Midrise Buildings

CBM ENGINEERS

CBM

In May 2015, CBM Engineers and Optimal Consultancy Services Pvt. Ltd. [OCSPL] entered into an agreement that allows both the parties to share its resources and provide with an array of unsurpassed design services. The corporation, under the helmsmanship of now a bigger management portfolio, stands at a combined resource strength of over 150 technical professionals; making CBM Plus the largest multinational company of the structural engineering discipline, in India.

A new and enriched business model was implemented, which recognised the demands of the current and future assignments and demands of the clients. Progressive interaction between the two sets of staff members, on both a professional and social level, resulted in a unique and unprecedented display of indulgence where a very assorted group of individuals disassembled in their level of knowledge, experience and age, came together to collectively contribute to uplift the CBM Engineers we are today.

This allows CBM Engineers, a powerhouse of knowledge and experience, to provide pristine engineering services and professional excellence to the clients, while ensuring commercial success and employee fulfilment.

Midrise Buildings

CBM ENGINEERS

STERLING ENGINEERING GROUP OF COMPANIES

CBM

optimal CONSULTANCY SERVICES PVT. LTD.

Background

Background

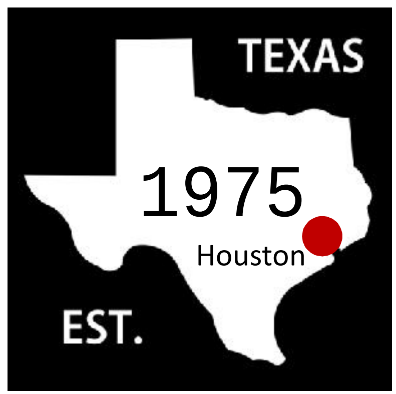
Biggest MNC in Structural Engineering and Design discipline, in India

40+ Years of experience in structural design

Several High-Rise buildings designed in USA,UAE & India

Landmark Projects across Three Continents

Pioneered a number of cost effective and innovative systems for building construction



Providing expert services across the globe

Specially developed design processes

Visit Us on: www.cbmengineers.com

Core strength: 150+ Technical Staff in India

Innovative solutions within a constructive society

Background

Services up to Tender Stage

Retrofit Services

Construction Administration

Feasibility Study

Scope of Services

Full Design

Forensic Engineering Services

Qualitative and Quantitative Analysis

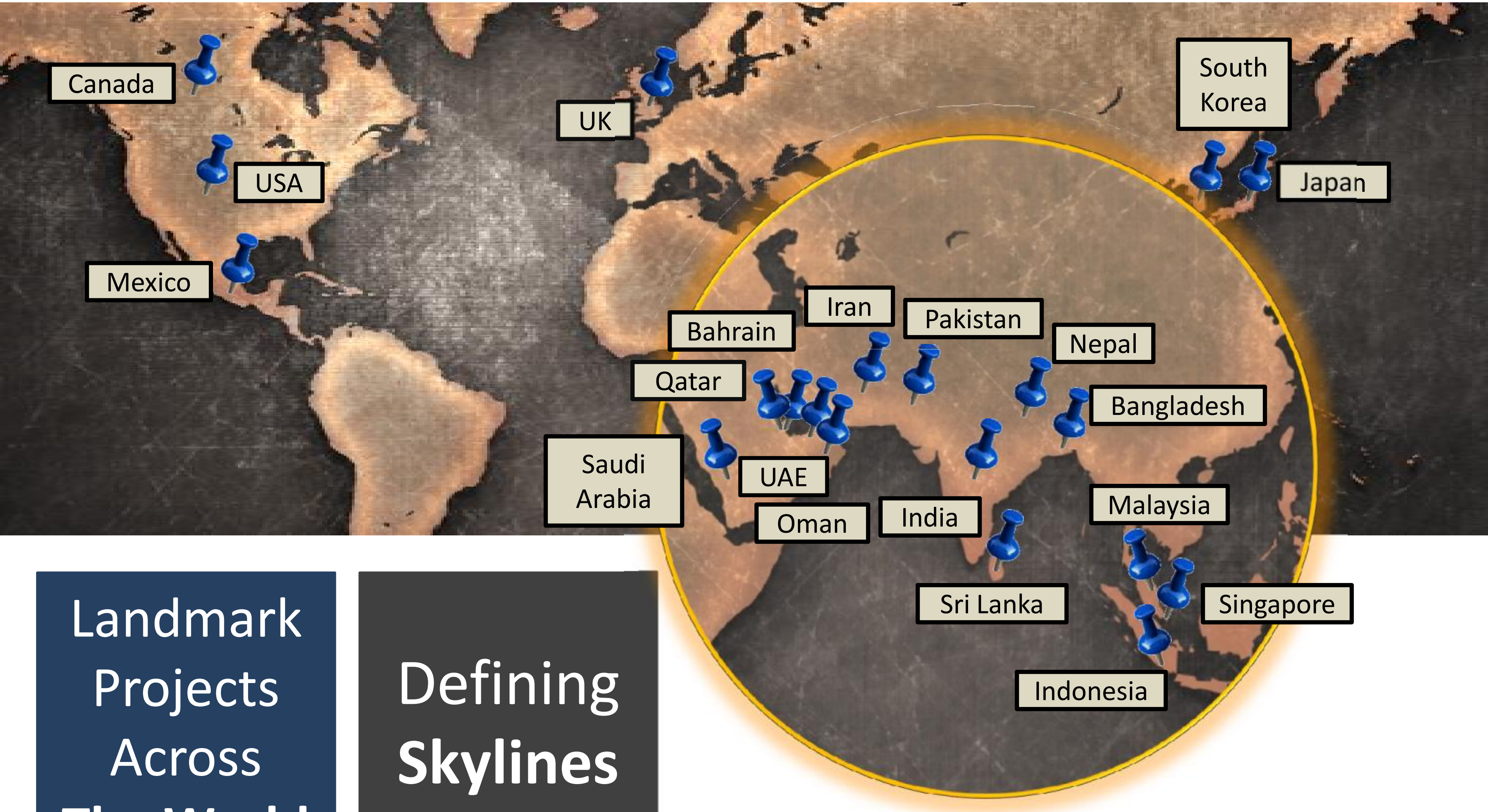
Peer Review

Value Engineering

Global Presence

Houston	Vadodara	Mumbai	New Delhi
Resources: 60+	Resources: 50+	Resources: 30+	Resources: 20+

Global Presence



Landmark Projects Across **The World**

Defining **Skylines**

Key Persons

Abhay Ghate

Director

40+ years of Experience in Structural Design & Engineering

Design Management Assignments, Scheduling & Quality Control

Recipient of Excellence in Consultancy Services Award 2006

Unrestricted Building Height Licence as a Structural Engineer in Dubai and Mumbai.

Shekhar Ghate

Director

35+ years of Experience in Structural Design & Engineering

Specialises in coordinated design management projects

Key Persons

25+ years of Experience

In-charge of Structural Practice since 15+ years

Sandeep Patel

STERLING ENGINEERING GROUP OF COMPANIES

Designed Numerous Buildings in USA

Chairman of the board (Sterling Group)

Vice President of Engineering

25+ Years Experience in Structural Engineering

Slaven Seferovic

Jarrod Hamilton

15+ Years Experience in Structural Engineering

Vice President of Engineering

Key Persons

12+ years of Experience in Structural Design & Engineering

Worked abroad and in India on all kinds of building types

Kunal Suthar

Director

Closely involved in and manages the overall operations in India. Practices as head of technical staff at Vadodara.

Responsible for overall setup, implementation of business plans and management of regional offices.

9+ years of experience in market research, general administration and client management.

Sejal Desai

Chartered Accountant and PGBDM

Head – Business Development

Optimisation in Midrise Buildings

Classifying Midrise buildings

Midrise Buildings	Low-rise Buildings
Upto **G + 10** Floors Upto **30 m** Height	**G + 10** to **G + 25** Floors **30 m** to **75 m** Height
Gravity Loads defines and governs the structural design	**Lateral Loads** defines and governs the structural design

CBM Engineers' Approach

Structural Systems	Structural Analysis	Design and Optimisation	Detailing
Gravity System	Zero – Premium Structure	Load Optimisation	Identification of lateral and gravity resisting systems
Lateral System			Ductile Detailing

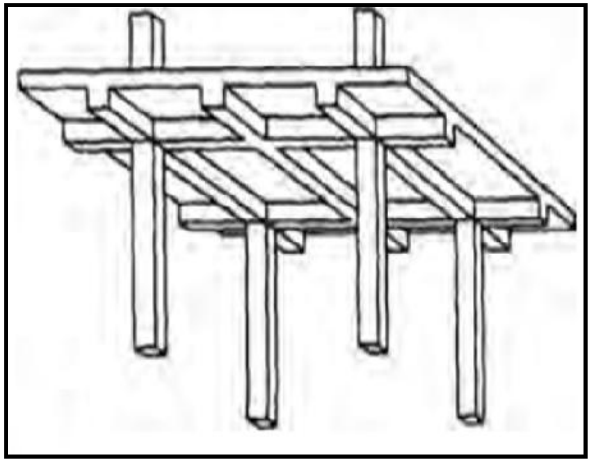
Structural System

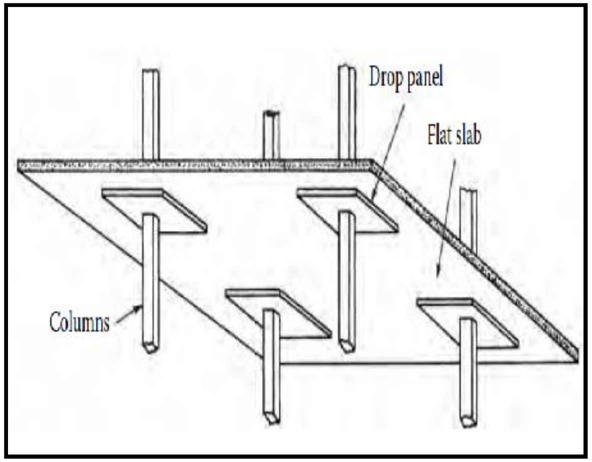
Structural systems for concrete buildings

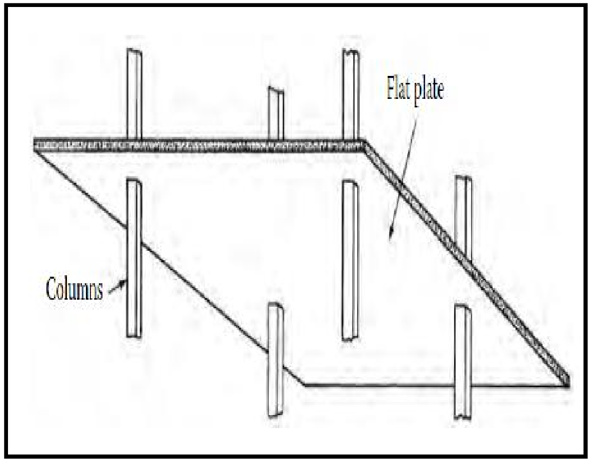
No.	System	Number of stories 0 10 20 30 40 50 60 70 80 90 100 110	Ultra-tall buildings 120–200 stories
1	Flat slab and columns		
2	Flat slab and shear walls		
3	Flat slab, shear walls and columns		
4	Coupled shear walls and beams		
5	Rigid frame		
6	Widely spaced perimeter tube		
7	Rigid frame with haunch girders		
8	Core supported structures		
9	Shear wall—frame		
10	Shear wall—Haunch girder frame		
11	Closely spaced perimeter tube		
12	Perimeter tube and interior core walls		
13	Exterior diagonal tube		
14	Modular tubes, and spine wall systems with outrigger and belt walls		

Structural System – Gravity Load Resisting System

Conventional Beam – Slab System	Flat Slab System with Drops	Flat Plate System
Presence of sunken slabs Heavy partition walls	Normally proposed for basement Floors	Beam-less floor plates







Structural System – Cost Effectiveness of Gravity System

Factors reducing the cost of *Formwork*

Design repetition

Use of standard dimensional units in accordance with the Metric Handbook

Dimensional consistency

Horizontal Framework – 50% cost is incurred for *Formwork*

Formwork

Gravity System shall optimise the floor-to-floor height.

Every 25 mm reduction in floor height yields a saving of ₹ 12 per square foot (approx)

25mm

reduction in height / floor

Equals

Saving

₹ 12

per sq ft

Structural System – Lateral Load Resisting System

Rigid Frames

Economical up to 25 floors

Advantages

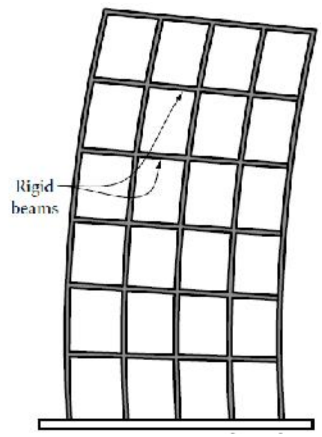
Simplicity and convenience of its rectangular form

Provides internal structural wall-free spaces

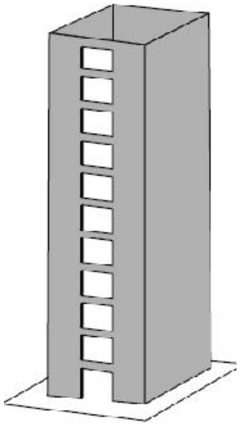
Disadvantages

More columns required

Beam depth may be restricted for clear floor-to-floor height



Rigid Frames



Coupled Shear Walls

Coupled Shear Walls

Economical up to 25 floors

Advantages

Providing sheer walls in both direction allows the building to resist lateral loads more effectively.

Disadvantages

Reduced wall-free spaces

Placement of walls depend on the results of a study on torsional effect on the building

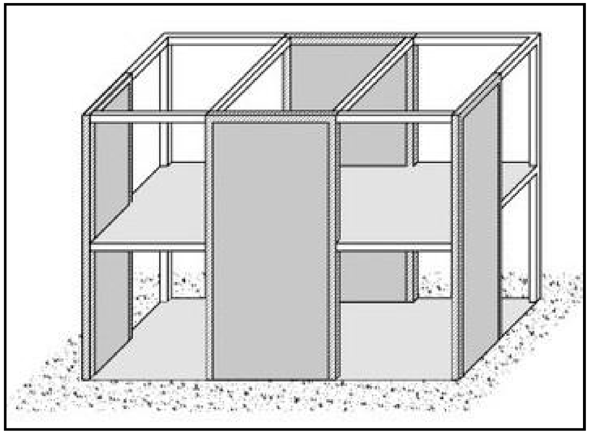
Structural System – Lateral Load Resisting System

When a rigid frame is combined with shear walls, the resultant system has a very high stiffness

Combination of Shear Walls & Rigid Frames

Shear Walls can be located at specific places within the frame, like around the lift pits and stairwell, while columns cab ne proposed to enable maximum clear space

Economical up to 40 floors or 125 metres



Structural System – Lateral Load Resisting System

Points considered while **Selecting Lateral System**

Solution varies with the type and configuration of the Building

Spans and column spacing

Shape and size of the structure

Floor –to-floor height and total height of the structure

Functional requirements and clear headroom

Placement of lateral elements; e.g.: arrangement of core walls, staircase, etc.

Structural Analysis – Zero Premium Structure

Steps of Analysis

Design for Gravity loads only

Apply lateral loads

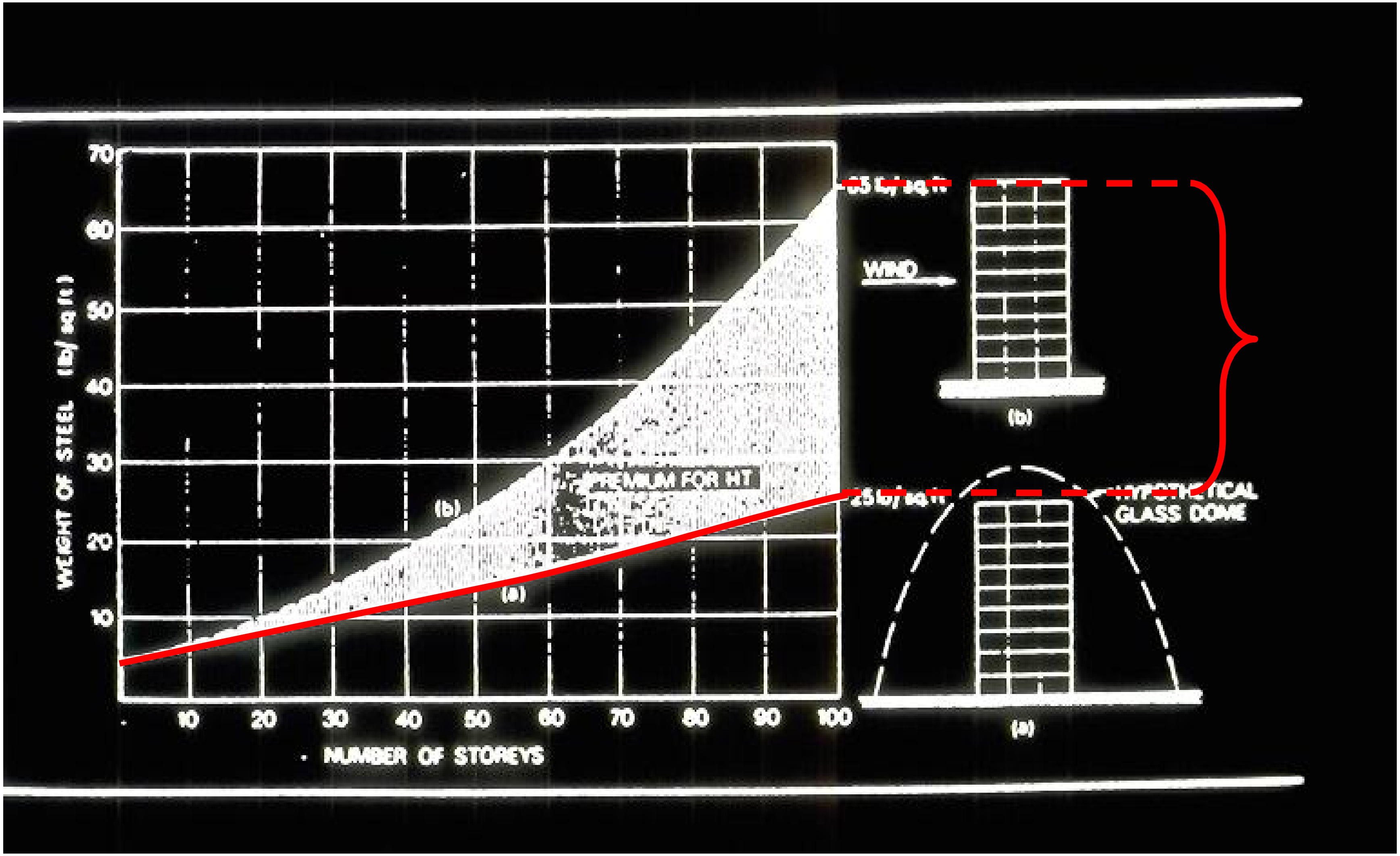
Analyse the structure

Identify the elements subjected to lateral loads

Redefine the element sized for lateral load distribution

Iterations to achieve the **optimised structural framing system**

Structural Analysis – Cost Effectiveness of Lateral System



Design Aspects

Suggestions for Optimisation of the Structure

Reduction of overall weight of the structure

- Use of light weight partition – reduction in wall dead load by 50%
- Elimination of screed – especially at parking floors / garages.
- Elimination of sunken slab.

Advantages of the reduction in the overall weight

- Lower design seismic loads.
- Lighter structure.
- Reduction in foundation sizes and cost.

Advantages of elimination of sunken slabs

- Easier formwork system and construction.
- Flat slabs and use of PT systems possible.
- Saves cost and time.

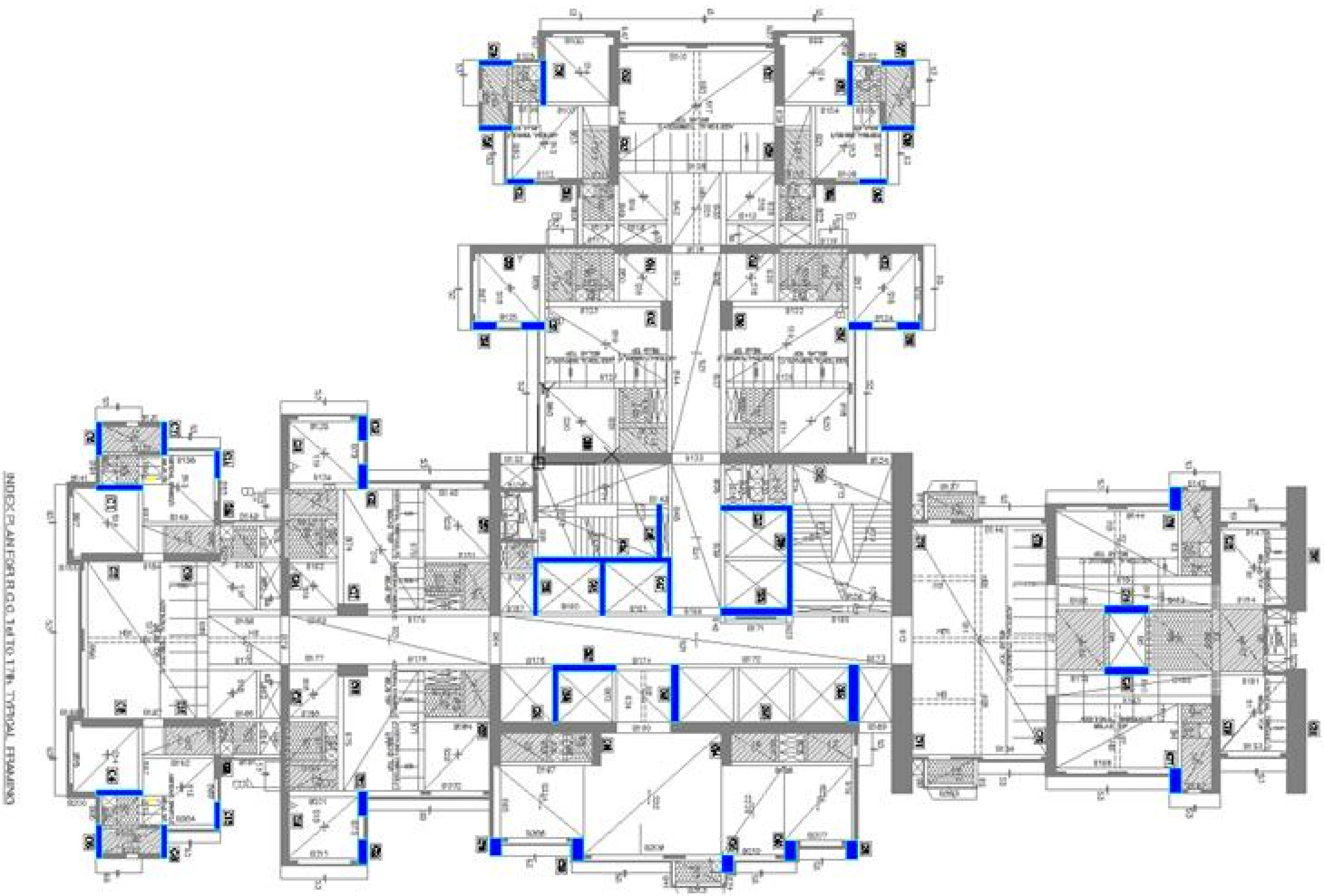
Detailing Structural Elements

Case Study – Omkar Altamonte

Tower B
G + 7P + Stilt
+ 55 +
terrace

Total height
225 m

Gravity load
Resisting
System



Detailing Structural Elements

Case Study – Omkar Altamonte

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Resisting
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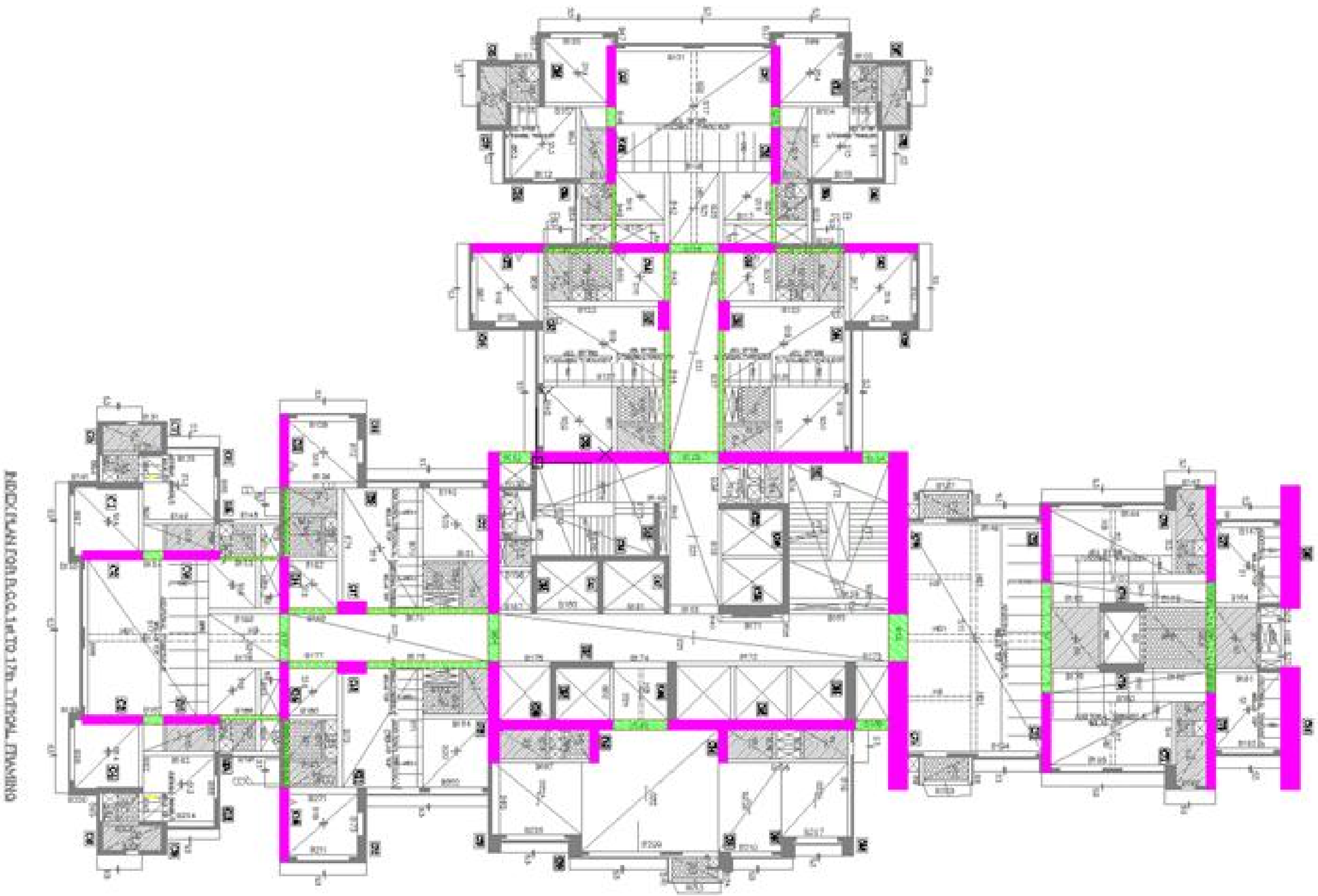


Detailing Structural Elements

Case Study – Omkar Altamonte

Summary of Savings

Element	Savings		
	Reinforcement (MT)	Concrete (m^3)	Shuttering (m^3)
Columns / Walls	400	2200	2500
Beams	23	336	616
Slabs	6	140	-

Arrangement of links as per IS 465 & 13920

Column No. C74 – C75	Ductile (Lateral)	Non Ductile (Gravity)	Remark
Vertical Reinforcement	42 – T16	42 – T16	Same
Vertical reinforcement (kg)	260	260	Same
Shear Reinforcement	10T@100 C/C + 8T@100 C/C	8T250 C/C	Savings
Shear Reinforcement (kg)	245	87	-
Total (kg)	505	347	Saving of158 kg in ties per floor

Detailing – Optimisation of Structural Elements

Optimisation of Structural Elements

By following proper design and detailing practice, structural elements can be further optimised

Column Bar Arrangement

Use of higher bar sizes with maximum spacing

Lesser bars means lesser ties (50% reduction in ties quantities)

Shear Wall Bar Arrangement

The length of boundary element shall be such that the web wall always has the minimum reinforcement

Case Studies

Case Study 1 – Mangla Aura, Vadodara

Client

Mangla Properties Vadodara

Sector

Residential building

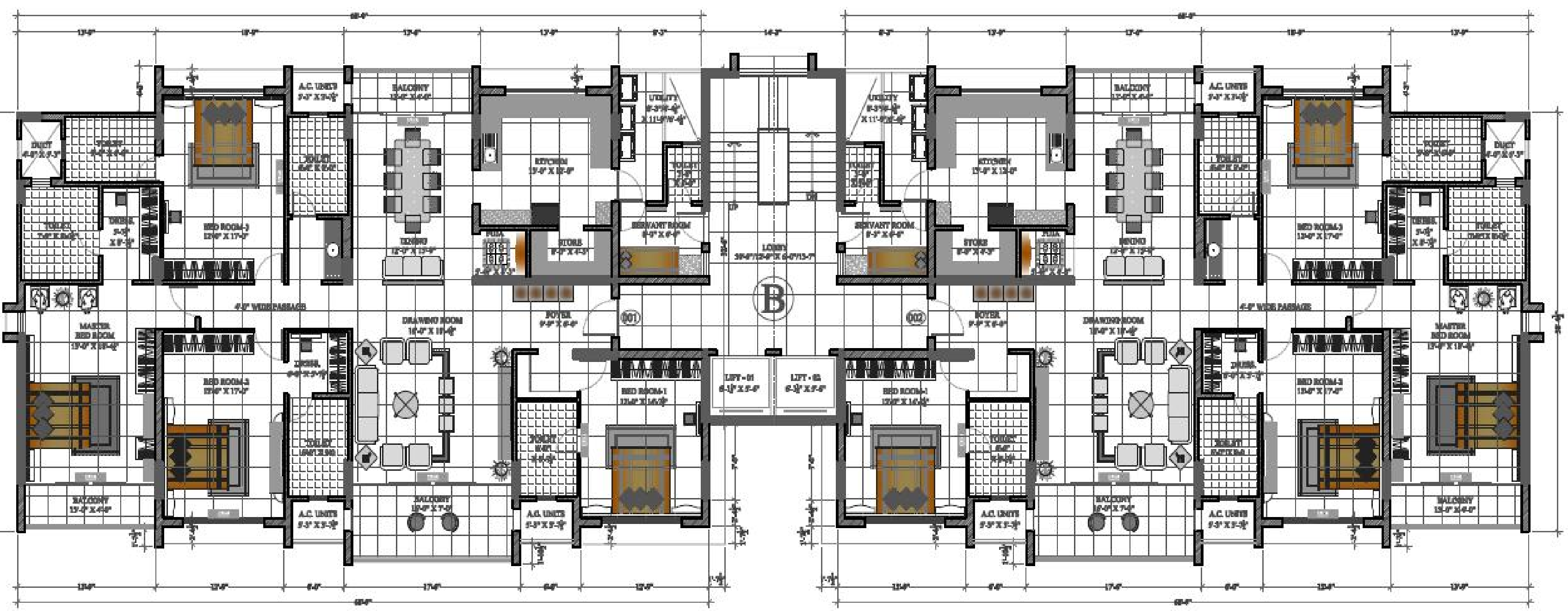
Layout

1B + G + 12 Floors

Proposed System

Flat plates with shear walls

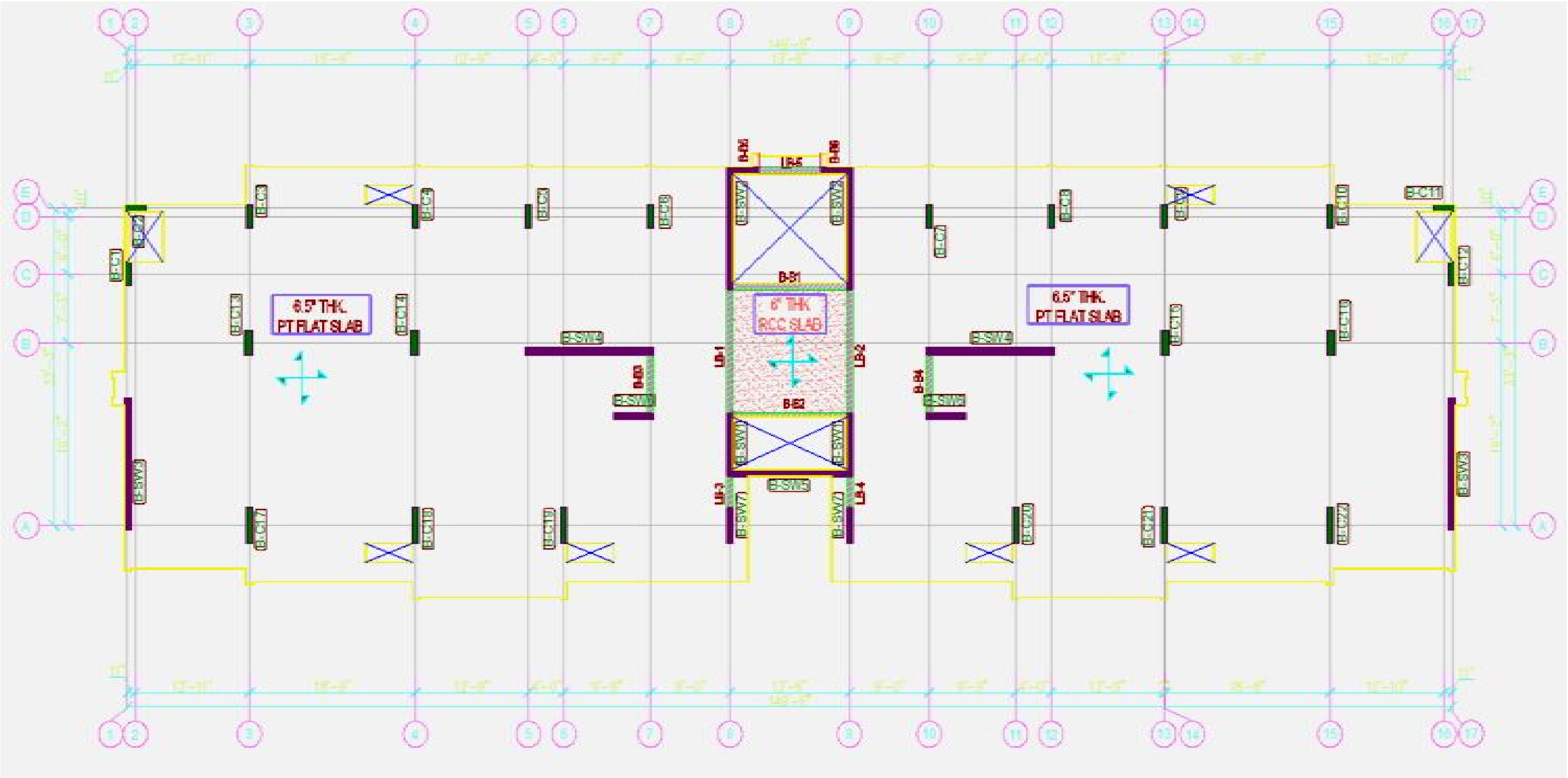
Architectural Layout



Case Studies

Case Study 1 – Mangla Aura, Vadodara

Structural layout proposed by CBM Engineers India



Case Studies

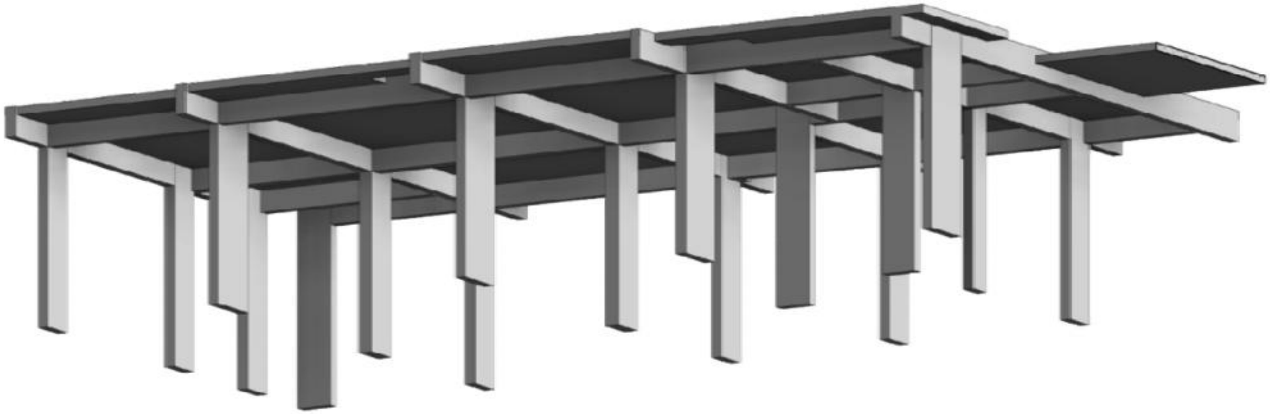
Case Study 1 – Mangla Aura, Vadodara

Flat Plate with Shear Walls

Conventional System

Beam (200 × 600)

RCC Slabs ▪ Columns



Proposed System

Flat Plate (RCC or PT) – Gravity System

Shear Walls – Lateral System

Case Studies

Case Study 1 – Mangla Aura, Vadodara

Load Comparison

CONVENTIONAL SYSTEM (with 300 mm TOILET SUNKS)			
LOAD TYPE	ELEMENT	WEIGHT (KN)	
		PER FLOOR	PER 12 FLOORS
DEAD LOAD	BEAMS (230 X 600)	700	8400
	RCC SLABS (200 MM)	2640	31680
SUPER DEAD LOAD	TOILET SUNK (300 mm sunk)	360	4320
	FINISHES	800	9600
	TOTAL	4500	54000

FLAT PLATE WITH SHEAR WALLS			
LOAD TYPE	ELEMENT	WEIGHT (KN)	
		PER FLOOR	PER 12 FLOORS
DEAD LOAD	PT SLABS (165 MM)	2178	26136
SUPER DEAD LOAD	FINISHES	800	9600
	TOTAL	2978	35736

TOTAL REDUCTION OF DEAD LOAD = 50%

Case Studies

Case Study 1 – Mangla Aura, Vadodara

Advantages of the Proposed System

Lesser Formwork

Major cost component eliminated.

Table form shuttering can be used.

Lesser shuttering = Faster construction

Clear Floor-to-floor Height

Cleat floor-to-floor height can be achieved.

25mm reduction in height / floor = ₹ 12 per sq ft

MEP Layout

Easier to lay out MEP services due to continuous flat bottom and neat grid.

Absence of Internal Walls

Flexibility at the later stages during construction

Case Studies

Case Study 1 – Mangla Aura, Vadodara

Advantages of the Proposed System

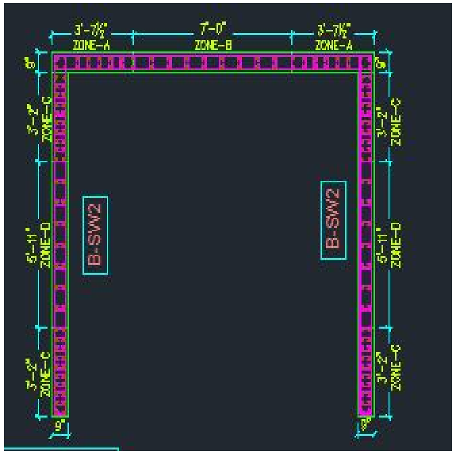
Ease in coordination - Structurally

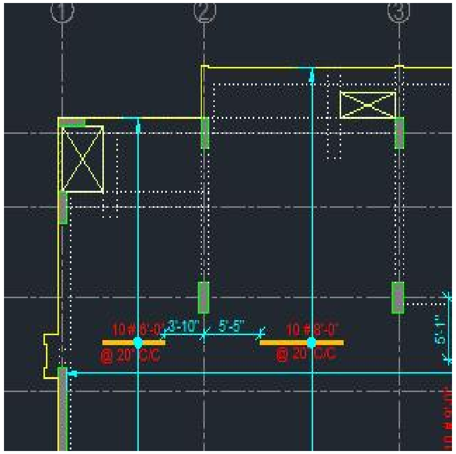
Less amount of structural drawings produced – only slabs and shear walls.

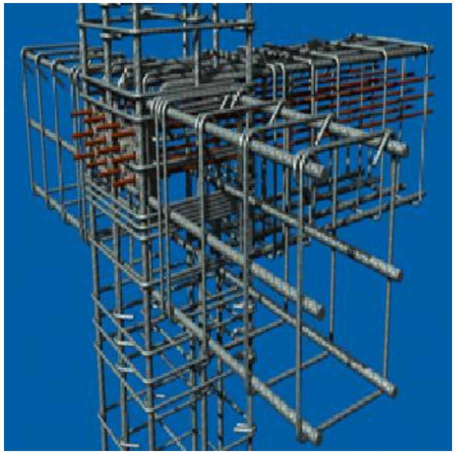
Ease in coordination at site

Beam Column Joint

Elimination of beam – column junction reinforcement







Case Studies

Case Study 2 – Godrej City, Panvel

Client
Godrej Properties
Panvel, Maharashtra

Sector
Residential building

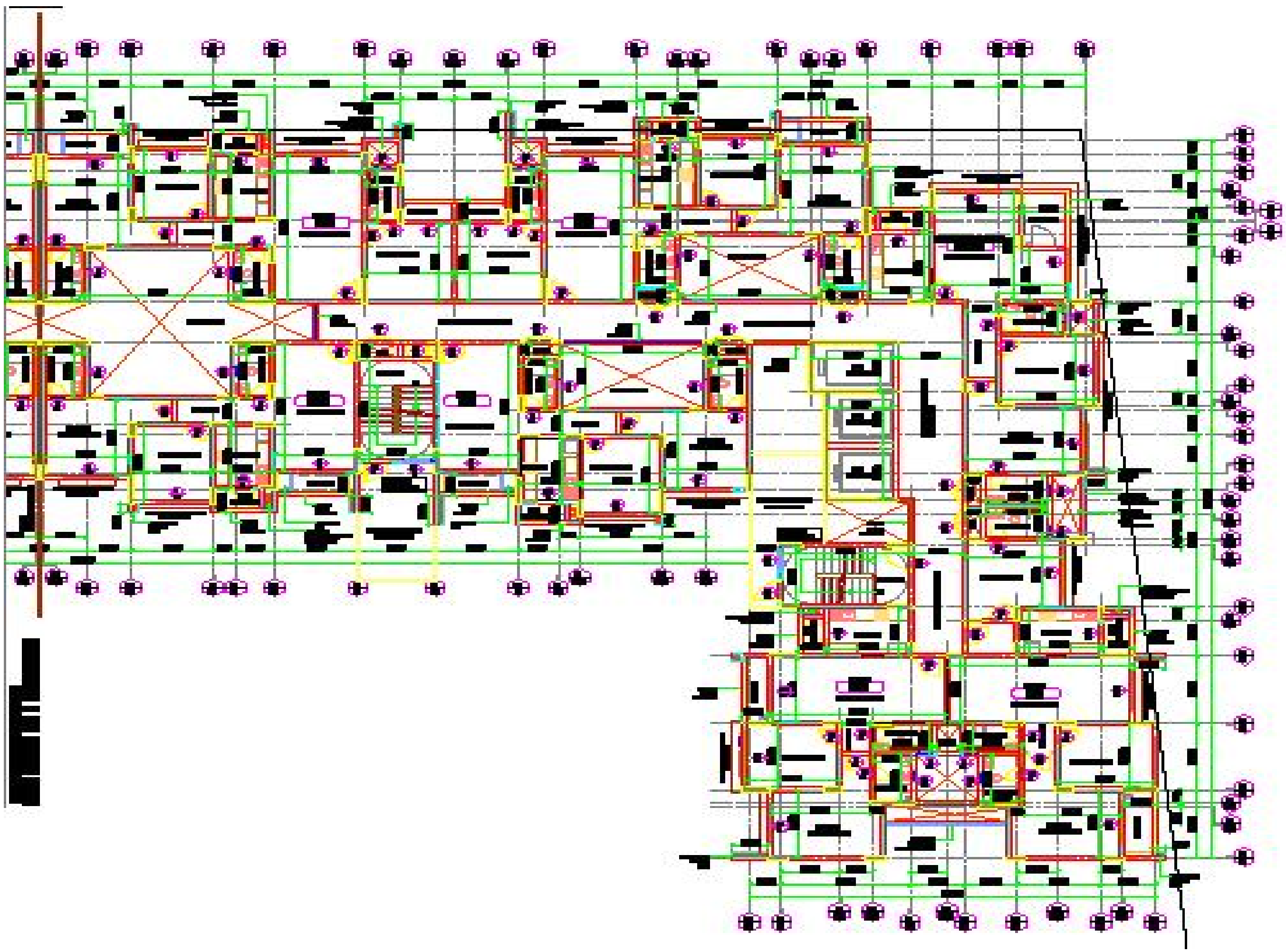
Proposed System
Flat Plates with Periphery Beams, Shear Walls and Columns.

Layout
2B + G + 22 Floors

Case Studies

Case Study 2 – Godrej City, Panvel

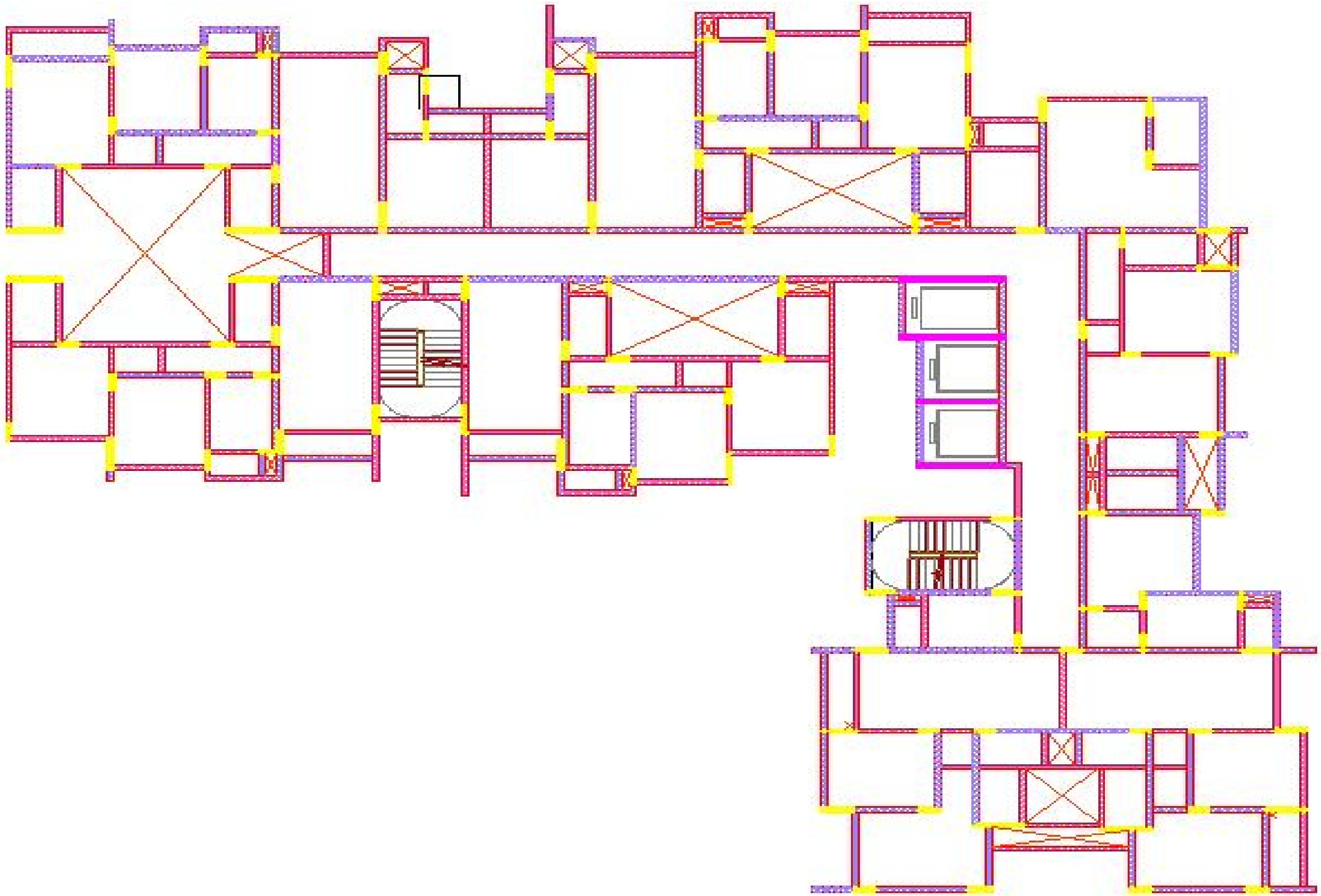
Architectural Layout



Case Studies

Case Study 2 – Godrej City, Panvel

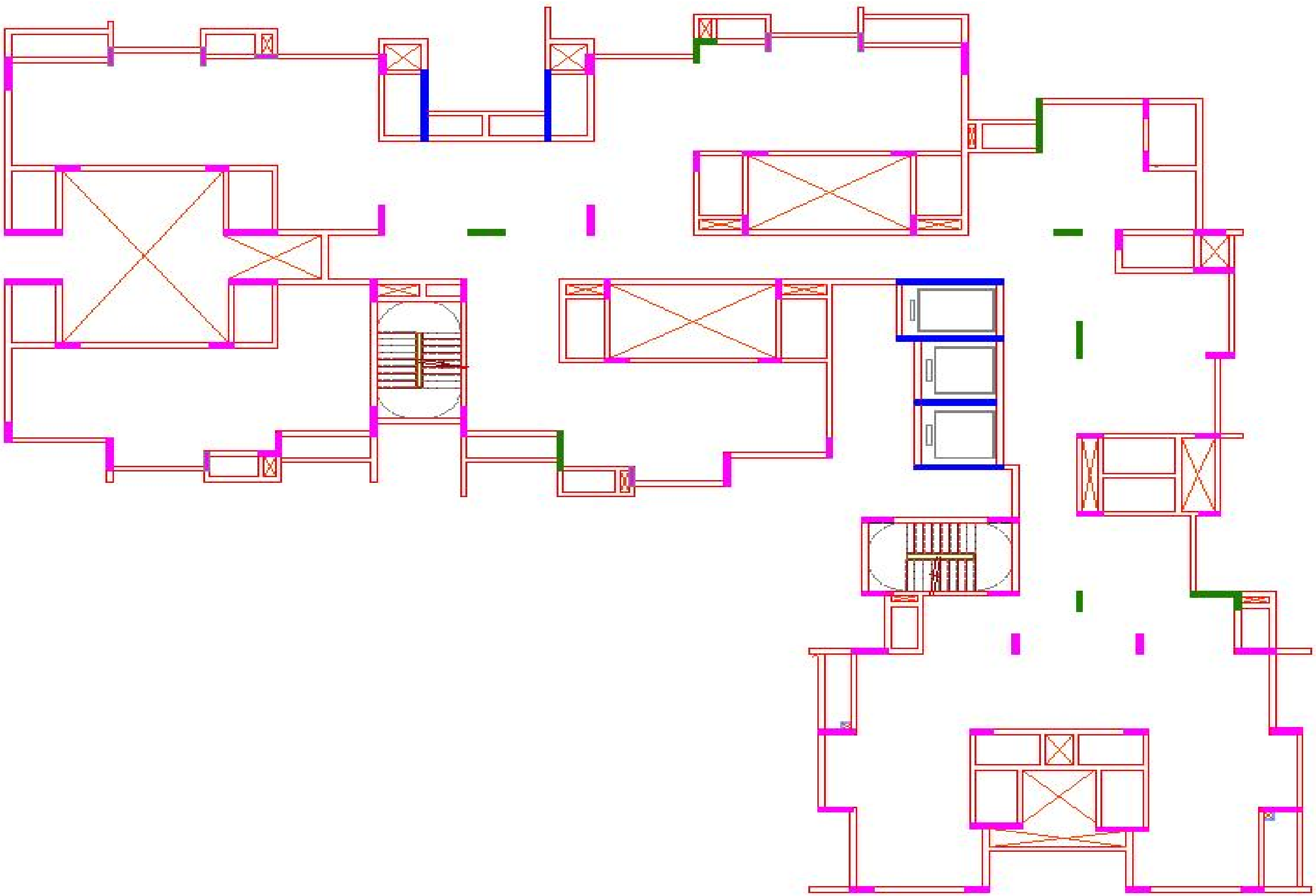
Structural layout proposed by Main Structural Consultant



Case Studies

Case Study 2 – Godrej City, Panvel

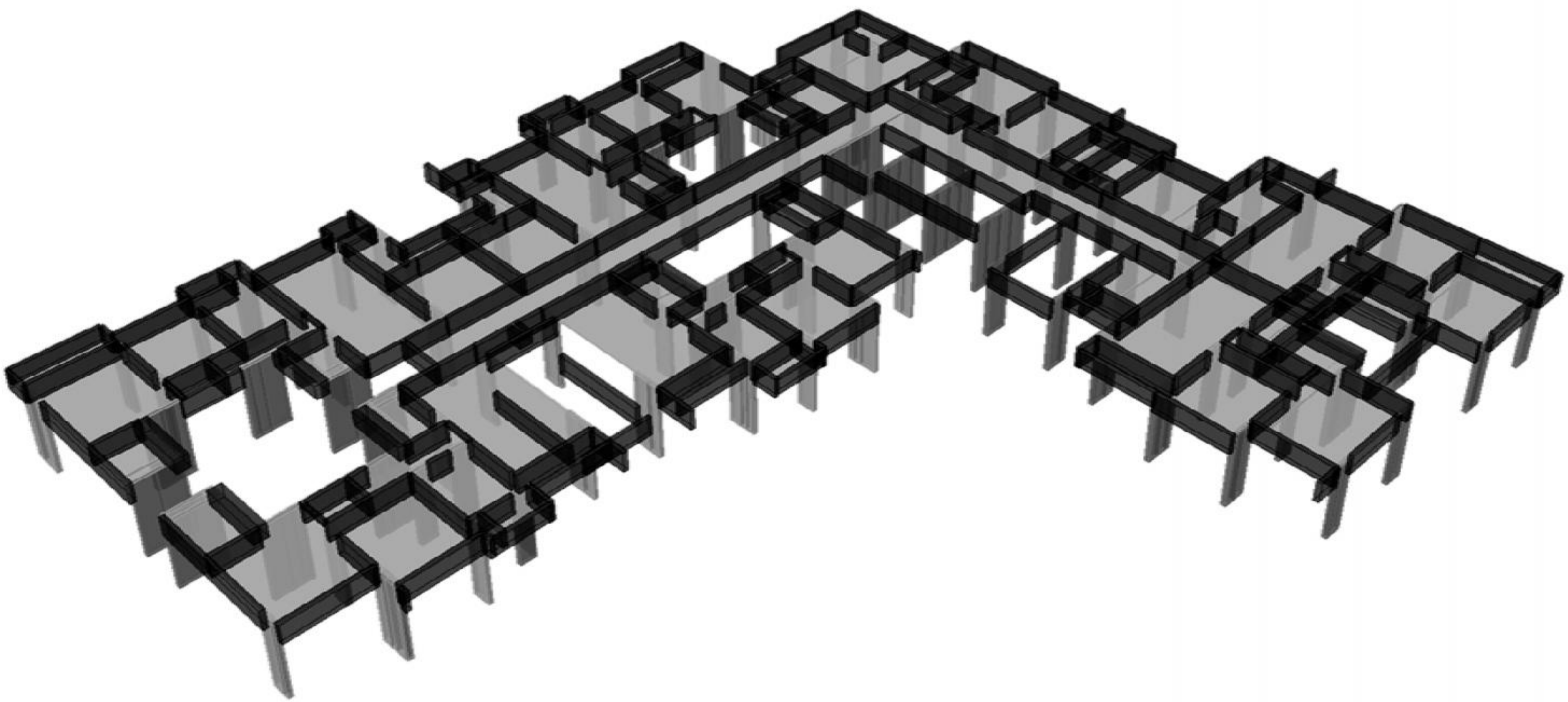
Structural layout proposed by CBM Engineers India



Case Studies

Case Study 2 – Godrej City, Panvel

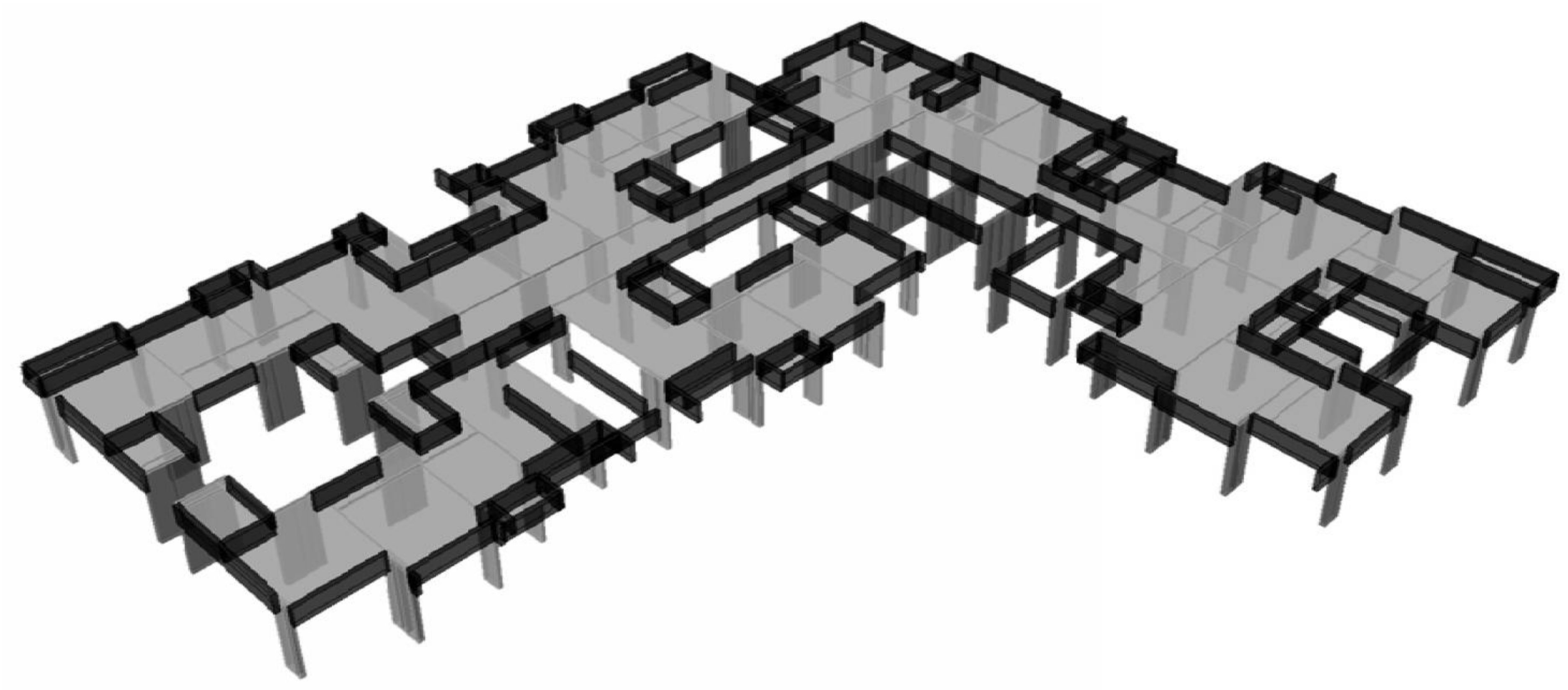
Structural layout proposed by Main Structural Consultant



Case Studies

Case Study 2 – Godrej City, Panvel

Structural layout proposed by CBM Engineers India



Case Studies

Case Study 2 – Godrej City, Panvel

Quantity Comparison – Main Structural Consultant

TOWER	ELEMENT		CONCRETE			Ratio	Ratio	Ratio
		(Fe 500)	M25	M30	Total			
		(kg)	(m^3)	(m^3)	(m^3)	(Kg /m^3)	(Kg /sq.ft.)	(m3 /sq.ft.)
TOWER 1 - C BLOCK - 2	COLUMN / WALL	197500	-	930	930	212.4	1.89	0.0089
	BEAM	148400	1120	-	1120	132.5	1.42	0.0107
	SLAB	78000	1079	-	1079	72.3	0.75	0.0103
TOTAL		**423900**	**2199.0**	**930.0**	**3129.0**	**135.5**	**4.06**	**0.0300**

SLAB AREA OF ONE FLOOR	=	746.0	**m^2**
	=	8025.8	**Ft^2**

TOTAL SLAB AREA OF 13 FLOORS	=	9698.0	**m^2**
	=	104335.0	**Ft^2**

Case Studies

Case Study 2 – Godrej City, Panvel

Quantity Comparison – CBM Engineers India

TOWER	ELEMENT		CONCRETE			Ratio	Ratio	Ratio
		(Fe 500)	M25	M30	Total			
		(kg)	(m^3)	(m^3)	(m^3)	(Kg /m^3)	(Kg /sq.ft.)	(m3 /sq.ft.)
TOWER 1 - C BLOCK - 2	COLUMN / WALL	193000	-	857	857	225.2	1.85	0.0082
	BEAM	112000	815	-	815	137.5	1.07	0.0078
	SLAB	104000	1300	-	1300	80.0	1.00	0.0125
TOTAL		**409000**	**2114.8**	**857.0**	**2971.8**	**137.6**	**3.92**	**0.0285**

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Case Studies

Case Study 2 – Godrej City, Panvel

Advantages	Disadvantaged
Periphery Beams To maintain the external architectural elevation / facade	Better suitable for sunken slab-free toilets
Beam-free Spaces Flexibility of merging flats. Ease for service ducts. Central AC systems can be proposed	

Case Studies

Case Study 3 – Godrej Anandam, Nagpur

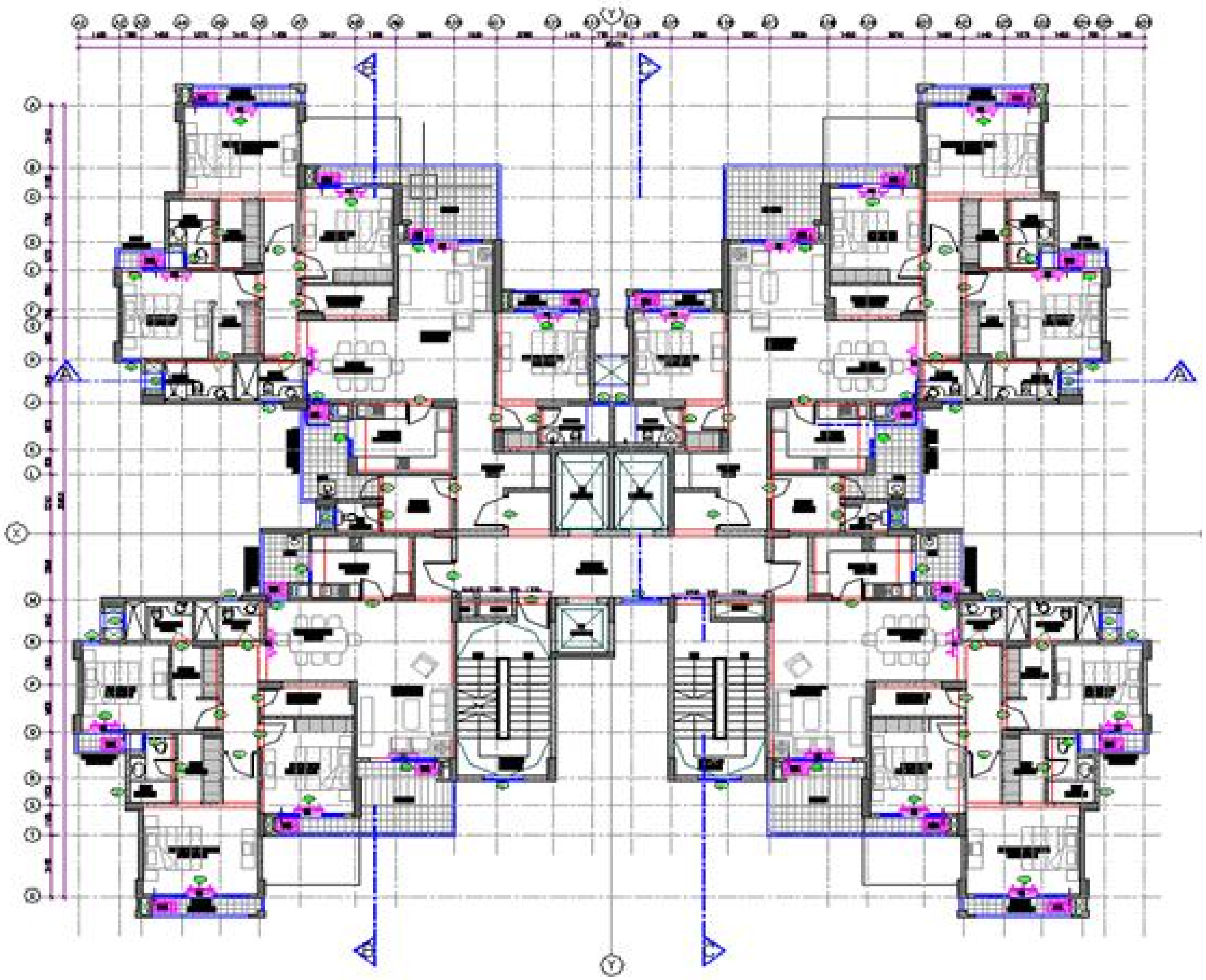
Client
Godrej Properties
Nagpur

Sector
Residential building

Proposed System
RCC Beam Slab

Layout
1B + G + 20 Floors

Architectural Layout
(Tower F)

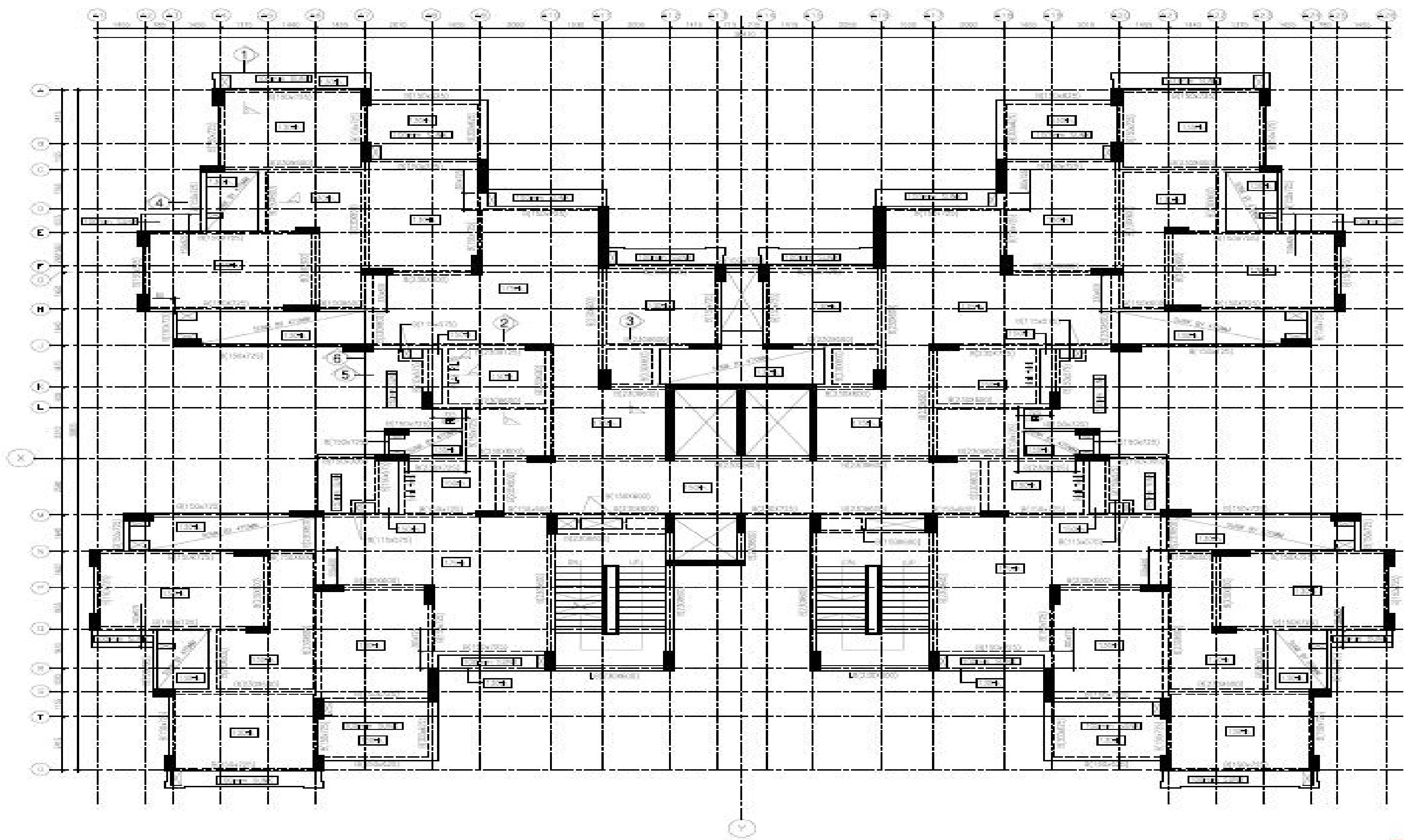


Case Studies

Case Study 3 – Godrej Anandam, Nagpur

Structural layout proposed by Previous Structural Consultant

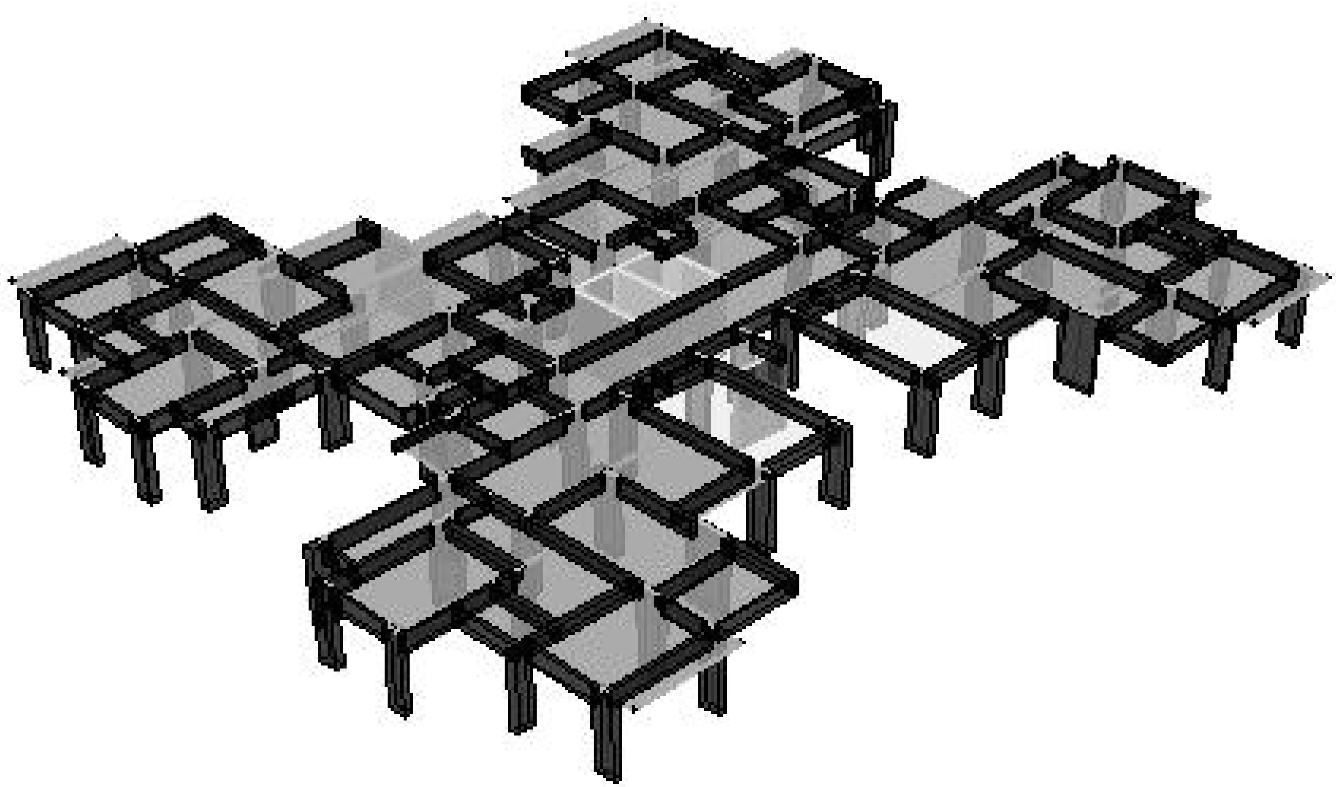
Structural Layout (Tower F)



Case Studies

Case Study 3 – Godrej Anandam, Nagpur

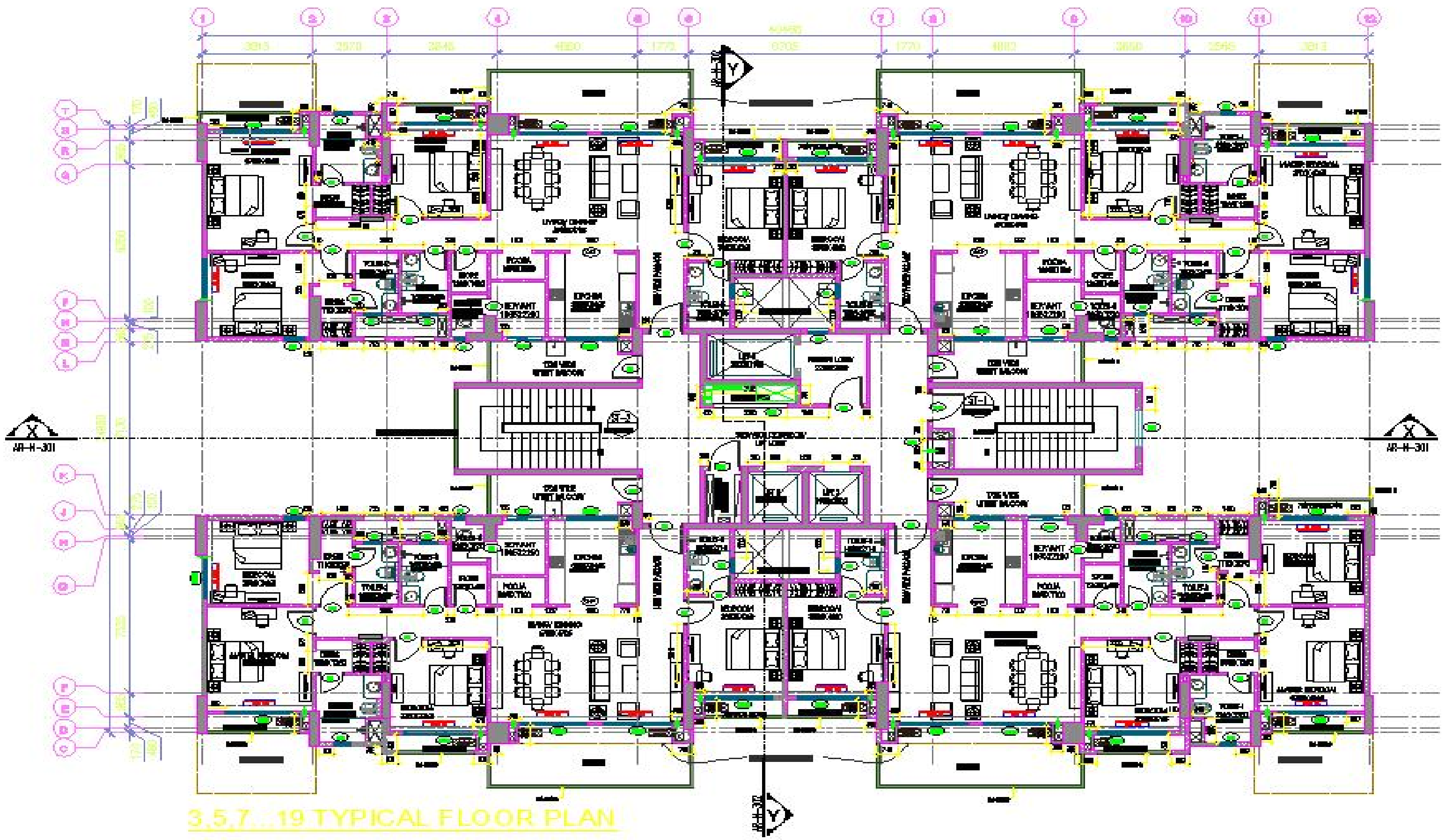
Structural layout proposed by Main Structural Consultant



Case Studies

Case Study 3 – Godrej Anandam, Nagpur

Architectural Layout (Tower N)

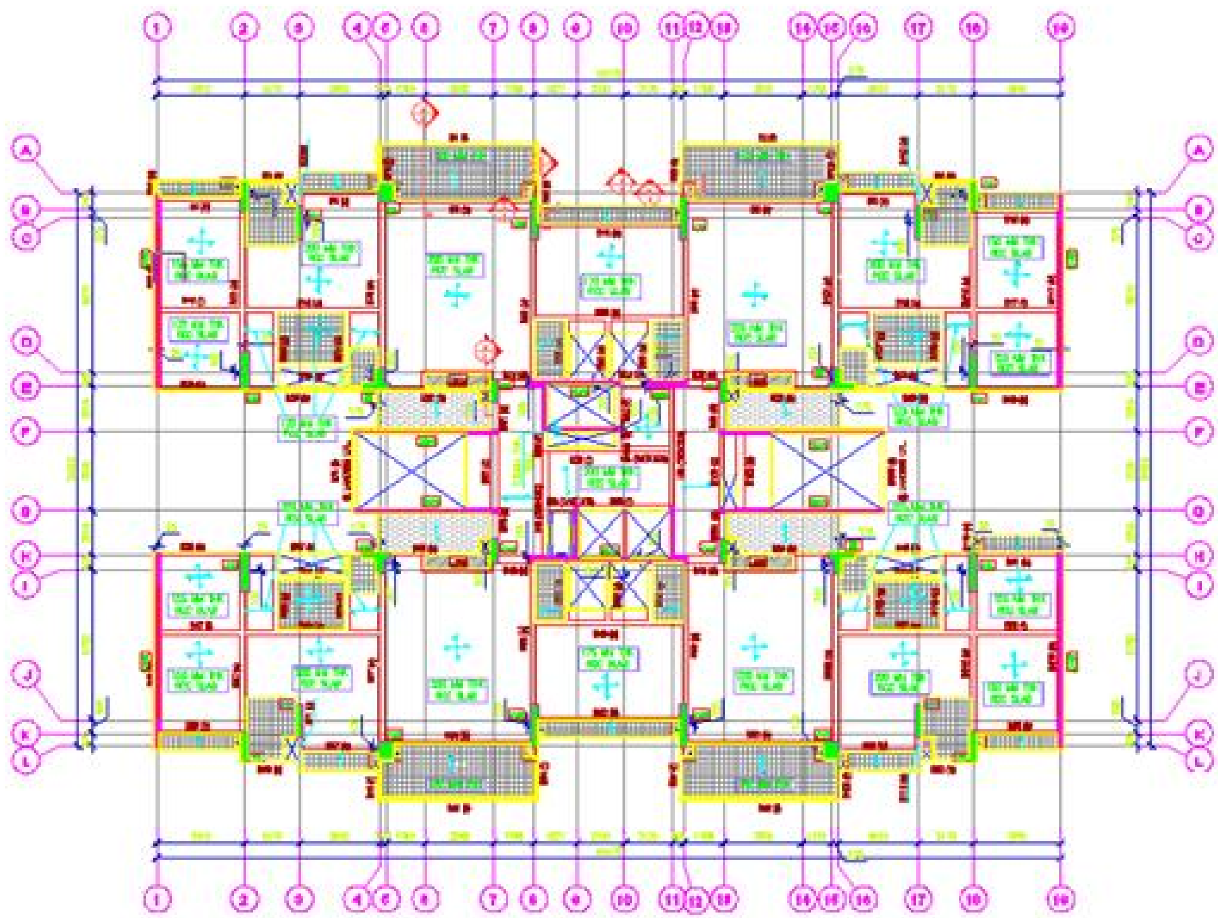


Case Studies

Case Study 3 – Godrej Anandam, Nagpur

Structural layout proposed by CBM Engineers India

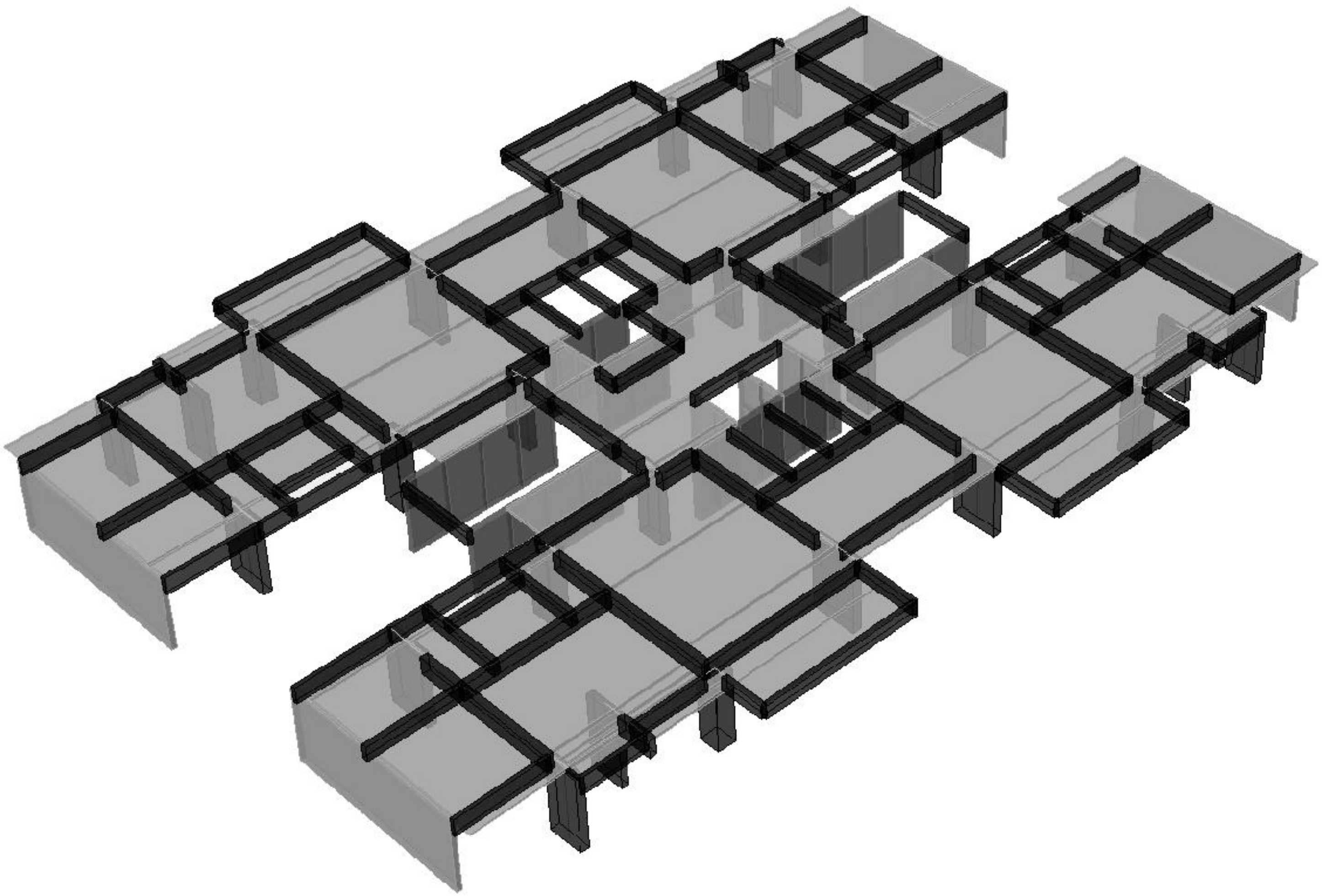
Structural Layout (Tower N)



Case Studies

Case Study 3 – Godrej Anandam, Nagpur

Structural layout proposed by CBM Engineers India



Case Studies

Case Study 3 – Godrej Anandam, Nagpur

Quantity Comparison – CBM Engineers India

TOWER	ELEMENT	STEEL (Fe 500) (kg)	CONCRETE M25 (m^3)	M30 (m^3)	M35 (m^3)	M40 (m^3)	TOTAL (m^3)	Ratio (Kg /m^3)	Ratio (Kg /sq.ft.)	Ratio (m3 /sq.ft.)
TOWER N	COLUMN	171500	-	361	477	700	1538	111.5	0.83	0.0074
	WALL	82000	-	263	285	428	976	84.0	0.39	0.0047
	BEAM	235750	1497	-	-	-	1497	157.5	1.13	0.0072
	SLAB	170000	2575	-	-	-	2575	66.0	0.82	0.0124
	STAIR CASE	34000	300	-	-	-	300	113.3	0.16	0.0014
	RAFT	198500	-	1642	-	-	1642	120.9	0.96	0.0079
	TOTAL	**891750**	**4371.5**	**2266.0**	**762.0**	**1128.0**	**8527.5**	**104.6**	**4.29**	**0.0410**

SLAB AREA OF ONE FLOOR	=	920.0	**m^2**
	=	9897.7	**Ft^2**

TOTAL SLAB AREA OF 21 FLOORS	=	19320.0	**m^2**
	=	207852.3	**Ft^2**

Case Studies

Case Study 4 – Godrej Garden City, Ahmedabad

Client
Godrej Properties
Ahmedabad

Sector
Residential building

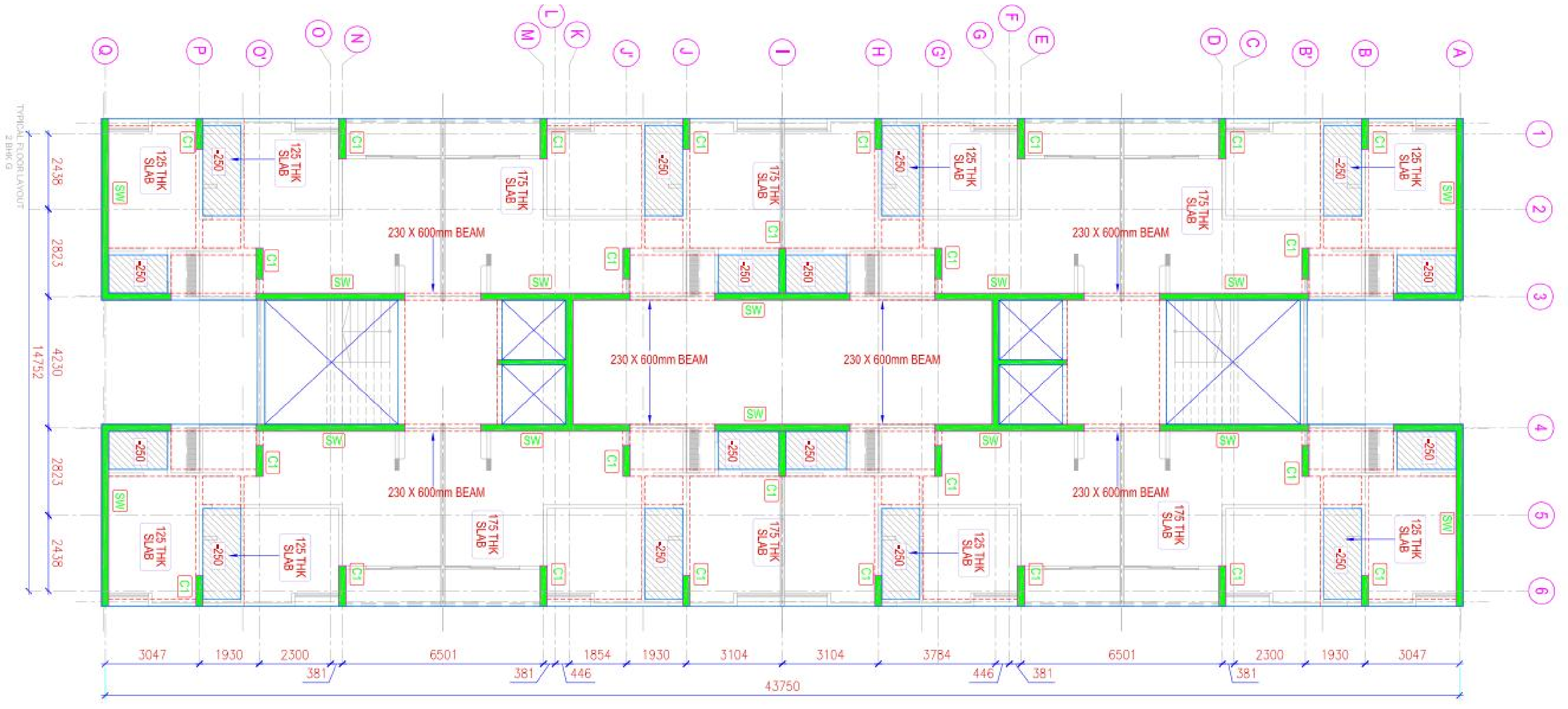
Proposed System
Option 1 – with sunken slabs
Option 2 – without sunken slabs

Layout
1B + G + 12 Floors

Case Studies

Case Study 4 – Godrej Garden City, Ahmedabad

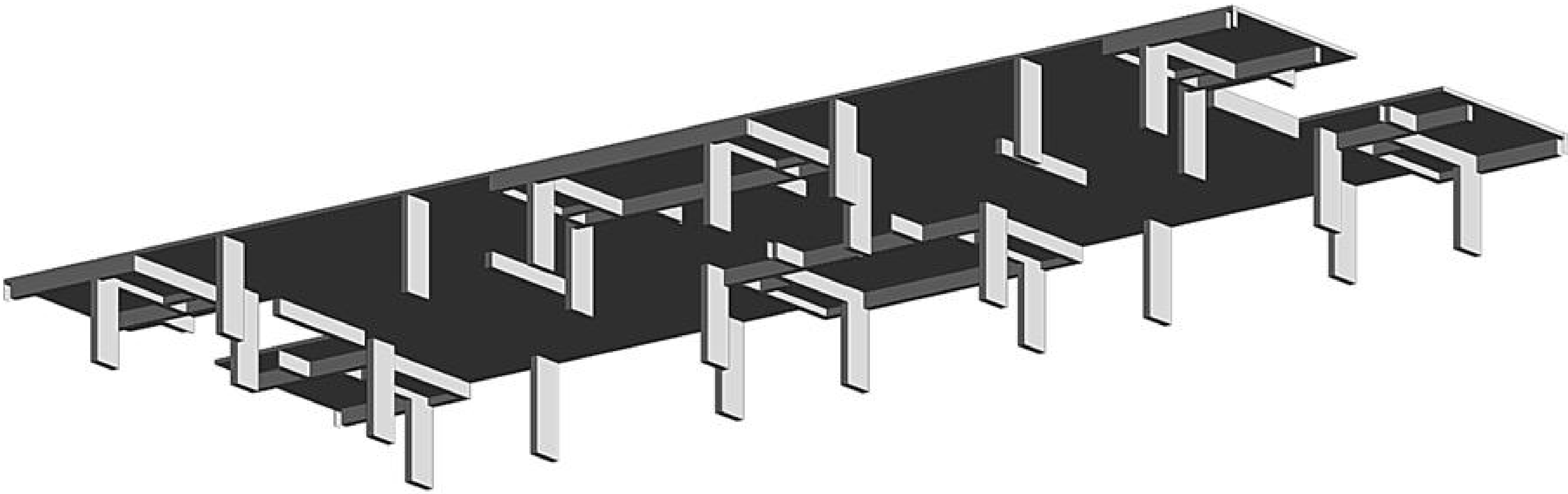
Structural layout proposed by CBM Engineers India
Option 1 – With Sunken Slabs



Case Studies

Case Study 4 – Godrej Garden City, Ahmedabad

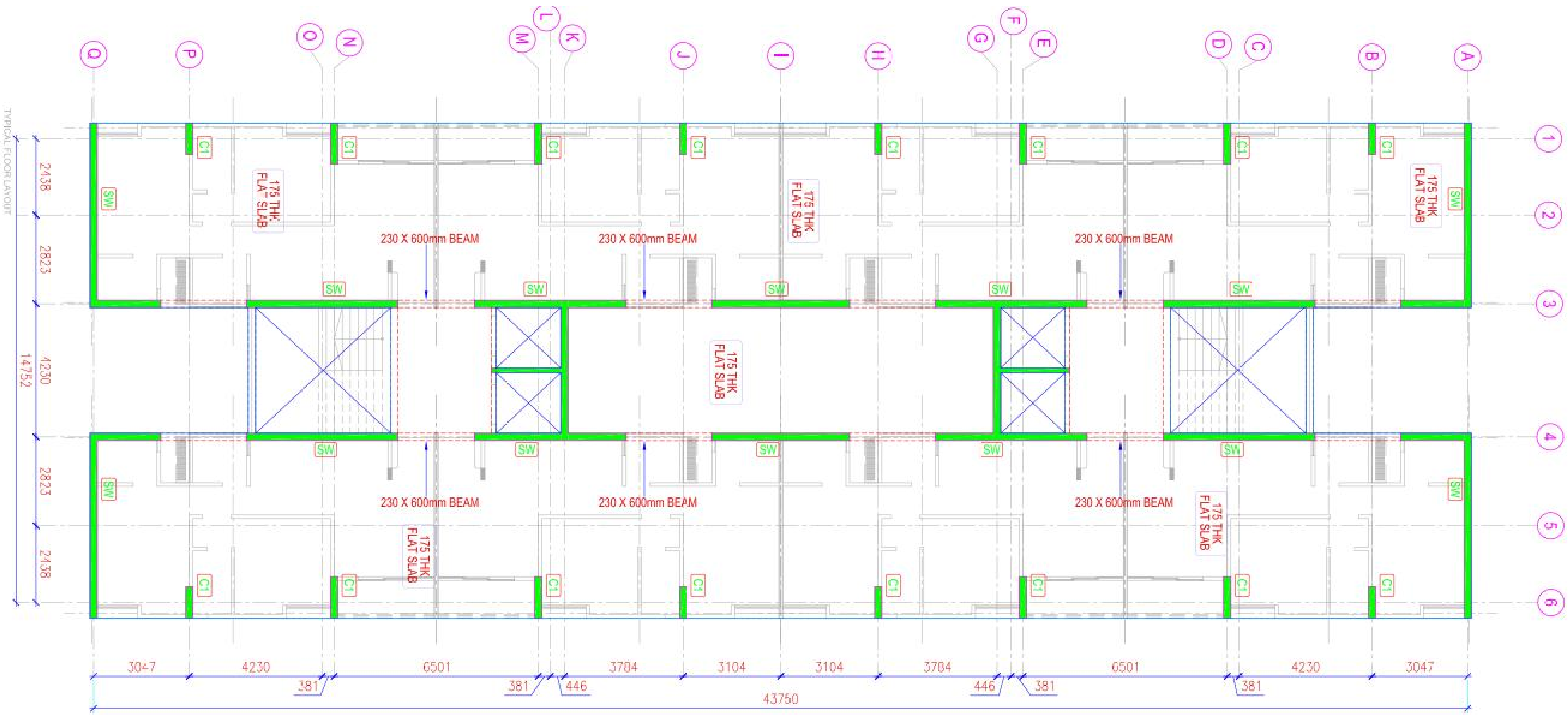
Structural layout proposed by CBM Engineers India
Option 1 – With Sunken Slabs



Case Studies

Case Study 4 – Godrej Garden City, Ahmedabad

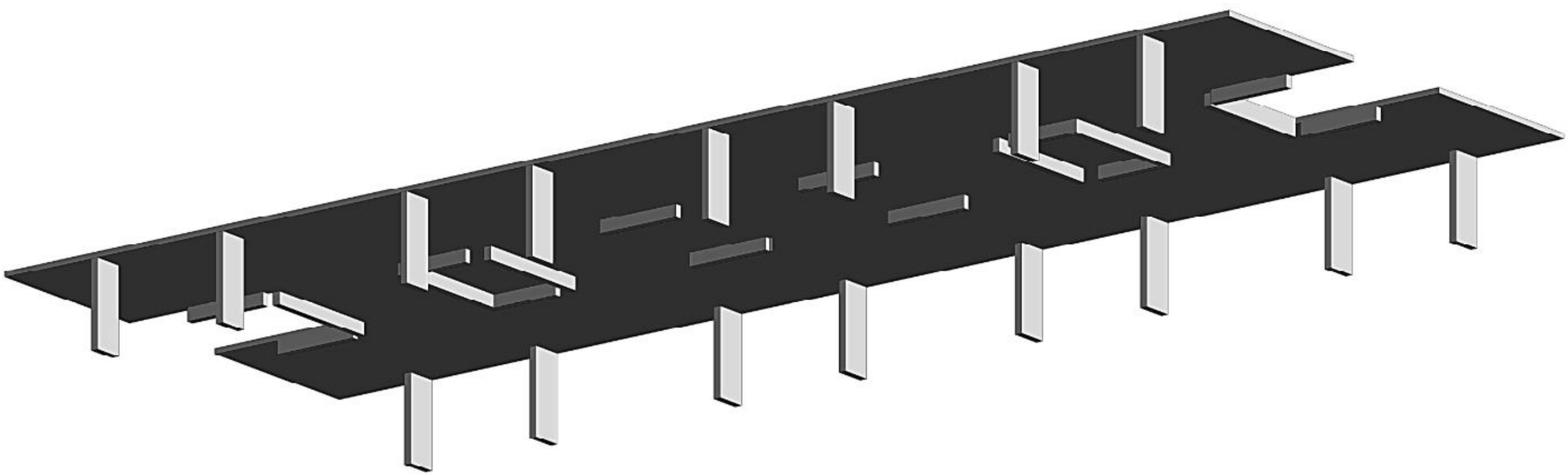
Structural layout proposed by CBM Engineers India
Option 2 – Without Sunken Slabs



Case Studies

Case Study 4 – Godrej Garden City, Ahmedabad

Structural layout proposed by CBM Engineers India
Option 2 – Without Sunken Slabs



Case Studies

Overall Reinforcement Quantities Derived

* Quantities mentioned exclude consumption in foundations

Mangla Properties – Aura, Vadodara	Godrej Properties, Godrej Garden City, Ahmedabad
CBM Engineers India	CBM Engineers India
Structural Steel Quantity	Structural Steel Quantity
3.75 kg/ft²	2.70 kg/ft² Option 2 – without sunken slabs

Case Studies

Overall Reinforcement Quantities Derived

* Quantities mentioned exclude consumption in foundations

Godrej Properties – Godrej Anandam, Nagpur

Previous Structural Consultant	CBM Engineers India
Structural Steel Quantity	Structural Steel Quantity
6.00 kg/ft²	4.50 kg/ft²

Conclusion

Selection of an appropriate Lateral load resisting system

For high rise buildings, major portion of total steel consumption is in the lateral system. Comparison of different lateral systems is necessary to arrive at the most cost effective solution

Selection of an appropriate Gravity load resisting system

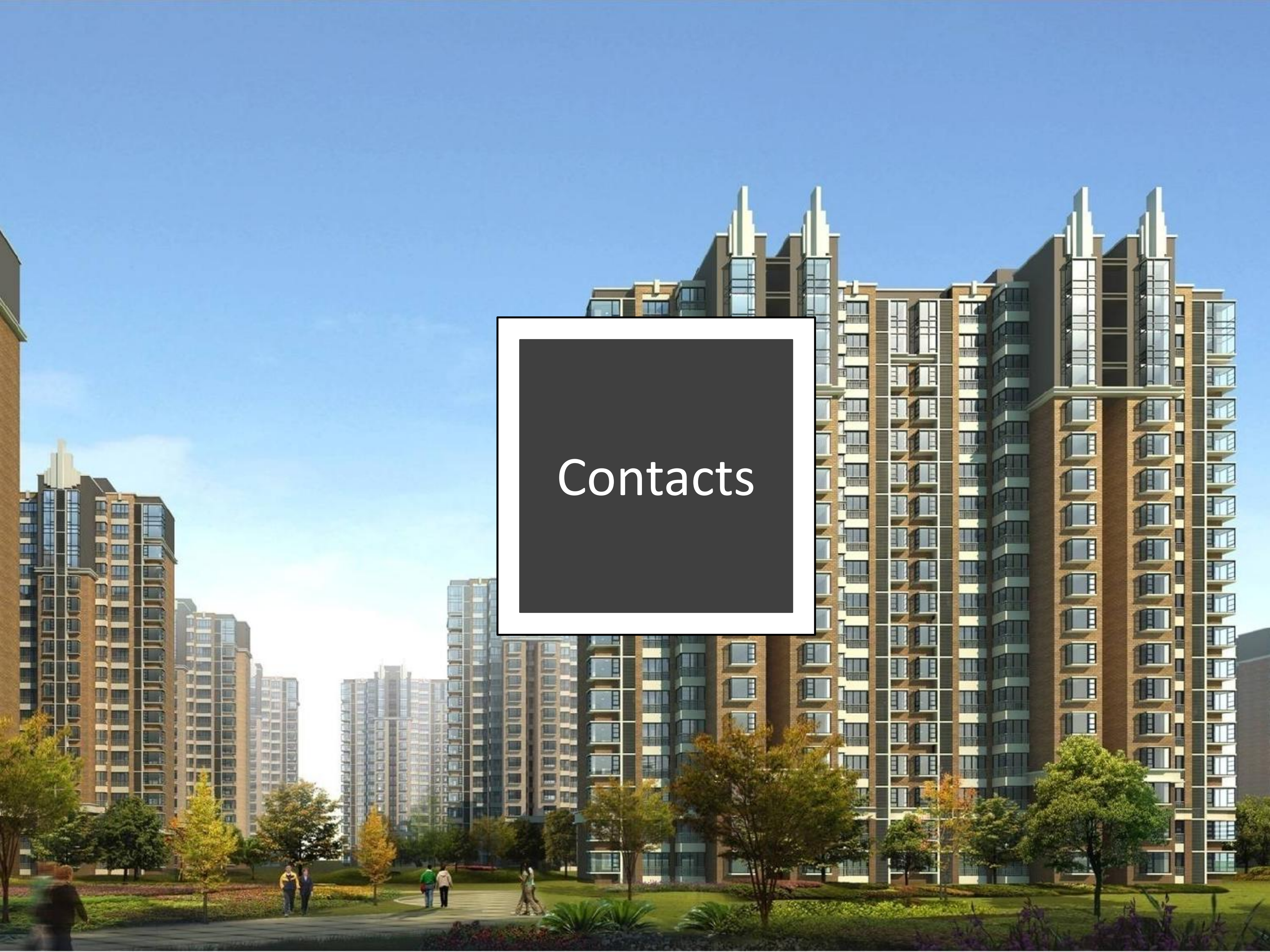
The savings will be lesser then those obtained from lateral systems

Efforts shall be towards the selection of formwork, the horizontal framework system including the possible use of PT

Efficient detailing practices for different structural elements

Analysis is Universal, Design is National and Detailing is Personal.

Lateral loads are code based, but attention shall be given to reduce the gravity load in terms of Light weight partition walls, elimination of sunk slabs and screed



Contacts

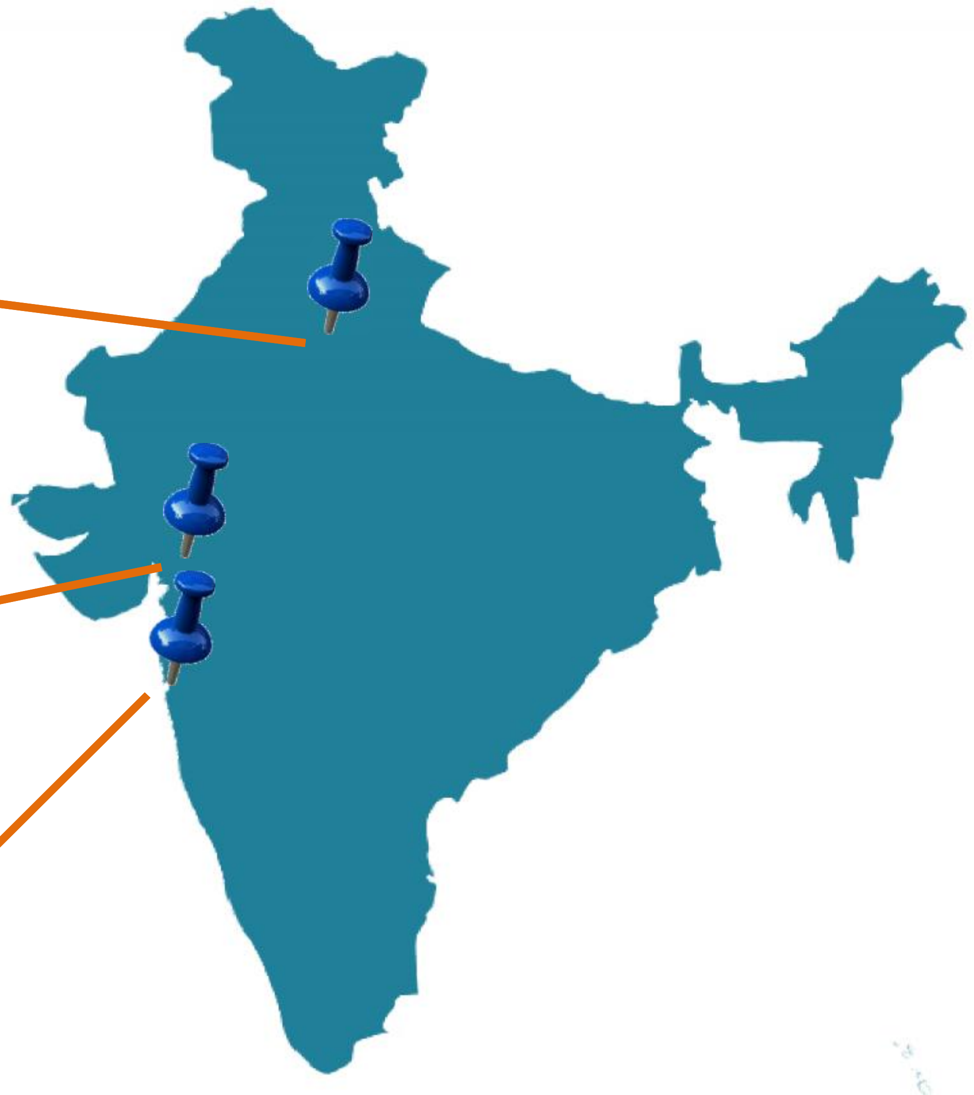
Get in Touch

Pan-India Presence

Delhi NCR
216A/13 First Floor,
Gautam Nagar,
New Delhi 110 049
Tel: +91 (0)11 4164 2803 / 2804

Vadodara
[HO– India Operations]
FF 1 to 12, Sun Enclave,
Opp. Jalaram Temple, Karelibaug,
Vadodara 390 018
Tel: +91 (0)265 248 1835

Mumbai
A - 523/524, Bonanza, Sahar Plaza,
Andheri Kurla Road, Andheri East,
Mumbai 400 059
Tel: +91 (0)22 6127 5143



Get in Touch

Vaibhav Khatri
Manager – Business Development
(M) +91 99099 42244
(E) vkhatri@cbmengineers.com

Kunal Suthar
Director
(M) +91 98257 11982
(E) ksuthar@cbmengineers.com

We are always eager to meet you and build upon new relationships.

Contact our **Business Development** Executives

Sejal Desai
Head – Business Development
(M) +91 98202 67044
(E) sdesai@cbmengineers.com

Abhay Ghate
Director
(M) +91 93124 34389
(E) abhay.ghate@optimal.in

For General Enquiries: cbmengineers@segoc.com

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optimal CONSULTANCY SERVICES PVT. LTD.

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