Design of Hostel Building through ETABS Software

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Abstract: **ETABS Structural Analysis is the branch in which we determine the behavior of structures through which we can predict the responses of different structural components under effect of different types of loads. Every structure will be subjected to either one or multiple loads, the various kinds of loads normally considered are dead load, live load, earth quake load and wind load. ETABS (Extended Three- Dimensional Analysis of Building System) is the ultimate integrated software for the structural analysis and design of building. In this project "Analysis and Design of hostel building (G+5) through ETABS software" is an attempt to design and analyze a hostel building using ETABS. A G+5storey building is considered for this study. The analysis is design is done as per IS 456:2000 guidelines. This project is designed as per INDIAN CODES – IS 1893 part II: 2002, IS 456:2000. Drawing and detail are done using Auto CAD.**

Keywords: **ETABS, Building, Design, Analyses.**

I. INTRODUCTION

In Civil Engineering there is a term called building which is used to mean a structure consisting various components like walls, columns, floors, roofs, doors, windows, ventilators, stairs lifts, foundation various types of surface finishes etc. Structural design and analyses are applied to create a structure having qualities such as resisting all applied loads without failure throughout its intended life. Before design and analyses of any structure, all the necessary information regarding soil has to be collected by using geotechnical investigation. A geotechnical site investigation is method of collecting information and evaluating the conditions of the site according to which the design and construction of the foundation is made for the structure. Structural engineers are always working to find the most economical and efficient design with accuracy as well as ensuring that the final draft of the building must be serviceable for its intended usage over its design life. There are various software packages which are available in the market for designing and analyzing all the types of structures viz. RISA, STAADPRO, ETABS, RAM, MIDAS, SAP and STRUDL etc.

3. To check the stability of beam and column for the designed load conditions
4. To analysis for Shear & Bending moment, and
5. Analyzing with all the Indian Standard Codes for buildings.
The main objective of this study is to analyze and design a G+5 commercial building using ETABS software.

- To design structural components like footing, Column, beam, slab.
- To create and draw reinforcement details of structural components through the application of Auto CAD.

To achieve the objectives of the study that is to design and analyze hostel building using ETABS. The fundamental requirements such as safety, durability, economy, aesthetic appearance, feasibility, practicability and acceptability should be met. The following methodology should be followed: -
- Site survey
- Soil investigation
- Structural planning
- Analysis and design in ETABS

In first phase, surveying is to be done and then a plan or map is prepared for the area showing topographical details related to design of structure etc. Therefore planning has to proper and perfect. The application of a geotechnical site investigation is necessary to obtain sufficient site information for designing a structure in the proper time with minimum cost. The structural plan is prepared using a computer aided software, in this case it is prepared using AutoCAD.

ETABS is used for design and analyses of any type of project which includes bridges, towers, stadium, culverts etc. ETABS provides us with good, compatible and scalable solution that will fulfill each and every demands of the project. This project is designed taking into consideration INDIAN CODES- IS 1893-part2:2002, IS 456:2000. The analysis is carried out by considering severe seismic zones and behavior is assessed by taking type-II Soil condition.

II. LITERATURE REVIEW

[1]   **Varalakshmi V et.al (2014)** analyzed and designed a G+5 storey residential building and many components like beam, slab, column and foundation. The live load and dead load were calculated as per HYSD bars and IS 875(Part I & II)-1987 i.e., Fe 415 are taken as per IS 1986- 1985. They concluded that the protection of the concrete building depends upon the initial architectural and structural configuration of the complete building, the standard of the structural analysis, design and reinforcement detailing of the building frame to attain stability of elements and their ductile performance.

• **Chandrashekar et.al (2015)** designed and analyzed the multistoried building by using ETABS software. A G+5 storey building under the lateral loading effect of wind and earthquake was considered for this study and analysis is done by using ETABS. They have also considered the probabilities of occurrence of spread of fireside side and therefore the importance of use of fire proof material up to highest possible standards of performance also as reliability. They suggested that the wide chances of ETABS software which is extremely innovative and easier for top rise buildings in order that time incurred for designing is reduced. Balaji.U and Selvarasan M.E (2016) worked on analysis and style of multistoried building under static and dynamic loading conditions using ETABS.

• **Balaji.U and Selvarasan M.E (2016)** designed and analyzed a multistoried building under dynamic and static loading conditions using ETABS. In this work a G+13 storey residential building was studied for the earth quake loads using ETABS. Here they took the material property to be linear, dynamic and static analyses were performed. The non-linear analysis was carried out by considering severe seismic zones and the behavior was assessed by considering type II soil condition. Different results like displacements, base shear was plotted and studied.

• **Geethu et.al (2016)** made a comparative study on analysis and design of multi storied building by STAAD Pro and ETABS software. They provided the details of both commercial and residential building design. Their plan was made in accordance with the national building code and was drawn using Auto CAD software. In that paper they concluded that comparing both software results, ETABS software shows higher values of bending moment and axial force.

III. METHODOLOGY

There are namely three philosophies for the design of reinforced concrete:
   1) Working Stress Method
   2) Ultimate Load Method
   3) Limit State Method

1) Working Stress Method-
This is the oldest method to design the structure. It is not commonly used now a day. In this method structural elements behave as elastic. In this method, permissible stress is kept below the strength of material. Factor of safety should be applied for serviceability of structure.

FOS = Strength / Permissible stress

2) Ultimate Load Method
   In this method load is provided until ultimate strength of the material is attained. The main problem which occurs in this method is the serviceability. Due to heavy load applied on structure, large deflection may occur.

3) Limit State Method
Limit State Method assumes both serviceability and safety of the structure. Thus we can conclude that this method is a combination of both Working Stress Method and Ultimate Stress Method.
The methodology followed for the design of G+5 building is:
   • Preparing the AutoCAD drawings (plan, section and elevation)
   • Calculation of loads
   . • Analysis of the structure.
   • Design and detailing of structural elements.

Load Combination
A. For seismic analysis of a building following load combination are considered.
                 a. 1.5(DL+IL)
                 b. 1.2(DL + IL ± EL)
                 c. 1.5(DL ± EL)
                 d. 0.9 DL ± 1.5 EL
B. For wind load analysis following load combination is considered in building:
                 a. DL +LL
                 b. DL+WL
                 c. DL+0.8LL+0.8WL
Load Combination

Loads are firstly considered in designing of any building since they define the nature and type of hazards or exterior forces which the building needs to be resisted to provide reasonable performance for the structural life.The loads considered in the design include

- Dead Load
- Live Load
- Wind Load
- Imposed load
- Earth quake load

Dead loads on building

RCC	25 KN/m^3
PCC	24 KN/m^3
Brick masonry	19 KN/m^3
Floor Finish	1 KN/m^3

Live loads on building

On Floors	4 KN/m^2
On Roofs	3.5 KN/m^2
On Stairs	5 KN/m^2

IV DESCRIPTION OF STUDY MODEL

A. Project Details
1. Purpose of the building: commertial
2. Shape of the building: regular (rectangular)
3. No. of stories: (G+5)
4. Type of wall: brick wall
5. Height of stories: 3m. (Similar stories)
B. Material Property
Grade of concrete (for all structural elements): M25
Unit weight of concrete: 25kN/m3
Unit weight of cement mortar: 24kN/m3
Unit weight of water: 10kN/m3
Unit weight of Brick: 20kN
Grade of concrete: M20
Grade of steel: Fe 415
Beam Size: 200X600
Column Size: 300X300
C. Description of Loads
   All moving loads come under live loads:
- Live load (on floors): 2kN/m2, (IS 875:1987 – Part -2)
- Live load (on roof): 1kN/m2, (IS 875:1987 – Part -2)
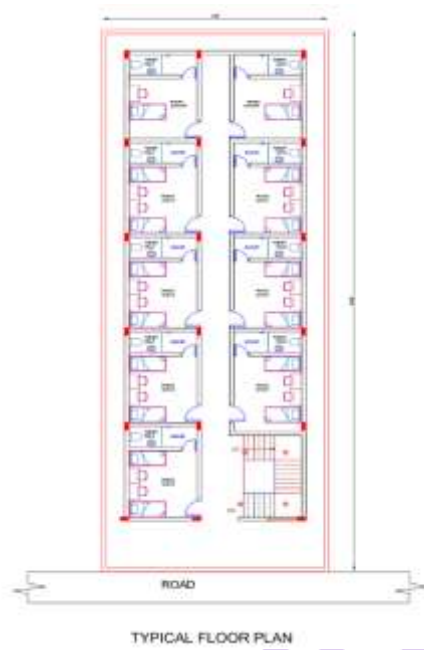
Floor finishes are the super imposed dead loads.
- Floor Finishes (on floors): 1.5kN/m2
- Floor Finishes (on roof): 2kN/m2

Wall loads are loads of bricks used in construction.
- For 9" wall(outer wall):12.45kN/m^2
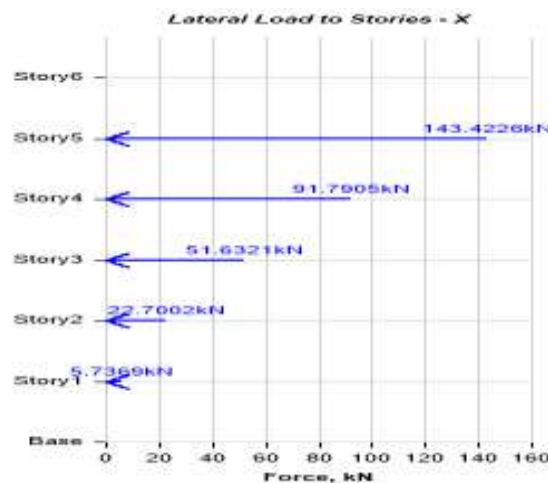- For 4.5" wall (inner wall): 6.21kN/m^2

V. ETABS ANALYSIS & DESIGN

A. Building Plan

TYPICAL FLOOR PLAN

B. Structural Data

Tower	Name	Height m	Master Story	Similar To	Splice Story	Color
T1	Story6	3	Yes	None	No	Cyan
T1	Story5	3	Yes	None	No	Cyan
T1	Story4	3	Yes	None	No	Cyan
T1	Story3	3	No	Story4	No	Red
T1	Story2	3	No	Story4	No	Magenta
T1	Story1	1.5	No	Story4	No	Yellow

C. Applied story force

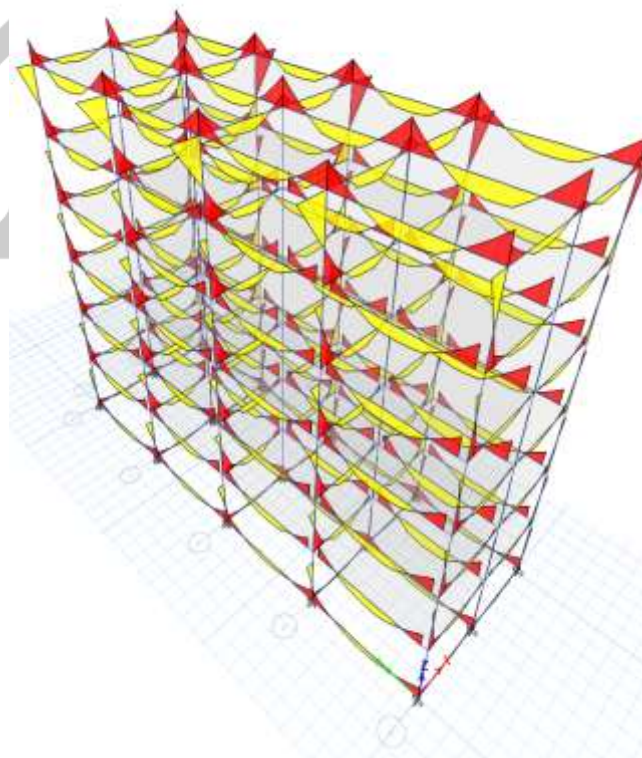| Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story6	18	0	0
Story5	15	143.4226	0
Story4	12	91.7905	0
Story3	9	51.6321	0
Story2	6	22.7002	0
Story1	3	5.7369	0
Base	0	0	0

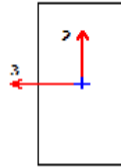D. 3D Elevation of building
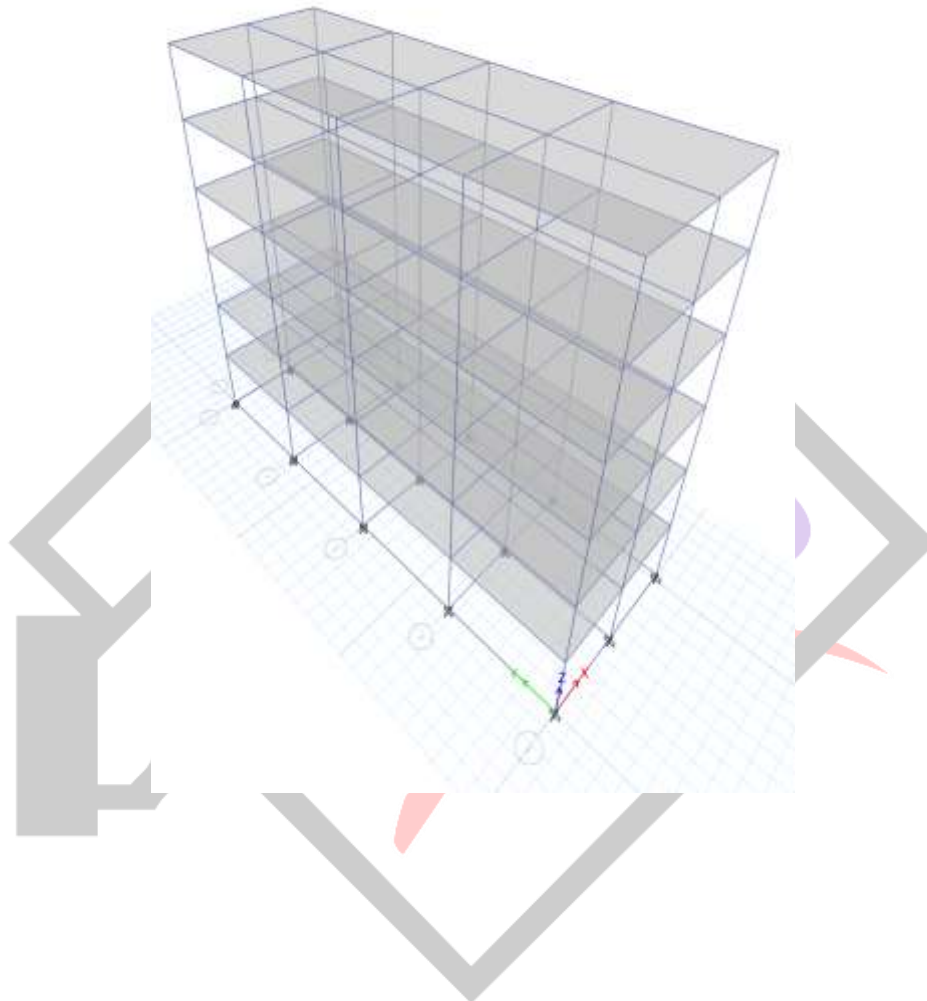
E. Shear Force Diagram of Building
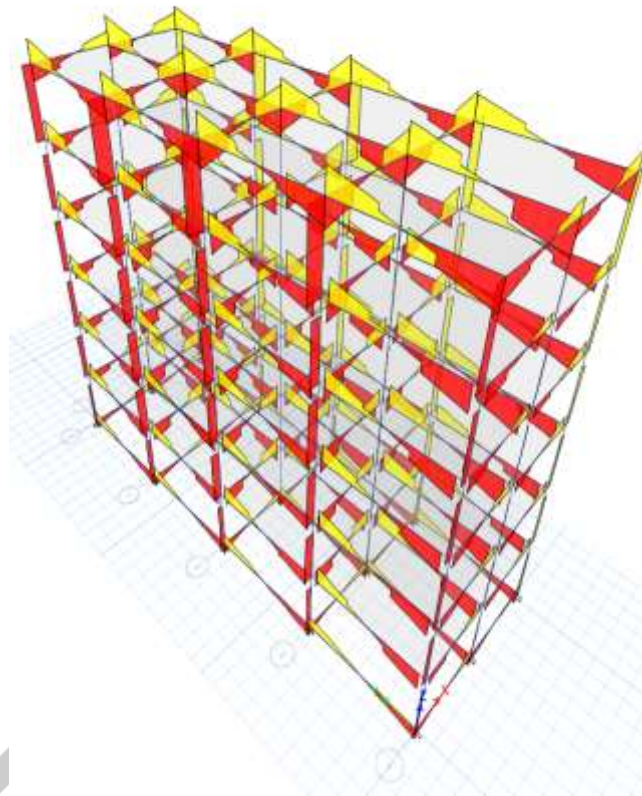
F. Bending Moment Diagram of Building

G. Design of beam

Beam Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
Story 3	B6	192	BEAM 200X600	UDCon27	2450	2600	1

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
200	500	200	0	60	60

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	500	415

Design Code Parameters

γ_C	γ_S
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
5.9209	1.6994	9.95	-0.1928

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
5.9209	3.4988	9.4198	0

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	0		189	0	2.217E-01	189
Bottom (-2 Axis)		9.4287	189	50	2.217E-01	189

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
61.3781	0	72.9585	38.3979	461.5

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
1.6887	9.91	100	400	0

CONCLUSION

- Column and beams were provided in structure of the size as mentioned below:

    Column = 600 X 600

    Beam = 200 X 600

- ETABS software saves the working time and helps us in designing the structure accurately

- We can economize the column by providing it in the required amount as specified by IS Codes. Minimum percentage Area of steel is usually 0.8% of the Gross cross sectional area and maximum area is taken as 6% as per IS code.

- As the height of structure is increased, the stiffness phenomenon (slenderness effect) i.e. long column effect will come into account

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