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Analysis and Design of Multistorey Building using ETABS

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***Abstract*— For tall structures to withstand the horizontal pressures generated by natural disasters like earthquakes and winds, structural engineers must first determine how the structure will react when exposed to these types of stresses. Adding shear walls to the inside of the planned building helps it to better withstand horizontal forces, also known as lateral loads, which are caused by earthquakes. These walls also give rigidity to the structure. Building a multi-story structure [G + 4(3 dimensional frame)] utilising ETABS is the main goal of this project. As part of the design process, ETABS analyses the whole structure. Limit State Design approaches that comply with the Indian Standard Code of Practice are used in ETABS research. ETABS has cutting-edge capabilities for dynamic and finite element analysis, as well as a visualisation tool, and robust analysis and design engines. Experts rely on ETABS for all of their model-related needs, including but not limited to: analysis, design, visualisation, and result verification. It all began with analysing basic 2D frames and then using the data to personally verify the software's correctness. The findings were spot-on for every conceivable combination of loads, including dead, live, wind, and seismic.**

Keywords—Analysis and designing,Etabs,commertial building

1. INTRODUCTION

Structural engineering is a wider discipline under the field of civil engineering. It is a vast topic with unlimited theories and practices. It's a field that is still developing with huge innovations and ideas. The roles and responsibilities of a structural engineer includes structural designing, selection of materials best suited for the structure, analysis of structures etc. The present project deals with the analysis and design of a multi storied commercial complex at Puthiyara, Kozhikode. Structural designing include calculating loads and stresses acting on the building, analysis for the loads, design of sections of structures to sustain the loads. So that the structure designed will withstand the load predicted safely.

Analysis of structure is presently carried out by software like ETABS, SAP, STAAD etc. As years pass new software are being developed for analysis of structures at different condition of loads like wind, earthquake etc. the results can be understood and interpreted from the software to know the validity of values provided as output.Now a days framed structures are preferred for commercial buildings. The framed system of construction has mainly two advantages. Firstly, the walls, which are used for, are not load bearing ones and hence the thickness of the walls can be reduced to a considerable extent. This reduces weight of the building and the load transferred to the foundation will be lessened. Subsequently the construction materials can be saved. Secondly the floor area of the building can be increasedA structure is subjected to various types of loading such as permanent, movable and occasional. The permanent loads are due to self-weight of structure, semipermanent ones are due to fixtures, furniture, stationary etc. which are rarely moved and isconsidered as Imposed Loads or live loads. 2 Movable loads are due to moving vehicles, etc. The occasional loads are due to wind, earthquake or floods.Earthquake has also become one of the natural challenging factor for the efficient construction work. It is one of the dominant constrains while designing the frame building in the earthquake prone zone. Earthquake is a natural phenomenon asold as history of earth itself and is considered to be the most unpredictable one among all other natural disasters. Now a days, designers and engineers are giving more emphasis towards the earthquake resistance while analyzing and designing any structure to minimize the seismic impact.

1.1 DESIGN PHILOSOPHIES

There are three philosophies for the design of reinforced concrete namely:

1) Working stress method
2) Ultimate load method
3) Limit state method

1.2 STAGES IN STRUCTURAL DESIGN

The process of structural design involves the following stages

- Structural planning.
- Estimation of loads.
- Analysis of structure.
- Member design.
- Drawing, detailing and preparation of structures.

2. OBJECTIVE

- To analyse and design a G+4 commercial building.
- To prepare the master plan for the commercial building
- To compare the result with ETABS

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3. PLAN OF COMMERTIAL BUILDING

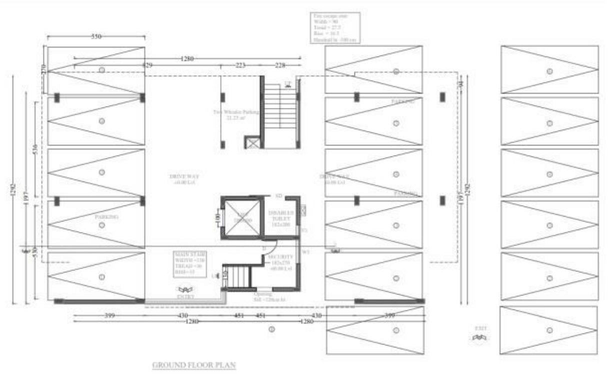

Fig :3.1 Ground Floor Plan

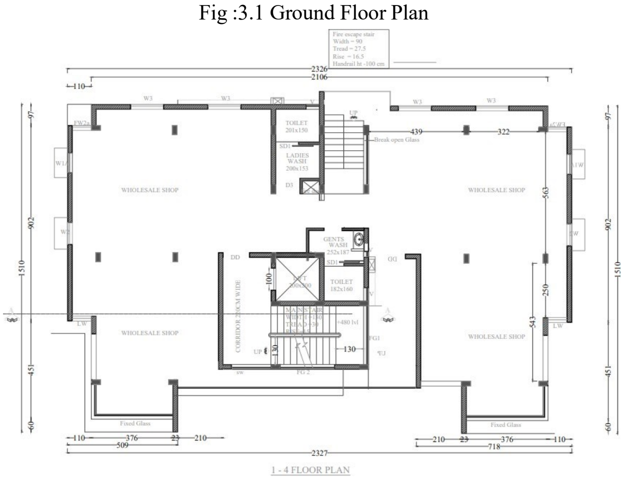

Fig 3.2. 1-4 Floor Plan

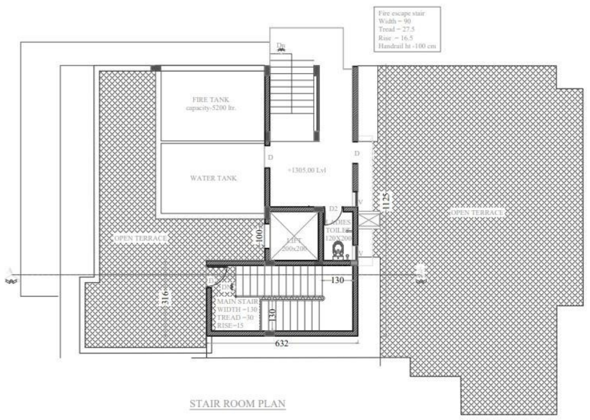

Fig 3.4 Stair Room Plan

4. METHODOLOGY

5. A BRIEF DESCRIPTION OF SOFTWARE'S USED IN TRAINING

5.1 ETABS 2017:

ETABS is an engineering software product that caters to multi-story building analysis and design. Modeling tools and details, and cross-sections may be generated for concrete and steel structures. ETABS provides an unequaled suite of tools for structural engineers designing buildings, whether they are working on one-story industrial structures or the tallest commercial high-rises. Immensely capable, yet easy-to-use, has been the hallmark of ETABS since its introduction decades ago, and this latest release continues that tradition by providing engineers with the technologically-advanced, yet intuitive, software they require to be their most productive

5.2 AUTO-CAD 2016:

All the drawing and detailing works for this training were done by making use of AutoCAD 2007, developed by M/s. AUTODESK, USA. As such, this is the pioneering software in CAD. AutoCAD is a vector graphics drawing program. It uses primitive entities such as lines, poly-lines, circles, arcs and text as the foundation for more complex objects. AutoCAD's native file format, DWG, and to a lesser extent, its interchange file format, DXF has become the standards for interchange of CAD data..

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6. MODELING IN ETABS

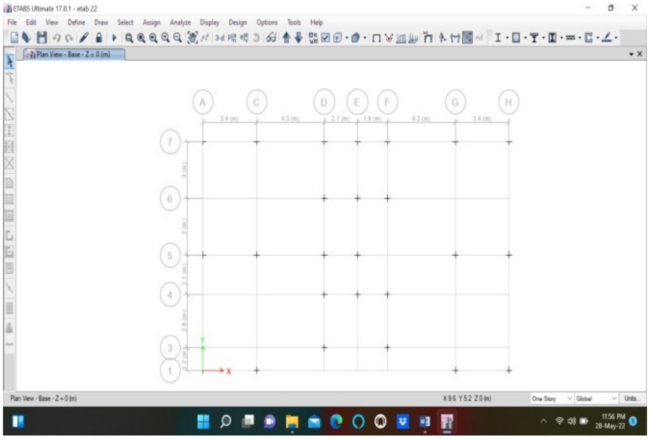
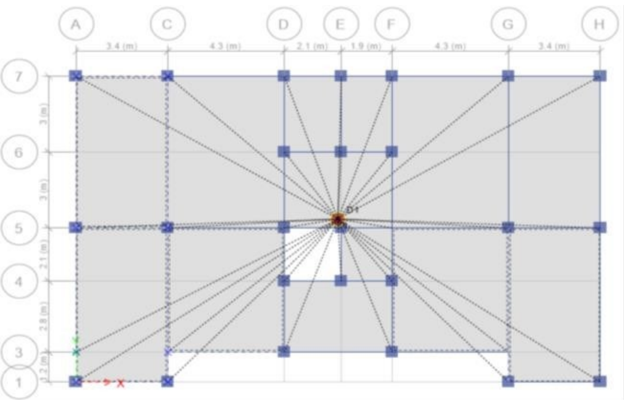


Fig 6.1 Importing of Floor Plan from Auto-cad:



Column locating

7. STRUCTURE DATA

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity

Story Data

Table 7.1 - Story Data

Name	Height mm	Elevation mm	Master Story	Similar To	Splice Story
Story6	3300	19600	Yes	None	No
Story5	3300	16300	Yes	None	No
Story4	3300	13000	No	Story5	No
Story3	3300	9700	No	Story5	No
Story2	3300	6400	No	Story5	No
Story1	3100	3100	No	Story5	No
Base	0	0	No	None	No

Grid Data

Table 7.2 - Grid Systems

Name	Type	Story Range	X Origin m	Y Origin m	Rotation deg	Bubble Size mm	Color
G1	Cartesian	Default	0	0	0	1250	ffa0a0a0

Mass

Table 7.3- Mass Source

Name	Include Elements	Include Added Mass	Include Loads	Include Lateral	Include Vertical	Lump at Stories	IsDefault
MsSrc1	Yes	Yes	No	Yes	No	Yes	Yes

Groups

Table 7.4 - Group Definitions

Name	Color
All	Yellow

7.1 Properties

This chapter provides property information for material frame sections ,shell sections and links.

Materials

Table 1-Material Properties- Summary

Name	Type	E MPa	v	Unit Weight kN/m³	Design Strengths
A416Gr270	Tendon	196500.6	0	76.9729	Fy=1689.91 MPa, Fu=1861.58 MPa
A615Gr60	Rebar	199947.98	0.3	76.9729	Fy=413.69 MPa, Fu=620.53 MPa
A992Fy50	Steel	199947.98	0.3	76.9729	Fy=344.74 MPa, Fu=448.16 MPa
Concrete M25	Concrete	25000	0.2	24.9926	Fc=25 MPa
Steel HYSD415	Rebar	200000	0	76.9729	Fy=415 MPa, Fu=485 MPa

Frame Sections

Table 2 - Frame Sections - Summary

Name	Material	Shape
Beam 250x450	Concrete M25	Concrete Rectangular
Column 450x450	Concrete M25	Concrete Rectangular
ISWB550	A992Fy50	Steel I/Wide Flange

Shell Sections

Table 3 - Shell Sections - Summary

Name	Design Type	Element Type	Material	Total Thickness mm
Slab 150	Slab	Membrane	Concrete M25	150

Reinforcement Sizes

Table 4 - Reinforcing Bar Sizes

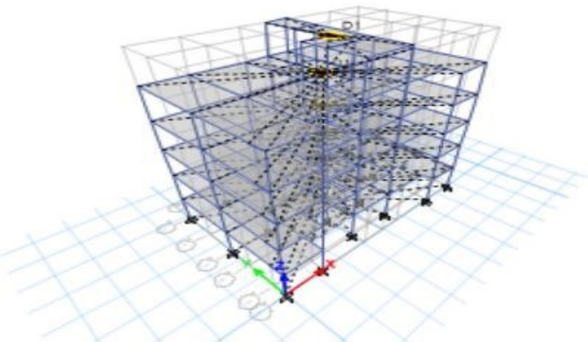
Name	Diameter mm	Area mm²
10	10	79
18	18	255
20	20	314

Tendon Sections

Table 5 - Tendon Section Properties

Name	Material	StrandArea mm²	Color
Tendon1	A416Gr270	99	Blue

7.2 Framing Of Model



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8. ANALYSIS IN ETABS

This chapter provides loading information as applied to the model.

Load Patterns

Table 4.1 - Load Patterns

Name	Type	Self Weight Multiplier	Auto Load
Dead	Dead	1	
Live	Live	0	
EQ X	Seismic	0	IS 1893:2016
EQ Y	Seismic	0	IS 1893:2016
WL X	Wind	0	Indian IS875:1987
WL Y	Wind	0	Indian IS875:1987

Load Cases

Table 6 - Load Cases - Summary

Name	Type
Dead	Linear Static
Live	Linear Static
EQ X	Linear Static
EQ Y	Linear Static
WL X	Linear Static
WL Y	Linear Static

8.1 Auto Wind Loading

Indian IS875:1987 Wind Load Calculation

Lateral wind loads for load pattern WL X according to Indian IS875:1987, as calculated by ETABS

Exposure Parameters

Exposure From = Diaphragms

Structure Class = Class B

Terrain Category = Category 2

Wind Direction = 0 degrees

Basic Wind Speed, V_b $V_b = 39$ meter/sec

Windward Coefficient, $C_{p,wind}$ $C_{p,wind} = 0.8$

Leeward Coefficient, $C_{p,lee}$ $C_{p,lee} = 0.5$

Top Story = Story6

Bottom Story = Base

Factors and Coefficients

Risk Coefficient, k_1 [IS 5.3.1] $k_1 = 1$

Topography Factor, k_3 [IS 5.3.3] $k_3 = 1$

Lateral Loading

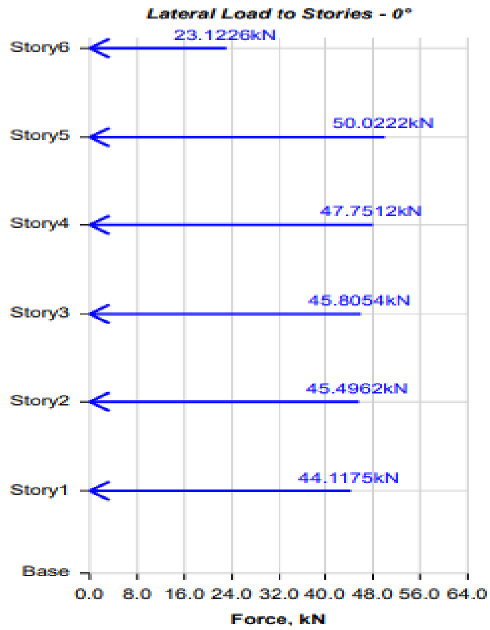
Design Wind Speed, V_z [IS 5.3]

$V_z = V_b\, k_1\, k_2\, k_3$ $V_z = 40.837095$

Design Wind Pressure, p_z [IS 5.4]

$p_z = 0.6\, V^2_z$

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story6	19.6	23.1226	0
Story5	16.3	50.0222	0
Story4	13	47.7512	0
Story3	9.7	45.8054	0
Story2	6.4	45.4962	0
Story1	3.1	44.1175	0
Base	0	0	0

Lateral wind loads for load pattern WL Y according to Indian IS875:1987, as calculated by ETABS

Exposure Parameters

Exposure From = Diaphragms

Structure Class = Class B

Terrain Category = Category 1

Wind Direction = 90 degrees

Basic Wind Speed, V_b $V_b = 39$ meter/sec

Windward Coefficient, $C_{p,wind}$ $C_{p,wind} = 0.8$

Leeward Coefficient, $C_{p,lee}$ $C_{p,lee} = 0.5$

Top Story = Story6

Bottom Story = Base

Include Parapet = No

Factors and Coefficients

Risk Coefficient, k_1 [IS 5.3.1] $k_1 = 1$

Topography Factor, k_3 [IS 5.3.3] $k_3 = 1$

Lateral Loading

Design Wind Speed, V_z [IS 5.3]

$V_z = V_b\, k_1\, k_2\, k_3$ $V_z = 42.787095$

Design Wind Pressure, p z [IS 5.4]

$p_z = 0.6\, V^2_z$

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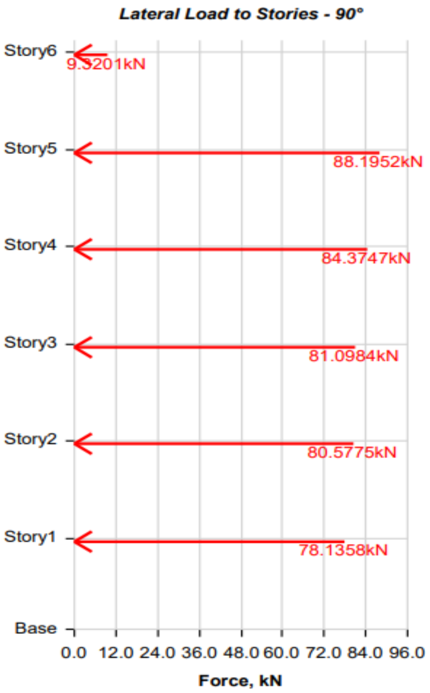
Applied Story Forces



Story	Elevation m	X-Dir kN	Y-Dir kN
Story6	19.6	0	9.3201
Story5	16.3	0	88.1952
Story4	13	0	84.3747
Story3	9.7	0	81.0984
Story2	6.4	0	80.5775
Story1	3.1	0	78.1358
Base	0	0	0

8.2 Auto Seismic Loading

IS 1893:2016 Seismic Load Calculation

Lateral seismic loads for load pattern EQ X according to IS 1893:2016, 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 3] Z = 0.36

Response Reduction Factor, R [IS Table 9] R = 5

Importance Factor, I [IS Table 8] I = 1

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, Sa /g [IS 6.4.2]

Sa g = 1.36 T Sa g = 2.396565

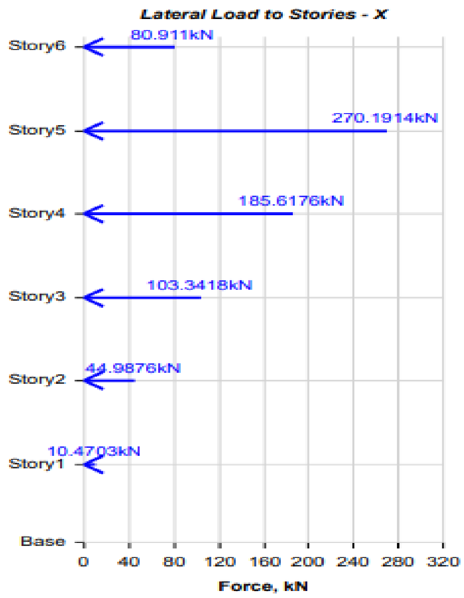
Equivalent Lateral Forces

Seismic Coefficient, Ah [IS 6.4.2] Ah = Z I S_a g 2 R

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	0.567	8061.532	695.5196

Applied Story Forces



Story	Elevation m	X-Dir kN	Y-Dir kN
Story6	19.6	80.911	0
Story5	16.3	270.1914	0
Story4	13	185.6176	0
Story3	9.7	103.3418	0
Story2	6.4	44.9876	0
Story1	3.1	10.4703	0
Base	0	0	0

lateral seismic loads for load pattern EQ Y according to IS 1893:2016, as calculated by ETABS.

Direction and Eccentricity

Direction = Y

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3] Z = 0.36

Response Reduction Factor, R [IS Table 9] R = 5

Importance Factor, I [IS Table 8] I = 1

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, Sa /g [IS 6.4.2]

Sa g = 1.36 T Sa g = 2.10472

Equivalent Lateral Forces

Seismic Coefficient, Ah [IS 6.4.2]

Ah = Z I S_a g 2 R

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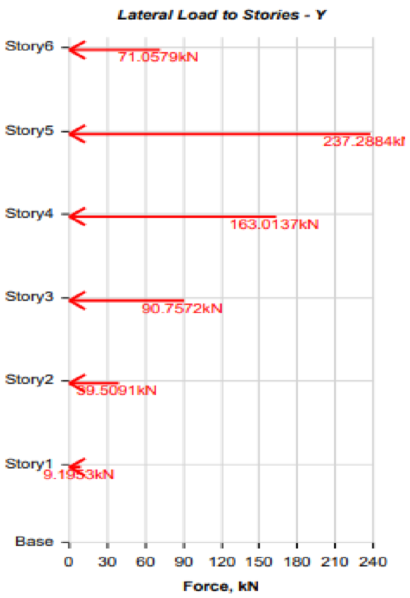
Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y	0.646	8061.532	610.8216

Applied Story Forces



Story	Elevation m	X-Dir kN	Y-Dir kN
Story6	19.6	0	71.0579
Story5	16.3	0	237.2884
Story4	13	0	163.0137
Story3	9.7	0	90.7572
Story2	6.4	0	39.5091
Story1	3.1	0	9.1953
Base	0	0	0

9. LOAD COMBINATIONS

Design of the structures would have become highly expensive in order to maintain either serviceability and safety if all types of forces would have acted on all structures at all times. Accordingly the concept of characteristics loads has been accepted to ensure at least 95 percent of the cases, the characteristic loads are to be calculated on the basis of average/mean load of some logical combinations of all loads mentioned above. IS 456:2000, IS 875:1987 (Part-V) and IS 1893(part-I):2002 stipulates the combination of the loads to be considered in the design of the structures. The different combinations used are:

Table 4.10 - Load Combinations

Name	Load Case/Combo	Scale Factor	Type	Auto
DSlbU1	Dead	1.5	Linear Add	Yes
DSlbU2	Dead	1.5	Linear Add	Yes
DSlbU2	Live	1.5		No
DCon1	Dead	1.5	Linear Add	Yes
DCon2	Dead	1.5	Linear Add	Yes
DCon2	Live	1.5		No
DCon3	Dead	1.2	Linear Add	Yes
DCon3	Live	1.2		No
DCon3	WL X	1.2		No
DCon4	Dead	1.2	Linear Add	Yes
DCon4	Live	1.2		No
DCon4	WL X	-1.2		No
DCon5	Dead	1.2	Linear Add	Yes
DCon5	Live	1.2		No
DCon5	WL Y	1.2		No
DCon6	Dead	1.2	Linear Add	Yes
DCon6	Live	1.2		No
DCon6	WL Y	-1.2		No
DCon7	Dead	1.5	Linear Add	Yes
DCon7	WL X	1.5		No
DCon8	Dead	1.5	Linear Add	Yes
DCon8	WL X	-1.5		No
DCon9	Dead	1.5	Linear Add	Yes
DCon9	WL Y	1.5		No
DCon10	Dead	1.5	Linear Add	Yes
DCon10	WL Y	-1.5		No
DCon11	Dead	0.9	Linear Add	Yes
DCon11	WL X	1.5		No
DCon12	Dead	0.9	Linear Add	Yes
DCon12	WL X	-1.5		No
DCon13	Dead	0.9	Linear Add	Yes
DCon13	WL Y	1.5		No
DCon14	Dead	0.9	Linear Add	Yes
DCon14	WL Y	-1.5		No
DCon15	Dead	1.2	Linear Add	Yes
DCon15	Live	1.2		No
DCon15	EQ X	1.2		No
DCon16	Dead	1.2	Linear Add	Yes
DCon16	Live	1.2		No
DCon16	EQ X	-1.2		No
DCon17	Dead	1.2	Linear Add	Yes
DCon17	Live	1.2		No
DCon17	EQ Y	1.2		No
DCon18	Dead	1.2	Linear Add	Yes
DCon18	Live	1.2		No
DCon18	EQ Y	-1.2		No
DCon19	Dead	1.5	Linear Add	Yes
DCon19	EQ X	1.5		No
DCon20	Dead	1.5	Linear Add	Yes
DCon20	EQ X	-1.5		No

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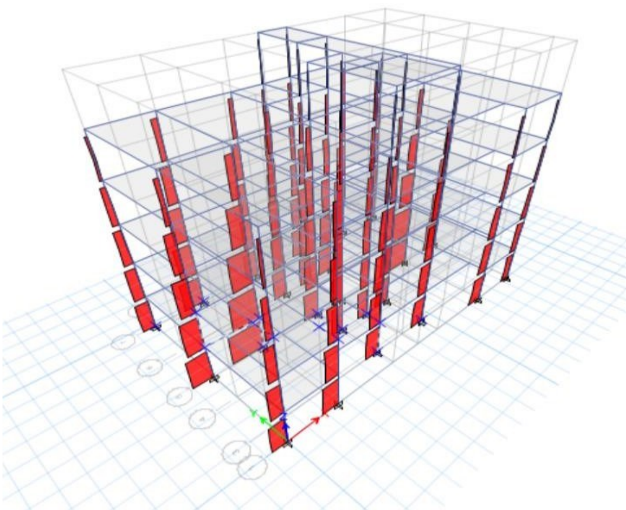
DCon21	Dead	1.5	Linear Add	Yes
DCon21	EQ Y	1.5		No
DCon22	Dead	1.5	Linear Add	Yes
DCon22	EQ Y	-1.5		No
DCon23	Dead	0.9	Linear Add	Yes
DCon23	EQ X	1.5		No
DCon24	Dead	0.9	Linear Add	Yes
DCon24	EQ X	-1.5		No
DCon25	Dead	0.9	Linear Add	Yes
DCon25	EQ Y	1.5		No
DCon26	Dead	0.9	Linear Add	Yes
DCon26	EQ Y	-1.5		No
DCon27	Dead	1.5	Linear Add	Yes
DCon28	Dead	1.5	Linear Add	Yes
DCon28	Live	1.5		No
DCon29	Dead	1.2	Linear Add	Yes
DCon29	Live	1.2		No
DCon29	WL X	1.2		No
DCon30	Dead	1.2	Linear Add	Yes
DCon30	Live	1.2		No
DCon30	WL X	-1.2		No
DCon31	Dead	1.2	Linear Add	Yes
DCon31	Live	1.2		No
DCon31	WL Y	1.2		No
DCon32	Dead	1.2	Linear Add	Yes
DCon32	Live	1.2		No
DCon32	WL Y	-1.2		No
DCon33	Dead	1.5	Linear Add	Yes
DCon33	WL X	1.5		No
DCon34	Dead	1.5	Linear Add	Yes
DCon34	WL X	-1.5		No
DCon35	Dead	1.5	Linear Add	Yes
DCon35	WL Y	1.5		No
DCon36	Dead	1.5	Linear Add	Yes
DCon36	WL Y	-1.5		No
DCon37	Dead	0.9	Linear Add	Yes
DCon37	WL X	1.5		No
DCon38	Dead	0.9	Linear Add	Yes
DCon38	WL X	-1.5		No
DCon39	Dead	0.9	Linear Add	Yes
DCon39	WL Y	1.5		No
DCon40	Dead	0.9	Linear Add	Yes
DCon41	Dead	1.2	Linear Add	Yes
DCon41	Live	1.2		No
DCon41	EQ X	1.2		No
DCon42	Dead	1.2	Linear Add	Yes
DCon42	Live	1.2		No
DCon42	EQ X	-1.2		No

DCon43	Dead	1.2	Linear Add	Yes
DCon43	Live	1.2		No
DCon43	EQ Y	1.2		No
DCon44	Dead	1.2	Linear Add	Yes
DCon44	Live	1.2		No
DCon44	EQ Y	-1.2		No
DCon45	Dead	1.5	Linear Add	Yes
DCon45	EQ X	1.5		No
DCon46	Dead	1.5	Linear Add	Yes
DCon46	EQ X	-1.5		No
DCon47	Dead	1.5	Linear Add	Yes
DCon47	EQ Y	1.5		No
DCon48	Dead	1.5	Linear Add	Yes
DCon48	EQ Y	-1.5		No
DCon49	Dead	0.9	Linear Add	Yes
DCon49	EQ X	1.5		No
DCon50	Dead	0.9	Linear Add	Yes
DCon50	EQ X	-1.5		No
DCon51	Dead	0.9	Linear Add	Yes
DCon51	EQ Y	1.5		No
DCon52	Dead	0.9	Linear Add	Yes
DCon52	EQ Y	-1.5		No

10 ANALYSIS RESULTS

The structure was analysed as ordinary moment resisting space frames in the versatile software Etabs 2015. Joint coordinate command allows specifying and generating the coordinates of the joints of the structure, initiating the specifications of the structure. Member incidence command is used to specify the members by defining connectivity between joints. The columns and beams are modelled using beam elements. Member properties have to be specified for each member. From the analysis, maximum design loads, moments and shear on each member was obtained. From these values, we design the structure

10.1 Axial Force.



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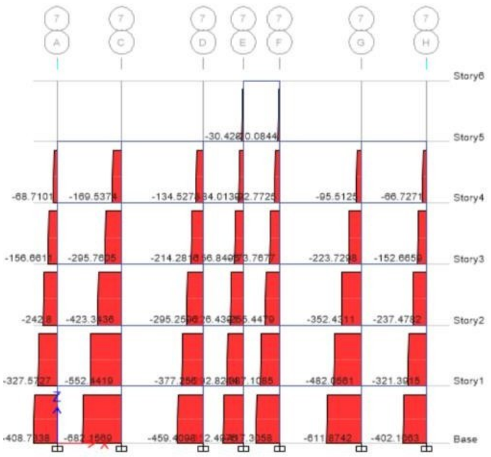
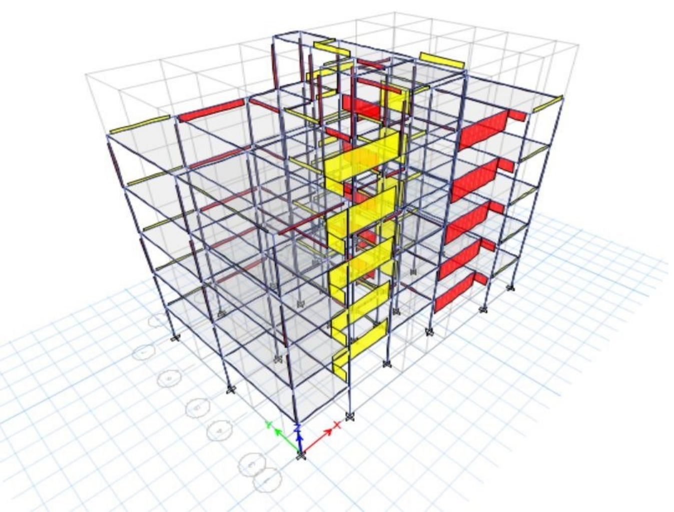
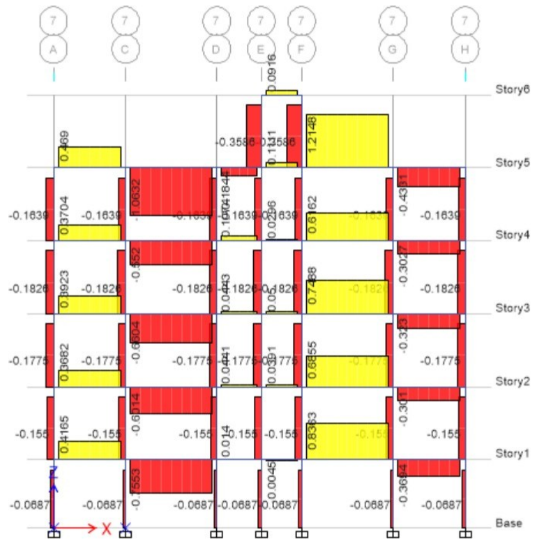
10.2 Elevation view of axial force diagram



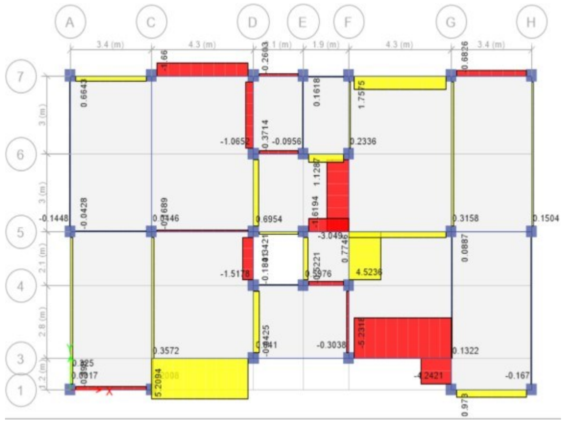
10.3 Torsion diagram



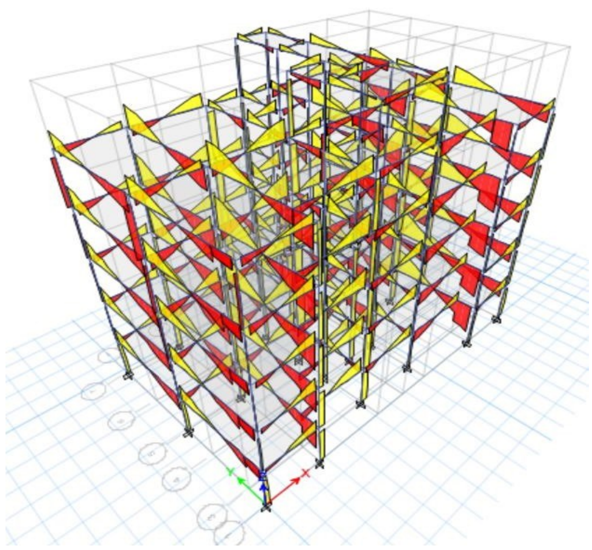
10.4 Elevation view of torsion diagram



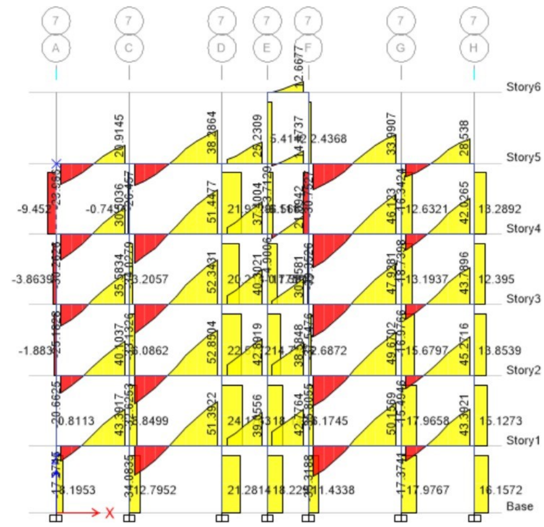
10.5 plan view of torsion diagram



10.6 Shear force diagram



10.7 Elevation view of shear force diagram



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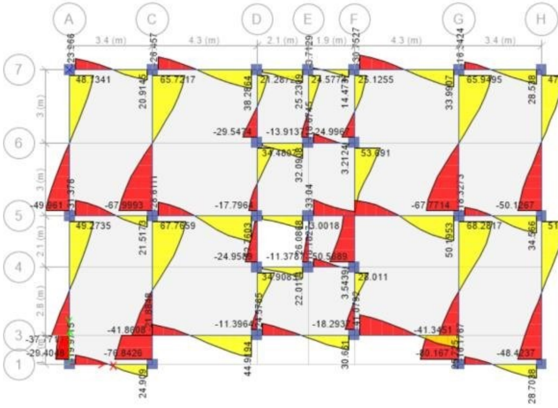
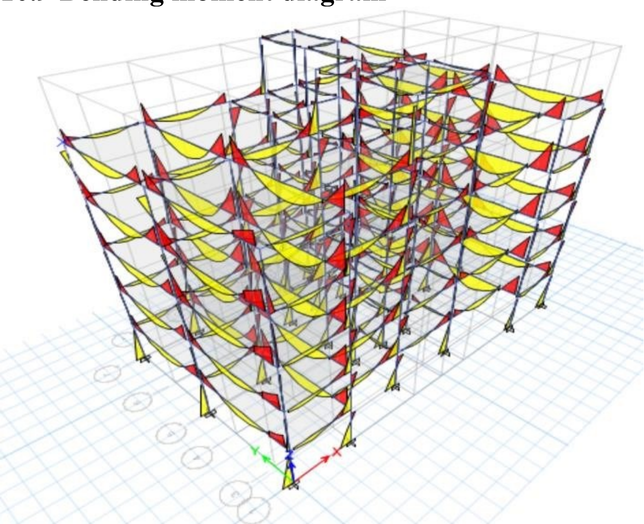
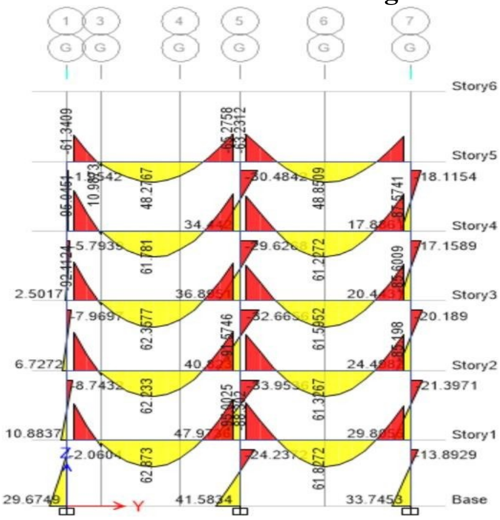
10.8 Plan view of shear force diagram



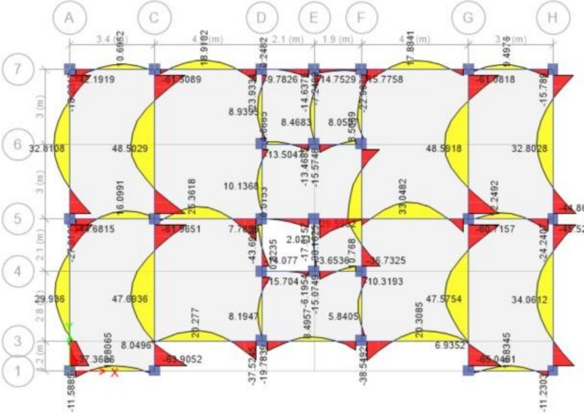
10.9 Bending moment diagram



10.10 Elevation view of bending moment diagram



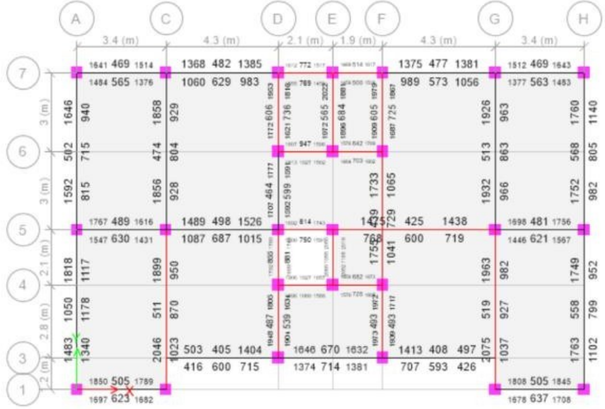
10.11 Plan view of bending moment diagram



11 DESIGN OF RC BUILDING

General The aim of structural design is to achieve an acceptable probability that the structure being designed will perform the function for which it is created and will safely withstand the influence that will act on it throughout its useful life. These influences are primarily the loads and the other forces to which it will be subjected. The effects of temperature fluctuations, foundation settlements etc. should be also considered. The design methods used for the design of reinforced concrete structures are working stress method, ultimate load method and limit state method. Here we have adopted the limit state method of design for slabs, beams, columns and stairs. In the limit state method, the structure is designed to withstand safely all loads liable to act on it through its life and also to satisfy the serviceability requirements, such as limitation to deflection and cracking. The acceptable limit of safety and serviceability requirements before failure is called limit state. All the relevant limit states should be considered in the design to ensure adequate degrees of safety and serviceability. The structure should be designed on the basis of most critical state and then checked for other limit states.

Plan view of 1st floor



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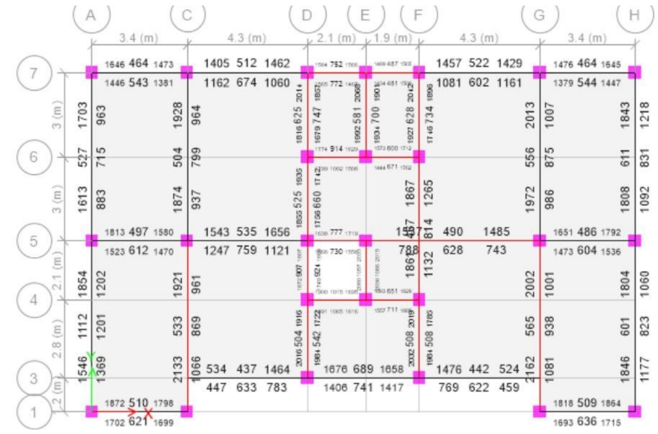
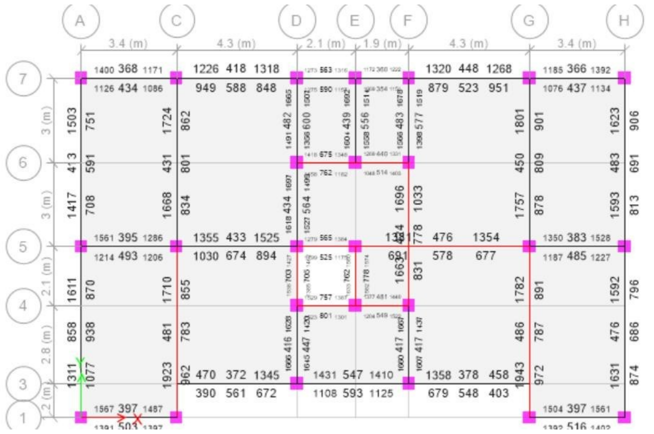
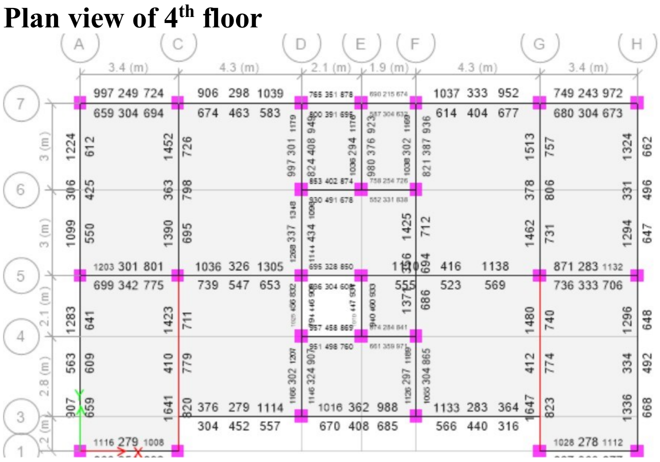
Plan view of 2nd floor



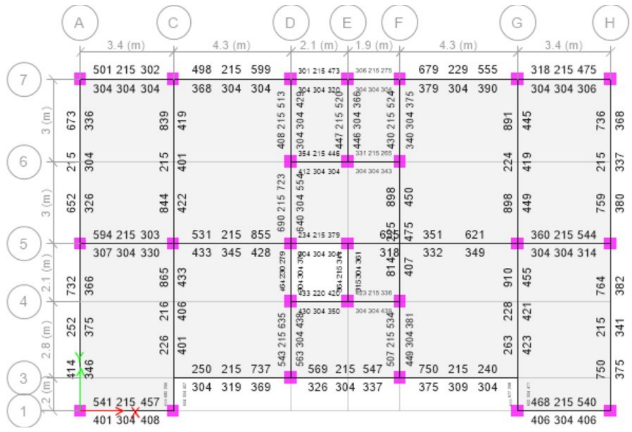
Plan view of 3rd floor



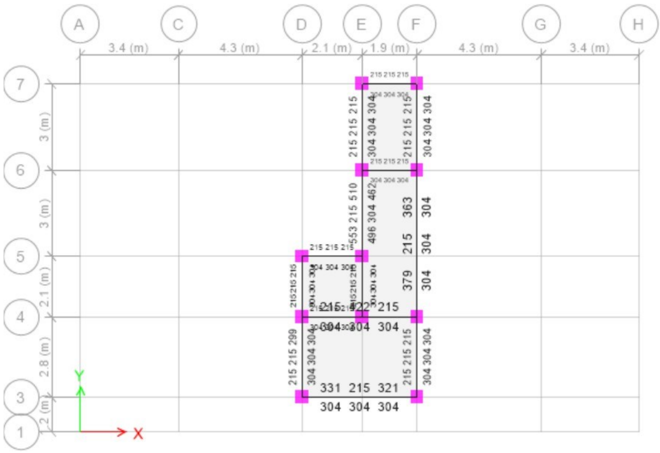
Plan view of 4th floor



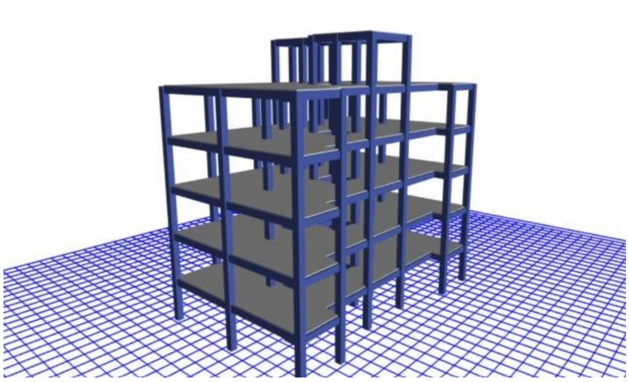
Plan view of 5th floor



Plan view of 6th floor



Rendered view



RESULT AND CONCLUSION:

An apartment building of G+10 stories is analysed and designed. The program ETABS V15.2, which has shown to be very effective in analysing and designing different portions, is used for the analysis. Included as well are the structural components, such as the RCC frame, shear wall, and retaining walls. A separate foundation is laid out in accordance with the results of the soil test. Beam and column designs for RCC frames were created using ETABS. Every effort was made to ensure that the analysis and design adhered to established requirements. The structural engineer was also aware of the many obstacles and limitations that had to be considered in order to complete the design up to the architectural drawing.

FUTURE SCOPE:

- Dynamic analysis can also be done using ETABS.
- Slab and footing can be designed using SAFE.
- In ETABS 2017 different types of slabs can be designed.
- The sections designed in ETABS can also be designed by conventional methods or STAAD-PRO and result can be compared.
- The irregular structures subjected to different load cases can also be analyzed and designed in ETABS.

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