



STRUCTURAL DESIGN FOR A TEN-
STORIED RESIDENTIAL BUILDING WITH
ROOFTOP COMMUNITY SPACE AT
JATRABARI, DHAKA

Advisor



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Background of the Project

A 10 Storied Framed RCC Residential Building of approximately 5 katha at Jatrabari, Dhaka including,

- 3 units in each floor
- A parking space
- A space for drivers in the ground floor
- A fully functioning lift
- A rooftop community space



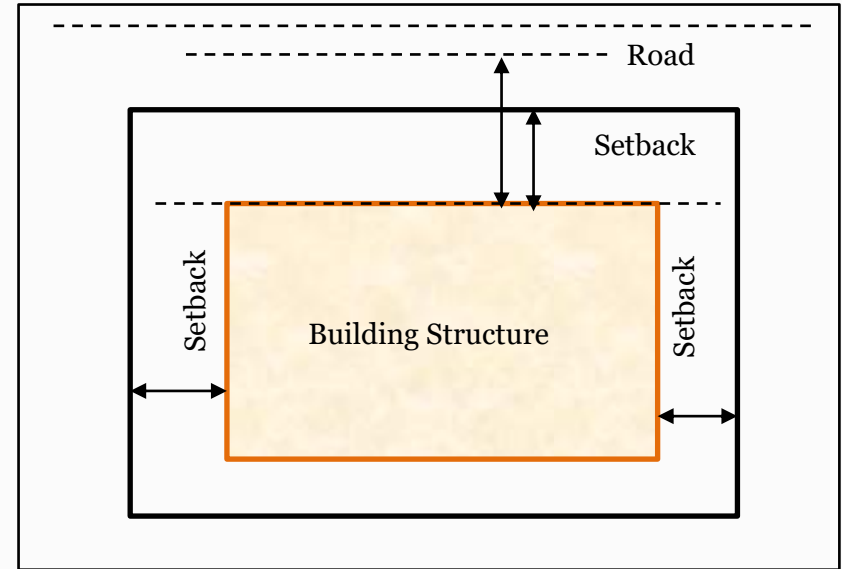
Objectives of the Study

- To investigate the site
- To assess environmental impact (EIA)
- To complete the design and analysis of the building with economy, safety, serviceability, and durability
- Reinforcement detailing of the structural components
- Project planning
- To prepare the Bill of Quantity (BOQ)

Review of the Documents Supplied by the Client

Super- Structure

- Maximum Ground Coverage (MGC)
- Setback
- Floor Area Ratio (FAR)
- Minimum Occupancy Requirements



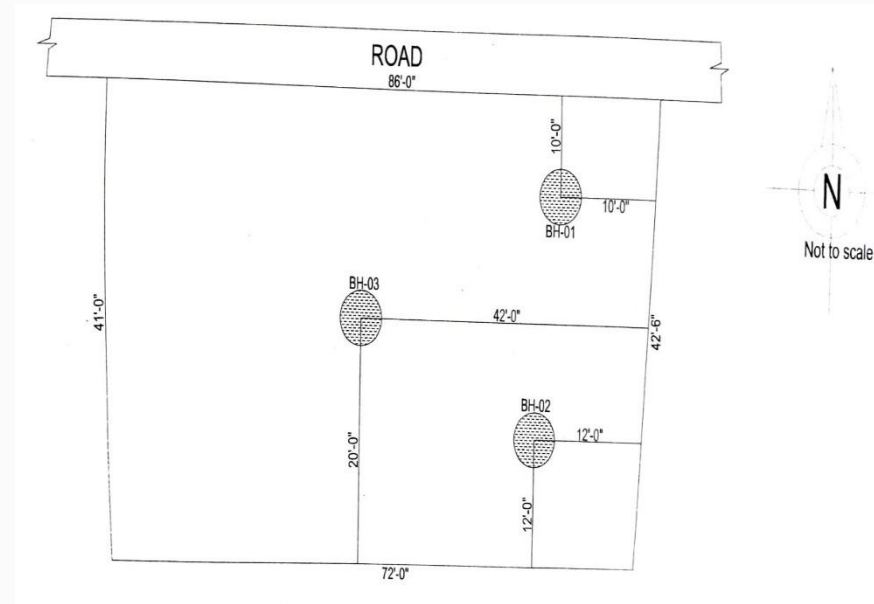
Cont. Review of the Documents Supplied by the Client

	Existing	Required according to Imarat Nirman Bidhimala-2008	Remarks
Maximum Ground Coverage (MGC)	77.78%	62.5%	Not satisfactory
Setback	1.88 m in south and no setback available in north.	1.5 meter in front side, 2 meter in the rear side, and 1.25 meter in each side. 4.5 m or 1.5 m from the plot boundary from the center of the existing road.	Not satisfactory
Floor area ratio (FAR)	2600 sq. ft.	1400 sq. ft.	Not satisfactory
Minimum Occupancy Requirements -	For unit 1, Area of bedroom 1 and 2 are 31.09 m ² and 31.58 m ² . Width of bedroom 1 and 2 are 2.5 m and 2.87 m. Area of bedroom 3 is 29.178 m ² , and width is 2.9 m.	For each unit one room with 9.5 m ² area and minimum width of 2.5 m. other rooms, area should be 5 m ² and width should be 2 m	Satisfactory for all 3 units.

Review of the Documents Supplied by the Client

Sub- Structure

- Number and location of boreholes for soil investigation
- Depth of Borehole
- Ground Water Table (GWT)
- Factor of Safety (FS)





Cont. Review of the Documents Supplied by the Client

	Existing	Required	Remarks
Number and location of boreholes for soil investigation	3	5	Not satisfactory
Depth of Borehole-	At least one borehole with a depth of 30 m or 100 ft.	Bore hole-02 has a depth of 30 m	Satisfactory
Factor of Safety (FS)	2.5	2.5	Satisfactory

Feasibility Study

Site Visit



Purposes of the Site Visit

To observe-

- Topography of the site
- Proximity of other buildings
- Most economical routes
- Availability of public utility services.



Site Condition

Drawbacks of the Site

- Narrow road
- Unavailability of lodging units for workers
- Untidy site



Narrow Road

Favorable Aspects of the Site

- Easily accessible by rickshaws, private vehicles, pickups and CNGs
- Utility facilities
- Storage space
- Local work force
- Dumping zone



Proposed Storage Space

Environmental Impact Assessment

- Air Pollution
- Soil Pollution
- Water Pollution
- Noise Pollution

Health, Safety and Societal Impact Assessment

Health and Safety Impacts

- Breathing and Lung Problems
- Electric Shock and Burns
- Hearing Deficiency to the Laborers

Societal Impacts

- Employment
- Economic Aspect
- Local Use
- Effects on Traffic Volume

Analysis and Design

Basic Considerations

Dead Load	Floor Finish (Roof and Floor Slab)	20 psf
	Wall load on beam	0.51 k/ft.
	Parapet wall load	0.151 k/ft.
	Partition wall load	44.7 psf
	Partition wall load (AB-46 Span)	51.407 psf
Live Load	Floor Slab	41.78 psf.
	Roof Slab (Community Space at Roof)	100.282 psf
Wind Load	Basic wind speed	210 mph.
	Exposure type	B
	Importance factor	1
	Wind pressure for X direction	1.282
	Wind pressure for Y direction	1.572
Earthquake Load	Soil profile type	SD
	Seismic zone factor	0.15
	Overstrength factor	8

Load Combinations

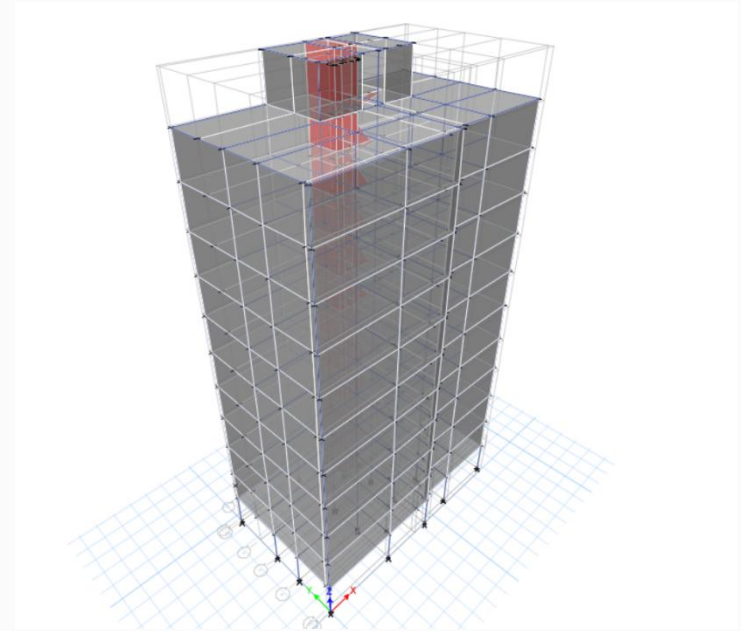
- Dead load + Live load + Super imposed dead load.
- $1.4 \text{ DL} + 1.7 \text{ LL}$.
- $0.75 [1.4 \text{ DL} + 1.7 \text{ LL} + 1.7 \text{ EQ-x direction}]$.
- $0.75 [1.4 \text{ DL} + 1.7 \text{ LL} + 1.7 \text{ EQ-y direction}]$.
- $0.75 [1.4 \text{ DL} + 1.7 \text{ LL} + 1.7 \text{ Wind-x Positive}]$.
- $0.75 [1.4 \text{ DL} + 1.7 \text{ LL} + 1.7 \text{ Wind-x Negative}]$.
- $0.75 [1.4 \text{ DL} + 1.7 \text{ LL} + 1.7 \text{ Wind-y Positive}]$.
- $0.75 [1.4 \text{ DL} + 1.7 \text{ LL} + 1.7 \text{ Wind-y Negative}]$.

Boundary Condition

- Pile foundation fixed support.

Analysis Software

- ETABS



Check for Serviceability

- Serviceability checking includes the storey drift and displacements due to the lateral load.

Displacement check:

Column			Beam	
Corner Column	Side Column	Middle Column	X- Direction	Y- Direction
10" × 26"	10" × 28"	12" × 28"	10" × 15"	10" × 18"

Cont. Analysis and Design

Load Combinations	Allowable Deflection as per BNBC (inch)	Maximum deflection at the roof (x-direction) Inch	Maximum deflection at the roof (y-direction) inch	Remarks
S2= DL+LL+EQ-x	2.64	3.190	0.489	Not safe
S3= DL+LL+EQ-y	2.64	0.429	1.896	Safe
S4= DL+LL+Wind-x (Positive)	2.64	6.809	1.487	Not safe
S5= DL+LL+Wind-x (Negative)	2.64	6.626	1.528	Not safe
S6= DL+LL+Wind-y (Positive)	2.64	0.813	8.00	Not safe
S7= DL+LL+Wind-y (Negative)	2.64	0.721	8.377	Not safe

Cont. Analysis and Design

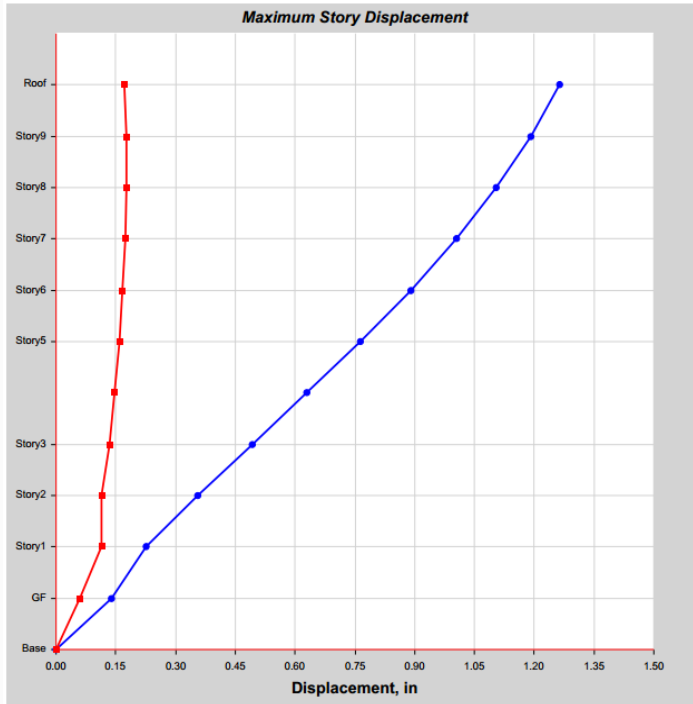
Changing the sectional properties:

Column			Beam	
Corner Column	Side Column	Middle Column	X- Direction	Y- Direction
15" × 30"	15" × 36"	12" × 28"	12" × 28"	12" × 30"

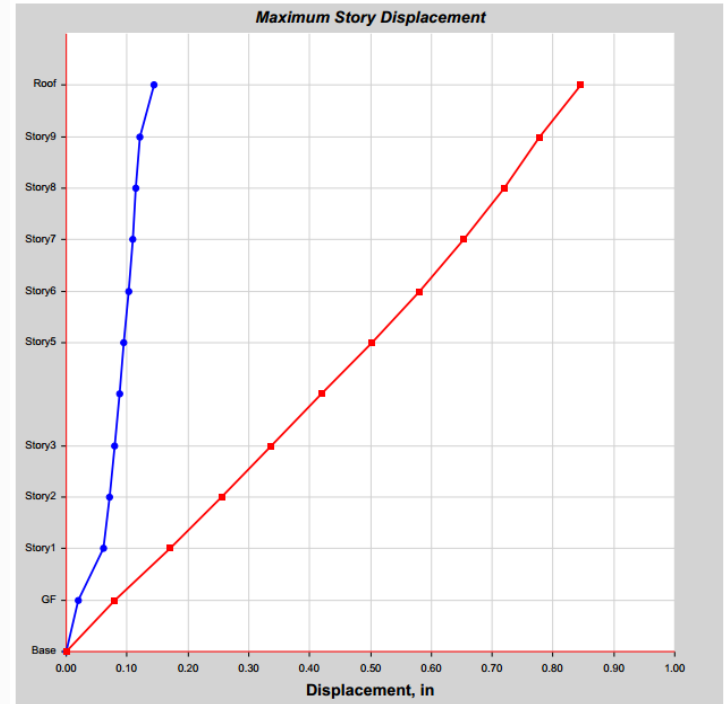
Cont. Analysis and Design

Load Combinations	Allowable Deflection as per BNBC (inch)	Maximum deflection at the roof (x-direction) inch	Maximum deflection at the roof (y-direction) inch	Remarks
S2= DL+LL+EQ-x	2.64	1.262951	0.17288	Safe
S3= DL+LL+EQ-y	2.64	0.14432	0.845738	Safe
S4= DL+LL+Wind-x (Positive)	2.64	2.426126	0.428108	Safe
S5= DL+LL+Wind-x (Negative)	2.64	2.404239	0.419314	Safe
S6= DL+LL+Wind-y (Positive)	2.64	0.210021	2.237821	Safe
S7= DL+LL+Wind-y (Negative)	2.64	0.221256	2.363818	Safe

Cont. Analysis and Design

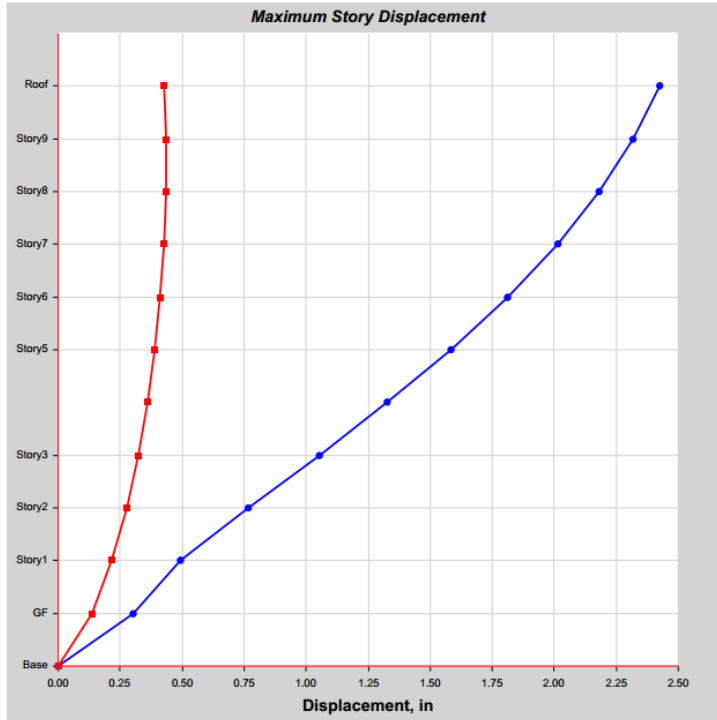


Deflection graph for S2 (DL+LL+EQ-x)

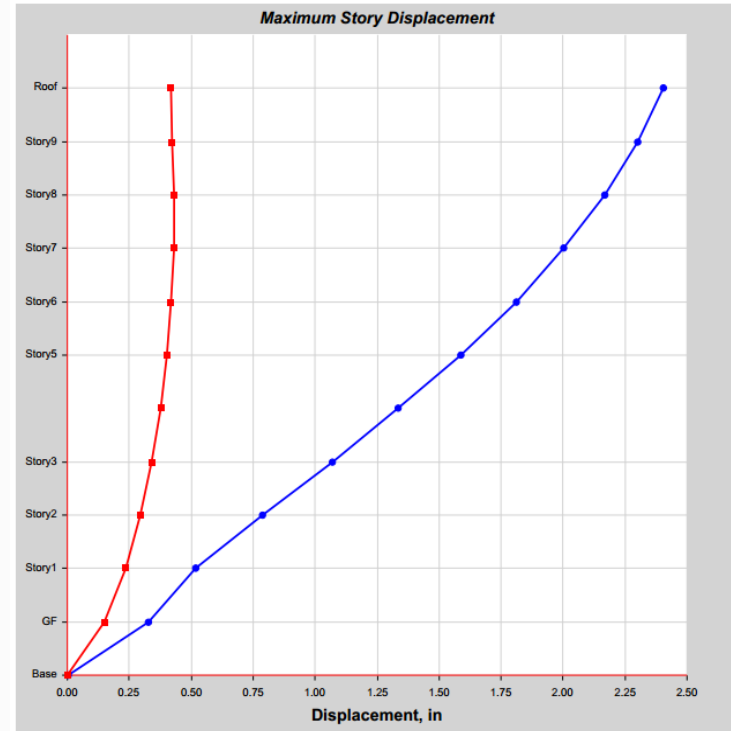


Deflection graph for S3 (DL+LL+EQ-y)

Cont. Analysis and Design

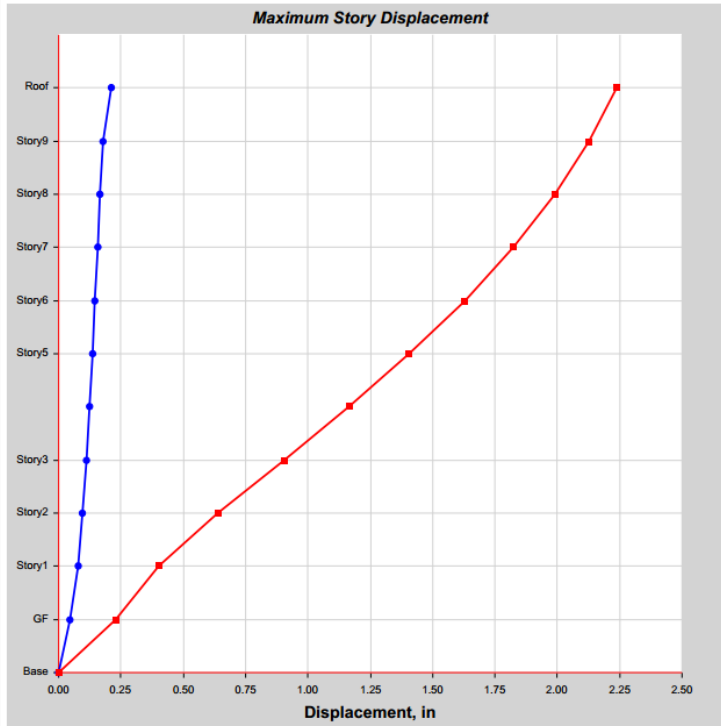


Deflection graph for S4 (DL+LL+Wind-x Positive)

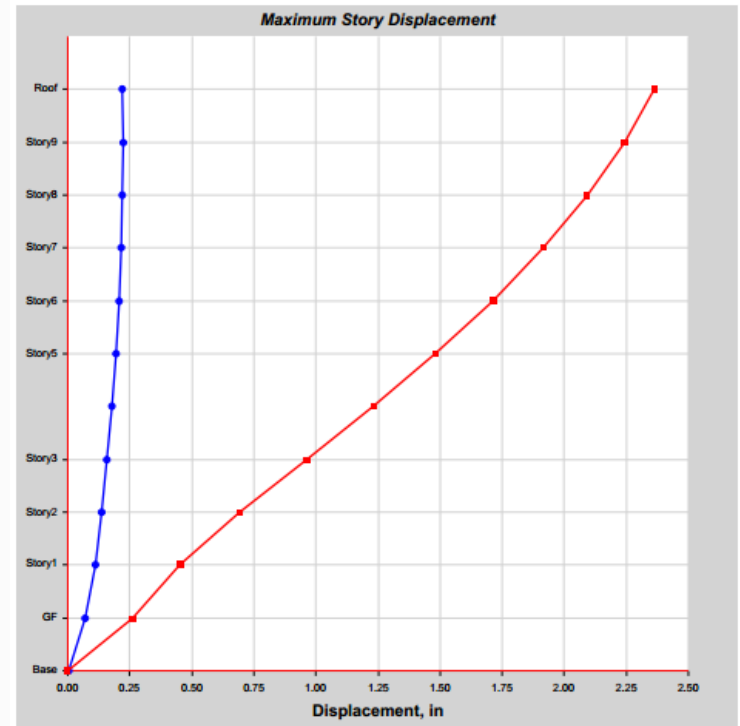


Deflection graph for S5 (DL+LL+Wind-x Negative)

Cont. Analysis and Design



Deflection graph for S6 (DL+LL+Wind-y Positive)



Deflection graph for S6 (DL+LL+Wind-y Negative)

Cont. Analysis and Design

Story Drift Check

Story	Height	Drift S ₂ (DL+LL+EQ-x)	Drift S ₃ (DL+LL+EQ-y)	Allowable Story drift	Remarks
Roof	110	0.000688	0.000487	0.1257	Safe
Story 9	100	0.000764	0.000581	0.1257	Safe
Story 8	90	0.000842	0.000669	0.1257	Safe
Story 7	80	0.000949	0.000752	0.1257	Safe
Story 6	70	0.001048	0.000821	0.1257	Safe
Story 5	60	0.001122	0.000869	0.1257	Safe
Story 4	50	0.001164	0.000888	0.1257	Safe
Story 3	40	0.001169	0.000865	0.1257	Safe
Story 2	30	0.001108	0.000758	0.1257	Safe
Story 1	20	0.000924	0.000587	0.1257	Safe
GF	10	0.001235	0.000665	0.1257	Safe



Verification of the Model

We have provided-

- Reinforcement Area of Beam
 - Dead Loads and Live Loads
 - SFD and BMD for Dead Load and Live Load
 - Lateral Load Analysis
-

Cont. Verification of the Model

Reinforcement Area of Beam

	ETABS (in^2)	Hand Calculation (in^2)	Comment
Left Support (Top)	1.08	1.023	5.278% variation only
Left Support (Bottom)	0.9952	1.06	6.511% variation only
Right Support (Top)	1.0454	1.06	1.397% variation only
Right Support (Bottom)	1.1	0.99	10% variation only
Mid Span (Top)	0.3827	0.351	8.283% variation only
Mid Span (Bottom)	0.4146	0.38	8.345% variation only

Cont. Verification of the Model

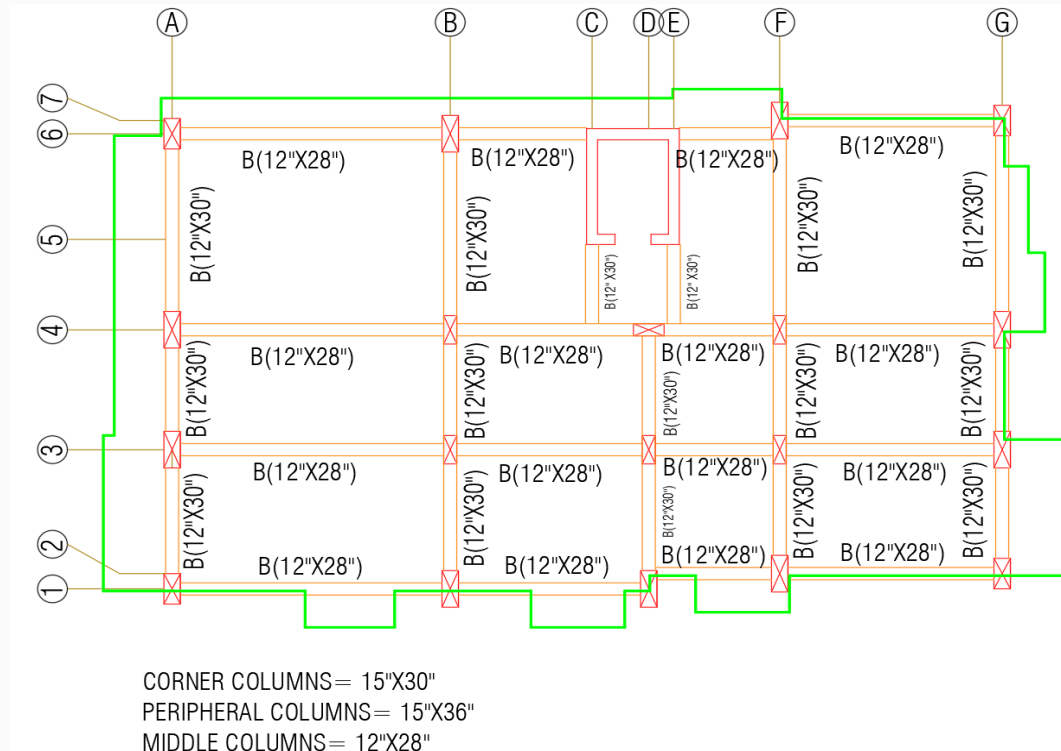
Live Load Beam SFD

Grid (3-ABDFG)	ETABS (k)	Hand Calculation (k)	Comment
3-AB	8.624	8.44	2.18% variation
3-BD	5.848	6.27	6.511% variation
3-DF	2.74	3.2	14.3% variation
3-FG	5.938	6.178	3.88% variation

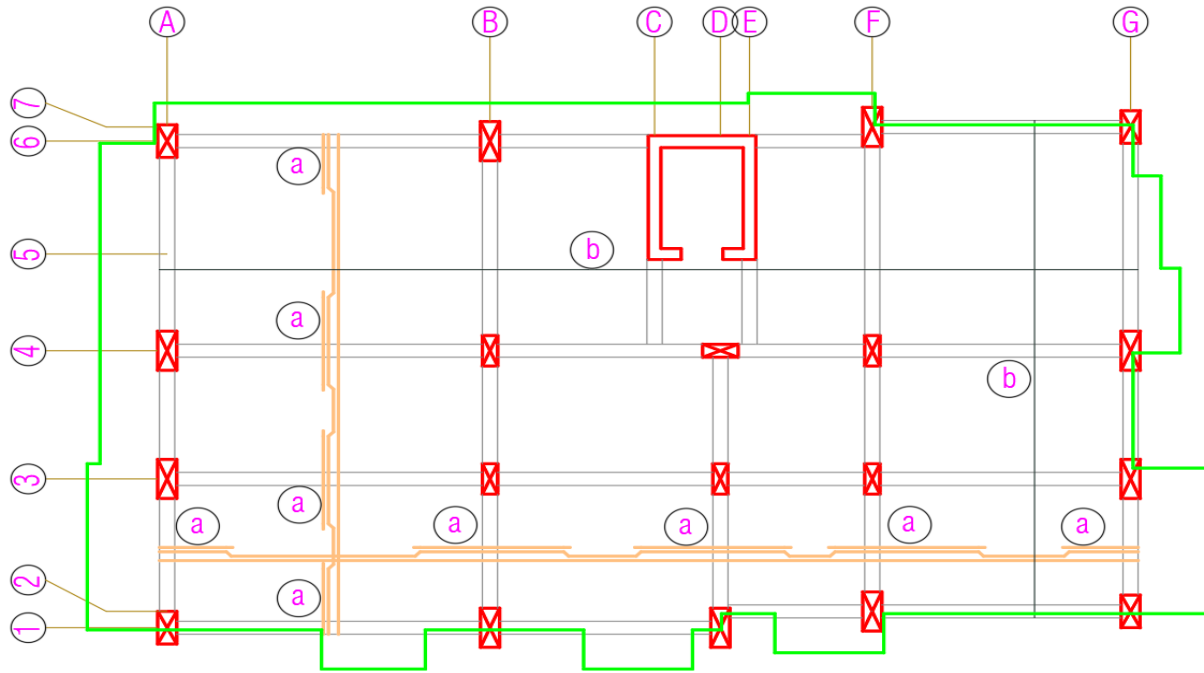
Lateral Load Analysis

Grid (A-1346)	ETABS (k)	Hand Calculation (k)	Comment
A-13	0.999	1.08	7.5% variation

Beam Column Layout



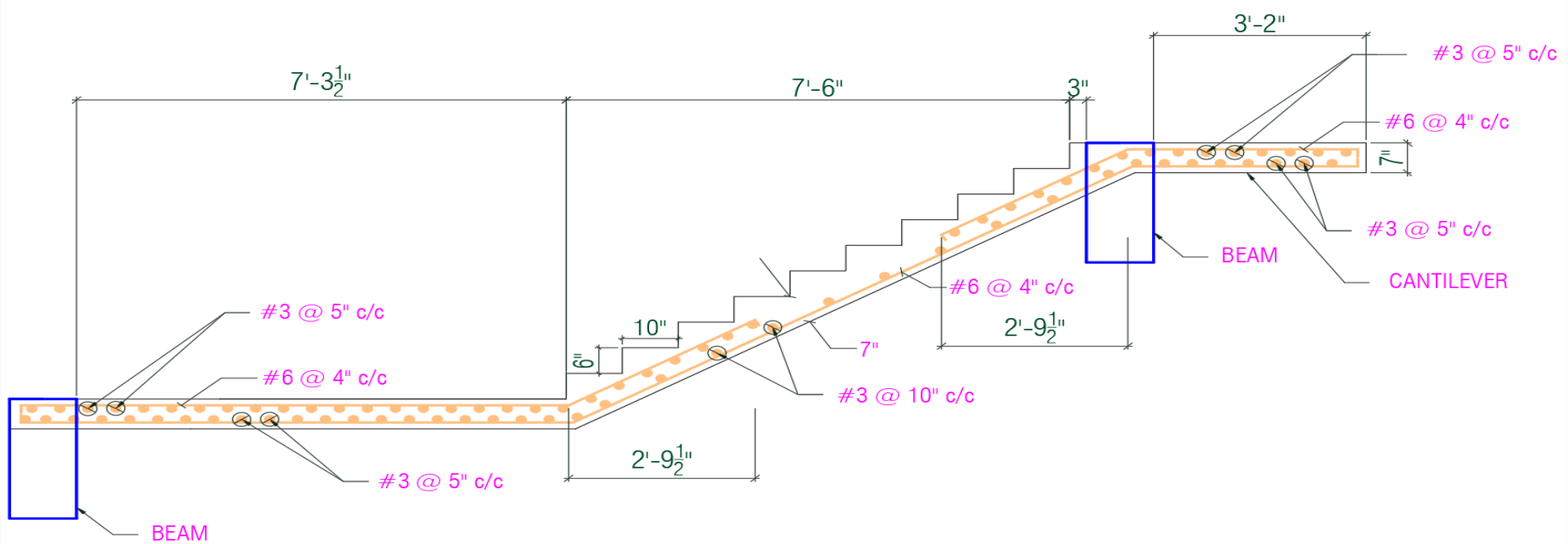
Reinforcement Detailing of Slab



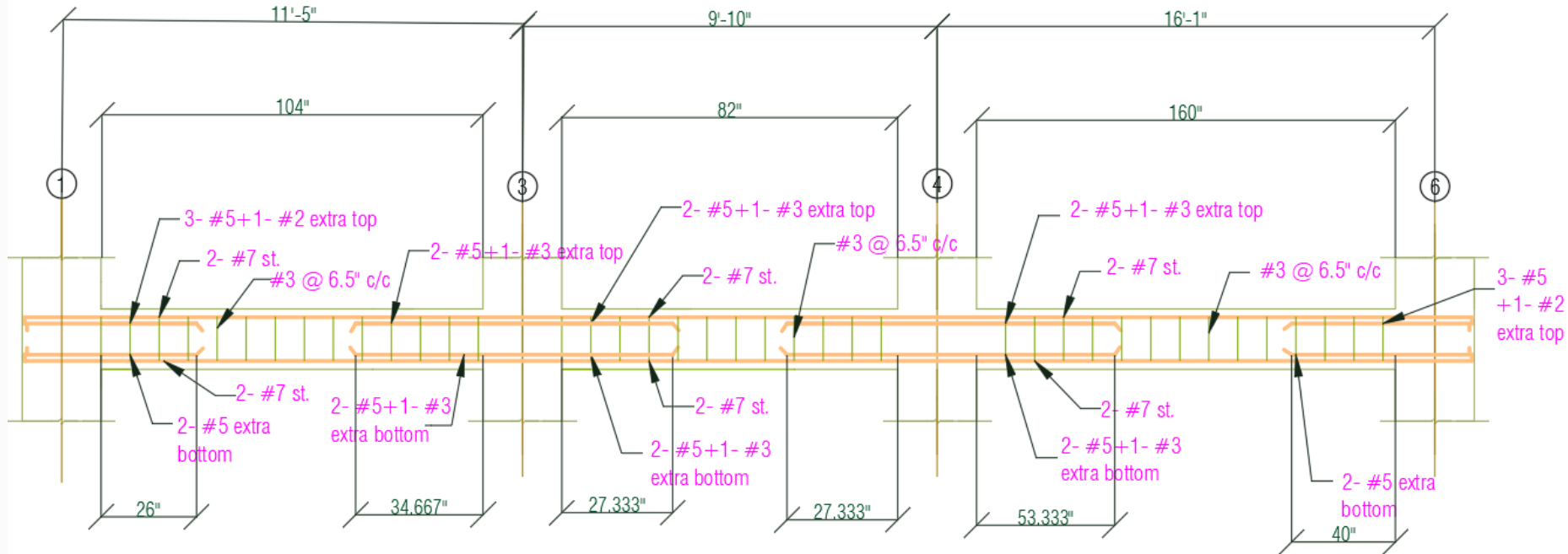
NOTE:

- a. 1- #3 extra top
- b. #3 @ 6" c/c

Reinforcement Detailing of Stair



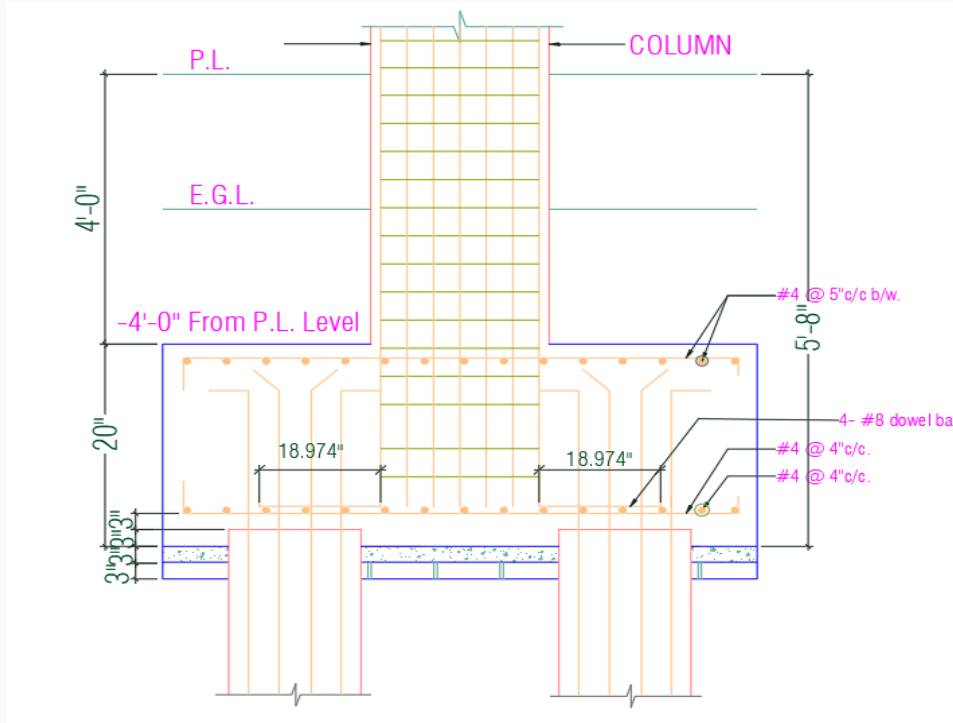
Reinforcement Detailing of Beam



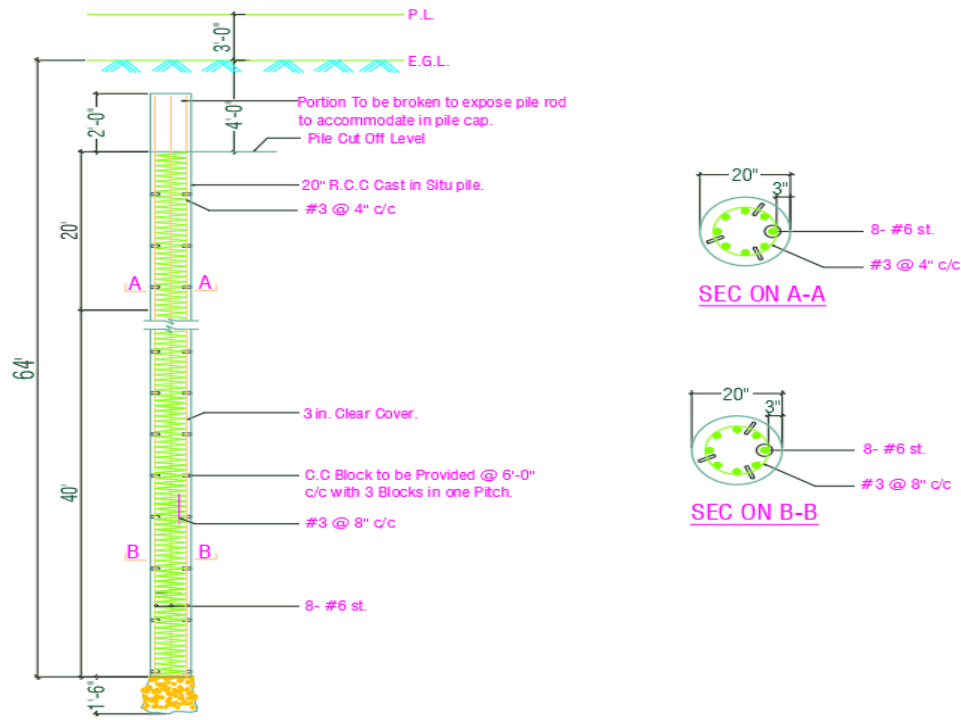
Reinforcement Detailing of Column

COLUMNS FLOORS	CORNER COLUMNS (A1, A6, G2, G7)	COLUMNS FLOORS	PERIPHERAL COLUMNS (A3, A4, B1, B6, D1, F2, F7, G3, G4)	COLUMNS FLOORS	MIDDLE COLUMNS (B3, B4, D3, D4, F3, F4)
BASE TO 1ST FLOOR	<p>2'-6" 1'-3" 1 1/2" #3 @ 8.5" c/c 2- #6 st. 8- #8 st.</p>	BASE TO 1ST FLOOR	<p>3'-0" 1'-3" 1 1/2" #3 @ 8.5" c/c 2- #4 st. 8- #8 st.</p>	BASE TO 2ND FLOOR	<p>2'-4" 1'-0" 1 1/2" #3 @ 8.5" c/c 2- #4 st. 8- #8 st.</p>
2ND TO 9TH FLOOR	<p>2'-6" 1'-3" 1 1/2" #3 @ 9" c/c 6- #8 st.</p>	2ND TO ROOF	<p>3'-0" 1'-3" 1 1/2" #3 @ 9" c/c 6- #8 st. 4- #4 st.</p>	3RD TO 6TH FLOOR	<p>2'-4" 1'-0" 1 1/2" #3 @ 9" c/c 8- #8 st.</p>
				7TH TO ROOF	<p>2'-4" 1'-0" 1 1/2" #3 @ 9" c/c 2- #6 st. 4- #8 st.</p>

Reinforcement Detailing of Pile Cap



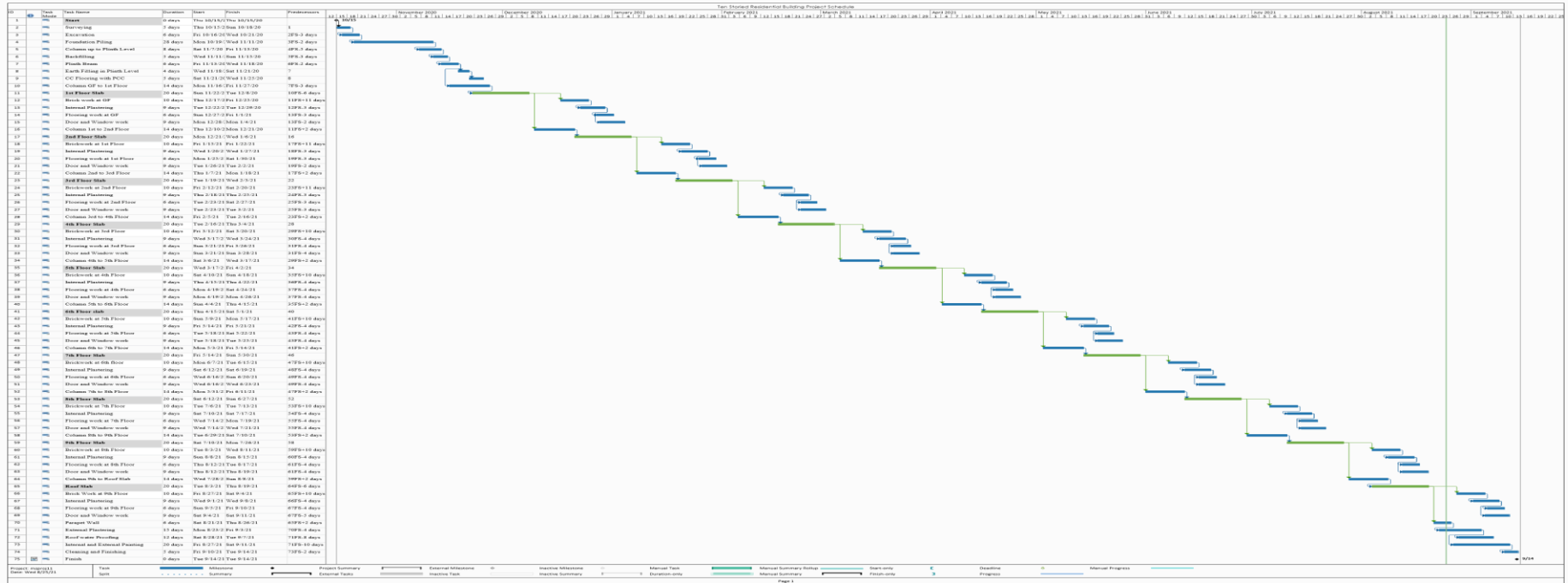
Pile Long Section Detail



LONG SECTION OF CAST IN SITU 64 ft. R.C.C PILE

Planning of the Project

Construction Scheduling



Bill of Quantity(BOQ)

Bill of Quantity	
Items of Works	Amount (Taka)
Foundation	Approximately sixty three lakhs
Ground Floor	Approximately seventy four lakhs
Typical Floor	Approximately ninety five lakhs
Roof	Approximately twenty one lakhs
Shuttering	Approximately two lakhs
Rates of man, material and mark-ups	Approximately ten lakhs

Total cost of this project will be approximately ten crores BDT.



Conclusion

- Some of the features comply with the rules and others do not
- Main challenge was to finalize suitable beam, column dimensions that cater to serviceability and economy
- Software results checked by manual calculation and found reliable with 10% error acceptable
- High construction cost due to poor accessibility to trucks
- Estimated project span 11 months
- Estimated total cost 103129002.6 BDT

Submission will contain-

- Report
- Logbook
- Meeting Minutes



THANK YOU