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INTEGRATED DESIGN AND 3D MODELING OF A G+4 MULTISTOREY BUILDING USING AUTOCAD, REVIT, STAAD PRO, AND BIM TECHNOLOGIES

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Abstract
This study leverages AutoCAD, Revit, STAAD Pro and BIM technologies to provide a comprehensive approach to the planning, design, and 3D modeling of a G+4 multistory residential and commercial building. Beginning with architectural planning and schematic design in AutoCAD, the project integrates structural components to ensure compliance with IS 1893-2000 for seismic loads and IS 875 for wind loads through detailed load analysis and member design in STAAD Pro. The integration of Revit and BIM facilitates collaboration and real-time visualization, enhancing efficiency and communication. This integrated approach demonstrates the project's commitment to creating efficient, stable, and flexible structures using modern civil engineering techniques.

Keywords:
Multistorey Building, AutoCAD, Revit, STAAD Pro, BIM Technology, Structural Design.

1. Introduction

Building construction is a branch of engineering that deals with designing and constructing structures, predominantly residential buildings. Throughout history, people have sought refuge in natural structures and gradually advanced to constructing intricate dwellings. Buildings serve as a measure of social advancement, as individuals spend most of their lives in residences. Ensuring safe and well-organized housing demonstrates a commitment to community welfare and societal progress. Contemporary building methods strive to provide cost-effective and streamlined housing solutions that fulfill the requirements of the community. Engineers and architects are responsible for the design and planning of buildings, while draughtsmen create the required drawings under their supervision.

Construction software has revolutionized the industry by streamlining project management, scheduling, budgeting, and collaboration. Key tools include AutoCAD, which is widely used for creating precise 2D and 3D technical drawings in various industries, and STAAD Pro, which is utilized for structural analysis and design, enabling engineers to analyze and design buildings, bridges, and other structures. Building Information Modelling (BIM) facilitates the creation and management of digital models, enhancing design accuracy, stakeholder collaboration, and project efficiency. Revit, a BIM software by Autodesk tailored for architects, engineers, and building professionals, allows users to design, model, simulate, and document building projects within a single software environment. These tools optimize timelines, resource allocation, and decision-making, enabling teams to deliver projects on time, within budget, and to high standards.

Various studies have been carried out on the design and analysis of multi-storeyed buildings using advanced software tools.[1] focuses on the design and analysis of a G+6 residential building using STAAD Pro for load analysis, ensuring compliance with building codes. Examines [2] a G+14 building integrating residential and commercial spaces, using AutoCAD and Revit for precise design

and material estimation. Aanalyzes [3] a G+12 RCC structure's seismic resistance across different zones using STAAD Pro, highlighting its effectiveness in seismic analysis. Conducts[4] a comparative study on a G+15 building in Zone IV, focusing on shear wall placement and its impact on structural parameters. Studies[5] a G+14 residential building using STAAD Pro for load analysis, emphasizing the software's data-sharing capabilities with AutoCAD.[6] present designs and analyses of a multi-storey building using STAAD Pro, detailing the calculation and application of various loads. [7]compared response spectrum and time history analysis methods for an 8-storey building with and without bracings and shear walls. [8] analyzes a G+5 building in Hyderabad using STAAD Pro, including the design of key structural elements and soil bearing capacity tests.[9] discuss the structural analysis of a Basement with G+2 building, focusing on load calculations and material properties.
Further studies include [10]exploring computer-aided design of residential buildings using STAAD Pro, comparing software analysis results with traditional calculations. Evaluate[11] and plan a G+2 building using STAAD Pro's limit state technique, comparing 2-D frame results with physical calculations for accuracy.[12] conduct a study on modeled structures subjected to various loads using STAAD Pro, emphasizing the importance of finite element analysis for dynamic loads like wind and earthquakes. [13] address land scarcity issues by designing multi-storey buildings using STAAD Pro and AutoCAD, showcasing efficient and accurate structural modeling.[14] used STAAD Pro and limit state technique to design and analyze a G+30 multi-storey structure. The software's easy-to-use interface allowed load values and dimensions to be entered to create reinforced concrete (RCC) frames. The study started with two-dimensional frames and progressed to multi-storeyed 2-D and 3-D frames under varying loads. [15]designed a G+5 multistory skyscraper. The project created 3-D models in Revit and AutoCAD 2014. STAAD Pro was used for structural analysis and design, and IS 456-2000[16] limit state design was used to verify findings against chosen members. These studies highlight the integration of software tools like STAAD Pro, AutoCAD, and Revit in enhancing the efficiency, accuracy, and safety of building design and analysis.
This study aims to comprehensively study the planning, architectural design, structural analysis, and 3D modeling of a G+4 residential and commercial building using advanced software tools. The objectives of the present study are to create detailed architectural plans using AutoCAD, ensuring compliance with local building codes. Structural analysis will be carried out using STAAD Pro to assess the building's stability, strength, and load-bearing capacity under various loads. The structural design of columns, beams, slabs, and foundations will be performed with STAAD Pro, optimizing for safety, performance, and cost. Design integration will utilize AutoCAD and STAAD Pro to synchronize architectural and structural drawings for a unified plan. A detailed 3D model will be created using Revit for visualization and simulation purposes. Enhancing sustainability, resilience, and performance through optimized design parameters will also be a key focus. This integrated approach demonstrates the project's commitment to creating efficient, stable, and flexible structures using modern civil engineering techniques.

2.Methodology

The study provides a detailed examination of the integrated design process for the building structure. This process begins with AutoCAD, which serves as the fundamental basis for structural planning. At this stage, great care is taken to create a detailed plan that clearly defines the design and purpose of the structure.
STAAD Pro plays a crucial role in converting these abstract concepts into comprehensive technical blueprints. It enables the improvement and fine-tuning of structural elements to comply with demanding technical criteria and requirements. This software allows for detailed analysis and design of structural components, ensuring they meet the necessary standards for safety and stability.
As the design progresses, Revit is employed to convert two-dimensional designs into a dynamic three-dimensional model. Revit's sophisticated functionalities actualize the architectural concept, offering

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stakeholders an interactive depiction of the final building design. This 3D modeling provides a realistic view of the structure, enabling better visualization and decision-making.
The seamless integration of AutoCAD, STAAD Pro, and Revit ensures the combination of structural stability and exceptional design throughout the entire process. This combination of precise engineering and aesthetic appeal results in a building that represents innovation and high quality. Figure 1 displays a flow chart that depicts the successive operations of the design stages. The following sections provide an elaborate explanation of every stage in this process, illustrating how each tool contributes to the overall methodology and the successful realization of the building project.

Site analysis

The site analysis section provides a detailed examination of the integrated design process for the building structure, beginning with a thorough understanding of the site using various tools and techniques. This process starts with AutoCAD, which serves as the fundamental basis for structural planning and site layout. At this stage, great care is taken to create a detailed plan that clearly defines the site characteristics, design, and purpose of the structure.

Drawing the plan and column marking in AutoCAD

Creating a plan and marking columns in AutoCAD involves several key steps. First, prepare your drawing by launching AutoCAD, setting up the environment, and choosing the appropriate units. Next, draw the plan using commands like "Line," "Rectangle," "Offset," "Trim," and "Extend" to outline the building, including walls, doors, windows, and other elements, and add dimensions and annotations for clarity. Identify where columns will be placed in your design, then draw them accurately using simple rectangles or advanced tools. Mark each column by adding text labels, symbols, or blocks with the "Text" command. Finally, use the "Dimension" command to add precise measurements for columns and other elements, strategically placing dimension lines for clarity (Figure 2).

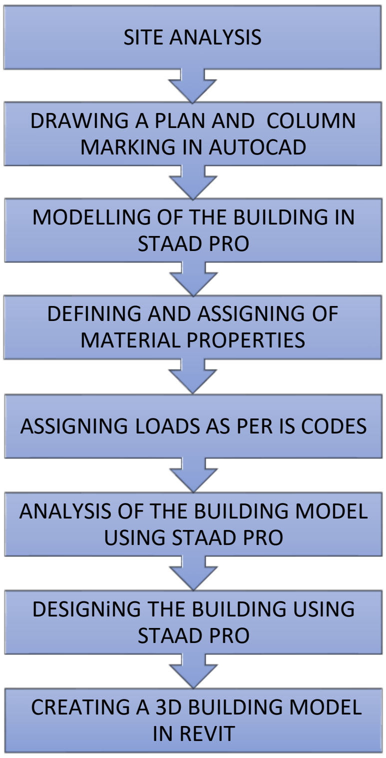

Fig. 1 Methodology Flow chart

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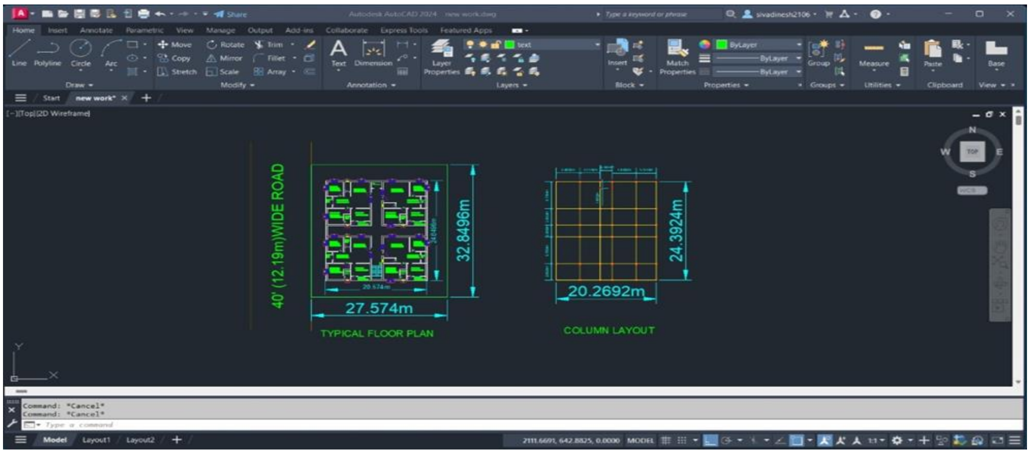

Fig. 2 Plan and column marking in AutoCAD

Modelling of the building in STAAD PRO

Modelling a building in STAAD Pro involves several detailed steps to ensure accurate representation and analysis of the structure. The process begins with the creation of a new project file within STAAD Pro. Upon starting a new project, it is essential to define the units (metric or imperial) and the coordinate system to be used throughout the project.

The next step involves creating nodes, which are the points where structural elements connect. These nodes are typically defined at corners and intermediate points of the building's structure. Once the nodes are established, the structural members, such as beams, columns, and braces, are defined. This includes specifying their material properties, section properties, and orientation within the structure.

Supports are then assigned at the nodes, setting boundary conditions or supports such as fixed supports or rollers. Following this, various loads are applied to the structure. These loads can include dead loads, live loads, wind loads, snow loads, and seismic loads, and can be applied either statically or dynamically.

Load combinations are defined next, specifying how different loads interact per design codes or standards. This step is crucial for ensuring the structure can withstand various load conditions. The structural analysis is then performed to determine the building's response to the applied loads.

The results of the analysis are reviewed to assess member forces, displacements, reactions, and stresses. Based on these results, the structural members are designed to meet criteria for strength, stiffness, and serviceability. The design process includes generating comprehensive reports to document the analysis and design steps. Iteration and optimization follow, refining the design to enhance performance, efficiency, and cost-effectiveness. The final step involves completing the model for construction documentation and implementation. The final model, which is prepared for actual construction, is shown in Figure 3.

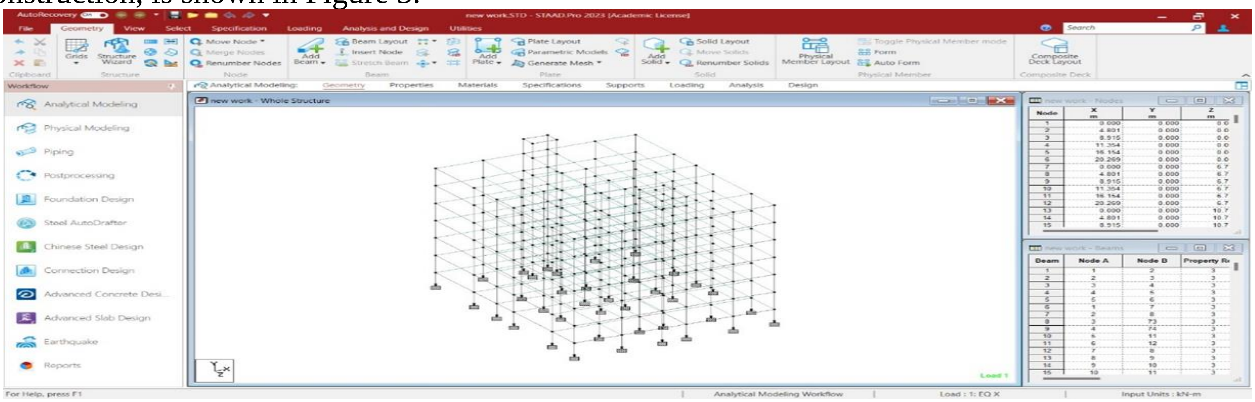

Fig. 3 Modelling a building in STAAD PRO

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Creating the 3D model in REVIT

Creating a 3D building model in Revit, as shown in Figure 4, involves a series of detailed steps to ensure a comprehensive and accurate representation of the structure.

First, set up the project by launching Revit and starting a new project with the appropriate template. This initial step establishes the foundation for all subsequent modeling activities. Next, create levels to define the building's floors and establish the vertical structure. These levels serve as reference planes for placing various architectural and structural elements.Using the Wall tool, draw the exterior walls on each level, specifying the types and dimensions to match the design requirements. Following this, add doors and windows by placing them from Revit's library or creating custom ones to fit the specific design.

Model structural elements such as columns, beams, and slabs, ensuring they align properly with the architectural elements. Insert building components like stairs, railings, ceilings, and roofs to complete the structural framework. Detail the interiors by modeling interior elements such as partitions, furniture, and fixtures, ensuring the model accurately represents the intended design. Assign materials to elements for realistic appearances using Revit's library or custom materials to enhance the visual fidelity of the model.

Add annotations, including dimensions, text, and symbols, to provide additional information and clarify the design. Create various views such as floor plans, elevations, sections, and 3D views to facilitate a comprehensive understanding of the model. Ensure all elements are properly aligned and resolve any clashes using Revit's coordination tools. Review and revise the model to verify its accuracy and make necessary adjustments. Finally, document and share the model by generating construction documentation and collaborating with team members. Use Revit's rendering tools to create high-quality visualizations of the model, providing a realistic representation of the final building design.

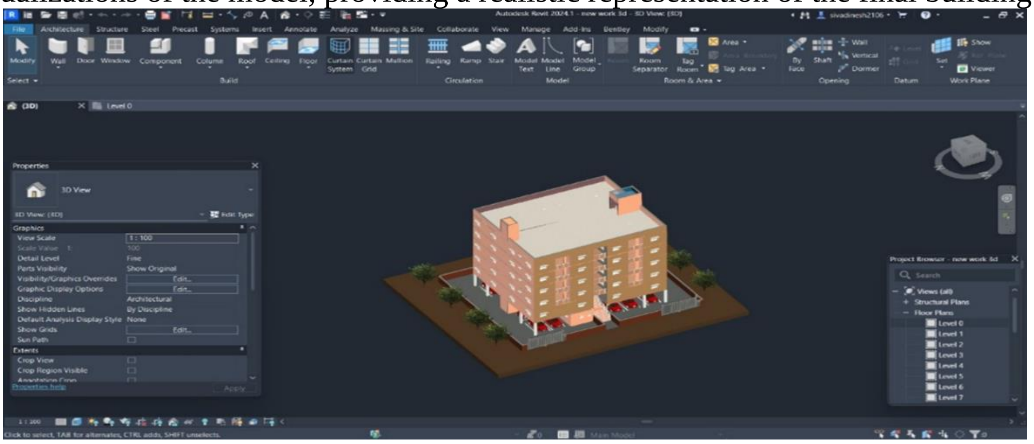

Fig. 4 D Building model in Revit

3. Details of the present study

The study offers a comprehensive analysis of the essential elements involved in the construction of a G+4 multifunctional building in Visakhapatnam, Andhra Pradesh, including both commercial and residential spaces. The first stage of the process, addressing aspects such as the identification of suitable locations, adherence to zoning restrictions, and the implementation of measures to optimize space usage. The design process is analyzed, focusing on architectural styles, structural factors, and the incorporation of facilities to fulfill both commercial and residential requirements. This study provides a thorough comprehension of the planning and design choices used in the creation of this multiuse structure.

The typical floor plan of the building is shown in Figure 5, commercial floor plan is shown in Figure 6,stilt floor plan is shown in Figure 7 and column layout is shown in Figure 8. All dimensions shown in figures are in meters.

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Building details: The material is used for construction is reinforced concrete with M-30 grade concrete and Fe-500 grade of steel.
Building Type: Residential combined with commercial Building, Location: Visakhapatnam
Type of Slab: Two-way and One-way both, Total Built-up Area: 511.2 sq.-m. (assumed 20.574m x 24.85m),Method of Analysis: Static Analysis
Material properties of the structure: Beam Sizes: 300mm x 380mm (12”X15”),Column Size: 300mm x 450mm(12”X18”),Slab Thickness: 150 mm, Number of stories: G+4,Height: 18m,Live Load: 4kN/m² for commercial purpose and 3kN/m² for residential purpose (as per IS 875 part II-2015)[17],Dead Load: Self -weight of members (as per IS 875 part I-2015)[18],Seismic Load: Calculated as per IS 1893(part I) – 2016[19].
Loads: Gravity loads, including dead, live, and snow loads, act vertically downward and are typically static. They are calculated using tributary areas to assign loads to structural elements like beams and columns. Wind forces act perpendicularly to the building surface and vary based on the building's geometry. Wind and seismic lateral loads affect the entire building, with wind pressures creating push-pull effects and seismic forces resulting from the building's dynamic response to ground motion. Flood loads are mitigated by elevating structures, while soil lateral loads affect foundation wall design. Overturning forces from lateral loads must be countered by the building's dead load and connections. Wind can simultaneously cause roof uplift and lateral loads, with dead loads potentially offsetting these forces in lower wind or seismic conditions. All load instances are tested by obtaining load factors and analyzing the building in various load combinations as per IS456. The findings are obtained and the highest load combination is chosen for the design.

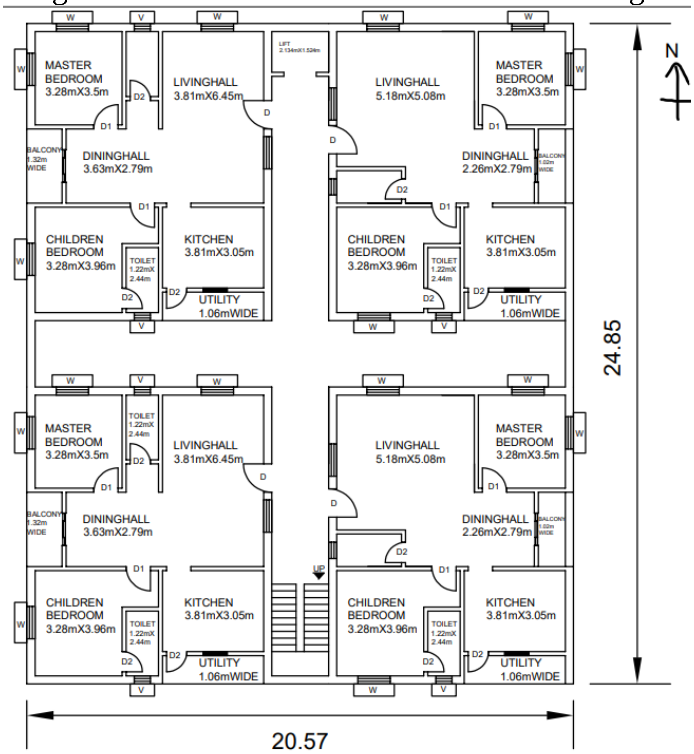

Fig. 5Typical floor plan of the designed G+4 building

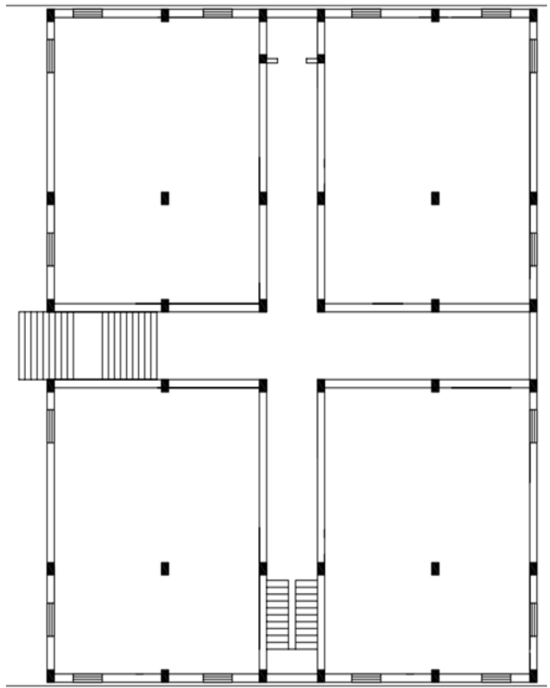

Fig. 6 Commercial floor plan (8.6m X10.6m each) of the designed G+4 building

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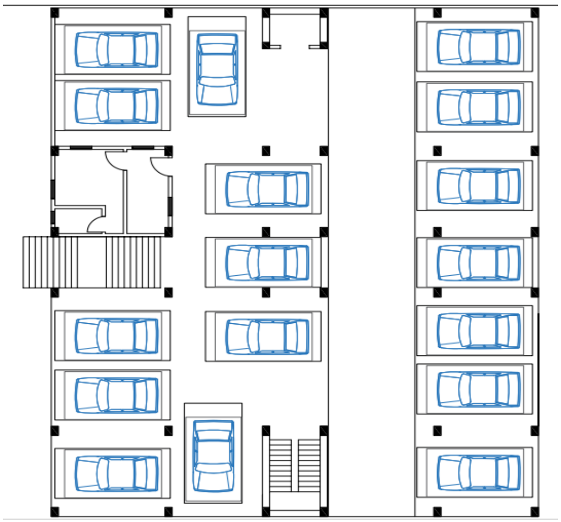

Fig. 7 Stilt floor plan (2.4m X 4.9m each)of the designed G+4 building

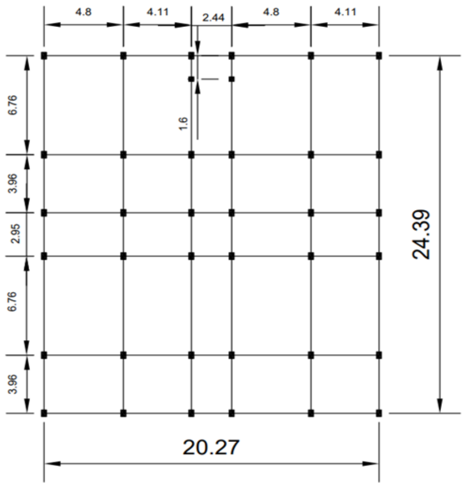

Fig. 8 Column layout of the designed G+4 building

4. Results and Discussions

The findings of the study provides more insights into the outcomes generated through AutoCAD, STAAD Pro, Revit and BIM technologies. Each tool played a crucial role in analyzing and designing structural elements, ensuring the overall efficacy of our approach.

AutoCAD was instrumental in creating detailed architectural plans that formed the foundation of our project. These plans meticulously outlined the structure's design and purpose, enabling precise drafting and modifications to meet design specifications. The comprehensive floor plans, elevations, and sections produced in AutoCAD provided a clear representation of the building's layout.

Using STAAD Pro, extensive evaluations of beams, columns, footings, and slabs were conducted. This software facilitated detailed analyses of key structural parameters such as deflection, bending moment, and shear force. These analyses were essential in verifying that structural components met stringent safety and performance standards.

Revit transformed the two-dimensional designs into dynamic three-dimensional models, offering invaluable insights into spatial vision and coordination. This 3D modeling capability allowed stakeholders to visualize the final design interactively, enhancing our understanding of spatial relationships and improving overall design quality.

The integration of BIM throughout the study enhanced collaboration and efficiency. By facilitating seamless communication among the design team, contractors, and stakeholders, BIM ensured alignment with project goals and requirements. It also improved cost estimates and scheduling accuracy, streamlining project management processes.

The study critically evaluate the effectiveness of the design decisions and their potential impact on the built environment. By analyzing the performance of structural elements and the overall design process enabled identify strengths and areas for improvement in leveraging AutoCAD, STAAD Pro, Revit, and BIM technologies. Use of these advanced tools resulted in a building design that is efficient, robust, and aligned with safety and performance criteria. This study exemplifies how modern engineering techniques can innovate and elevate building design, showcasing our commitment to excellence in civil engineering practices.

Design of components

Beams: Beams transfer load from slabs to columns. Beams are designed for bending. In general, we have two types of beams: singly reinforced and double reinforced. Similar to columns geometry and perimeters of the beams are assigned. Design beam command is assigned and analysis is carried out, and after that reinforcement details are taken. A reinforced concrete beam should be able to resist

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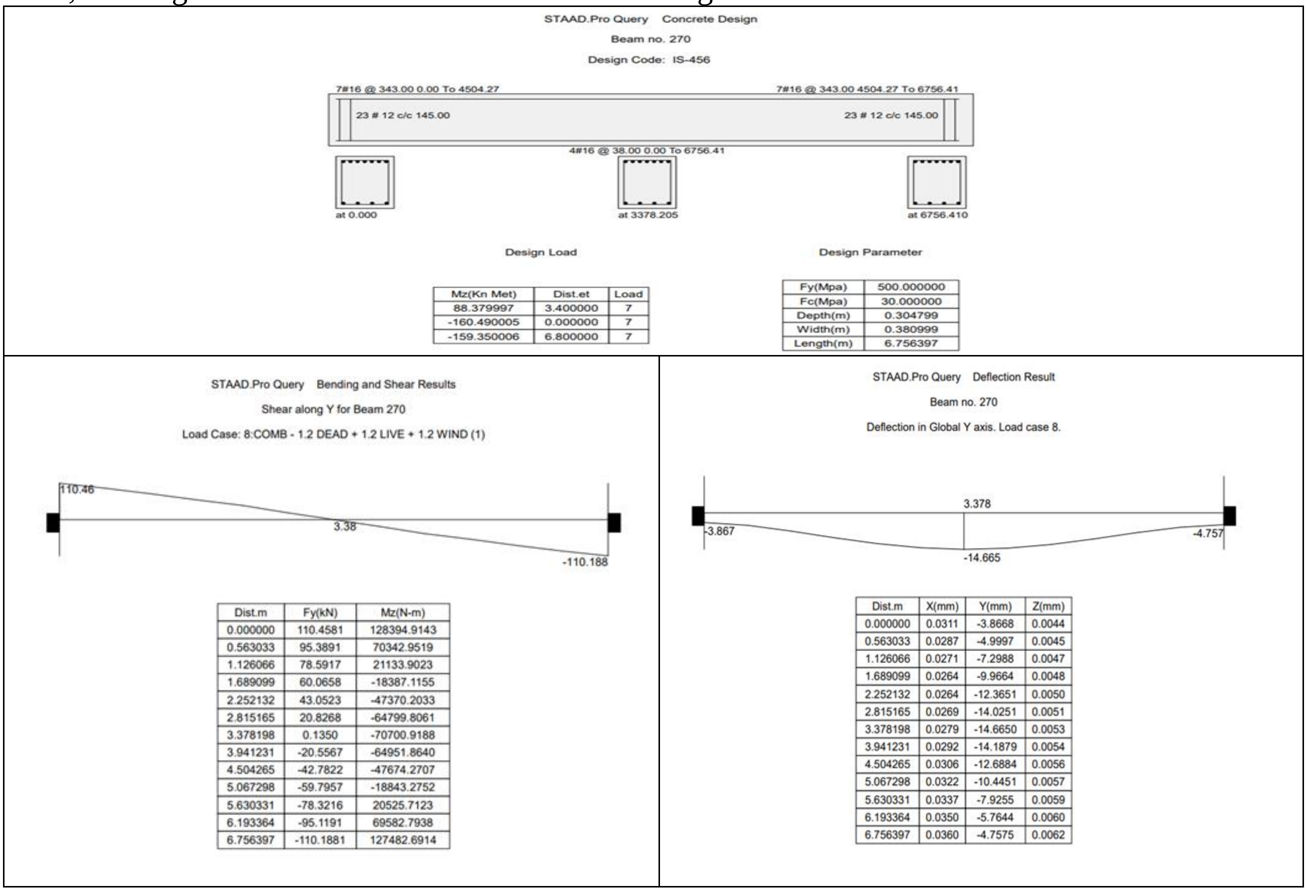
tensile, compressive and shear stress induced in it by loads on the beam. Beam concrete design shear force, bending moment and deflection are shown in Figure 9.



Mz(Kn Met)	Dist.et	Load
88.379997	3.400000	7
-160.490005	0.000000	7
-159.350006	6.800000	7

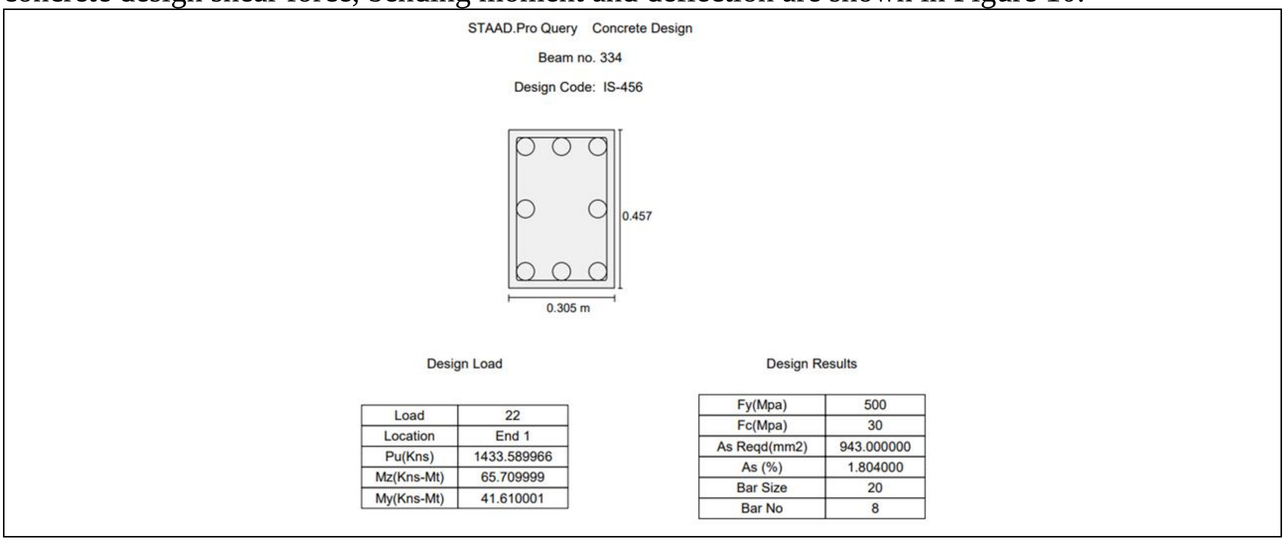
Fy(Mpa)	500.000000
Fc(Mpa)	30.000000
Depth(m)	0.304799
Width(m)	0.380999
Length(m)	6.756397

Dist.m	Fy(kN)	Mz(N-m)
0.000000	110.4581	128394.9143
0.563033	95.3891	70342.9519
1.126066	78.5917	21133.9023
1.689099	60.0658	-18387.1155
2.252132	43.0523	-47370.2033
2.815165	20.8268	-64799.8061
3.378198	0.1350	-70700.9188
3.941231	-20.5567	-64951.8640
4.504265	-42.7822	-47674.2707
5.067298	-59.7957	-18843.2752
5.630331	-78.3216	20525.7123
6.193364	-95.1191	69582.7938
6.756397	-110.1881	127482.6914

Dist.m	X(mm)	Y(mm)	Z(mm)
0.000000	0.0311	-3.8668	0.0044
0.563033	0.0287	-4.9997	0.0045
1.126066	0.0271	-7.2988	0.0047
1.689099	0.0264	-9.9664	0.0048
2.252132	0.0264	-12.3651	0.0050
2.815165	0.0269	-14.0251	0.0051
3.378198	0.0279	-14.6650	0.0053
3.941231	0.0292	-14.1879	0.0054
4.504265	0.0306	-12.6884	0.0056
5.067298	0.0322	-10.4451	0.0057
5.630331	0.0337	-7.9255	0.0059
6.193364	0.0350	-5.7644	0.0060
6.756397	0.0360	-4.7575	0.0062

Fig. 9 Beam concrete design, Shear force, Bending moment and Deflection diagrams

Columns: Columns are vertical structural elements used in multi-storeyed buildings to support the weight of the floors and transfer loads to the foundation. They play a critical role in providing stability and resisting lateral forces such as wind and seismic loads. In multi-storeyed buildings, the positioning of columns is crucial for efficient structural performance and effective space utilization. Column concrete design shear force, bending moment and deflection are shown in Figure 10.



Load	22
Location	End 1
Pu(Kns)	1433.589966
Mz(Kns-Mt)	65.709999
My(Kns-Mt)	41.610001

Fy(Mpa)	500
Fc(Mpa)	30
As Reqd(mm2)	943.000000
As (%)	1.804000
Bar Size	20
Bar No	8

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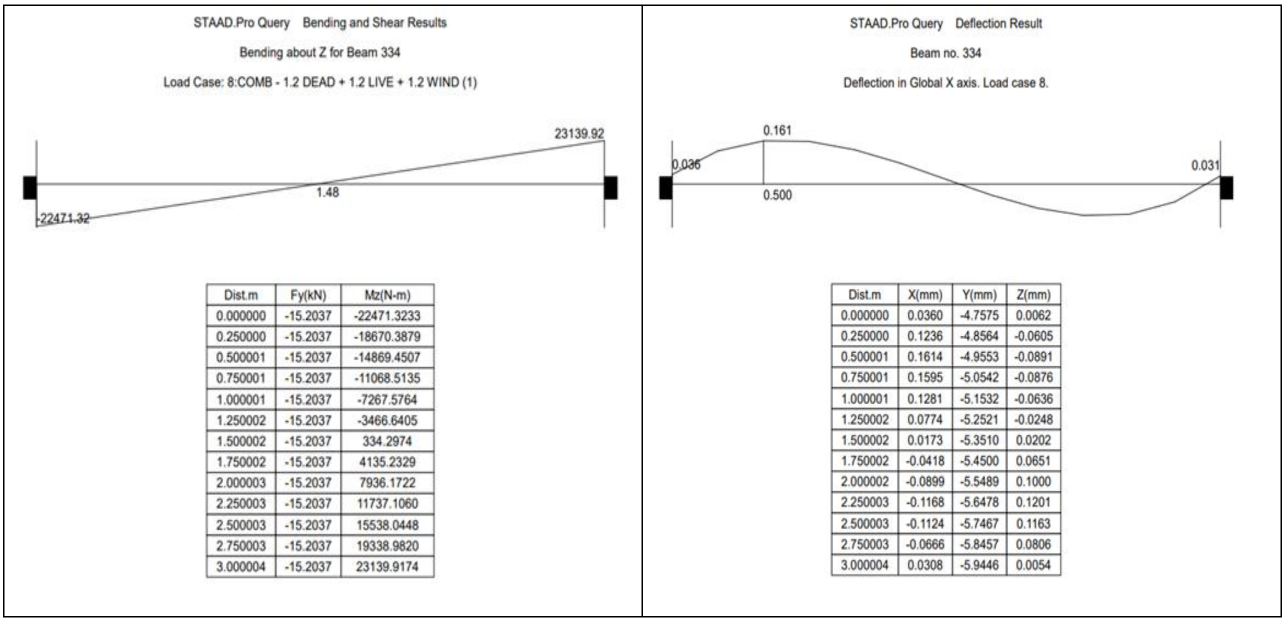

Dist.m	Fy(kN)	Mz(N-m)
0.000000	-15.2037	-22471.3233
0.250000	-15.2037	-18670.3879
0.500001	-15.2037	-14869.4507
0.750001	-15.2037	-11068.5135
1.000001	-15.2037	-7267.5764
1.250002	-15.2037	-3466.6405
1.500002	-15.2037	334.2974
1.750002	-15.2037	4135.2329
2.000003	-15.2037	7936.1722
2.250003	-15.2037	11737.1060
2.500003	-15.2037	15538.0448
2.750003	-15.2037	19338.9820
3.000004	-15.2037	23139.9174

Dist.m	X(mm)	Y(mm)	Z(mm)
0.000000	0.0360	-4.7575	0.0062
0.250000	0.1236	-4.8564	-0.0605
0.500001	0.1614	-4.9553	-0.0891
0.750001	0.1595	-5.0542	-0.0876
1.000001	0.1281	-5.1532	-0.0636
1.250002	0.0774	-5.2521	-0.0248
1.500002	0.0173	-5.3510	0.0202
1.750002	-0.0418	-5.4500	0.0651
2.000002	-0.0899	-5.5489	0.1000
2.250003	-0.1168	-5.6478	0.1201
2.500003	-0.1124	-5.7467	0.1163
2.750003	-0.0666	-5.8457	0.0806
3.000004	0.0308	-5.9446	0.0054

Fig. 10 Column concrete design, Shear force, Bending moment and Deflection diagrams

Footing: Foundations are structural elements that transfer loads from the building or individual column to the earth. If these loads are to be properly transmitted, foundations must be designed to prevent excessive settlement or rotation, to minimize differential settlement and to provide adequate safety against sliding and overturning. The foundation details are shown in Table 1. The details of the foundation design are shown in Figure 11.

Table 1 Foundation details

Type of foundation	Isolated
Unit weight of concrete	25kN/m^3
Minimum bar spacing	50mm
Maximum bar spacing	450mm
Strength of concrete	30 N/mm^2
Yield strength of steel	500N/mm^2
Minimum bar size	12mm
Maximum bar size	20mm
Bottom clear cover	50mm
Unit weight of soil	17.6kN/m^3
Soil bearing capacity	120kN/m^3
Minimumlength	2000mm
Minimum width	2000mm
Minimum thickness	700mm
Maximum length	6000mm
Maximum width	6000mm
Maximum thickness	1200mm
Safety against friction	0.5
Safety againstoverturning	1.5
Safety against sliding	1.5

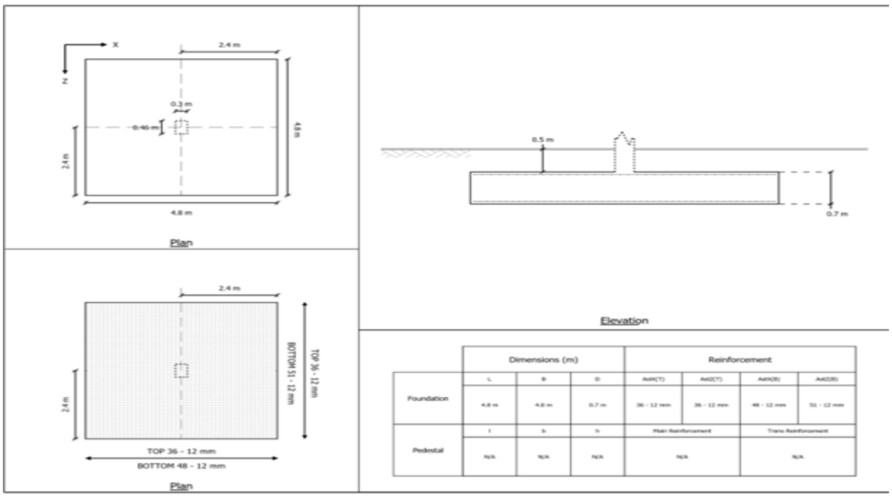

Fig. 11 Foundation Design Sheet

Slab: Slabs are horizontal structural elements used in building construction to provide a flat surface for floors, roofs, and ceilings. They distribute loads from above evenly to the supporting beams and columns. Table 2 shows the Crack Width and Stress Check for slab. Slab cross section details are shown in Figure 12.

Design parameters:

Design Settings

Detailing Style : Curtailed Bars
Preferred Span / D
Cantilever : 7
Simply Supported (One-way Slab) : 20
Continuous (One-way Slab) : 26
Simply Supported (Two-way Slab) : 28
Continuous (Two-way Slab) : 32
Curtailment Location
Bottom End Support : L/6
Bottom Cont. Support : L/6
Top End Support : L/4
Top Cont. Support : L/4
Detailing Option : Rebar
Preferred Rebar : 10

Material Property

Analysis materials used : No
Concrete Grade : M30
Steel Grade : Fe500
Cover : 25 mm
Min. Slab Thickness : 100 mm

Rebars

Available Rebars : 8,10,12,16,20,25,32,40

Bar Spacing

Min. Spacing : 100 mm
Max. Spacing : 300 mm
Roundoff Factor : 5 mm
Crack Width Settings:
Crack Width IS 456 : 2000 + IS 13920 : 2016 Check : Yes
Permissible Crack Width : 0.2 mm

Crack Width IRS Check : No
Initial Thermal Crack Width Check : No
Slab design calculations: Considering one sample slab for design calculations.
Notes:
1. Slab is designed as per 1 m width of panel.
2. Density of concrete assumed as 25 kN/m^3.
3. Maximum spacing of Main steel is smaller of (3 x Def and 300 mm)
4. Maximum spacing of Distribution steel is smaller of (5 x Def and 450 mm)
5. All 6 mm diameter bars assumed of Fe250 grade with Fy=250 N/sq.mm

Table 2 Crack Width and Stress Check for slab as per IS 456 : 2000 + IS 13920 : 2016

	Bottom @ Lx	**Bottom @ Ly**	**Top @ Lx (Cont)**	**Top @ Ly (Cont)**
BM (Unfactored) (kNm)	8.9446	5.0676	11.9262	6.7568
Cmin (mm)	25	25	25	25
Reinforcement	T10@270	T10@300	T10@200	T10@300
Ast Prv (sqmm/m)	291	262	393	262
Xact (mm)	22.9553	20.8703	26.2192	20.8703
Icr (mm^4)	29600642.0616	22441261.3534	38242865.145	22441261.3534
acr (mm)	133.2932	147.9706	99.4031	147.9706
Check for Stress in Steel				
Fst (N/sqmm)	273.6965	187.8524	272.9609	250.4699
FstPerm (N/sqmm)	275	275	275	275
Check for Stress in Concrete				
Fc (N/sqmm)	6.9365	4.7129	8.1766	6.2838
FcPerm (N/sqmm)	10	10	10	10
Crack Width Check				
Epsilon-deff, E1	0.0018	0.0014	0.0018	0.0018
Epsilon-m, Em	0.0008	0.0002	0.0011	0.0006
Wcr (mm)	0.124	0.0259	0.15	0.0953
WcrPerm (mm)	0.2	0.2	0.2	0.2

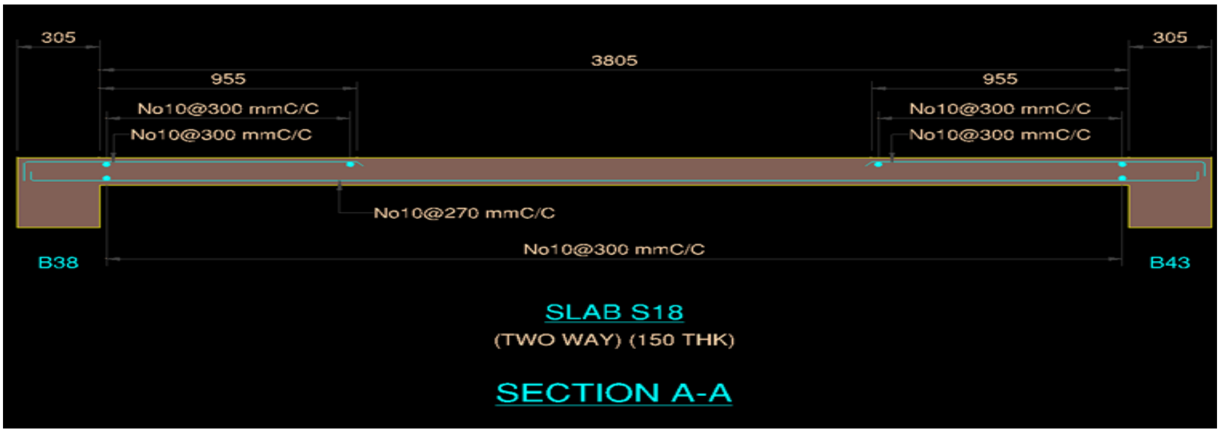

Fig. 12 Slab cross-section details

3-D Model from REVIT (BIM)

The 3D model generated from Revit provides a comprehensive view of the building. It includes detailed representations of the building's floors, walls, columns, slabs, stairs, doors, windows, and

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other architectural elements. Figures. 13 and 14 shows the 3D model view 1 and view 2 details of the generated building model. Figures. 15 and 16 shows the front view and parking view of the 3D models. Figures. 17 and 18 shows the residential and commercial floor isometric views of the 3D model.

Fig. 13 3-D model isometric view 1

Fig. 14 3-D model isometric view 2

Fig. 15 3-D model front view

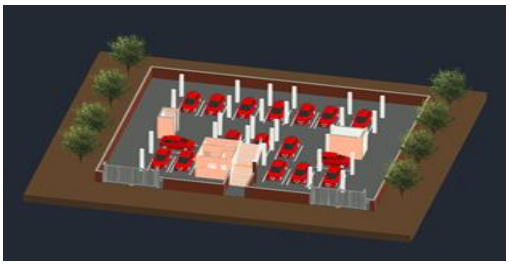

Fig. 16 3-D model parking view

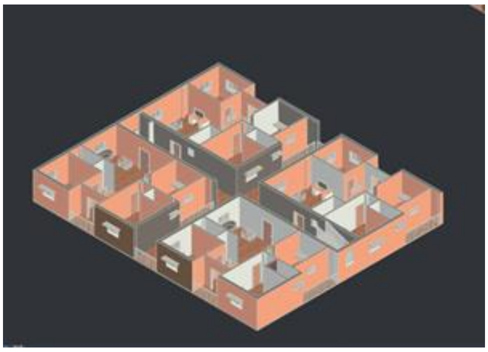

Fig. 17 Residential floor isometric view

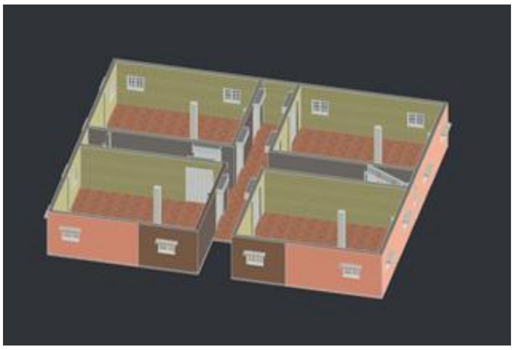

Fig. 18 Commercial floor isometric view

5. Conclusions

The study of the five-story (G+4) RCC building demonstrates successful integration of AutoCAD, STAAD Pro, and Revit software for ensuring structural integrity, safety, and performance. AutoCAD optimized layout designs for commercial and residential spaces. STAAD Pro rigorously analyzed loads, ensuring strength and stability while minimizing costs. Revit facilitated comprehensive 3D modelling, enhancing visualization and communication. Wind and seismic forces were analyzed, confirming structural safety, with designs meeting Indian Standards. This integrated approach highlights efficient, stable, and compliant multistorey construction practices.

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