ANALYSIS AND DESIGN OF (G+5) RESIDENTIAL BUILDING USING ETABS

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ABSTRACT

The design process of structural planning and design requires not only imagination and conceptual thinking but also sound knowledge of science of structural engineering besides the knowledge of practical aspects, such as recent design codes, bye laws, backed up by ample experience, intuition and judgment. The purpose of standards is to ensure and enhance the safety, keeping careful balance between economy and safety. In the present study G+5 building at Ameerpet, Hyderabad, India is designed (Slabs, Beams, Columns and Footings) using Auto CAD software. In order to design them, it is important to first obtain the plan of the particular building that is, positioning of the particular rooms (Drawing room, bed room, kitchen toilet etc.) such that they serve their respective purpose and also suiting to the requirement and comfort of the inhabitants. Thereby depending on the suitability; plan layout of beams and the position of columns are fixed. Thereafter, the loads are calculated namely the dead loads, which depend on the unit weight of the materials and the live loads, which according to the code IS:456- 2000 and

HYSD BARS FE415 as per IS:1786-1985. Safe bearing capacity of soil is adopted as 350KN/M2 at a depth of 6ft and same soil should extent 1.5 times the width of footing below the base of footing. Footings are designed based on the safe bearing capacity of soil. The main motto of our project is to cultivate a thought of application of new techniques and idea of our modern residential building this project possess the shear effort for the analysis and design of a residential building by using ETABS with process of structural planning and designing requires not only imagination and conceptual thinking but of practical aspects, such as relevant design codes and bye-laws, backed up by sample experience, institutions.

KEYWORDS: *Structural Planning, Design Process, Structural Engineering, Building Design, AutoCAD, ETABS, G+5 Building, Design Codes, IS:456-2000, Footings Design, Residential Building*

2. INTRODUCTION

2.1 NEED FOR MULTI-STOREYED BUILDING It cannot be over emphasized that the present housing accommodation in India is not only unsatisfactory but also likely to worse in future. Inadequate housing naturally retards the growth of the country. The rapid industrial growth and population explosion have given rise to acute housing shortage, especially in urban and metropolitan areas. High land costs and the need for proximity between the house and work space in the view of the rising transport costs, have made multi-storied buildings an appropriate solution to overcome housing problem to an extent. The construction of high rise buildings has become possible because of the recent advances in design and service. Especially R.C.C. has established he most popular technique for high rise buildings.

2.2 BUILDING IN GENERAL Building is defined as a structure for the whatsoever purpose and of whatsoever material used as a human habitation or not and includes foundation, plinth, walls, floors, chimneys, plumbing and building services, fixed platforms, veranda, balcony cornice(or projection) and sign and outdoor display structures. Broadly, buildings consist of three parts, namely (1) Sub-structure (2) Plinth (3) Superstructure.

2.3 CLASSIFICATION OF MULTI-STOREYED BUILDINGS Multi-storied buildings can be of following types: 1) Load Bearing Construction 2) Composite Construction 3) Framed Construction Load bearing construction Mainly consists of brick columns, walls and strip foundations. The brick columns and walls are load bearing components. It is economical only up to 2 to 3 storey. In Composite construction it is usual to provide reinforced concrete beams, slabs and stair cases. Thus it is a mixed construction in which dead and live loads are resisted by R.C. slabs and beams and brick columns and walls, while wind and earthquake loads are resisted by all brick walls acting as a unified structural system. Thus, it is economical up to 5 storeys. Beyond 5 storeys the lateral forces due to wind and earth quake become quite significant. In Framed construction the gravity as well as wind loads can be conveniently be resisted by reinforced slabs, beams and columns. The walls are used as non-load bearing components. During earthquakes the partitions walls do offer significant mass and lateral stiffness. For 6 or more storey, it is necessary to imply framed construction.

3. LITERATURE REVIEW

3.1 Introduction

The construction of multi-storey residential buildings is a growing necessity in urban and semi-urban areas due to increasing population and limited land availability. Structural analysis and design form the backbone of any safe and economical building project. Software tools like ETABS (Extended Three-Dimensional Analysis of Building Systems) have revolutionized this process by enabling precise modelling, analysis, and design of complex structures under various load conditions. This literature review highlights key past studies and the evolution of structural analysis and design of G+5 (Ground plus 5 floors) residential buildings using ETABS. ---

3.2 Importance of Structural Analysis and Design in Residential Buildings

Structural analysis is essential for ensuring a building can withstand applied loads without failure. Design involves selecting appropriate materials and dimensions to ensure stability, serviceability, and safety, according to national codes like IS 456:2000 (for concrete structures), IS 875 (for loads), and IS 1893:2016 (for seismic analysis). Researchers have emphasized: Accurate modeling for real-world conditions (e.g., Bhatt & Shah, 2014). Importance of integrating load combinations, dynamic analysis, and optimization for safety and economy. Inclusion of lateral loads such as wind and earthquake forces especially for multi-storey buildings (Rathod et al., 2016). ---

3.3 ETABS Software in Structural Design

ETABS, developed by CSI, is tailored for building analysis and design. It supports both static and dynamic analysis and complies with various international design codes. Key features include: Automatic generation of loads (seismic, wind, dead, live). 3D modeling with realistic visualization. Design and detailing of structural elements (beams, columns, slabs, shear walls). Time-history and response spectrum analysis. Jain and Kulkarni (2017) demonstrated how ETABS reduces human error and analysis time while maintaining design accuracy. ---

3.4 Previous Studies on G+5 and Mid-Rise Buildings Using ETABS

Static and Dynamic Analysis Patil et al. (2016) performed static and dynamic analysis of a G+5 building using ETABS and compared results with manual calculations. They concluded that the software provides faster and more reliable outputs. Deshmukh & Salunkhe (2015) emphasized the significance of incorporating seismic load analysis for G+5 and above buildings in Zone III and above. 4.2 Seismic Analysis Kumar & Singh (2018) analyzed a G+5 RCC structure in seismic zones III and IV. They found that using shear walls significantly improved lateral stability. Singh et al. (2020) studied different seismic load resisting systems using ETABS and concluded that moment-resisting frames with bracings and shear walls offered better performance. 4.3 Material and Cost Optimization Thakur et al. (2017) used ETABS to optimize column and beam sizes in a G+5 residential building to reduce construction cost while satisfying safety requirements. Kamble et al. (2019) explored different concrete grades in the same building layout, showing that M30 concrete offered a balance between strength and cost. 4.4 Load Distribution and Load Combinations Studies by Rao & Reddy (2015) stressed the importance of considering proper load combinations (as per IS 875 Part 5) for design. Their ETABS-based study showed that ignoring certain live load combinations underestimates internal stresses.

3.5 Building Code Integration and Compliance

ETABS supports various international and Indian codes: IS 456:2000 (Concrete design) IS 875:1987 (Load combinations) IS 1893:2016 (Seismic design) IS 13920:2016 (Ductile detailing) Many studies, such as Chavan & Kadam (2020), showed that when used properly, ETABS ensures compliance with these codes and helps generate detailed structural drawings. ---

3.6 Challenges and Limitations Identified

Despite its strengths, some researchers point out limitations: Modeling errors due to incorrect geometry or constraints can produce wrong results (Kamble et al., 2018). Over-reliance on software without engineering judgment can lead to unsafe designs. Interpretation of results (e.g., base shear, storey drift) requires knowledge of structural behavior.

Here is a comprehensive and in-depth "Analysis and Design of G+5 Residential Building Using ETABS"

3.7 Role of Structural Analysis and Design in G+5 Buildings

The structural integrity of a multi-storey building depends on accurate analysis of the forces acting on it and a design that ensures safety against possible failure modes such as bending, shear, deflection, and collapse. A G+5 building requires: Adequate load transfer mechanism from slab to beams, beams to columns, and columns to foundation. Resistance against lateral forces such as earthquake and wind loads. Serviceability against deflection and vibration. Conformance with national standards like IS 456:2000 (Concrete), IS 875 (Loadings), IS 1893:2016 (Seismic Design), and IS 13920:2016 (Ductile Detailing). Researchers like Murty (2005) and Agarwal & Shrikhande (2007) emphasized the criticality of considering lateral forces and ductile detailing in seismic zones for mid-rise buildings. ---

3.8 Overview of ETABS as a Structural Design Tool

ETABS, developed by Computers and Structures, Inc. (CSI), is a dedicated software tool for building analysis and design. It supports 3D modeling, linear and nonlinear analysis, and design based on various international codes. Key Features of ETABS: Automatic load calculations and combinations. Structural modeling with grids, materials, and cross-sections. Static, dynamic (response spectrum and time history), and pushover analysis. Design of RC and steel components. Integration with AutoCAD and Revit for BIM. Studies such as Chopra (2012) and CSI (2019) have demonstrated the accuracy and speed of ETABS in multi-storey building design. ---

3.9 Key Research Findings and Case Studies

3.1 Seismic Analysis of G+5 Buildings Seismic performance is critical in structural design, especially in high seismic zones. Ramesh and Prasad (2016) carried out a study of a G+5 RC frame structure in Zone IV using ETABS and found that base shear and lateral deflections were significantly affected by building symmetry and stiffness irregularities. Patel and Shah (2018) performed a response spectrum analysis of a G+5 building in Zone III using ETABS and compared it with manual design. The ETABS model captured the effect of mass participation and dynamic behavior more effectively. 4.2 Structural Optimization Kumar et al. (2017) used ETABS to analyze the impact of varying beam and column sizes in a G+5 residential building. They found that material savings of up to 15% could be achieved with optimized section sizes without compromising safety. Rajput and Mehta (2019) explored different configurations of shear walls and their placement using ETABS. Their study showed that centrally located shear walls significantly reduce lateral displacement and base shear. 4.3 Load Combination and Behavior Study Seth and Thakkar (2020) analyzed a G+5 building under various IS 875 (Part I, II, III, V) load combinations in ETABS. Their findings reinforced the necessity of including all critical combinations to account for the worst-case scenario. Gokhale and Pawar (2021) studied the effect of wind loads on G+5 structures and concluded that wind load contribution becomes significant in zones with high exposure, and ETABS offers reliable wind load simulation according to IS 875: Part 3. 4.4 Soil-Structure Interaction and Foundation Modeling Though ETABS primarily focuses on superstructure analysis, Nayak and Kulkarni (2018) incorporated foundation stiffness as spring supports to model soil-structure interaction for a G+5 building. The results showed that flexible supports increase displacements and need to be considered in seismic zones. 4.5 Material Alternatives and Sustainability Patil et al. (2022) analyzed a G+5 building using different grades of concrete (M20, M25, M30) and concluded that M25 offers a better balance of cost and strength for most mid-rise structures. ETABS facilitated quick reanalysis for multiple material configurations. ---

3.10 Integration with Building Codes

ETABS supports various Indian Standards including: IS 456:2000 – Plain and Reinforced Concrete IS 875:1987 – Structural Loadings (Parts 1 to 5) IS 1893:2016 – Seismic Design of Buildings IS 13920:2016 – Ductile Detailing Kulkarni et al. (2017) highlighted how ETABS enables full code compliance, automatically verifying parameters like drift, story shear, column interaction, and ductile detailing provisions. ---

3.11 Comparative Studies with Other Software

Desai and Jadhav (2019) compared ETABS G+5 RCC buildings. While both software platforms yielded similar results for axial forces and bending moments, ETABS was favored for buildings due to its intuitive interface, faster modeling, and detailed building-specific reports. Rana and Singh (2021) compared manual analysis with ETABS results and reported that ETABS reduced design time by over 60%, with acceptable variation (under 5%) in structural quantities. ---

3.12 Limitations and Research Gaps

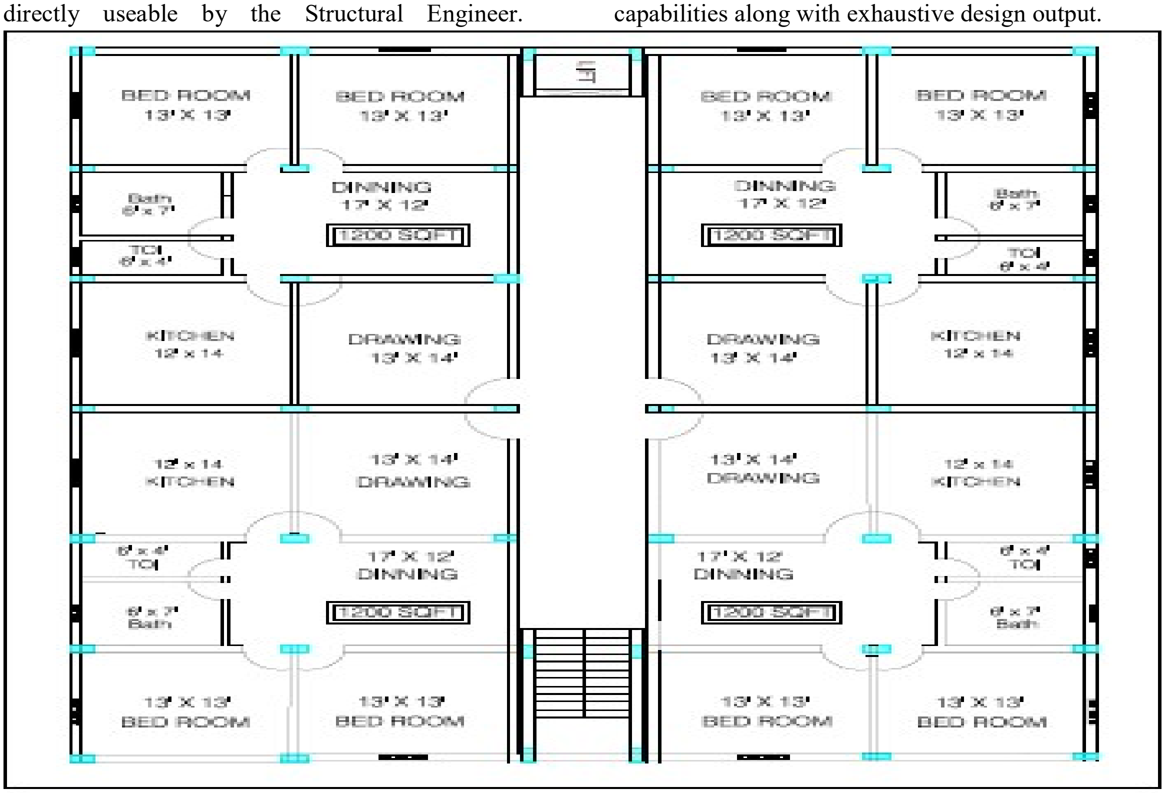
Despite ETABS' capabilities, researchers have identified the following challenges: Accuracy of Model Inputs: Incorrect member dimensions, boundary conditions, or load applications can lead to misleading results. Interpretation of Results: Software users may misinterpret outputs like drift, torsion, or modal mass participation without proper engineering judgment. Foundation Analysis: ETABS requires external tools for rigorous foundation and geotechnical design, which limits complete integration. Sharma et al. (2022) recommended combining ETABS with SAFE or PLAXIS for better soil-structure interaction modeling in multi-storey buildings.

4. STRUCTURAL DESIGN

Introduction to Analysis of Structures The primary function of a structure is to receive loads at certain points & transmit them to some other point. In performing this primary function the structure develops internal forces in its. components members known as structural elements. It is the duty of the structural engineer to design it in such a way that the structural elements perform their functions adequately. The inadequacy of one or more structural element may lead to malfunctioning or even collapse of the entire structure. The object of structural analysis is to determine the internal forces & the corresponding displacements of all the structural elements as well as those of the entire structural system. The safety & proper functioning of the structure can be ensured only through a thorough structural analysis. The importance of proper structural analysis cannot, therefore, be over emphasized. A systematic analysis of structural system can be carried out by using matrices. The Matrix approach for the solution of structural problems is also eminently suitable for a solution using modern digital computers. Hence the advantage of using the matrix approach for large structural problems is evident. By using matrix approach, the structural analysis can be performed in two methods: i) Flexibility method ii) Stiffness method In this project, the frames have been analyzed by using ETABS., Which uses stiffness method for analysis of structure. ETABS, over the years, has developed to become the world's most popular & powerful structure engineering software. ETABS features a state-of-the-art user interface, visualization tools, powerful analysis & design engines with advanced finite element& seismic analysis capabilitie From model generation, analysis & design to visualization & result verification, ETABS is the choice of the design professionals around the world for the analysis & design of steel, concrete,compastive,timber,aluminium & cold-formed steel structures. 3.2 Loads: The load on a structure varies in nature. In general all the buildings will be subjected two types of loading-Dead loads & live loads. Dead or Static loads include the self weight of roof slabs, beams, columns, footings, lintels, brick work, furniture, static machinery, etc. These loads do not change their place where as live load include all such loads, which are liable to change their position from time to time. The live load varies in magnitude from building to building form a minimum of 2 KN/ m for dwelling houses, to a 10 KN/m for factories. in the present case of the building project, slabs are assumed 130mm thickness from stiffness/deflection, consideration. Beams are taken separately. The self-weight is calculated & added separately on the frame. 3.3 Loads on beams: (I) Dispersion of load on slab to the beam: The load of slab is dispersed on to the supporting beams in accordance with clause 24.5 of IS: 456 -2000, which states that the load on beams supporting solid spans, spacing in two directions at right angles & supporting uniformly distributed loads, may be assumed to be in accordance with Fig 7 Load due to trapezoidal loading = $\mathrm{W}u * Lx$ 6 load due to triangular loading = $\mathrm{W}u * Lx$ 3 (3 − (Lx) 2) Ly Ws = load/m on slab (2) Self weight of beams: This load acts on the beams as a UDL. this is calculated after assuming the suitable cross section (by stiffness /deflection consideration) of the beam. (3) Load due to brick masonry wall: Since the loads are transferred to the column by beams. in limited structure wall does not play any significant part in carrying loads & transference of loads, wall need not be excessively thick. Nominal thickness of wall, so. as to shield the wall will be transferred to the beams. (4) Point load from intersecting beam: If there is any beam meeting the beam, then the load of that beam is considered as point load

5. TOOL USED ETABS

"ETABS" is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building systems. ETABS features an intuitive and powerful graphical interface coupled with unmatched modelling, analytical, and design procedures, all integrated using a common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of geometrical nonlinear behaviours, making it the tool of choice for structural engineers in the building industry. The accuracy of analytical modelling of complex Wall Systems has always been of concern to the Structural Engineer. The computer models of these systems are usually idealized as line elements instead of continuum elements. Single walls are modelled as cantilevers and walls with openings are modelled as pier and spandrel systems. For simple systems, where lines of stiffness can be defined, these models can give a reasonable result. However, it has always been recognized that a continuum 2 model based upon the finite element method is more appropriate and desirable. Nevertheless this option has been impractical for the Structural Engineer to use in practice primarily because such models have traditionally been costly to create, but more importantly, they do not produce information that is directly useable by the Structural Engineer.

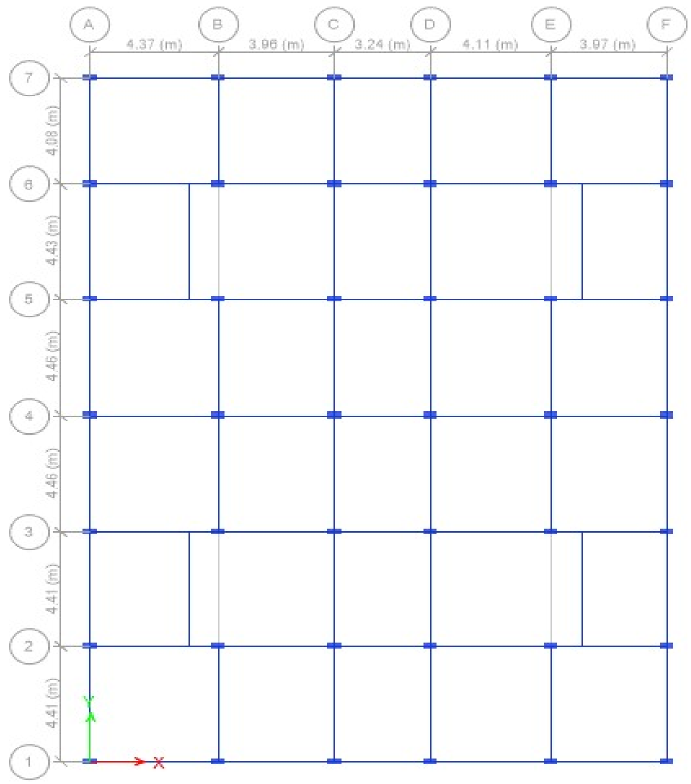


PLAN LAYOUT

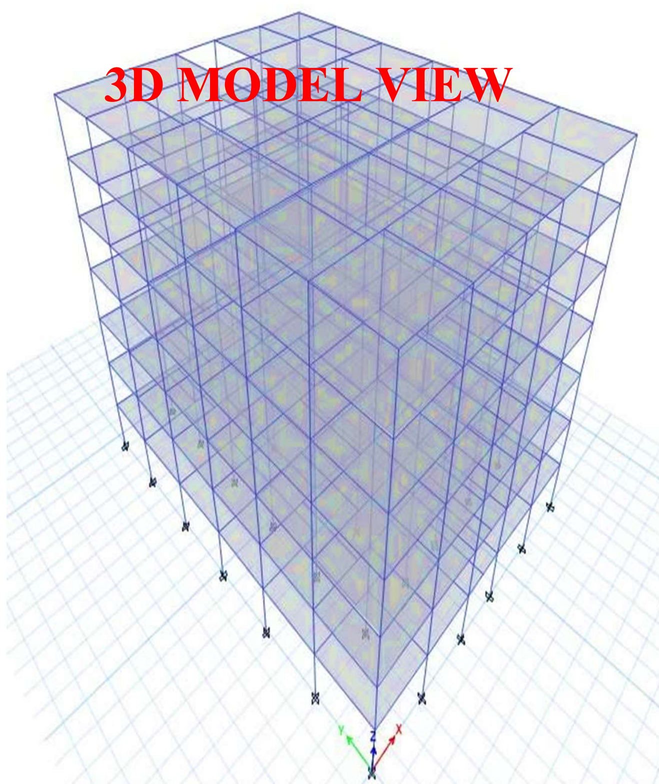
TOTAL AREA =5040Sq.ft

However, new developments in ETABS using object based modelling of simple and complex wall systems, in an integrated single interface environment, has made it very practical for Structural Engineers to use finite element models routinely in their practice. ETABS ● Developed by practicing engineers for practicing engineers around the globe ● Evolved over 20 years & is constantly guided by a premier industry-based steering committee ● Has building codes for most countries including US, Britain, Canada, Australia, France. Germany, Spain. Norway, Finland, Sweden, India, China, Euro Zone, Japan, Denmark, & Holland. More are constantly being added. ● Fully COM (Component Object Model) compliant & is designed using an open architecture. ● ETABS User Interface is the industry standard. lts powerful graphics, text & spreadsheet interfaces provide true interactive model generation, editing, analysis & easily generates comprehensive custom reports. ●Can export all data to Microsoft Word or Microsoft Excel! ● Supports multi-maten‘al design codes such as timber, steel, cold-formed steel, concrete & aluminum. ● Dynamic & soil-structure interaction capabilities along with exhaustive design output.

GRID LINE PLAN



3D MODEL VIEW



6. FEATURES:

1) Utility of building : Residential

2) No. of storey : G + 7

3) No. of flats in a storey : 4

4) No. of staircases : 1

5) Type of construction : R.C.C. Framed Structure

6) Type of walls : External walls 230 mm Partition walls115 mm

7. GEOMETRIC DETAILS:

1) Floor-floor height : 3.2 m 2) Height of Plinth : 0.5 m Above G.L 3) Depth of Foundation : 1.5 m Below G.L MATERIALS: 1) Concrete mix for slabs, : M20 beams, columns, footings 2) Main Steel : Fe 500 3) Secondary Steel : Fe 415 4) S.B.C. of soil : 300 KN/m2

8. SPECIFICATIONS

1. STRUCTUR : R.C.C. Framed Structure.
2. WALLS : All external and internal walls shall be in brick masonry in C.M (1:8), external plastering in sponge finish and internal plastering in smooth finish.
3. DOORS : Door frames in non-teak and flush door shutters.
4. WINDOWS : Windows are non-teak wood frames with full glass shutters and safety bars.
5. FLOORING : i) White mosaic flooring in hall with skirting

ii) Grey mosaic flooring with skirting in other areas
iii) Ceramic flooring in toilets

6. KITCHEN : Marble stone in platform with built in sink and storage lofts above the platform.
7. TOILETS : One Indian and one European W.C. with Concealed plumbing
8. PAINTING : Enamel paint on doors and windows, oil Bound distemper on interior walls cement based paint on exterior walls.
9. ELECTRIFICATION : Concealed P.V.C. pipes and wiring with piano type switches on hylam sheet.
10. LIFT : Standard make lift for 6 passengers.

9. CALCULATIONS

1. Using partial safety factors for loads in accordance with clause 36.4 of 18456-2000 as

$\gamma\gamma f = 1.5\, \gamma\gamma$

2. Partial safety factor for material in accordance with clause 36.4.2 is 18-456-2000 is

taken as l.5 for concrete 8: 1.15 for steel.

3. Using partial safety factors in accordance with clause 36.4 of 18-456-2000

combination of load. D.L + L.L(1.5) D.L+L.L + W.L(1.2)

4. Density of material used in accordance with Ref (IS) 875-1987:

MATERIAL Density plain concrete 24KN/m reinforced 25 KN/m flooring material (cm) 20 KN/m brick masonry 19 KN/m

5. Live load :

live load on slabs 2 KN/m live load on passage 3 KN/m live load on stairs 3 KN/m 3.8 Design Constants: using M20 & Fe500 grade of steel fck (characteristics strenght for M20) = 20 N/mm fy (characteristics strenght for steel)= 500 N/mm

10. CONCLUSION

The analysis and design of the G+5 residential building using ETABS has demonstrated the effective application of structural engineering principles and modern software tools in real-world construction projects. The building components including slabs, beams, columns, and footings were successfully designed in compliance with IS codes. ETABS facilitated accurate modeling, load application, and structural analysis, enabling efficient and optimized design. This project not only ensured structural stability and safety but also emphasized economy, serviceability, and adherence to building standards. The outcome reinforces the significance of integrating theoretical knowledge with practical tools for sustainable and reliable civil engineering solutions. --- Let me know if you need a longer or more detailed version.

Based on the detailed content of the project report titled "Analysis and Design of (G+5) Residential Building Using ETABS", here is a comprehensive and detailed conclusion for your civil engineering major project: --- Conclusion The project titled "Analysis and Design of (G+5) Residential Building Using ETABS" successfully demonstrates the application of theoretical knowledge and practical techniques in structural engineering, specifically in the domain of multi-storey residential construction. This study aimed at designing a safe, efficient, and economical G+5 (Ground + 5 Floors) RCC framed residential building using ETABS, one of the most widely adopted structural analysis and design tools in civil engineering. Throughout the project, various essential steps of structural design were systematically carried out, starting from architectural planning, structural analysis, estimation of loads, to the final design of structural elements like slabs, beams, columns, footings, and staircases. The design was done in accordance with relevant IS codes such as IS 456:2000 for general RCC design and IS 875 for loading considerations. Limit State Method was used for structural design, ensuring a balanced approach between safety (limit state of collapse) and serviceability (deflection, cracking, durability). Key conclusions derived from the project are:

1. Structural Safety and Stability:

All structural elements—slabs, beams, columns, footings, and staircases—were designed to safely withstand applied dead, live, and seismic loads. The structural configuration and ETABS analysis ensured proper load transfer paths, stability under vertical and lateral loads, and acceptable deflection and shear behavior.

2. Software-Based Design Efficiency:

ETABS enabled efficient modeling, quick iteration, accurate load calculations, and visualization of stress diagrams (axial, shear, moment, and torsion). It significantly reduced manual calculation errors and improved the speed and reliability of the structural design process.

3. Economical Design:

Through proper structural planning and optimization in design (e.g., appropriate section sizes, reinforcement detailing), the overall construction was made cost-effective without compromising safety and performance.

4. Code Compliance and Detailing:

All designs were prepared considering IS codes, ensuring the building meets national safety and performance standards. Detailing for reinforcement and connections was accurately executed, considering practical constructability.

5. Application of Theoretical Knowledge:

This project served as a bridge between classroom learning and real-world application. It helped us understand how concepts such as structural analysis, load distribution, and material strengths translate into tangible design outcomes.

6. Holistic Understanding:

The project enhanced our understanding of planning, analysis, and design stages of multistorey construction. It also improved our command over civil engineering tools like AutoCAD for drafting and ETABS for analysis. --- In conclusion, this project not only fulfilled its primary objective of designing a G+5 residential building using ETABS but also strengthened our professional skills, engineering judgment, and confidence to tackle real-world civil engineering challenges. It marks a vital step toward our readiness for the industry, research, or higher education in the field of structural engineering. --- Let me know if you'd like a shorter summary or a PowerPoint slide based on this conclusion.

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