

Structural Design & Construction Planning Of A Residential Building Using Etabs & Primavera

Mr. G. Srikanth^{*1}, Mr. Mohammed Jalaluddin^{*2},
Mr. Sabeel Ahmed Khan^{*3}, Mr. Abraar Meraj Quraishi^{*4}, Mr. Mohammed Hamza^{*5}, Mr. Mohammed Hamza Shareef^{*6}

^{*1,2} Assistant Professor, Dept. Of Civil, Lords Institute Of Engineering And Technology

^{*3, 4, 5, 6} B.E Student Dept. Of Civil, Lords Institute Of Engineering And Technology

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Abstract:

This project presents the structural design and construction planning of a residential building using **ETABS** and **Primavera P6**. The primary objective of the study is to integrate structural analysis with effective project scheduling to achieve a safe, economical, and time-efficient construction process for a multi-storey residential building. The structural design phase was carried out using **ETABS**, where the building was modelled as a G+3 reinforced concrete framed structure. All relevant loads including dead loads, live loads, and wind loads were applied in accordance with standard design codes. The analysis focused on determining critical parameters such as storey displacement, base shear, bending moments, and axial forces to ensure structural stability and serviceability. In the construction planning phase, **Primavera P6** was used to develop a detailed project schedule. Work Breakdown Structure (WBS), Organizational Breakdown Structure (OBS), and Enterprise Project Structure (EPS) were defined to organize project activities systematically. Logical sequencing of construction activities, along with durations and dependencies, was established to generate a realistic baseline schedule. The study also highlights the importance of monitoring project progress through scheduling tools to minimize delays and improve resource coordination. The integration of **ETABS** and **Primavera** provides a comprehensive approach that combines structural safety with efficient project management. The results demonstrate that proper planning and accurate structural design significantly enhance project execution efficiency, reduce time overruns, and ensure compliance with design standards.

Keywords : Structural Analysis, Reinforced Concrete, Multi-storey Building, **ETABS**, **Primavera P6**, Load Analysis, Wind Load, Storey Displacement, Project Planning, Scheduling, Work Breakdown Structure (WBS), Construction Management, RCC Design, Project Management Tool.

1. INTRODUCTION

Structural engineering is a major branch of civil engineering that deals with the analysis, design, and construction of structures capable of safely resisting all loads acting on them. These loads include dead loads, live loads, wind loads, and seismic forces. The primary objective of structural engineering is to ensure safety, stability, and serviceability of structures throughout their design life.

With the advancement of technology, modern structural design increasingly relies on software tools such as **ETABS** for analysis and design, and **Primavera** for planning, scheduling, and project management. These tools improve accuracy, efficiency, and coordination in construction projects.

1.1 Statement of the project

In modern construction, designing safe and economical multi-storey buildings is a complex task due to the involvement of various loads such as dead load, live load, wind load, and seismic

forces. Manual analysis methods are time-consuming and prone to errors, especially for multi-storey structures like a **G+4 residential building with a stilt floor**.

From the given drawings, the building includes:

- Multiple floors with varying functional spaces such as parking, residential units, and service areas
- Structural components like beams, slabs, and columns arranged as per framing and center-line plans

The challenge lies in:

- Accurately modeling the structure
- Applying appropriate loads and combinations
- Designing safe and economical structural members
- Planning construction activities efficiently

Hence, there is a need to use advanced software tools like **ETABS** and **Primavera** to address these challenges effectively.

1.2 Justification of Project

The selection of this project is justified due to the increasing demand for safe, economical, and efficiently planned residential buildings in urban areas.

Key reasons include:

- Multi-storey residential buildings are common in real-world practice
- Understanding structural behavior is essential for civil engineers
- Integration of **design (ETABS)** and **planning (Primavera)** reflects industry practices
- Helps bridge the gap between theoretical knowledge and practical application

The given project drawings simulate a real-life construction scenario, making this study highly relevant for professional training.

1.3 Aim & Objectives of the Project

Aim

To perform structural analysis and design of a G+4 residential apartment building using ETABS, and to develop construction planning and scheduling using Primavera.

Objectives

To achieve the above aim, the following objectives are defined:

- To study the given architectural and structural drawings
- To prepare a structural model using ETABS based on center-line and framing plans
- To apply loads and load combinations as per IS codes
- To analyze the structure and design structural elements
- To identify construction activities and sequence them logically
- To prepare project schedule using Primavera

1.4 Significance of the Project

This project holds significant importance in both academic and practical aspects:

- Provides hands-on experience with industry-standard software (**ETABS & Primavera**)

- Enhances understanding of structural behavior under different loading conditions
- Develops skills in project planning and time management
- Helps in understanding real construction workflow from design to execution
- Prepares students for roles such as:
 - Structural Engineer
 - Site Engineer
 - Planning Engineer

Additionally, this study improves decision-making skills in selecting structural dimensions and optimizing construction schedules.

1.5 Scope of the Project

The scope of this project includes:

- Study of architectural and structural drawings provided
- Preparation of structural model based on center-line and framing plans
- Application of loads as per relevant codes
- Analysis and design using ETABS
- Preparation of construction activities, sequencing, and duration
- Development of project schedule using Primavera up to project completion

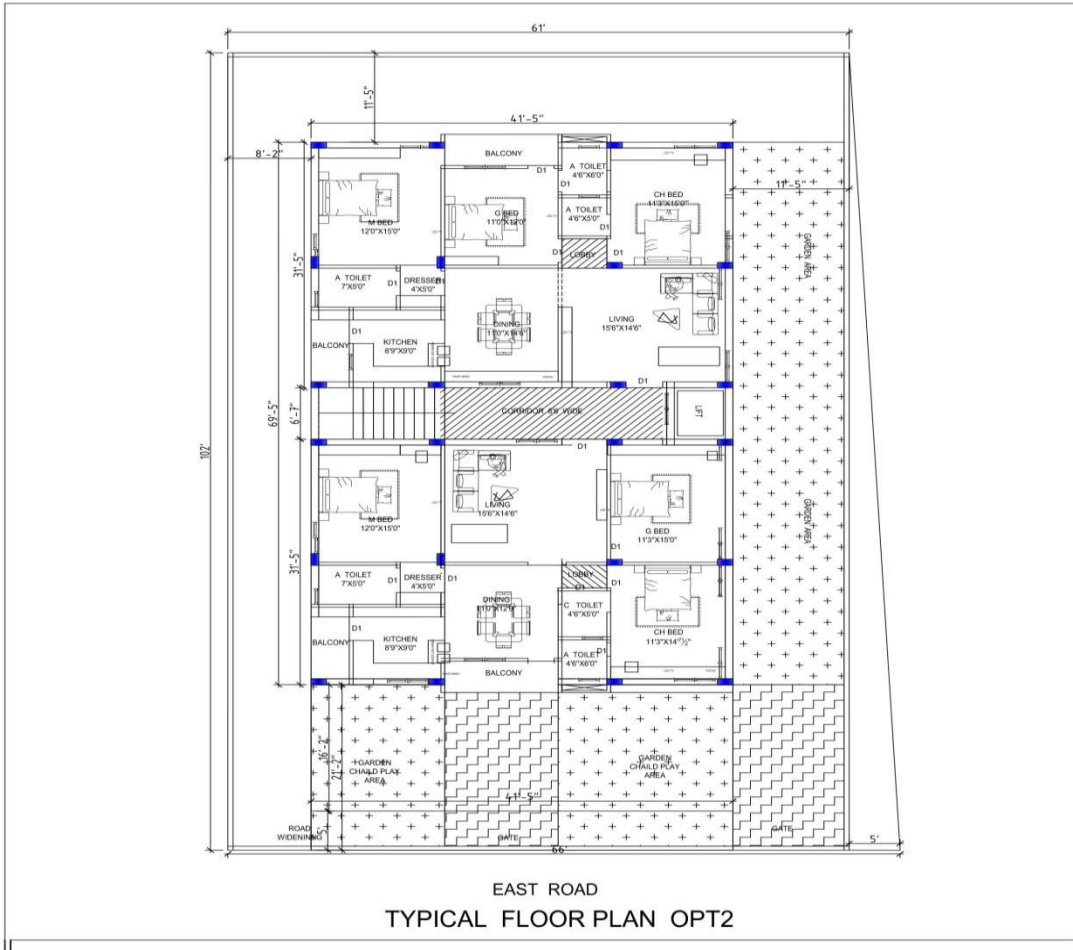
1.6 Importance of software in Modern Construction

- **ETABS** helps in:
 - 3D modeling of structures
 - Load analysis (including seismic and wind)
 - Design as per IS codes
- **Primavera** helps in:
 - Project scheduling
 - Resource allocation
 - Tracking progress and delays

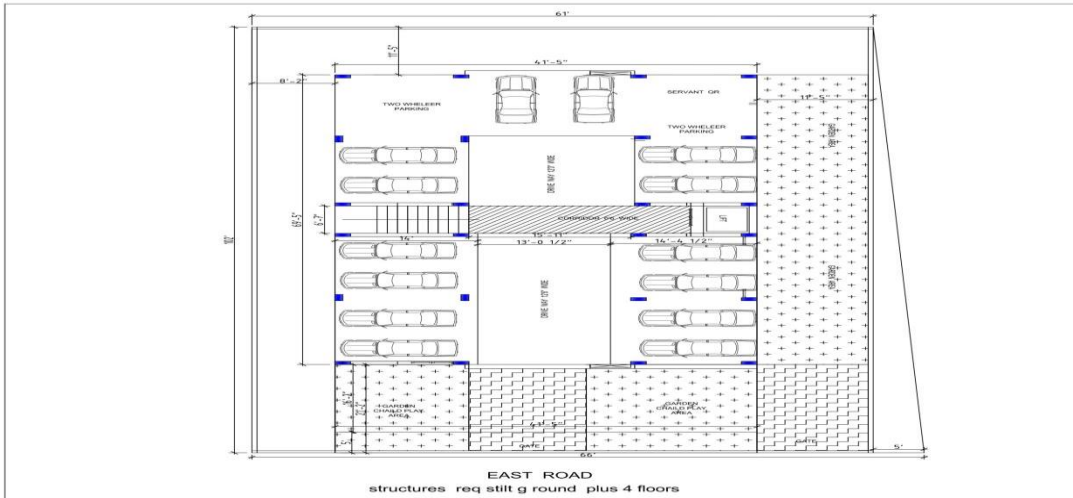
Together, they provide a complete understanding from **design stage to execution stage**

1.7 Project Drawings

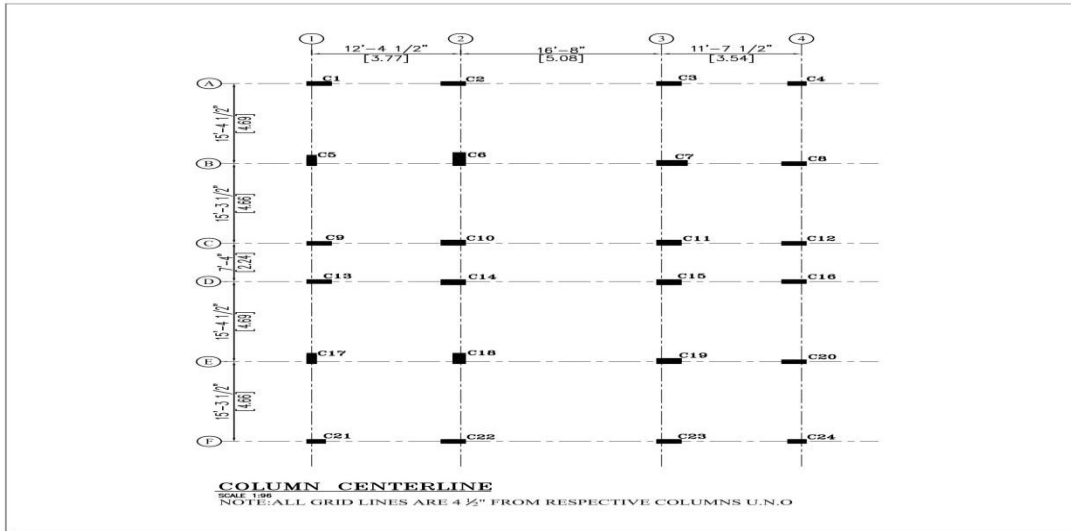
1.8.1. Typical Floor Plan



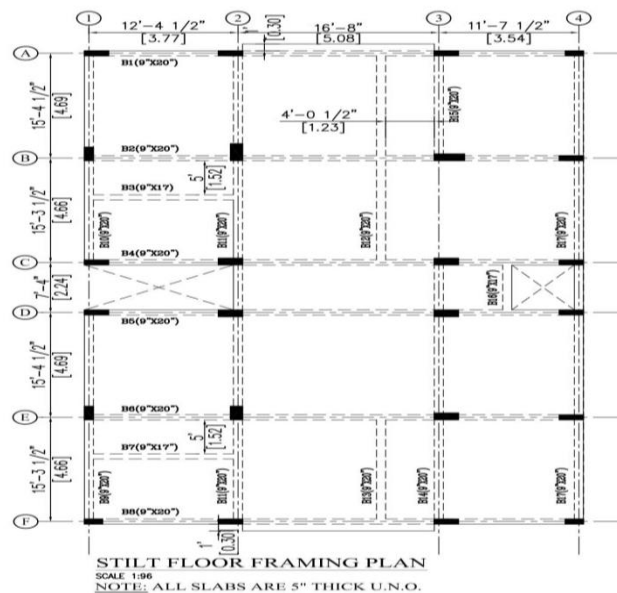
1.8.2. Stilt Floor Plan



1.8.3. Centerline Plan



1.8.4. Beam Framing Plan



1.8 Introduction to the Project

The project involves the design and construction of a **G+4 residential building** located in Hyderabad, Telangana. The building is planned with **four floors above ground level**, including a ground floor for Parking and upper floors for residency. The structural system is designed using **reinforced concrete (RC)** with **M30 grade concrete** for the main elements and **Fe500 steel** reinforcement, ensuring adequate strength, durability, and serviceability for residential use. The foundation

consists of isolated footings with PCC bed and 7-day curing. The building is designed to withstand **dead loads, live loads, and wall loads**.

Architectural and structural drawings include **floor layouts, grid lines, column locations (inner and outer), beam placement, wall locations, and centerlines**, providing a detailed reference for construction. The design also includes provisions for headroom above the roof and appropriate load combinations as per standard codes.

1.9 Project Details

Type of Building	Residential (G+4)
Type of Structural System	Framed
Total No.of Floors	5 (Ground+4)
Story Height	3.0m
Elevation Height	15.0
Plot Area	102'x61' / 31.0x19.0m ~ 581 m ²

Table 1 : Building Details

Outer Columns	230mmx450mm
Inner Columns	230x500mm

Primary Beams	230x500mm
Secondary Beams	230x450mm
Slab Thickness	125mm
Foundaton	

Table 2 : Structural Member Sizes

2. LITERATURE REVIEW

2.1 Overview

The literature review presents an overview of the fundamental concepts and previous studies related to structural design and construction planning of multi-storey buildings. It focuses on the contributions of various authors and researchers in the fields of reinforced concrete design, structural analysis, and project management.

Renowned authors such as B. C. Punmia, N. Subramanian, and Unnikrishna Pillai have provided essential knowledge on the design and behavior of reinforced concrete structures. Their works emphasize safe and economical design practices based on standard codes.

In addition, authors like K. K. Chitkara and Kumar Neeraj Jha have highlighted the importance of construction planning, scheduling, and management techniques using modern tools such as Primavera.

B.C. Punmia (2009) explained the fundamental principles of reinforced concrete design, emphasizing the importance of strength, durability, and serviceability of structures. The study highlights that proper proportioning of structural members such as beams, slabs, and columns ensures safety and economy in construction. The author also focused on limit state design concepts and reinforcement detailing for effective load resistance. The objectives of the study include:

N.Subramanian (2010) discussed the application of advanced structural analysis methods using software tools such as ETABS. The study emphasizes the role of computer-aided design in analyzing complex multi-storey buildings subjected to various loads including seismic and wind loads. It highlights the importance of accurate modeling and analysis in achieving safe structural performance. The objectives of the study include:

- To analyze multi-storey buildings using advanced software tools
- To understand the effect of lateral loads on structures
- To improve accuracy and efficiency in structural analysis

Unnikrishna Pillai and Devdas Menon (2012) presented detailed concepts of reinforced concrete design based on limit state method. Their work explains the design of structural elements considering ultimate and serviceability limits, ensuring both safety and functionality. The study also focuses on design philosophy as per Indian standards.

3. METHODOLOGY

3.1 ETABS Methodology

The ETABS workflow begins with a thorough **study of architectural drawings**, which helps in understanding the building layout, dimensions, and functional requirements. Following this, **structural planning** is carried out to determine column locations, beam grids, floor systems, and load paths in accordance with design codes. Next, the **ETABS modeling** phase involves defining grids, storeys, materials, and section properties, followed by creating beams, columns, slabs, and walls to form a 3D structural model. Once the model is ready, **loads are defined and assigned**, including dead, live, wind, and seismic loads, as per applicable standards. The **analysis** stage then computes internal forces, moments, and displacements throughout the structure. Based on these results, the **design of structural elements** like beams, columns, slabs, and shear walls is performed, ensuring safety and serviceability. The model may go through **iteration and optimization** to refine member sizes and reduce material usage. Afterward, **column loads are extracted** to facilitate the design of isolated or combined footings, followed by the **design of footings** to safely transfer loads to the soil. Finally, **detailing** is prepared, including reinforcement drawings and bar schedules, to guide construction accurately.

3.1.1 Study of Architectural drawings & Structural Planning

The architectural drawings of the building are carefully studied to understand the layout, dimensions, and functional requirements. This includes identifying room arrangements, wall positions, floor heights, and overall building configuration.

4. RESULTS & DISCUSSION

4.1 Results from ETABS Analysis

4.1.1 Structural Model Behavior

The ETABS model of the G+4 residential building was successfully analyzed under the action of:

- Dead Load (DL)
- Live Load (LL)
- Wind Load (WL)

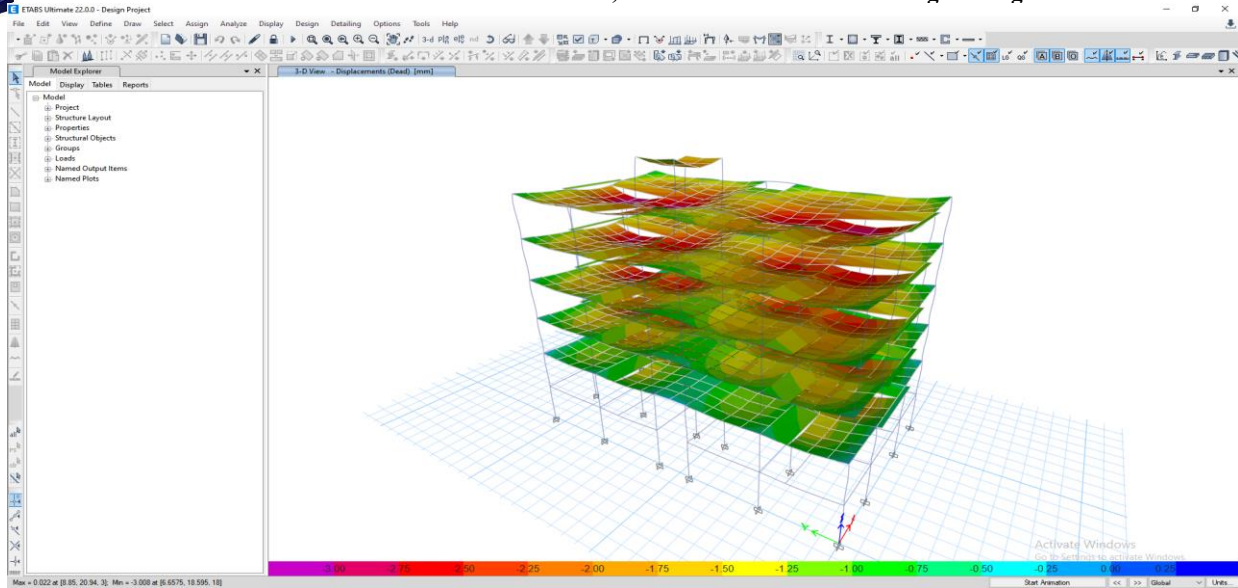


Image 1 : Behaviour of structure under given load conditions after analysis

The deformed shape of the structure indicates stable behavior with no irregularities or excessive deformation. The lateral displacement pattern shows gradual increase from base to top, which confirms proper load transfer and structural stability.

- Maximum lateral displacement was observed at the top storey.
- The displacement values increased gradually from base to top, indicating proper load transfer.
- All storey displacements were within permissible limits as per IS 1893.

4.1.2 Storey Displacement

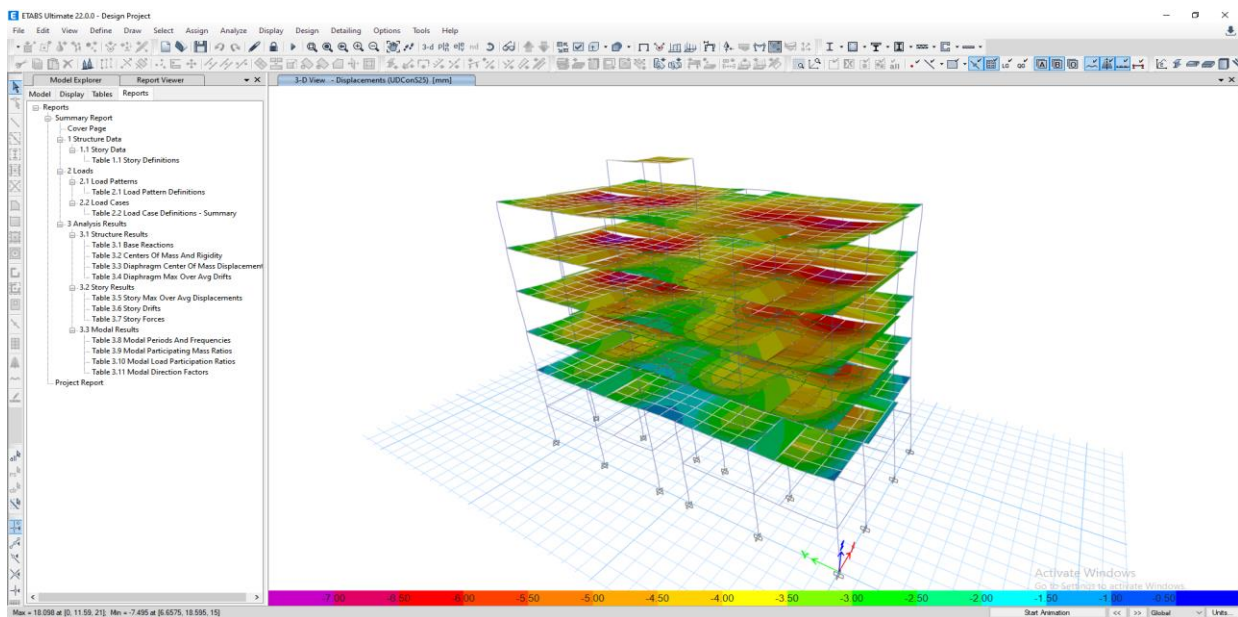


Image 2 : Maximum Storey displacement

Story	Output Case	Case Type	Direction	Maximum mm	Average mm	Ratio
Headroom	UDConS25	Combination	Y	18.098	18.054	1.002
5F	UDConS25	Combination	Y	16.037	16.009	1.002
4F	UDConS25	Combination	Y	15.037	14.99	1.003

3F	UDConS25	Combination	Y	13.242	13.184	1.004
2F	UDConS25	Combination	Y	10.673	10.613	1.006
FF	UDConS25	Combination	Y	7.356	7.303	1.007

Table 3 : Maximum Storey Displacements

Discussion:

The gradual increase in displacement confirms that the structure behaves as expected under lateral loads. Since the values are within allowable limits, the structure is considered safe against excessive sway.

- Storey drift values were checked for all floors.
- Maximum drift occurred in intermediate storeys.
- Drift values were within the permissible limit of:

4.1.3 Storey Drift

$$Drift \leq 0.004 \times Storey\ Height$$

Story	Output Case	Case Type	Direction	Drift	Drift/	Label	X m	Y m	Z m
Headroom	UDConS25	Combination	X	0.00025	1/3999	16	3.77	11.59	21
5F	UDConS25	Combination	Y	0.000346	1/2888	1	0	4.66	18
4F	UDConS25	Combination	Y	0.000605	1/1652	1	0	4.66	15
3F	UDConS25	Combination	Y	0.000858	1/1166	1	0	4.66	12
2F	UDConS25	Combination	Y	0.001106	1/904	8	12.39	4.66	9
FF	UDConS25	Combination	Y	0.001372	1/729	22	3.77	0	6
Stilt	UDConS25	Combination	Y	0.001149	1/871	12	12.39	20.94	3

Table 4 : Maximum Story Drifts

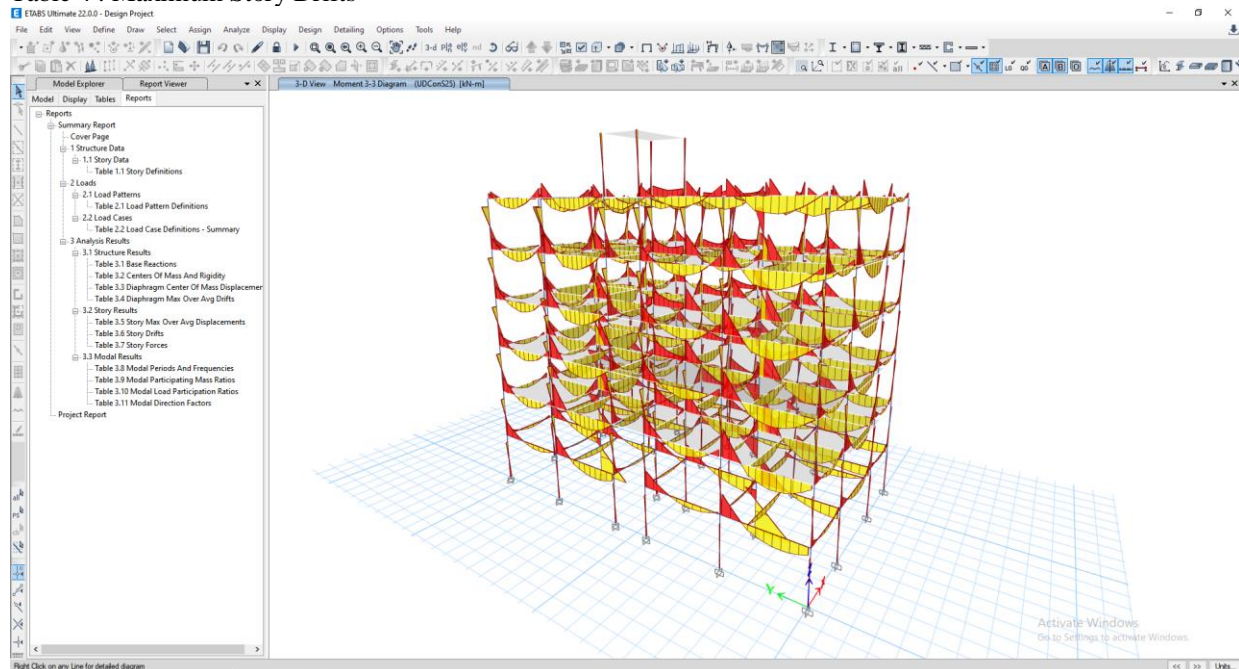


Image 3 : Bending Moment Diagram for Beams

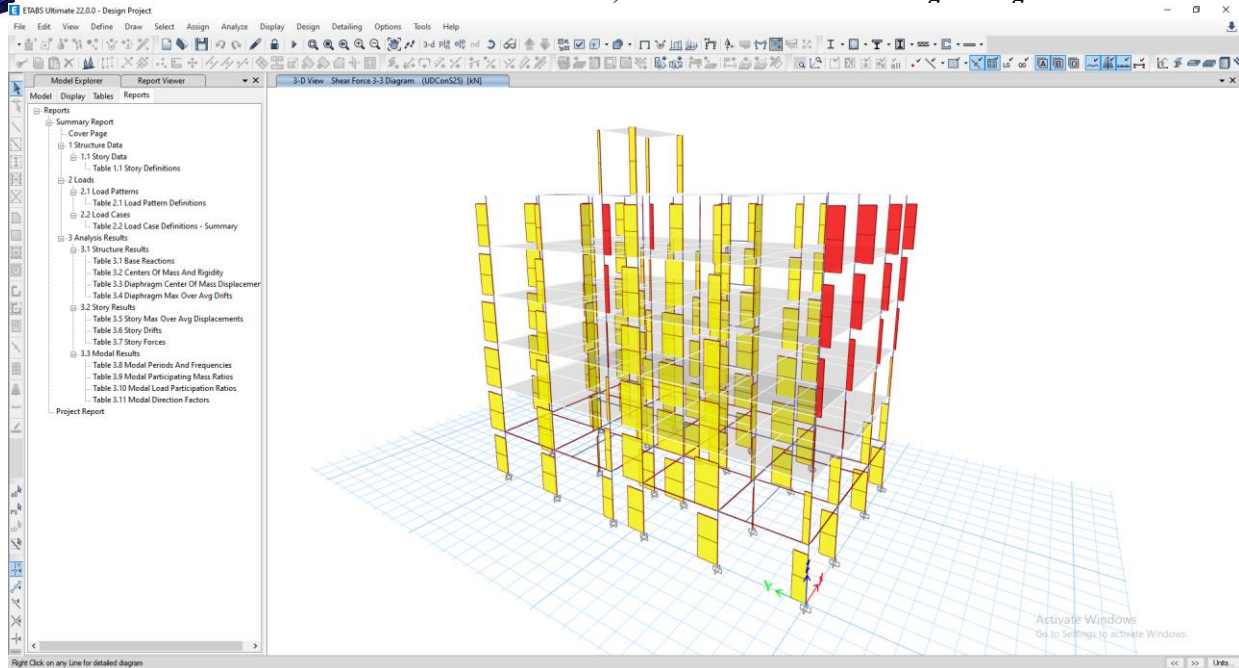


Image 41 : Shear Force Diagram for Beams

Table 5 : Maximum B.M & S.F among all members

Story	Beam	Output Case	Case Type	V2 kN	M3 kN-m
5F	B33	UDConS25	Combination	-29.6777	-4.5526
4F	B3	UDConS25	Combination	-2.8918	-15.0115

Discussion:

These results are consistent with the theoretical behavior of continuous beams. The critical values of bending moment and shear force were used for the design of reinforcement in beams, ensuring safety against flexural and shear failure.

4.2 Results from Structural Design

4.2.1 Beam Design

- Beams were designed for flexure and shear.
- Reinforcement was provided based on maximum moment and shear force.
- All beams passed design checks.

Discussion:

The reinforcement provided ensures adequate strength and ductility. No beam was found unsafe, indicating proper sizing and load distribution.

4.2.2 Column Design

- Columns were designed for axial load and bending moment.
- Interaction diagrams confirmed safe design.
- Reinforcement percentages were within permissible limits.

Discussion:

Columns are the most critical elements. The results show that all columns are safe and capable of carrying combined loads without failure.

4.3 Results From Primavera Planning & Scheduling

4.3.1 Project Scedhule

- Total project duration was determined using Primavera.
- Activities were sequenced logically using relationships (FS, SS, etc.).

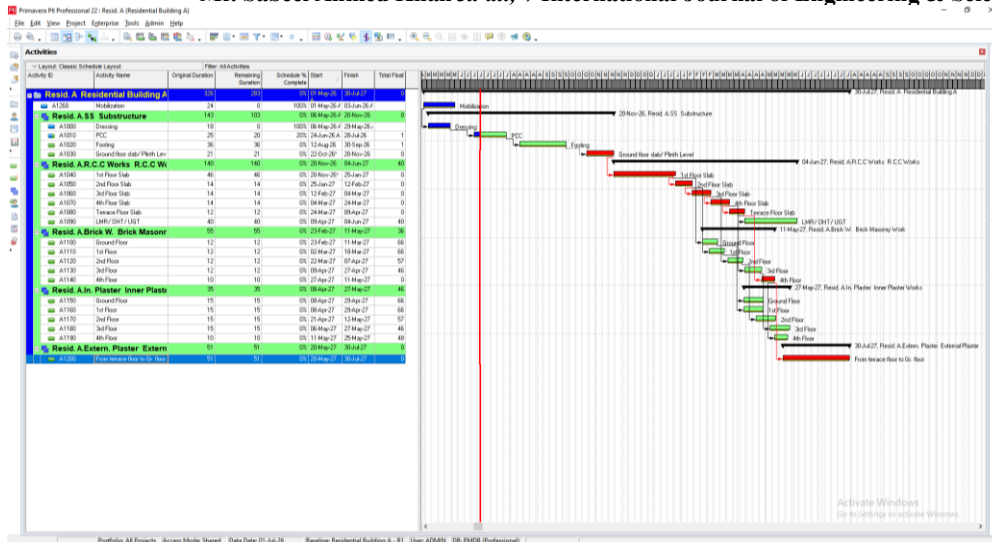


Image 5 : Project schedule (Gantt Chart) prepared

Discussion:

The project schedule was developed using Primavera P6 by defining all construction activities and their respective durations. The activities were logically sequenced using appropriate relationships such as Finish-to-Start (FS). The Gantt chart represents the timeline of the project, showing the start and finish dates of each activity. The total project duration was calculated based on the sequence and duration of all activities.

The schedule provides a clear understanding of project execution and helps in effective planning and monitoring of construction activities.

4.3.2 Critical Path Analysis

- The critical path was identified.
- Activities on the critical path had zero float.

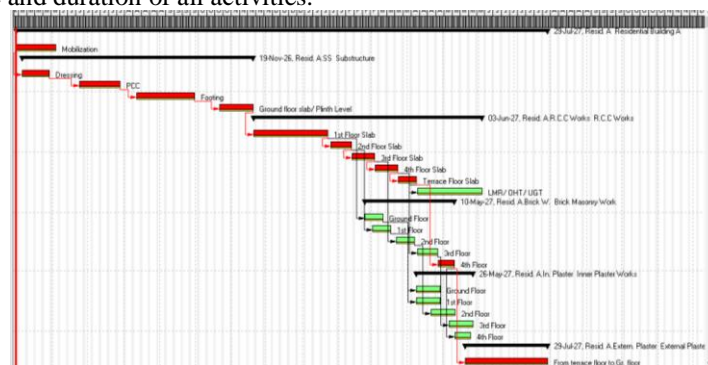


Image 52 : Critical Path activities are represented by red bars

Discussion:

Float analysis was carried out in Primavera to determine the flexibility available for each activity. Float represents the amount of time an activity can be delayed without affecting the overall project duration. Activities with zero float were identified as critical activities, forming the critical path of the project. Non-critical activities were found to have positive float, indicating scheduling flexibility.

Float analysis helps in better resource allocation and allows adjustments in scheduling without impacting the project completion time.

4.3.3 Baseline Comparison

- A baseline schedule was created.
- Any deviation from the baseline can be tracked.

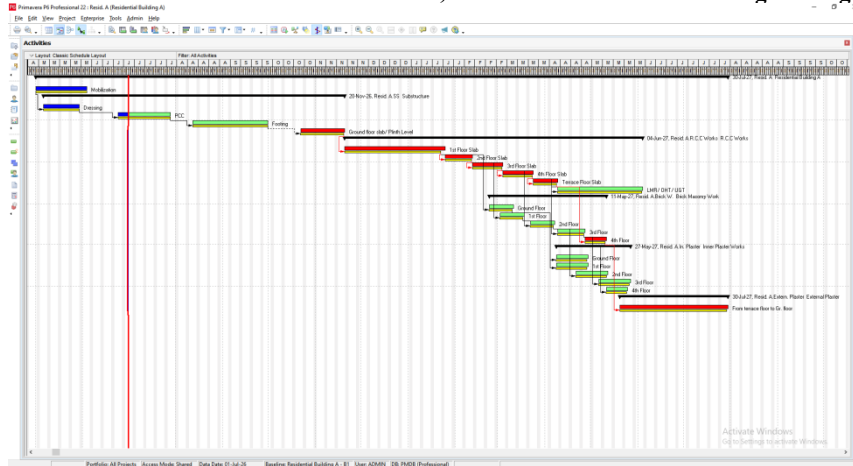


Image 6 : Baseline scedhule

Discussion:

A baseline schedule was created in Primavera to serve as a reference for the original project plan. The baseline represents the initial approved schedule against which actual progress can be compared. When changes occur in the project schedule, the activity bars shift while the baseline remains unchanged. This allows for easy identification of delays and deviations from the planned schedule. Baseline comparison is essential for effective project monitoring and control, as it helps in tracking performance and taking corrective actions when necessary.

4.4 Overall Discussion

- The structure is **safe under all loading conditions**, including seismic and wind loads.
- Displacement and drift are within permissible limits, ensuring serviceability.
- Structural elements (beams, columns, slabs, footings) are adequately designed.
- Construction planning using Primavera provides a **clear and manageable project timeline**.
- Critical path identification ensures focus on key activities.

4.5 Conclusion

The present project focused on the structural design and construction planning of a G+4 residential building using ETABS and Primavera P6. The structural analysis was carried out by considering all relevant loads including dead load, live load, wind load, and earthquake load as per IS code provisions. The results obtained from ETABS analysis showed that the structure is safe and stable, with storey displacement and drift values within permissible limits. All structural elements such as beams, columns, slabs, and footings were designed and found to be safe under the applied loading conditions.

Construction planning was performed using Primavera, where project scheduling, critical path identification, float analysis, and baseline comparison were carried out. The project schedule

was optimized, and critical activities were identified to ensure timely completion.

Overall, the integration of ETABS for structural design and Primavera for construction planning proved to be effective in achieving a safe, economical, and well-planned residential building project.

5. CONCLUSION

5.1 Conclusion for ETABS

The structural analysis and design of the residential building were successfully carried out using ETABS software. A three-dimensional model of the G+4 structure was developed by defining grid systems, story data, material properties, and section properties in accordance with standard engineering practices.

All relevant loads, including dead load, live load, and wind load, were applied as per Indian Standard codes. The software automatically calculated the self-weight of structural elements, and additional loads were assigned manually where required. The analysis results provided detailed information on bending moments, shear forces, axial forces, and displacements for various structural components.

From the analysis, it was observed that the structure behaves satisfactorily under the applied loading conditions. The lateral displacements and inter-story drift were found to be within permissible limits, ensuring stability against wind effects. The design of beams, columns, and slabs was carried out using limit state design principles, and all members were found to be safe in terms of strength and serviceability.

The use of ETABS significantly simplified the complex process of structural analysis and design by providing accurate and reliable results in a short time. It also helped in optimizing member sizes, leading to an economical design without compromising safety.

In conclusion, ETABS proved to be an effective and efficient tool for the analysis and design of multi-storey buildings, ensuring structural safety, stability,

5.2 Conclusion for Primavera

The construction planning and scheduling of the residential building were successfully carried out using Primavera P6 software. A systematic methodology was followed to organize and manage the project efficiently.

The project was initially structured using the Enterprise Project Structure (EPS) and Organizational Breakdown Structure (OBS), which helped in defining the hierarchy and responsibility distribution. The Work Breakdown Structure (WBS) was then developed to divide the project into manageable components, ensuring clarity in execution.

Activities were identified, sequenced, and assigned appropriate durations based on standard construction practices. Logical relationships between activities were established, and necessary lags were introduced to reflect realistic construction conditions. The project schedule was generated, and the critical path was identified, highlighting the activities that directly affect the overall project duration.

Calendars were defined to represent working days and hours, ensuring accurate scheduling. The use of scheduling tools in Primavera enabled proper time management and efficient allocation of work sequences. Baseline creation allowed comparison between planned and actual progress, making it easier to monitor delays and take corrective actions. The application of Primavera P6 in this project demonstrated its effectiveness in planning, scheduling, and controlling construction activities. It provided a clear visualization of project timelines and dependencies, improving coordination and decision-making.

In conclusion, Primavera P6 serves as a powerful tool for construction project management, ensuring timely completion, better resource utilization, and efficient project control.

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