5th Semester Industrial Training Report

on

STRUCTURAL DESIGN OF RESIDENTIAL BUILDING USING ETABS

Carried out by

Summer of Core -IIT Bombay

Submitted in partial fulfilment of the requirement for the Award

of

Degree of Bachelor of Engineering

in

CIVIL ENGINEERING

by

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Submitted to the

Department of Civil Engineering

MAULANA AZAD NATIONAL INSTITUTE OF TECHNOLOGY

BHOPAL

CERTIFICATE

CERTIFICATE
OF COMPLETION

THIS IS TO CERTIFY THAT

Pallavi Kumari

Has successfully completed the workshop on ETabs conducted as part of the Summer of Core organized by the Civil Engineering Association, IIT Bombay, held in July 2025.

Their active participation and eagerness to learn are truly appreciated.

Department General Secretary

Joint Secretary of Academic Affairs

ACKNOWLEDGEMENT

I would like to express my heartfelt gratitude to **Summer of Core – IIT Bombay**, organized by the **Civil Engineering DGSEC Committee**, for their warm welcome and invaluable support during my training. The practical exposure and hands-on experience I gained from working on projects in the field of **Design and Detailing** have been instrumental in enhancing my technical knowledge and shaping my future in civil engineering.

I would like to extend my sincere appreciation to **Shaswat Prasad** and **Vansh Chandarana** for their valuable guidance, insightful feedback, and continuous encouragement throughout the training period. Their mentorship greatly contributed to making my learning experience enriching and rewarding.

I am grateful to the **faculty and staff of the Department of Civil Engineering** for providing a strong academic foundation that laid the groundwork for the successful completion of this training.

Finally, I would like to express my deepest gratitude to my **family and friends** for their constant support, patience, and motivation throughout this journey.

This report would not have been possible without the collective efforts and guidance of all those mentioned above. I am truly thankful for their contribution and inspiration, and I look forward to applying the knowledge and skills I have gained in my future endeavors as a civil engineer.

TABLE OF CONTENT

CHAPTER 01: INTRODUCTION OF BUILDING

The construction and development of residential buildings have become increasingly essential in addressing the growing demand for urban housing. This report presents the design and structural considerations of a multi-storey residential building project undertaken as part of industrial training. The project comprises a Ground pl6us Seven (G+7) storey residential structure, located on a site measuring 23.07 meters by 48.730 meters, making it a twin expansion of an earlier prototype building with dimensions 23.07 meters by 24.365 meters.

This residential building is designed to accommodate more than 200 occupants, with each floor from the 1st to the 7th consisting of eight identical apartment units. Each unit contains three bedrooms with attached bathrooms, a living room, and a kitchen, ensuring a high standard of living for future residents. The ground floor has been allocated for vehicle parking, reflecting practical space utilization and catering to the transportation needs of the residents.

The structural system adopted for this project is a reinforced concrete framed structure integrated with shear walls, providing enhanced lateral load resistance, particularly essential for multi-storey buildings in urban settings. The design considers a moderate exposure condition, which influences durability provisions as per relevant IS codes. Each storey has a uniform height of 3.0 meters, contributing to an overall building height of approximately 30 meters.

To support the efficient vertical circulation of occupants, the building includes eight elevators (lifts) and two staircases, ensuring compliance with safety norms and comfort in daily use. The spatial planning, material selection, structural safety, serviceability, and durability have been meticulously considered to conform with Indian Standard codes and modern construction practices.

This report encapsulates the learnings from the industrial training by providing insights into the planning, analysis, and design processes involved in the development of such a building. It also reflects the practical application of theoretical knowledge gained during academic studies, highlighting the importance of site feasibility, structural stability, service provision, and sustainability in modern construction.

1.1 DESIGN INTENT

Parameter	Description
Building Detail	G+7
Building Plan area	28.04m X 48.73m
Seismic Importance Factor	1.2 (Residential building - with occupancy more than 200 persons)
Seismic Zone	IV
Wind Speed	47 m/s (IS 875 P-3: 2015)
Foundation Type	Raft
Soil Bearing Capacity	160 kN/m²
Depth of Foundation	3m

Exposure condition	Moderate
Material Used	Grade of Concrete : M40 Reinforcement : HYSD 500

1.2 BUILDING PLAN

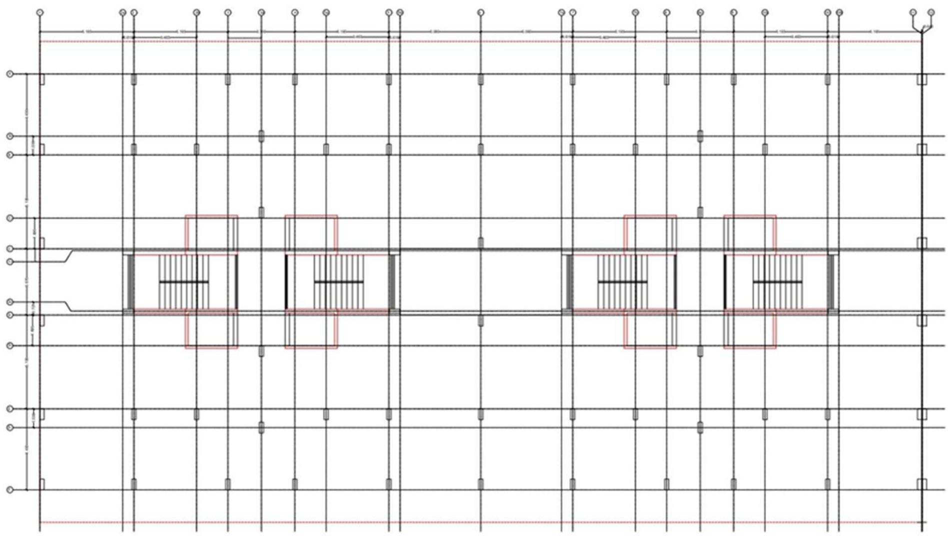


Figure 1 SILT FLOOR PLAN

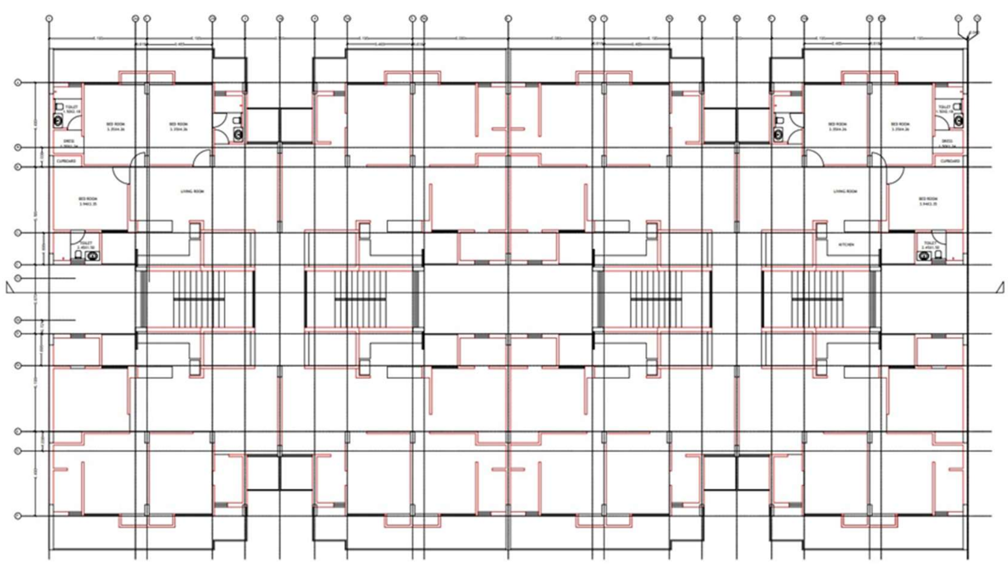


Figure 2 1ST TO 7TH FLOOR PLAN

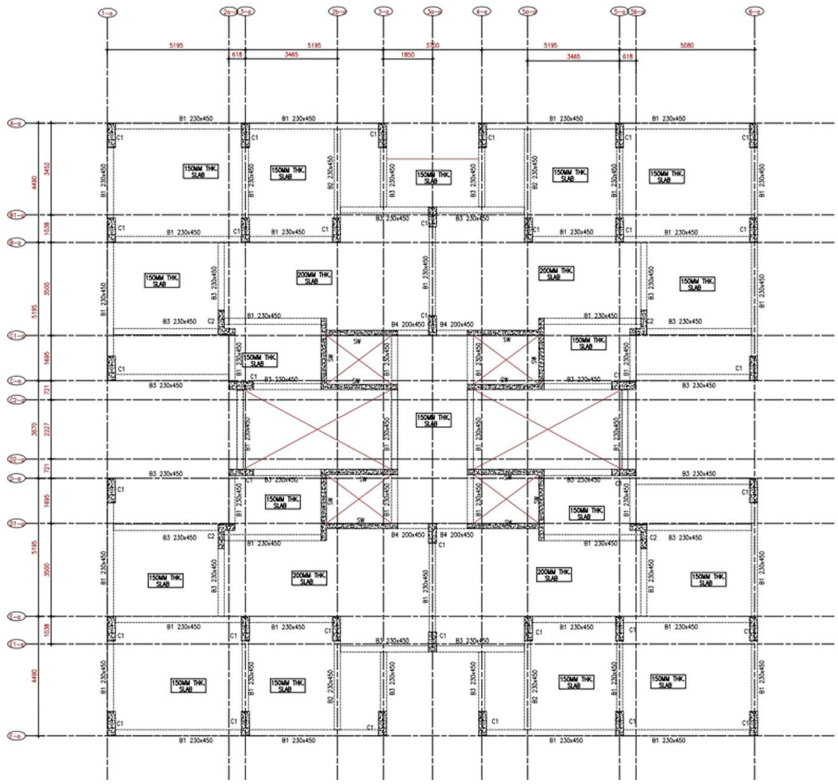


Figure 3 FRAMING PLAN AT SILT LEVEL

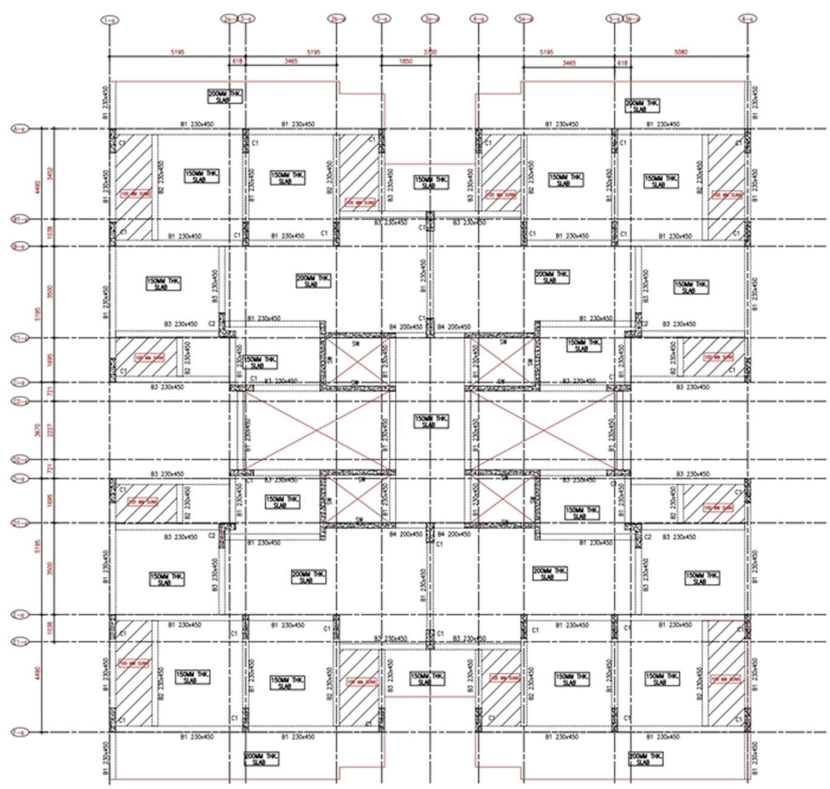


Figure 4 FRAMING PLAN AT TYPICAL LEVEL

CHAPTER 02: LITERATURE REVIEW

2.1 LOADS ON BUILDING

Loads acting on building are generated either by force or nature or are manmade. The natural forces are due to temperature, air, earth quake, gravitational force etc. Manmade forces are generated by movement of people, impact loads etc. The loads considered in the design includes Dead Fond, Live Load, Wind Load, Seismic Load etc.

2.1.1 DEAD LOAD

All permanent Constructions of the structure form the Dead Loads. Dead Loads shall be calculated on the basis of unit weights which shall be established taking into account the materials specified for construction from IS 875 (Part 1) 1987.

2.1.2 LIVE LOAD

The imposed loads to be assumed in the design of building shall be the greatest loads that probably will be produced by the intended use or occupancy, but shall not be less than the minimum loads specified in 18 875 (Part 2) 1987. Floors shall be investigated for UDL and corresponding concentrated load. Imposed loads do not include loads due to wind. earthquake, snow etc.

2.1.3 WIND LOAD

Wind is air in motion relative to the surface of the Earth. The primary cause of wind is traced to the Earth's rotation, and difference in terrestrial radiation. The radiation effects are primarily responsible for convection, either upwards or downwards. The wind generally blows horizontal to ground at high wind speeds. Since vertical components of atmospheric motion are relatively small, the term wind denotes almost exclusively the horizontal wind; vertical winds are always identified as such. The wind speeds are assessed with the aid of anemometers or anemographs which are installed at meteorological observatories at heights generally varying from 10 to 30 m above ground. Wind loads are calculated conforming to IS 875 part III 1987.

2.1.4 SEISMIC LOAD

The earth's crust is not static; it is subjected to constant motion. Since the foundation is a point of contact between building and earth, seismic motion acts on the building by shaking the foundation back and forth. The severity of earthquakes in different parts of India is different. The seismicity at a place is assessed by its distance from the active fault in the rock formation. In general the seismic zoning of a country depends on the seismic history of different regions. As per IS 1893 (Part 1): 2002, India has been divided into four zones, designated as Zone II, III, IV and V. Chandigarh is in zone IV.

2.2 CODE PROVISIONS

- IS 456.2000

Limit state method of design.

- IS 875 (Part I): 1987

Unit Weight of Building Materials.

- IS 875 (Part II): 1987

This standard covers imposed load to be assumed in design of buildings.

- IS 875 (Part III):2015

This standard gives wind forces and their effects.

- IS 1893 (Part I): 2016

This standard deals with the assessment of seismic loads on various structures and earthquake resistant design of buildings.

CHAPTER 03: STRUCTURAL ANALYSIS

Structural analysis is a crucial aspect of any civil or structural engineering project, and its importance should be clearly highlighted in an industrial training report. It serves as the foundation for understanding how various loads and forces—such as dead loads, live loads, wind, and seismic forces—affect buildings, bridges, or other structures. During industrial training, students observe real-time application of theoretical knowledge, and structural analysis is often at the core of these observations. It ensures that the structure will be safe, stable, and efficient throughout its service life. By accurately analysing the internal forces, moments, deflections, and reactions in different structural members, engineers can determine the correct size and material specifications, which helps in optimizing cost without compromising safety. In the context of a training report, emphasizing structural analysis demonstrates the trainee's awareness of how essential calculations, design software (like STAAD Pro or ETABS), and engineering judgment are applied to ensure compliance with relevant codes and standards. It also reflects a practical understanding of how analysis connects the conceptual design phase with the actual construction process, making it a vital learning component during industrial training.

3.1 PROPERTIES OF MEMBER SECTION

3.1.1 SLAB SECTION

Slab 1	150 mm
Slab 2	200 mm

3.1.2 BEAM SECTION

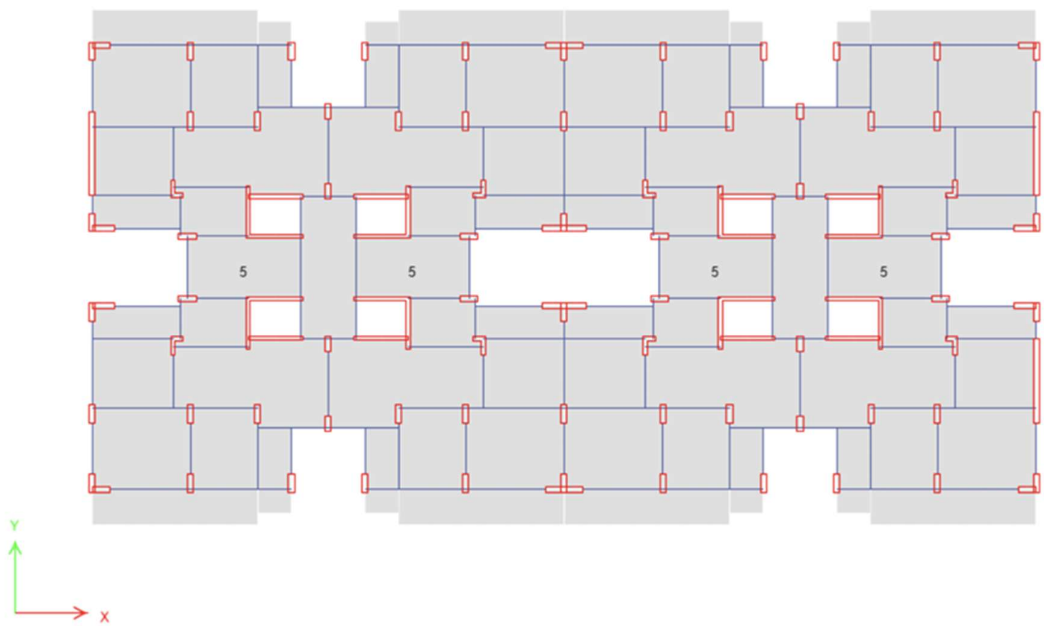
Beam 1	230 X 450 mm
Beam 2	275 X 450 mm

3.1.3 SHEAR WALL

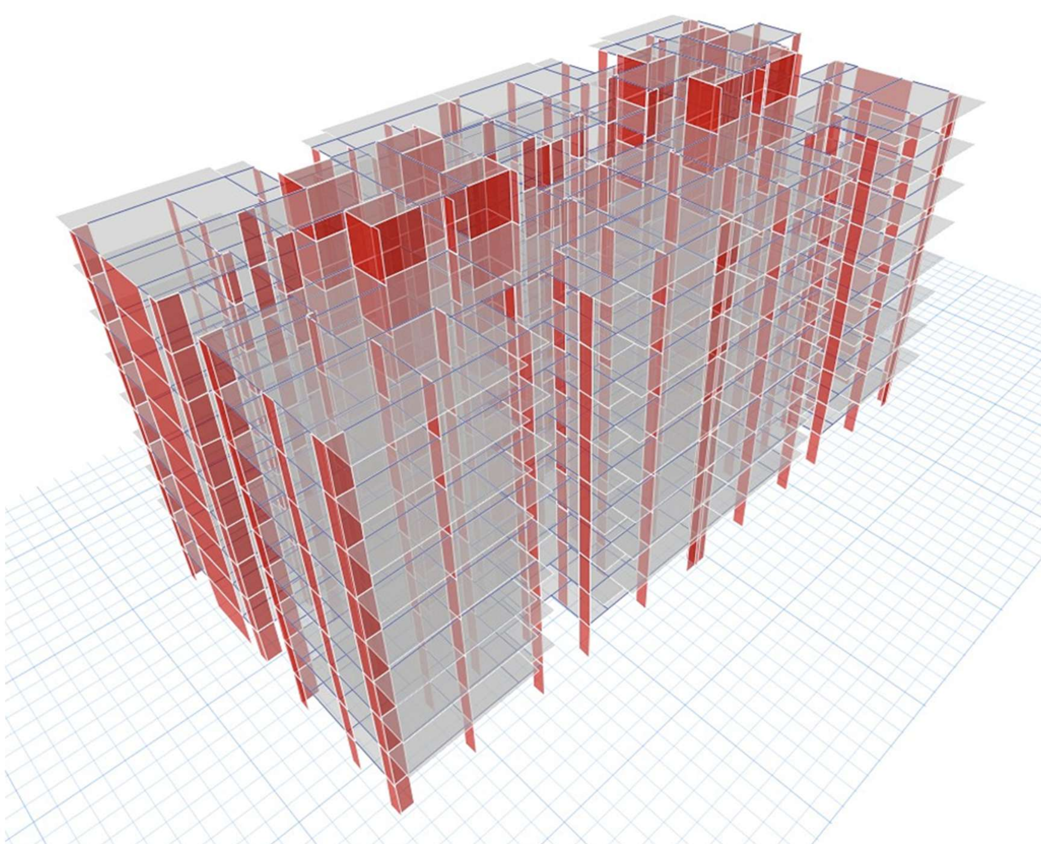
Shear Wall 1	200 mm
Shear Wall 2	230 mm
Shear Wall 3	300 mm

3.2 STRUCTURAL MODELING IN ETABS

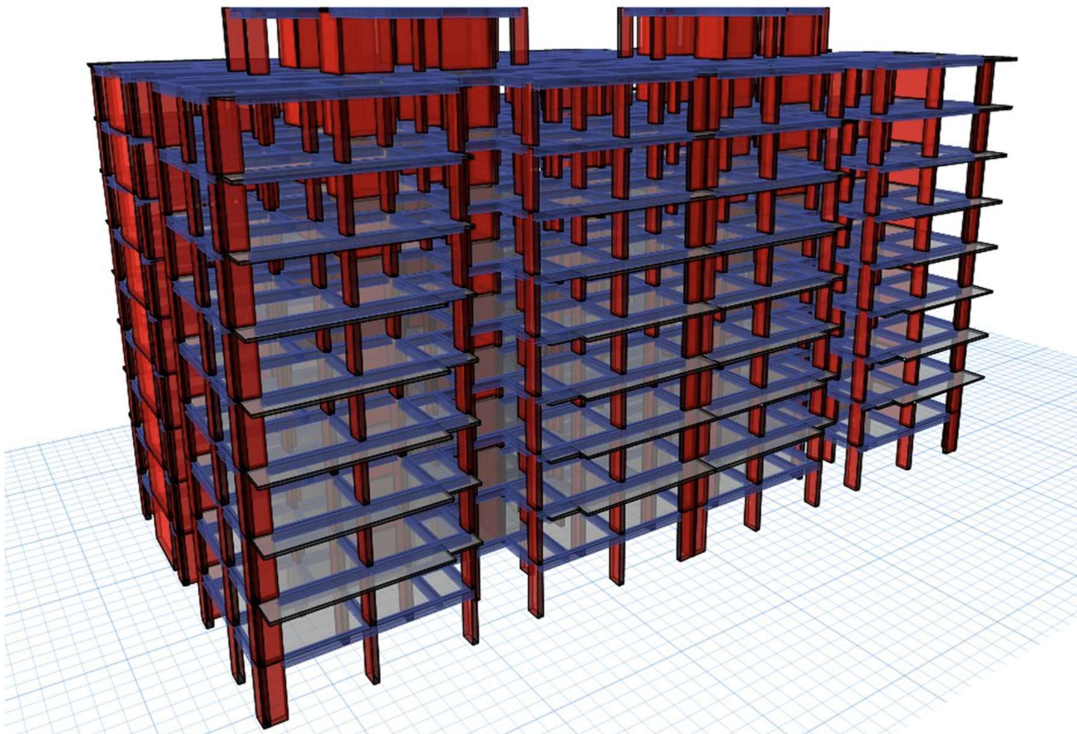
3.2.1 PLAN



3.2.2 3D VIEW



3.2.3 3D RENDERED VIEW



3.3 LOADS CALCULATION

The different load cases which ae considered are dead load, live load, wind load and seismic load.

3.3.1 DEAD LOAD CALCULATION

Dead load is primarily due to self-weight of structural members, permanent position walls, fixed permanent equipment and weights of different materials. Loads shall be calculated on the basis of unit weight of materials used and is specified in IS 875 (P-1) 1987.

Self-weight of a brick wall due to brick = Unit weight of brick X Thickness of wall X (Height of wall – Depth of beam)

a) For beam 450 mm depth

Self-weight = 19 X 0.22 X (3-0.45) = 10.65 kN/m

b) Floor finish = 0.075 X 25 = 1.8 kN/m2

3.3.2 LIVE LOAD CALCULATION

Live loads were taken from IS 875 (P-2) 1987.

1. Bedroom	2 kN/m2
2. Toilet and Bathroom	2 kN/m2
3. Corridors, Passage, Lobby, Balcony	3 kN/m2
4. Staircase	5 kN/m2

3.3.3 WIND LOAD CALCULATION

Wind Load is crucial factor in structural design, influencing the safety and stability of buildings. It is calculated based on the basic wind speed, terrain category and structural characteristics as per IS 875(P-3): 2015. Accurate wind load estimation ensures the structure can resist wind pressure and perform reliably under varying environmental conditions.

STRUCTURE PARAMETERS

Length = 48.73m

Width = 28.04m

Height = 27m

Wind Speed (Vb)	47 m/s
Terrain Category	2
Risk Coefficient (k1)	1
Importance Factor (k2)	1
Topography Factor (k3)	1

3.3.3.1 DESIGN WIND SPEED (Vz)

$V_z = V_b \times k_1 \times k_2 \times k_3$

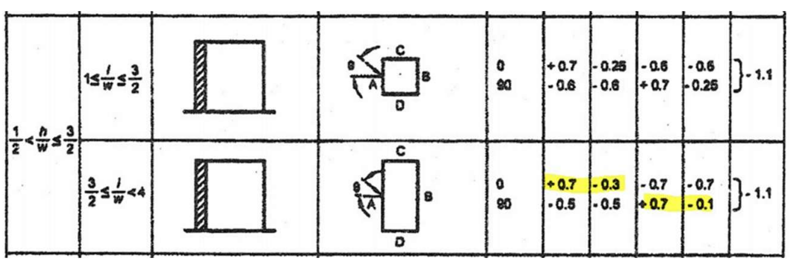
$= 47 \times 1 \times 1 \times 1 = 47$ m/s

3.3.3.2 DESIGN WIND PRESSURE (Pz)

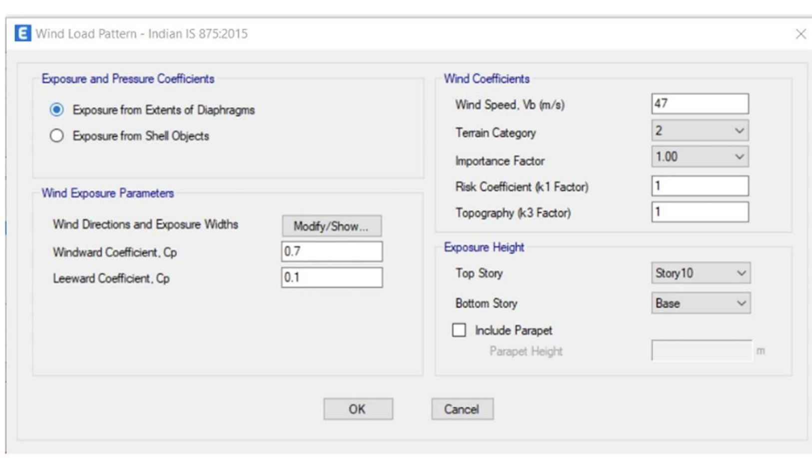
$P_z = 0.6 \times V_z^2$

$= 0.6 \times (47)^2 / 1000 = 1.32$ kN/m2

Figure 5 FROM TABLE:5 (IS 875 P-3:2015) External Pressure Coefficients (Cpe)



3.3.3.3 WIND LOAD PATTERN (ETABS)



3.3.4 SEISMIC LOAD CALCULATION

Seismic loads refer to the forces exerted on a structure due to ground motion caused by an earthquake. These dynamic forces arise from the inertia of the structure as it resists sudden movement. Unlike static loads, seismic loads are unpredictable and can vary in intensity, direction and duration. The design of the structures in seismically active regions requires careful consideration of these forces to ensure safety, stability and performance during and after an earthquake. In industrial settings, where large equipment and critical operations are housed, accounting for seismic loads is crucial to minimize structural damage and operational downtime. Design codes such as IS 1893:2016 P-1 in India provide guidelines to estimate and resist seismic effects effectively.

The base shear or total design lateral force along any principal direction shall be determined by the following expressions:

VB = Ah x W

Where Ah shall be estimated as per 6.4.2, and W as per 7.4 (IS 1893 P-1:2016)

VB = Design seismic base shear

Ah = Design horizontal acceleration spectrum

W = Seismic weight of the building

The design horizontal seismic coefficient Ah for a structure shall be determined by:

$$A_h = \frac{\left(\frac{Z}{2}\right)\left(\frac{S_a}{g}\right)}{\left(\frac{R}{I}\right)}$$

Where,

Z = Zone factor

Table 3 Seismic Zone Factor *Z*
(*Clause* 6.4.2)

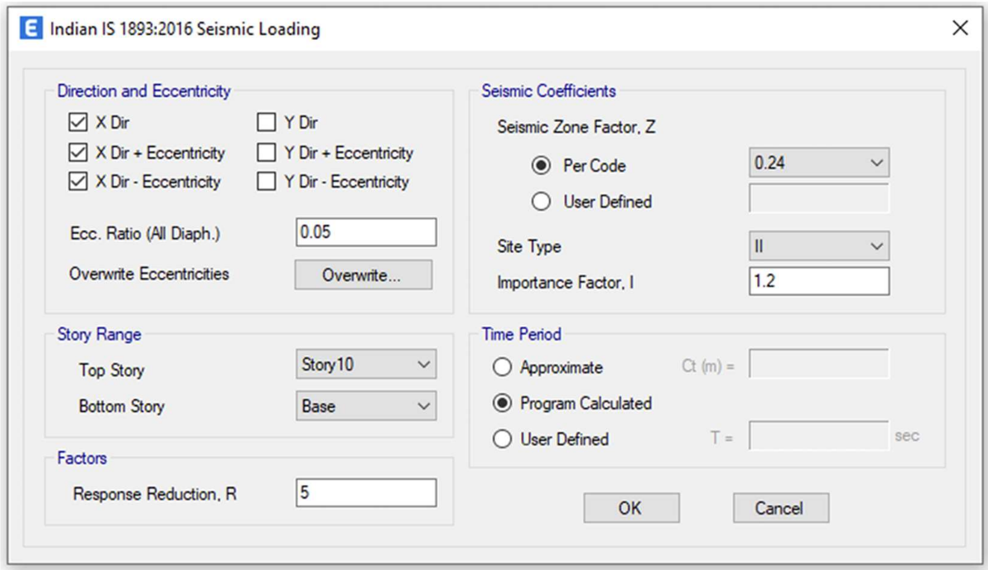
Seismic Zone Factor (1)	II (2)	III (3)	IV (4)	V (5)
Z	0.10	0.16	0.24	0.36

I = Importance Factor (Table 8 Clause 7.2.3)

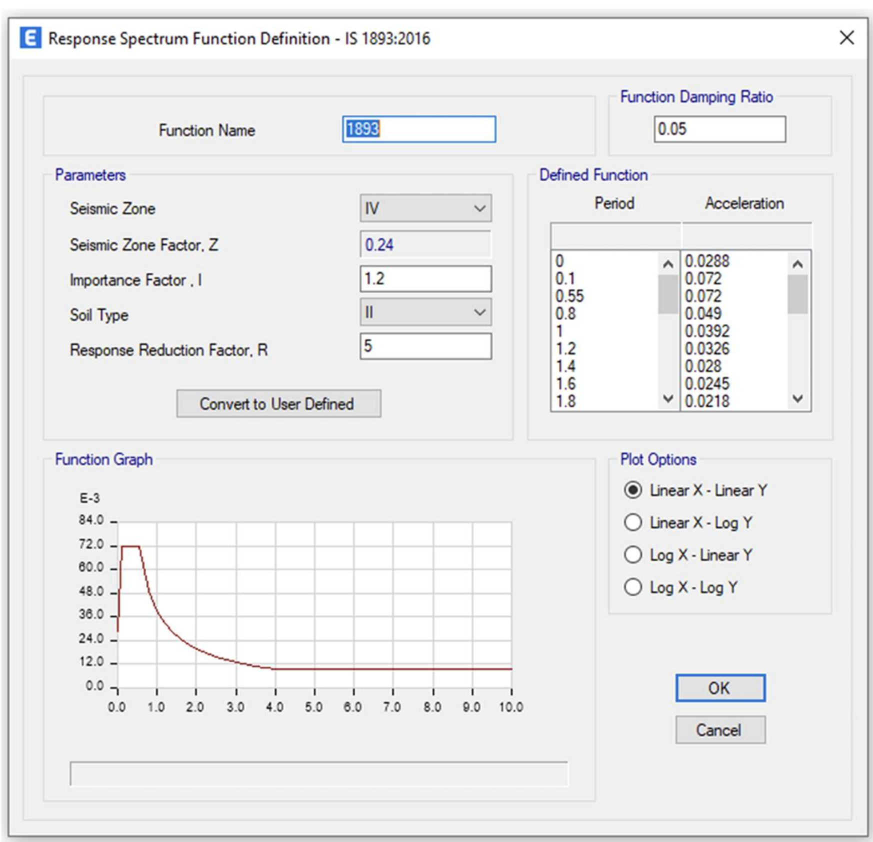
R = Response reduction factor (Table 9 Clause 7.2.6)

s/g = Average response acceleration coefficient

3.3.4.1 SEISMIC LOAD PATTERN (ETABS)



3.3.4.2 RESPONSE SPECTRUM FUNCTION (ETABS)



CHAPTER 04: DESIGN MEMBERS

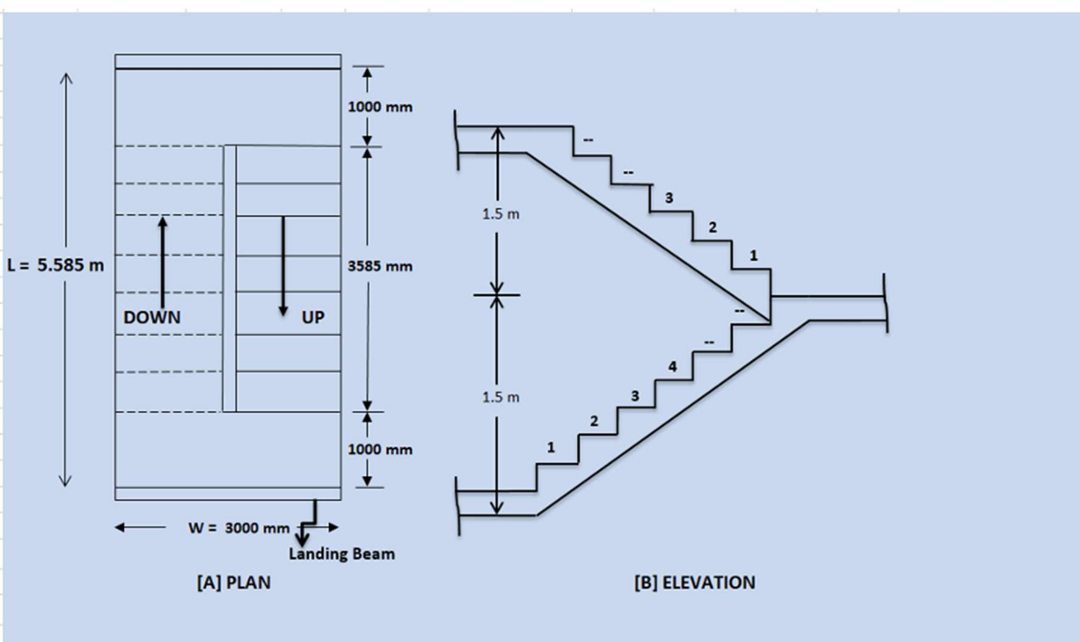
4.1 STAIRCASE DESIGN

Staircase in residential buildings are designed for safety, comfort and durability. They must follow standard dimensions for treads and risers, provide adequate support, and comply with building codes.

Calculation are done using excel sheets as per IS code provision.

Design and detailing of DOG-LEGGED staircase

Data			
Internal Dimensions			
Length, L	=	5.585	m
Width, W	=	3	m
Floor Height, H	=	3	m
Fck	=	30	N/mm2
Fy	=	500	N/mm2
Riser, R	=	150	Mm
Tread, T	=	250	Mm
Start Landing, A 1	End landing, B		1
Width of Support	=	230	Mm
Height of each Flight	=	1.50	m
No. of Risers in each Flight	=	10	No.
No. of Tread in each Flight	=	9	No.
In plan flight length	=	3.585	m
Inclined flight length	=	3.886158	m
Effective Span Length	=	5.815	m
Assume Clear Cover	=	20	
Assume diameter of bar	=	10	
Modification Factor (M.F)	=	1.5	



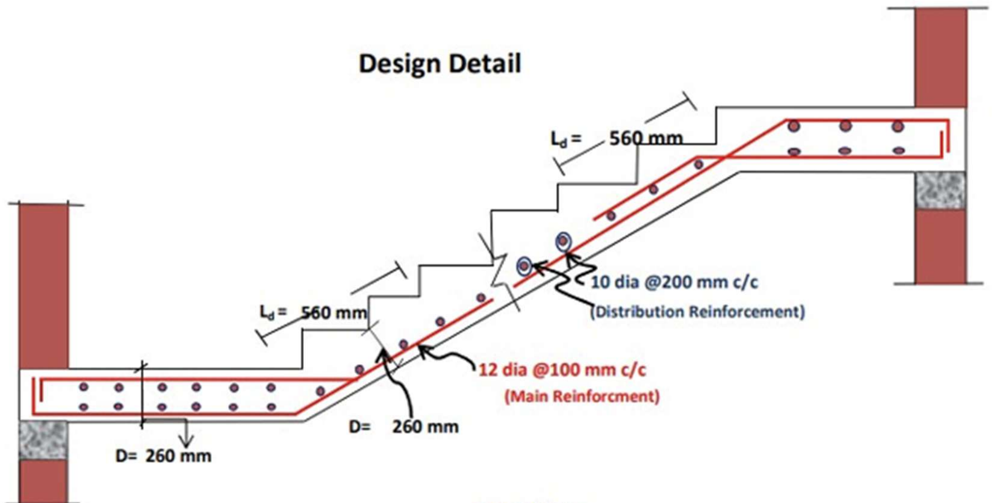
Trial Depth			
dreq	=	Eff. Span	
		20 X M.F	
dreq	=	193.8333	mm
Dreq	=	216.7408	mm
Dpro	=	260	mm
dpro	=	244.185	mm

Load Calculation on Step Portion			
(a) Dead load of waist slab	=	D X 25 X $\sqrt{(R2+T2)}$/T	
(b) Dead load of steps	=	25 x(R/2)	KN/m2
	=	1.875	KN/m2
(c) F.F	=	1.85	KN/m2
(d) L.L	=	3	KN/m2
Total Load	=	14.30524	KN/m2
Factored Load, w	=	21.45786	KN/m2
Maximum BM, Mu= (wl2/8)	=	90.6976	KN-m
Maximum SF, Vu= (wl/2)	=	16.09339	kN

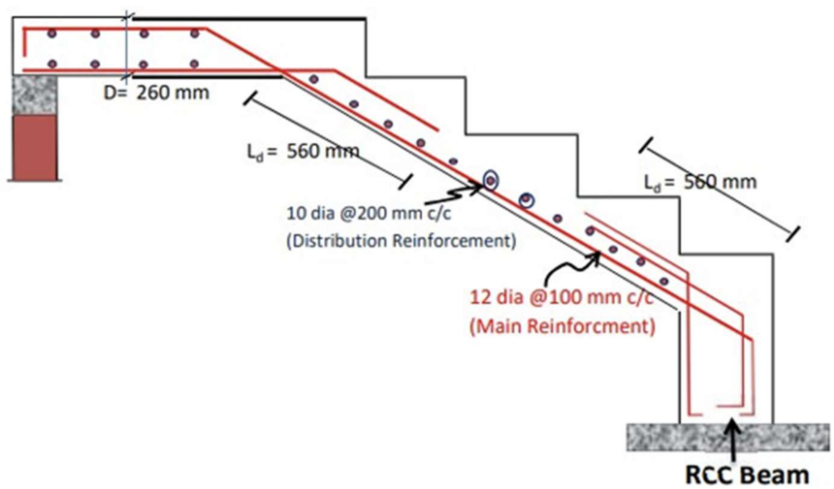
Main and Distribution Reinforcement					
Type of steel	**Ast (Required)**	**Dia. (mm)**	**Spacing Required(mm)**	**Spacing Provided(mm)**	
Main Steel	**911**	**12**	124.16	200.00	
Distribution Steel	**312**	**10**	251.73	200.00	
Main Steel		**12 dia @100 mm c/c**			
Distribution Steel		**10 dia @200 mm c/c**			
(a)Check Depth for flexure					
dreq=	148.01	mm			
dpro=	244.19	mm	**SAFE**		
(b)Check for Deflection					
Ast required =	911	mm2	Ast provided =	1130	mm2
fs=0.58 fy ($Ast\ required$)/($Ast\ provided$) =		359		MPa	
Percentage of reinforcement provided, Pt =		0.42		%	
Modification Factor (M.F) fROM 23.2.1 of IS 456					
$Kt\ or(M.F)$=1/(0.225+0.00322 fs−0.625 log_10 (bd/100Ast)) =			1.2		
(($Span$ (l))/($depth$(d)))$Actual$		23.814		**SAFE**	
(($Span$ (l))/($depth$(d)))$maxpermissible$		24			

(c) Development Length					
IS 456-2000, Development Length, Ld		(ø σs)/4Ʈbd)			IS456-2000, Page 43
					Values-Tbd Design bond stress N/mm2
Grade of Concrete	30	Ʈbd =	2.4	Conc. Grade	Ʈbd

Required, Ld	=	543.8		m	20	1.9
				m		2
Provide , Ld	=	560		m	25	2.2
				m		4
					30	2.4
					35	2.7 2
					40	3.0 4



DETAILING



Scheduling of Staircase

Slab Name	Slab Thickness (mm)	Main Steel	Distribution Steel	
ST	260	12 dia @100 mm c/c	10 dia @200 mm c/c	

4.2 BEAM DESIGN

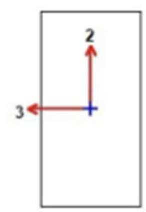
Beams are designed using ETABS by modelling structural elements, applying loads, and analysing results as per IS codes. The software calculates bending moments, shear force and reinforcement requirements, ensuring safe and efficient design.

4.2.1 Beam 1 (230 X 450) mm

ETABS 22.1.0 License #*1UTNGZMPP6RBEJP

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)



Beam Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story2	B143	1202	B1 230X450	DConS19	1315	1315	1	Ductile Frame

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
230	450	230	0	63.5	63.5

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	550	550

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
-114.5484	1.3305	159.1717	0

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-114.5484	2.3139	0	-116.8623

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)	-116.8623		712	0	712	245
Bottom (-2 Axis)		0	356	0	0	356

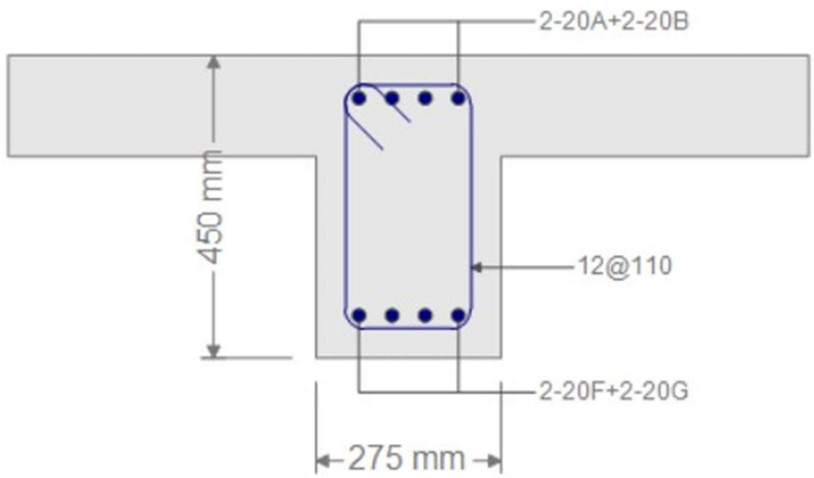
Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv}/s mm²/m
159.1717	0	168.4274	129.6299	1207.57

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
1.3305	159.1717	123	343	814.84

DESIGN DETAIL



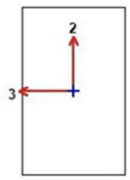
3D VIEW

4.2.2 Beam 2 (275 X 450) mm

ETABS 22.1.0 License #*1UTNGZMPP6RBEJP

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)



Beam Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story9	B87	212	B2 275X450	DConS20	0	2645	1	Ductile Frame

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
275	450	275	0	63.5	63.5

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
29580.4	35	1	550	550

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
-109.3214	0.5833	89.1939	0

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-109.3214	0.9045	0	-110.226

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)	-110.226		662	0	662	274
Bottom (-2 Axis)		0	331	0	0	331

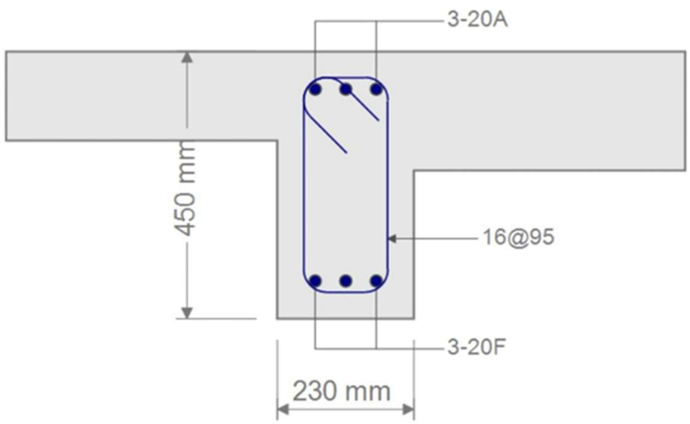
Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv}/s mm²/m
154.1968	0	157.5904	108.8436	1129.87

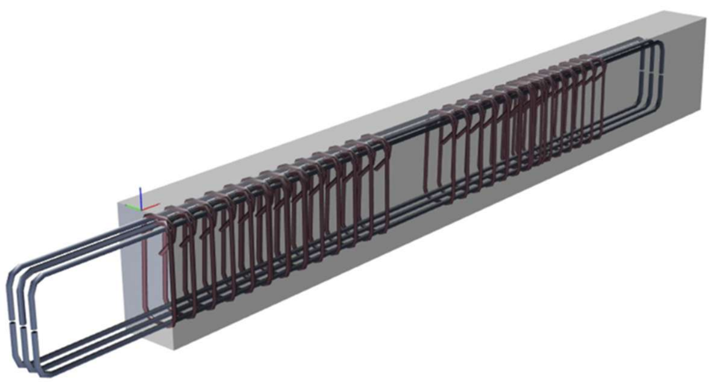
Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt}/s mm²/m
0.5833	89.1507	168	343	316.15

DESIGN DETAIL



3D VIEW



4.3 SHEAR WALL

In ETABS, Shear wall is designed as vertical structural elements to resist lateral loads, following IS 456:2000 and IS 13920: 2016. The software analyzes load combinations from IS 875 and IS 1893 and designs reinforcement based on ductile detailing provisions. It ensures the wall has adequate strength stiffness, and ductility to perform safely under seismic and wind loads.

4.3.1 Shear Wall -1 (200 mm)

ETABS 22.1.0 License #*1UTNGZMPP6RBEJP

ETABS Shear Wall Design

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
Story10	P1	18741.3	14079.9	2783	200	1

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	17349.8	14079.9	20132.8	14079.9	2783	200
Bottom	Leg 1	17349.8	14079.9	20132.8	14079.9	2783	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	1392	0.0025	0.0028	DWalS32	59.6412	-4.4146	-73.9861	556600
Bottom	1392	0.0025	0.0028	DWalS32	154.9177	3.6866	5.2853	556600

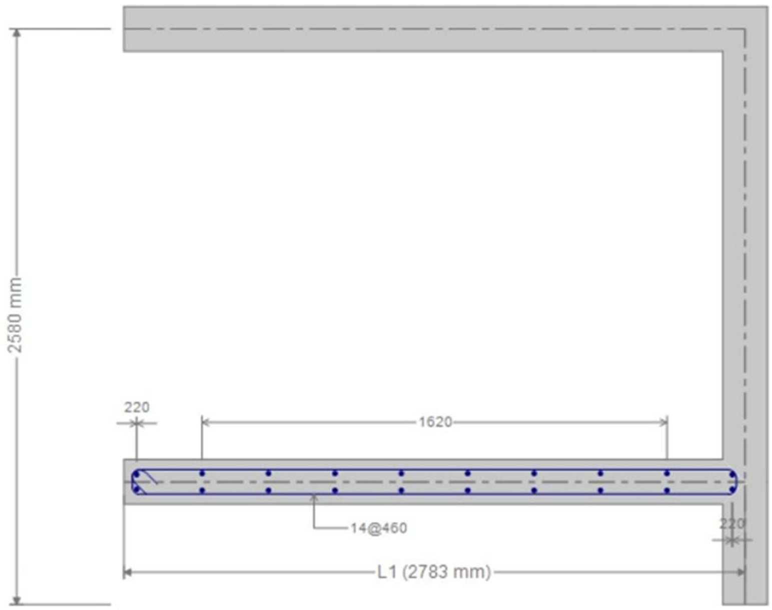
Shear Design

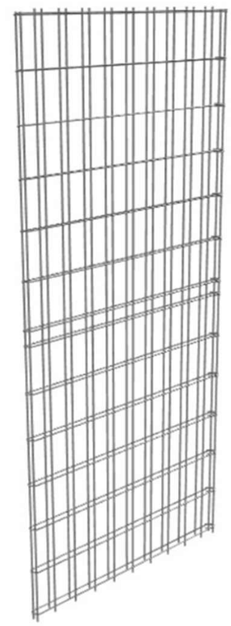
Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	DWalS19	112.9621	-213.5661	75.8574	135.6174	537.3375
Bottom	Leg 1	500	DWalS21	247.2014	169.7173	103.9461	138.0337	539.7538

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	0	DWalS19	112.9621	-213.5661	1.03	8
Top–Right	Leg 1	0	DWalS29	100.0134	87.8257	0.52	8
Bottom–Left	Leg 1	0	DWalS22	55.6034	-3.7335	0.11	8
Botttom–Right	Leg 1	0	DWalS21	265.8665	167.5012	1.13	8

DESIGN DETAIL 3D View





4.3.2 Shear Wall -2 (230 mm)

ETABS Shear Wall Design

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
Story10	P1	18741.3	14079.9	2783	200	1

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	17349.8	14079.9	20132.8	14079.9	2783	200
Bottom	Leg 1	17349.8	14079.9	20132.8	14079.9	2783	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	1392	0.0025	0.0028	DWalS32	59.6412	-4.4146	-73.9861	556600
Bottom	1392	0.0025	0.0028	DWalS32	154.9177	3.6866	5.2853	556600

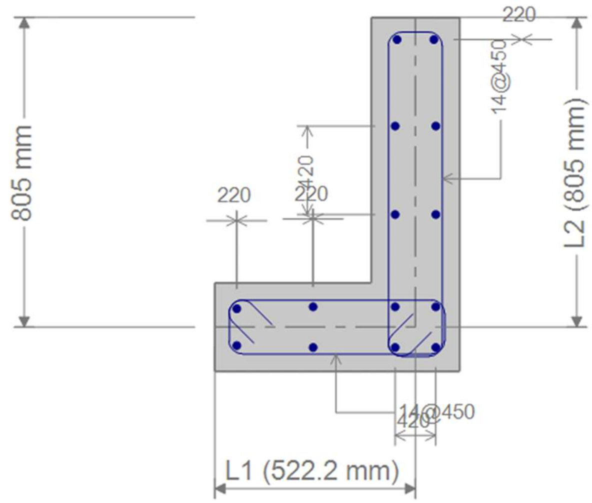
Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	DWalS19	112.9621	-213.5661	75.8574	135.6174	537.3375
Bottom	Leg 1	500	DWalS21	247.2014	169.7173	103.9461	138.0337	539.7538

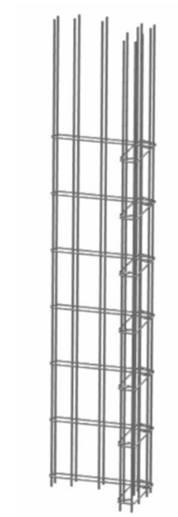
Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	0	DWalS19	112.9621	-213.5661	1.03	8
Top–Right	Leg 1	0	DWalS29	100.0134	87.8257	0.52	8
Bottom–Left	Leg 1	0	DWalS22	55.6034	-3.7335	0.11	8
Botttom–Right	Leg 1	0	DWalS21	265.8665	167.5012	1.13	8

DESIGN DETAIL



3D VIEW



4.3.3 Shear Wall -3 (300 mm)

ETABS 22.1.0 License #*1UTNGZMPP6RBEJP

ETABS Shear Wall Design

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
Story2	P2	43829.8	25199.9	920	300	0.581

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	43829.8	24739.9	43829.8	25659.9	920	300
Bottom	Leg 1	43829.8	24739.9	43829.8	25659.9	920	300

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	690	0.0025	0.0033	DWalS32	1250.9088	-25.0182	-10.653	276000
Bottom	690	0.0025	0.0033	DWalS32	1269.5334	-25.3907	-121.7214	276000

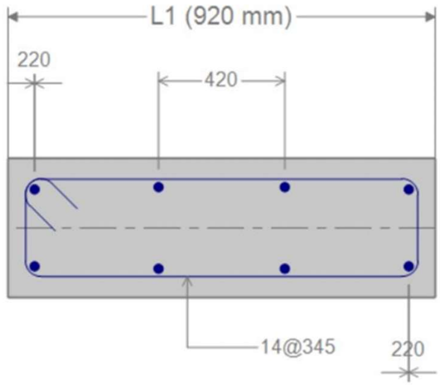
Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	750	DWalS22	1724.9094	101.7251	-105.0777	97.2885	296.4887
Bottom	Leg 1	750	DWalS22	1755.9503	-217.4591	-105.0777	97.8472	297.0475

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	DWalS21	2112.9491	-16.4826	8.05	8
Top–Right	Leg 1	300	DWalS30	2018.4806	78.847	9.18	8
Bottom–Left	Leg 1	300	DWalS30	2049.5214	-139.655	10.73	8
Botttom–Right	Leg 1	300	DWalS21	2143.99	127.7909	10.79	8

DESIGN DETAIL   3D VIEW



CHAPTER 05: ANALYSIS RESULT

Analysis result can be obtained in the graphical as well as in the tabular form, from which the maximum bending moment values are obtained for each member. Concrete dimensions and reinforcement quantities are designed from these quantities appropriately.

5.1 DISPLACEMENT

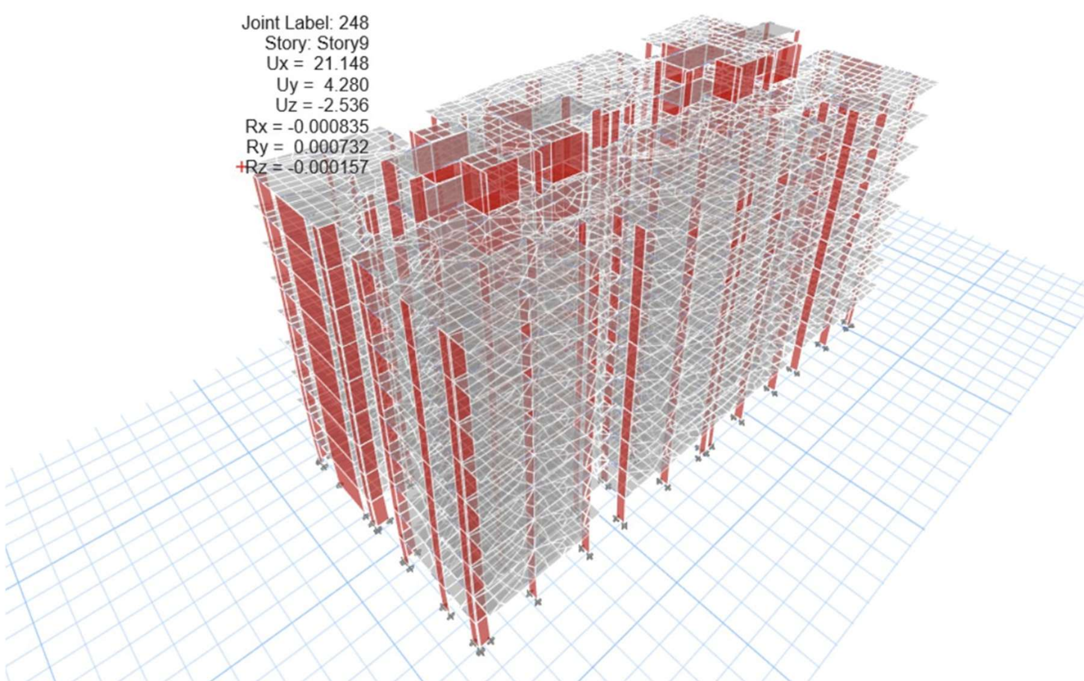


Figure 6 DISPLACEMENT DIAGRAM

(Critical Load Combination 1.5DL +1.5 EQX)

Allowable displacement,

$$Drift = \frac{H}{500} = \frac{30}{500} = 0.06\, m = 60\, mm$$

Max = 21.284 at [40.2148, 21.9899, 30];

Min = -6.411 at [11.2091, 30.8799, 24] (ETABS OUTPUT)

Maximum Displacement < Allowable Displacement

21.284 mm < 60 mm

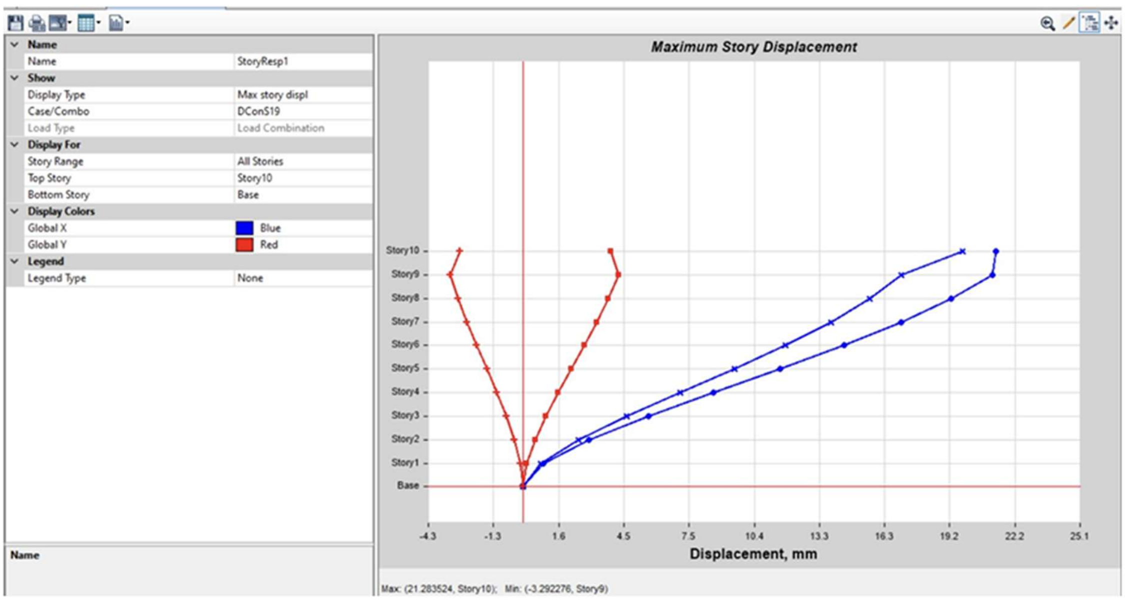


Figure 6 Graphical Representation for maximum-minimum displacement (mm)

5.2 BENDING MOMENT DIAGRAM

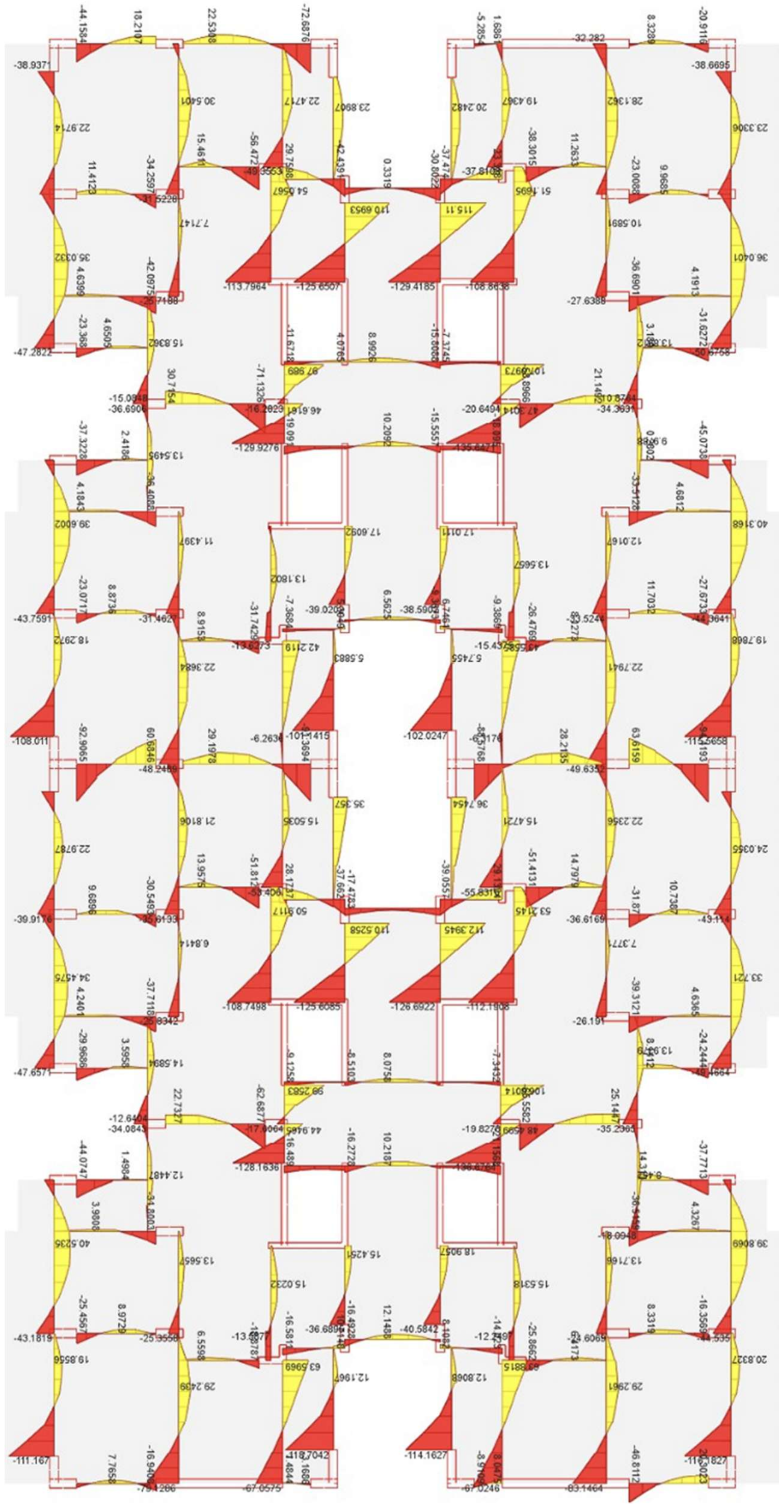


Figure 7 Bending Moment Diagram (kNm) of Floor

(Critical Load Combination 1.5DL +1.5 EQX)

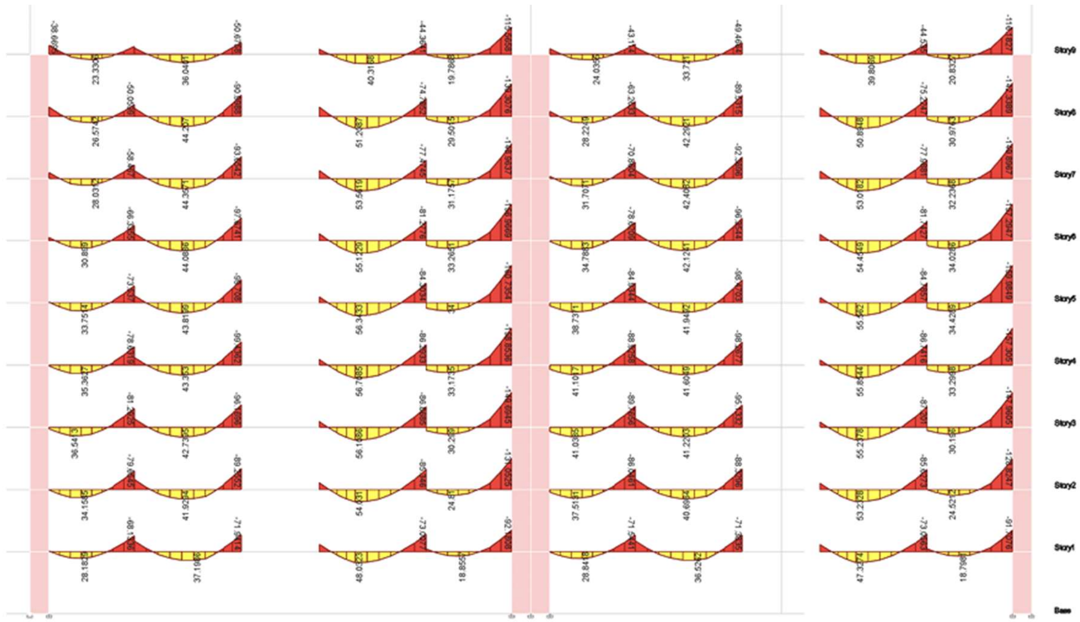


Figure 8 Bending Moment in the Elevation view along X- axis (kNm)

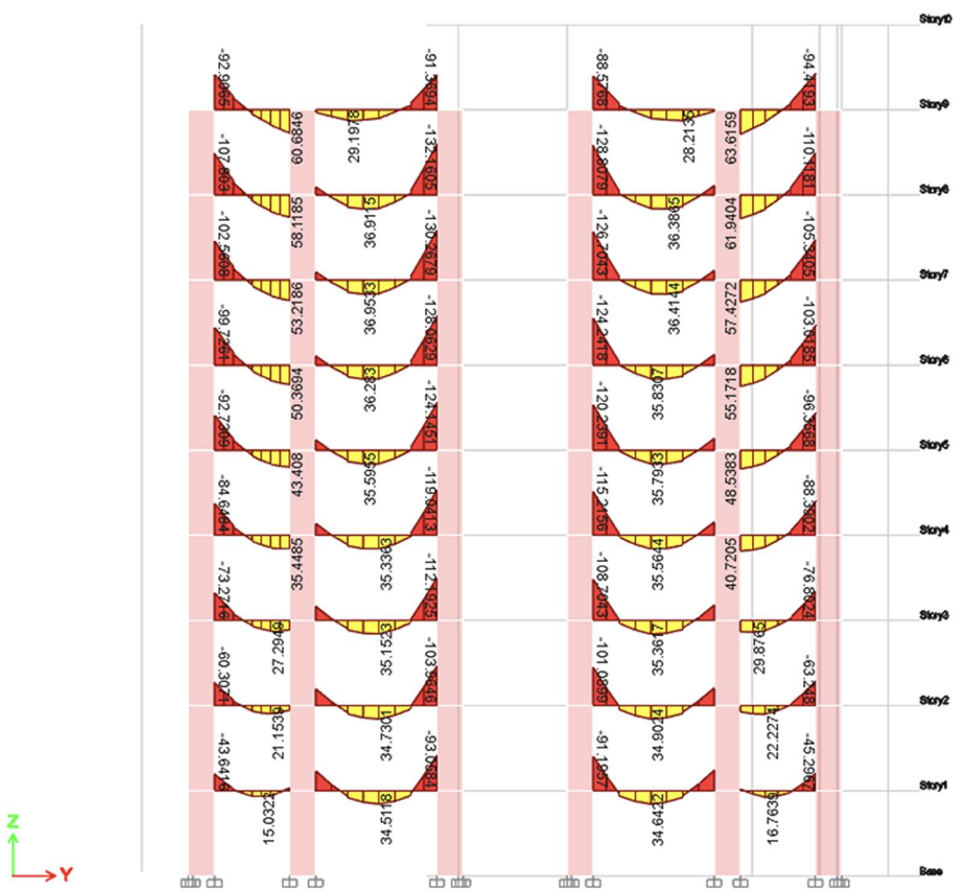


Figure 9 Bending Moment in the Elevation view along Y- axis (kNm)

5.3 SHEAR FORCE DIAGRAM

Figure 10 Shear Force Diagram (kN) of Floor

(Critical Load Combination 1.5DL +1.5 EQX)

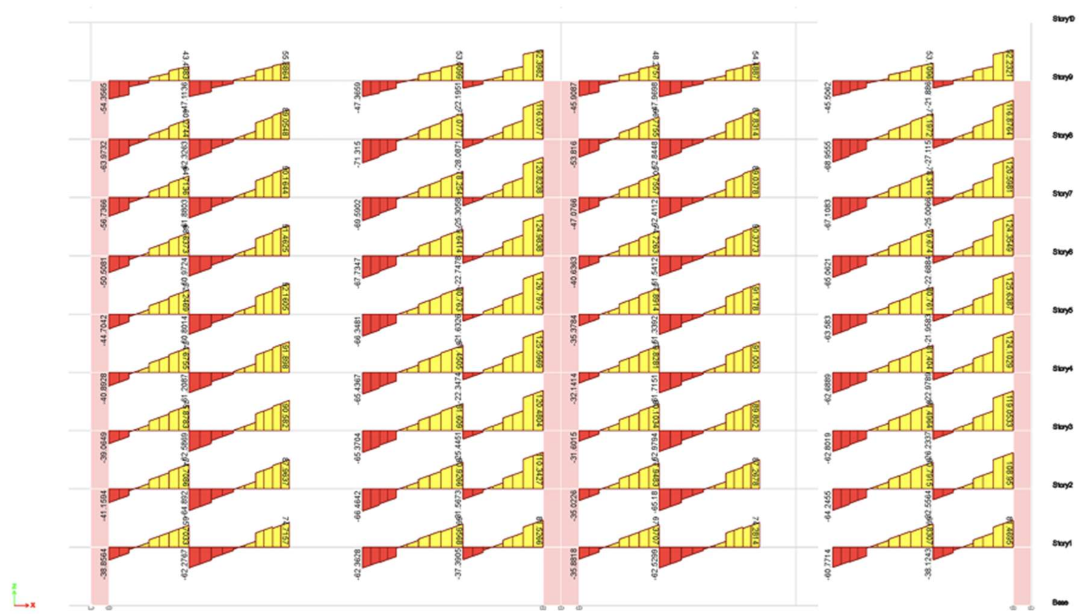


Figure 11 Shear Force in the Elevation view along X- axis (kN)

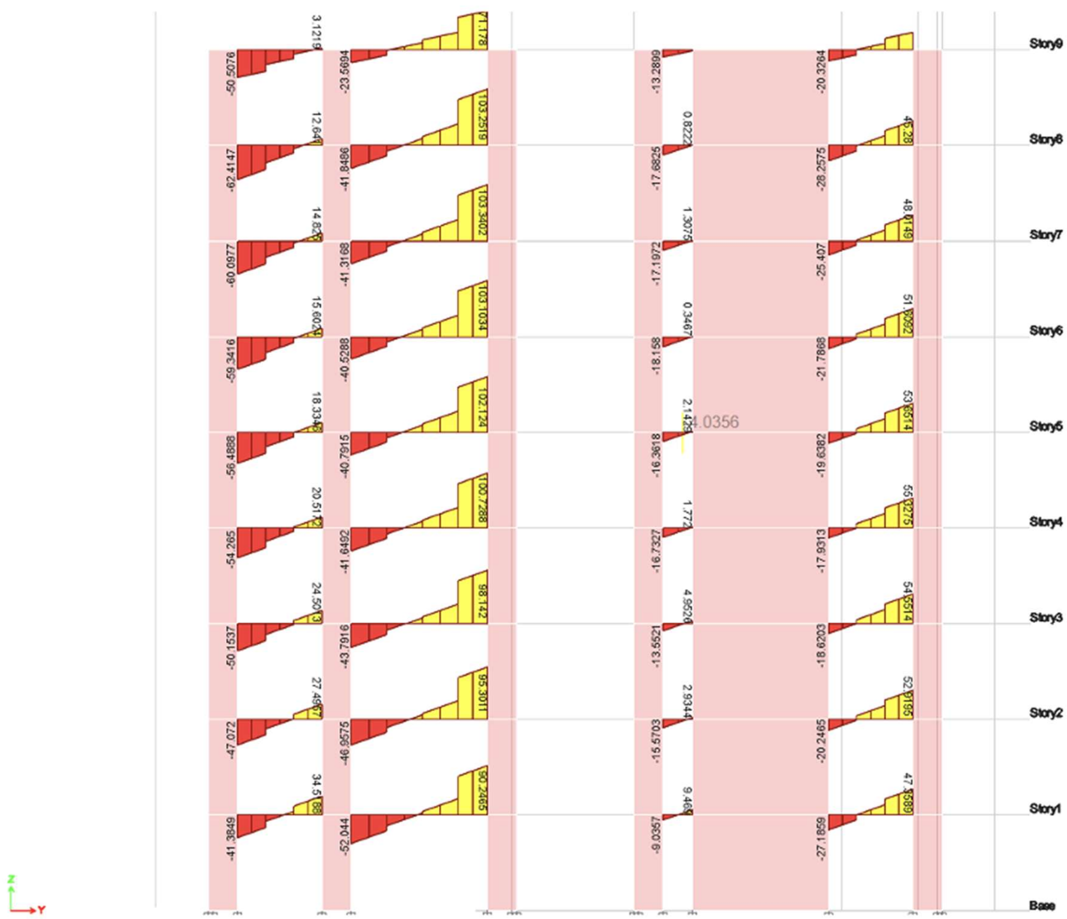


Figure 12 Shear Force in the Elevation view along Y- axis (kN)

CONCLUSION

The **ETABS Workshop** organized by the **Civil Engineering Association, IIT Bombay**, provided me with an excellent opportunity to gain in-depth exposure to the principles and practices of **structural analysis and design** using modern software tools. Throughout the duration of the workshop, I learned how to effectively utilize ETABS for modeling, analyzing, and designing multi-storey building structures subjected to various types of loads such as dead load, live load, wind load, and seismic forces.

The training sessions offered a comprehensive understanding of how theoretical concepts from structural engineering are applied in practical scenarios. Detailed demonstrations and guided exercises helped me become familiar with the workflow of structural modeling, defining material and section properties, assigning loads, and interpreting analysis results for design verification. The **hands-on sessions** were particularly valuable in enhancing my ability to use ETABS efficiently for structural modeling and result interpretation.

In addition to the technical aspects, the workshop also emphasized the importance of **accuracy, safety, and code compliance** in structural design, as well as the relevance of Indian Standard codes in professional practice. This exposure enabled me to appreciate the complexities involved in real-world structural design and the significance of using advanced computational tools to achieve optimal and safe solutions.

Overall, the workshop proved to be a **highly enriching and insightful learning experience**. It not only strengthened my understanding of structural behavior and analysis but also inspired me to further explore advanced topics in **structural engineering and building design**. The skills and knowledge I gained through this program will undoubtedly serve as a strong foundation for my future professional development and research in the field of civil engineering.