

# King's Cross Plot 2

Architects: AHMM  
Engineers: AKT II

Group 3 Precedent Study

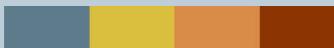


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- I. *Material*
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- I. *Appraisal - sustainability & aesthetics*



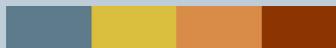
## *I. Concept & brief*

*I. Material*

*I. Structural system*

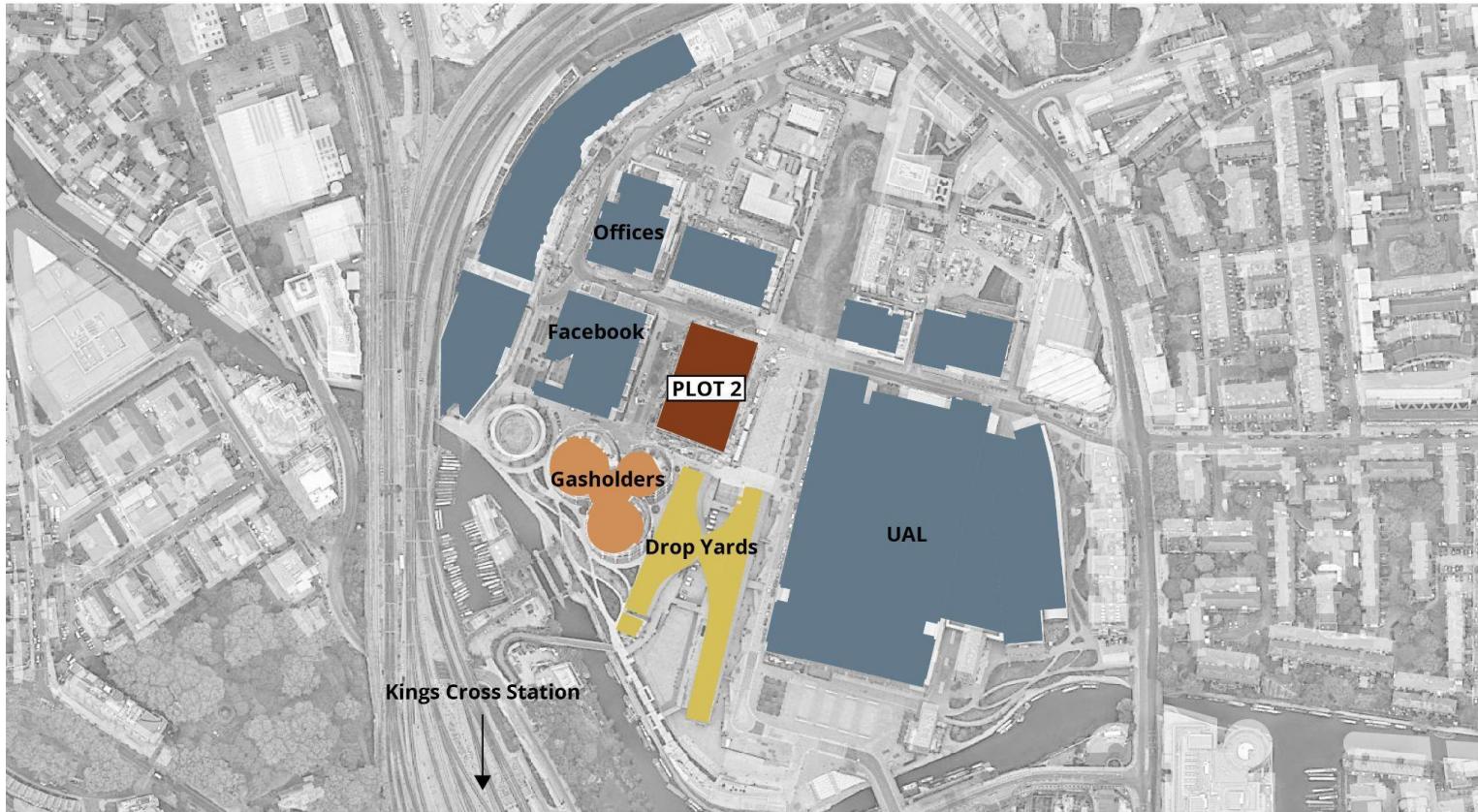
*I. Structural analysis - corner beam & roof cranked beam*

*I. Appraisal - sustainability & aesthetics*

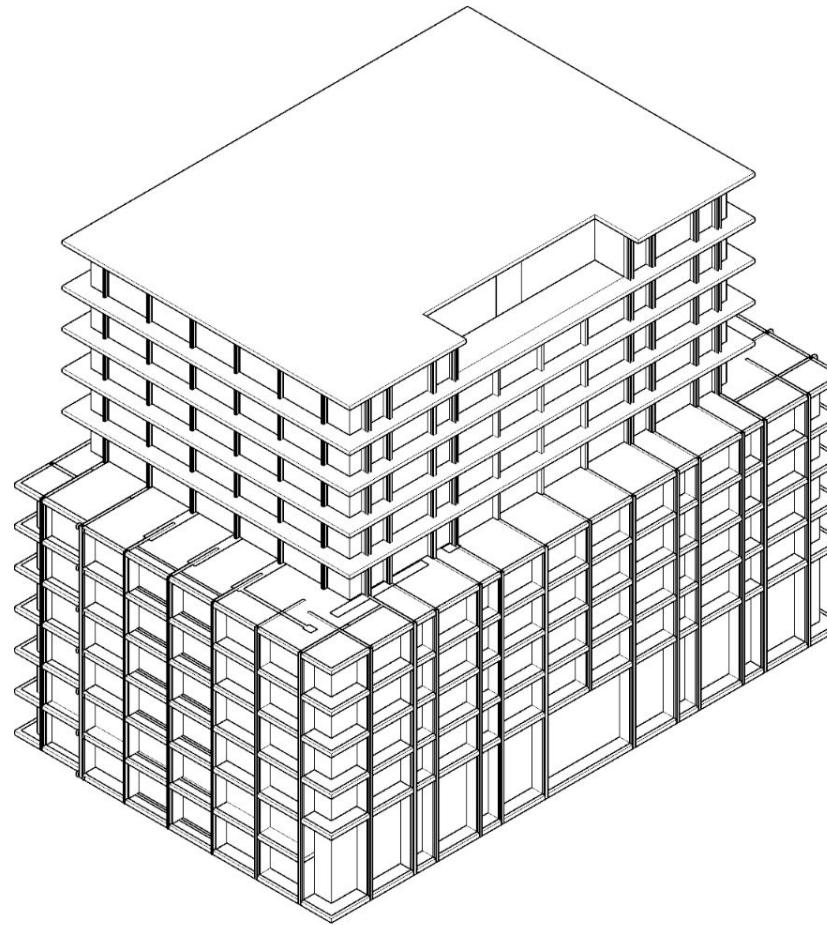


# Concept & brief | Surroundings

Architectural concept: Multifunctional and dynamic building to tie with the surroundings areas.

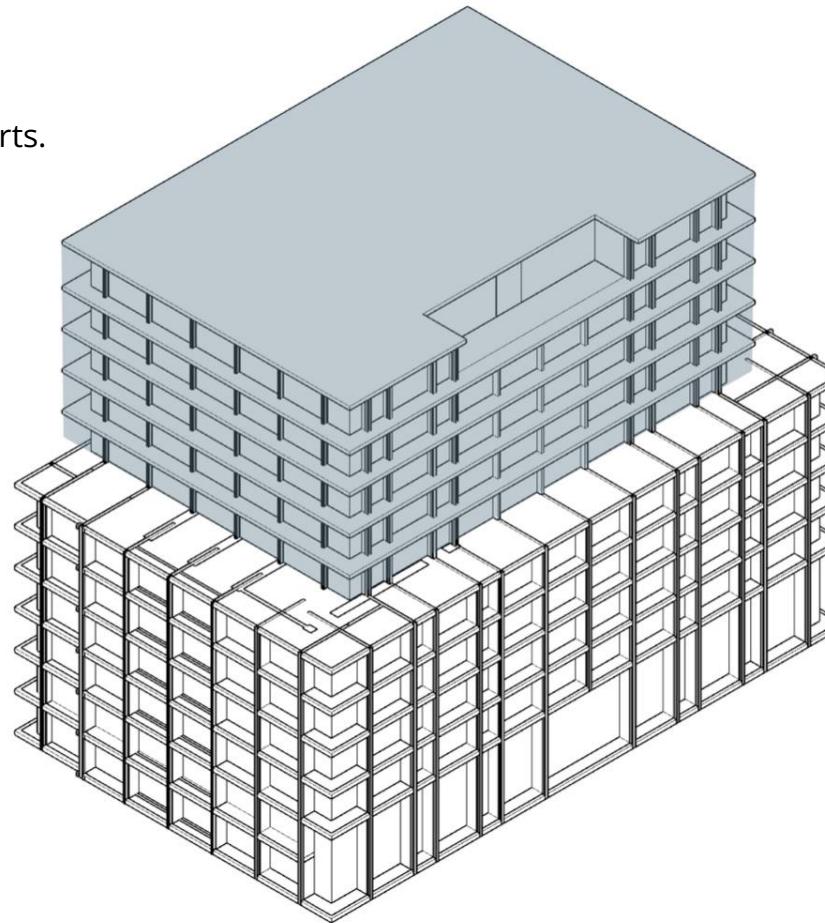


# Concept & brief | Structural and architectural requirements

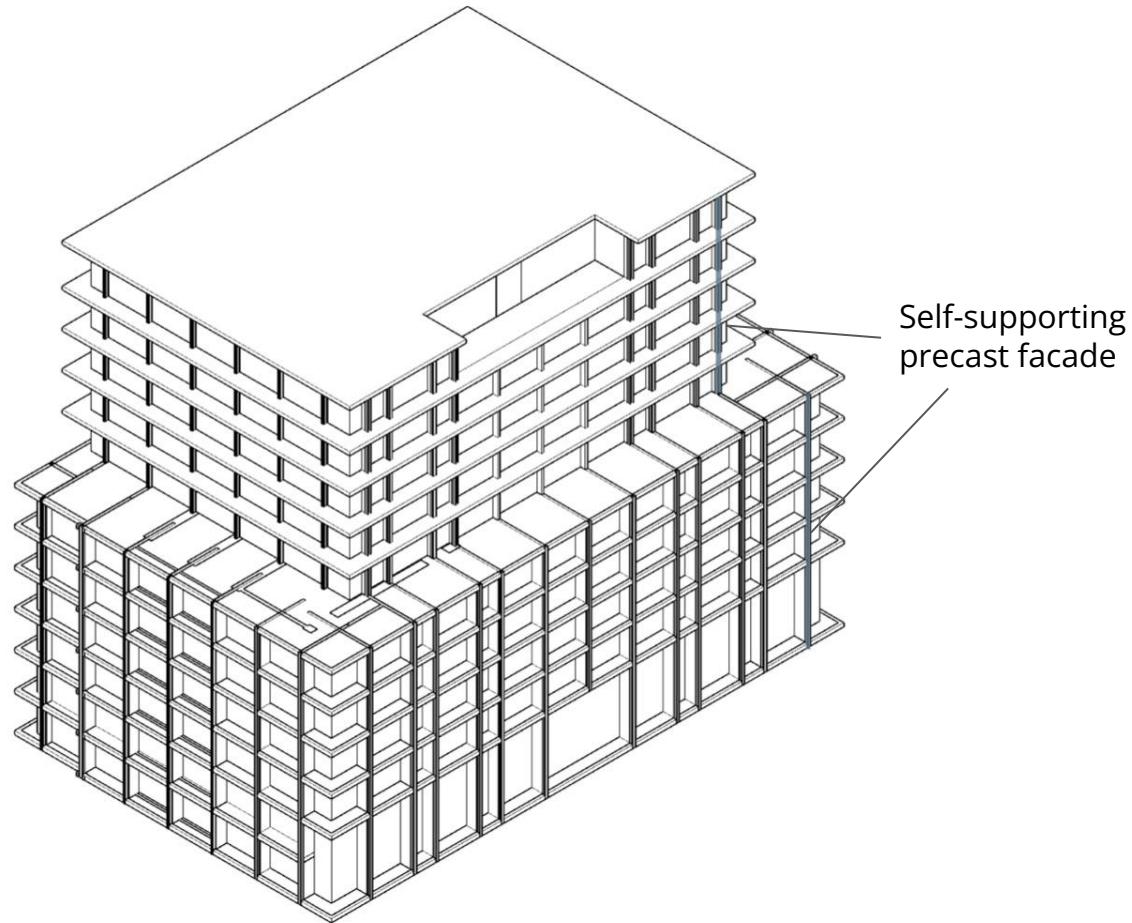


# Concept & brief | Structural and architectural requirements

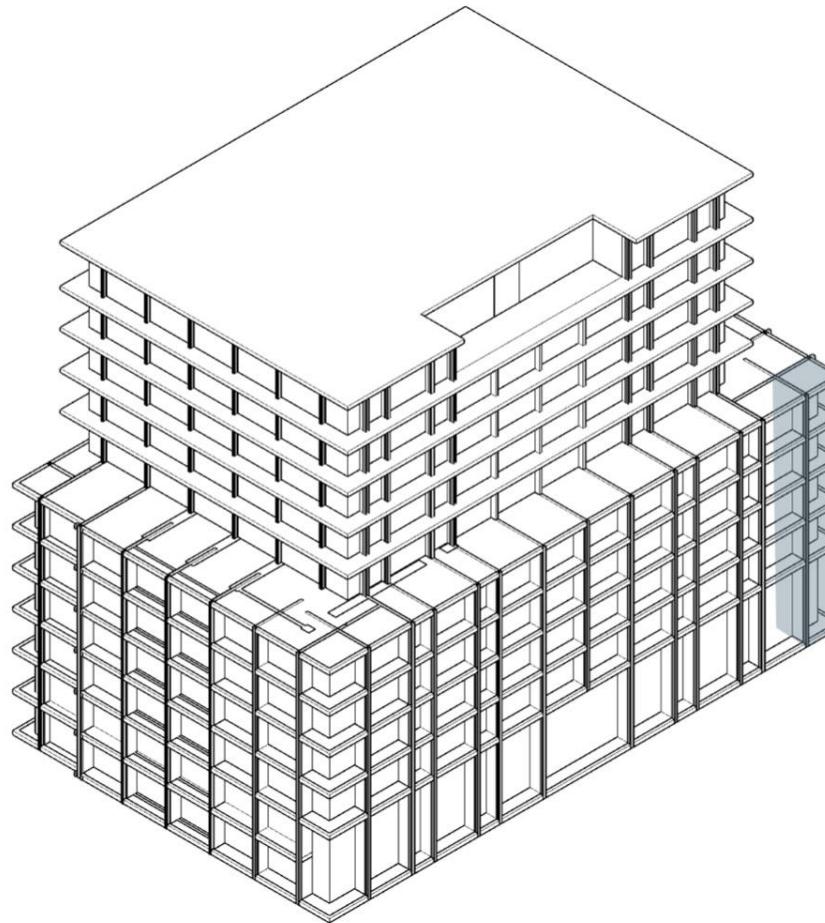
Building divided into two parts.  
The top part is set back.



# Concept & brief | Structural and architectural requirements



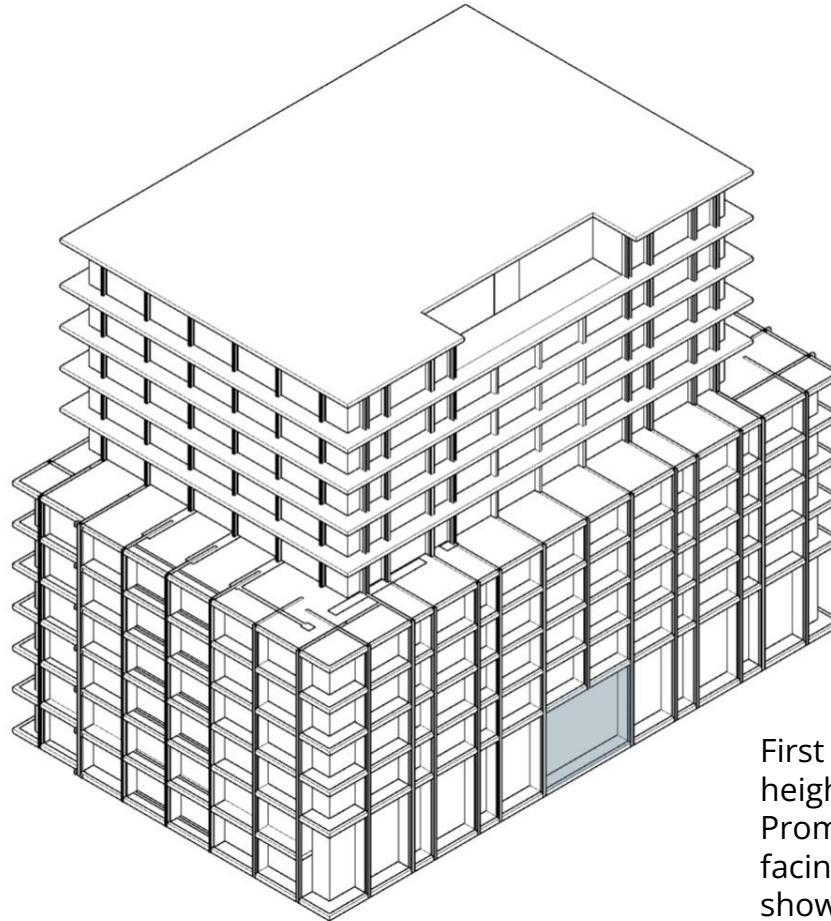
# Concept & brief | Structural and architectural requirements



Column-free glazing:  
aesthetics + maximisation of  
the spans of slabs



# Concept & brief | Structural and architectural requirements

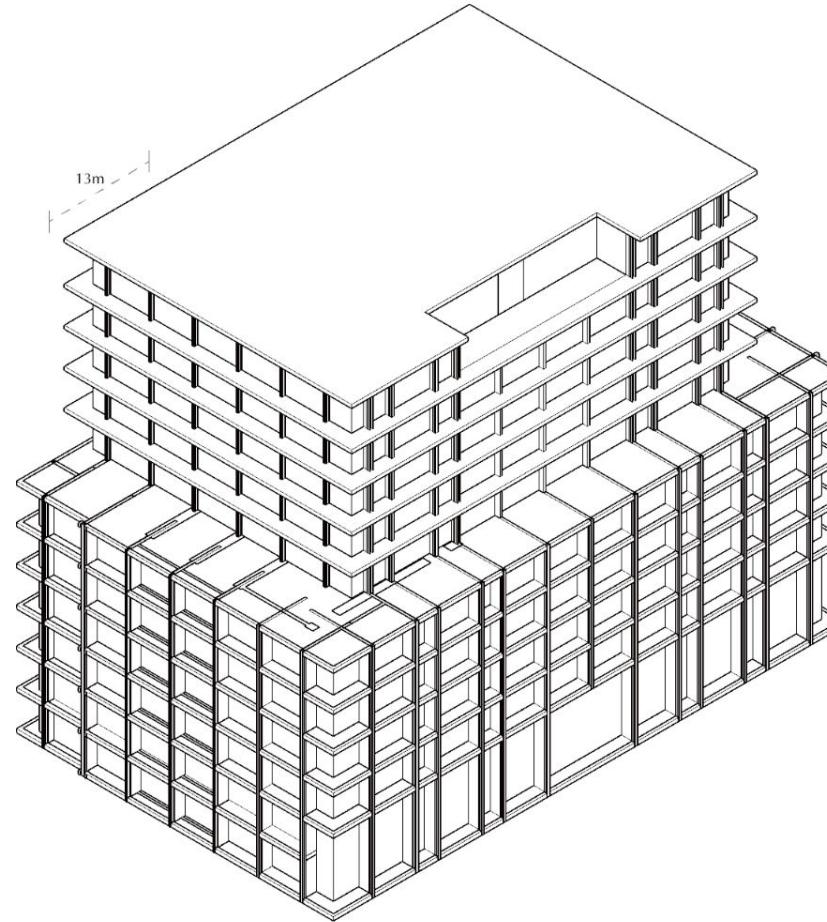


First floor has a height of 5m.  
Prominent facade facing the square to show presence.

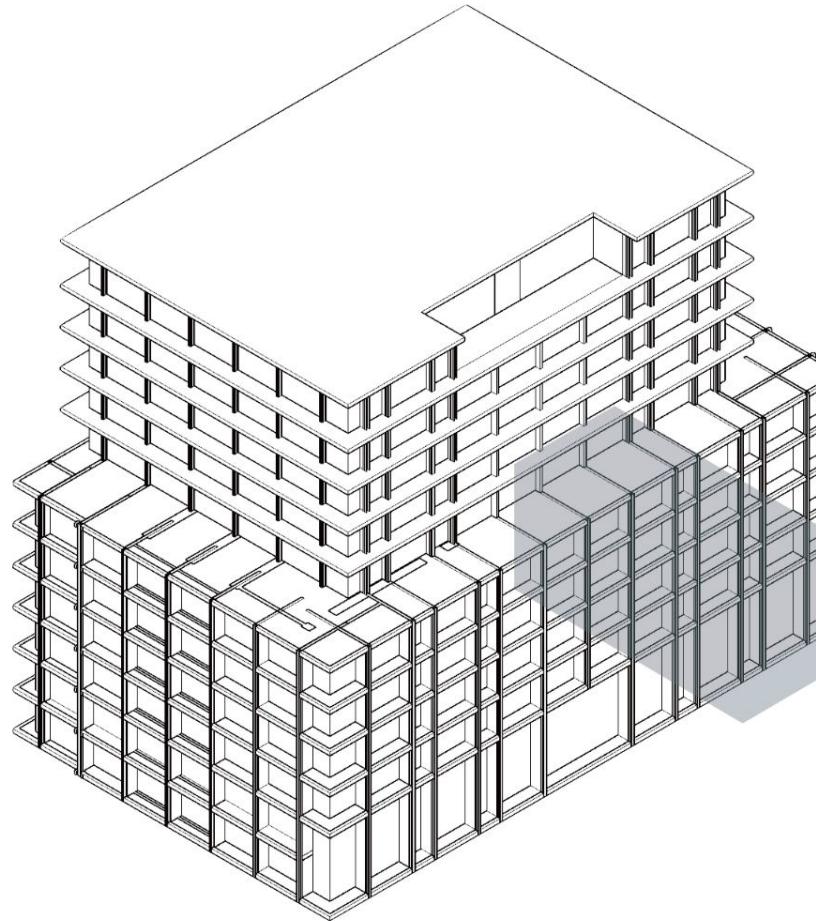
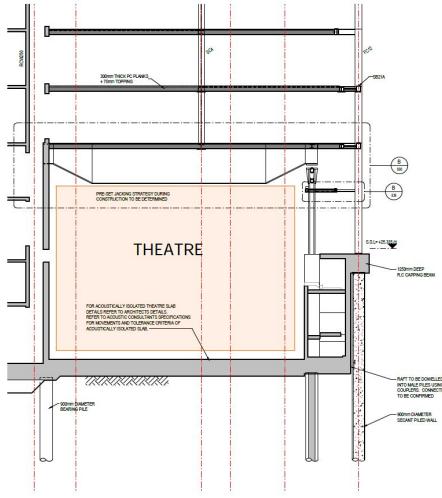


# Concept & brief | Structural and architectural requirements

Column-free span of  
13m on the top part  
of the building



## Concept & brief | Structural and architectural requirements



Theatre in the building:  
required to be  
independent and  
isolated to avoid  
transferring vibration

## Undergroun



I. Concept - architectural & structural

## **I. Material**

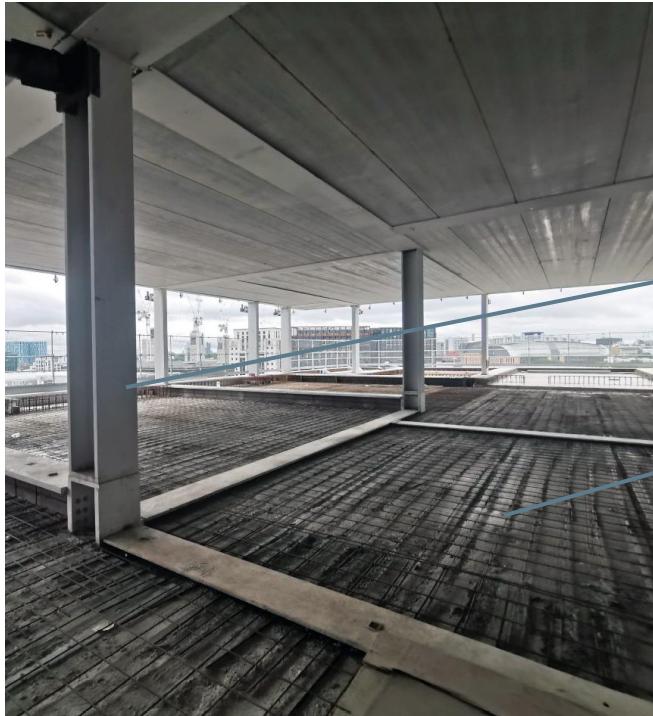
I. Structural system

I. Structural analysis - corner beam & roof cranked beam

I. Appraisal - sustainability & aesthetics



# Materials | Steel, concrete, glazing



Steel  
Structural I and  
H beam

Steel & concrete  
Slim floor system



Precast concrete  
Free-standing facade

Glazing

# Materials | Requirements & choices



## Steel

- 13 m column-free span
- relatively lightweight for its strength



## Pre-cast concrete

- reduces risk, saves time
- ensures quality and precision
- produced in large scale



## Concrete

- Steel and concrete together form slim slabs, which can bear weight effectively



## Glazing

- large glazing ratio provides better daylight penetration
- different g-value

# Materials | Sustainability



## Steel

- long lifecycle
- 100% recyclable



## Concrete

- hollow-core concrete
- reduced material consumption



## Pre-cast concrete

- less carbon emission
- saves time & materials
- more eco-friendly



## Glazing

- exploits solar gain
- reduces energy consumption
- recyclable

I. Concept - architectural & structural

I. Material

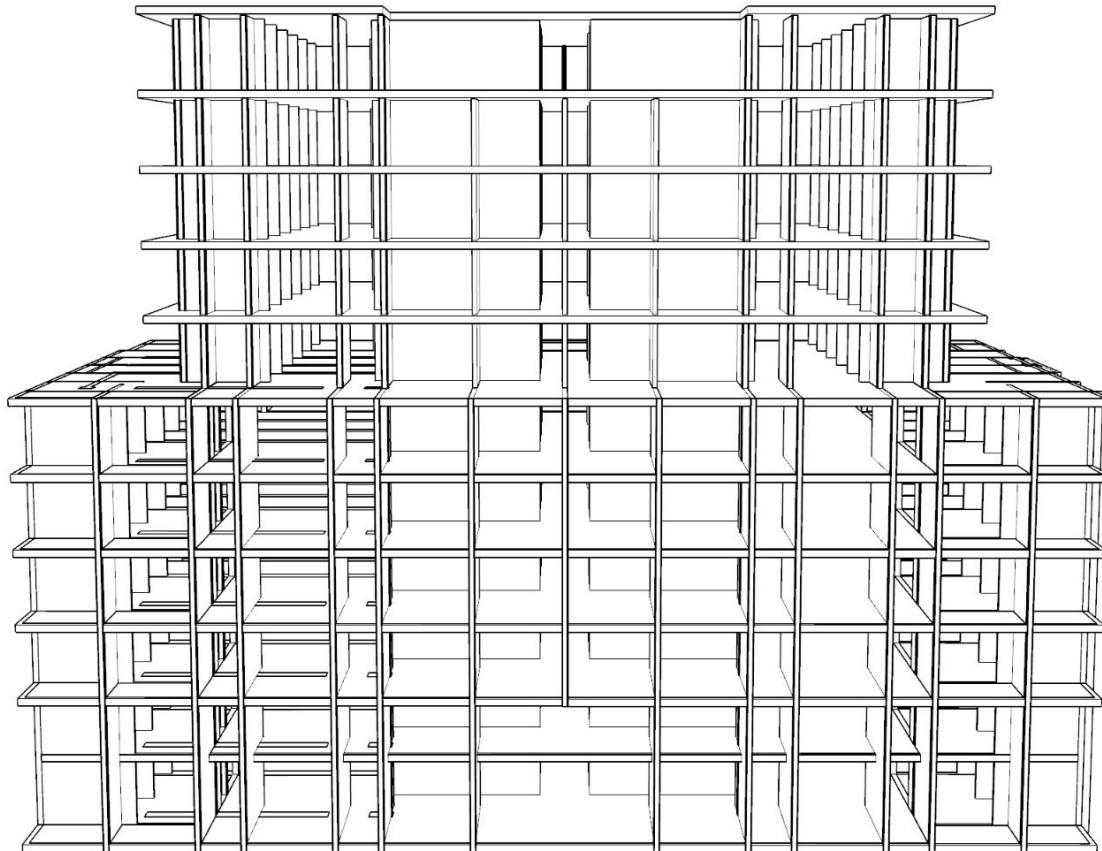
## **I. Structural system**

I. Structural analysis - corner beam & roof cranked beam

I. Appraisal - sustainability & aesthetics

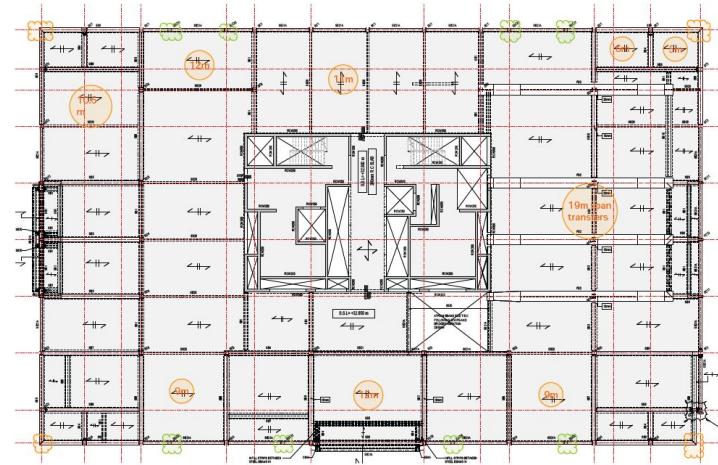
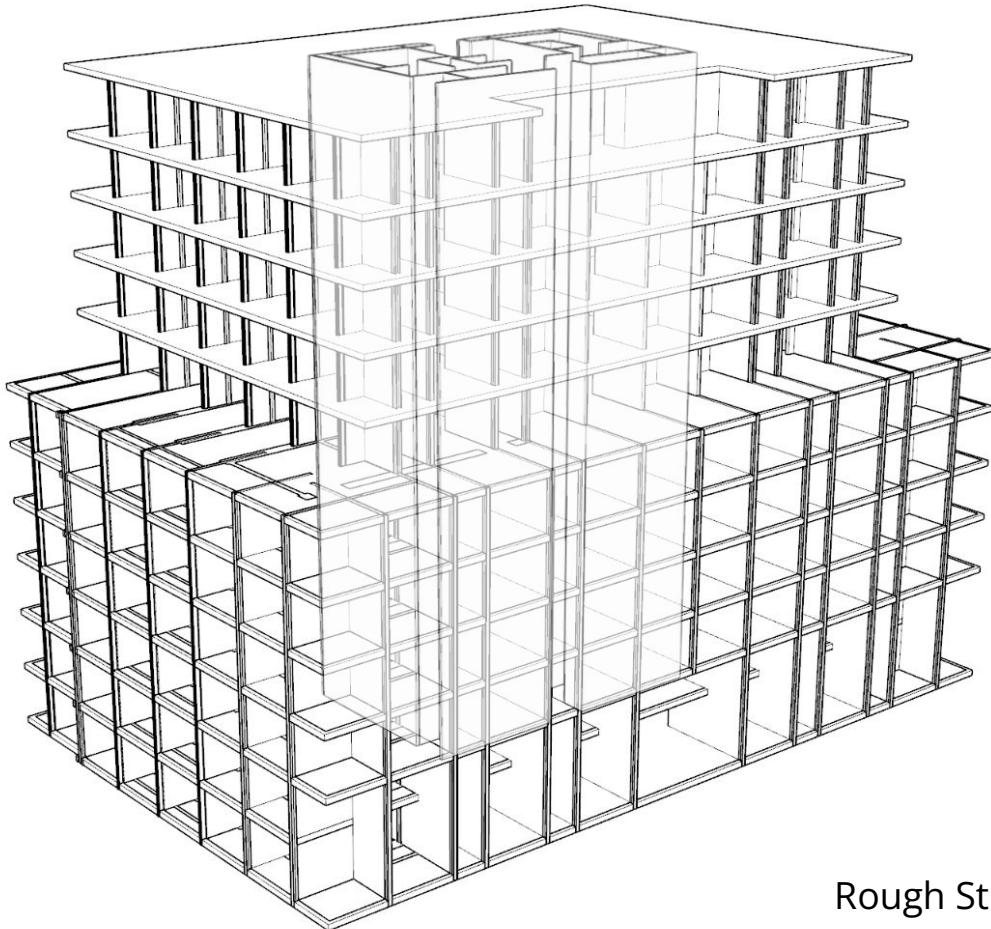


# Structure



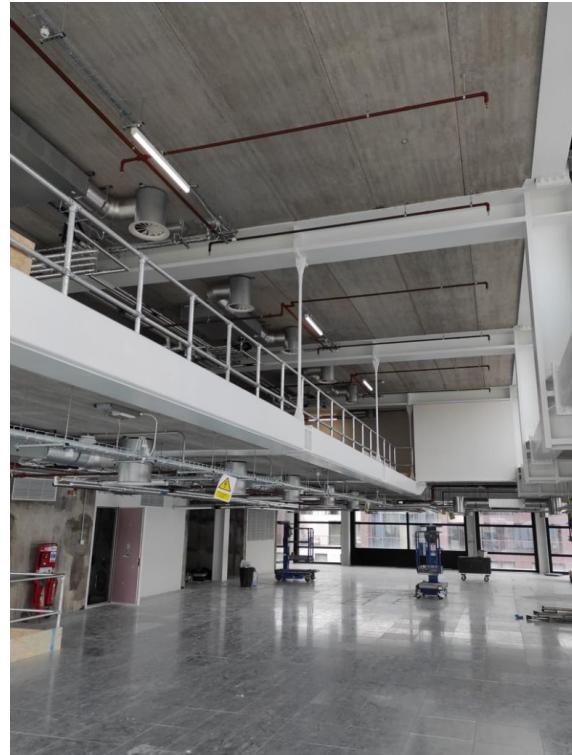
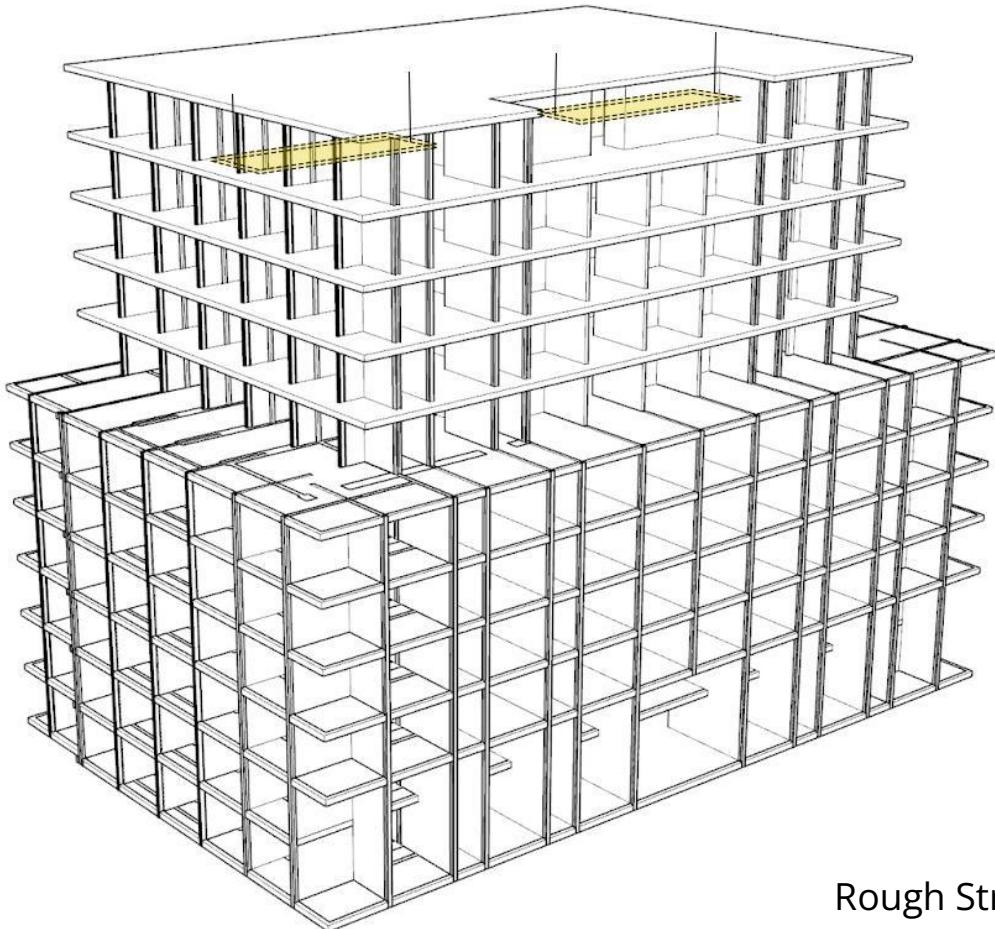
Rough Structural Model | Elevation with depth

# Structure | Layout



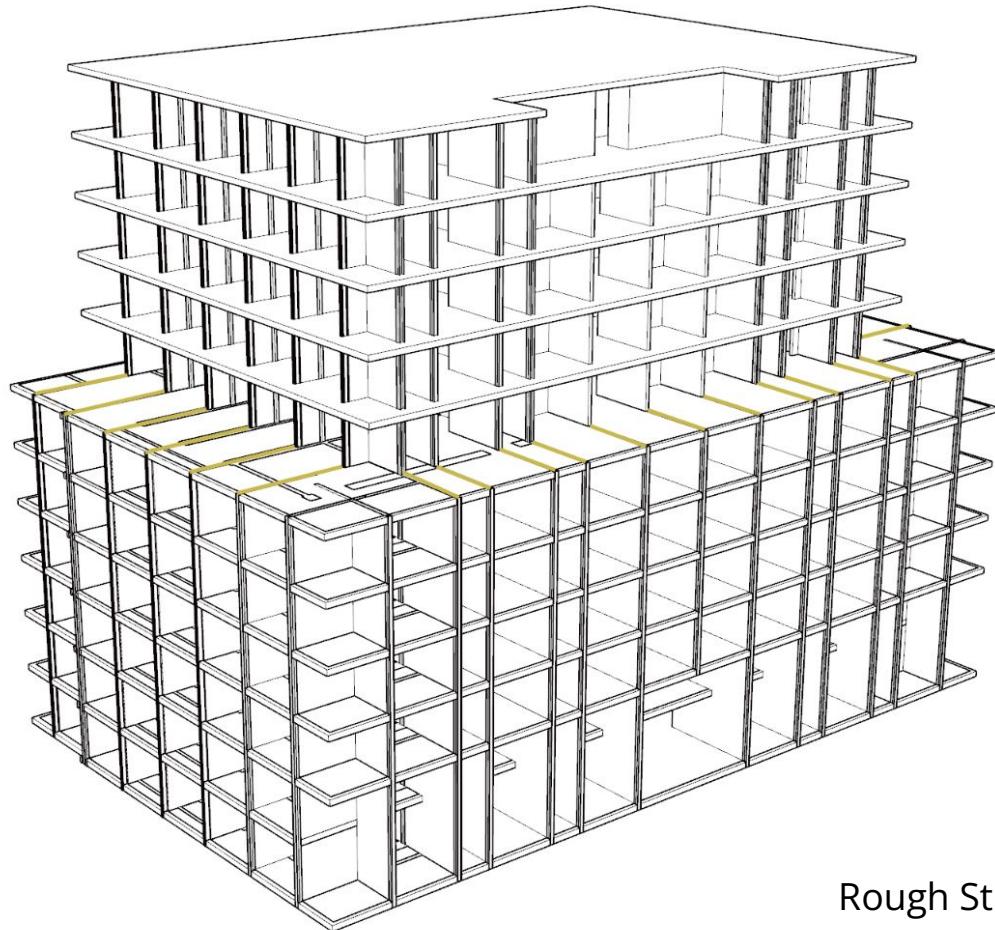
Rough Structural Model | Perspective without Windows

# Structure | Layout



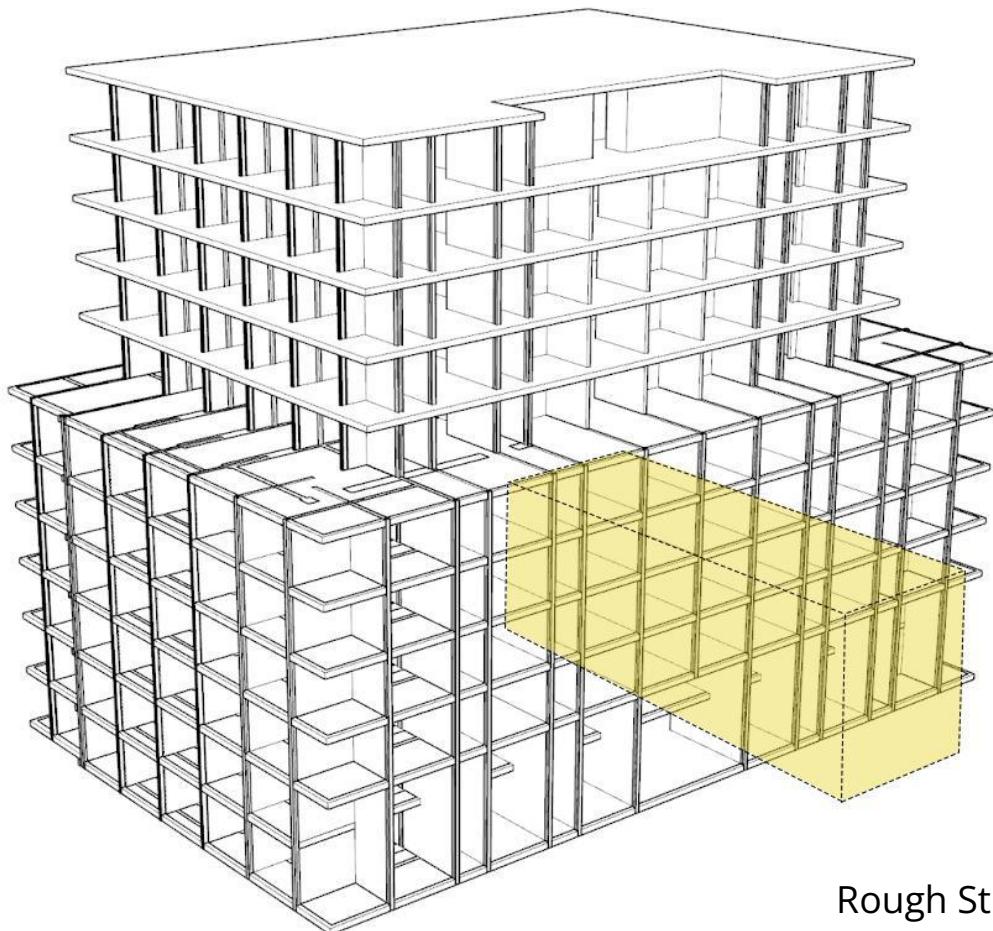
Rough Structural Model | Perspective without Windows

# Structure | Layout

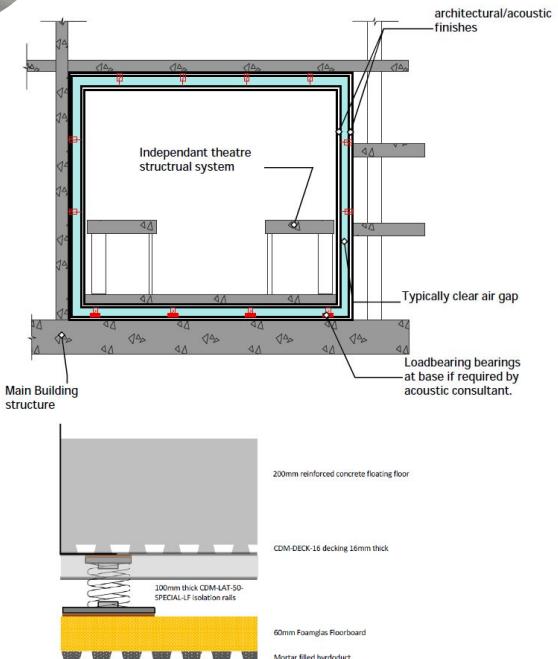


Rough Structural Model | Perspective without Windows

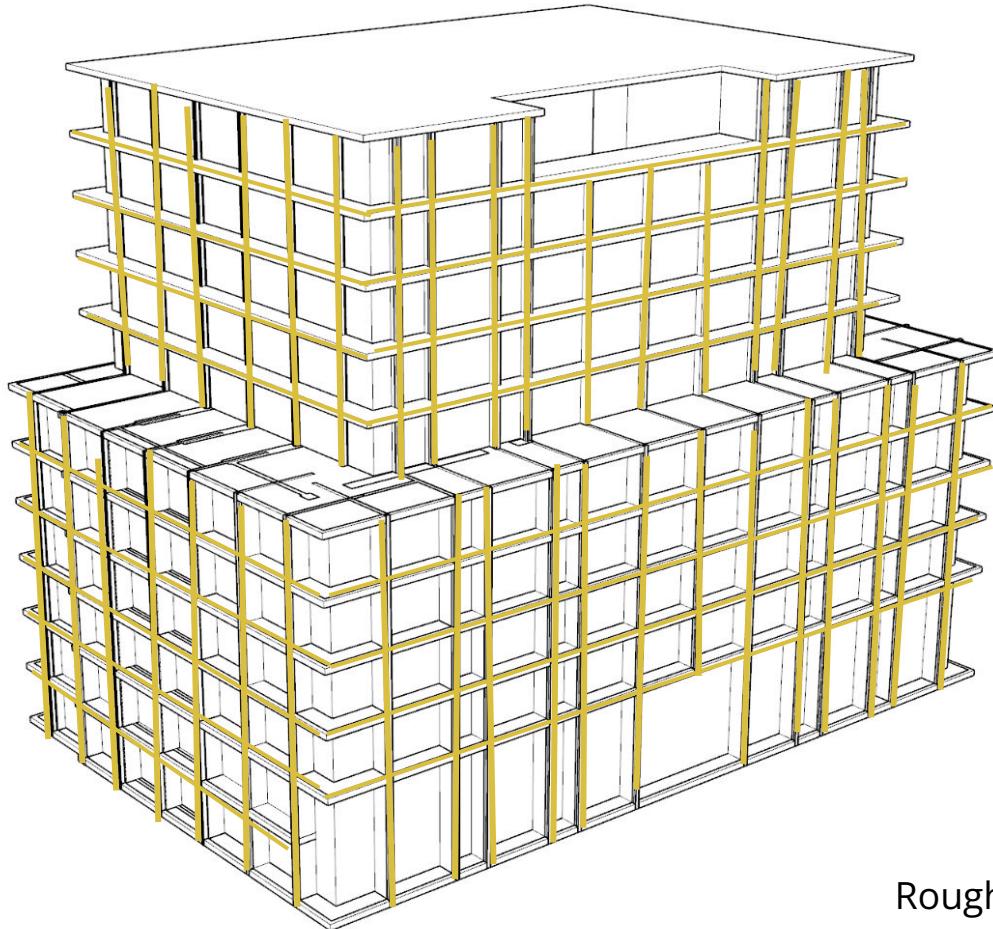
# Structure | Layout



Rough Structural Model | Perspective without Windows

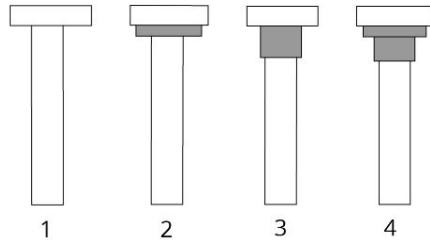


# Structure | Façade

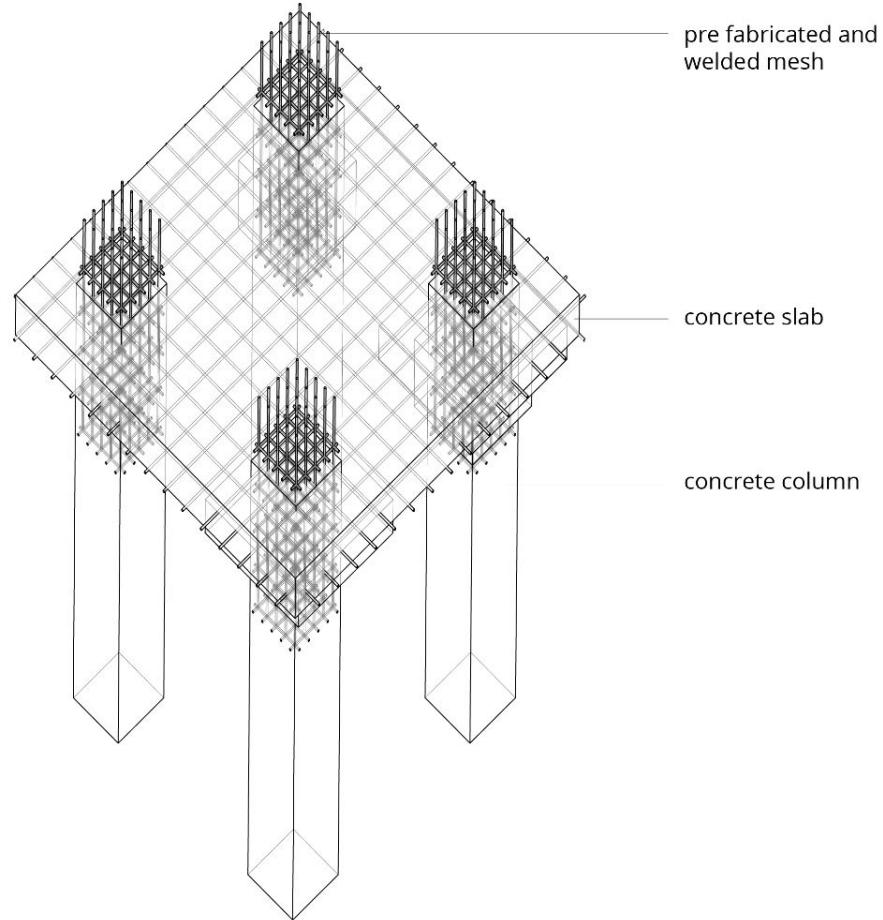


Rough Structural Model | Perspective with Windows

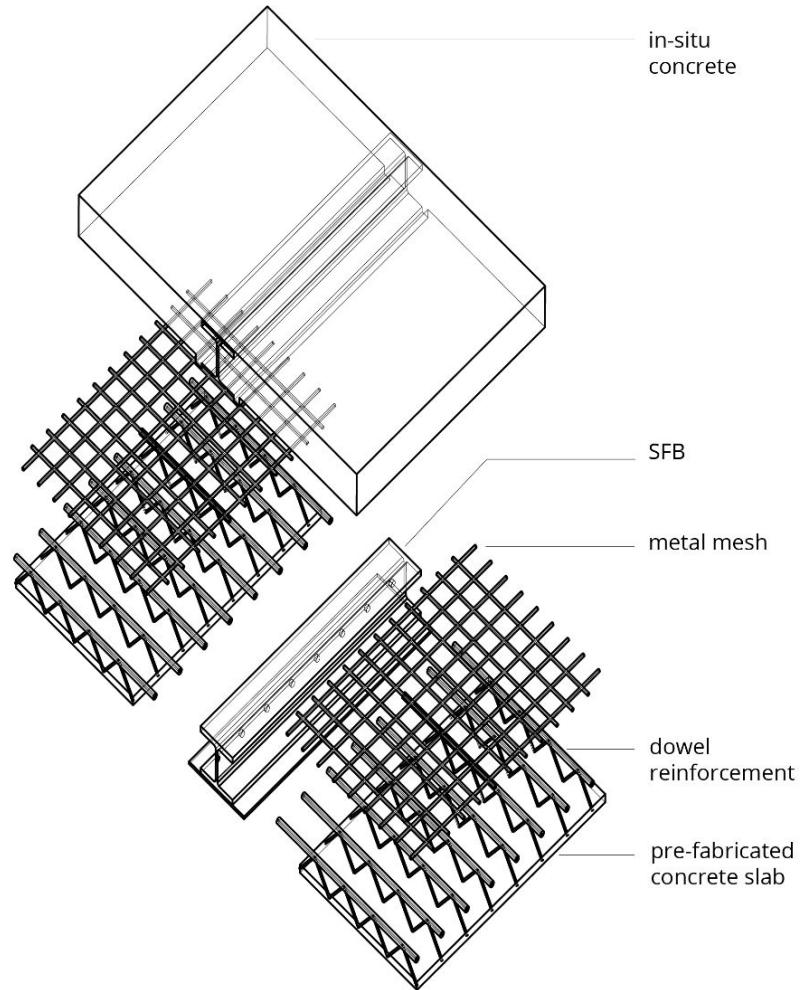
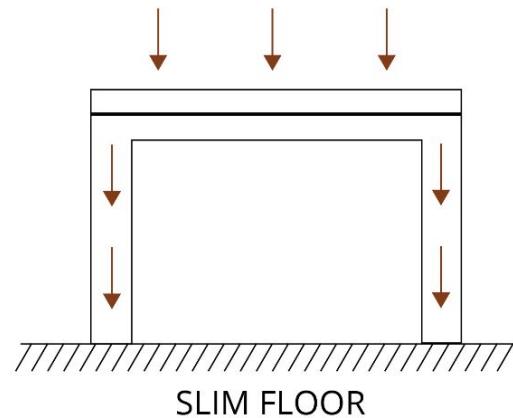
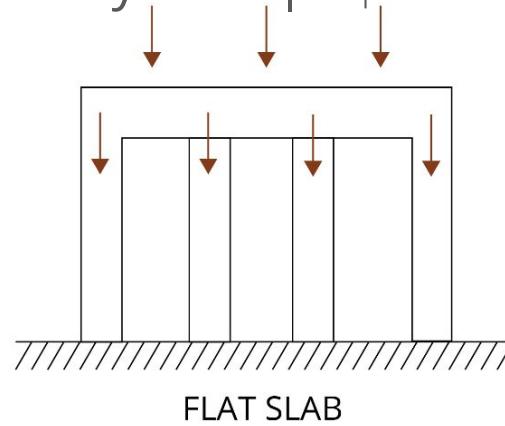
# Flat Slab System | In comparison to Slim Floor System



- 1 simple column
- 2 drop panels
- 3 column heads
- 4 drop panels and column heads



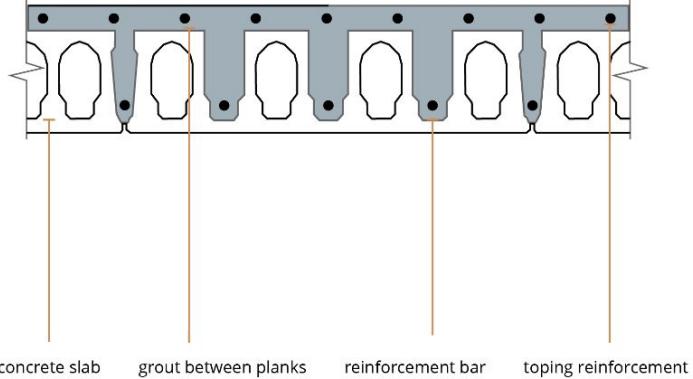
# Slim Floor System | Explanation



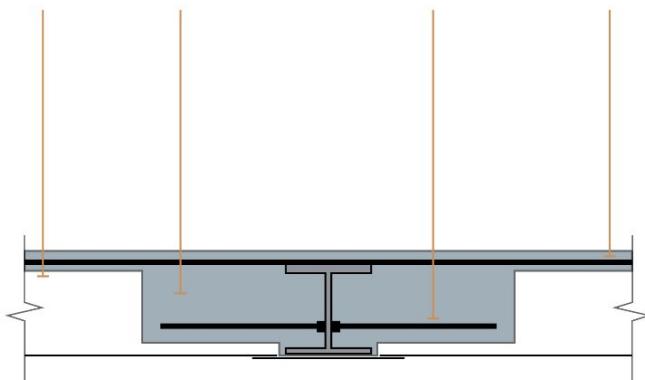
# Slim Floor System | In-situ details



SIDE SECTION

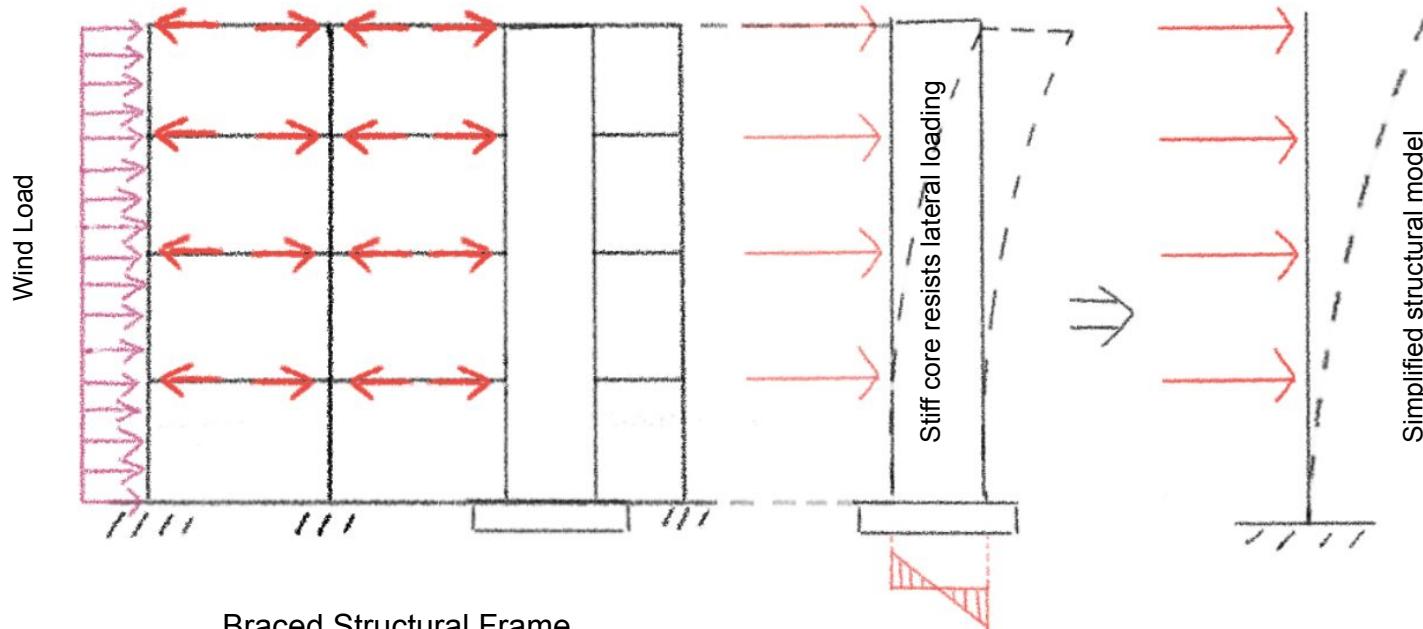


FRONT SECTION



# Structural Core | Explanation

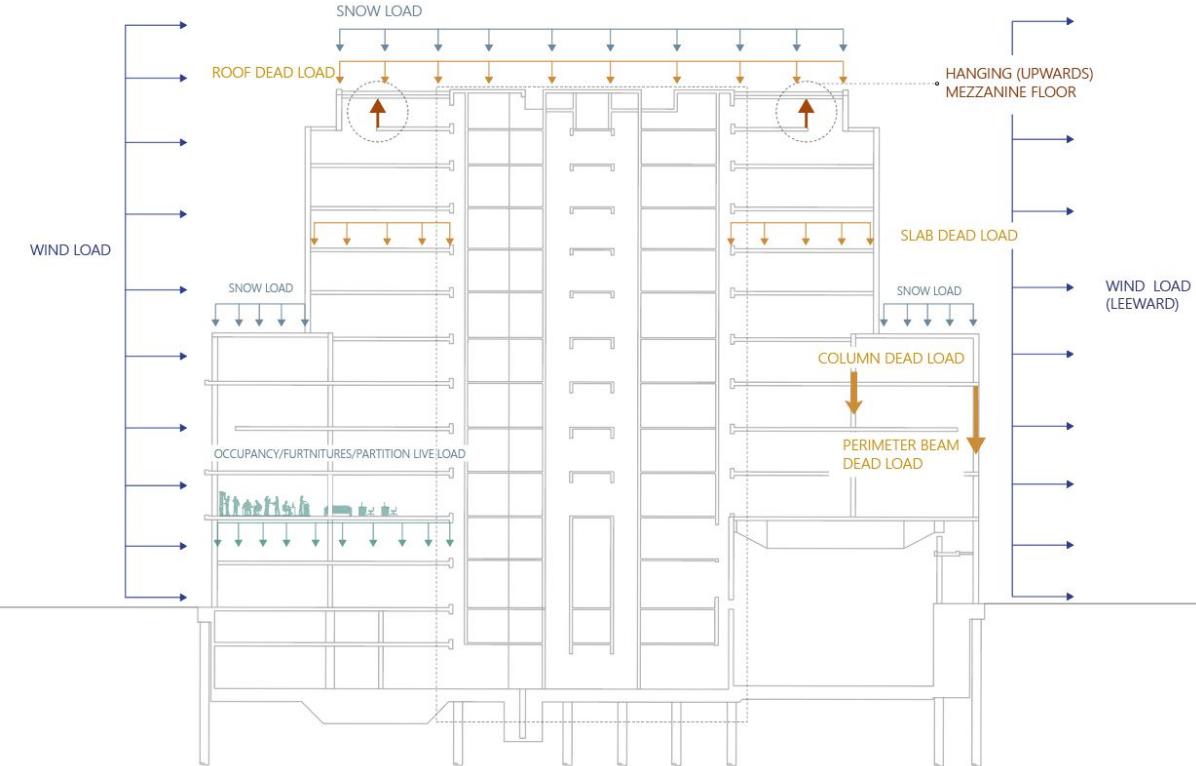
Floor slabs act as a stiff diaphragm transferring wind loads directly into core



Plot 2 is a reinforced concrete (RC) frame buildings with a core system.

The core acts like vertical cantilevers, providing the building's resistance to lateral loads such as wind.

# Loading Conditions



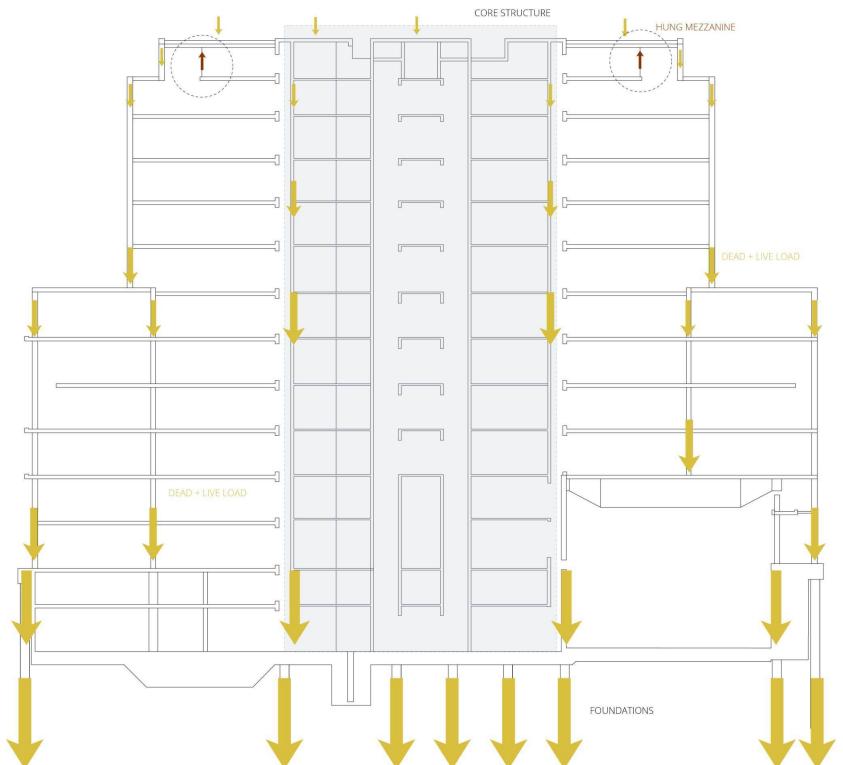
█ █ DEAD LOADS  
█ █ LIVE LOADS

## Known Load Condition

Snow Load	kN/m <sup>2</sup>	0.29
Wind Load	Windward (kN/m <sup>2</sup> )	0.83
	Leeward (kN/m <sup>2</sup> )	-0.52
Slabs on Mezz Level/Floors	Dead Load (kN/m <sup>2</sup> )	6.5
	Live load (kN/m <sup>2</sup> )	3
	Total (kN/m <sup>2</sup> )	9.5
Slabs on Roof	Dead Load (kN/m <sup>2</sup> )	8.75
	Live load (kN/m <sup>2</sup> )	0.75
	Total (kN/m <sup>2</sup> )	9.5
Slabs on Corner Free Column Beam	Dead Load (kN/m <sup>2</sup> )	12.6
	Live load (kN/m <sup>2</sup> )	3
	Curtain Wall Cladding (kN/m)	4.1

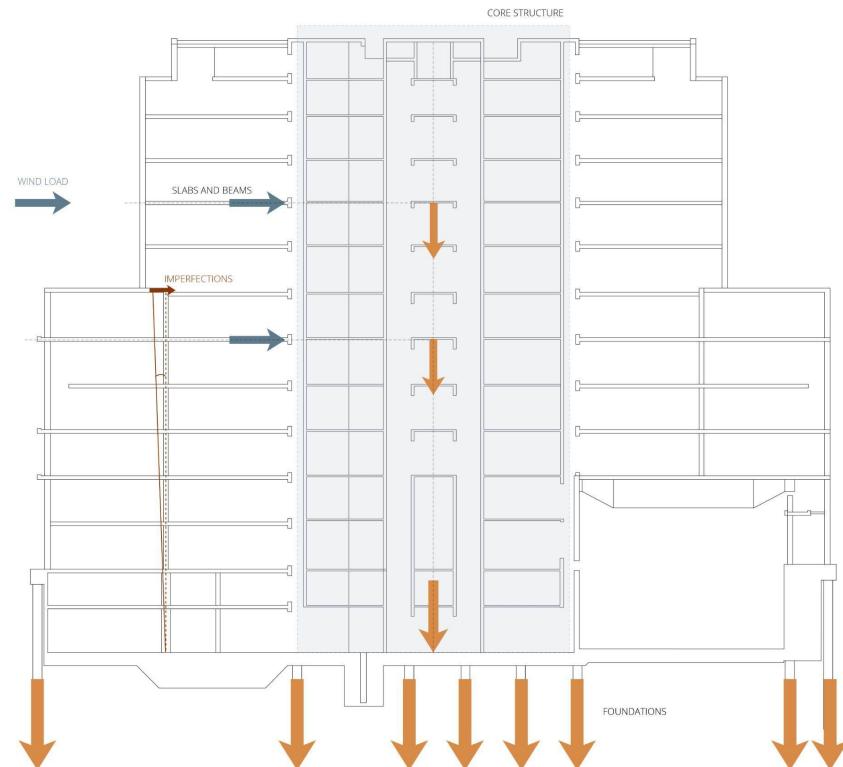
# Load Path | Main structure

Vertical Load

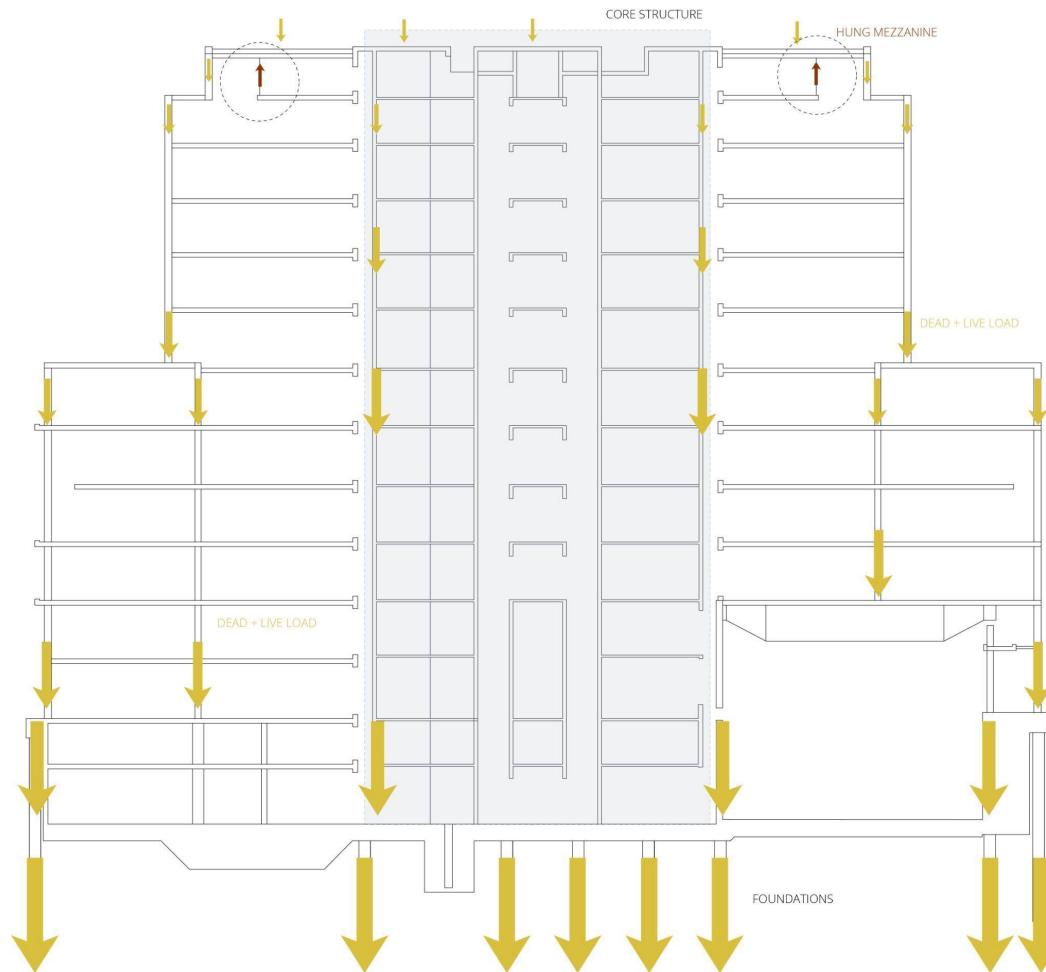


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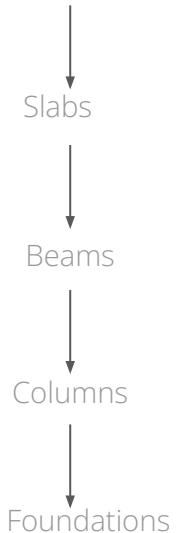
Horizontal Load



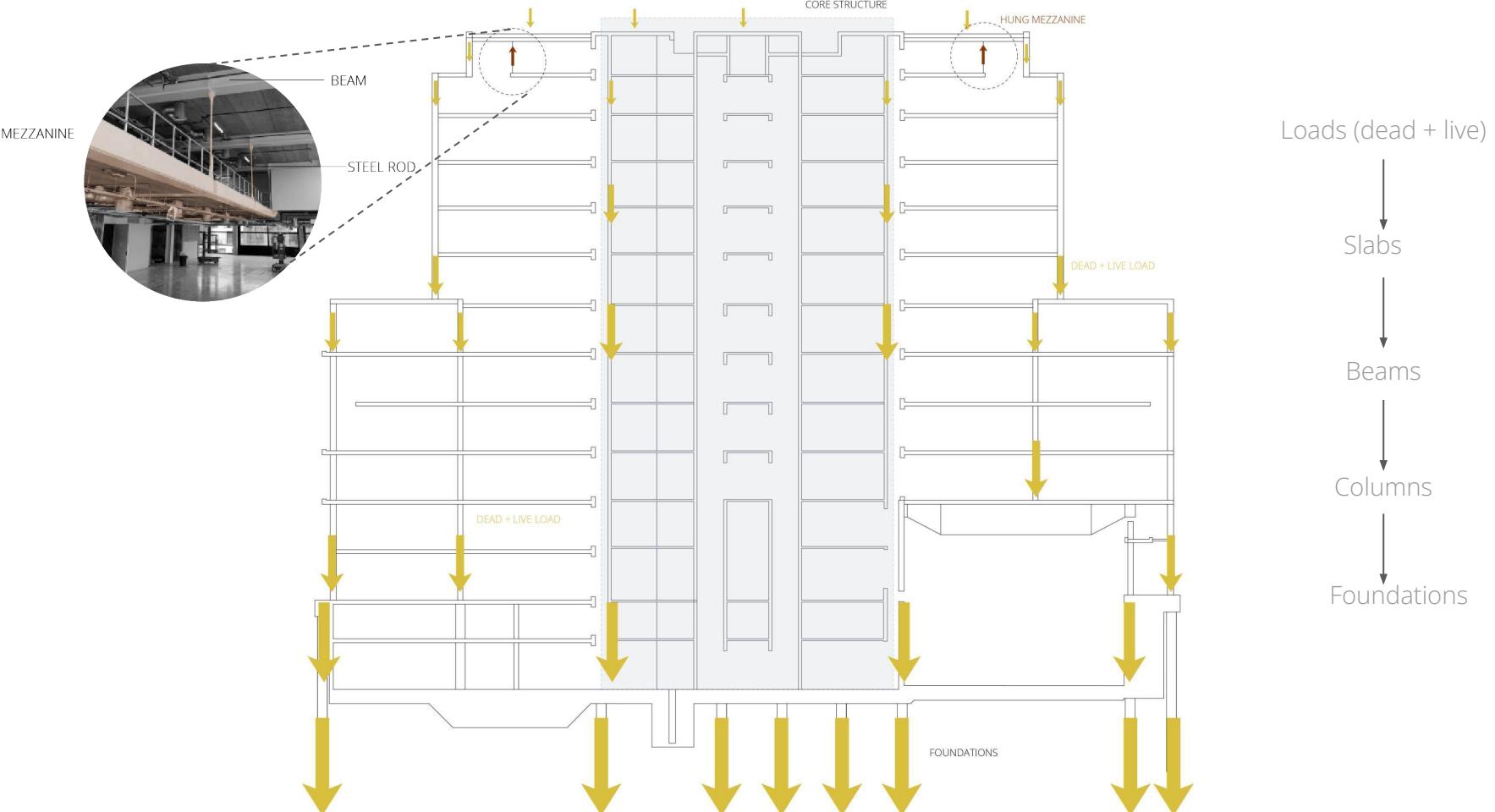
# Load Path | Main structure - Vertical Load



Loads (dead + live)

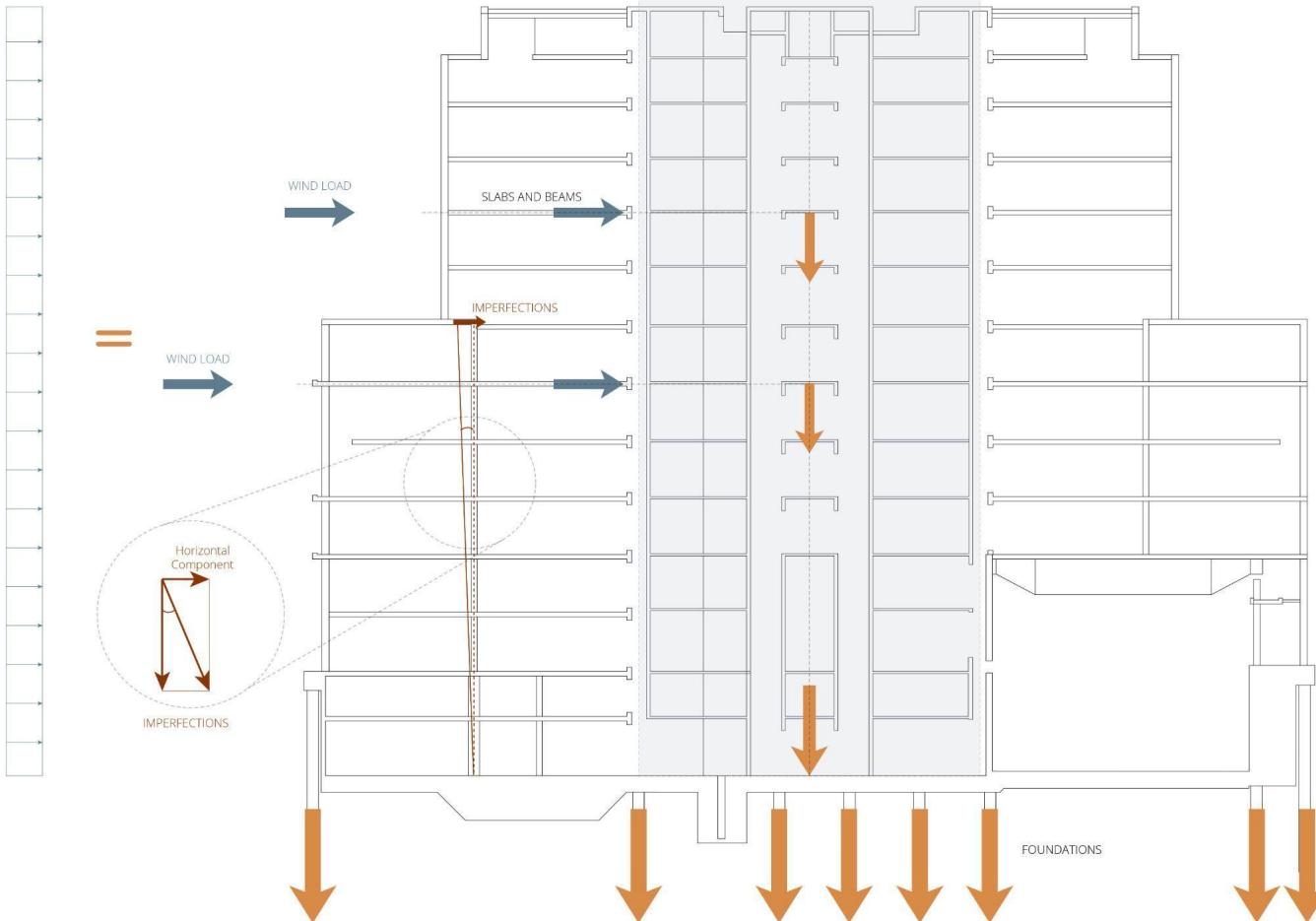


# Load Path | Main structure - Vertical Load



# Load Path | Main structure - Horizontal Load

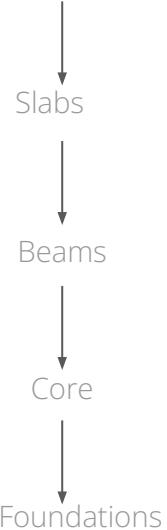
WIND LOAD



CORE STRUCTURE

FOUNDATIONS

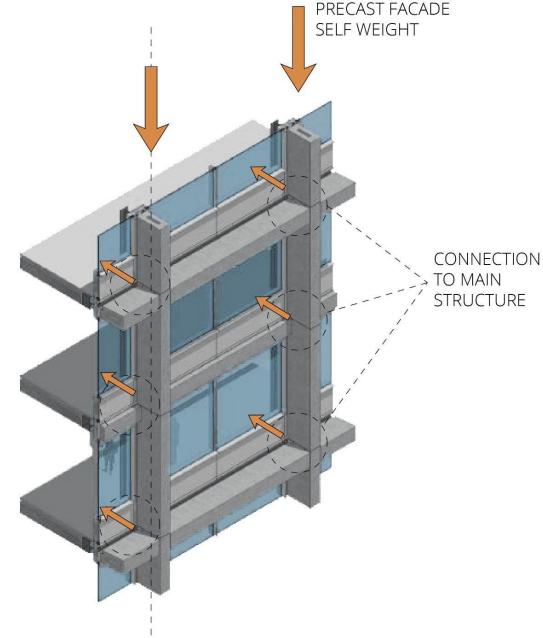
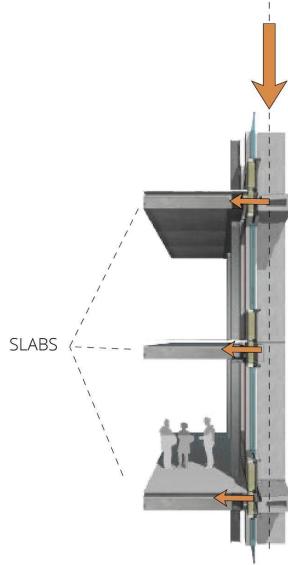
Loads (wind + imperfection)



# Load Path | Self-supporting Facade



- Facade design was an architectural requirement.
- Structural challenge as the structure would be too heavy.
- Solution proposed was a self-supporting structure.



## Benefits:

1. Main structure is not loaded by the weight of the facade.
2. Main structure can be slimmer. Less material: More cost-effective + more sustainable.

- I. Concept - architectural & structural
- I. Material
- I. Structural system
- I. *Structural analysis - corner beam & roof cranked beam***
- I. Appraisal



# Corner Beam | Imposed force & torsion

## I. Loads

Load type	Elements	Load (kN/m <sup>2</sup> )	Length of influence (m)	Load (kN/m)
Dead load	planks	6.2	2.3	33.1
	RC topping	1.9		
	SIDL	1.5		
Live load		3	5.3	70.9
overall		12.6	2.1	31.8
	Curtain wall	Load (kN/m)		
Dead load	Curtain wall	4.1		

Loading on the roof (UDL)

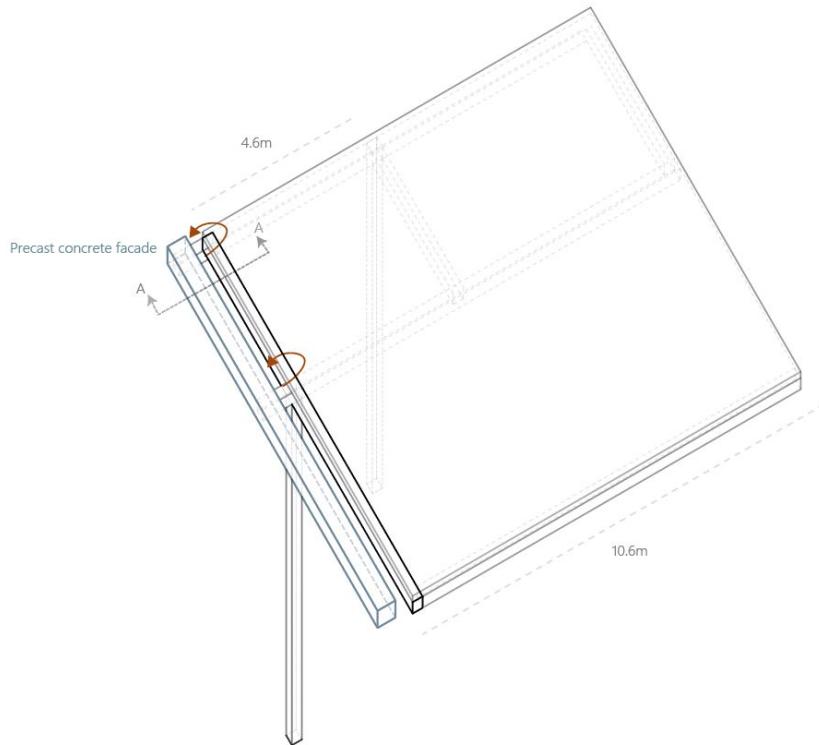
Load type	Elements	Load (kN)	Offset of load (m)	Moment at tip (kNm)
Dead load	Precast concrete facade	35	1.09	40

Load - precast concrete facade (torsion)

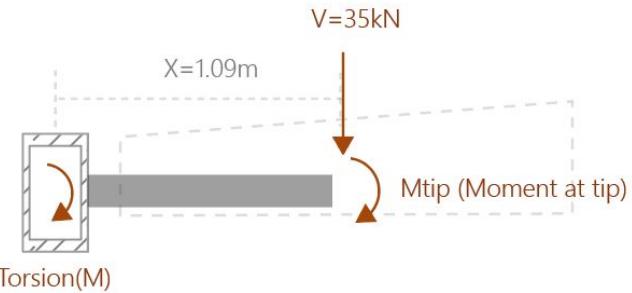


# Corner Beam | Diagrams

Calculation of torsion:



Section AA



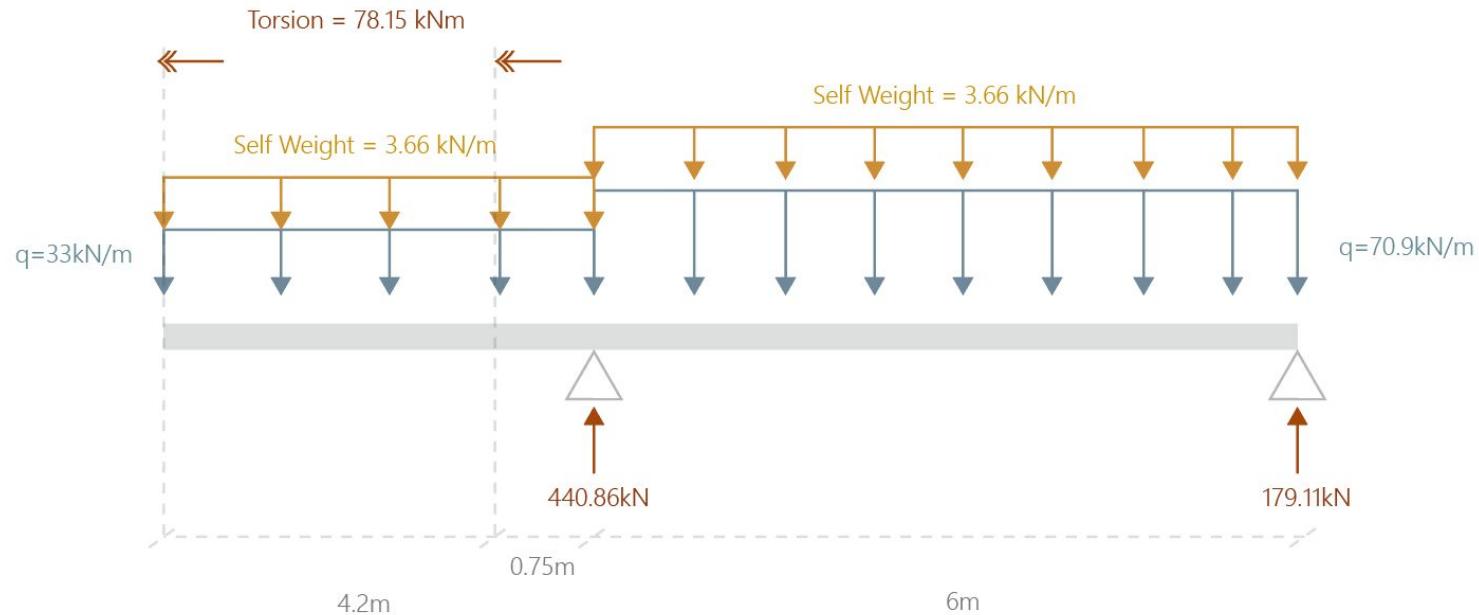
$$M = V \cdot x + M_{tip}$$

$$= 35\text{kN} \cdot 1.09\text{m} + 40\text{kNm}$$

$$= 78.15\text{kNm}$$

# Corner Beam | Diagrams

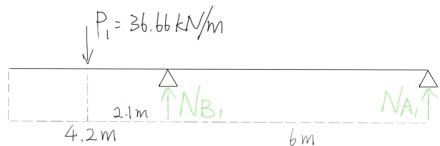
Calculation regarding distributed loads



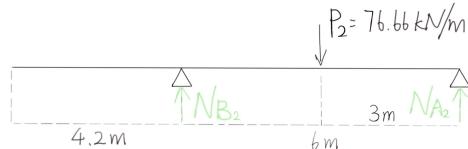
# Corner Beam | Diagrams

Calculation regarding distributed loads

Scenario 1:



Scenario 2:



To get the reaction forces (self-weight at left):

$$V \downarrow +, \quad P_1 - N_{A1} - N_{B1} = 0$$

$$M \leftarrow +, -P_1 \times 4.2m \times (2.1 + 6)m + N_{B1} \times 6m = 0$$

$$N_{A1} = -53.89\text{kN}$$

$$N_{B1} = 207.86\text{kN}$$

To get the reaction forces (self-weight at right):

$$V \downarrow +, \quad P_2 - N_{A2} - N_{B2} = 0$$

$$M \leftarrow +, -P_2 \times 6m \times 3m - N_{A2} \times 6m = 0$$

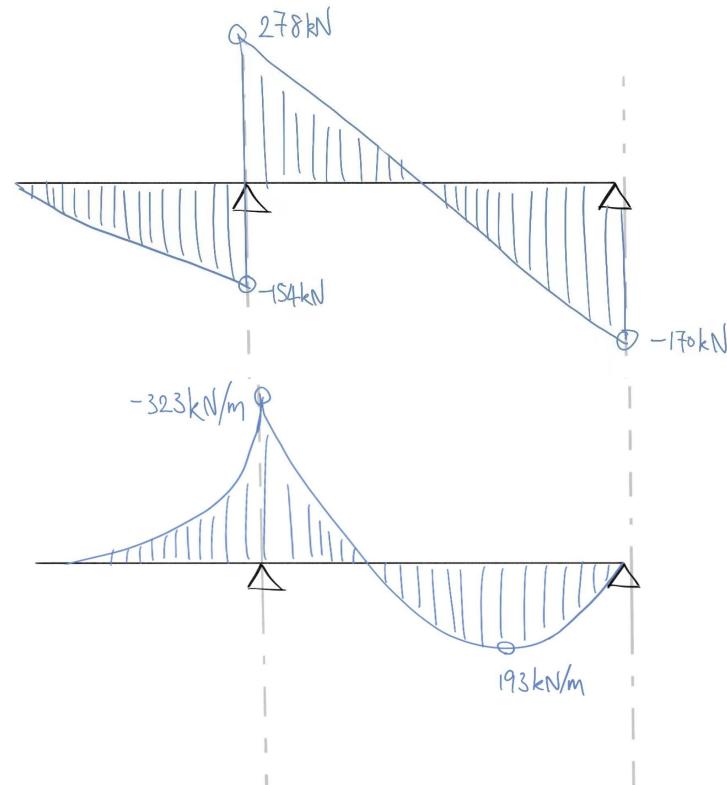
$$N_{A2} = 38.83\text{kN}$$

$$N_{B2} = 427.13\text{kN}$$

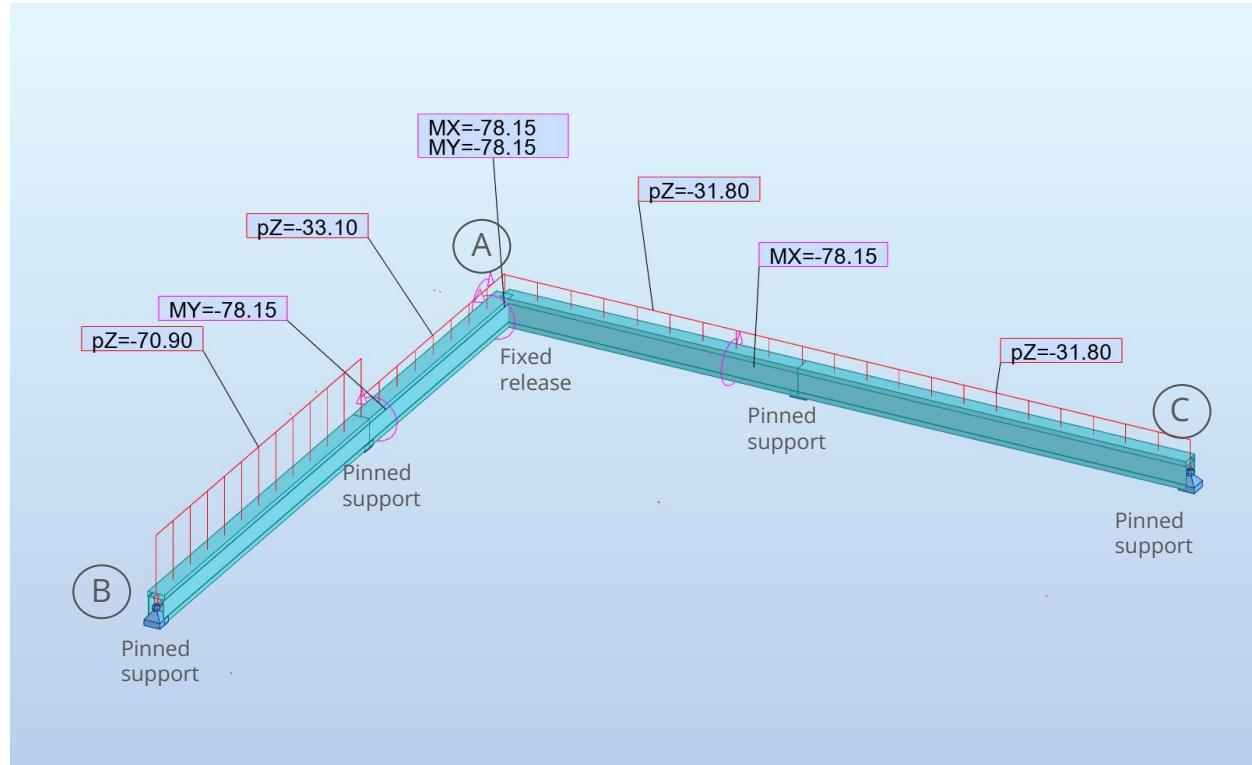
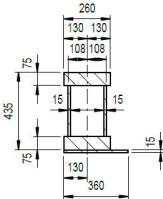
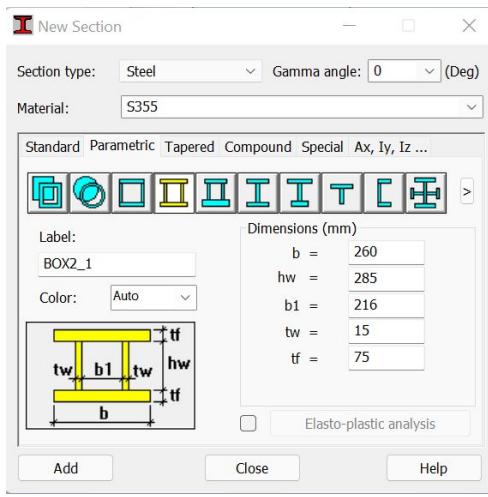
Therefore, the total reaction forces:

$$N_A = -15.06\text{kN}$$

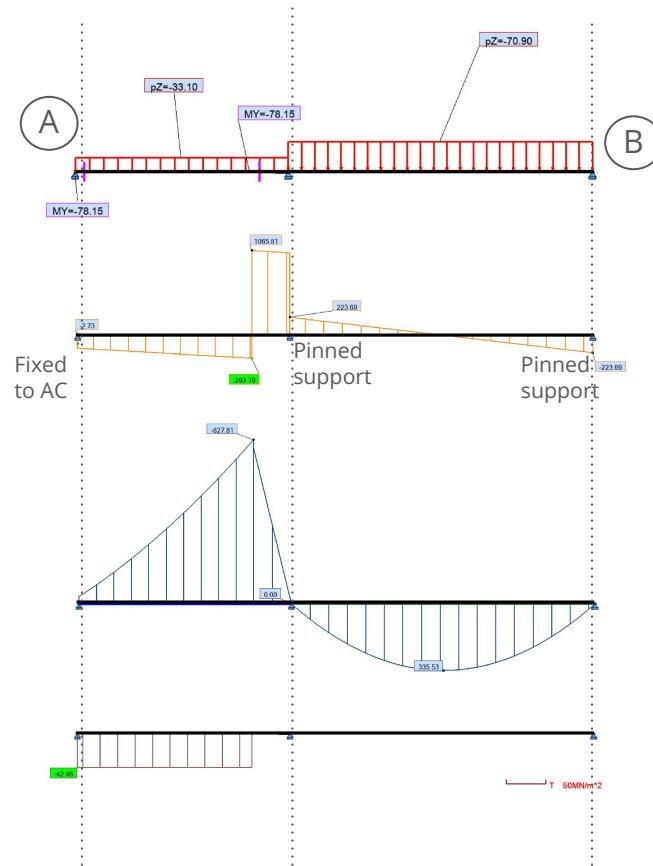
$$N_B = 634.99\text{kN}$$



# Corner Beam | Simulation



# Corner Beam | Diagrams



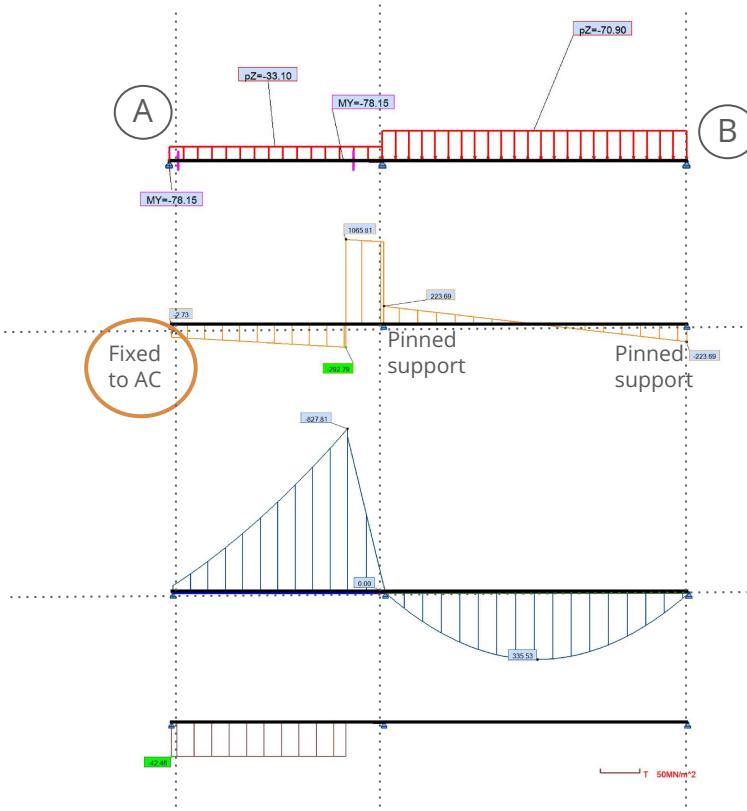
Applied load

Shear force

Moment

Torsional stress

# Corner Beam | Diagrams



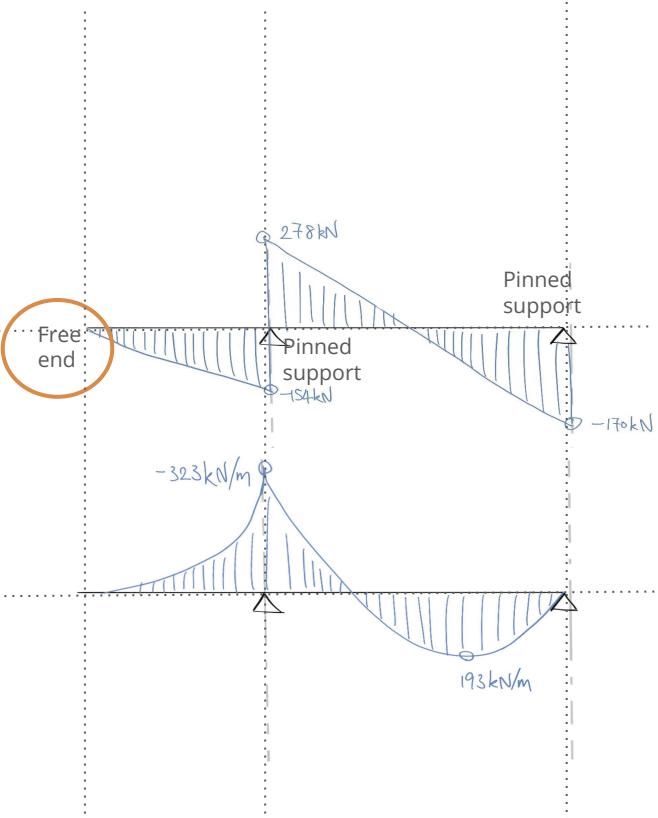
Diagrams of beam AB considering orthogonal beam AC

Applied load

Shear force

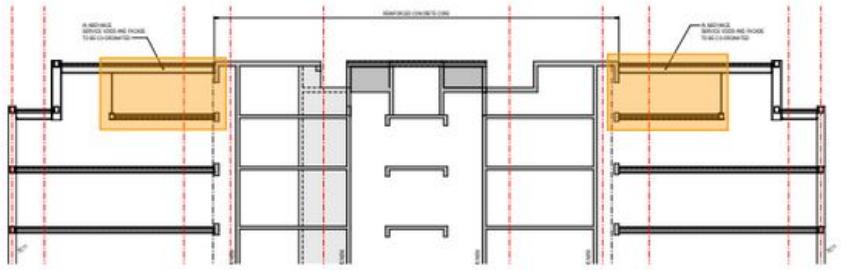
Moment

Torsional stress



Diagrams of beam AB without orthogonal beam AC

# Roof Cranked Beam | Stiffness method



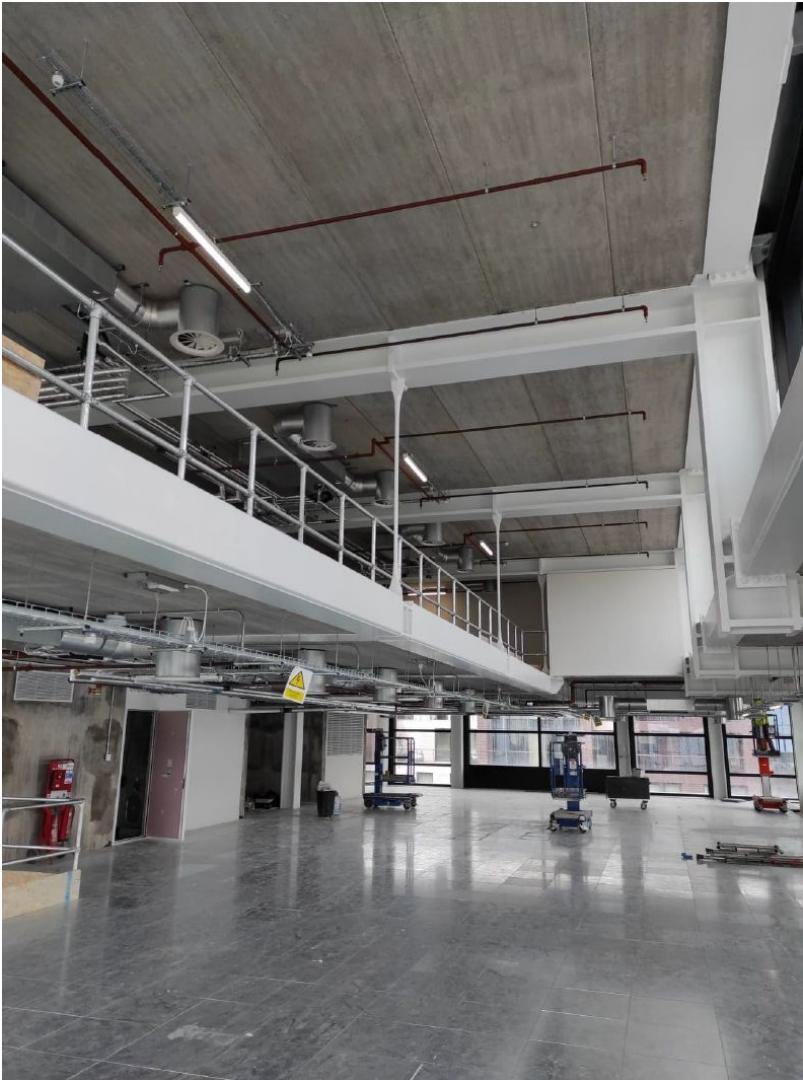
# Roof Cranked Beam | Stiffness method

Load type	Elements	Load (kN/m <sup>2</sup> )	Slab width (m)	Load (kN/m)
Dead load	planks	3.1	6	
	RC topping	1.9		
	SIDL	3.75		
Live load		0.75		
	overall	9.5		57

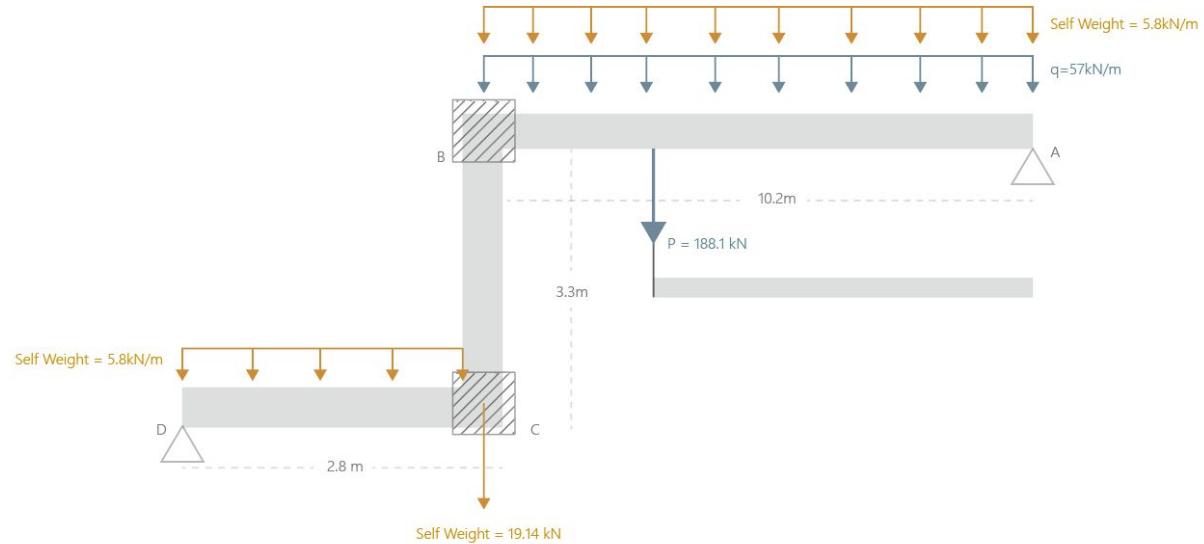
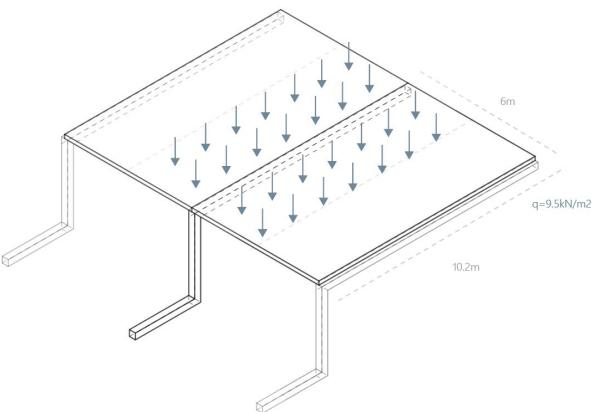
Loading on the roof (UDL)

Load type	Elements	Load (kN/m <sup>2</sup> )	Area to hang (m <sup>2</sup> )	Load (kN)
Dead load	planks	3.1	19.8	
	RC topping	1.9		
	SIDL	1.5		
Live load		3		
	overall	9.5		188.1

Load - hung mezzanine level (point load)

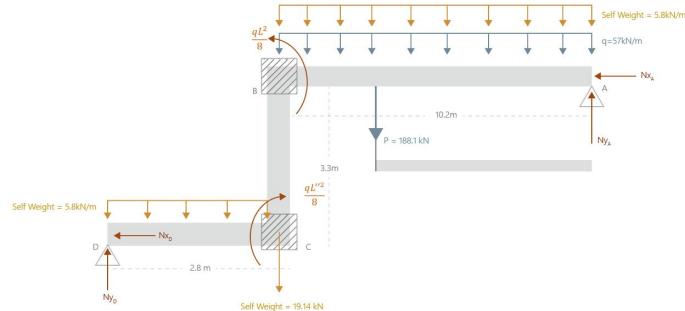


# Roof Cranked Beam | Loadings



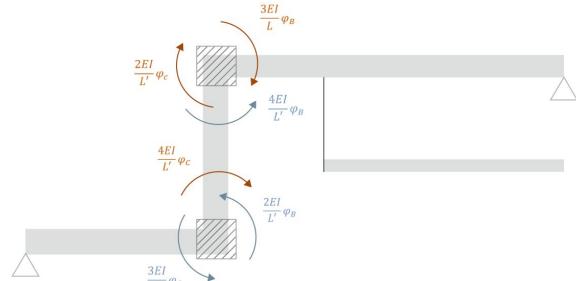
# Roof Cranked Beam | Stiffness method

## I. Loads



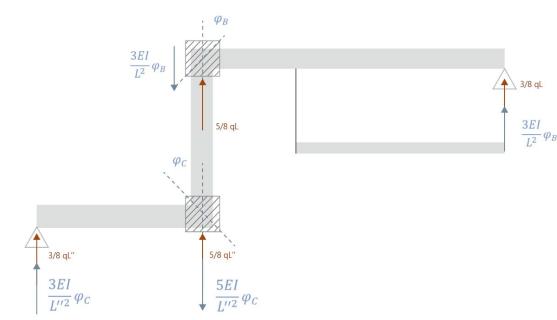
Reaction forces

## II. Rotation



- Relation to B
- Relation to C

## III. Shear Force - Load + Rotation



- Load
- Rotation

# Roof Cranked Beam | Overall

## Calculations

To get the bending moment at B and C(Stiffness Method):

$$\text{Dead Load} = 3.1 + 1.9 + 3.75 = 8.75 \text{ kN/m}$$

$$\text{Live Load} = 0.75 \text{ kN/m}$$

$$\text{Beam Load} = 7850 \text{ kg/m}^3 \times 9.81 \text{ N/kg} \times 0.0754 \text{ m}^2 = 5.8 \text{ kN/m}$$

$$q = (8.75 + 0.75) \times 6 + 5.8 = 62.8 \text{ kN/m}$$

$$EI = 2.1 \times 10^5 \text{ MPa} \times 5.82 \times 10^9 \text{ mm}^4 = 1.22 \times 10^9 \text{ Nm}^2$$

Scenario 1 – UDL at AB

$$\frac{qL^2}{8} + \frac{3EI}{L} \varphi_B - \frac{4EI}{L'} \varphi_B + \frac{2EI}{L'} \varphi_C = 0 \quad ①$$

Scenario 2 – UDL at CD

$$\frac{qL''^2}{8} + \frac{3EI}{L''} \varphi_C - \frac{4EI}{L'} \varphi_C + \frac{2EI}{L'} \varphi_B = 0 \quad ②$$

$$\varphi_A = 4.75 \times 10^{-7} \text{ kNm}$$

$$\varphi_B = 1.72 \times 10^{-6} \text{ kNm}$$

## Reaction forces summary

At A	Horizontal (Nx A)	<b>0</b> kN
	Vertical (Ny A)	<b>308.5</b> kN
At B	Horizontal (Nx B)	<b>0</b> kN
	Vertical (Ny B)	<b>461</b> kN
	Moment(MB)	<b>752.1</b> kN/m
At C	Horizontal (Nx C)	<b>0</b> kN
	Vertical (Ny C)	<b>-1260</b> kN
	Moment(MC)	<b>1116</b> kN/m
At D	Horizontal (Nx A)	<b>0</b> kN
	Vertical (Ny D)	<b>864.3</b> kN

To get the reaction force at A and B (caused by the point load P):

$$V \downarrow +, \quad P - N_A - N_B = 0$$

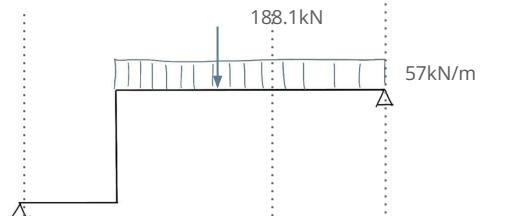
$$M \leftrightarrow +, \quad P \times 4\text{m} - N_A \times 10.2\text{m} = 0$$

$$N_A = 73.77 \text{ kN}$$

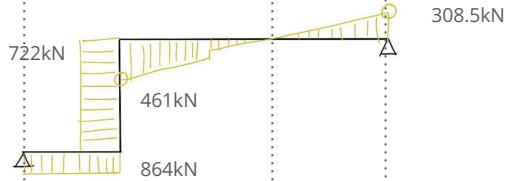
$$N_B = 114.34 \text{ kN}$$

# Roof Cranked Beam | results

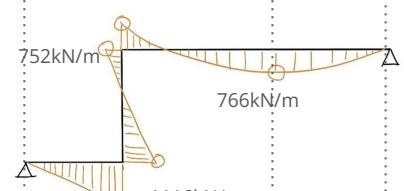
Applied load



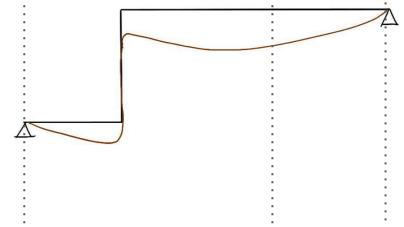
Shear force



Moment



Deformation

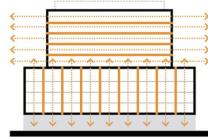
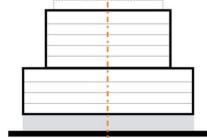
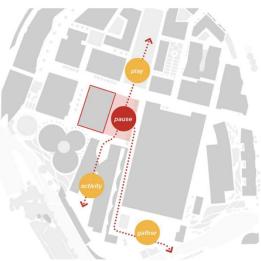
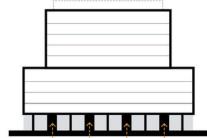
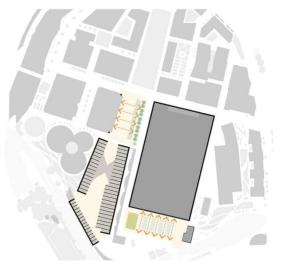


- I. Concept - architectural & structural
- I. Material
- I. Structural system
- I. Structural analysis - corner beam & roof cranked beam

## ***I. Aesthetics & Appraisal***



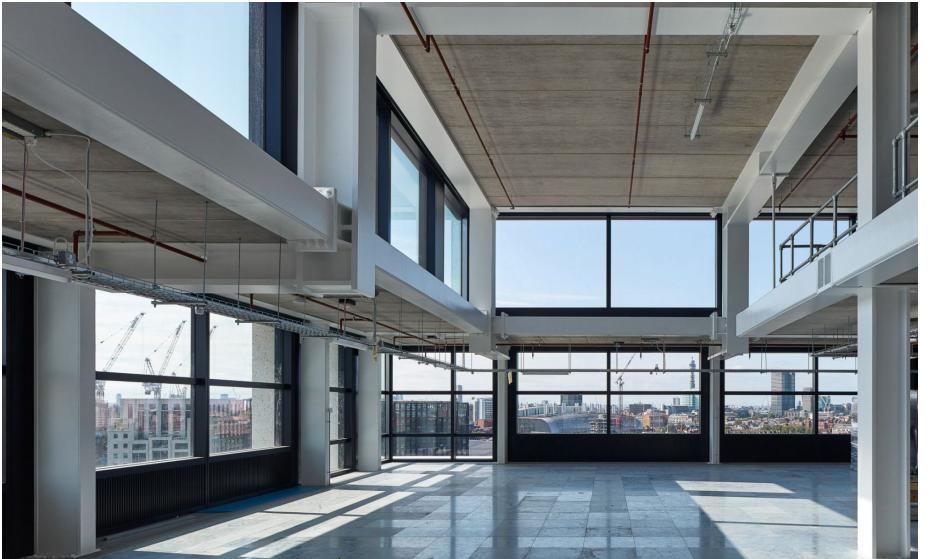
# Aesthetics | Coherence with the surroundings



# Aesthetics | Privacy & public space



# Aesthetics | Environmental Integration



Provision of daylight and sunlight



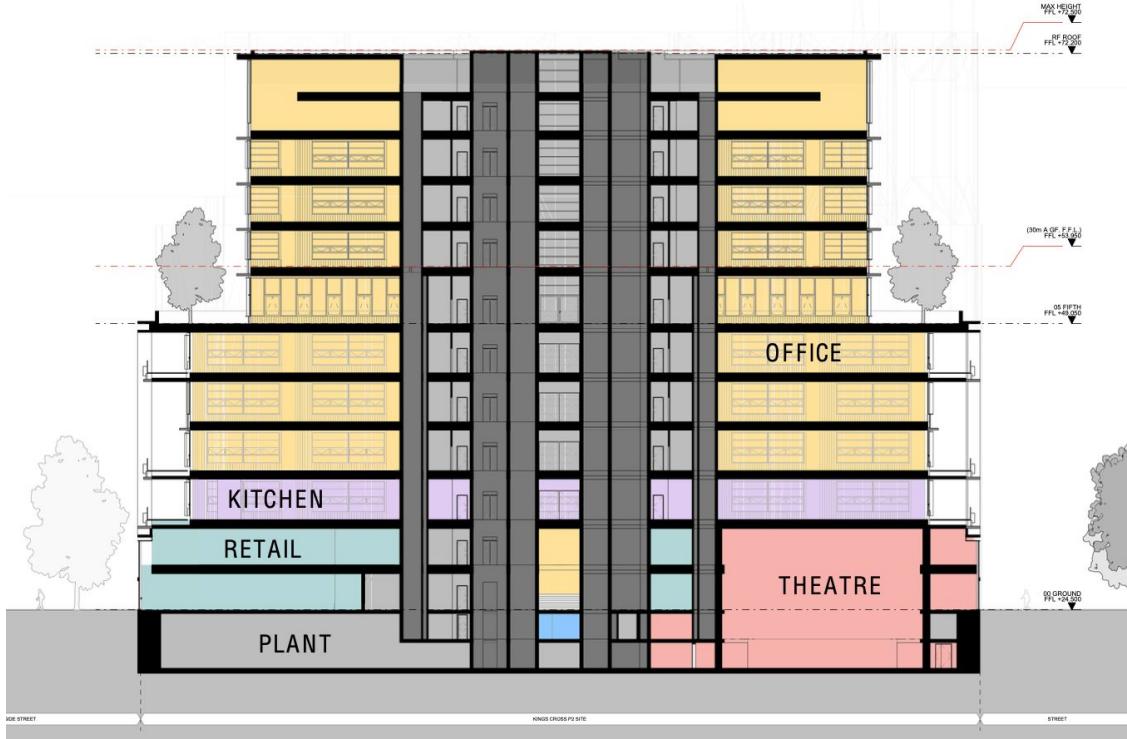
Deep precast concrete facade  
provides shading

# Aesthetics | Flexibility



Large floor plates of generous height  
create flexible working environments

# Appraisal



- Multi-purpose
- Column-free corners
- Precast facade
- Slim slab systems
- All in all, a nice building :D

Thank you

