and Using STAAD. Pro with Shear Wall Configurations on Hard Soil

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Abstract
The rapid growth of urban infrastructure has increased the demand for economical, safe, and efficient design of multi-storeyed reinforced concrete (RCC) buildings. Traditional manual design methods provide a fundamental understanding of structural behaviour but require extensive calculations and considerable time. Modern structural analysis software such as STAAD.Pro enables engineers to perform accurate analysis, optimize structural members, and evaluate building performance under various loading conditions. This study presents a comparative investigation of a multi-storeyed RCC building on hard soil designed using both manual calculations and STAAD.Pro in accordance with the relevant Indian Standard codes. The comparison includes the design of structural components such as slabs, beams, columns, and foundations under dead, live, and wind loads. In addition, the influence of shear wall location on the structural behaviour of the building is evaluated by considering inner-core and outer-perimeter shear wall configurations. The analytical performance of both models is compared using parameters including storey displacement, storey drift, base shear, bending moments, shear forces, axial forces, and overall structural stability. The study demonstrates that STAAD.Pro provides reliable and efficient structural analysis while significantly reducing design time. Furthermore, the provision of properly located shear walls enhances lateral stiffness, minimizes storey displacement and drift, and improves the overall seismic and wind resistance of multi-storeyed buildings constructed on hard soil.

Keywords: *STAAD.Pro, Manual Design, Multi-Storeyed Building, Reinforced Concrete, Shear Wall, Hard Soil, Storey Displacement, Storey Drift, Base Shear, Structural Analysis, Wind Load, RCC Building, Comparative Study.*

I. Introduction

The rapid growth of urbanization has led to a significant increase in the construction of **multi-storeyed reinforced** concrete (RCC) buildings for residential, commercial, and institutional purposes. These structures must be designed to safely resist dead loads, live loads, wind loads, and seismic forces while maintaining structural stability, serviceability, durability, and economy. Proper structural design ensures that loads are effectively transferred from the superstructure through the foundation to the supporting soil. The uploaded thesis introduces the basic components of buildings, structural systems, and loading requirements for multi-storeyed construction.

Traditionally, the design of reinforced concrete buildings has been carried out using manual calculations based on the provisions of Indian Standard codes. Although manual design provides a clear understanding of structural behaviour and design principles, it involves extensive calculations and becomes increasingly time-consuming for multi-storeyed structures. The development of advanced structural analysis software such as STAAD.Pro has enabled engineers to analyse complex buildings efficiently, optimize structural members, and obtain reliable design results within a shorter time. The uploaded thesis emphasizes the importance of comparing manual design with computer-aided structural analysis.

Lateral loads produced by wind and earthquakes have a significant influence on the behaviour of tall buildings. As building height increases, lateral displacement and storey drift become critical design considerations. One of the most effective methods of improving lateral stability is the incorporation of reinforced concrete shear walls, which increase structural stiffness, reduce horizontal displacement, and improve the building's resistance to seismic and wind loads. The location of shear walls within the building plan plays an important role in determining the overall structural performance. The uploaded thesis investigates the influence of inner-core and

outer-perimeter shear wall configurations on multi-storeyed buildings.

Modern structural design also requires compliance with the relevant Indian Standard codes, including IS 456:2000 for reinforced concrete design and IS 875 (Parts 1, 2, and 3) for dead, live, and wind loads. These standards provide the necessary guidelines for ensuring structural safety and serviceability. STAAD.Pro enables engineers to incorporate these code provisions while accurately evaluating member forces, bending moments, shear forces, axial loads, deflections, and reinforcement requirements. The thesis explains that the software results are compared with manual calculations to verify structural accuracy and efficiency.

The present study performs a comparative analysis of a multi-storeyed RCC building constructed on hard soil using manual design and STAAD.Pro. The investigation further evaluates the effectiveness of inner-core and outer-perimeter shear wall arrangements by comparing important structural response parameters such as storey displacement, storey drift, base shear, bending moments, shear forces, axial forces, and overall structural performance. The objective is to assess the accuracy of computer-aided structural analysis and identify the most efficient shear wall configuration for improving the stability and safety of multi-storeyed buildings. These objectives are described in the uploaded thesis.

II. Literature Review

The design and analysis of multi-storeyed reinforced concrete (RCC) buildings have evolved considerably with the advancement of structural engineering practices and computer-aided analysis software. Conventional manual design methods remain essential for understanding structural behaviour and design principles; however, they become increasingly complex and time-consuming as the height and complexity of buildings increase. Modern software packages such as STAAD.Pro provide efficient analytical capabilities that improve design accuracy, optimize structural members, and reduce computational effort. The uploaded thesis emphasizes the need for comparing manual design with computer-based structural analysis for multi-storeyed buildings.

Several researchers have reported that computer-aided structural analysis produces more reliable and economical designs than conventional manual methods for complex reinforced concrete buildings. Software-based analysis enables accurate determination of bending moments, shear forces, axial loads, member deflections, and reinforcement requirements while complying with the provisions of Indian Standard codes. The uploaded thesis discusses the advantages of STAAD.Pro in improving structural design efficiency and reducing analysis time.

The influence of lateral loads, particularly wind and earthquake forces, has been extensively investigated for multi-storeyed buildings. Previous studies indicate that increasing building height results in larger lateral displacement and inter-storey drift, making lateral load-resisting systems an essential component of structural design. Proper modelling and analysis of these loads are necessary to ensure structural safety, serviceability, and occupant comfort. The uploaded thesis reviews the effects of dead, live, wind, and earthquake loads on reinforced concrete buildings and the corresponding Indian Standard provisions.

Researchers have also demonstrated that reinforced concrete shear walls significantly improve the seismic and wind performance of multi-storeyed buildings. Shear walls increase the lateral stiffness of the structure, reduce storey displacement and inter-storey drift, and improve resistance against overturning moments and lateral forces. The location of shear walls within the building plan plays a major role in determining structural efficiency. The uploaded thesis compares inner-core and outer-perimeter shear wall configurations to evaluate their influence on overall building performance.

The design of reinforced concrete buildings is governed by several Indian Standard codes, including IS 456:2000 for reinforced concrete design, IS 875 (Parts 1, 2, and 3) for dead, live, and wind loads, and relevant seismic design provisions. These standards ensure adequate structural strength, stability, durability, and serviceability under different loading conditions. The uploaded thesis follows these code provisions for both manual design and STAAD.Pro analysis.

Summary of Literature

The literature presented in the uploaded thesis indicates that STAAD.Pro provides an efficient and reliable alternative to conventional manual structural design while maintaining compliance with Indian Standard codes. Previous investigations also confirm that the incorporation of shear walls substantially improves the lateral performance of multi-storeyed reinforced concrete buildings by reducing displacement and drift. However, comparatively fewer studies evaluate both manual versus STAAD.Pro design and inner versus outer shear wall configurations within a single investigation. Therefore, the present study performs a comparative analysis of a multi-storeyed RCC building on hard soil, evaluating the structural behaviour obtained from manual calculations and STAAD.Pro together with the effectiveness of inner-core and outer-perimeter shear wall arrangements using parameters such as storey displacement, storey drift, base shear, bending

moments, shear forces, axial forces, and overall structural performance.

III. Methodology

The present study was carried out in two phases. The first phase involved the manual design and STAAD.Pro analysis of a multi-storeyed reinforced concrete (RCC) building constructed on hard soil. The second phase investigated the influence of shear wall location on the structural behaviour of the building by comparing inner-core and outer-perimeter shear wall configurations. The methodology adopted in the uploaded thesis follows this two-stage analytical procedure.

A. Structural Modelling

A three-dimensional model of a multi-storeyed RCC building was developed using STAAD.Pro. The structural system consisted of reinforced concrete slabs, beams, columns, and foundations, with appropriate material properties and member dimensions assigned according to the relevant Indian Standard codes. The analytical model was prepared to evaluate the structural response under gravity and lateral loading conditions. The uploaded thesis describes the building components and structural system considered in the investigation.

B. Manual Design and STAAD.Pro Analysis

The structural members were first designed manually using the relevant **Indian Standard (IS) code provisions**. The same building was then analysed and designed using **STAAD.Pro**, enabling a comparison between conventional design calculations and computer-aided structural analysis. The comparison focused on verifying the accuracy, reliability, and efficiency of software-generated results with manual calculations. This comparative approach forms the first part of the investigation described in the thesis.

C. Loading Conditions

The analytical model was subjected to the following design loads:

- Dead Load
- Live Load
- Wind Load

The loading calculations were carried out in accordance with the applicable **Indian Standard codes**, considering the building to be located on **hard soil**. The combined action of gravity and lateral loads was used to evaluate the structural behaviour and design of the building. The thesis discusses these loading conditions and their application in structural analysis.

D. Shear Wall Configurations

To investigate the effect of shear walls on lateral stability, two different structural configurations were analysed:

- **Inner-Core Shear Wall Configuration**
- **Outer-Perimeter Shear Wall Configuration**

Both models were analysed under identical loading conditions, and their structural responses were compared to determine the most effective shear wall arrangement for reducing lateral displacement and improving structural stability. This forms the second phase of the study presented in the uploaded thesis.

E. Performance Evaluation

The performance of the building models was evaluated by comparing the following structural response parameters:

- Storey Displacement
- Storey Drift
- Base Shear
- Bending Moments
- Shear Forces
- Axial Forces
- Overall Structural Stability

The analytical results obtained from **manual calculations**, **STAAD.Pro analysis**, and the two **shear wall configurations** were compared to assess structural performance, design efficiency, and the effectiveness of shear walls in resisting lateral loads. The methodology outlined in the uploaded thesis forms the basis of this comparative evaluation.

IV. Results And Discussion

The comparative analysis was carried out to evaluate the structural performance of a multi-storeyed reinforced concrete (RCC) building designed manually and analysed using STAAD.Pro. In addition, the influence of shear wall location was investigated by comparing inner-core and outer-perimeter shear wall configurations under identical loading conditions. The structural response was assessed using storey displacement, storey drift, base shear, bending moments, shear forces, axial forces, and overall structural stability. The results presented below are based on the analytical comparisons described in the uploaded thesis.

A. Comparison of Manual Design and STAAD.Pro Analysis

The comparison between manual calculations and STAAD.Pro analysis indicated that both approaches produced structurally acceptable designs when carried out in accordance with the relevant Indian Standard codes. However, **STAAD.Pro** performed the analysis more efficiently by automatically evaluating member forces, support reactions, bending moments, shear forces, axial loads, and reinforcement requirements. The software also

reduced computational time and minimized the possibility of calculation errors associated with manual procedures. The uploaded thesis highlights the advantages of computer-aided structural analysis over conventional manual calculations.

B. Storey Displacement and Storey Drift

The analytical results showed that **storey displacement increased progressively from the base to the roof level**, which is typical for multi-storeyed buildings subjected to lateral loads. The incorporation of **shear walls** significantly reduced lateral displacement and inter-storey drift by increasing the overall stiffness of the structural system. Buildings with properly positioned shear walls exhibited improved resistance to horizontal loading and better serviceability performance. The thesis compares the lateral response of the different structural configurations.

C. Base Shear and Member Forces

The **base shear, bending moments, shear forces, and axial forces** obtained from STAAD.Pro provided a comprehensive understanding of the load distribution within the structural system. The software accurately identified the critical structural members and facilitated the design of beams, columns, and foundations according to the applicable code requirements. The comparison demonstrated that software-based analysis enables rapid evaluation of complex load combinations while maintaining design accuracy. These response parameters form part of the analytical evaluation described in the thesis.

D. Influence of Shear Wall Location

A comparison between the **inner-core** and **outer-perimeter shear wall configurations** indicated that the location of shear walls has a significant effect on the lateral behaviour of the building. Both configurations enhanced structural stiffness and reduced lateral deformation; however, the analytical results demonstrated noticeable differences in storey displacement, drift, and force distribution depending on the position of the shear walls. The comparative study presented in the thesis was undertaken to identify the more effective arrangement for improving overall structural stability.

E. Overall Performance Assessment

The overall investigation demonstrates that **STAAD.Pro** is an efficient and reliable tool for the analysis and design of multi-storeyed RCC buildings. Compared with manual calculations, the software provides faster analysis, improved accuracy, and easier evaluation of multiple load combinations. The inclusion of **shear walls** further enhances the structural performance by reducing storey displacement and drift while increasing lateral stiffness. Consequently, the combination of computer-aided structural analysis and an appropriate shear wall configuration provides a safer and more economical design for multi-storeyed buildings constructed on hard soil. These conclusions are consistent with the comparative objectives and analytical approach presented in the uploaded thesis.

V. Conclusion

The present study investigated the design and analysis of a multi-storeyed reinforced concrete (RCC) building constructed on hard soil by comparing manual design calculations with STAAD.Pro analysis. In addition, the influence of shear wall location on structural behaviour was evaluated by considering inner-core and outer-perimeter shear wall configurations. The structural analysis was carried out in accordance with the relevant Indian Standard codes, considering gravity and lateral loading conditions. The objectives and analytical approach are presented in the uploaded thesis.

The comparative investigation demonstrated that STAAD.Pro provides results that are consistent with manual structural design while significantly improving computational efficiency and reducing the time required for analysis. The software accurately evaluated member forces, bending moments, shear forces, axial loads, deflections, and reinforcement requirements, thereby facilitating economical and reliable structural design. The comparison confirms that computer-aided structural analysis is an effective alternative to conventional manual calculations for multi-storeyed RCC buildings. These observations are consistent with the findings reported in the uploaded thesis.

The study further established that the incorporation of reinforced concrete shear walls considerably improves the lateral performance of multi-storeyed buildings. Both inner-core and outer-perimeter shear wall arrangements enhanced structural stiffness, reduced storey displacement and storey drift, and improved the building's resistance to wind and seismic forces. The comparative analysis indicates that the selection of an appropriate shear wall configuration plays a crucial role in achieving improved structural stability, serviceability, and overall performance. The uploaded thesis concludes that combining manual design principles, STAAD.Pro analysis, and optimized shear wall placement provides a safe, economical, and efficient design approach for reinforced concrete buildings constructed on hard soil.

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