North Asian International Research Journal of Sciences, Engineering & I.T.

IRJIF. I.F. : 3.821

ISSN: 2454-7514 Vol. 11, Issue-4, April-2025

Index Copernicus Value: 52.88 Indian Citation Index Thomson Reuters ID: S-8304-2016

A Peer Reviewed Refereed International Journal

DOI: doiglobal.org/doilink/10.2025/68027405c54d4

DESIGN AND DETAILING OF RCC RESIDENTIAL VILLA WITH E-TABS, SAFE AND RCDC

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ABSTRACT:

Reinforced Cement Concrete (RCC) Residential House Villa, is a type of single-family dwelling that incorporates modern construction techniques and materials to provide a safe, durable, and comfortable living space. Mainly, this project focuses on the structural design and detailing of an RCC residential villa using AutoCAD, ETABS, SAFE, RCDC and Ms Excel for efficient planning, analysis, reinforcement detailing and calculations.

It assures structural safety, code compliance, and cost-effectiveness through optimum load calculations and foundation design, as well as the design calculation of the residential project in accordance with Indian standards. The villa uses RCC frames and walls to construct the building, which offers strength, durability, and resistance to natural disasters. This describes the process of designing and detailing an RCC villa utilizing AutoCAD for drafting and where the layout, floor plans, elevations, and sectional details are developed to optimize space utilization and aesthetic appeal, ETABS for structural analysis where the entire RCC frame structure is modeled, considering dead loads, live loads, seismic loads, and wind loads, SAFE for foundation design and used to analyze and design isolated, combined, or raft foundations, ensuring appropriate load distribution and settlement control, and RCDC for reinforcement detailing based on structural analysis results, enhancing accuracy and minimizing manual errors and MS Excel is utilized for determining the required reinforcement and load calculations, which simulates various structural scenarios and checks the design against international building codes and standards.

The results show that the RCC Residential House Villa is a structurally sound, weather-resistant, and energy-efficient living space that meets the needs of modern living. The plan highlights the benefits of using RCC frames and walls in residential construction, including cost-effectiveness, low maintenance, and sustainability. The RCC Residential House Villa is an ideal option for those looking for a safe, comfortable, and modern living space.

***KEYWORDS**: RCC Villa, Structural Design, AutoCAD, ETABS, SAFE, RCDC, MS Excel, Reinforcement Detailing, Load Calculation.*

I. INTRODUCTION

RCC residential villas are becoming a popular choice for people who want a blend of luxury, privacy, and a personalized living space. With more people working from home and looking to escape the noise of city life, villas offer the perfect balance and peaceful surroundings with access to modern amenities. Designing and building these villas isn't just about good looks and it requires smart planning and reliable tools. That's where software like AutoCAD, E-TABS, SAFE, and RCDC come in. AutoCAD helps create detailed floor plans and layouts, making sure everything fits well and looks great. E-TABS handles the heavy lifting when it comes to structural safety, ensuring the villa can stand up to loads and even earthquakes. SAFE focuses on strong foundations and solid slabs, making sure the building is stable from the ground up. RCDC takes the design data and turns it into clear, construction-ready reinforcement details, so nothing's left to guesswork. When used together, these tools make villa construction smoother, safer, and more efficient, giving homeowners peace of mind and a beautiful, well-built place to call home.

The design and detailing of RCC residential buildings have evolved significantly with the integration of advanced structural engineering tools like E-TABS, SAFE, RCDC, and AutoCAD. Several studies, including those by Varalakshmi et al. (2014), Deshpande et al. (2017), and Thakur & Bhardwaj (2021), demonstrate the efficiency of ETABS in analyzing multi-storey structures under various load conditions. These works highlight how E-TABS facilitates accurate modeling of structural components such as slabs, beams, columns, and footings, while adhering to IS standards such as IS 875 and IS 456. Studies by Balaji and Selvarasan (2016) and Sayyed et al. (2017) further explore the effectiveness of E-TABS in static and dynamic load analysis, especially under seismic conditions, ensuring that buildings remain structurally sound even in high-risk zones. Moreover, integration with software like AutoCAD aids in generating detailed structural and architectural drawings, enhancing design clarity and communication.

Recent research, such as that by BonuShanmukha Sai et al. (2024) and Pawar et al., showcases how the use of E-TABS significantly enhances precision and efficiency in the structural design of residential villas and G+1 buildings. The use of RCDC in some of these studies supports automated detailing, ensuring code compliance and faster output of bar bending schedules. Overall, these contributions reinforce that software-based design provides a practical, time-efficient, and reliable method for structural analysis, particularly in the context of growing urbanization and architectural complexity. These studies collectively emphasize the shift from manual calculations to integrated software workflows, which streamline the design process while ensuring safety, durability, and functionality in modern RCC residential structures.

II. METHODOLOGY

Design and Drawing in Auto CAD

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Designing & Analysisin E-TABS

↓

Analysis of Foundationin SAFE

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Detailing in RCDC

First, we start the design process of an RCC residential villa with AutoCAD, where the architectural planning takes place. In this stage, we prepare detailed floor plans, elevations, and sections while following to local building regulations. AutoCAD helps us visualize and draft the spatial layout of the villa, ensuring that the design is functional, aesthetically pleasing, and compliant with building codes. This architectural drawing becomes the basis for all later structural and engineering work.

Once the architectural layout is finalized, we move into the structural phase using E-TABS. Here, we create a 3D structural model of the villa by placing beams, columns, slabs, and walls with appropriate material properties such as M25 concrete and Fe500 steel. We apply various loads including dead loads, live loads, wind loads, and seismic forces as per relevant design standards such as IS 875 and IS 1893. E-TABS performs a comprehensive structural analysis, allowing us to study internal forces, bending moments, shear forces, and deflections. Based on this data, we optimize the size and reinforcement of structural members to ensure both safety and economy.

After completing the structural analysis in E-TABS, weproceed to the detailed design of foundations using SAFE. SAFE is specifically developed for the design of structural floors and footing systems. With input from the E-TABS model, we evaluate slab performance under service and ultimate loads, verify deflection and cracking limits, and design appropriate foundation systems based on soil bearing capacity. Depending on the project specifications, we can design isolated footings, combined footings, or a raft foundation. SAFE also provides precise reinforcement layouts that ensure the structure’s serviceability and long-term performance.

Once the foundation designs are finalized, we transfer all structural data into RCDC for automated detailing. RCDC enables us to carry out detailed design and reinforcement detailing of beams, columns, slabs, and footings in accordance with IS codes. The software automatically creates reinforcement details, bar bending schedules,and full design reports. These outputs significantly reduce manual effort and it help us maintain accuracy and consistency across all structural drawings.

Finally, we bring the entire project back into AutoCAD to produce clean, well-labeled construction drawings. These drawings include all necessary structural details, reinforcement layouts, schedules required for execution at the construction site.

III. RESULTS

Auto CAD Results: The 2D AutoCAD Architectural plan covers a plot area of 4762 sq ft, with a ground floor built area of 2535 sq ft, a first floor built space of 2570 sq ft, a roof floor build area of 452 sqft, and a terrace area of 1996 sqft. Furthermore, rooms are placed in specific directions according to the science of architecture (Vastu Shastra) for each floor.

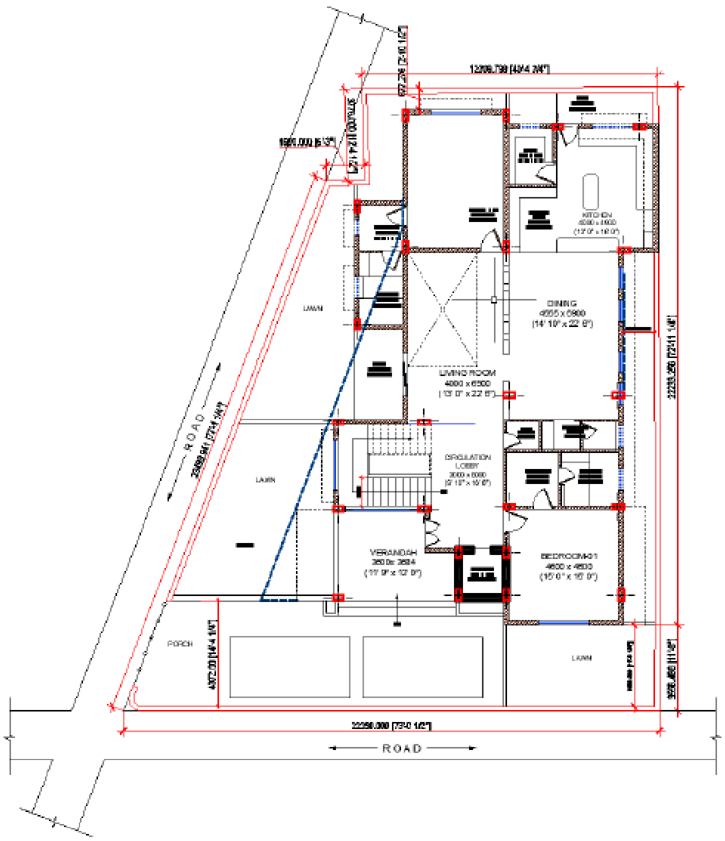

Fig 1:2D Plan of Ground Floor

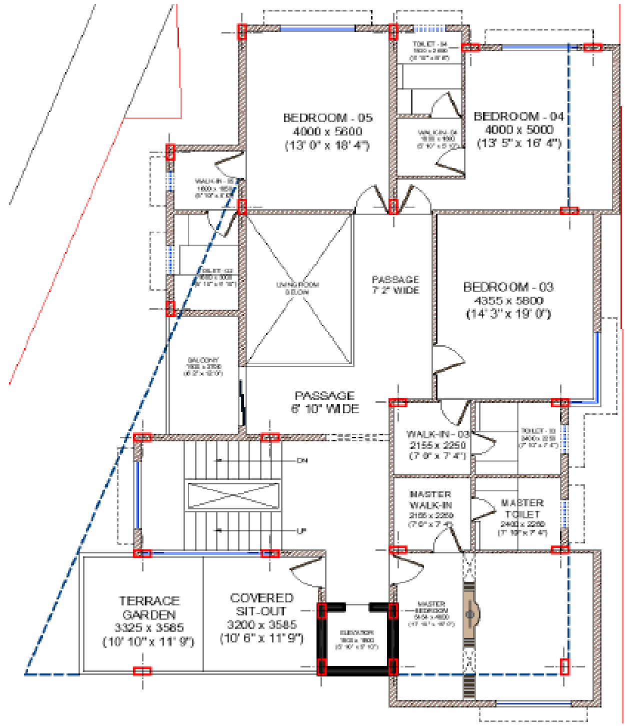

Fig 2: 2D Plan of First Floor

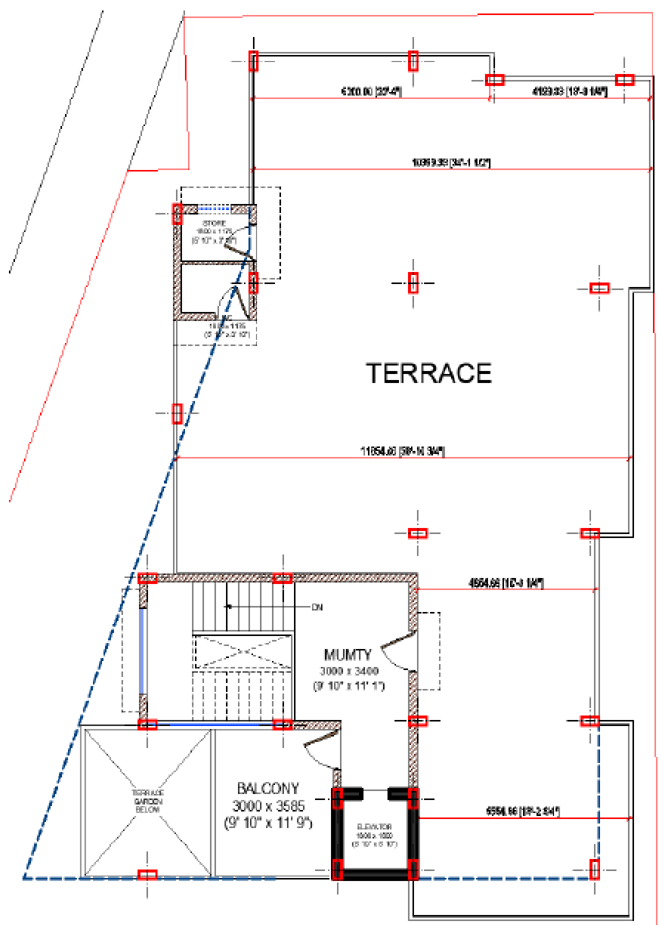

Fig 3: 2D Plan of Roof Floor

IV. E-TABS RESULTS

The Maximum Bending moments and shear force are obtained for Beam forces are -156.858 KN-m and 168.2683 KN respectively, whereas for Column forces shows Maximum Bending moments as -35.8731 KN-m (M2), -112.051 KN-m (M3) and maximum shear force as -1181.76 KN. Maximum area of reinforcement required in the beams and columns are identified as 531 $mm^2$and 1968 mm^2 and Maximum Shear reinforcement is 221.69 mm2/m after designing the structure.

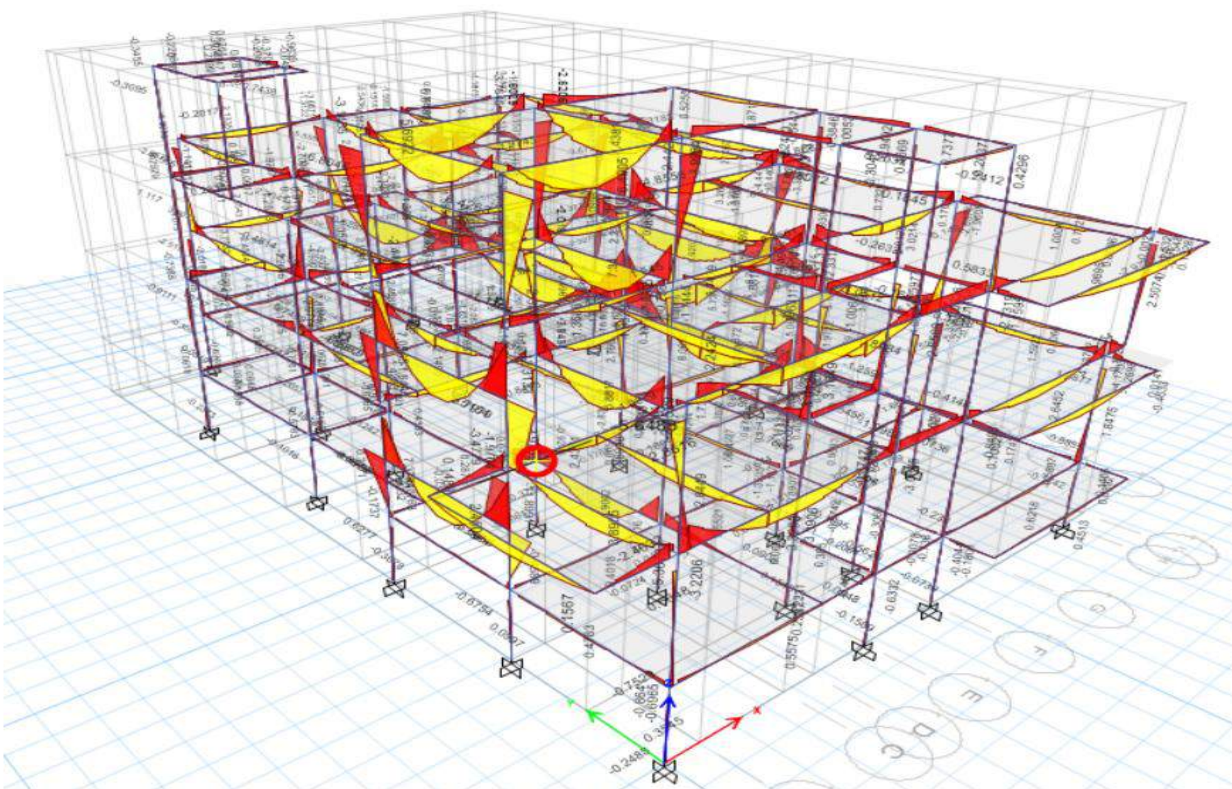

Fig 4: Bending Moment Diagram

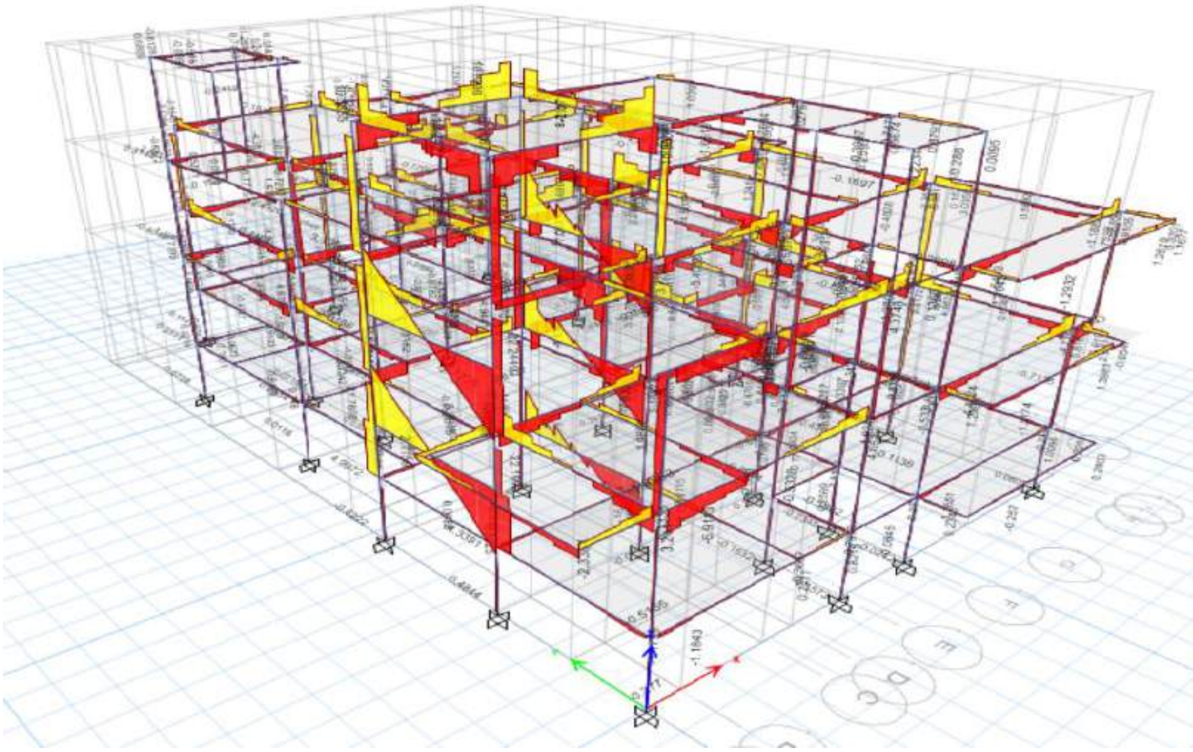

Fig 5: Shear Force Diagram

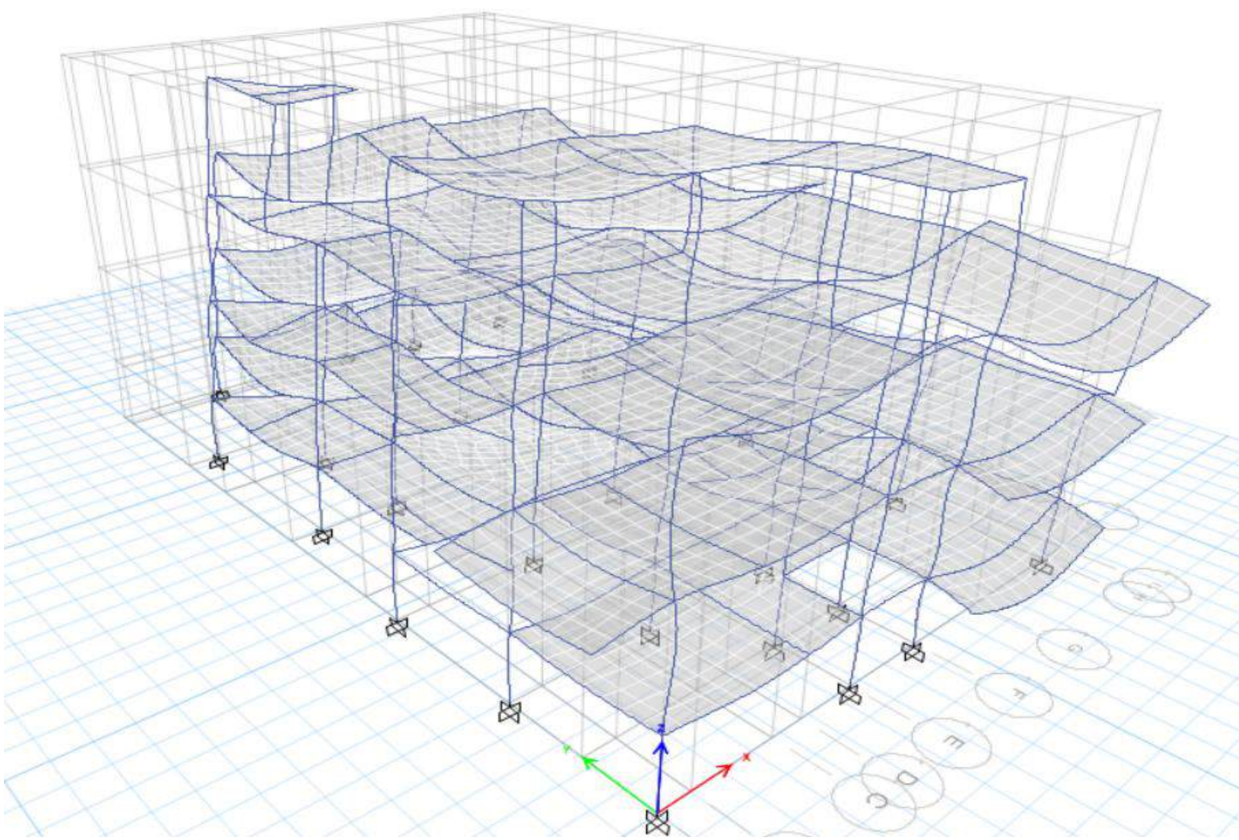

Fig 6: Displacement Diagram

Story	Beam	UniqueName	Combo	Station	P	V2	V3	T	M2	M3
				m	kN	kN	kN	kN-m	kN-m	kN-m
FF	B109	221	1.5DL-1.5EQY-2	0.3	0	-163.75	0	-0.47133	-1.3E-13	**-156.858**
FF	B113	176	1.5DL+1.5EQY-2	4.25	0	**168.2683**	-1.7E-13	0.673898	3.79E-15	-115.195

Table 1: Maximum Values of Beam Forces

Story	Column	UniqueName	Combo	Station	P	V2	V3	T	M2	M3
				m	kN	kN	kN	kN-m	kN-m	kN-m
GF	C6	14	1.5DL-1.5EQY-2	0	**-1181.76**	-56.4365	-3.54999	-0.48127	-4.61012	-112.051
FF	C21	62	1.5DL-1.5EQY-2	0	-441.134	10.79233	-23.2847	-0.729	**-35.8731**	21.31631
GF	C6	14	1.5DL-1.5EQY-2	0	-1181.76	-56.4365	-3.54999	-0.48127	-4.61012	**-112.051**

Table 2: Maximum Values of Column Forces

SAFE Results:

Actual soil-bearing capacity is 200 kN/m². From structure the Minimum Soil Bearing capacity of Footing is 186.0696 KN/m^2, Maximum Soil Bearing capacity of Footing is 197.5106Kn/m² and the Maximum settlement is -21 mm.

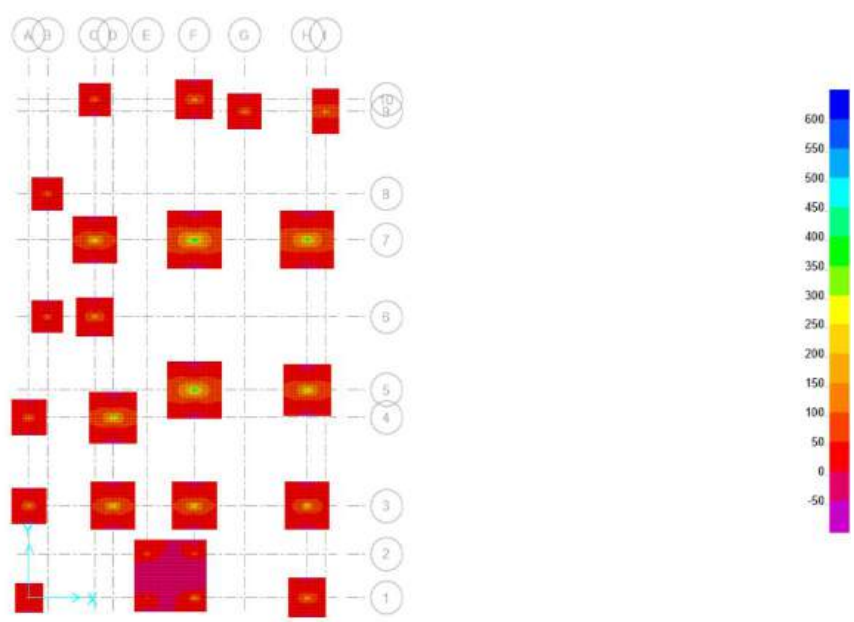

Fig 7: Bending Moment Diagram

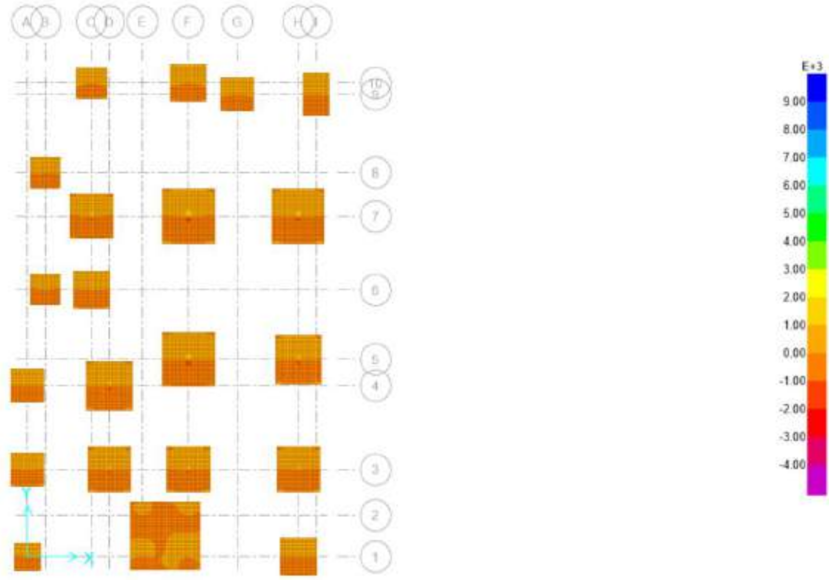

Fig 8: Shear Force Diagram

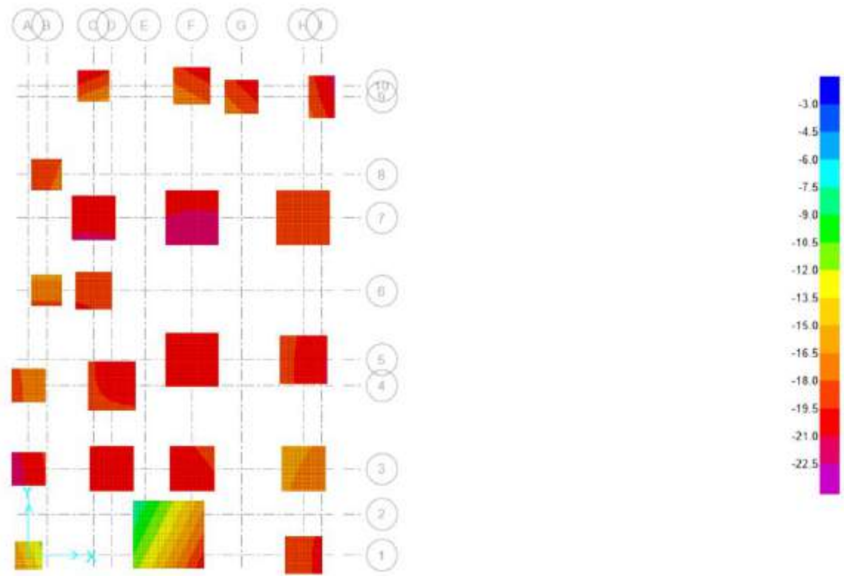

Fig 9: Settlement Diagram

RCDC Results:

When we use RCDC, we get detailed reinforcement designs for structural elements like beams, columns, slabs, and footings. It also provides bar bending schedules, 2D drawings.

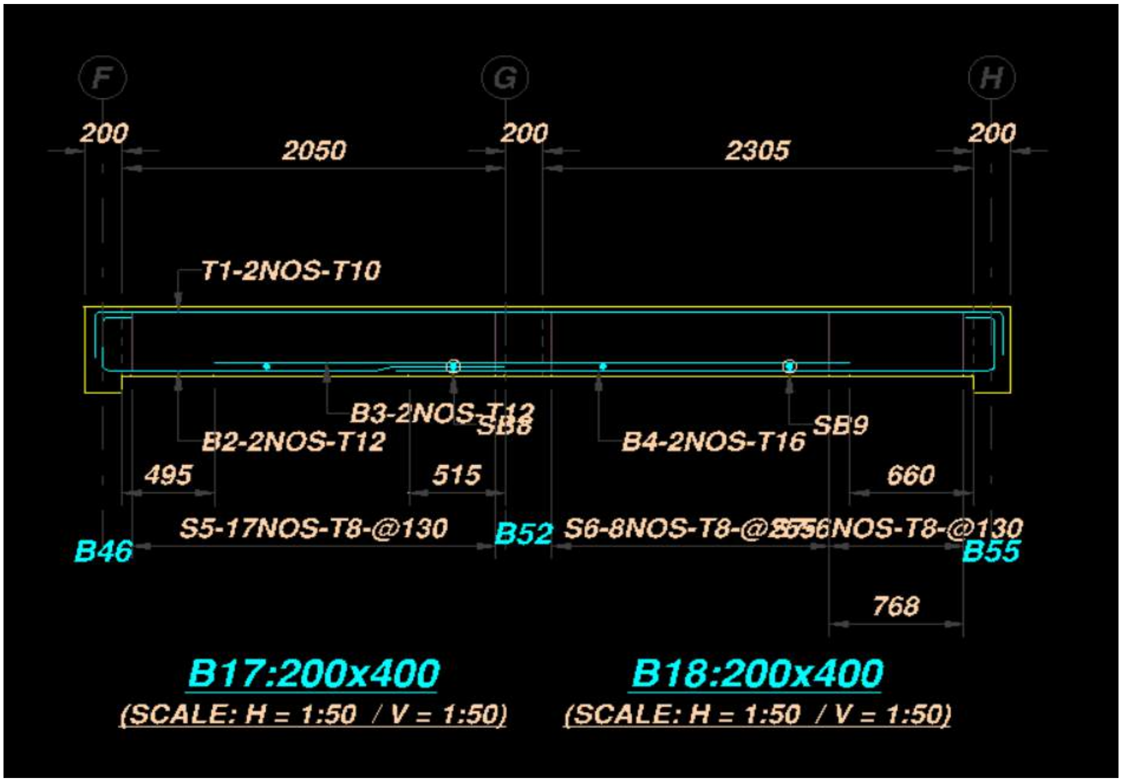

Fig 10: Detailing of Beam

ELEMENT	BAR MARK	BAR NOS.	REBAR	BAR SHAPE	CUTTING LENGTH mm	DIMENSIONS (mm)						
						A	B	C	D	E	F	R
B17, B18	T1	2	10	A B C	5315	265	4860	255				40
	B2	2	12	B A C D F E	2490	150	305	1470	50	10	590	48
	B3	2	12	A	3400	3400						
	B4	2	16	C B A	3565	3210	305	150				64
	S5	17	8	A B	1195	150	350					32
	S6	8	8	A B	1195	150	350					32
	S7	6	8	A B	1195	150	350					32
	SB8	2	32	A	170	170						
	SB9	2	32	A	170	170						

Fig 11: Bar Bending Schedule of Beam

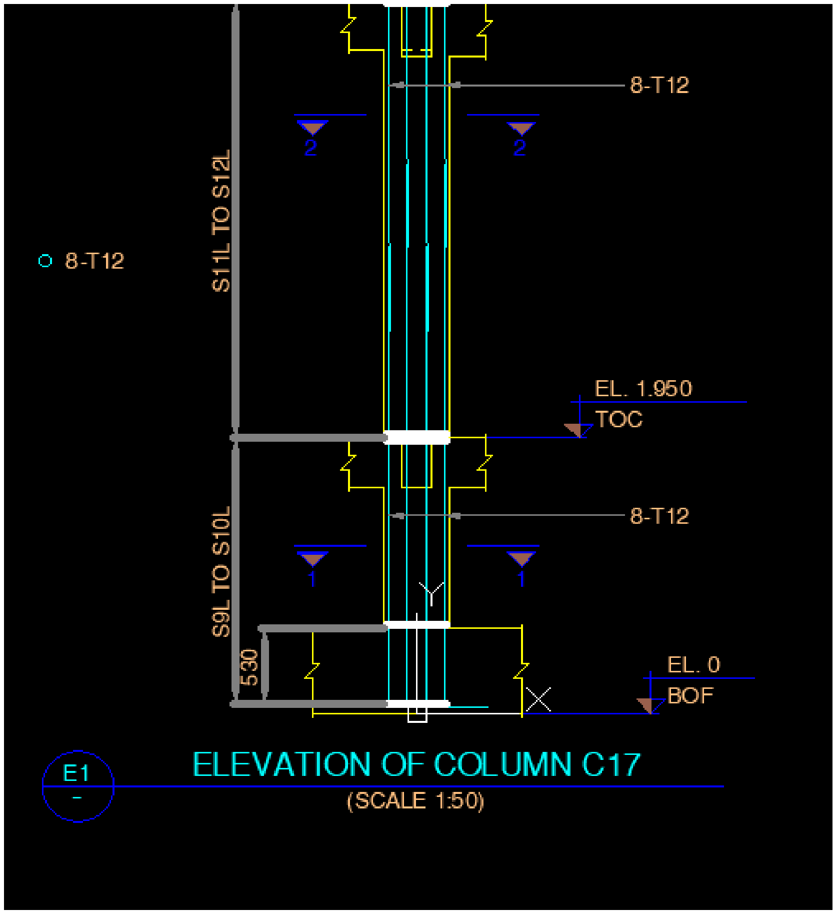

Fig 12: Detailing of Column

ELEMENT	BAR MARK	LEVEL	BAR NOS.	REBAR	BAR SHAPE	CUTTING LENGTH (MM)	DIMENSIONS					
							A	B	C	D	E	R
C17	B1	1	4	12	A B	4110	300	3842				48
	B2	1	4	12	A B	3520	300	3254				48
	B3	2	4	12	C A B D	3715	588	73	12	3053		
	B4	2	4	12	C A B D	3715	588	73	12	3053		
	B5	3	4	12	C A B D	3690	588	73	12	3028		
	B6	3	4	12	C A B D	3690	588	73	12	3028		
	B7	4	4	12	D E C B A	1965	300	1040	73	12	588	48
	B8	4	4	12	D E C B A	2555	300	1628	73	12	588	48
	S9L	1	9	8	A B	1295	400	150				32
	S10L	1	9	8	A B	780	142	150				32
	S11L	2	19	8	A B	1295	400	150				32
	S12L	2	19	8	A B	780	142	150				32
	S13L	3	19	8	A B	1295	400	150				32
	S14L	3	19	8	A B	780	142	150				32
	S15L	4	19	8	A B	1295	400	150				32
	S16L	4	19	8	A B	780	142	150				32

Fig 13: Bar Bending Schedule of Column

Fig 14: Slab Layout

BAR MARK	BAR NOS.	REBAR	BAR SHAPE	CUTTING LENGTH mm	DIMENSIONS(mm)						
					A	B	C	D	E	F	R
B1	7	10		3310	1620	120	85	1600			40
B2	1	10		2300	1810	120	85	400			40
B3	7	10		3315	1625	120	85	1600			40
B4	1	10		3380	95	1625	120	85	1600		40
B5	4	10		4650	3660	120	85	900			40
B6	4	10		4955	95	3400	120	85	1400		40
T7	14	10		1685	1685						
T8	16	10		1690	1690						
T9	8	10		890	890						
T10	3	10		610	610						
T11	4	10		1460	1460						
T12	3	10		4275	4275						
T13	3	10		1460	1460						
B14	10	10		4690	100	3185	130	90	1335		40
B15	3	10		4870	100	3205	130	90	1500		40
B16	6	10		4520	100	3500	130	90	780	100	40
B17	8	10		5895	100	4700	130	90	960	100	40
B18	7	10		6840	100	4170	130	90	2500		40
T19	7	10		1610	1610						
T20	15	10		2200	2200						
T21	5	10		1400	1400						
T22	5	10		430	430						
T23	12	10		430	430						
B24	9	10		4495	100	3500	130	90	760	100	40
B25	9	10		4665	100	3200	130	90	1300		40
B26	5	10		5265	4270	130	90	900			40
B27	3	10		5415	100	4300	130	90	880	100	40
B28	4	10		6490	100	3825	130	90	2500		40
B29	1	10		5415	100	4300	130	90	880	100	40
B30	1	10		5575	100	3905	130	90	1500		40

Fig 15: Bar Bending Schedule of Slab

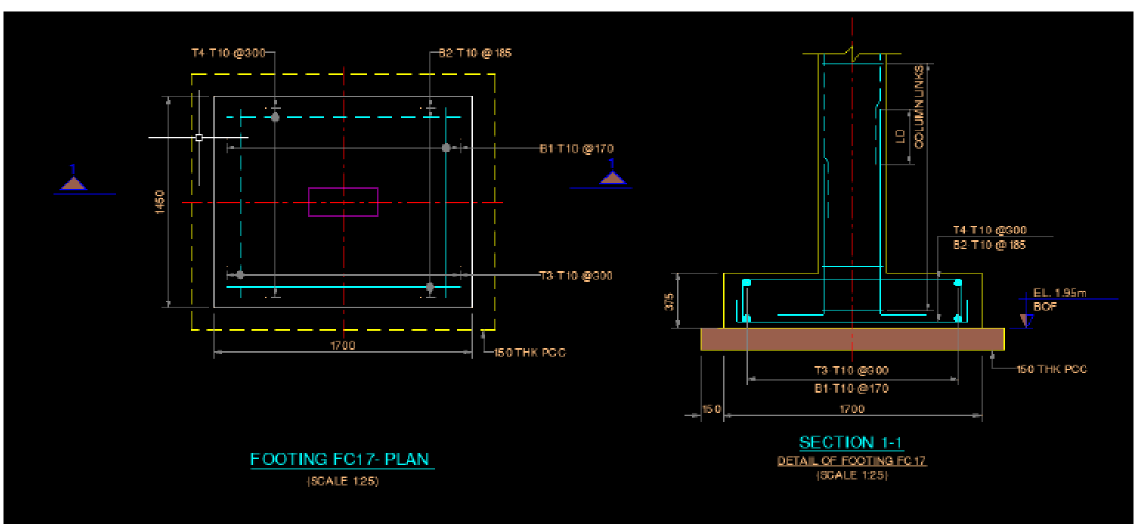

Fig 16: Detailing of Footing

ELEMENT	BAR MARK	BAR NOS.	REBAR	BAR SHAPE	CUTTING LENGTH mm	DIMENSIONS (mm)					
						A	B	C	D	E	R
FC17	B1	12	10	A B C	1600	150	1360	150			40
	B2	9	10	A B C	1850	150	1610	150			40
	T3	7	10	B A C	1890	295	1360	295			40
	T4	6	10	B A C	2140	295	1610	295			40

Fig 17: Bar Bending Schedule of Footing

V. CONCLUSION

The structural analysis shows maximum beam forces of -156.858 kN-m (bending moment) and 168.2683 kN (shear force), while column forces reach -35.8731 kN-m (M2), -112.051 kN-m (M3), and -1181.76 kN (shear) and the maximum shear reinforcement is 221.69 mm^2/m. Actual soil-bearing capacity is 200 kN/m², but from our analysis Bearing capacity applied on soil from structure is ranging from 186.0696 kN/m² to 197.5106 kN/m² and a maximum settlement of -21 mm, all verified through analysis diagrams, RCDC and SAFE.

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