Design of Multistoried Residential Building (G+5) Using ETABS software

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***Abstract*: ETABS is a Design and Analysis software which is used for "Extended Three Dimensional Analysis of Building Systems". This software is useful in the design of high rise multi-floored building in a systematic manner. In this study we considered (G+5) Residential building, where in we need to Analysis all the design aspect and Stability condition of building in natural calamities. Plan of the building is drafted by using AutoCAD which is then transferred for Analysis in ETABS. Placement of beam and column was also done with dimension and spacing consideration. the stability is often governed using this software as this helps us to know beforehand the sustainability of building and the functioning age. Analysis saves the cost of construction by designing the building in the same manner as required by the specification. Indian Standards as specified are also taken care of and designing is done in accordance to it so as to avoid the deformation if any. The designed and analyses of building frame has been performed using ETABS software. In our project which is "(G+5) Residential building", we are considering the design as well as analysis for both gravity and lateral loads as stated by Indian Standards. With the help of this software building can be analyzed before the construction, and we can check the failure in the analysis and redesign them, so that failure can be prevented. Once we get the results construction can be done according to design. This project is designed as per INDIAN CODES – IS 1893 part II: 2002, IS 456:2000.**

***Keywords*: AutoCAD, ETABS, Design Software, multistory residential building**

I. INTRODUCTION

Whenever we think of Design and Analysis of residential building in 21st centaury one thing that comes in our mind is that construction of high rise building has been involved. In Ancient times human lived life as Nomads and accommodated themselves either under trees or in the caves to protect themselves from wild animals, and natural sources like sun rain etc. as the time moved on the people started living either in huts made of timber or mud. Now those houses have been made into beautiful and high floored houses which completely changed the lifestyle of the people.

Single storied building generally consists of ground storey only. While multi storied building consist of multiple stories, typically containing vertical structure in form of ramp, stairs, lift etc.

With the need of multi storied building requirement all over the world and the buildings touching the sky, safety is the biggest requirement, so people can live happily.

A. Objectives

Following are the objectives of the project-

1. To Design and Analysis (G+5) Residential building using ETABS software.
2. To identify the stability and workability of structure against various supernatural events
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 objective of structural design is to design the structure for strength, stability as well as workability. The design of structure must be satisfying basically three design requirement-

1. **Stability** Prevent the structure by overturning, sliding or buckling, or any of the parts under the action of load.
2. **Strength** to resist the stress induced in various parts of structure.
3. **Serviceability** so that structure gives satisfactory results under service load condition- which gives idea that provide adequate strength and stiffness, reinforcement to resist deflection and vibration within desirable limits.

Assumption regarding Design

i) We assume that slab is continuous over interior supports, and partially fixed over the edges, due to construction in form of monolithic and construction of wall over it.

ii) Beams are also assumed to be continuous over the interior support and framing takes place into the ends of columns.

II. LITERATURE REVIEW

- **Sayyed A.Ahad1, Hashmi S Afzal2, Pathan Tabrej3, Shaikh Ammar4, Shaikh Vikhar5, Shivaji Bidve6,** Design and Analysis of the residential building which has (G+10) stories has been done. Analysis was done using ETABS software Version 15.2 which proved to be good enough in the design for construction and the structural analysis of all the sections. All the elements of structure like concrete wall, which retains weight of soil are provided. As per soil investigation reports they provided isolated footing. The sectional and design analysis were done using STAAD-PRO and result can be compared.

- **K. KIRAN MAI1, MOHD AMER2, MD. SHAIBAZ ALI3, MOHAMMED FAZAL AHMED4, MOHAMMED OMAIR5, AFTAB TANVEER6,** This paper mainly deals with the analysis done by comparing the results which we have obtained from the analysis of a multi storied building structure through manual method as well as by using ETABS software. In their construction site they considered a plan under zone –IV**.** Seismic Intensity came out to be Severe and Zone Factor is 0.24.

- **S Abhishek1, Manoj S K2, Roopa B D3, Bhagyashree M S4, Guruprasad C H M5,** They took into consideration residential buildings (G+1) design and analysis using ETABS, wherein they got very productive results through which they got a great industrial exposure and saved their designing time as well as analysis. They took load consideration for the worst cases for the loading in structures. They designed structural components manually as well as on the software and further compared.

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 takes into consideration 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: Residential
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 the loads of bricks used in construction.

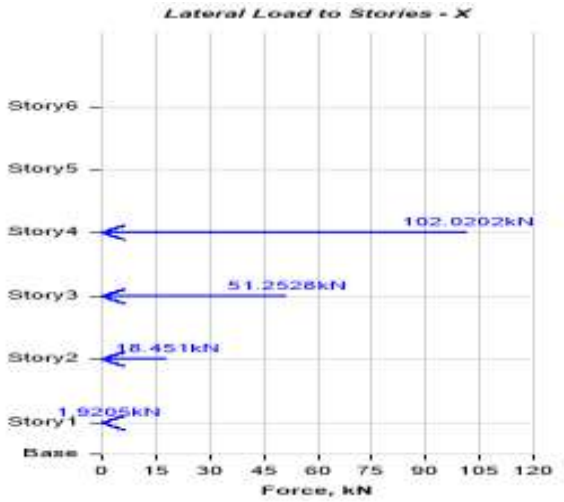
- For 9” wall(outer wall):12.45kN/m^2
- For 4.5” wall (inner wall): 6.21kN/m^2

V. ETABS ANALYSIS & DESIGN

A. Building B. Structural Data

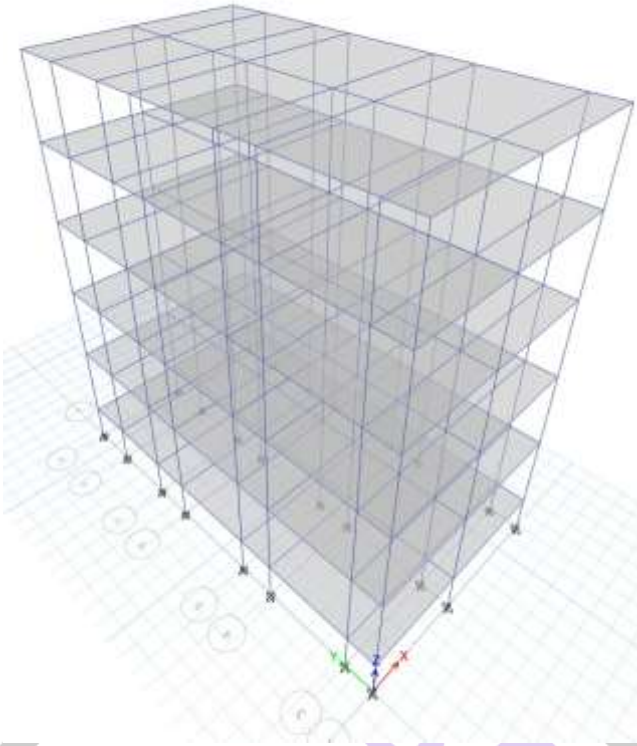
Tower	Name	Height m	Master Story	Similar To	Splice Story	Color
T1	Story6	3	Yes	None	No	Cyan
T1	Story5	3	Yes	None	No	Cyan
T1	Story4	3	Yes	None	No	Cyan
T1	Story3	3	No	Story4	No	Red
T1	Story2	3	No	Story4	No	Magenta
T1	Story1	1.5	No	Story4	No	Yellow

C. Applied story force

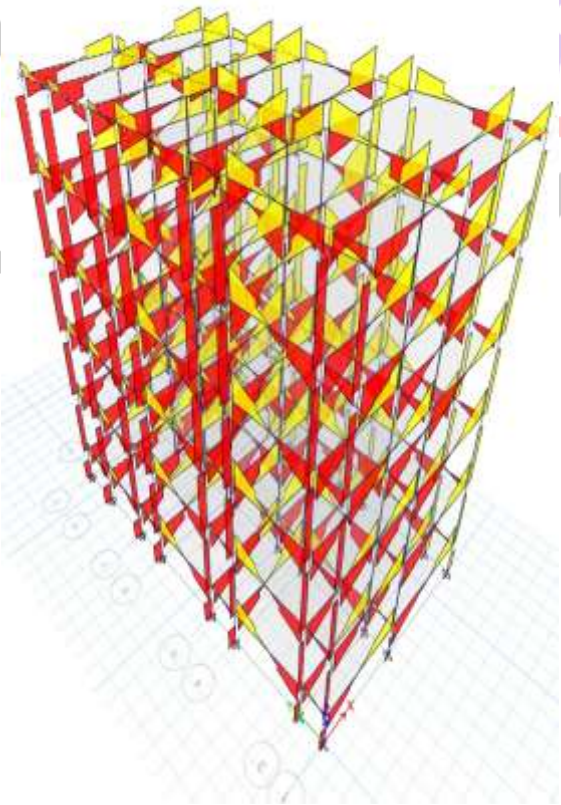


Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story6	16.5	0	0
Story5	13.5	0	0
Story4	10.5	102.0202	0
Story3	7.5	51.2528	0
Story2	4.5	18.451	0
Story1	1.5	1.9205	0
Base	0	0	0

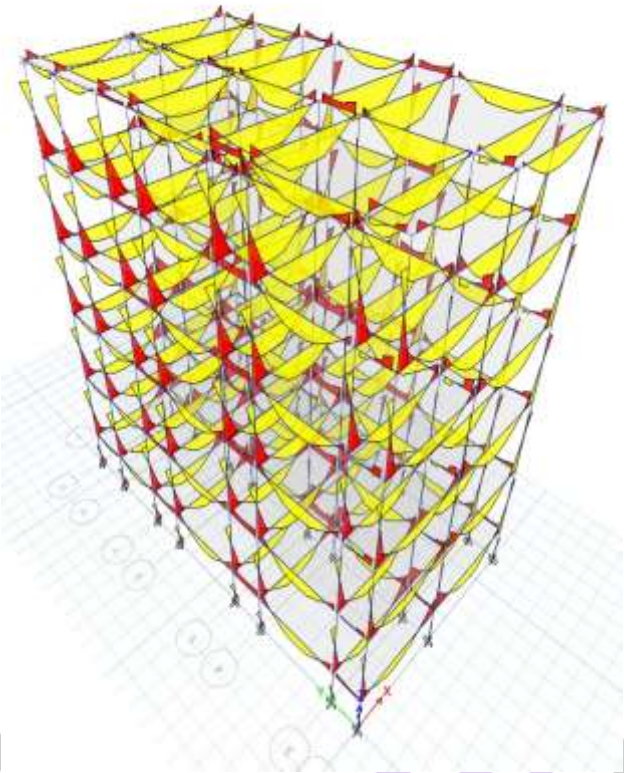
D. 3D Elevation of building



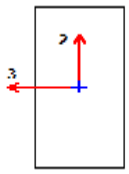
E. Shear Force Diagram of Building



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)		9.4198	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
60.3181	0	73.9135	42.3973	465.5

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
1.6994	9.95	100	400	0

VI CONCLUSION

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

  Column = 300 X 300

  Beam = 200 X 600
- As our project is based on most economical column method so we will do it by reducing the size of section. As load is more at bottom as compared to top there is no need of providing big size column at top.
- 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
- Usage of ETABS software saves the working time and helps us in the Designing the structure accurately

REFERENCES

[1] Khokhar, M. I. A., Rozière, E., Turcry, P., Grondin, F., & Loukili, A. (2010). Mix design of concrete with high content of mineral additions: Optimisation to improve early age strength. *Cement and Concrete Composites*, *32*(5), 377-385.

[2] Le, T. T., Austin, S. A., Lim, S., Buswell, R. A., Gibb, A. G., & Thorpe, T. (2012). Mix design and fresh properties for high-performance printing concrete. *Materials and structures*, *45*(8), 1221-1232.

[3] Mallikarjun, M., & Prakash, D. P. S. (2016). Analysis and Design of a Multi Storied Residential Building of (Ung-2+ G+ 10) By Using Most Economical Column Method. *International Journal of Science Engineering and Advance Technology, IJSEAT, ISSN 2321-6905 FEBRUARY*, *4*(2).

[4] Ahad, S. A., Afzal, H. S., Tabrej, P., & Ammar, S. (2017). Analysis and Design of Multistory Apartment Building Using ETABS. *International Journal of Engineering and Computer Science ISSN: 2319-7242 Volume 6 Issue 5 May 2017, Page No. 21269-21285 Index Copernicus value (2015): 58.10 DOI: 10.18535/ijecs/v6i5. 13. Accessed online at: www. ijecs. in*.

[5] IS456-2000 (2000) Indian Standard Plain and Reinforced Concrete Code of Practice. Bureau of Indian Standards, New Delhi.

[6] IS: 875 (Part I) - 1987, Indian Standard Code of Practice for Design Loads (Other than Earthquake) (Dead Loads) for Buildings and Structures, Bureau of Indian Standards, New Delhi.
[7] IS: 875 (Part 2) - 1987, Indian Standard Code of Practice for Design Loads (Other than Earthquake) (Imposed Loads) for Buildings and Structures, BIS, New Delhi.
[8] IS: 875 (Part 3) - 1987, Indian Standard Code of practice for design loads (other than earthquake) (Wind Loads) for buildings and structures, Bureau of Indian Standards, New Delhi.