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# Analysis and Design of Residential Building (G+2) Using ETABS Software

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**ABSTRACT:** “Practical knowledge is an important and essential skill required by every engineer. For obtaining this skill, a commercial building is analysed and designed, located in Belgaum Karnataka with (G+2) store’s having a commercial shops and car parking facility provided at basement floor. For completing the project very popular Civil Engineering software’s such AutoCAD, GOOGLE SKETCHUP, ENSCAPE and ETAB software have been used. In this project all the drafting of commercial building was done using AutoCAD. Whereas GOOGLE SKETCHUP gives the overall view of the building. And The modeling and analysis of the structure is done by using ETABS. Design of beam, column and footing are done manually. The design methods involves load calculations manually and analysing the whole structure by ETABS. Along with analysing and designing of this building, construction sites were also visited.”

**KEYWORDS:** -“AutoCAD, ETABS, Design Software, multistory residential building.”

## I. INTRODUCTION

Any construction project to begin with starts with the Layout of the building or structure followed by Design and Analysis of the structure which is succeeded by planning for the said project. This project involves the layout, design, analysis, planning of a G+2 commercial building located in Belgaum, India. For completing the project very popular Civil Engineering software’s such AutoCAD, GOOGLE SKETCHUP, ENSCAPE and ETAB software have been used. The present study is to analyse and design a G+2 story commercial building of 1500.00sq.ft floor area located at Belgaum.

### 1.1 A Brief Description of Software’s Used

#### 1.1.1. AutoCAD:

AutoCAD is a commercial computer-aided design (CAD) and drafting software application. AutoCAD can be defined as the use of computer systems to assist in the creation, modification, optimization of a design. In this, we can create both 2D and 3D drawings used in construction and manufacturing. AutoCAD is used in industry, by architects, project managers, engineers, graphic designers, city planners and other professionals.

- The designers and architects can create accurate models, sketches, and drawings with AutoCAD. This is next to impossible when done manually.
- With the introduction to AutoCAD, the user can even model 3D objects with colours & materials that can be applied to various surfaces, making it simpler for the user to anticipate the outcome, which cannot be fulfilled in manual 3D sketches.
- Creating drawings manually is a time-consuming task. When designers create drawings on a digital platform with computer software, they get the benefit of the application interface.

#### 1.1.2. ETABS

ETABS is simple to use and user-friendly and it is unique in its ability to address the full spectrum of tasks involved in the process of structure analysis and design.

ETABS is a very suitable package for, Multi-storied building analysis. The entire input data may be generated either graphically or by typing simple English language based commands. It is equipped with the sophisticated algorithms and state of the art graphics, residing in an extremely user-friendly environment.

#### Features and Benefits of ETABS

- The input, output and numerical solutions technique of ETABS are specifically designed to take advantage of the unique physical and numerical characteristics associated with building type structures.
- The need for the special purpose program has never been more evident as structural engineers put nonlinear dynamic analysis into practice and use the greater computer power available today to create a larger analytical model.
- Over the past decades, ETABS as numerous mega projects to its credit and as established itself as the standard of the industry. ETABS software is clearly recognized as the most practical efficient tool for the static and dynamic analysis of multi-storeyframe and shear wall buildings.

#### 1.1.3. GOOGLE SKETCHUP

Sketch Up is a CAD solution ideal for creating and editing 2D and 3D concepts. Built for designers, drafters, architects, or engineers.

This tool offers powerful, professional-quality features like lighting effects, textures, a layer manager, animations, and unique access to Trimble's 3D warehouse.

Sketch Up is a program used for a wide range of 3D modelling projects like architectural, interior design, landscape architecture, and video game design, to name a few of its uses.

##### Main features of Sketch Up are:

- Textures
- Lighting effects
- 3D models
- 2D models
- Layer manager
- Animations

#### 1.1.4. ENSCAPE

Enscape plugs directly into your modelling software, giving you an integrated visualization and design workflow.

It is the easiest and fastest way to turn your models into immersive 3D experiences by eliminating the inconveniences of production, shortening the feedback loop, and giving you more time to design

With Escape's real-time technology, your project is visualized as a fully rendered 3D walkthrough which can be navigated and explored from every angle.

##### Main features of ENSCAPE are:

- Revamped User Interface
- Create Custom Assets
- Create 360 Panoramas
- Create A Video

## II. METHODOLOGY

#### DETAILS OF THE PROJECT:

The proposed project is a double storied building. The analysis of the building is done using ETAB software. The design is being done in a sequence starting with design of slabs followed by design of beams, columns and footings.

##### The analysis and design is done using the following data

- |                      |                        |
|----------------------|------------------------|
| 1. Type of building  | : Commercial           |
| 2. Layout            | : As shown in the plan |
| 3. Number of Storeys | : (Ground+ One)        |
| 4. Storey height     | : 3.0 m each           |
| 5. Materials         | Concrete: M20 mix      |

Steel: Fy415 N/mm<sup>2</sup>

6. Design philosophy

: Limit state method conforming to IS 456-2000

**Structural details:**

Length of building	9.69 m
Width of building	7.14 m
Height	$0.6 + 2 \times (3 + 0.15) = 6.90$ m
Live load on Floor	3.0 KN/m <sup>2</sup>
Grade of Concrete	M30
Steel	Fe415
Column Size	0.23m X 0.475m
Beam Size	0.3m X 0.3m
Slab Thickness	150mm
Total No Columns	12
Total No Beam	57
No of footing	12

**Table 1:****2.1 LOADS AND LOAD COMBINATIONS**

The loading that has been considered to act upon the structure are as follows:

- Dead Load.
- Live Load.
- Load Combinations.

**2.2 DEAD LOAD OR PERMANENT LOAD:**

This consists of the weights of the walls, partitions, floors, roofs, including the weights of all other permanent construction in the buildings. A schedule of unit weights of the building materials is given in IS code 875 part 1- 1987. Some of the Unit weights of building materials (IS code 875 part 1- 1987 and IS code 456:2000) are shown below.

Materials	Unit Weight
Brick masonry	18.85 to 22KN/m <sup>3</sup>
Plain concrete	24KN/m <sup>3</sup>
Reinforced concrete	25KN/m <sup>3</sup>
Floor Finish(Marble)	1KN/m <sup>2</sup>

**Table 2:****2.3 LIVE LOAD OR IMPOSED LOAD:**

The live or imposed loads shall comprise all loads other than dead loads. The minimum live load on different floors are specified in IS code 875 (part-2) - 1987.

Sl/No.	Occupancy Classification	UDL (KN/m <sup>2</sup> )	Point load (KN)
<b>commercial building</b>			
1	All rooms and kitchens	2.00	1.8
2	Toilet and Bathrooms	2.00	-
3	Corridors, passages, staircase,	3.00	4.5
4	Balconies	3.00	1.5/m run
5	Flat roof access provided	0.75	-

**Table 3: UDL AND POINT LOADS**



## 2.4 LOAD COMBINATIONS:

As per IS code 875 (part-5) – 1987, the following load combinations, whichever combination produces the most unfavourable effect on the building, foundation and structural member concerned may be adopted.

- DL
- LL
- $1.5(DL + LL)$

The values of partial safety factors of loads under different conditions are shown in the table below in accordance with clause 36.4 of the IS code 456- 2000.

## 2.5 ETABS ANALYSIS AND DESIGN

### PREPARATION OF PLAN IN AUTOCAD

#### 2.5.1 DRAWING

After planning the drawing should be prepared for execution. The drawing shall be prepared manually or using drafting software. In our project all the drawings we have drawn using drafting software AUTO CAD.

#### 2.5.2 AUTO CAD

Auto cad is drafting software, by using Auto cad we have drawn many drawings. AutoCAD cuts drawing planning and also save money on drawing materials and more. It gives accurate drawings. In layers command we can give different type of object and different type of style. AutoCAD is just a replacement for the manual engineering drawing.

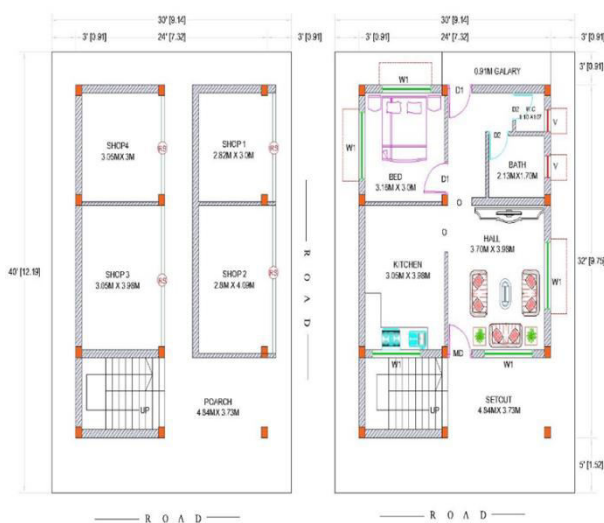


Fig.1: Ground floor and first floor plan Fig.

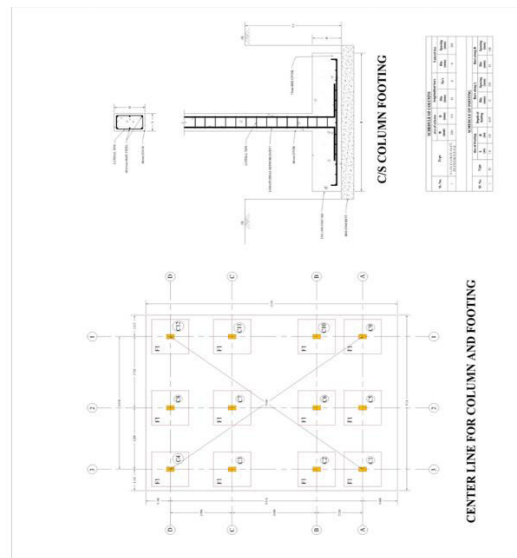


Fig 2: Centre line, column and footing position layout

## 2.6 GOOGLE SKETCHUP

Sketch Up is a CAD solution ideal for creating and editing 2D and 3D concepts. Built for designers, drafters, architects, or engineers.

This tool offers powerful, professional-quality features like lighting effects, textures, a layer manager, animations, and unique access to Trimble's 3D warehouse.

Sketch Up is a program used for a wide range of 3D modelling projects like architectural, interior design, landscape architecture, and video game design, to name a few of its uses.



Fig.3: Elevation Of Building In 3D

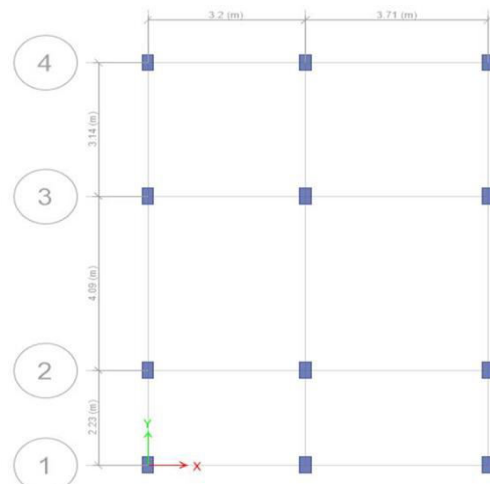


Fig 4: Plan View

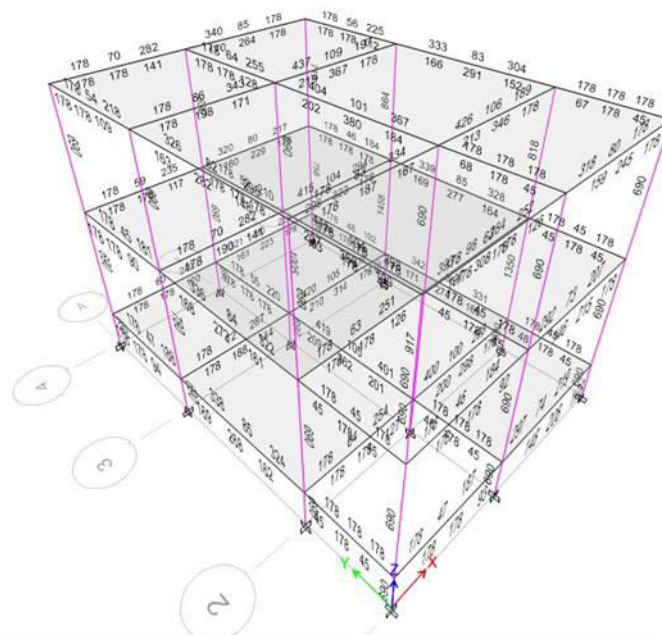


Fig 5: REINFORCEMENT CHECK OF CONCRETE MEMBERS

## DESIGN OF COLUMN USING MS EXCEL

### Column-C8

Axial load =P =	437.86	Kn				
Length of column = L =	3	m	3000	mm		
Grade of steel = $f_y$ =	415	N/mm <sup>2</sup>				
Grade of concrete = $f_{ck}$ =	20	N/mm <sup>2</sup>				
Breadth of the column = b =	0.23	m	230	mm		
Depth of the column = D =	0.375	m	375	mm		

<b>EFFECTIVE LENGTH</b>							
Axial load = P =				437.86	Kn	437860	N
Factored load = P*1.5 = P <sub>u</sub> =				656.79	Kn	656790	N
For effectively held in position at both ends, restrained against rotation at one end.							
(As per IS 456:2000, table 28, page no. 94)							
Effective length, l =		0.7*L		l =	2.1	m	2100 mm
<b>CHECK FOR SLENDERNES RATIO</b>							
S. R. = l <sub>eff</sub> /b =				9.13			
S. R. = l <sub>eff</sub> /D =				5.60			
Condition							
1. If L <sub>eff</sub> /b or D < 12 Short column							
2. If L <sub>eff</sub> /b or D > 12 Long column							
			Check =	Short column			
<b>CHECK FOR MINIMUM ECCENTRICITY</b>							
From IS:456:2000, clause 25.4, page no. 42							
e <sub>min</sub> = (l/500) + (D/30) =						16.70	mm
Permissible eccentricity as per code = e <sub>per</sub> = 0.05*D =						18.75	mm
Condition							
If e <sub>min</sub> < e <sub>per</sub> then Design is safe							
If e <sub>min</sub> > e <sub>per</sub> then Design is not safe							
Check =						Design is Safe	
<b>LONGITUDINAL REINFORCEMENT</b>							
P <sub>u</sub> = 0.4*f <sub>ck</sub> *A <sub>c</sub> +0.67*f <sub>y</sub> *A <sub>sc</sub>							
P <sub>u</sub> *10 <sup>3</sup> = 0.4*f <sub>ck</sub> *A <sub>g</sub> -A <sub>sc</sub> +0.67*f <sub>y</sub> *A <sub>sc</sub>							
		P <sub>u</sub> =	656790	N			
		A <sub>g</sub> =	86250	mm <sup>2</sup>			
P <sub>u</sub> *10 <sup>3</sup> = 0.4*f <sub>ck</sub> *A <sub>g</sub> -A <sub>sc</sub> +0.67*f <sub>y</sub> *A <sub>sc</sub>							
		a) 0.4*f <sub>ck</sub> *(A <sub>g</sub> ) =	7E+05				
		b) 0.4*f <sub>ck</sub> *-A <sub>sc</sub> =	-8	*A <sub>sc</sub>			
		c) 0.67*f <sub>y</sub> *A <sub>sc</sub> =	278.1	*A <sub>sc</sub>			
		(b)+(c) =	270.1	*A <sub>sc</sub>			
A <sub>sc</sub> =[P <sub>u</sub> -(0.4*f <sub>ck</sub> *A <sub>g</sub> )] / [(0.67*f <sub>y</sub> )-(0.4*f <sub>ck</sub> )]							
				A <sub>sc</sub> =	-122.98	mm <sup>2</sup>	

Since the load on column is very low, we getting the negative reinforcement.								
Hence from IS 456:2000, clause 26.5.3.1, In column the minimum reinforcement is 0.8% and maximum is 6% of total cross sectional area of column.								
Providing	1.2	% reinforcement of c/s area of column.						
					$A_{sc} =$	1035	$\text{mm}^2$	
<b>NO'S OF BARS REQUIRED</b>								
Assuming dia of bar = $\phi =$						16	mm	
Area of one bar = ( $a_{sc}$ ) = $\pi/4 * \phi^2 =$						201.06	$\text{mm}^2$	
No. of bars ( N ) = $A_{sc} / a_{sc} =$					5.15	$\approx$	6	NO.
Provide	6	bars of	16	mm diameter as longitudinal reinforcement				
<b>LATERAL TIES</b>								
The diameter of the lateral ties greater of the following								
		1. $< 6\text{mm} =$			6	mm		
		2. $1/4 * \text{main diameter} =$			4	mm		
				Greater of above =		6	mm	
	Providing	6	mm diameter of bar					
<b>SPACING OF LATERAL TIES</b>								
Least of the following								
		1. least lateral dimension =			230	mm		
		2. $16 * \text{diameter of main bar} =$			256	mm		
		3. 300 mm =			300	mm		
			Least of above =				230	mm
	Provide lateral ties of		6	mm dia at		230	mm c/c	

### III. RESULTS AND DISCUSSION

#### COMPARISION OF COLUMN

COLUMN NO.	SIZE OF COLUMN (mm)	LOAD ON COLUMN (KN)	
		MANUALLY	ETAB
1	230X375	224.598	162.54
2	230X375	387.233	381.53
3	230X375	374.06	388.95
4	230X375	233.27	222.85



5	230X375	271.74	107.92
6	230X375	527.97	599.15
7	230X375	568.77	634.14
8	230X375	386.47	394.17
9	230X375	180.27	182.32
10	230X375	396.148	382.51
11	230X375	740.714	449.66
12	230X375	285.52	245.63

Table 4: LOAD ON COLUMN

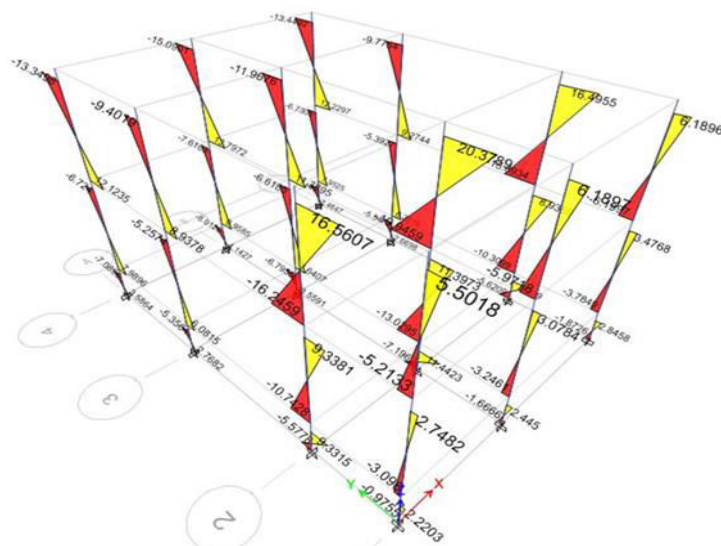


Fig 6: Bending moment of columns from ETABS

BEAM NO.	MANUALLY				ETAB			
	SIZE (mm)	A <sub>sc</sub> (mm <sup>2</sup> )	DIA (mm)	No.	SIZE (mm)	A <sub>sc</sub> (mm <sup>2</sup> )	DIA (mm)	No.
C1,C2,C3,C4,C5, C6,C7,C8,C9,C10,C11,C12	230X375	1035	16	6	230X275	690	16	4

Table 5: A<sub>s</sub> FOR COLUMN



#### **IV. CONCLUSION**

1. For drafting and planning we used Auto-cad software we prepared plans, section, elevation and layouts etc. through which we got extra knowledge about Auto-cad.
2. We Analysed and designed the residential building (G+1) by manual calculation method and software application (ETABS) method and we compared the results. Analysing and designing by using ETABS software is reduces a lot of time in design work. We can easily modify the failed member and details of each and every member can be obtained by using ETABS.
3. After designing the members using software and manually, we got a clear picture that software gives more precise result than manually. but when we think of economy manually design becomes more economic but also it is more time consuming.
4. As we are fresher designer, we experienced the fluctuation between the manual results ETABS out are closer to each other but ETABS output are better with high accuracy than the manual calculation.

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