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Planning, Analysis and Structural Design of a G+4 Extension Block for an Existing School Building Using STAAD.Pro

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Abstract— The planning, analysis, and structural design of multi-storey buildings play vital roles in civil engineering. These help in achieving structural safety, stability, and efficiency in space utilization. This project aims at the planning, analysis, and structural design of G+4 extension block of an existing school building through the use of STAAD.Pro software. The objective of this project is to provide a suitable plan of the building and to analyze its structural elements subjected to expected loading conditions.

This extension block of the building is designed as per the requirement of an educational building. The structural model of the building is developed through STAAD.Pro software. The development of the model is done by providing the building geometry, structural elements, materials and loadings (dead and live). Analysis of the building provides the values for support reactions, bending moment, shear force, and displacement of the structural elements. Analysis results can be used to design the structural elements like beams, columns, slabs and foundation.

Keywords: G+4 Building, School Extension Block, STAAD.Pro, Structural Analysis, Structural Design, Dead Load, Live Load, Bending Moment, Shear Force.

I. Introduction

The erection of an extension school block is important in improving the facilities. However, it should be properly planned and constructed to ensure safety, convenience, durability, and good utilization of space. The extension of the block should satisfy the criteria of functionality and compatibility with the existing block. This is a proposal for construction of the extension block of G+4 made up of reinforced cement concrete (RCC) framed structure for the current school building. This is because RCC has the following attributes.

This is because the plan will consider the different classrooms, offices, bathrooms, passages, staircases, and many other facilities that are needed to ensure that the functioning of the school is effective. Other considerations include circulation, ventilation, lighting, and many others.

The architectural drawings & plan are made using the AutoCAD software, while the structural analysis is made using the STAAD.Pro V8i software. For the structural analysis of the structure, the various types of loads along with the Indian standard codes of practice for that particular structure have been considered. Various types of dead loads, live loads and other relevant loads have been considered.

Since the proposed extension is going to be built on an existing building, it becomes necessary to analyze the existing building's status and its load-bearing capacity before beginning construction work. It is necessary to consider the foundation system, the bearing capacity of soil, and the interaction of the existing structure and proposed structure. Suitable connections need to be made as per the need of the structural system so that there can be no structural interaction. The proposed extension having 4 storeys will cater to the increasing number of students and offer them improved learning facilities. Proper planning of the classrooms and common areas is essential to make effective use of space in the building.

The primary objective in this project is to come up with an extension block that is both safe and economical to satisfy the needs of the institution in the coming future. The design of such an extension block will involve architectural planning, structural modeling, structural loading analysis, structural analysis, structural member design, and drawing of construction documents. Quality control in the process of construction such as provision of reinforcement, mixing of concrete, compacting of concrete, and curing of concrete is vital.



II. Literature Review

Multi-story reinforced concrete structures have been studied extensively in civil engineering in order to enhance structural safety, efficiency, and ease of construction. The advent of computer-aided analysis has made it easier for engineers to develop models of structural systems and to carry out calculations concerning internal forces and displacements. Such technological advancements aid in the evaluation of structural performance of the building and enable appropriate structural layout selection.

Earlier works done on reinforced concrete frames of buildings have emphasized the need for the selection of suitable beam-column configurations to facilitate load transmission and ensure overall structural stability. The correct evaluation of dead loads, live loads, and other relevant loads is very important to know the magnitude of the force transmitted by the structural elements. Structural element configuration and dimensions affect the structure's stiffness and strength.

The software known as STAAD.Pro is frequently employed in the modeling and analysis of reinforced concrete structures. The software helps in creating structural models, specifying materials, support conditions, loading, and analyzing the structure. The analysis will yield values for support reactions, bending moment, shear force, axial force, and displacements. The values will be helpful in determining the behavior of the structural elements and designing them.

IS Codes have laid down important guidelines on structural loading, reinforced concrete design, and detailing. IS 456:2000 is a code specifying all the aspects concerning plain and reinforced concrete structures, whereas IS 875 is the code for building loads. IS 1893 (Part 1) contains the guidelines for designing earthquake-resistant structures when seismology becomes relevant. Adhering to the code specifications can ensure that the structural elements meet strength and stability requirements.

Design of multi-storey structures involves an analysis of the behavior of slabs, beams, columns, and foundations with respect to each other. Floor loads will be transferred from the slab to the beams, from the beams to the columns, and from the columns to the foundations. This understanding of how the load transfers occurs is critical in designing the structure for safety and efficiency.

For instance, in the event where the extension block is being joined to an existing building structure, more consideration needs to be made. The state of the existing building, the capacity of its foundation, and structural form of the extension needs to be taken into account before the construction process begins. Factors such as differential settlement and interaction between the two buildings could influence the structural behavior of the building. Based on the design requirement, the extension can be joined to the existing building or separated by a joint.

There is also the issue of functional needs that need to be addressed in the design of a G+4 reinforced concrete building extension for a school. The layout of classrooms, corridors, stairs, and other services should work in harmony with the structural design. The structural system must have adequate strength and stiffness and allow efficient use of space.

In summary, based on the available literature, it is evident that computer-based structural analysis, adherence to design codes, correct member sizing, and proper detailing are very important in designing safe reinforced concrete structures. The application of this knowledge in the proposed design of the school structure is an organized way of conducting structural design for safe and functional building structure.

III. Methodology

The approach used in the current research comprises literature review, building planning, development of drawings with the help of AutoCAD software, structural analysis of the model using STAAD.Pro software and designing the structural components. The planning is done in accordance with National Building Code (NBC). Structural analysis takes into consideration the loads acting on the structure to calculate the force and moment values of the structural elements. On the basis of the results of the analysis, the slabs, beams, columns, footings and staircases are designed in accordance with IS code.

A. Collection of Literature Review

- Gather data from academic articles, journals, and literature review on design of multi storey buildings.
- Study the relevant IS codes and National Building Code (NBC).
- Know the process of structural analysis and design.

B. Planning

- Prepare the construction plans considering the needs of the school.
- Look at arrangement of rooms, ventilation, lighting, and circulation.



- Apply NBC guidelines accordingly.

C. Drawing- AutoCAD

- Draw the building plan and structure layout using the AutoCAD program.
- Indicate the positions of columns, beams, walls, and other structural components.
- Specify accurate dimensions and drawings for structural modeling.

D. Analysis- STAAD.Pro

- Design the structural model using the STAAD.Pro software.
- Consider the appropriate dead load, live load, and any other applied loads on the structure.
- Perform analysis to find support reactions, bending moment, shear force, and deflections.

E. Designing

- Prepare the designs for slabs, beams, columns, footings, and staircases considering the findings of the analyses.
- Adhere to the necessary IS codes such as IS 456 and other applicable codes from IS 875.
- Evaluate the structural strength, stability, and serviceability of the components.

F. Project Report

- Summarize all the planning information, drawings, and structural analysis information.
- Include the design calculations and structural member reinforcement details.
- Summarize the results and conclusions of the project.

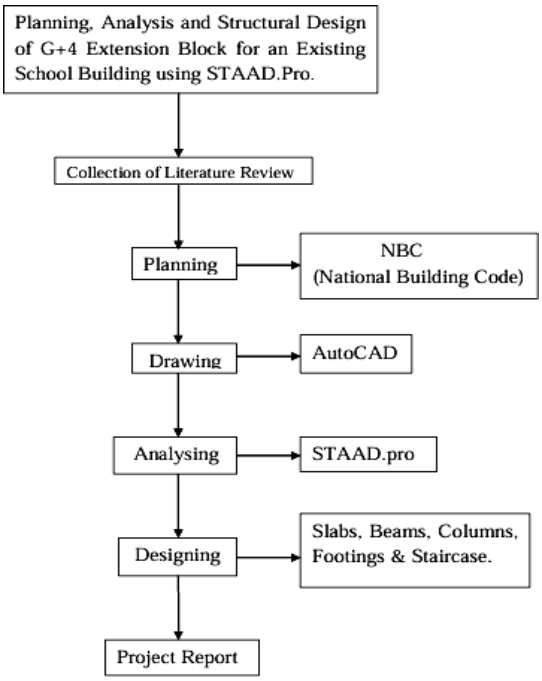


Fig.1. Methodology

IV. EXISTING SYSTEM

In conventional building design, structural analysis and structural member design might require manual calculation and preparation of separate structural drawings. This process consumes a lot of time as well as demands coordination among the building layout, loads and structural design.

Calculation by hand becomes equally complex if there are multiple levels to the building with many interlinked members.

The significant drawbacks of conventional methods are as follows:

1. Time-consuming calculations for structures.

2. Difficulties in manual analysis of multi-story frames.

3. Repetitive calculations in case of change in structural dimensions.

4. Complications in tabulating results for various loading conditions.

5. More efforts for matching analysis results with design of structures.

These limitations support the use of structural analysis software to improve the efficiency of the design process.



Fig.2. Existing System

The current system operates on a conventional/manual approach for the construction quantity and cost estimation process. Initially, the architecture plans and project specifications are gathered in order to understand the scope of the construction work involved. Manual calculations are done to determine the quantities of different construction materials, the material needs, and the calculation of cost estimates using the appropriate rates. The measured quantities are tabulated to generate a bill of quantities (BOQ) that includes the necessary materials and their specifications. Once the BOQ is ready, the total cost of the project is computed by summing up all the material costs, labour costs, and other necessary charges. An invoice/cost sheet is prepared manually in PDF or hard copy format. The final output includes the BOQ, cost estimates, and the invoice. However, the conventional approach might take much time and effort, and manual calculations may result in errors in case of incorrect measurement/quantities.

V. PROPOSED SYSTEM

The suggested system uses computer-based methods for planning, analysis, and structural design of an extension block of G+4 level for an already existing school building through the use of software called STAAD.Pro. First, the architectural drawing of the structure is done according to the needs of the school building in terms of rooms, dimensions of the building, and arrangement of grid systems. The next step is making a three-dimensional structural model using STAAD.Pro.

Dead loads, live loads, wall loads, etc. are calculated and distributed as per Indian Standard Codes. Structural analysis is done to get support reactions, bending moments, shear force, axial force, displacement, and other structural information. This is used to design beams, columns, slabs, and foundations as per IS 456 code and other related codes.

Design calculations are then checked and structural drawings, structural analysis, bar bending schedule, and project report are prepared. Existing structure along with its foundations should also be analyzed to check the suitability for the new extension.

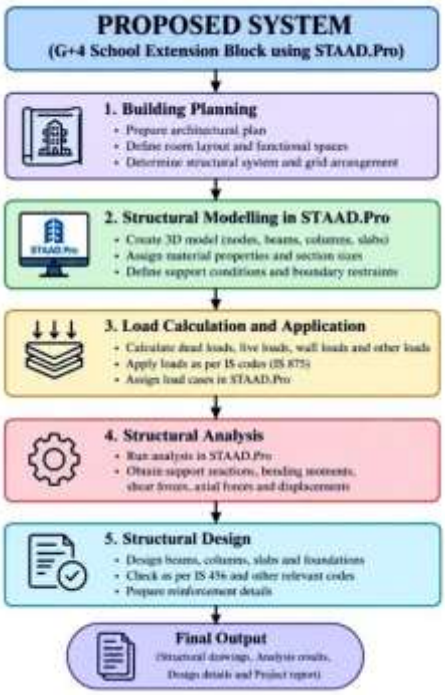


Fig.3. Proposed System

VI. RESULTS AND DISCUSSION

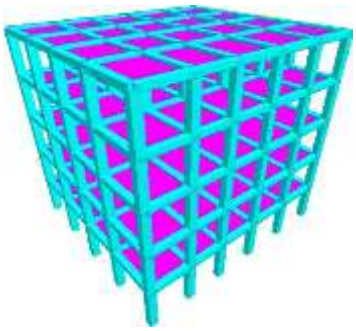


Fig.4. Rendering View



Fig.5. Result



The output results of the structural analysis done through STAAD.Pro software were used in designing the various main structural elements of the school building. The bending moment and shear force output values were used in determining the necessary reinforcement for the beams. The output values for slab design were used in determining the necessary reinforcement. The output results for the forces acting on the structure were used in designing the columns. The output results of the column loads and soil bearing capacity were used in the design of footings. The results generated in this study will provide insight into the behavior of the RCC structure under the applied load. This study was done in compliance with the Indian Standard codes of practice.

VII. CONCLUSION

The current project deals with the planning, analysis, and structural design of a G+4 extension block of an existing school building through STAAD.Pro. The proposed methodology consists of planning of the building, structural modeling, calculation of loads, analysis of the structure, and designing of members. STAAD.Pro is a useful tool for modeling the structure and analyzing the forces and displacements generated due to the loads applied. Analysis helps to design the beams, columns, slabs, and foundations of the structure as per Indian Standards. The project shows the use of structural analysis software in the design of multi-story educational buildings. The final suitability of the extension block can be determined only after validation of the structural model, load calculations, and the safety provisions. It is vital to keep in mind that an extension to the existing school building should not be assumed to be safe merely based on the structural analysis of the new frame. The existing foundations, columns, beams, material, and suitability of the building to house the additional construction should also be determined by a structural engineer.

VII. FUTURE SCOPE

The below improvements can be considered for future work:

1. The detailed analysis of the current building along with its foundation system.
2. The evaluation of the loads due to earthquakes and other environmental loads.
3. The comparison between manual calculations and STAAD.Pro.
4. Dimensions of beam and column optimization according to design requirements.
5. Preparing the reinforcement drawing.
6. Further analysis of the interaction of the existing building and the new addition.

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