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Design And Analysis Of G+5 Residential Building

Ms.Sd. Farhana Tabasum[1], Mr.K.Giridhar Reddy[2], Mr.V.Karthik Reddy[3], Mr.K.Ganesh[4], Mr.Y.Hemanth Kumar[5]

[1]Assistant professor, Department of civil Engineering, Sree venkateswara college of Engineering, Kodavaluru(V&M) SPSR Nellore, Andhra Pradesh, India.

[2,3,4,5] Students, Department of civil Engineering, Sree venkateswara college of Engineering, Kodavaluru(V&M) SPSR Nellore, Andhra Pradesh, India.

Abstract:

Structural analysis is a subject which involves designing, planning to build a perfect building. Basically, each project is different with their design criteria such as incoming load, soil properties, dynamic load, built up area etc. In the present days of improving science and technology, analyzing and designing of a building has been made easy by using ETABS and Auto cad software. Design of residential building by Auto CAD (COMPUTER AIDED DESIGN) and analysis of the building by using ETABS (EXTENDED THREE-DIMENSIONAL ANALYSIS OF BUILDING SYSTEM) which includes- generating a structural framing plan, getting model analysis of structure and design of structure. TABS software helps civil engineers to make their work easy and decreases time necessary for planning. The project going to be done is the design of a multi-storey residential building. The building plan has been drafted using the Auto Cad software by the requirements and available area. The super structure i.e. The building frame has been analyzed and designed using the ETABS software. In the present project G+5 Residential building is going to be analyzed and designed for gravity and lateral (wind and earth quake) loads as per Indian standards.

Keywords: AUTOCAD, ETABS, Building, Wind and Earthquake loads, design, analysis.

1. Introduction

1.1. Background

Structural design is the primary aspect of civil engineering. Structural analysis means determination of the general shape and all the specific dimensions of a particular structure so that it will perform the function for which it is created and will safely withstand the influences which will act on it throughout its useful life. The foremost basic in structure is the design of simple basic component sand members of a building like slabs, beams,columns, and footings. In order to design them it is important to first obtain the plan of the particular building.Thereby depending on the suitability plan layout of beams and the position of columns are fixed. Thereafter, the vertical loads are calculated namely the dead load and live load. Once the loads are obtained, the component takes the load first i.e.the slabs can be designed.

For a G+5 building, Auto CAD can be used to create the initial design drawings and detailed construction plans, while ETABS can be used to analyze the structure and optimize the design. The two software programs work together to provide a comprehensive design and analysis package that can ensure the safety and efficiency of the building.

1.2. Theme of the Project Work

The theme of the project is to structurally analyze and design an multi- storeyed building. During the execution of the project, we have acquired knowledge and skill to emphasis on practical application besides the utilization of analytical methods and design approaches, exposure and application of various available codes of practices.

1.3. Objective

The specific objectives are:

i. Preliminary design of the structural elements.
ii. Detailed structural analysis of the building using ETABS
iii. Applying gravity loads and different load combinations as per Indian codal provision.
iv. Design of various structural components.
v. Preparation of detailed structural drawings.
vi. Better acquaintance with the code provisions related to RCC design.
vii. using Auto Cad and ETABS software for building design and analysis provides accurate and efficient workflows, ensures safety and compliance, optimizes energy efficiency.
viii.

1.4. Scope

This project work provides us the information about how to analyse and design the multi-storeyed building. It further deals with

1.4.1. Work Scope

- Study architectural drawing and fixing structural system of the building to carry all the live load, dead load and lateral load.
- Calculation of loads including lateral loads.
- Preliminary design of structural elements.
- Identification of loads and load cases.
- Calculation of shear force, bending moment to determine size of the building components.
- To be familiar with structural analysis software i.e. ETABS for different load cases.
- Design of beam, columns and slab by following different codes.

2. Methodology

Each building has its own purposes and importance. Basically, buildings were constructed based on client requirement, geographical condition of the site, safety, privacy, available facilities, etc. and designed as:

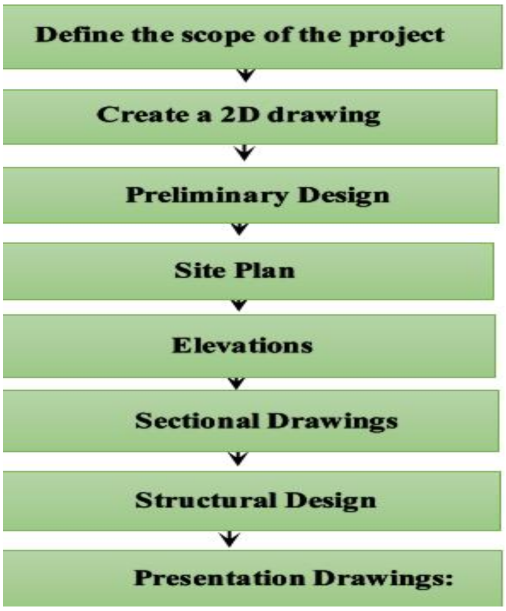
Modeling and Analysis of structure

A brief explanation of software used are

1. Auto CAD
2. ETABS

Auto CAD

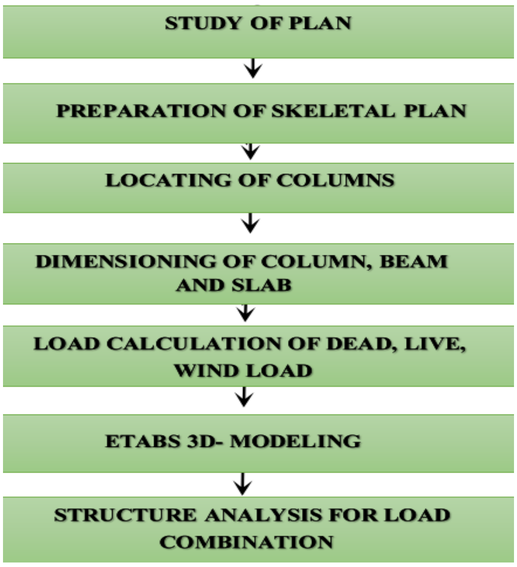
Auto CAD is a computer-aided design (CAD) software that is widely used in various industries such as architecture, engineering, construction, and manufacturing. Auto CAD was first introduced in 1982 by Autodesk Inc. and has since become one of the most popular CAD software in the world. The software is used for creating and editing 2D and 3D designs and drawings. The software includes libraries of pre-made objects, as well as the ability to create custom objects, dimensions, and annotations. AutoCAD also offers the ability to import and export files in various formats, making it easy to collaborate with others who may use different software.



ETABS:

ETABS (Extended Three-dimensional Analysis of Building Systems) is a widely used software program for structural analysis and design of building systems. The following is a brief methodology for using ETABS:

Model Creation: The step in using ETABS is to create a structural model of the building. This can be done using the software's graphical user interface, where you can input the building geometry, material properties, and loads.



5. DESIGN AND DETAILING

5.1 DESIGN OF TWO-WAY SLAB

Concrete, fck = 25N/mm²

Steel, fy = 415 N/mm²

DIMENSIONING

Clear span distance in shorter direction,lx= 3.69 m

Clear span distance in longer direction,ly = 4.38 m

As per IS 456:2000, Clause 24.1

Thickness of slab =longer span / 26 = 170mm

Assume 40mm cover and 8mm diameter bars Eff:depth, d = 170 – 40 – 8/2 = 126 mm

Load calculation

Dead Load on Slab =3.150 kN/m²

Live Load on Slab = 2kN/m²

Floor Finish = 1kN/m²

Total load = 6.15 kN/m²

Factored load = 1.5×6.150= 9.22 kN/m

ULTIMATE DESIGN MOMENTCOEFFICIENTS

As per IS 456:2000 table 26, take the moment coefficients for

L_{ey}/L_{ex} = 1.18 one short edge discontinuous,

Lex 1	= Centre to Centre of support = 3.69 m
Lex 2	= clear span + eff. Depth = 3.69 + 0.81= 4.5m

	Lex1	= centre to centre of support
		= 4.38 m
		= clear span + eff. Depth
	Lex2	= 4.38 + 0.81 = 5.19 m
Eff: span along short span,	Lex	= 4.5 m
Eff: span along long span,	Ley	= 5.19 m

L_{ey}/L_{ex}= 4.50/3.81 = 1.18< 2.
Hence, design as two-way slab.

Short span moment coefficients:
Negative moment coefficient, αx = 0.047
Positive moment coefficient, αx = 0.035
Long span moment coefficients:
Negative moment coefficient, αy = 0.037
Positive moment coefficient, αy = 0.028

DESIGN MOMENTS
Mx(-ve) = αxW lx^2 = 6.29 kNm
Mx(+ve) = αx W lx^2 =4.68kNm
My(-ve) = αyW lx^2 =4.95 kNm
My (+ve) = αyW lx^2 = 3.74 kNm

CHECK FOR DEPTH

$$M_u = 0.133 f_{ck} b d^2$$

$$D_{req}^2 = \frac{(M_u)}{0.133 \times f_{ck} \times b}$$

$$= \frac{8.371\times10^6}{0.133\times25\times1000}$$

=50mm<81mm

Hence, the effective depth selected is sufficient to resist the design ultimate moment.

REINFORCEMENTS ALONG SHORT AND LONG SPAN DIRECTIONS

As per IS: 456 Annex G Clause. G.1

The area of reinforcement is calculated using the relation:

$$Mu = 0.87\ fy\ Ast\ d\ [1 - \frac{Ast\ fy}{bd\ fck}]$$

			Area (mm^2)
Short span	+ve moment (kNm)	6.325	272.840
	-ve moment (kNm)	8.371	367.297
Long span	+ve moment (kNm)	5.209	222.704
	-ve moment (kNm)	6.883	298.266

Calculation of Ast

CHECK FOR AREA OF STEEL

As per IS 456 clause 26.5.2.1

$A_{st\ min} = 0.12\ \%\ of\ bD = \frac{0.12 \times 1000 \times 125}{10} = 150\ mm^2$

CHECK FOR SPACING

As per IS 456:2000 Clause. 26.3.3(b)

Maximum spacing = 3d or 300mm,whichever is less = 3×81 = 243mm (or) 300mm

=300 mm

Reinforcement provided

Short span: Provide 8mm diameter bars @ 275mm c/c($A_{st\ prov}$ = 367.297 mm^2)

Long span: Provide 8mm diameter bars @ 275mm c/c($A_{st\ prov}$ = 367.297 mm^2)

Spacing $_{prov}$ < spacing $_{max}$

CHECK FOR SHEAR

As per IS 456:2000, Table13 Shear force,Vu= WL/2 =20.666 KN

As per IS 456:2000 Clause 40.1

Nominal shear stress, $Tu = \frac{Vu}{Bd}$ =0.255 N/mm^2

Percentage of steel, pt = 100 Ast / bd = 0.45

Permissible shear stress, = 0.464 N/mm^2 (IS 456:2000,Table 19)

Design shear strength of concrete $= k\tau_c = 1.3 \times 0.464 = 0.60\ N/mm^2$

S 456:2000 Clause 40.2)

Maximum shear stress,

T_{cmax}= 3.1 N /mm^2 (IS 456:2000 Table 20)

$T_v < kT_c < T_{cmax}$, so shear is safe.

Check for deflections

Ast provided = 367.297 mm^2

Ast required = 150 mm^2

$$f_s = \left(\frac{0.58\ fy\ Ast\ req}{Ast\ provi}\right) = \frac{0.58 \times 345 \times 150}{367.297} = 81.71\ N/mm^2$$

Pt = 100 As/ bd= (100 ×367.297) / (1000 ×81)

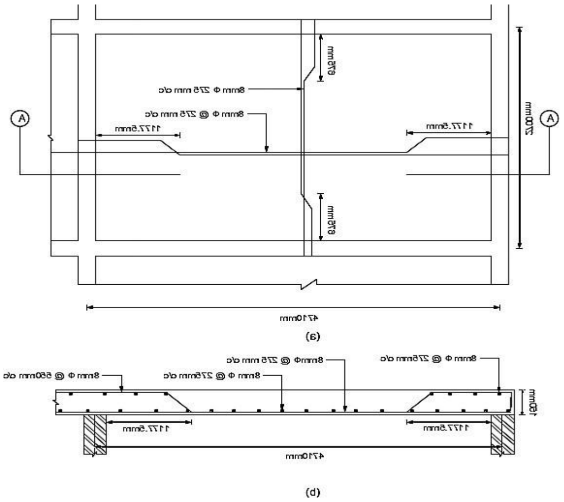
= 0.45

Modification factor = 2

Permissible l/d ratio = 35 × 2 = 70

Actual l/d= (5190/81) =64<70

Hence, deflection for provided length is safe.



DESIGN OF A BEAM :

F_{ck} = 25 mm^2

F_y = 415 mm2

PRELIMINARY DIMENSIONING OF BEAM

Width of beam, b = 300 mm

Depth of beam, D = 500 mm

Assume 20mm cover and 20 mm Φ bars

Effective depth, d = 500– 20 – 10 = 470 mm

ULTIMATE BENDING MOMENT

Maximum +ve bending moment, Mu = 434kNm

Maximum -ve bending moment, Mu = 434 kNm

LIMITING MOMENT OF RESISTANCE

$$(M_u)_{lim} = 0.134 \times f_{ck} \times b \times d^2$$

$= 0.134 \times 25 \times 300 \times 470^2 = 222$ kNm

Mu > Mu $_{lim}$, Hence doubly reinforced section.

Design for positive and negative moments:

Mu - Mu $_{lim}$ = (434 – 222) = 212 kNm

Stress in compression steel,

Xu max = limiting value of neutral axis depth

= 0.48 d = 0.48 ×470= 225.6 mm

d' = 20+10 = 30mm

d-d' = 470-30 = 440 mm

f_{sc} = 606.91 N/mm^2

But, f_{sc} should not be greater than 0.87 f_y

= 0.87 × 415 = 361.05 N/mm^2

$$Asc = \frac{Mu - M\ \ lim}{fsc\ (d-d')}$$

,

= 1334.49 mm^2

$$A_{st2} = \frac{Asc.fsc}{0.87\,fy} = \frac{1334.49 X 361.05}{0.87 X 415} = 1334.49 \text{ mm}^2$$

$$A_{st} = \frac{0{\cdot}36\,fck\,b\,xumax}{0.87\,fy}$$

A_{st1}= 1687.07 mm^2

Provide 4 bars of 20 mm pi (A_{sc} = 1334.49 mm^2)

Total tension reinforcement= Ast =Ast_1 +Ast_2

= 1334.49 + 1687.07 = 3021.56 mm^2

Provide 6 bars of 22mm pi in two layers (3021.56 mm^2).

Check for shear reinforcements

Vu = 216.3 kN

τ = Vu/bd = 1.5 N/mm^2

P_t = 2.14

As per IS 456-2000, table 19

T_c= 0.83 N/mm^2

$T_v > T_c$, So shear reinforcement is required Strength of shear reinforcement,

$V_{us} = (v_u - T_c bd)$

$= 216.3 \times 10^3 - (0.83 \times 300 \times 470)$

= 100 kN

(From Clause.40.4 (a) of IS 456:2000)Spacing of stirrups,

$S_v = \frac{0.87\, fyAsvd}{v_{us}}$

= 266.55 mm

Provide 10 mm diameter 3-L stirrups

According to IS 456:2000, Clause 26.5.1.5, the spacing of stirrups in beams should not exceed the least of:

- 0.75d = 0.75 × 470 = 352.5mm or
- 300mm

Hence, provide 10 mm diameter 3 legged stirrups @225 mm c/c

DESIGN OF COLUMN

Concrete, f_{ck} = 25 N/mm²

Steel, f_y= 415 N/mm²

Depth of column, D = 400 mm

Breadth of column, b = 400 mm

Unsupported length of column,l = 2600 mm

Support condition: - two ends Fixed As per Table 28 of IS 456:2000

Multiplication factor for effective length = 0.5

Effective length of column,

$l_{eff} = 0.5 \times l = 0.5 \times 2.6 = 1.3$ m

Factored axial Load, P_u = 1920 Kn.

Factored Moment in X-dir., M_{ux}= 27.44kNm

Factored Moment in Y-dir., M_{uy}= 37.91kNm

EQUIVALENT MOMENT FOR AXIAL COMPRESSIVE LOAD Mu is

$M_U = 1.15\sqrt{M_{UX}^2 + M_{UY}^2}$ =53.81 KNm

LONGITUDINAL REINFORCEMENT

$\frac{Pu}{fckbd^2} = \frac{1920X1000}{3025X400X400}$ =0.48

$\frac{Mu}{Fckbd^2}$ =0.03

$\frac{Pu}{Fck}$ =0.03

P =0.03X25=0.75

Area of steel As $= \frac{Pbd}{100}$ = 1200 mm²

Use 12 bars of 20mm dia bars.

$\frac{Mux1}{Fckbd^2} = 0.033$

$Mux_1 = 0.03 x Fck x b x d^2$

$Mux_1 = 52.8$ KN

$\alpha n = \frac{Pu}{Puz}$

$P_{uz} = 0.45$ fck Ac+0.75 fy Asc

$P_{uz} = 2173.5$ KN $\alpha n = 0.88$

From IS:456-2000

$$\left\{\frac{Mux}{Mux1}\right\}^{\alpha n} + \left\{\frac{Muy}{Muy1}\right\}^{\alpha n} \leq 1.0$$

$=0.78 \leq 1.0$

So the section is under given loading.

Earthquake loads by etabs

IS1893 2002 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQX according to IS1893 2002, as calculated by ETABS.

Direction and Eccentricity

Direction = X

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2]	$Z = 0.16$
Response Reduction Factor, R [IS Table 7]	$R = 5$
Importance Factor, I [IS Table 6]	$I = 1$

Site Type [IS Table 1] = III

Seismic Response

Spectral Acceleration Coefficient, S_a /g [IS 6.4.5] $\frac{S_a}{g} = 2.5 \frac{S_a}{g} = 2.5$

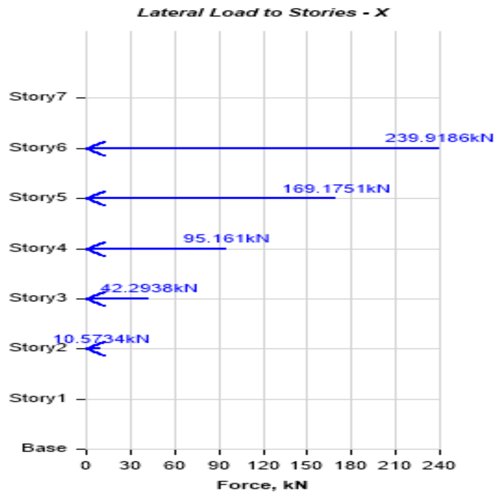
Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	0.419	13928.04	557.12

Calculated Base Shear

Directio n	Period Used (sec)	W (kN)	V_b (kN)
		61	18



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story7	21	0	0
Story6	18	239.9186	0
Story5	15	169.1751	0
Story4	12	95.161	0
Story3	9	42.2938	0
Story2	6	10.5734	0
Story1	3	0	0
Base	0	0	0

IS1893 2002 Auto Seismic Load Calculation

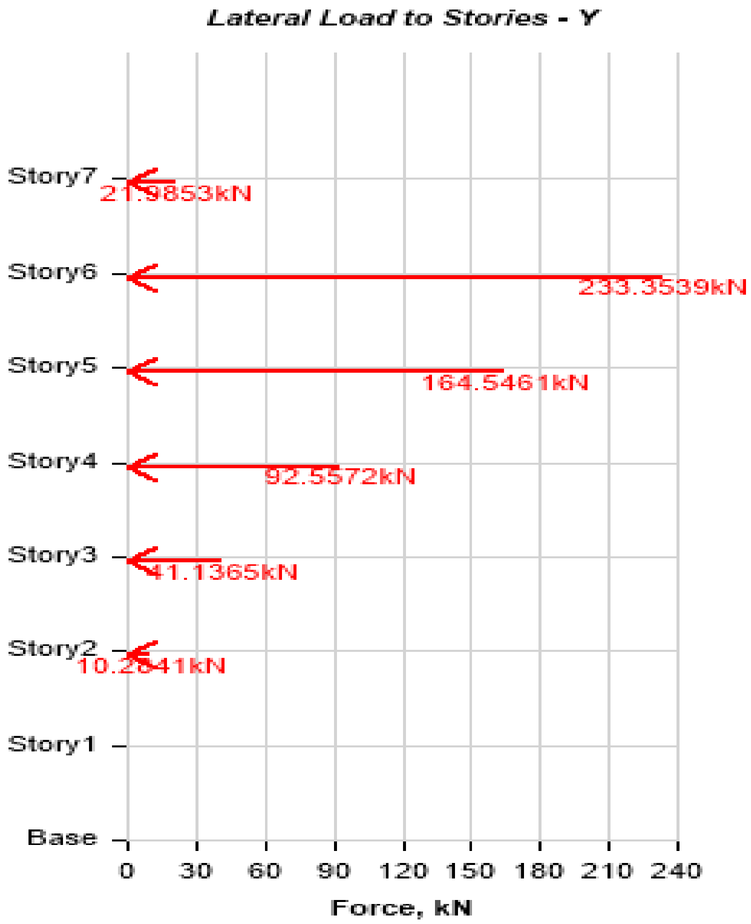
Direction and Eccentricity

Direction = Y

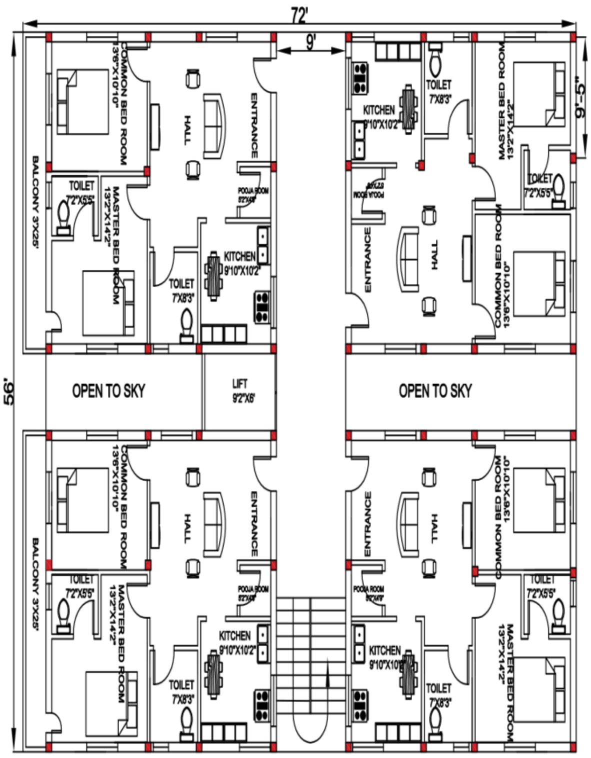
Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y	0.512	14096.5776	563.8631

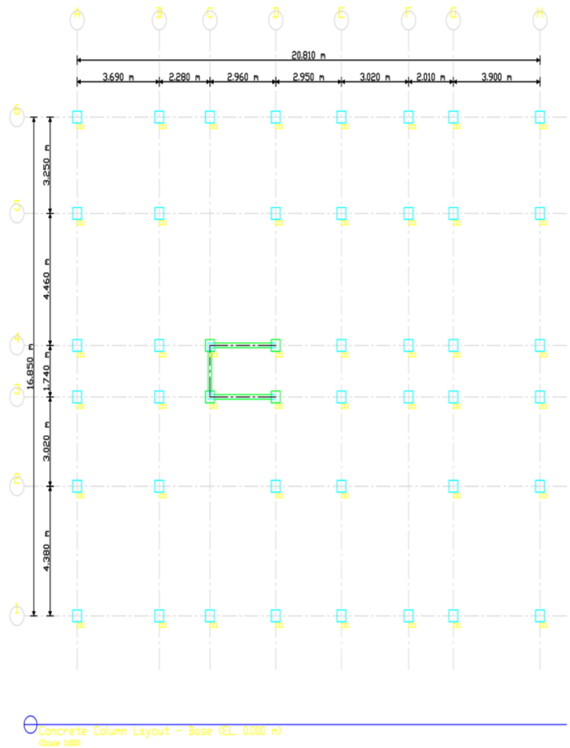
Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story7	21	0	21.9853
Story6	18	0	233.3539
Story5	15	0	164.5461
Story4	12	0	92.5572
Story3	9	0	41.1365
Story2	6	0	10.2841
Story1	3	0	0
Base	0	0	0



Auto CAD drawings

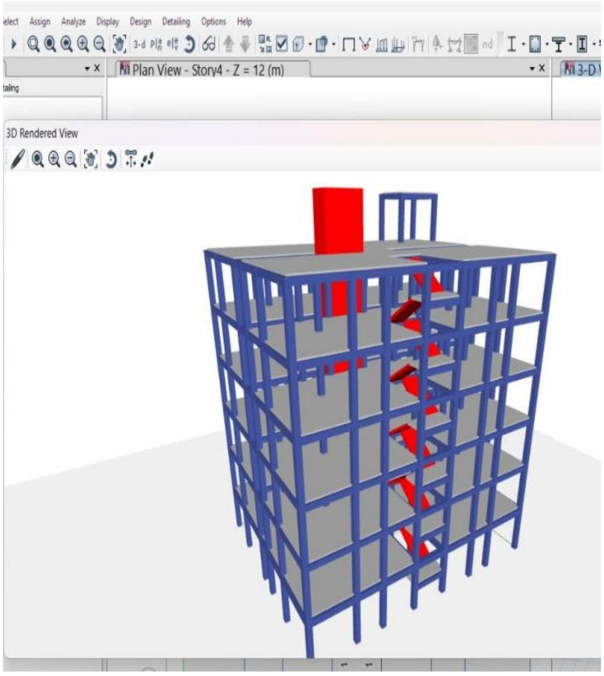


TYPICAL FLOOR PLAN

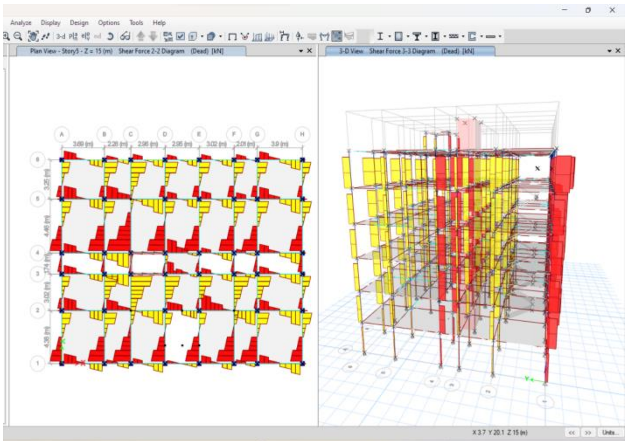


CONCRETE COLUMN LAYOUT

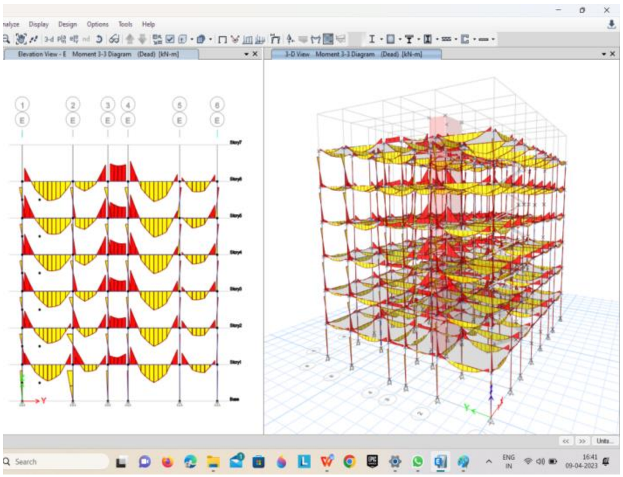
Etabs structure drawing

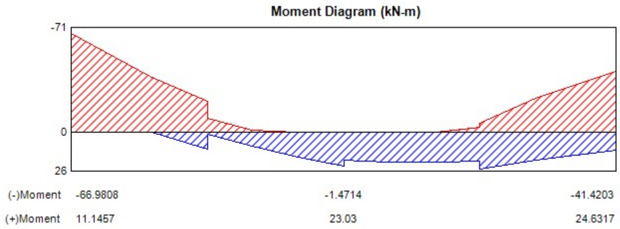


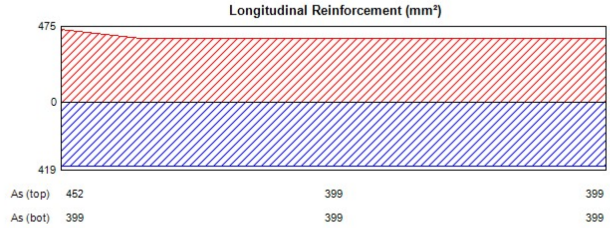
SHEAR FORCE DIAGRAM

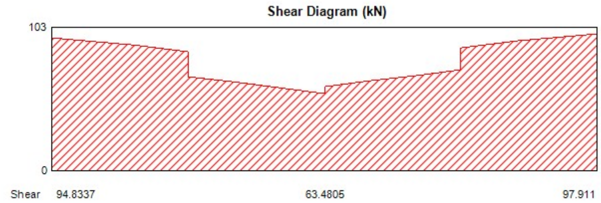


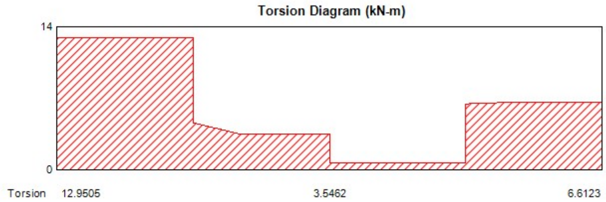
BENDING MOMENT DIAGRAM











Conclusion

In conclusion, the design and analysis of a G+5 residential building involves various aspects such as site selection, structural analysis, architectural design, building materials selection. A thorough analysis of the project is necessary to ensure the building's safety, stability, and durability.The selection of appropriate building materials, such as reinforced concrete and steel, is crucial to ensure the building's structural integrity. The design and construction of a G+5 building requires compliance with local building codes and regulations to ensure the safety of the occupants.Moreover, the architectural design of the building should prioritize functionality and aesthetics while providing comfortable living spaces. Proper ventilation, lighting, and thermal insulation are essential factors that need to be considered.

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