



Sustainability challenges in the structural design of contemporary high-rise buildings

Sustainable High-rise Construction: The Nordics Perspective
Prof. David Ruggiero
EPFL-CONSTRUCT
Switzerland

30 January, 2024



Stefano Boeri



IMPACT ENVIRONNEMENTAL INSTALLATION D'ARBRES SUR LES BALCONS

TOUR DES CÈDRES
1008 CHAVANNES-PRÈS-RENENS

« En prenant en compte les éléments analysés de la structure porteuse, l'installation d'arbres sur les balcons représente une **augmentation ... de 65.9 % l'émission de gaz à effet de serre** dues en comparaison d'une variante sans arbres. »

« En effet, les promoteurs du projet mettent en avant les vertus environnementales de l'installation de **80 arbres** et 3'000 m² d'arbustes sur le projet de la Tour des Cèdres ... [L]a compensation des émissions de CO₂ sur un horizon temporel de 60 ans nécessiterait de planter environ **20'000 arbres** au moment de la construction. »

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Société coopérative 2401 - Avenue des Alpes 50 - 1820 Montreux - contact@2401.ch - Construire durable ensemble

Julien Pathé – Société coopérative 2401



IMPACT ENVIRONNEMENTAL INSTALLATION D'ARBRES SUR LES BALCONS

TOUR DES CÈDRES
1008 CHAVANNES-PRÈS-RENNES

“Taking into account the analyzed elements of the load-bearing structure, the installation of trees on the balconies represents **an increase... of 65.9% in greenhouse gas emissions** compared to a variant without trees.”

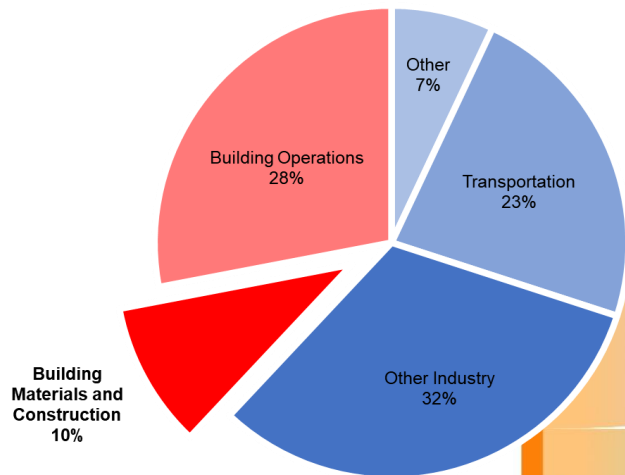
“Indeed, the project’s promoters highlight the environmental virtues of installing **80 trees** and 3,000 m² of shrubs on the Cedar Tower project.... To offset CO₂ emissions over a 60-year time horizon would require the planting of around **20,000 trees** at the time of construction.”

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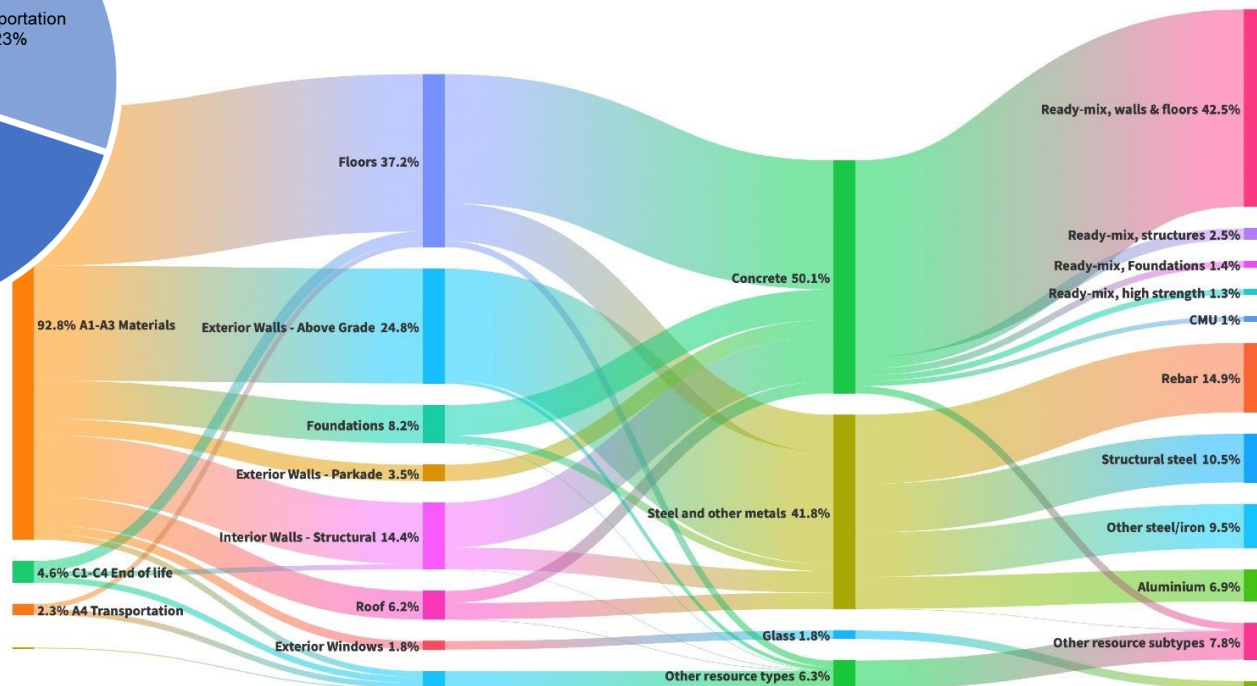
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Julien Pathé – Société coopérative 2401

Embodied emissions in buildings

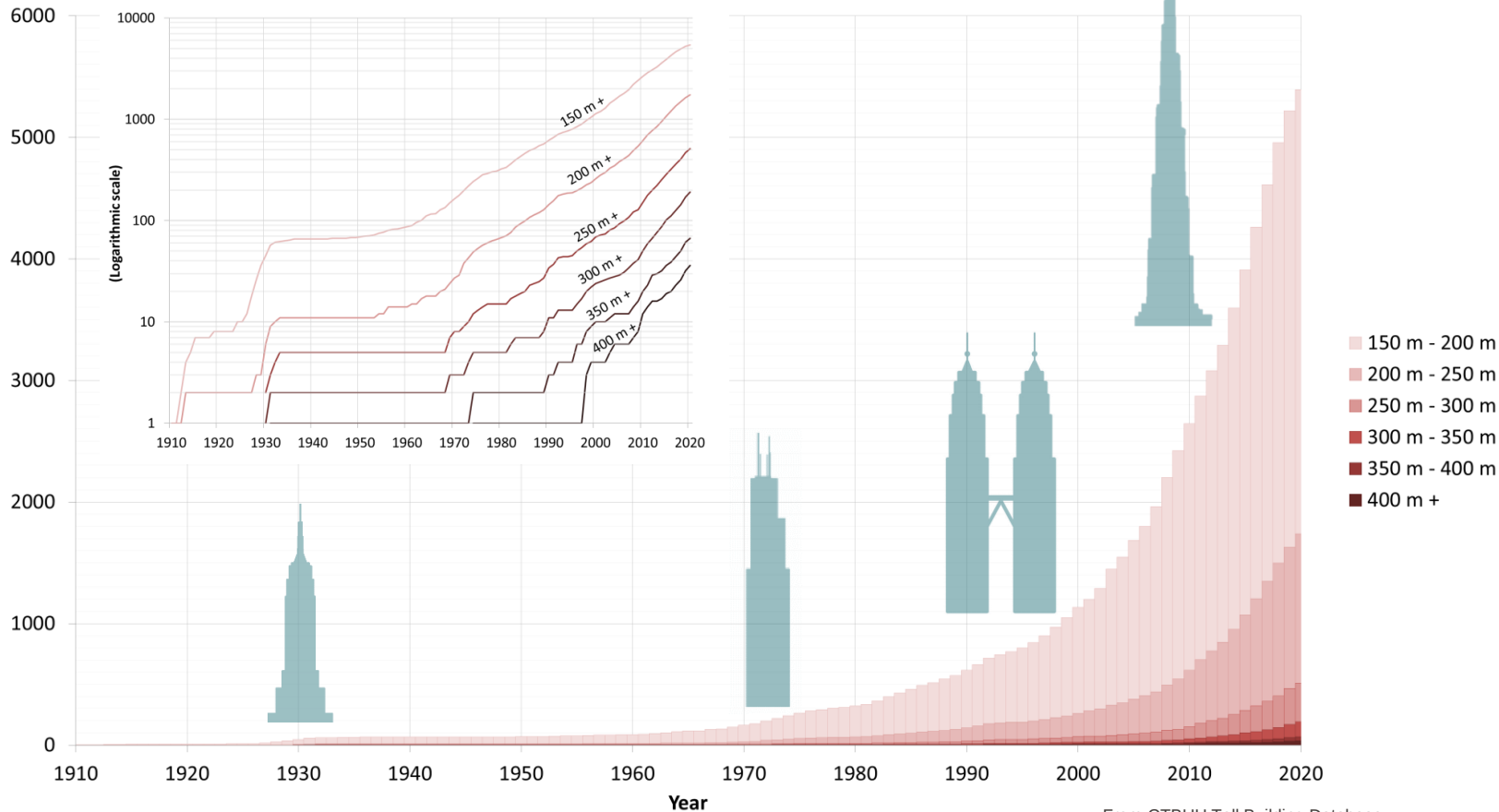


UN 2020 Global Status Report for Buildings and Construction



Skyscrapers in the world

Cumulative number of buildings taller than 150 m (global)





City of Toronto Archives, Fonds 1526, File 46, Item 20



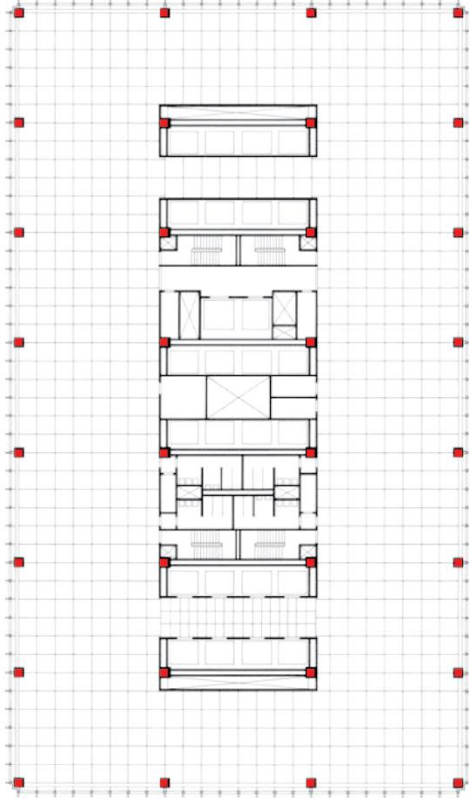
Then ...



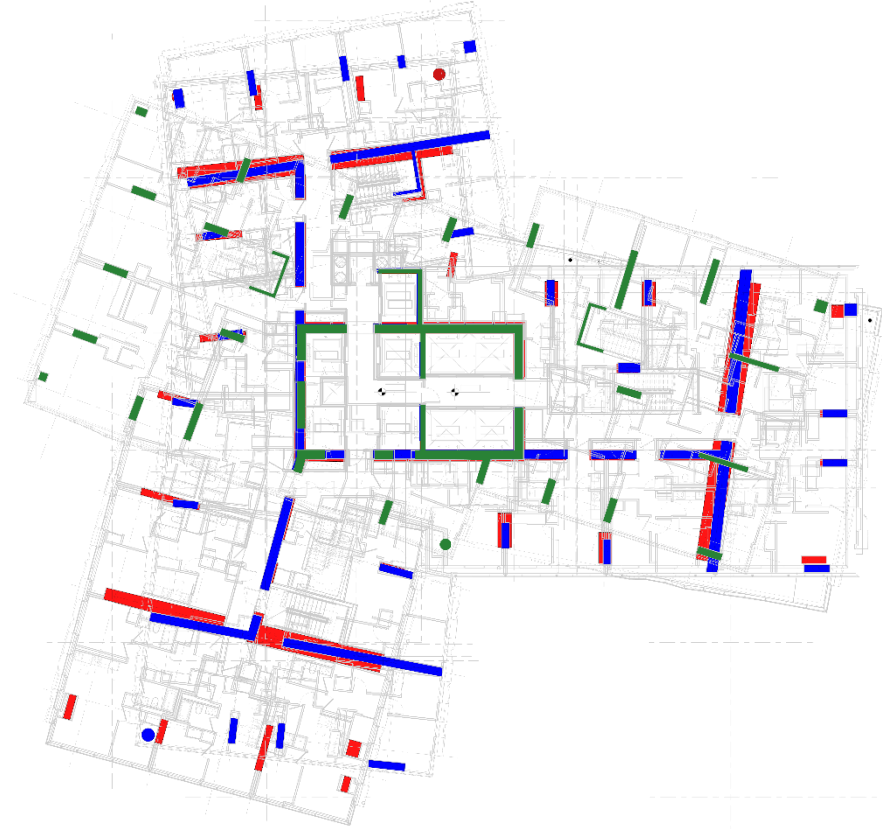
... and now



Then ...



... and now



Nordic influence?

■ SUSTAINABILITY CHALLENGES IN THE STRUCTURAL DESIGN OF CONTEMPORARY HIGH-RISE BUILDINGS



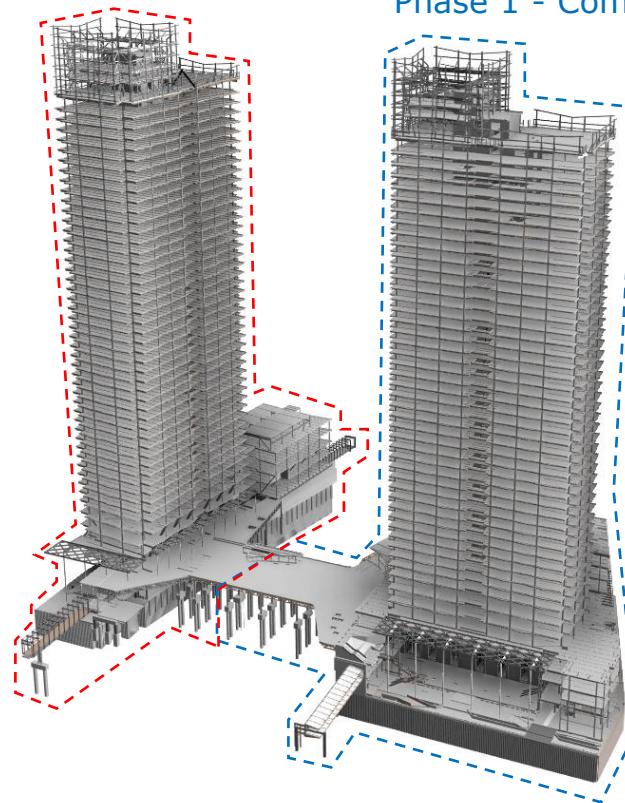
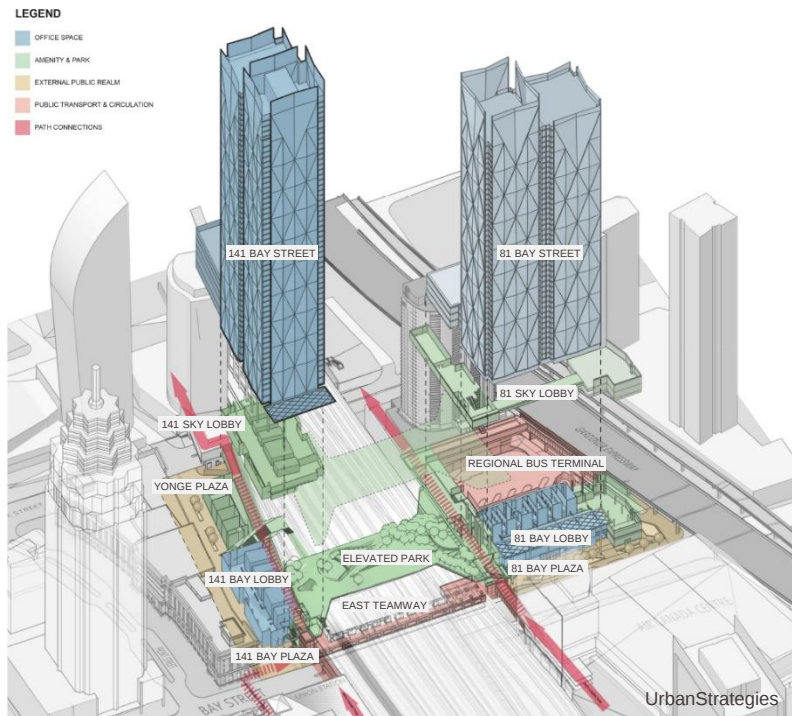


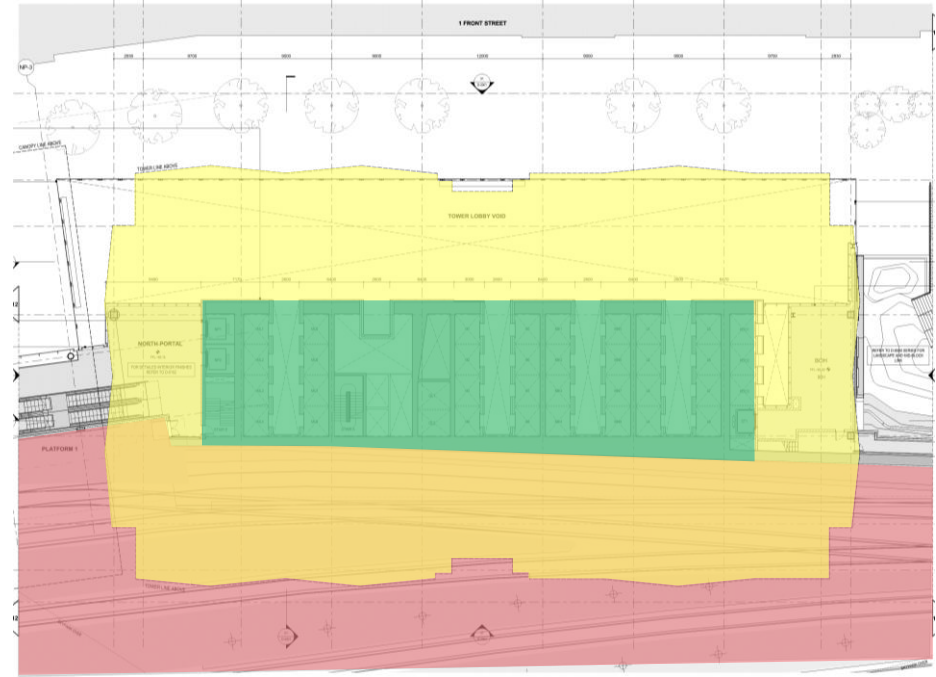
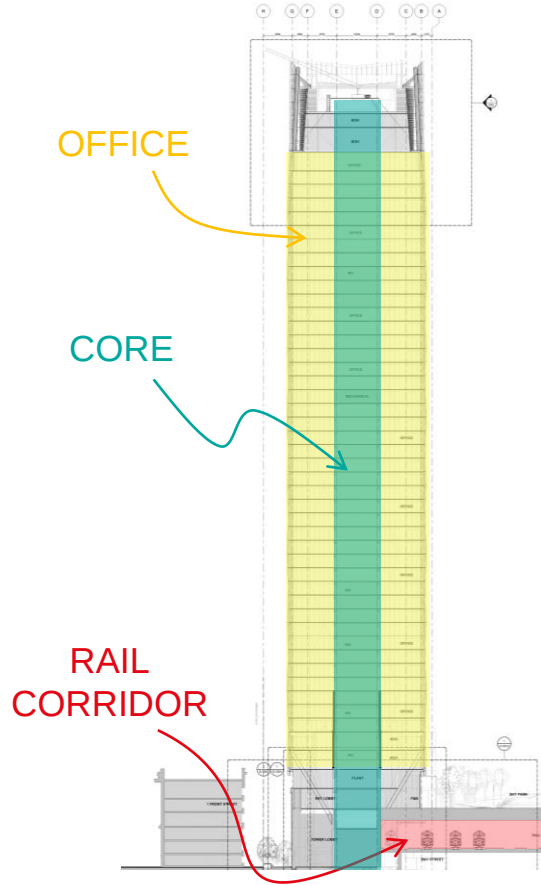
Case study: CIBC Square, Toronto

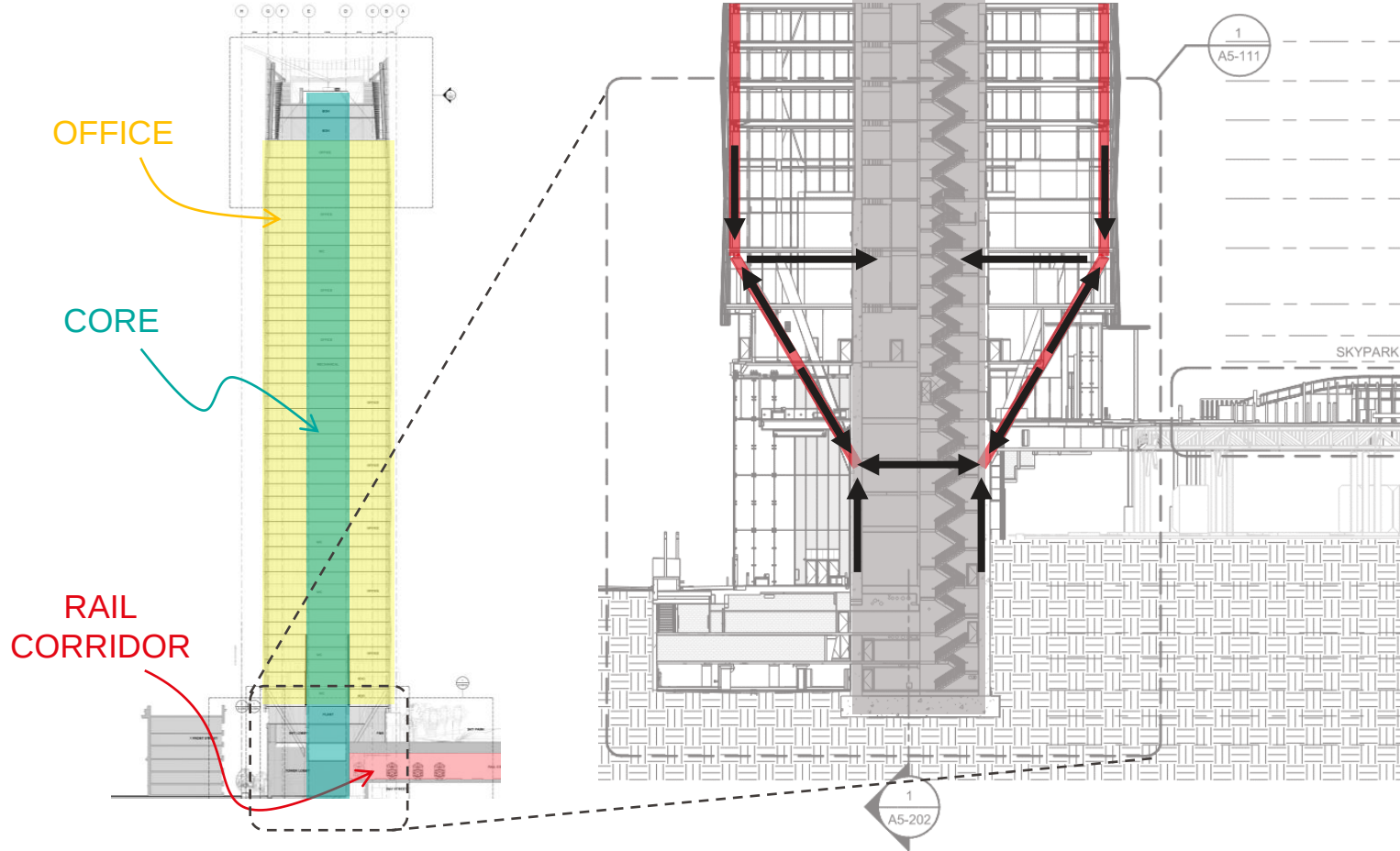
Complex program, constrained site

Phase 2 – Under Construction

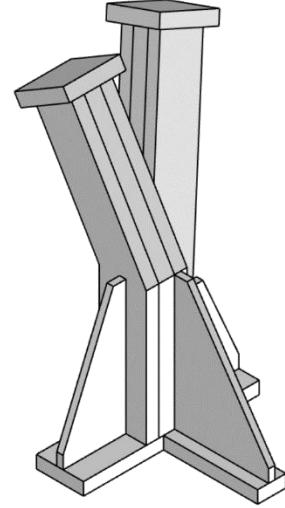
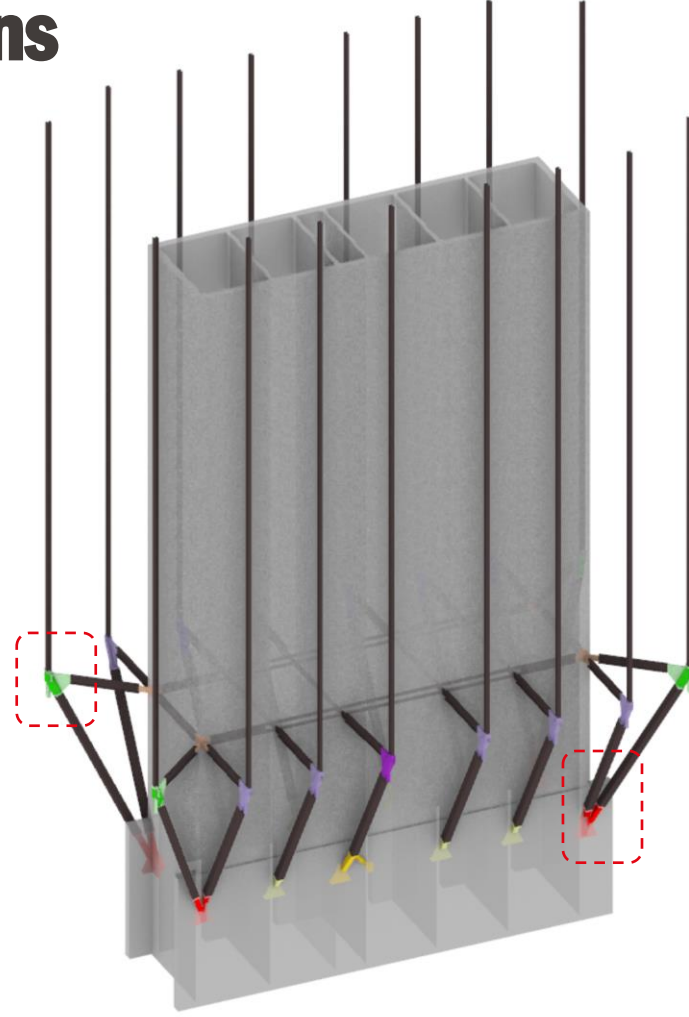
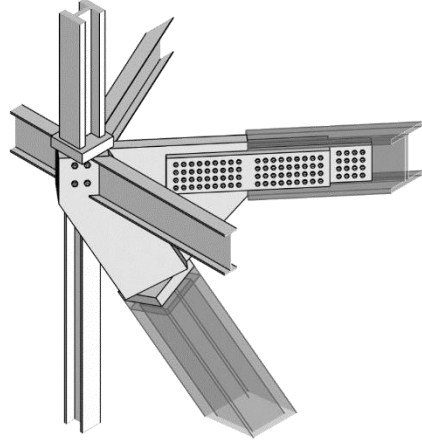
Phase 1 - Complete







Sloping columns

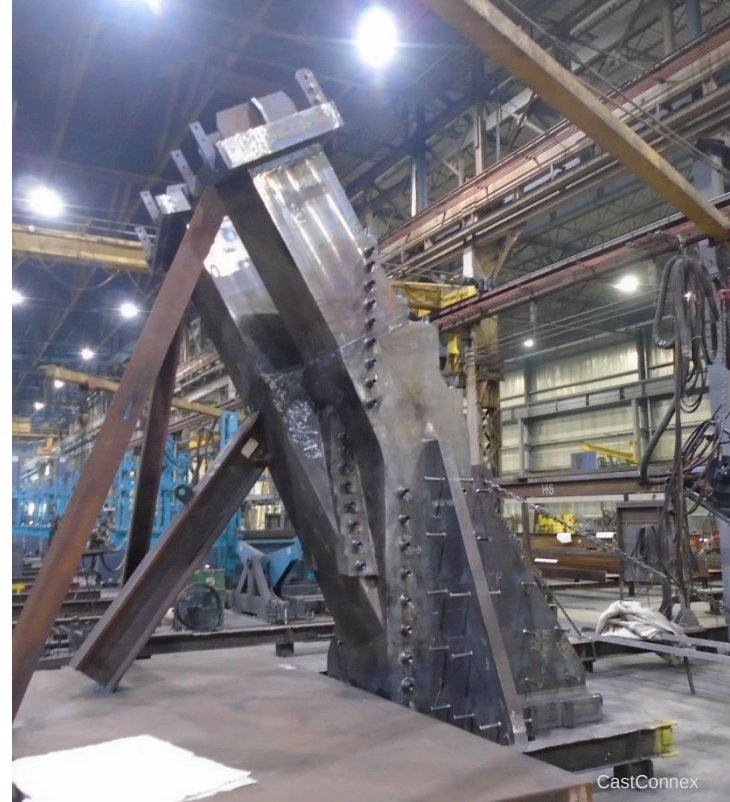


Cast steel nodes



CastConnex

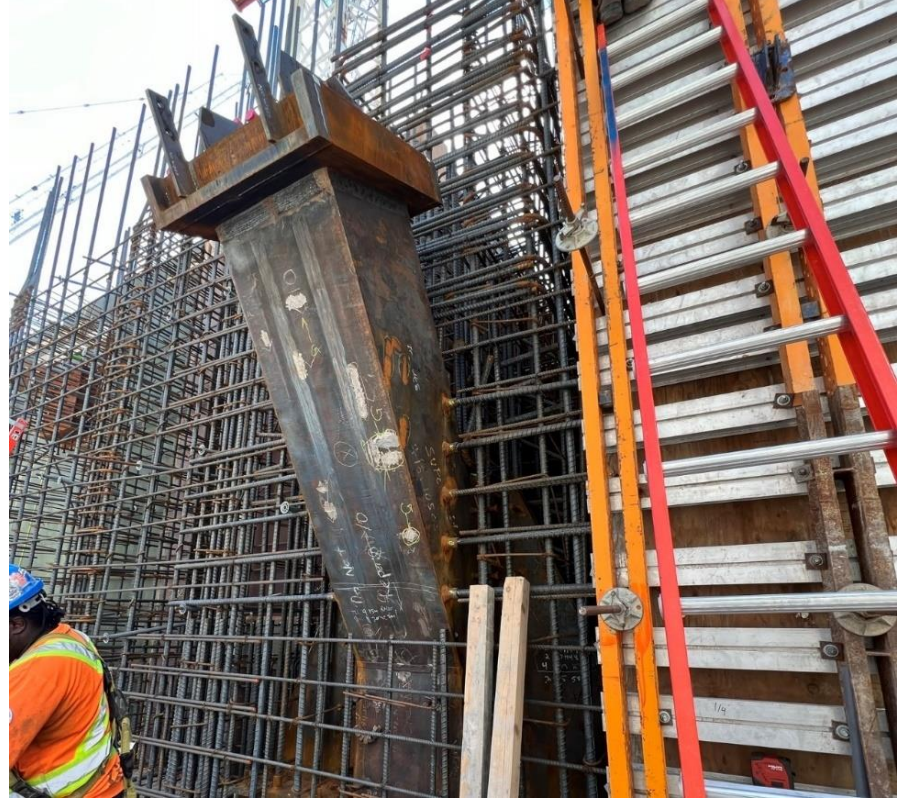
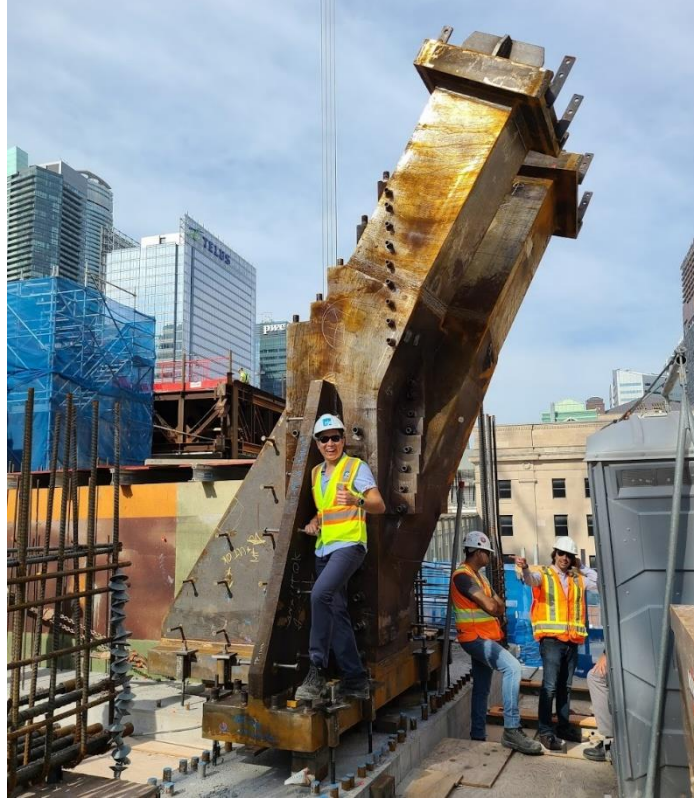
Cast steel nodes



Cast steel nodes



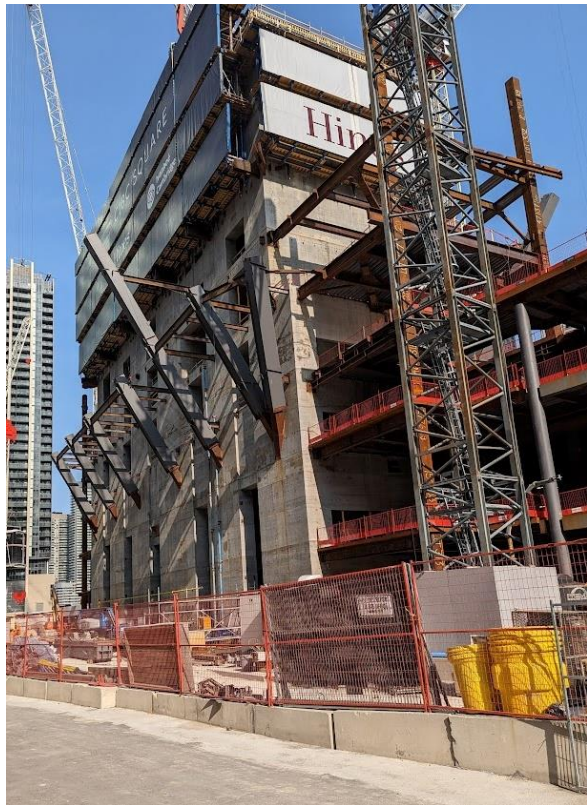
Cast steel nodes



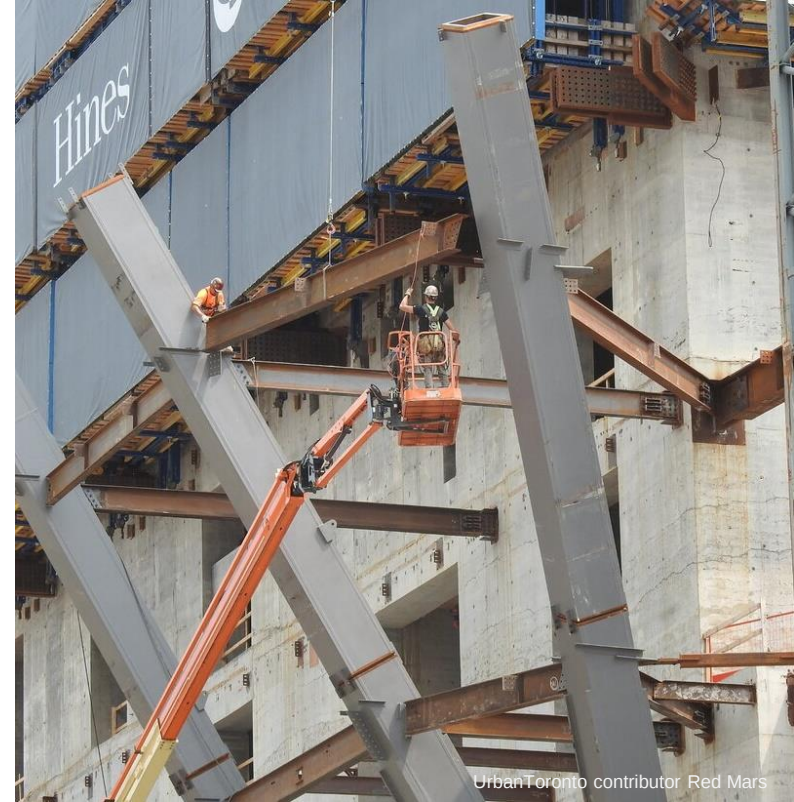
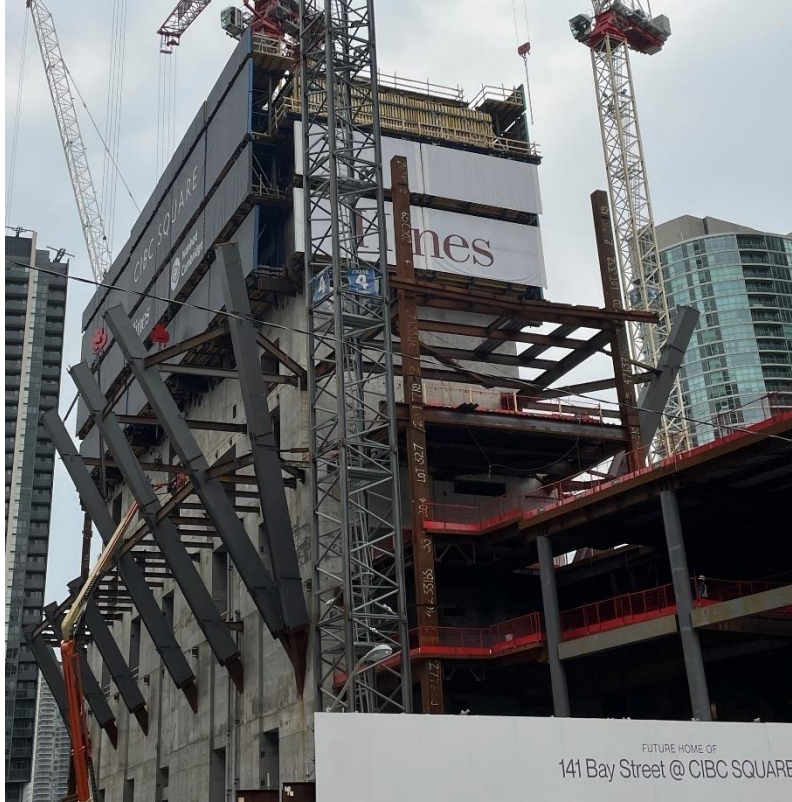
Sloping columns



Sloping columns



Sloping columns



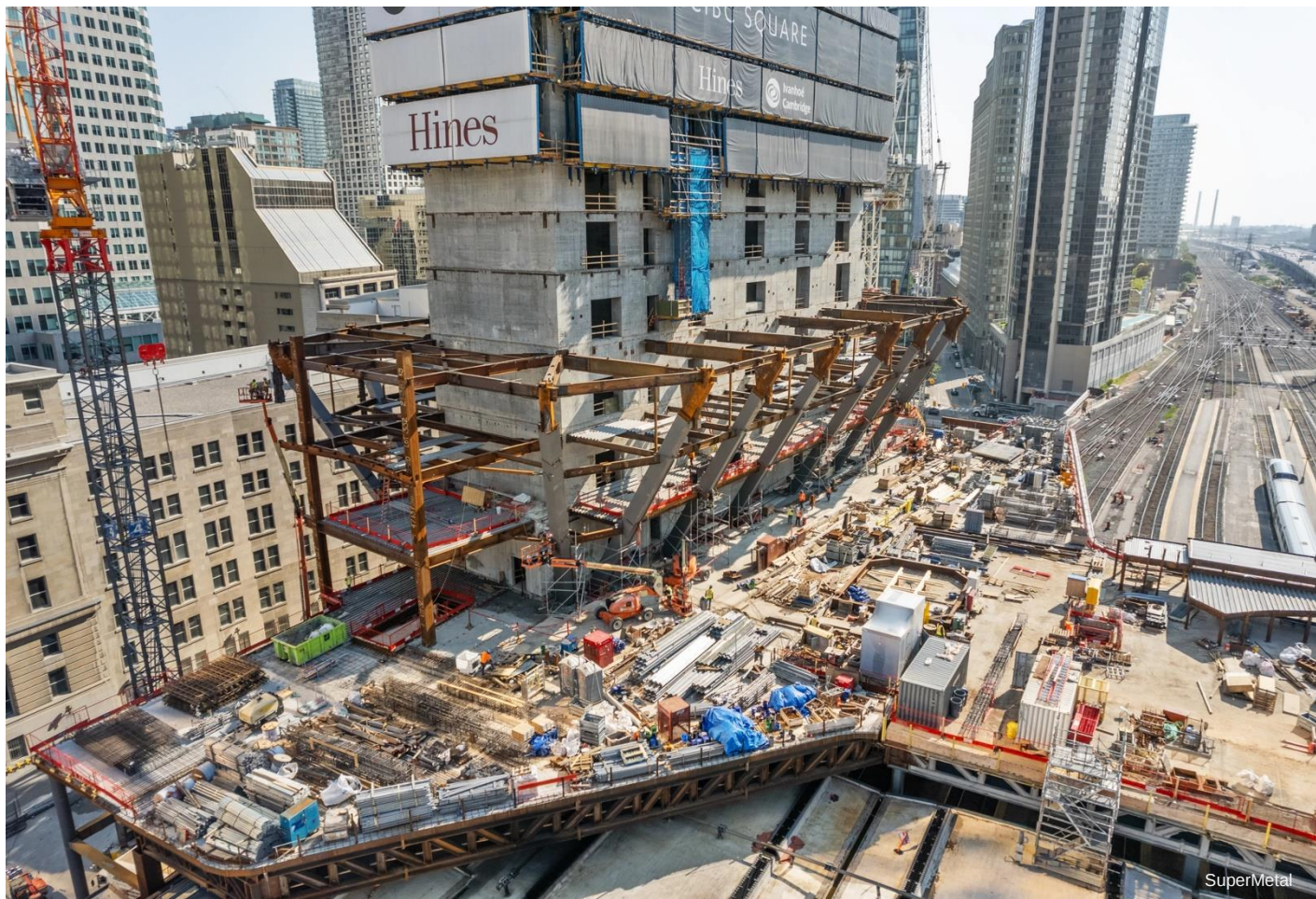
Sloping columns

■ SUSTAINABILITY CHALLENGES IN THE STRUCTURAL DESIGN OF CONTEMPORARY HIGH-RISE BUILDINGS



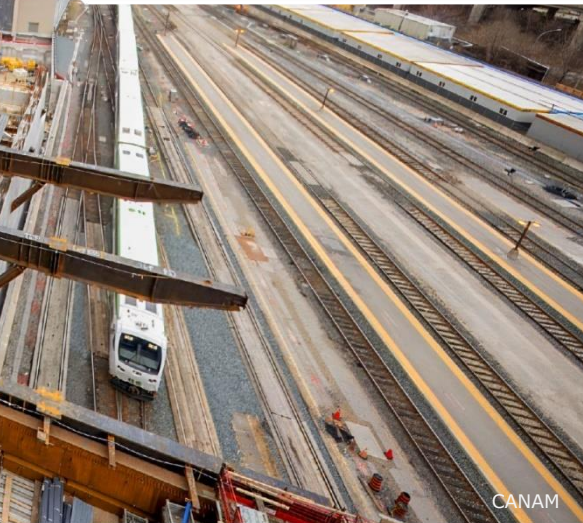
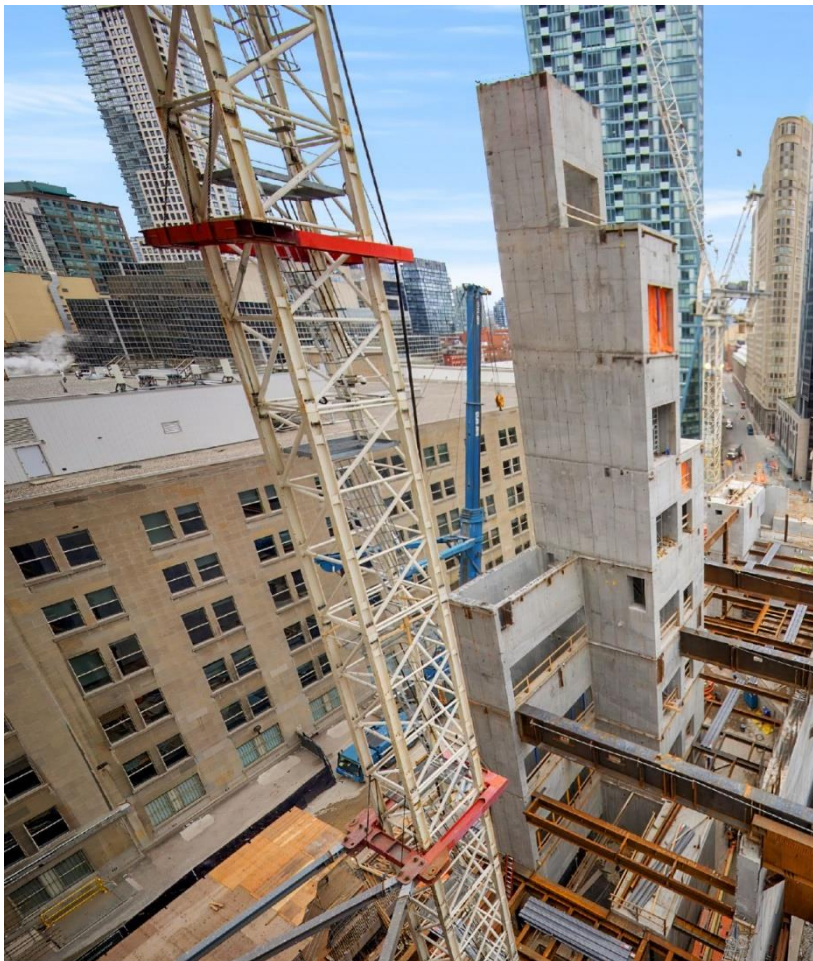
Sloping columns

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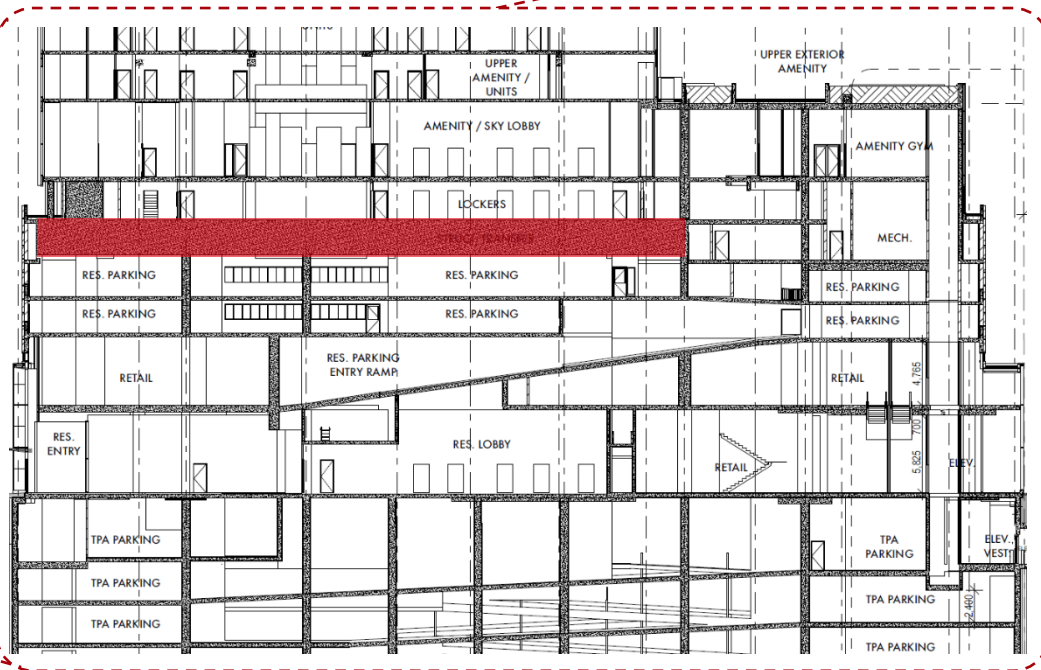
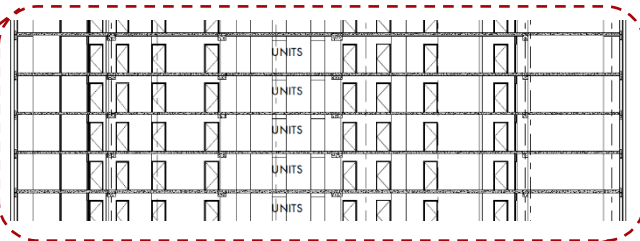
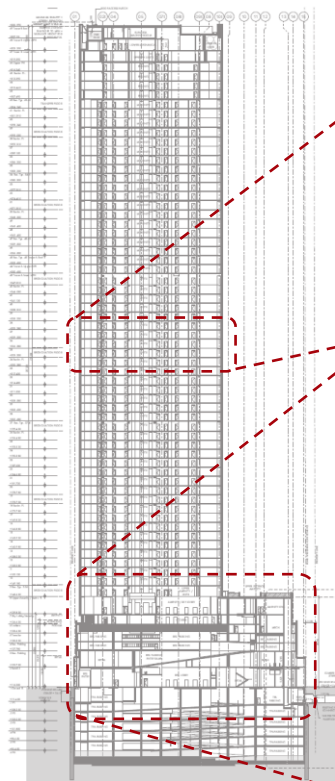
SuperMetal

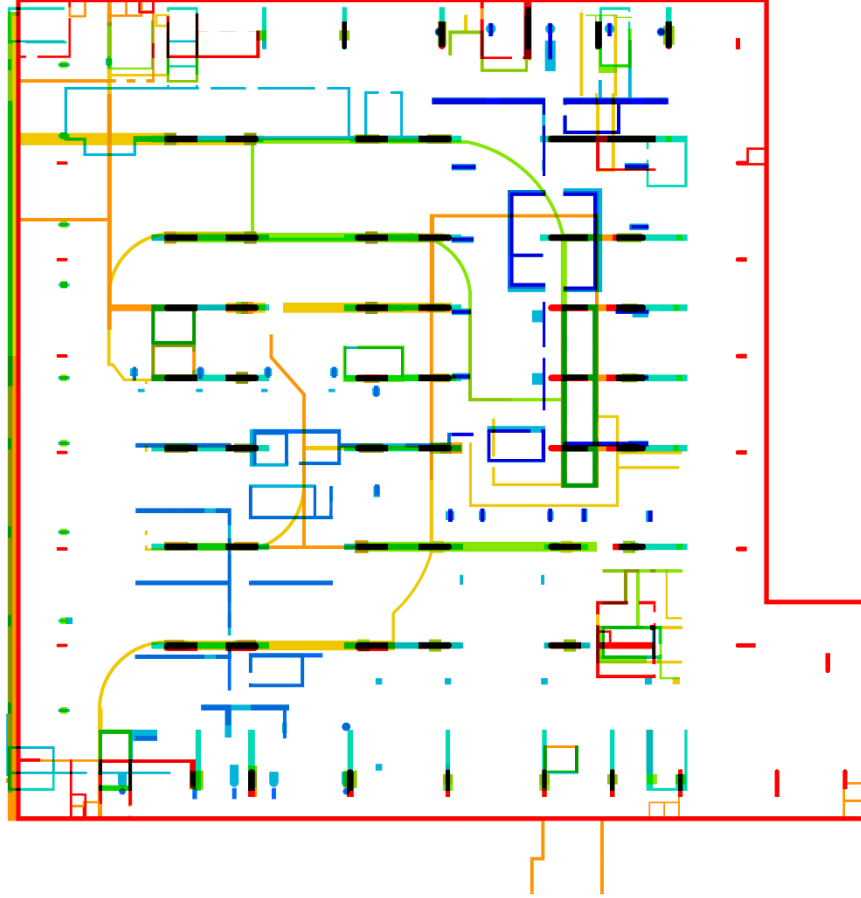
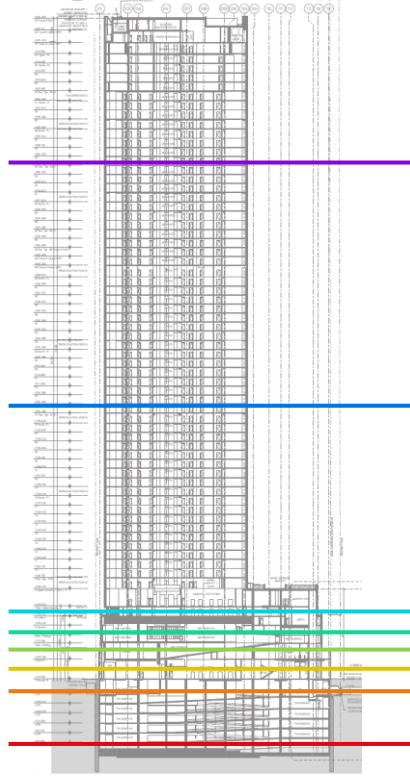
Podium cantilever



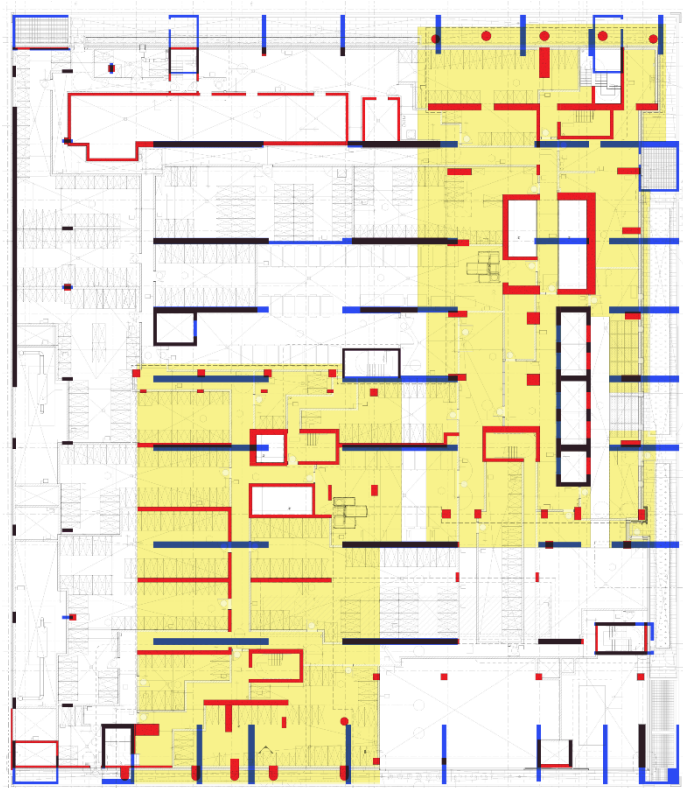
Case study: 68-storey residential, Toronto



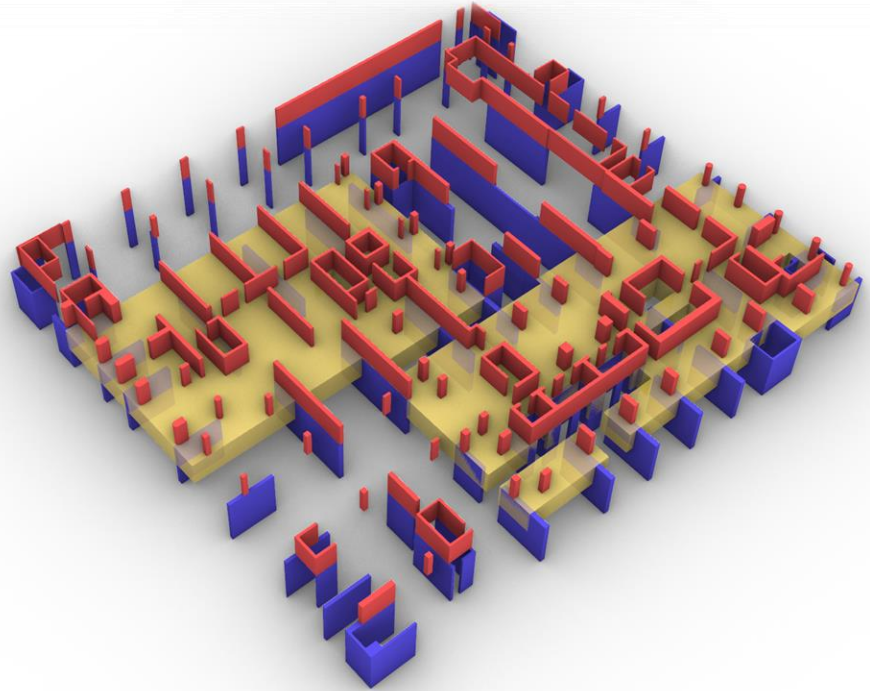




Transfer slabs



■ Above ■ Below ■ Transfer slab



Transfer slabs



Increasing complexity



UrbanToronto contributor Rascaciolo

Increasing complexity



Increasing complexity

SUSTAINABILITY CHALLENGES IN THE STRUCTURAL DESIGN
OF CONTEMPORARY HIGH-RISE BUILDINGS



UrbanToronto contributor Red Mars

Increasing complexity

■ SUSTAINABILITY CHALLENGES IN THE STRUCTURAL DESIGN OF CONTEMPORARY HIGH-RISE BUILDINGS



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Tim MacDonald

Increasing complexity

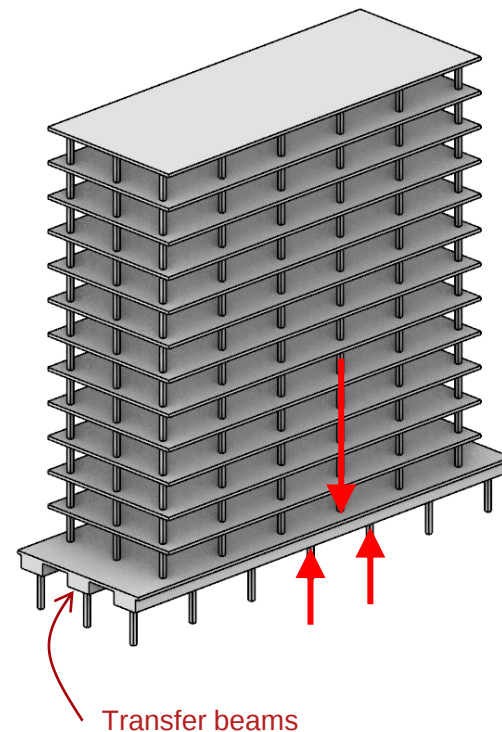
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Transfer beam study

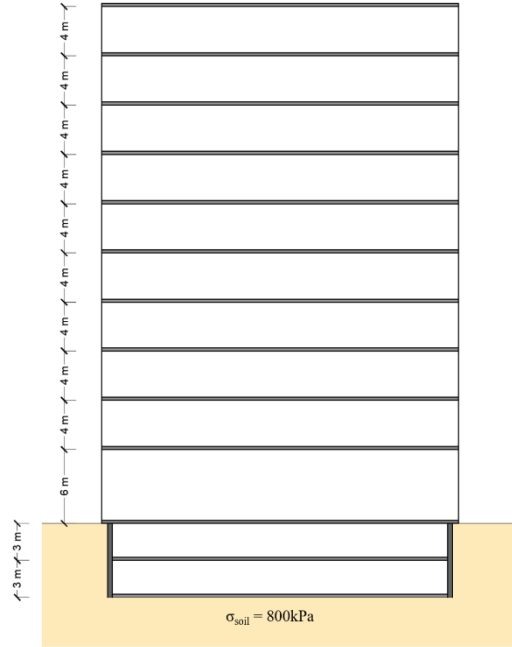
Approximate embodied carbon
share of transfer beams

Superstructure height	50 storey	3%	4%	7%	9%	12%
	40 storey	3%	4%	7%	10%	12%
	30 storey	3%	5%	7%	10%	13%
	20 storey	3%	5%	8%	11%	13%
	10 storey	4%	6%	9%	12%	15%
		4 m	6 m	8 m	10 m	12 m
		Structural bay length				

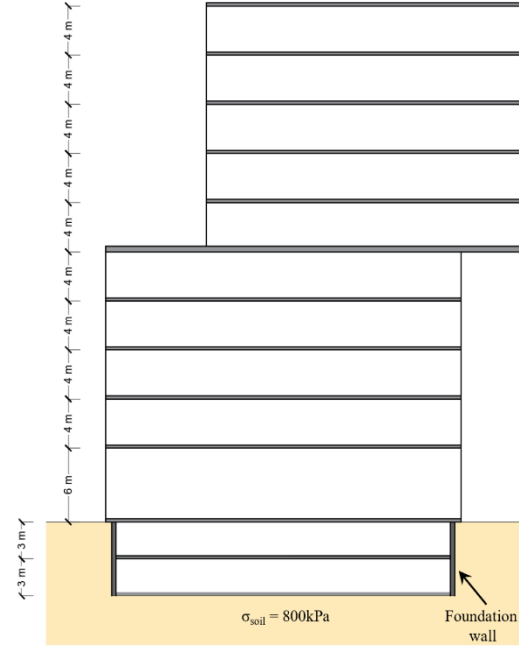


* Relative to gravity system (slabs + columns); no foundations

Carbon cost of irregularity

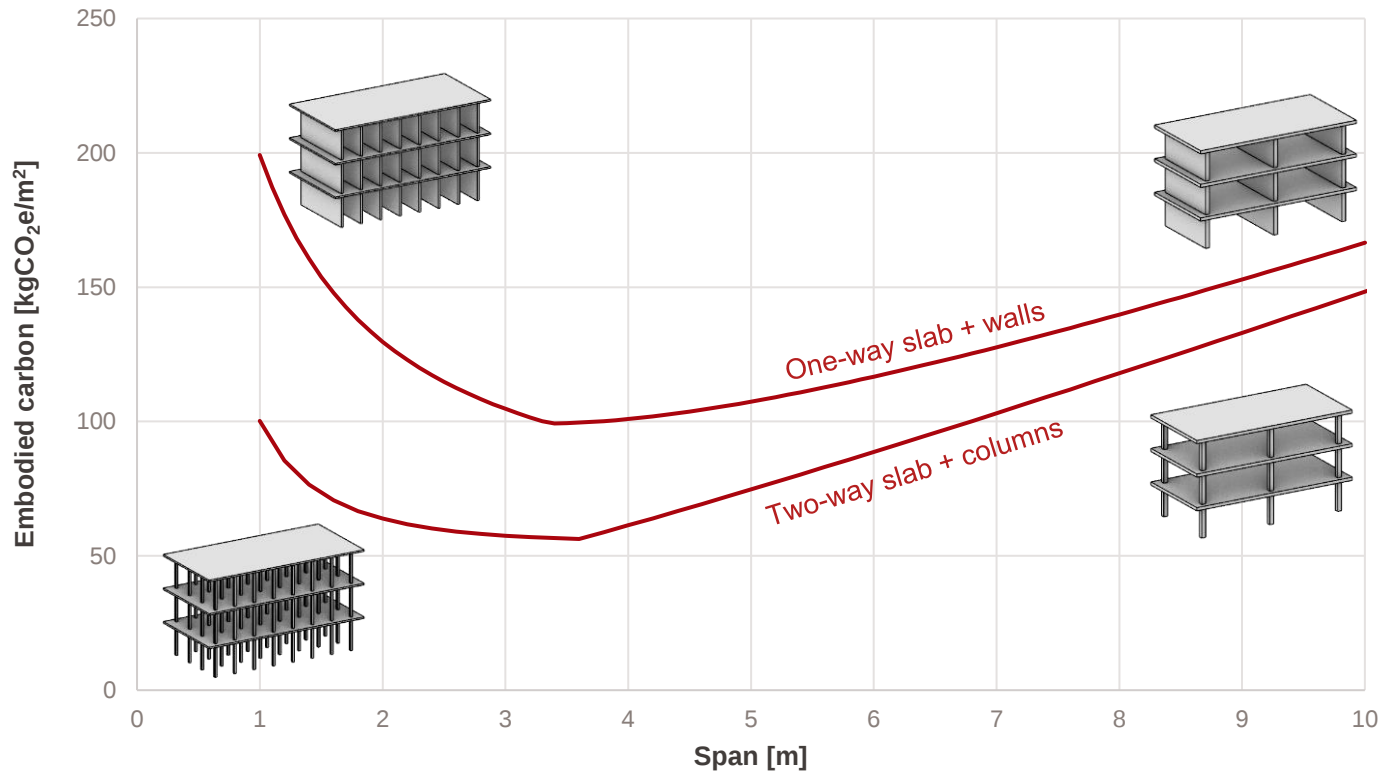


VS.

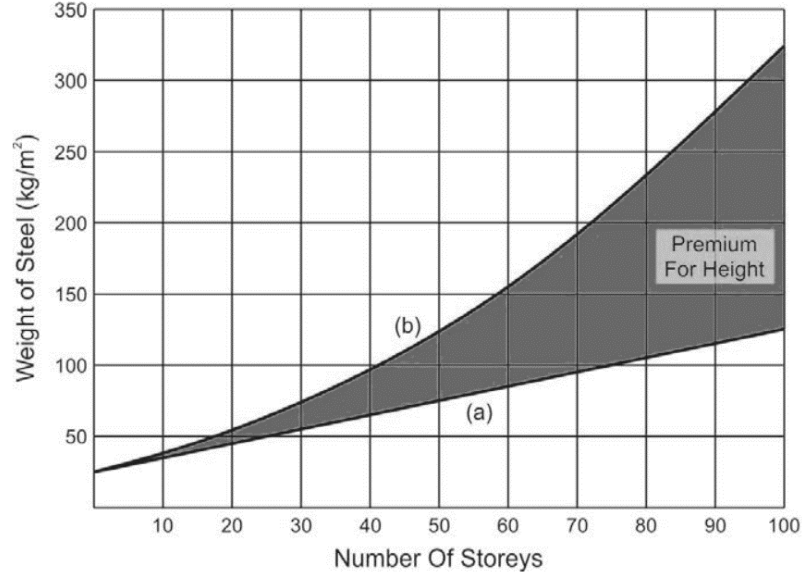


~50% more embodied carbon on average

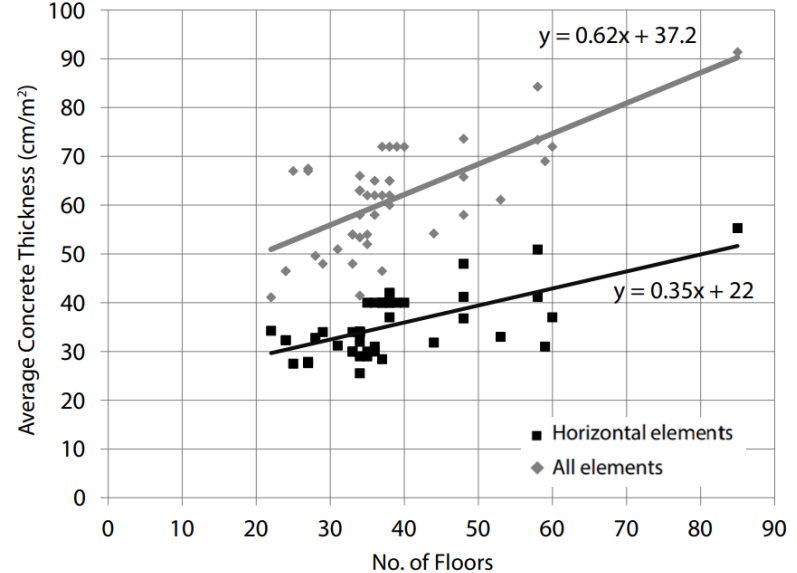
Gravity system embodied carbon



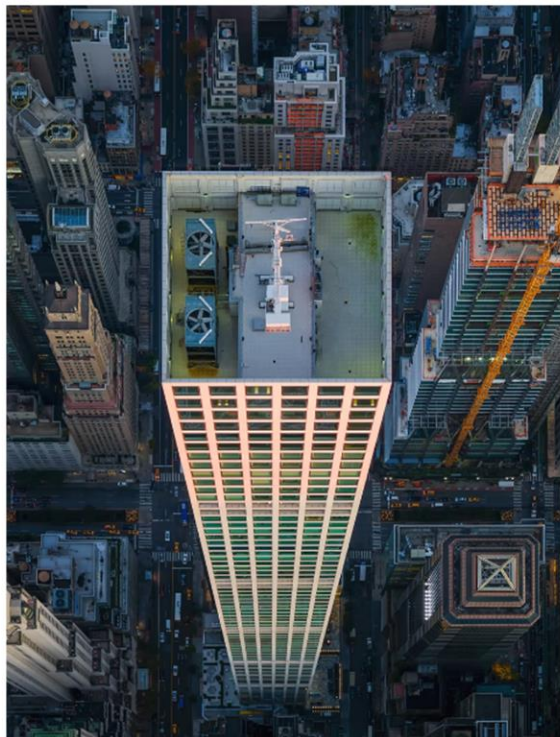
Material efficiency of tall buildings



Helal, J., Stephan, A., and Crawford, R.H. (2018). "Beyond the "premium-for-height" framework for designing the structural systems of tall buildings." *2nd International Conference of the Architectural Science Association 2018*, Melbourne, Australia. After Khan (1967).



Sherif, A. (2010). "Structural Design of Reinforced Concrete Tall Buildings." *CTBUH Journal 2010 Issue 1*:34-41.



TECHNOLOGY

HOW TALL IS TOO TALL?

The rise and rise and rise of the supertall skyscraper

By Bianca Bosker

Photographs By Jeffrey Milstein

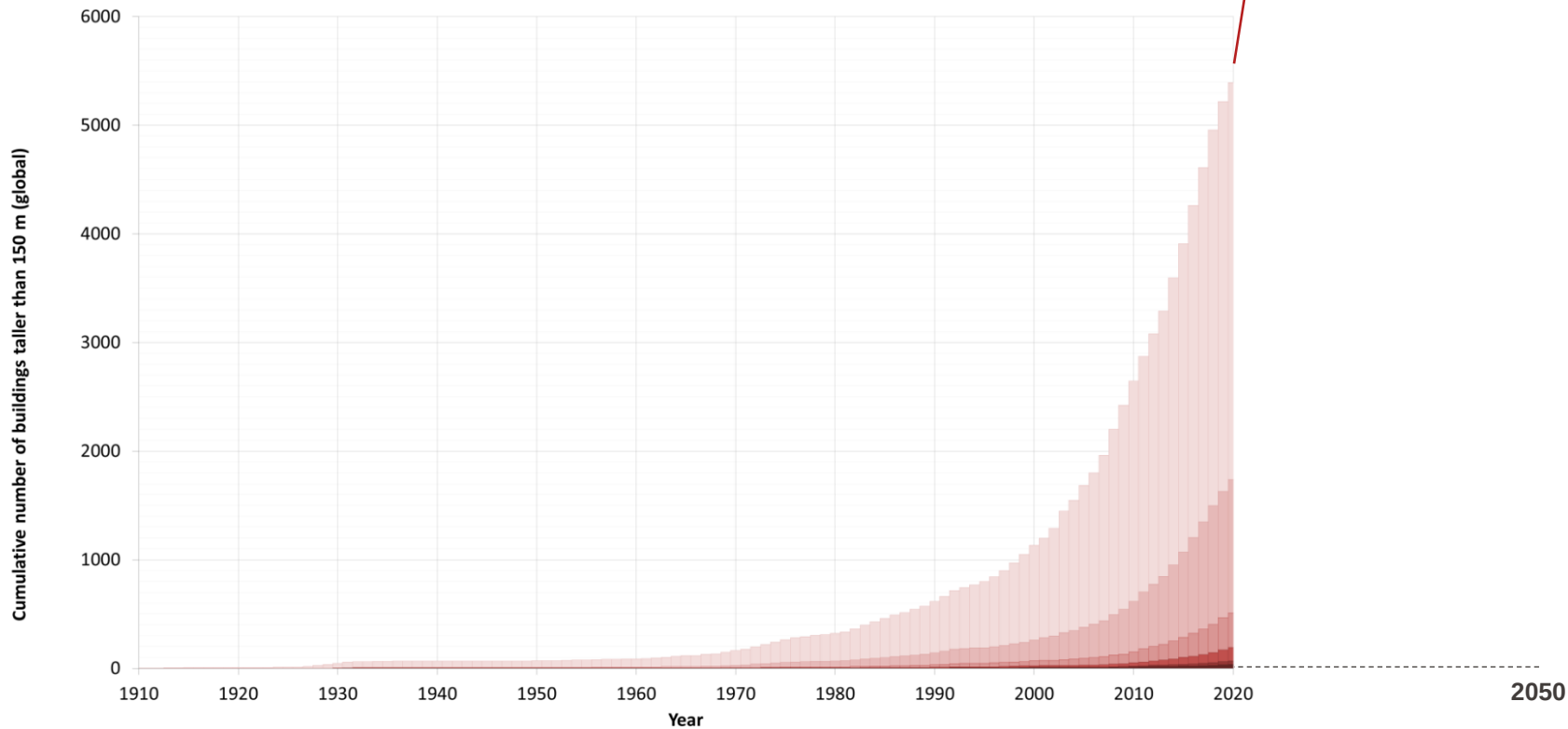
The Atlantic

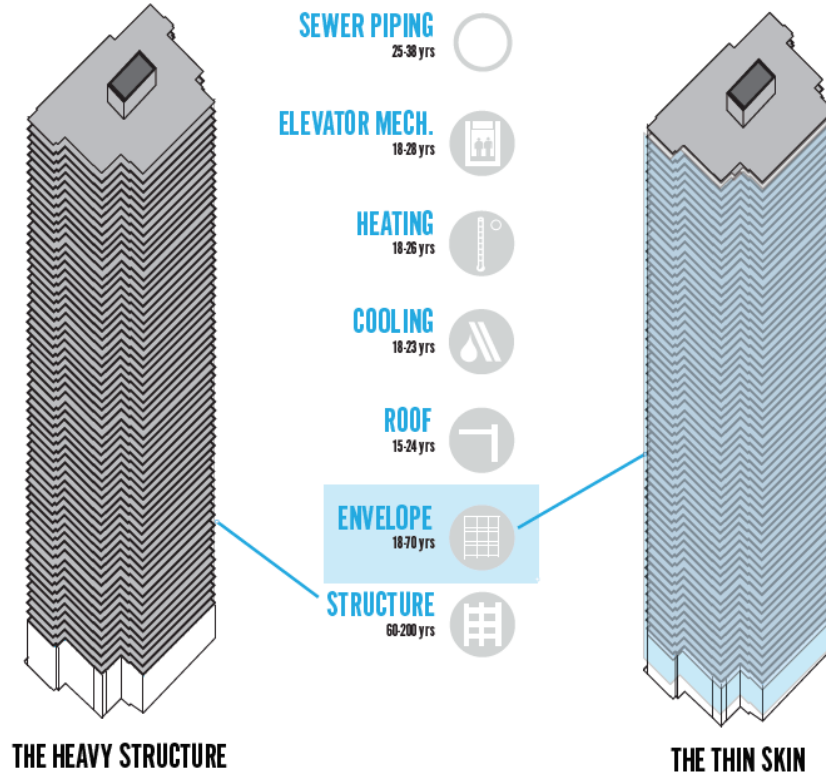
January/February 2023 Issue

“Billionaires’ Row”









Building resilience in condoland, SPACING magazine



1899 years old



39 years old

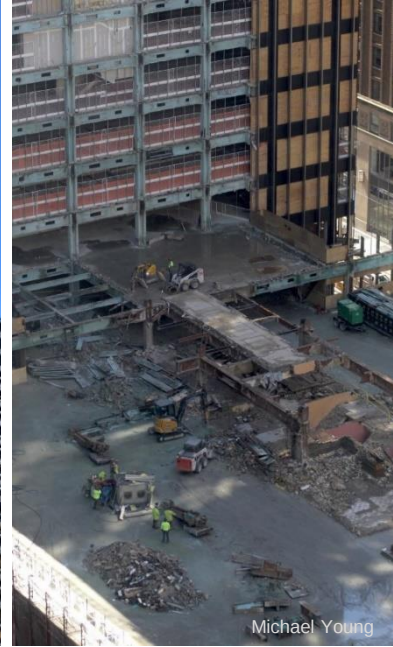
Vik Pahwa



[Skyscrapers] need to be designed to be **never taken down**, such that their life cycle is as **close to forever** as you can get... No-one's talking about when the **pyramids** are going to come down.

Antony Wood, President of the Council on
Tall Buildings and Urban Habitat

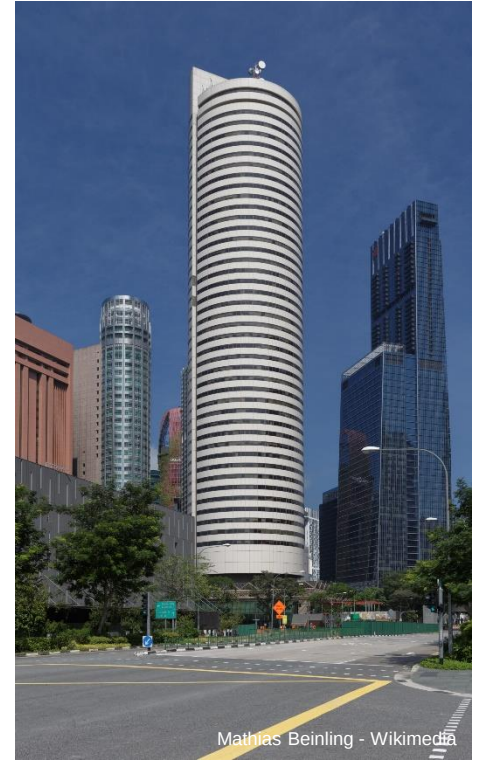
Skyscraper demolition



Skyscraper demolition



Vincent Cheang - YouTube



Mathias Beinling - Wikimedia

Informal reuse?



A Promise to Future Generations



All appropriate measures shall be taken to ensure that the rights of future generations are protected and not sacrificed for the expedience and convenience of the present generation.

Oath for graduating Civil Engineering students at the University of Toronto



Thank you!
Questions?