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ANALYSIS, DESIGN AND STRUCTURAL ESTIMATION OF RCC STRUCTURE USING ETABS AND MICROSOFT EXCEL

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Abstract

☐ Since India is a developing country, many new projects are being started on a daily basis that must be finished within a certain time frame. The main factors in project completion are design and implementation, which aid in the stability of the structure. In this dissertation, we describe our novel method to design utilising ETABS and Microsoft Excel. We start by designing the structure and simulating it in ETABS software using various loads and load combinations according to the IS codebook, then exporting to MS Excel and additional processing delivers the entire detailed and schedule drawings of the RCC structure. Following the design of structural elements, we must acquire the bar bending schedule in order to achieve structural estimation. So, after we have the bar bending schedule, we can calculate the quantity of steel and concrete required in the building, and then we can estimate the cement, sand, coarse aggregate, and bricks based on the concrete given. The outcome of our proposed strategy demonstrates that the procedure is very efficient, saving time and money. Normally, the design process takes many hours to complete, but with the aid of this proposed approach, efficient solutions may be obtained in just a few minutes.

INTRODUCTION

☐ Every structure has two parts: the superstructure and the substructure foundations. The superstructure is the upper component of the building that serves the function of its intended use, whereas the substructure is the lower portion of the building that transmits the load of the superstructure to the sub soil, and the footing is the lower portion of the foundation that has direct contact with the sub-soil. The foundation is the most fundamental component of any structure. In India, structural designers use ETABS to perform analysis and design by going through several processes such as modelling, material properties, support conditions, materials and their mixtures, analyses, design options, and so on. ETABS is a comprehensive structural engineering software system that covers all phases of structural engineering, including model generation, verification, analysis, and design. With ETABS, we can simply analyse diverse materials such as concrete, steel, reinforced concrete, and so on, and the results may be exported without any errors. It can automatically generate gravitational loads, lateral loads, and self- weights.

Structural design is the art and science of creating a safe, usable, and durable structure with economy and elegance, primarily to meet the functional requirements and economy of the structure for its intended use across the life cycle of the structure. The beams and columns were analysed using E-TABS software, and the slabs and footings were developed utilising the "LIMIT STATE METHOD" inaccordance with IS: 456-2000. M-20 concrete and Fe-500 steel are the materials used. For the study and design of the structures, the dead load, live load, and superimposed loads were taken into account in line with the specifications of IS: 456-2000 and IS:875-1987 (Part 1 & Part2).

The dead and live loads are applied, and the beams, columns, footings, and slabs are designed.

MS Excel was utilised for design calculations. This study demonstrates that using MICROSOFT EXCEL, we can construct a software that can compute reinforcement bars and distribution bars based solely on the dimensions and the attributes of the reinforced parts. A massive amount of documented data is necessary for the investigation. It will be captured by reviewing analysis reports and extracting values from them. MS EXCEL will be used extensively for analysis and design

OBJECTIVE

- The building should be able to withstand all anticipated loads without failing. Complete a thorough study and design of the primary structural elements of a multi-story structure, such as slabs, columns, and beams. Getting acquainted with structural software (ETABS) The goals include doing structural analysis on a multi-story RCC structure utilising software (ETABS). The beam, column, footing, and slab are all analysed. MS-Excel is used for further computations.

METHODOLOGY

- Importing/Preparing Architectural Grids
- Assigning the properties
- Checking and analysing the model
- Exporting the Results to the MS Excel
- Importing the values to respected cells.
- Designing using the MS Excel spreadsheet.
- Creating the drawing of the Cross section and Longitudinal section of the material.

LITERATURE SURVEY

- **Nancy Thakur** (2017) They started by designing the structure and then simulating it with various loads in ETABS software. The combination of values that provides them the best result by performing the number of iterations is exported to MS Excel, and the exported results are further processed to design commands that can be directly utilised in AutoCAD for structure design by simply copying and pasting the commands. They introduced our novel approach to design process automation using ETABS, Microsoft Excel, and AutoCAD in this paper. The outcome of their proposed approach demonstrates that the technique is very efficient, saving time and money. Normally, the design process takes many hours to complete, but with the proposed technique, the process is much faster.
- **Aman Katare** (2018) In this work, the EXCEL spreadsheet software was utilised to analyse and calculate

the rebars of various RC elements such as beams, columns, and slabs. In this project effort, five different types of EXCEL spreadsheets were calculated: simply supported beam, cantilever beam, short column and long column, one way and two-way slab. The MS-EXCEL sheet is an extremely useful tool for calculating rebars in various RC elements such as beams, columns, and slabs. For the design of reinforced concrete elements, these excel sheets can be used in conjunction with analytical software such as STAAD and ETABS. These are effective and aid in the rapid design of buildings and other structures on a variety of tasks.

- **Varkuppala Krishna** (2015) This project
offers a (parking floor +5) higher stories RCC framed building that was analysed and developed using ETABS under the lateral loading influence of wind and earthquake (Extended Three-Dimensional Analysis of Building system). ETABS is equipped with all of the key analysis engines, including static, dynamic, linear, and nonlinear, among others, and this software is used to analyse and design buildings in particular.
- **Varsha S Danavandi** (2017) investigated the design of foundations and their types, slabs and their types, columns, beams and their types, and staircases. Developed a

computerised application to eliminate paper work and save time in management, increasing efficiency and reducing work load. The emphasis is on construction management and structural engineering ideas ranging from a simple cost estimation problem through structural design analysis and sophisticated applications.

- **Santosh Kumar P.T.** (2014) created a simple way using current Indian codal methods utilising MS-EXCEL sheets. The results are compared to the existing literature, and the completion of work graphs show that the results match the existing literature. As a result, these EXCEL SHEETS can be utilised in combination with analytical software such as STAAD and ETABS for design of column.
- **Mahesh Kumar** (2012) The usage of basic spreadsheet programmes such as MS EXCEL aids in the development of efficient and speedy designs of buildings and other structures on various projects. While common software such as STAADPRO was utilised for frame analysis, self-created excel sheets were used for foundation, beam, and slab design, among other things.
- **Fernandes R. J** (2017) created a VBA software to access the analysis findings from STAAD Pro to MS Excel, making the design process totally automated and reducing operator intervention. For the design of a selective Catalytic Reduction Pile Cap Foundation, a spreadsheet was created. The micro piles were modelled in STAAD Pro v8i, and the forces were extracted to an Excel spreadsheet using an Open STAAD VBA macro.

Summary of the Literature Review

- The foundation study demonstrated how current software fails to satisfy the demands of structural engineers.

- The many issues with various software's such as STAADPRO and ETABS are thatthey are not user pleasant and require a large amount of input data to complete the analysis, whereas EXCEL sheets are highly user friendly.
- Instead of creating two sheets to calculate the rebars of one way and two-way slabs, a single sheet is created for the slabs utilising Excel's conditional properties. In this study, I developed a user-friendly excel spreadsheet for calculating the rebars of a simply supported beam, requiring fewer input values to get the desired outcome.

Flow chart of Methodology

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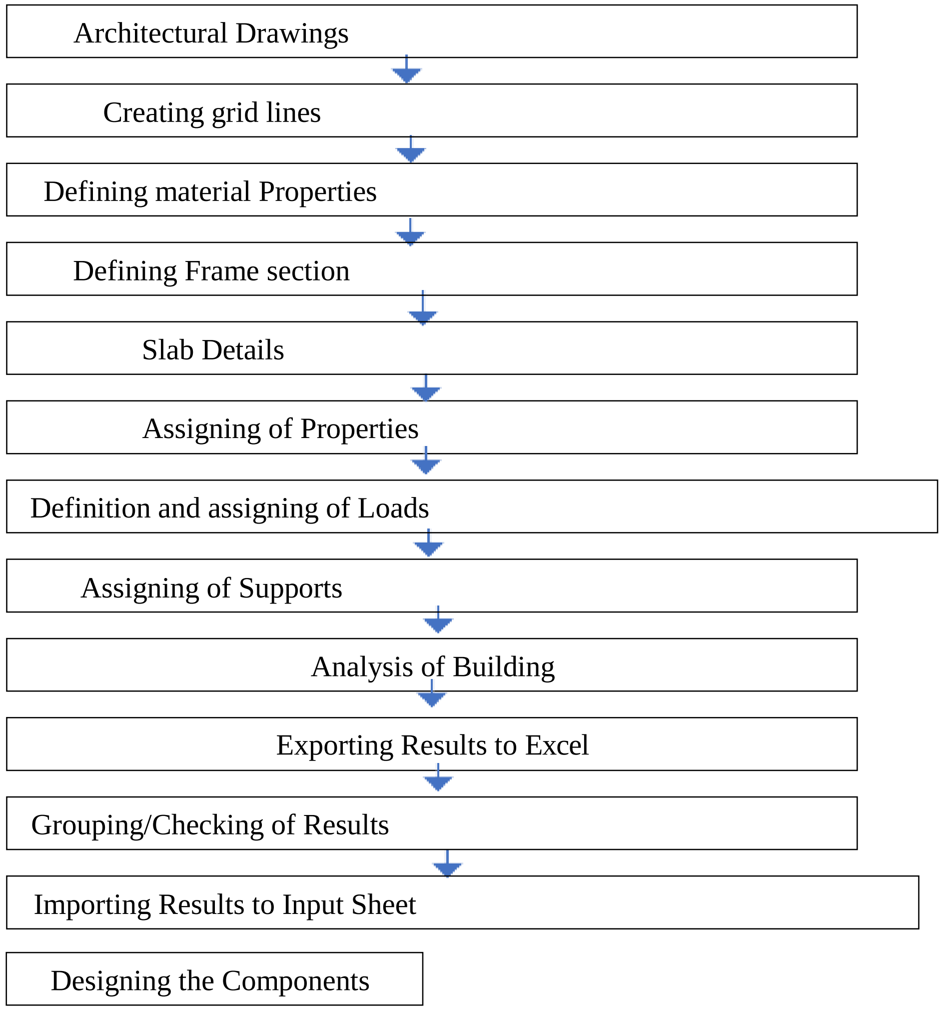

Summary about the Structure

- This chapter discusses the standard step-by- step approach for modelling the fundamental regular structure.
- M-20 grade concrete and Fe-500 structural steel are used in the RC analysis:
- Steel Young's Modulus, Es = 20 N/mm2
- Concrete Young's Modulus, Ec = 500 N/mm2
- Concrete's characteristic strength, fck = 25 N/mm2,
- Steel's yield stress is 500 N/mm2, or fy.
- Concrete's maximum strain, cu = 0.0035e
- Design Geometry
- The model is two-story, with a cantilever portion on the horizontal side (X direction) approximately 1.5m from the structure's commencement, followed by a 4m beam/slab after 8m of span (in X direction).
- The story height is 3m from the ground level, and the overall height is 9m.
- And the vertical beams/slabs (in the Y direction) are all 3m long. The table below contains model information.

Sl n o	Descripti on	Span in X(in m)	Spa n in Y (in m)	Cross section (in mm)
1	Beam	1.5,4, 8	3	230X300
2	Column	-	3	230X300
3	Slab	1.5,4, 8	3	150,175(thickne ss)

Loads

- Dead load is pre-assigned to the structure by the programme, and dead loads and floor finish are obtained from the code book (IS 875 part 1), and live load is the load on the beam given from the code book (IS 875 part 2).

1) Dead Load by ETABS
2) Live load on Beam 3.58kN/m^2 (wall load)
3) Live Load on Slab from IS 875 part 2
4) Floor Finish on Slab from IS 875 part 2

- When the Material Properties option in ETABS software is selected from the Define menu, a window appears in which the properties of a rectangular portion are defined. Figure 7 depicts the window for specifying the material parameters of a rectangular piece. For beam creation, the name of the rectangular portion, measurements (depth and width), and material are specified. Figure 7 depicts the properties of the created column.

Analysis

- When the (Analyse option) Run Analysis option in ETABS software is chosen, displacements based on the load applied and material selected are displayed in the programme. After completing all of the preceding processes, we arrive at a specific conclusion after numerous iterations, and a table for various values of load dimensions is generated, which is to be exported from ETABS to MS Excel, and additional analysis is conducted to design the equations for drawing Beams and Columns, etc. for the structure.
- **Importing to Excel**
- In this section, we have divided the beams into groups based on their bending moment, columns based on their footing conditions, and slabs based on their geometry (one way, two way).
- We have three types of beams based on the bending moment, and four types of columns based on the footing circumstances.
- Slab has three varieties based on geometric criteria.

Gr oup	Struc tural Elem ent	Name	Mo ment	Loa d	Sh ear
Gr oup 1	Beam	B28,B40,B32, B36	+45. 84,- 69.2 7	-	73. 36
	Colu mn	C17,C18,C19, C20	5.87	650	-
	Slab	F19,F20,F21	41.8 5	26. 17	90. 1
	Footi ng	C17,C18,C19, C20	5.87	650	-
Gr oup 2	Beam	B47,B49,B41, B43,B48, B36,B34	+16. 79,- 37.0 3	-	37. 03
	Colu mn	C23,C24,C25, C26	101. 95	593 .5	-
	Slab	F13,F15,F14,F 16,F18	6.58	3.5 8	32. 61
	Footi ng	C23,C24,C25, C26	101. 95	593 .5	-
Gr oup 3	Beam	B44,B46,B38, B42B,B50, B52,B45,B51, B31,B35,	+9.7 9,- 29.1 0	-	27. 51
	Colu mn	C21,C22,C27, C28	56.6 1	525 .79	-
	Slab	F12,F22,F11	6.2	2.6	34. 4
	Footi ng	C21,C22,C27, C28	56.6 1	525 .79	-
Gr oup 4	Beam	37,33,29,25	+41	-	69
	Colu mn	C29,C30,C31, C32	76.9 2	959 .33	-
	Slab	-	-	-	-
	Footi ng	C29,C30,C31, C32	76.9 2	959 .33	-

- Design of elements
- The components are created based on the provided data. Footing, Column, Beam, and Slab designs are shown here. Along with the inspection, all design processes are followed.
- We are displaying the COLUMN design here.

- **Column**
- The column is designed in accordance with SP 16 code, and the appropriate data is loaded from the results sheet.
- We shall have three checks or parameters to verify here: the grade of steel, the grade of concrete, and the ratio of depth of column to cover. By using the interpolation approach, we may obtain a chart and a page number to refer to.
- Then we must refer to $p_u/f_{ck}bd$ and $m_u/f_{ck}bd^2$.
- And, using the chart, we must interpret the value and apply it to the p_t/f_{ck} (percentage value of steel)cell, after which we obtain the pt value by multiplying the grade of concrete.
- And by determining the amount of Pt, we can calculate the area of reinforcement and the number of bars by giving the diameter of steel bars.
- We give the steel bars in two layers here, so the reinforcing area is evenly distributed.
- Shear reinforcement is given in accordance with IS 456; the diameter of the bars shall be 1/4th the diameter of the main steel, with a minimum separation of (300mm, 16 times of diameter of steel used, depth of column).

DETAILING OF THE STRUCTURE

- **SUMMARY OF THE DETAILING**
  - **Beam**

B3	230X300 Span =4m	#2-10Φ Bottom #2-12Φ Top 10Φ(2L)@725 mm c/c	#4-10Φ Top #2-12Φ Bottom 10Φ(2L)@725 mm c/c
CB	230X300 Span =1.5m	#2-16 Bottom #2-12Φ Top 8Φ(2L)@150 mm c/c	#4-16Φ Top #2-12Φ Bottom 8Φ(2L)@150 mm c/c
PB	230X300 Span =4,8	#4-12Φ Bottom #2-12Φ Top 10Φ(2L)@125 mm c/c	#4-12Φ Bottom #2-12Φ Top 10Φ(2L)@125 mm c/c

Detailing of Beam

B1 for Group 1B3 for Group 3 PB for Plinth Beam B2 for Group 2 CB for Cantilever Beam

- **Column**

Column Name	Section	Reinforcement
C1	230X350 Span =3m	#4-8Φ +#4-8Φ 10Φ(2L)@128 mm c/c
C2	230X350 Span =3m	#4-20Φ+#4-20Φ 10Φ(2L)@300 mm c/c
C3	230X350 Span =3m	#4-16Φ+#4-20Φ 10Φ(2L)@250 mm c/c
C4	230X350 Span =3m	#6-16Φ+#4-20Φ 10Φ(2L)@256 mm c/c

Detailing of Column

Bea m Nam e	Section	Mid Span	Support
B1	230X30 0 Span =8m	#4-12Φ Bottom #2-12Φ Top 10Φ(2L)@22 5 mm c/c	#6-12Φ Top #2-12Φ Bottom 10Φ(2L)@22 5 mm c/c
B2	230X30 0 Span =4m	#2-12Φ Bottom #2-12Φ Top 10Φ(2L)@72 5 mm c/c	#4-12Φ Top #2-12Φ Bottom 10Φ(2L)@72 5 mm c/c

C1 for Group 1 C2 for Group 2

C3 for Group 3 C4 for Group 4

- **Slab**

Slab Nam e	Section	Main Reinforceme nt	Distribution Reinforceme nt
F1	8mX3m Thicknes s =175mm	12Φ@175 mm c/c	12Φ@525 mm c/c

F	4mX3m Thicknes s =150mm	12Φ@1075 mm c/c	10Φ@975 mm c/c
F2	1.5mX3 m Thicknes s =150mm	10Φ@300 mm c/c	10Φ@800 mm c/c

TOTAL STEEL REQUIRED

Diameter of Steel	Length	Weight(in kg)
8.00	580.42	229.30
10.00	4822.47	2976.83
12.00	7386.92	6566.15
16.00	1130.14	1785.91
20.00	873.70	2157.27
25.00	0.00	0.00
32.00	0.00	0.00

Detailing of Slab

F1 for Two-way slab F2 for One -way Slab CB for Cantilever Slab

Weight of Steel =

Steel data
13715.46
13.72 tonns

AMOUNT OF BRICKS

Footing

Number of Bricks

Column Name	Section	Main Reinforce ment	Distributio n Reinforce ment
Square Footing	2000X2 000	12Φ@100 mm c/c	12Φ@175 mm c/c
Rectang ular Footing	2000X1 900	12Φ@225 mm c/c	12Φ@225 mm c/c
Strap Footing	2000X1 500	12Φ@325 mm c/c	12Φ@350 mm c/c
Combine d Footing	4500X2 400	12Φ@300 mm c/c	12Φ@550 mm c/c
Strap Beam	4200X1 500	#2-16Φ Bottom #2-12Φ Top 12Φ(4L)@ 100 mm c/c	-

Total Volume of Bricks in m^3 =

Detailing of Footing

Number of Bricks =

Brick Data

Name	No	L	b	d	Volume
Long wall	8	17.50	0.23	2.65	85.33
Short wall	8	9.00	0.23	2.65	43.88
Inter wall			0.23	2.65	0.00
Inter wall 1			0.23	2.65	0.00
			Total Volume =		129.21

m^3 m^3 m^3 m^3 m^3

m^3 m^3 m^3 m^3 m^3 m^3 m^3 m^3 m^3 m^3

Deduction	No	L	b	d	Volume
Main door	2	2.13	0.23	1.07	1.05
Door	20	2.13	0.23	0.91	8.92
Door1	8	2.13	0.23	0.76	2.98
Small Door	0	2.13	0.23	0.74	0.00
Window	32	1.22	0.23	1.50	13.47
Kitchen W	4	0.91	0.23	1.50	1.26
Kitchen W1	2	0.91	0.23	1.22	0.51
Kitchen W2	0	0.91	0.23	0.91	0.00
Ventilation	8	0.60	0.23	0.30	0.33
				Volume =	28.51

m^3 m^3 m^3 m^3 m^3 m^3

m^3 m^3 m^3 m^3 m^3 m^3 m^3 m^3 m^3 m^3

55.14

Sill concrete					
Window	32	1.22	0.23	1.50	13.47
Kitchen W	4	0.91	0.23	1.50	1.26
Kitchen W1	2	0.91	0.23	1.22	0.51
Kitchen W2	0	0.91	0.23	0.91	0.00
Ventilation	8	0.60	0.23	0.30	0.33
				Volume =	15.57

Lintel Conc					
Main door	2	2.21	0.23	1.07	1.09
Door	20	2.21	0.23	0.91	9.23
Door1	8	2.21	0.23	0.76	3.08
Small Door	0	2.21	0.23	0.74	0.00
Window	32	1.30	0.23	1.50	14.31
Kitchen W	4	0.99	0.23	1.50	1.36
Kitchen W1	2	0.99	0.23	1.22	0.55
Kitchen W2	0	0.99	0.23	0.91	0.00
Ventilation	8	0.68	0.23	0.30	0.37
				Volume =	30.00

m^3 CONCRETE DESIGN

Concrete mix Design			
Volume of Concrete =	166.16	m^3	
Concrete Mix	M20		
Mix Ratio	Cement	Sand	Aggregate
20	1	1.5	3
Volume(in m^3)=	46.52	69.79	139.57
Weight (in kg) =	66994.50	117379.95	209357.82
Number of bags	1339		

Concrete Data

CONCLUSION

- In this work, we introduced our unique method to design process automation utilising ETABS and Microsoft Excel.

- These excel sheets may be used in conjunction with analytical tools such as STAAD and ETABS to design reinforced concrete components.
- When we refer to ETABS details, most of the time the section will be over strengthened or the amount of steel utilised will be more, resulting in a safer structure or section. Because it is excessively reinforced, the structure or component will not be cost effective. As a result, we should utilise the analysed data to calculate the rebars such that the section is both inexpensive and safe.

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