iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL
FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 Issue: V Month of publication: May 2026

DOI: https://doi.org/10.22214/ijraset.2026.83299

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

Structural Analysis and 3D Modelling of G+5 Storey RCC Building

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Abstract: Rapid urbanization and population growth have increased the demand for safe, economical, and structurally efficient multi-storey residential buildings. Structural analysis plays a major role in ensuring the safety and serviceability of reinforced concrete structures subjected to various loading conditions. This research presents the structural analysis, three-dimensional modelling, and fabrication of a G+5 storey reinforced cement concrete residential building. The structural analysis was carried out using STAAD.Pro software in accordance with Indian Standard codes such as IS 456:2000, IS 875, and IS 1893:2016. Dead load, live load, and seismic load were considered during analysis. The building consists of RCC beams, columns, slabs, and isolated footings designed to withstand gravity and lateral forces. A three-dimensional model was developed using SketchUp software to improve visualization and understanding of the building geometry. The digital model was converted into STL format and fabricated using Flash Forge Dreamer NX 3D printer through additive manufacturing technology. The use of 3D printing enhanced project presentation, visualization, and structural understanding. The analysis results indicated that the proposed structure remained stable under the applied loading conditions and satisfied strength and serviceability requirements. The fabricated model was successfully produced using PLA filament through Fused Deposition Modeling (FDM) technology. The integration of structural analysis, digital modelling, and physical fabrication provides an effective approach for educational, visualization, and engineering applications in civil engineering projects.
***Keywords*: RCC Building, Structural Analysis, STAAD.Pro, SketchUp, 3D Printing, Dreamer NX, Residential Building, Fabrication.**

I. INTRODUCTION

The construction industry has witnessed rapid development due to increasing urbanization and population growth. Multi-storey reinforced concrete buildings are widely used in urban regions because of their durability, strength, economy, and architectural flexibility. Structural analysis and design are important processes that ensure the safety, stability, and serviceability of buildings subjected to different loading conditions such as dead loads, live loads, wind loads, and seismic forces.

Reinforced cement concrete structures are preferred in modern construction due to their ability to resist compressive and tensile stresses effectively. Proper structural analysis helps engineers determine internal forces, bending moments, shear forces, and displacements occurring in structural members. In recent years, computer-aided structural analysis software such as STAAD.Pro has become an essential tool in civil engineering for accurate analysis and efficient design of structures.

Three-dimensional modeling is another important aspect of modern civil engineering projects. Digital modeling software such as SketchUp helps engineers and designers visualize building geometry, architectural layout, and structural arrangement before actual construction. Three-dimensional visualization improves communication, planning, and project presentation.

Additive manufacturing or 3D printing technology has emerged as an innovative method for physical fabrication of engineering models. The use of 3D printing in civil engineering enables fabrication of scaled models for educational, research, and presentation purposes. Physical models help improve understanding of structural behaviour and architectural arrangement. The integration of structural analysis, digital modeling, and 3D printing provides a modern approach for engineering visualization and learning.

This project focuses on the structural analysis, three-dimensional modeling, and fabrication of a G+5 storey RCC residential building. The building was analyzed using STAAD.Pro software according to relevant Indian Standard codes. A detailed three-dimensional model was created using SketchUp software, and the model was fabricated using FlashForge Dreamer NX 3D printer. The project demonstrates the application of modern software tools and additive manufacturing technology in civil engineering projects.

Fig. 1 Three-dimensional view of the proposed G+5 RCC residential building developed using SketchUp software.

II. LITERATURE REVIEW

Several researchers have carried out studies related to structural analysis, RCC building design, and 3D printing technology in civil engineering applications.

SL. No	Author & Year	Title of Study	Key Findings	Research Gap
1	Patil & Kumbhar (2013)	Analysis and Design of Multi-Storey RCC Building Using STAAD.Pro	Demonstrated that STAAD.Pro provides accurate structural analysis and reduces manual calculation errors. Improved efficiency in RCC building design.	Study focused only on structural analysis and did not consider 3D modeling or physical fabrication techniques.
2	Sharma & Gupta (2015)	Seismic Analysis of RCC Framed Structures	Evaluated structural performance under earthquake loading conditions and improved understanding of seismic resistance.	No digital visualization or fabrication methodology was incorporated.
3	Kumar & Singh (2016)	Structural Analysis of G+5 RCC Residential Building	Investigated behavior of beams, columns, and slabs under different loading conditions. Structural safety requirements were satisfied.	Lack of 3D modeling and physical representation of the structure.
4	Reddy & Rao (2017)	Dynamic Analysis of Multi-Storey Buildings	Studied dynamic response and vibration characteristics of RCC structures. Optimized member design improved structural efficiency.	Did not include digital modeling or additive manufacturing applications.
5	Sarkar et al. (2018)	Application of SketchUp in Building Visualization	Demonstrated that 3D modeling improves visualization, planning, and communication of engineering projects	Structural analysis and fabrication aspects were not considered.
6	Mehta & Jain (2019)	Applications of 3D Printing inCivil Engineering	Highlighted the effectiveness of additive manufacturing in producing engineering models and improving presentation quality.	No structural design verification or analysis was performed.
7	Pandey & Verma (2020)	Seismic Response of RCC Buildings in Zone IV	Examined displacement and structural response under seismic loading. Improved understanding	Digital modeling and 3D fabrication techniques were not

			of earthquake-resistant design.	integrated.
8	Chaudhary & Mishra (2021)	Digital Fabrication Techniques for Civil Engineering	Demonstrated the educational benefits of fabricated structural models using modern manufacturing techniques.	Limited focus on structural analysis and design calculations
9	Khan & Ali (2022)	Structural Analysis of RCC Buildings Using STAAD.Pro	Showed that software-assisted structural analysis improves design reliability and load distribution assessment.	No integration of visualization and 3D printing technologies
10	Shrestha & Rai (2023)	Educational Applications of 3D Printed Building Models	Found that physical models enhance understanding of structural systems and improve learning outcomes.	Structural analysis and digital modeling were not fully integrated

Research Gap

Previous studies have primarily focused on either structural analysis, three-dimensional modeling, or additive manufacturing individually. Very few researchers have attempted to integrate structural analysis using STAAD.Pro, digital visualization through SketchUp, and physical model fabrication using 3D printing technology. Therefore, the present study aims to bridge this gap by combining all three approaches into a single framework for the analysis, visualization, and fabrication of a G+5 storey RCC residential building.

III. OBJECTIVES OF THE STUDY

The primary objective of this study is to analyze, model, and fabricate a G+5 storey RCC residential building using modern engineering software and additive manufacturing technology.

The specific objectives are as follows:

1) To perform structural analysis of a G+5 RCC residential building using STAAD.Pro software.
2) To evaluate the behavior of beams, columns, slabs, and foundations under various loading conditions.
3) To study the seismic response of the building in accordance with IS 1893:2016 provisions.
4) To develop an accurate three-dimensional model of the building using SketchUp software.
5) To convert the digital model into STL format suitable for additive manufacturing.
6) To fabricate a scaled physical model using FlashForge Dreamer NX 3D printer.
7) To improve visualization and understanding of structural systems through physical model representation.
8) To demonstrate the integration of structural analysis, digital modeling, and 3D printing technology in civil engineering applications.

IV. METHODOLOGY

The methodology adopted for this project includes structural analysis, digital modeling, and fabrication processes.

Initially, architectural planning and building dimensions were finalized. Structural parameters such as beam size, column size, slab thickness, concrete grade, and steel grade were selected according to Indian Standard recommendations. The structural model was developed in STAAD.Pro software.

Dead loads, live loads, and seismic loads were applied according to IS 875 and IS 1893:2016. Structural analysis was performed to determine internal forces, bending moments, shear forces, and displacements.

A three-dimensional model of the building was developed using SketchUp software. The model included balconies, staircases, parking areas, and rooftop structures. The SketchUp model was exported into STL format for additive manufacturing.

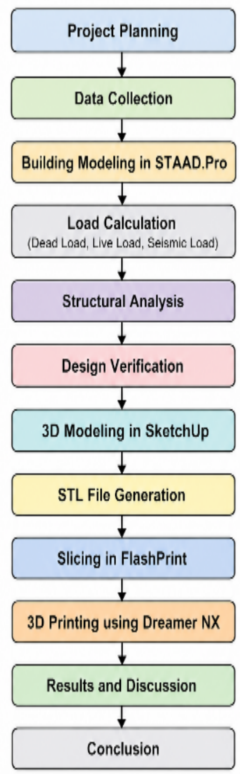

Fig. 2 Methodology adopted for structural analysis, 3D modeling and fabrication of the G+5 RCC residential building.

The STL model was sliced using FlashPrint software. Printing parameters such as layer height, nozzle diameter, print speed, and support settings were adjusted according to fabrication requirements. Finally, the building model was fabricated using FlashForge Dreamer NX 3D printer with PLA filament.

V. BUILDING DESCRIPTION

The proposed structure is a G+5 storey RCC residential building having plan dimensions of 24 m × 16 m. The building consists of reinforced concrete beams, columns, slabs, and isolated footings. The structure was designed for residential occupancy and includes parking spaces at the ground level.

The building consists of six floors including the ground floor. The typical floor height was considered as 3 m. The total structural height of the building was approximately 18 m. The structure was analyzed under gravity and seismic loading conditions.

The following parameters were considered during analysis and design:

Concrete Grade: M25

Steel Grade: Fe415

Slab Thickness: 150 mm

Column Size: 600 mm × 460 mm

Beam Size: 460 mm × 600 mm

Foundation Type: Isolated Footing

Seismic Zone: Zone IV

Soil Type: Medium Soil

The structural system consists of reinforced concrete frames capable of resisting vertical and lateral loads effectively.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
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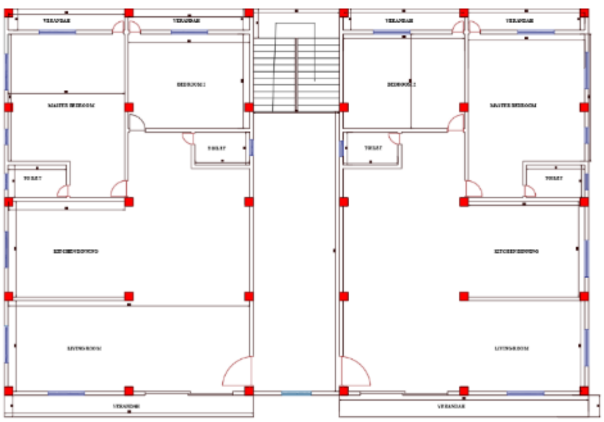
Table I. Building Parameters

Parameter	Value
Building Type	Residential
Number of Storeys	G+5
Building Length	24 m
Building Width	16 m
Concrete Grade	M25
Steel Grade	Fe415
Slab Thickness	150 mm
Column Size	600 mm × 460 mm
Beam Size	460 mm × 600 mm
Foundation Type	Isolated Footing
Soil Type	Medium Soil
Seismic Zone	Zone IV



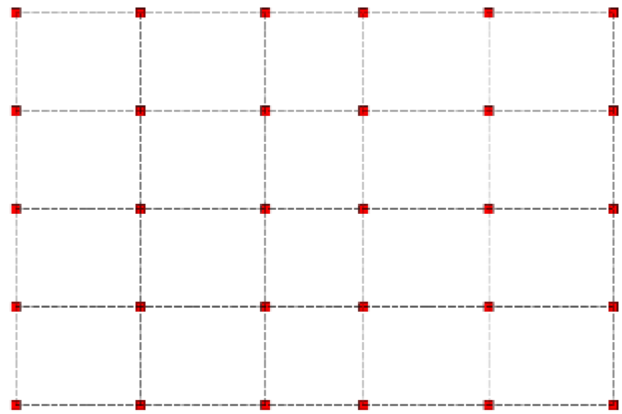


Fig. 3 Architectural Floor PlanFig. 4 Column Layout

Fig. 5 Building Elevation

VI. STRUCTURAL ANALYSIS USING STAAD.PRO

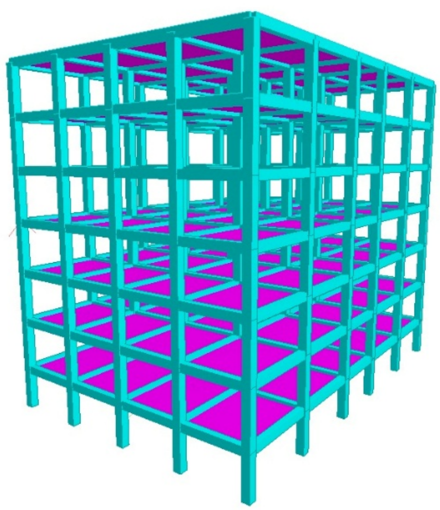
The structural analysis of the proposed G+5 RCC residential building was carried out using STAAD.Pro software. The building was modeled as a three-dimensional reinforced concrete frame structure consisting of beams, columns, slabs, and isolated footings. The software was utilized to evaluate the structural behavior of the building under various loading conditions and to ensure compliance with relevant Indian Standard codes.

The structural model was developed based on the architectural layout and building dimensions. Material properties corresponding to M25 grade concrete and Fe415 grade reinforcement steel were assigned to the structural members. The support conditions were defined as isolated footings resting on medium soil conditions.

Dead loads, live loads, and seismic loads were considered during the analysis. The dead load included the self-weight of structural components along with additional floor loads, while the live load represented occupancy loads acting on the building. Seismic analysis was performed according to IS 1893:2016 considering Zone IV conditions.

The analysis was carried out to determine internal forces, shear forces, bending moments, and structural response under applied loading conditions. The generated diagrams assisted in identifying critical regions of the structure and evaluating member performance.

Fig. 6 – 3D Rendered STAAD.Pro ModelFig. 7 – Support Conditions and Foundation Layout



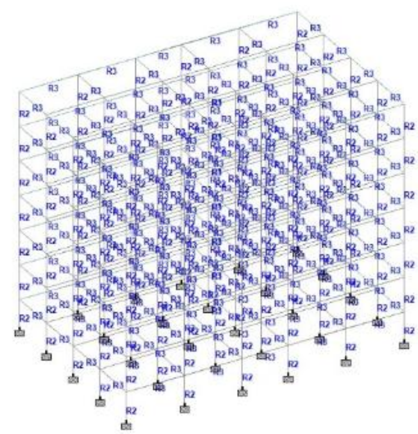
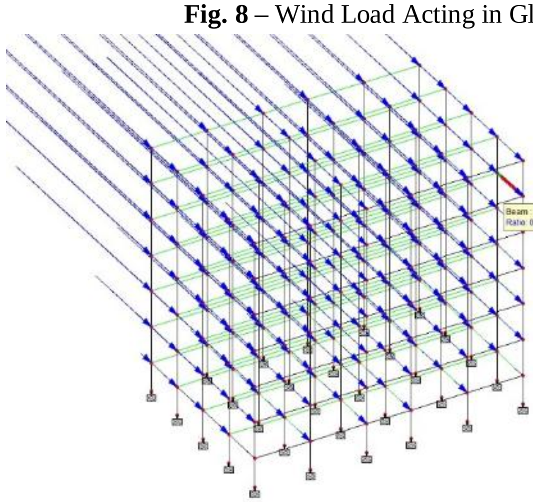


Fig. 8 – Wind Load Acting in Global X-DirectionFig. 9 – Wind Load Acting in Global Z-Direction



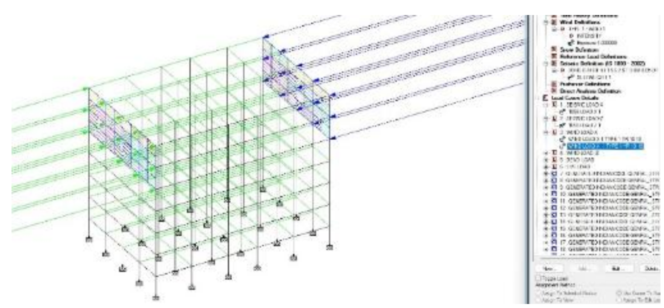


Fig. 10 – Live Load Assignment on Floor Slabs

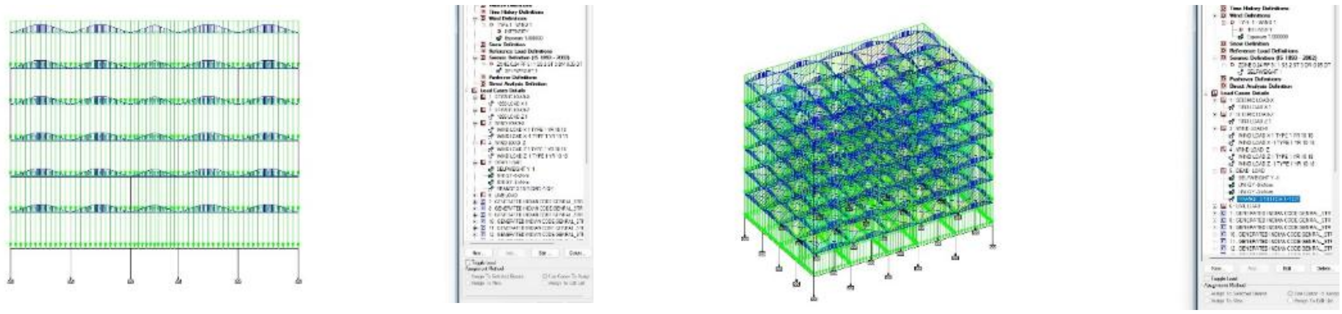
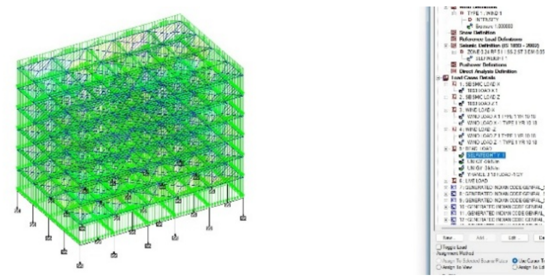
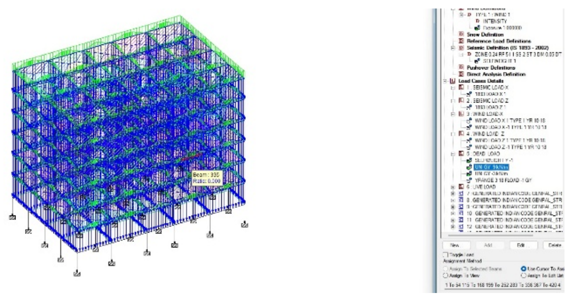


Fig. 11 – Dead Load Assignment on Slabs and Beams

1) *Self-Weight*



2) *UNI GY -9 kN/m*



3) *UNI GY -3 kN/m*

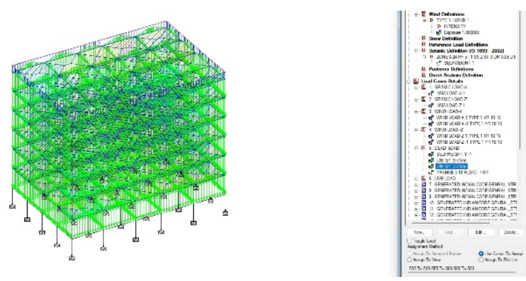


Table II. Structural Modeling Parameters

Parameter	Value
Building Type	G+5 RCC Residential Building
Analysis Software	STAAD.Pro CONNECT Edition
Structural System	RCC Moment Resisting Frame
Concrete Grade	M25
Steel Grade	Fe415
Foundation Type	Isolated Footing
Slab Thickness	150 mm
Column Size	600 mm × 460 mm
Beam Size	460 mm × 600 mm

Storey Height	3.0 m (Approx.)
Number of Floors	Ground + 5 Floors

Table III. Loading Parameters Used in Analysis

Load Type	Value
Self Weight	Automatically Calculated
Floor Finish Load	3 kN/m²
Dead Load	9 kN/m²
Live Load	3 kN/m²
Wind Load X	As per IS 875 (Part 3)
Wind Load Z	As per IS 875 (Part 3)
Seismic Zone	Zone IV
Zone Factor (Z)	0.24
Importance Factor (I)	1.0
Response Reduction Factor (R)	5.0
Soil Type	Medium Soil

Fig. 12 Maximum Nodal Displacement Diagram

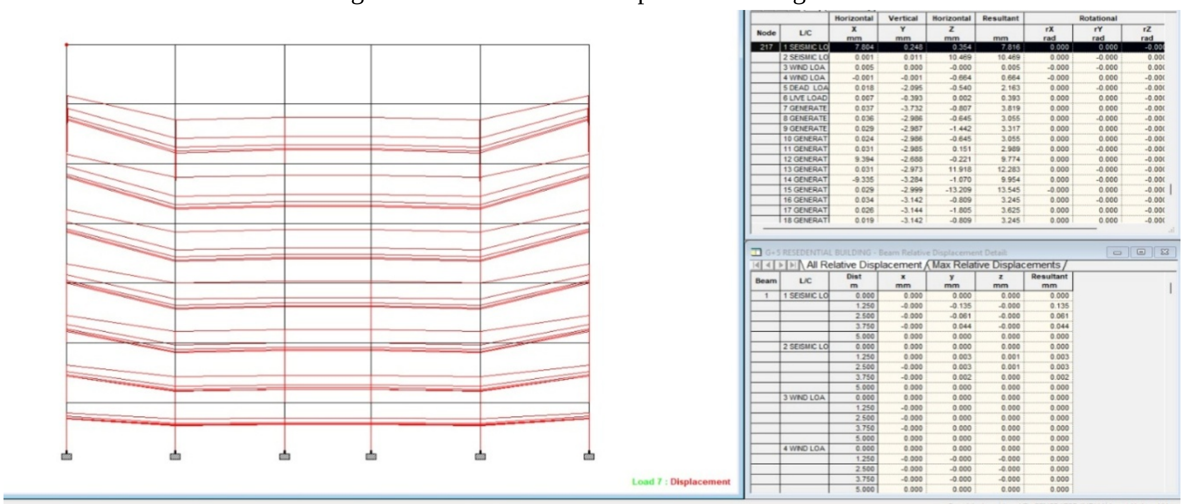


Fig. 13 Shear Force Diagram

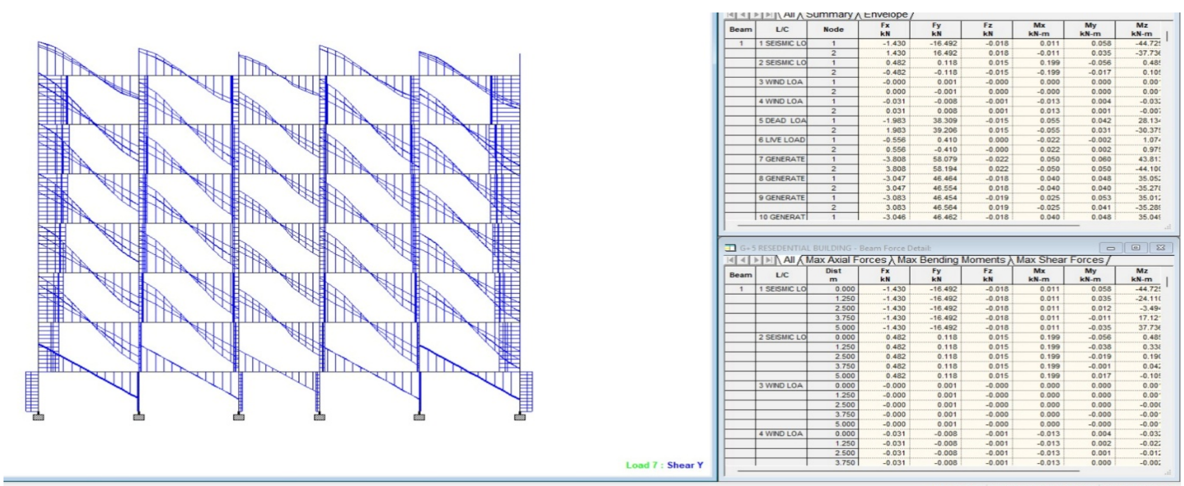


Fig. 14 Bending Moment Diagram

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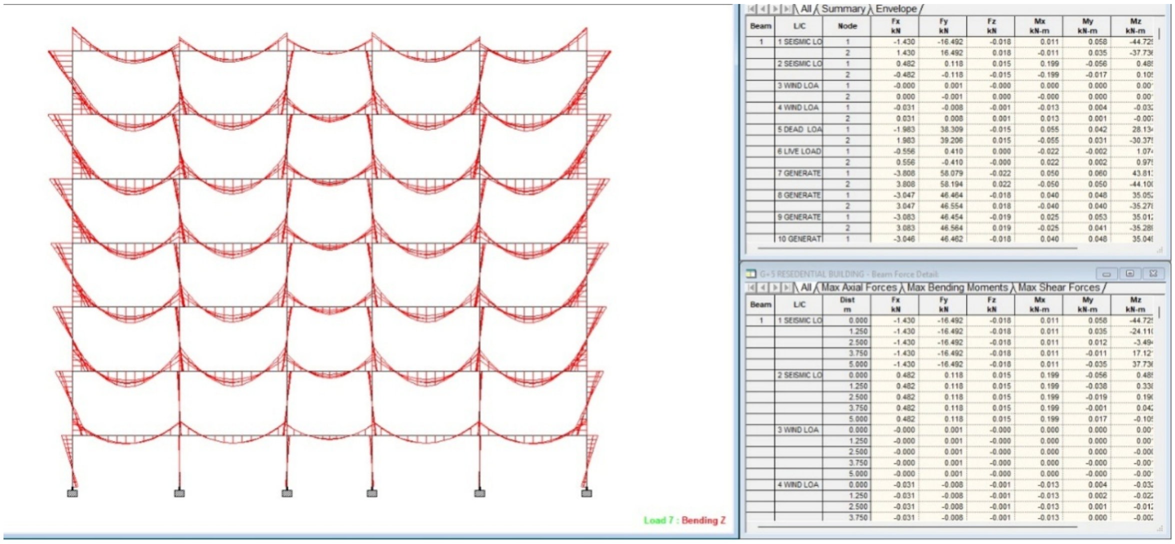

Table IV. Structural Analysis Results

Parameter	Observation
Structural Stability	Satisfactory
Load Transfer Mechanism	Uniform
Maximum Displacement	Within Permissible Limit
Shear Force Distribution	Higher Near Supports
Bending Moment Distribution	Maximum at Beam Mid-Spans
Wind Load Performance	Stable
Seismic Response	Acceptable
Foundation Behavior	Safe Under Applied Loads
Overall Structural Performance	Safe and Stable

VII. 3D MODELING USING SKETCHUP

Three-dimensional modeling plays a significant role in modern civil engineering projects by providing realistic visualization of structural and architectural components. In the present study, SketchUp software was used to develop a detailed three-dimensional model of the proposed G+5 storey RCC residential building.

The model was prepared based on the architectural layout and structural configuration of the building. Various structural and architectural elements such as columns, beams, slabs, balconies, staircases, windows, entrance gates, boundary walls, parking spaces, and rooftop structures were incorporated into the model. The use of SketchUp enabled accurate representation of the building geometry and improved understanding of the overall structural arrangement.

The three-dimensional model served as a visualization tool for evaluating the appearance and spatial relationships of different building components. The digital model also facilitated communication of design concepts and enhanced project presentation quality.

After completion of the modeling process, the SketchUp model was exported into STL format for additive manufacturing. The exported file was further processed using FlashPrint slicing software before fabrication using the FlashForge Dreamer NX 3D printer. The integration of SketchUp modeling with 3D printing technology significantly improved the practical understanding of the project and demonstrated the usefulness of digital modeling in civil engineering applications.

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Fig. 15 SketchUp 3D Model

Table V. Software Used in the Project

Software	Purpose
AutoCAD	Architectural Drafting
STAAD.Pro	Structural Analysis
SketchUp	3D Modeling
FlashPrint	Slicing and G-Code Generation
Dreamer NX	3D Printing and Fabrication

VIII. 3D PRINTING AND FABRICATION

The three-dimensional model of the proposed G+5 RCC residential building was fabricated using FlashForge Dreamer NX 3D printer. The model developed in SketchUp software was exported into STL format and prepared for additive manufacturing. The STL file was imported into FlashPrint slicing software, where printing parameters such as layer height, infill density, print speed, and support settings were adjusted. After slicing, a G-code file was generated and transferred to the printer.

The fabrication process was carried out using Fused Deposition Modeling (FDM) technology with PLA filament material. The printer deposited molten material layer by layer until the complete building model was formed. The fabricated model provided a realistic representation of the structural and architectural features of the building and improved project visualization and presentation

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Table VI. Dreamer NX Printing Specifications

Parameter	Values
Nozzle Diameter	0.4 mm
Technology	FDM
Layer Height	0.2 mm
Material	PLA
Build Volume	200 × 200 × 200 mm

Printing Process:

- STL File Generation
- Model Slicing in FlashPrint
- G-Code Generation
- 3D Printing
- Post-Processing and Finishing

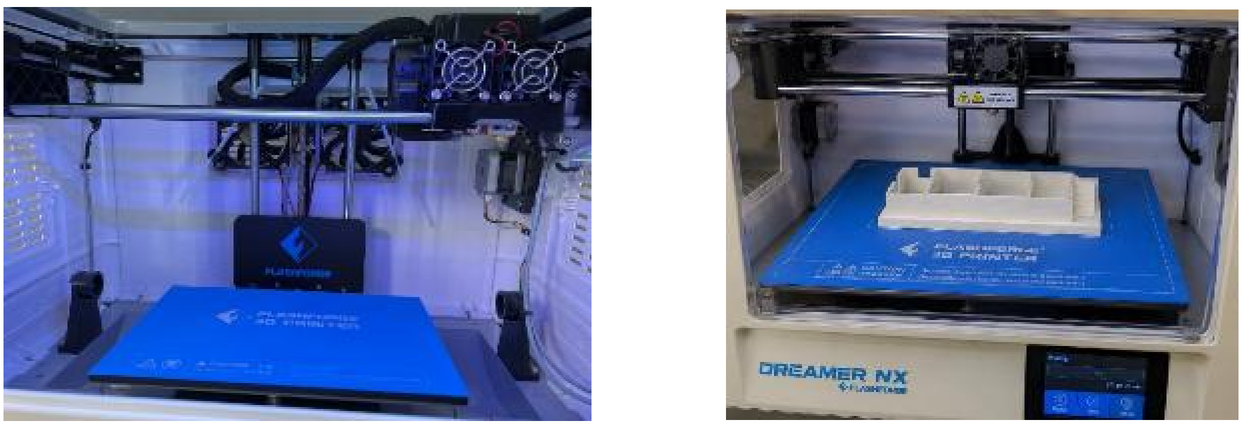

Fig. 163D Printing and Fabrication Process

IX. RESULTS AND DISCUSSION

The structural analysis results indicated that the G+5 RCC residential building remained stable under applied loading conditions. The displacement values obtained from STAAD.Pro were within permissible limits specified by Indian Standard codes.

Bending moment and shear force diagrams demonstrated effective load transfer through beams and columns. The structural members were capable of resisting gravity and seismic forces safely.

The three-dimensional SketchUp model improved understanding of building geometry and spatial arrangement. The use of digital modeling enhanced architectural visualization and project communication.

The FlashForge Dreamer NX printer successfully fabricated the physical model of the building. The printed model accurately represented structural and architectural features of the proposed structure. The integration of structural analysis, digital modeling, and additive manufacturing proved effective for educational and presentation purposes.

The project demonstrated that modern engineering software and fabrication technologies can significantly improve structural visualization, project presentation, and learning outcomes in civil engineering education.

The successful fabrication of the physical model further validated the effectiveness of integrating structural analysis, digital modeling, and additive manufacturing techniques in engineering projects.

Table VII. Structural Performance Summary

Parameter	Observation
Structural Stability	Satisfactory
Load Transfer	Uniform
Seismic Response	Acceptable

Fabrication Accuracy	Good
Visualization Quality	Excellent

X. CONCLUSION

1) Structural analysis of the G+5 RCC residential building was successfully performed using STAAD.Pro software.
2) The building exhibited satisfactory performance under dead load, live load, and seismic load conditions.
3) Three-dimensional modeling using SketchUp improved visualization and understanding of the structural system.
4) The building model was successfully fabricated using FlashForge Dreamer NX 3D printer.
5) Additive manufacturing enhanced project presentation and educational understanding.
6) The integration of structural analysis, 3D modeling, and fabrication proved effective for civil engineering applications.

XI. FUTURE SCOPE

1) Integration of Building Information Modeling (BIM) with structural analysis.
2) Development of smart and sustainable building systems.
3) Large-scale 3D printing applications in construction projects.
4) Use of eco-friendly and sustainable construction materials.
5) Application of Artificial Intelligence for automated structural design and optimization.

XII. ACKNOWLEDGMENT

The authors express their sincere gratitude to the Department of Civil Engineering, Centre for Computers and Communication Technology (CCCT), Chisopani, Namchi, Sikkim, for providing the academic environment, resources, and facilities necessary for the successful completion of this project. The authors are deeply thankful to the faculty members of the department for their continuous encouragement, valuable suggestions, and technical support throughout the study.

The authors would like to convey their heartfelt appreciation to Mr. Aniket Mukhia, Project Guide, for his constant guidance, constructive feedback, motivation, and expert supervision during every stage of the project. His valuable insights and encouragement played a significant role in the successful completion of this work.

The authors also acknowledge the support provided by the ATL Laboratory and Sadam Senior Secondary School for granting access to the FlashForge Dreamer NX 3D printer and related fabrication facilities. The opportunity to utilize advanced manufacturing equipment greatly contributed to the practical implementation and visualization of the project.

Special thanks are extended to the management and staff members of CCCT Chisopani for their cooperation and support. The authors are also grateful to their friends, classmates, and well-wishers who provided assistance and encouragement throughout the project duration.

Finally, the authors express their sincere gratitude to their parents and family members for their unwavering support, motivation, and encouragement, which helped them successfully complete this project. Their continuous belief and support served as a source of inspiration throughout the research work.

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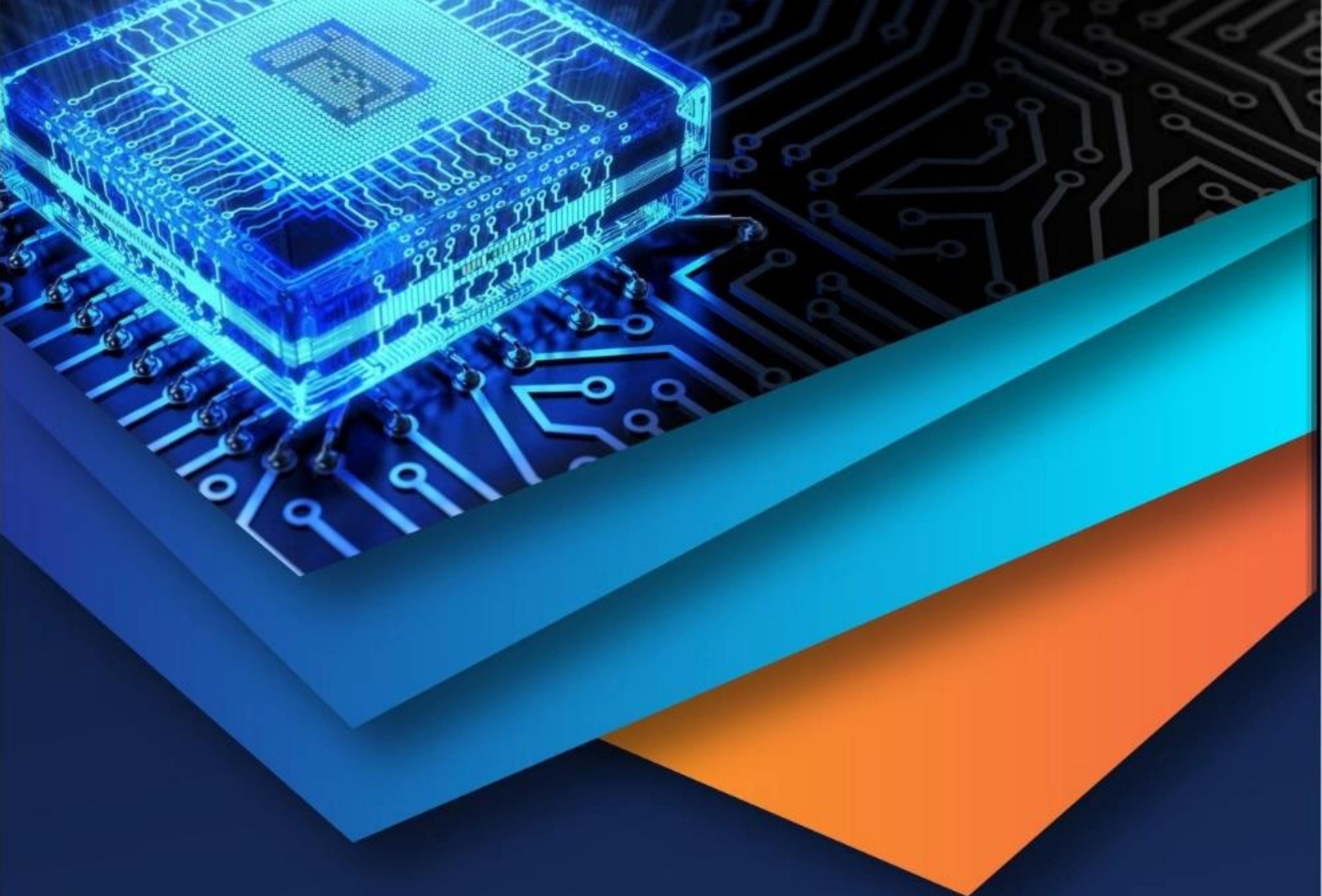

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