High-Rise Building – Lessons Learned

CWSC Sustainable Construction Summit

Prof. David Ruggiero

Concrete Behaviour and Structural Design Laboratory, EPFL

14 January, 2025

École polytechnique fédérale de Lausanne

The beginning…

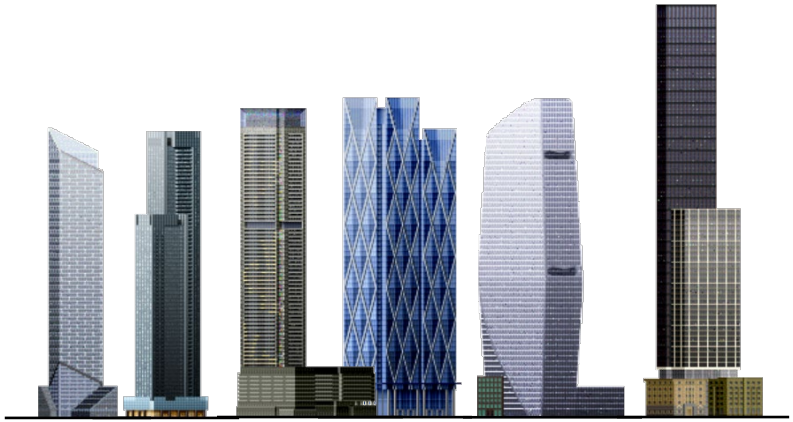
MAXIS

With this smiling kid… it was the early 1990s, Christmas morning, opening up gifts and getting a new computer game called SimTower—a simulation game where you had to build and manage a skyscraper. The game in retrospect was not that great but I sure loved it.

Skyscrapers captured-- the kid is me in case that wasn't clear – skyscrapers captured my imagination like nothing else, and led me down a path that would, ultimately bring me here, with a few twists along the way.

About me

- Ph.D. from University of Toronto
- Postdoctoral studies in seismic engineering at the Institute for Advanced Studies of Pavia, Italy
- 5 years as structural engineer at Read Jones Christoffersen (RJC) Toronto
- Tenure Track Assistant Professor and head of Concrete Behaviour and Structural Design Laboratory (CONSTRUCT) at EPFL
- Associate Member of Canadian Standards Association CSA A23.3 Technical Committee on Design of Concrete Structures
- Chair of Joint Committee on the GLO*BE* Consensus



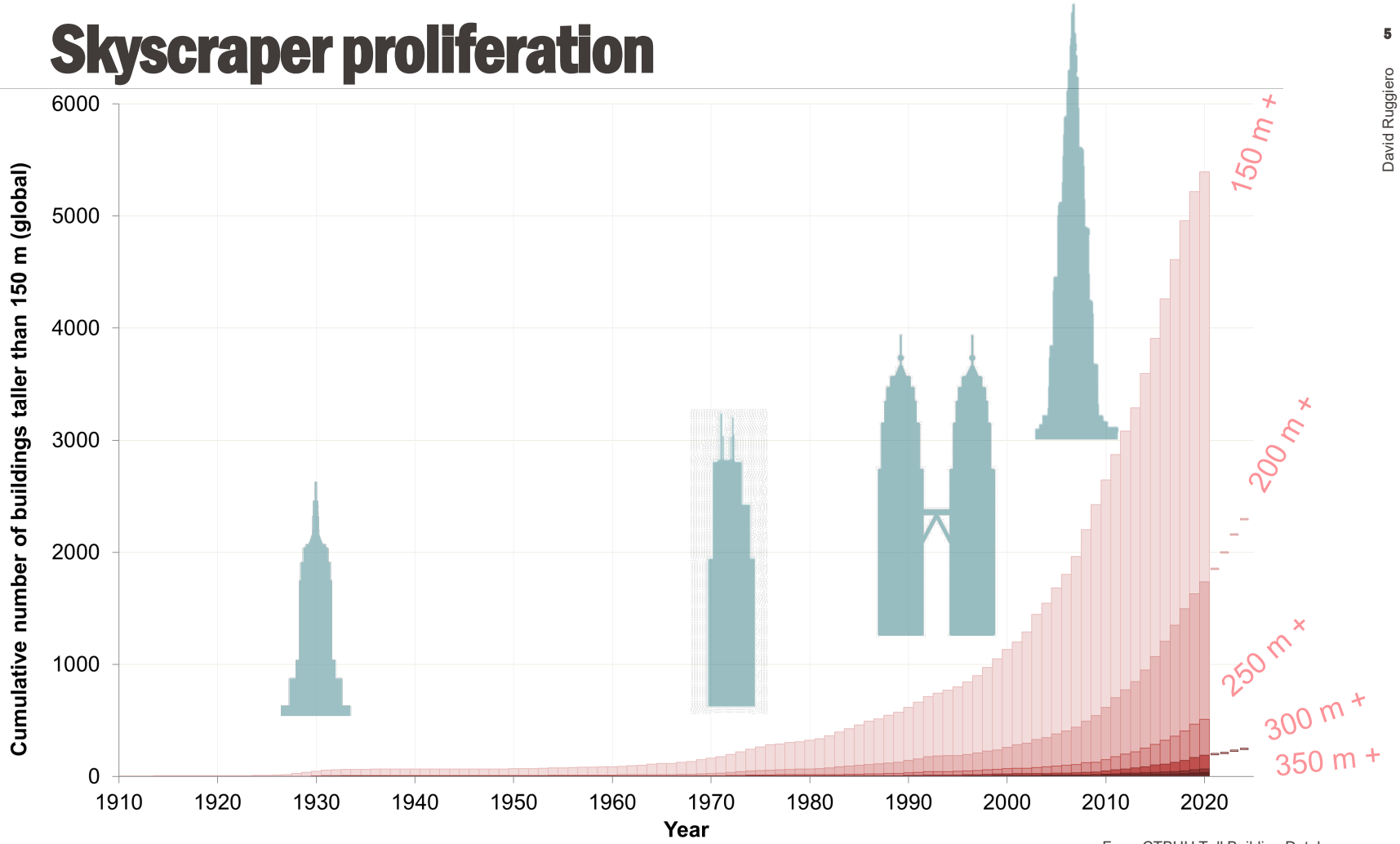
SkyscraperPage contributor Koops65

Death of the skyscraper?

The age of skyscrapers is at an end. It must now be considered an experimental building typology that has failed. With the arrival of the global economic slump in 2007/08, so began the end of the age of tall buildings.

Adapting Buildings and Cities for Climate Change (Second Ed.)
2010
Sue Roaf, David Crichton, Fergus Nicol

Skyscraper proliferation

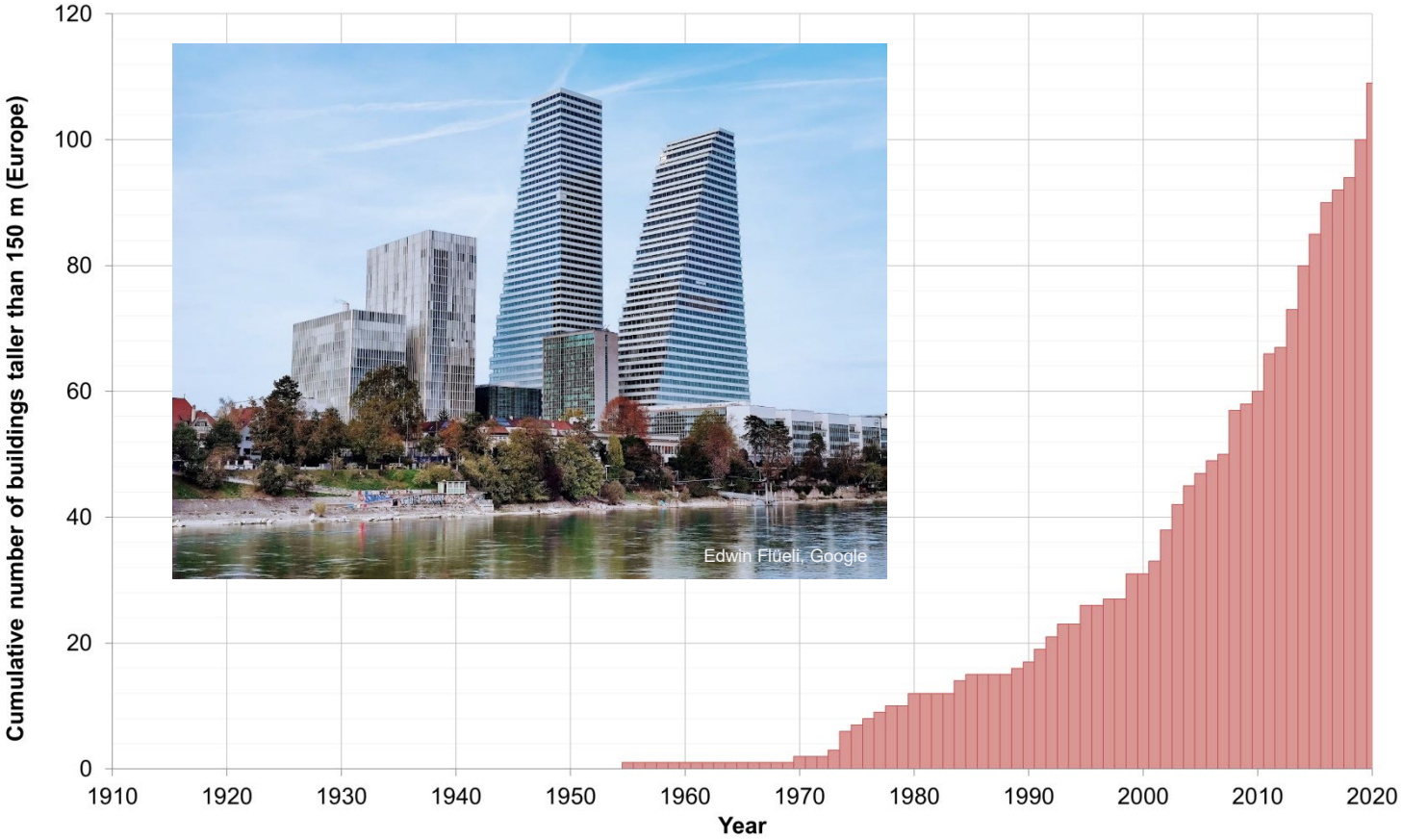


From CTBUH Tall Building Database

David Ruggiero

Skyscrapers in Europe

David Ruggiero



From CTBUH Tall Building Database

Material efficiency of tall buildings

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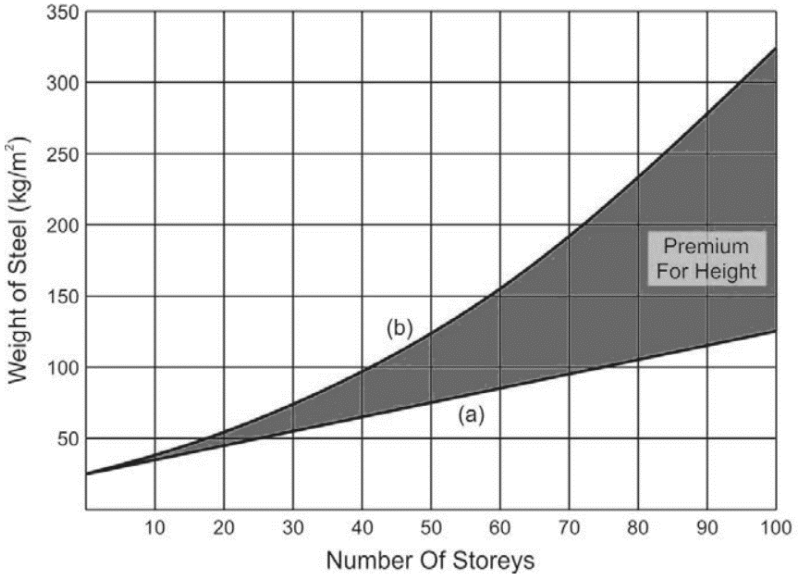
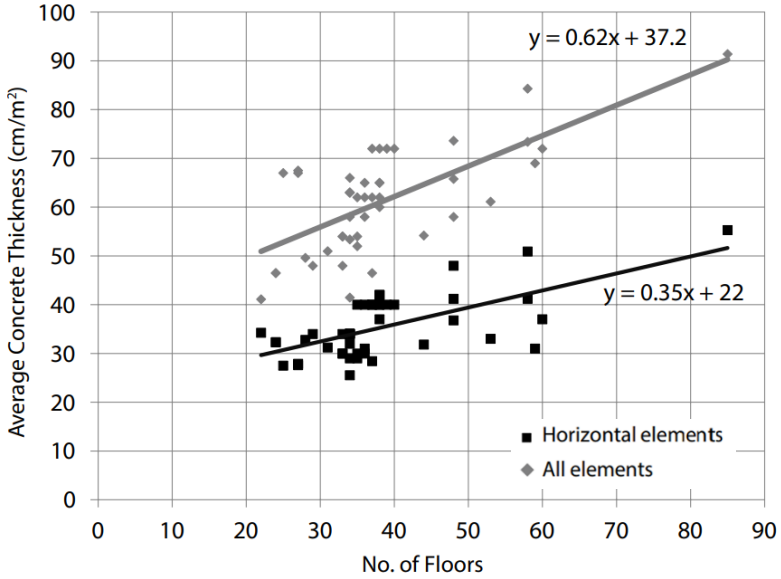
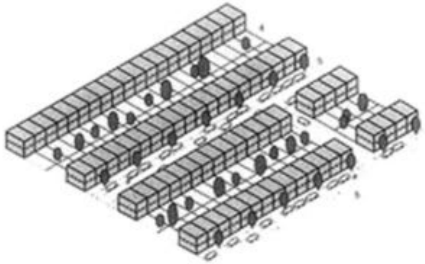


Helal, J., Stephan, A., and Crawford, R.H. (2018). "Beyond the "premium-for-height" framework for designing the structural systems of tall buildings." *2nd International Conference of the Architectural Science Association 2018,* Melbourne, Australia. After Khan (1967).

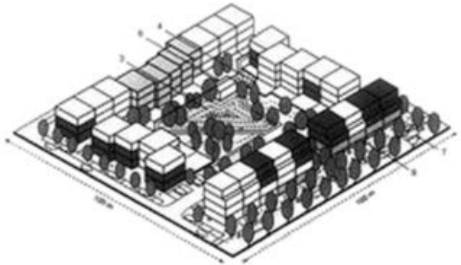


Sherif, A. (2010). "Structural Design of Reinforced Concrete Tall Buildings." *CTBUH Journal* 2010 Issue I:34-41.

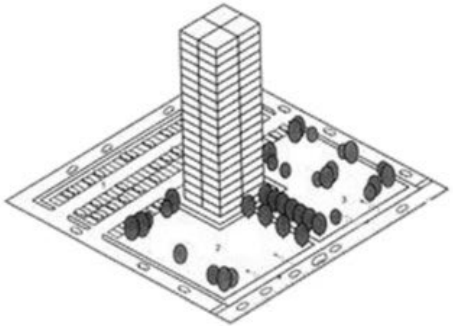
Urban density



75 dwellings per hectare



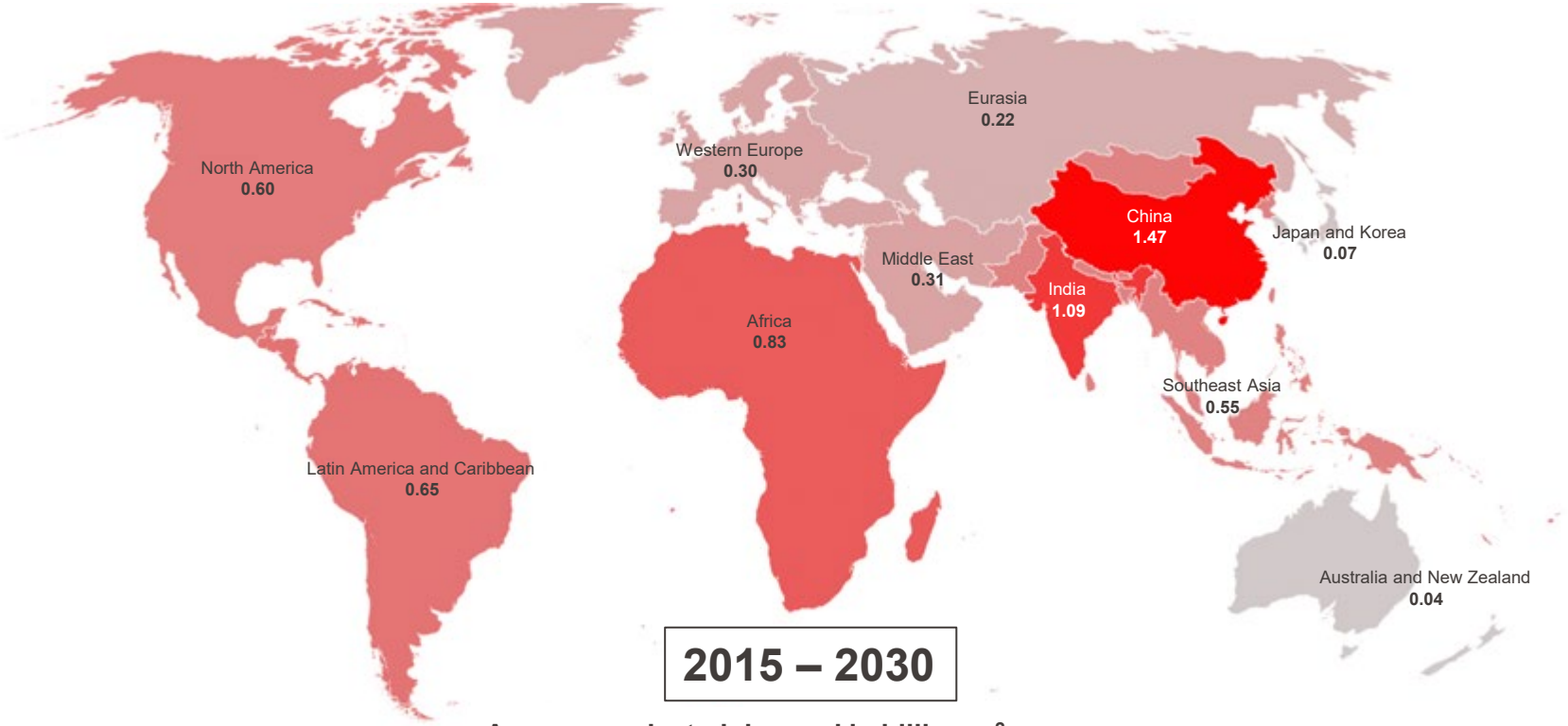
75 dwellings per hectare



75 dwellings per hectare

Lehmann, S. (2016). Sustainable urbanism: towards a framework for quality and optimal density? Future Cities and Environment, 2(1), 8. https://doi.org/10.1186/s40984-016-0021-3

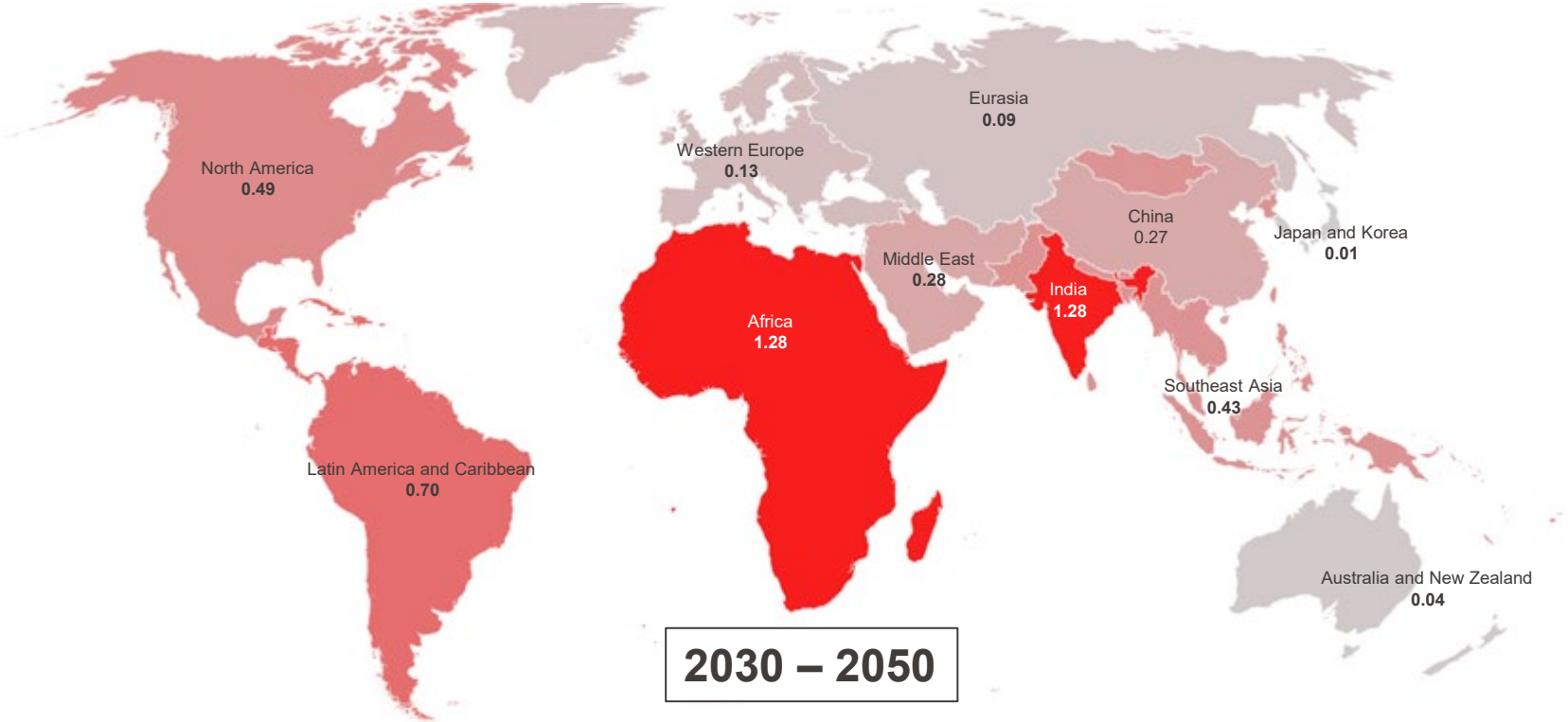
Global demand for net increase in floor area



Average projected demand in billion m^2 per annum

UNEP, 2016, United Nations Environment Programme, *Towards zero-emission efficient and resilient buildings, Global Status Report 2016*

Global demand for net increase in floor area



Average projected demand in billion m^2 per annum

UNEP, 2016, United Nations Environment Programme, *Towards zero-emission efficient and resilient buildings, Global Status Report 2016*

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> By one estimate, the world will add 2 trillion square feet of buildings by 2060—the equivalent of putting up another New York City every month for the next 40 years.

Bill Gates

Gates Notes, “Buildings are bad for the climate”, 2019
Photo: The Guardian

Toronto, Canada – 1972

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

David Ruggiero

Toronto, Canada – 2022

Then ...

... and now

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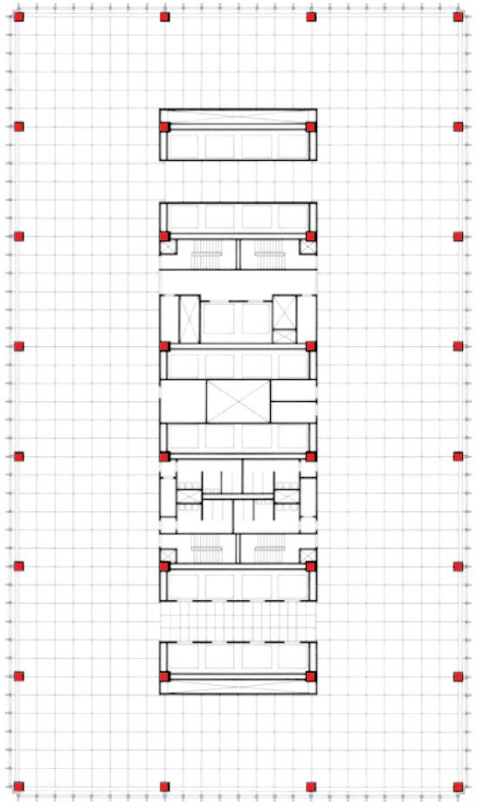
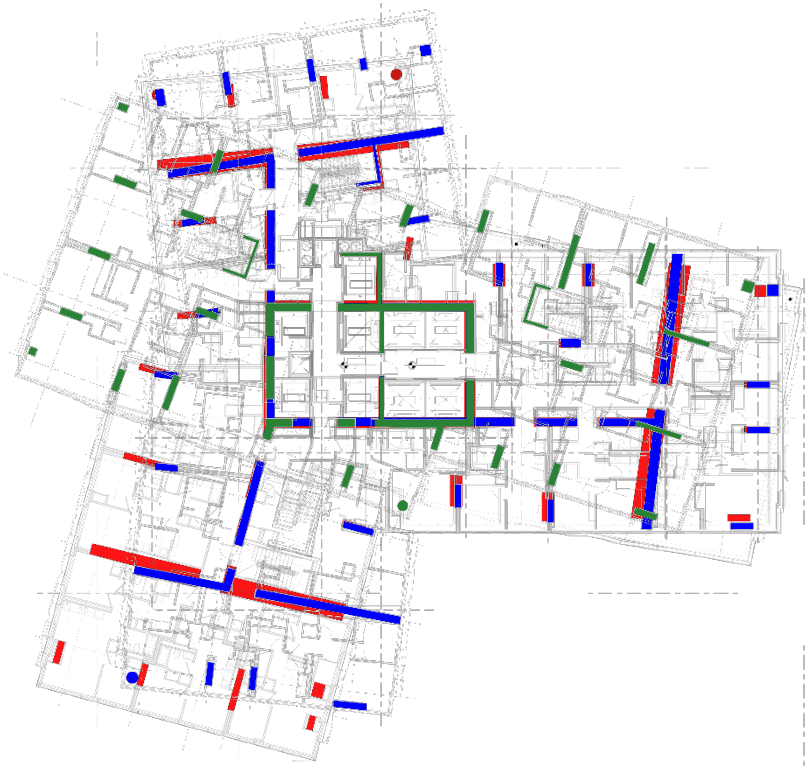
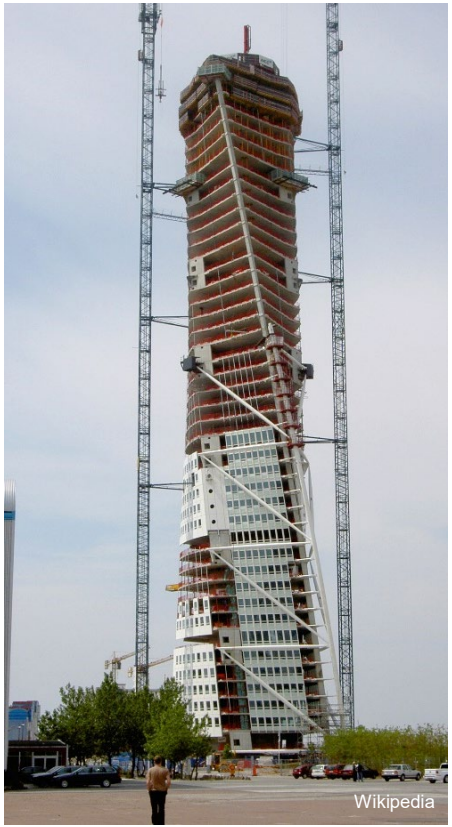
Then ...



... and now

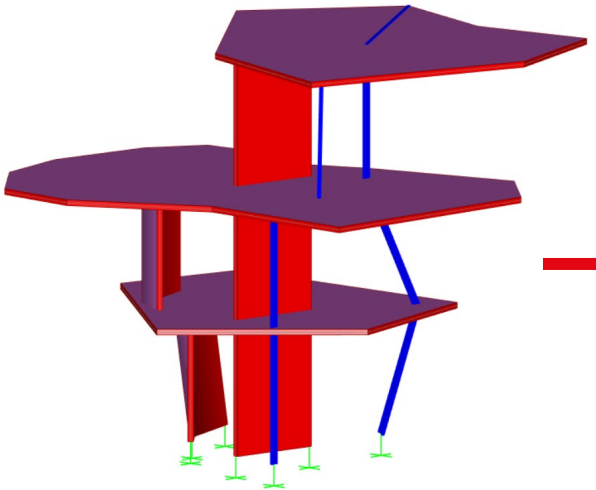


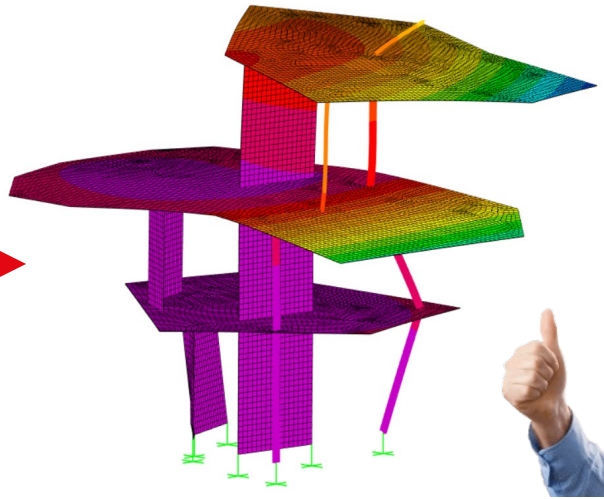

Wikipedia


Westbank


Dezeen

Computer software

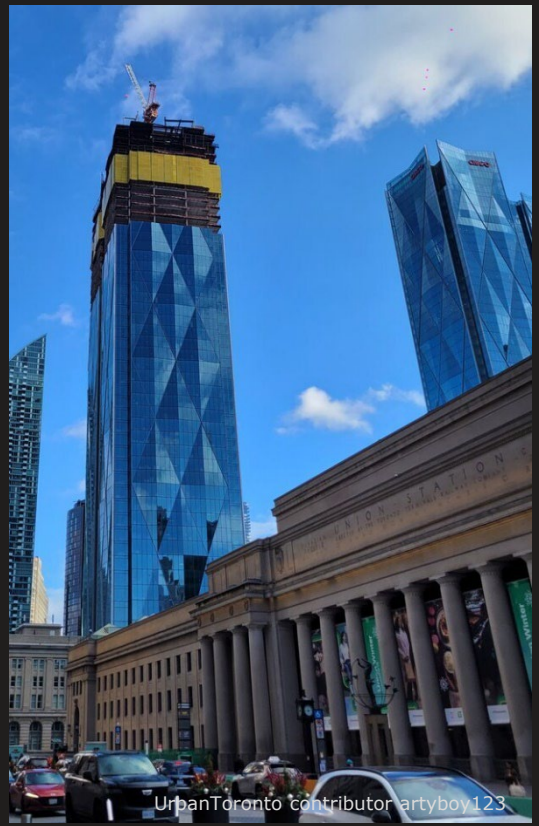




Garbage in …

… Garbage out

Case studies in complexity



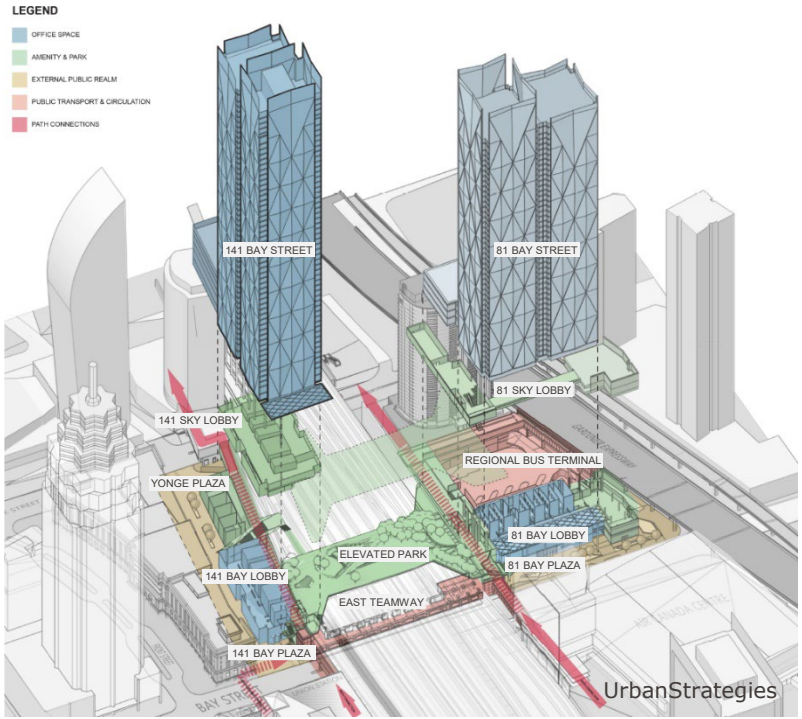
UrbanToronto contributor artyboy123

Pemberton

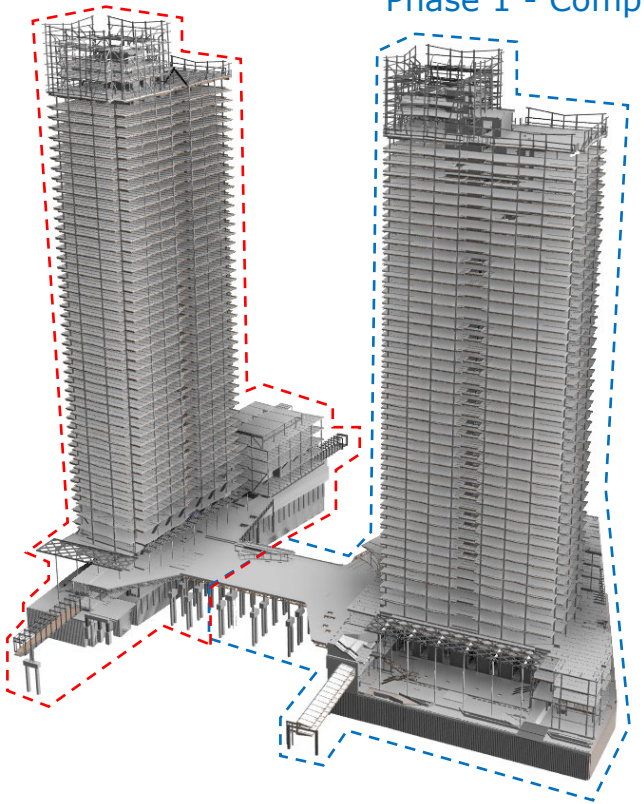
David Ruggiero

240 m-tall commercial

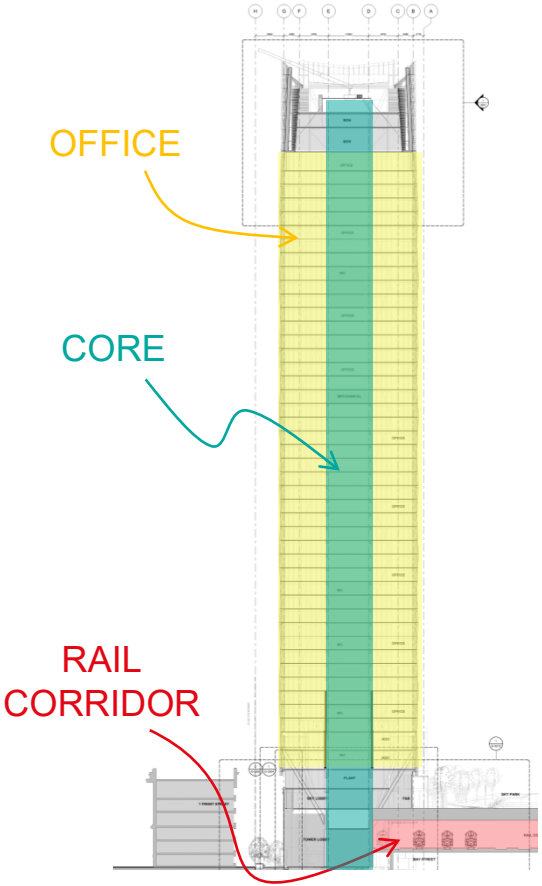
Phase 2 – Under Construction

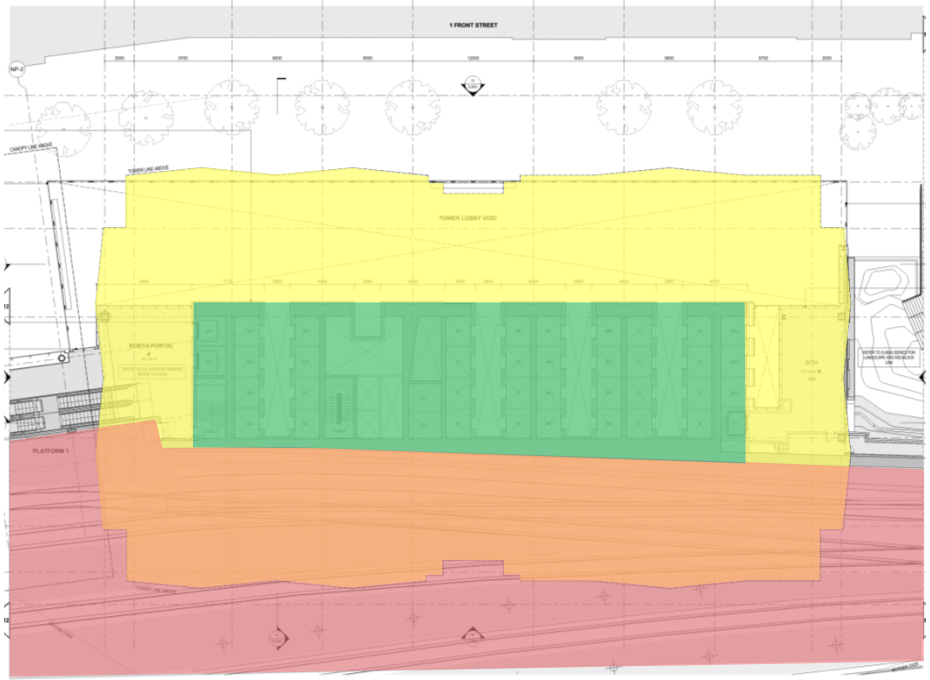


Phase 1 - Complete

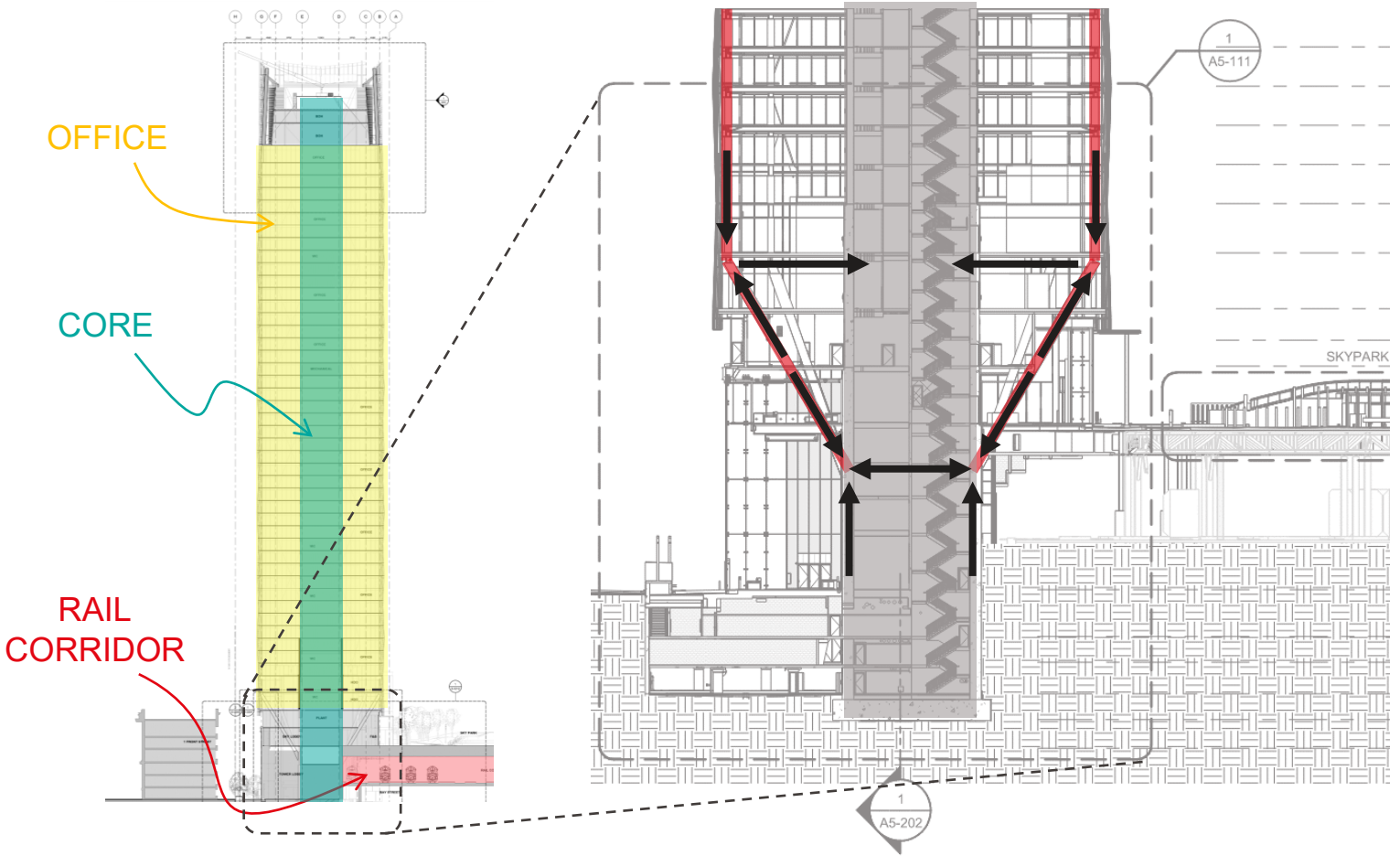


Phase II

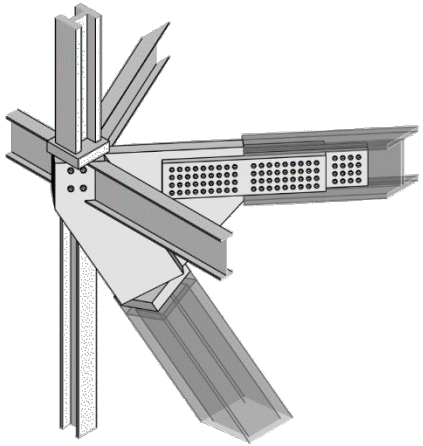

OFFICE
CORE
RAIL
CORRIDOR

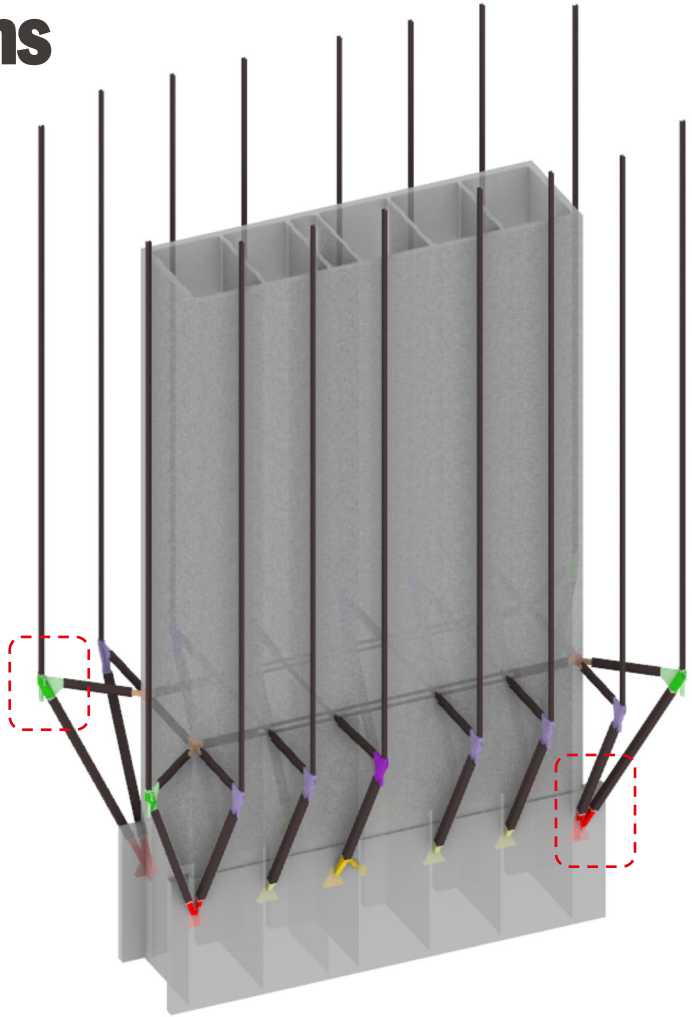

1 FRONT STREET
TOWER LOBBY VOID
NORTH PORTAL
PLATFORM 1

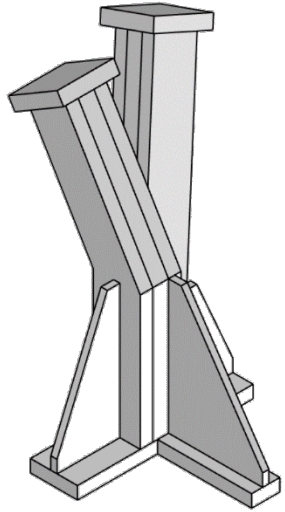
Phase II



Sloping columns







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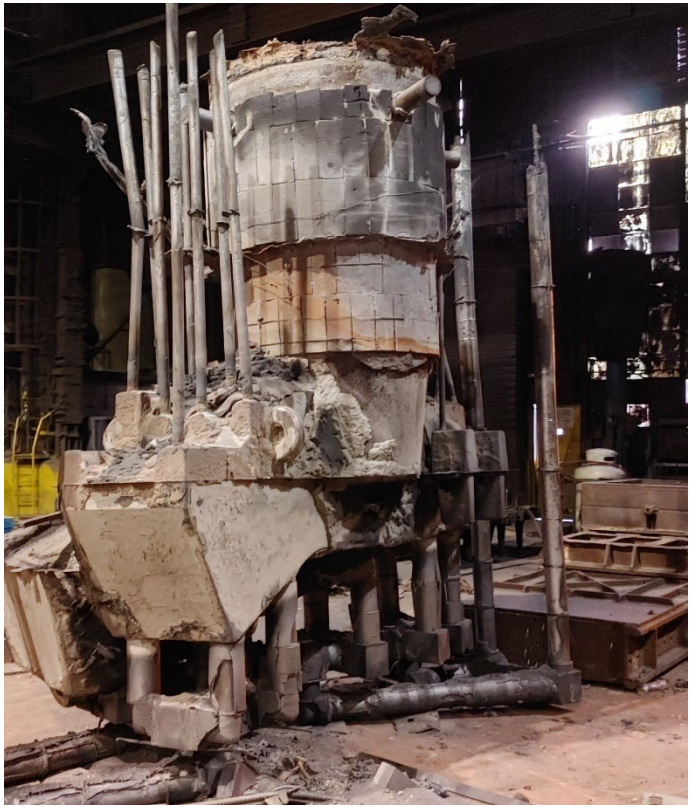
Cast steel nodes



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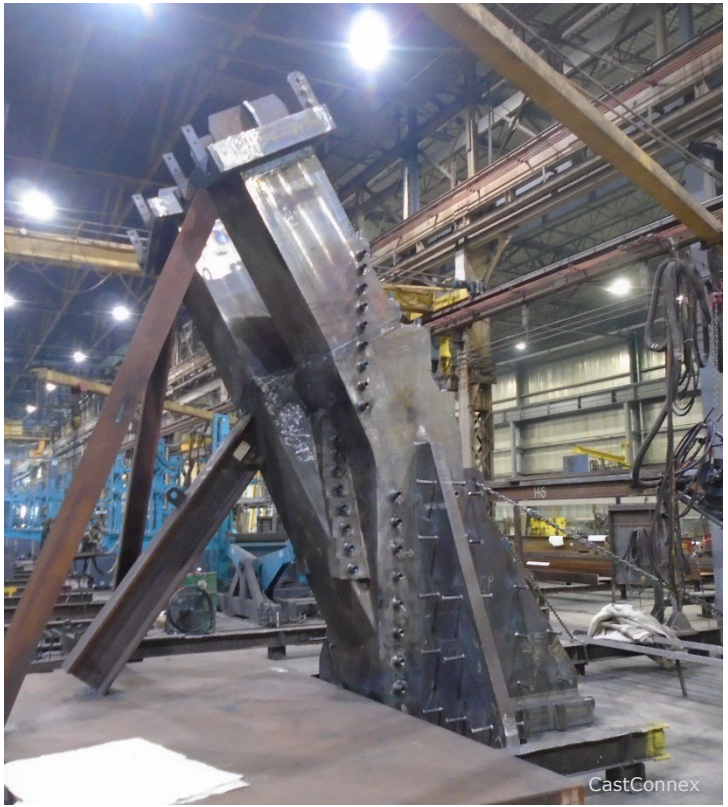
Cast steel nodes



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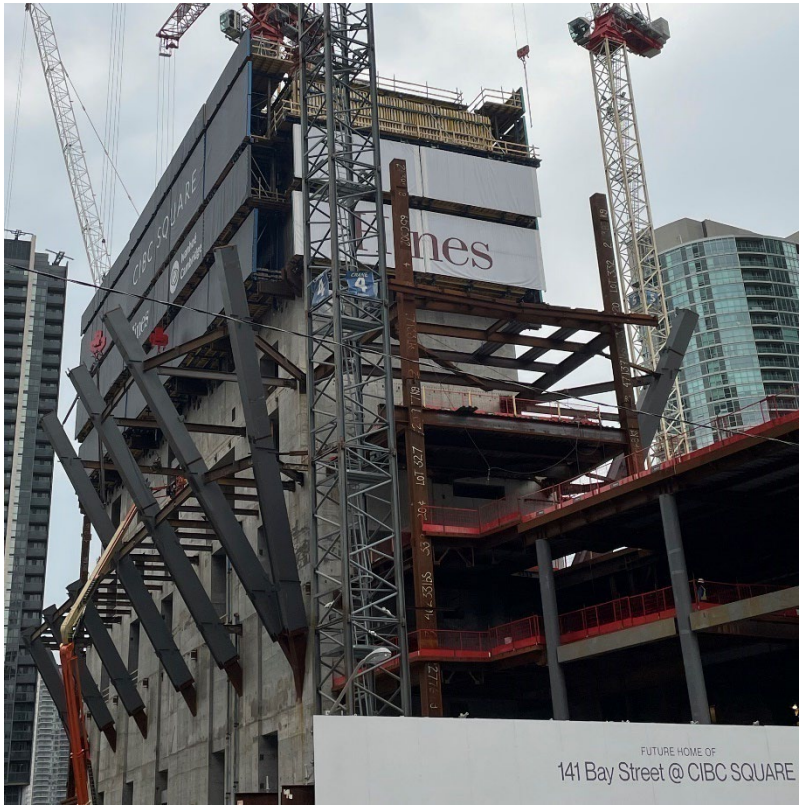
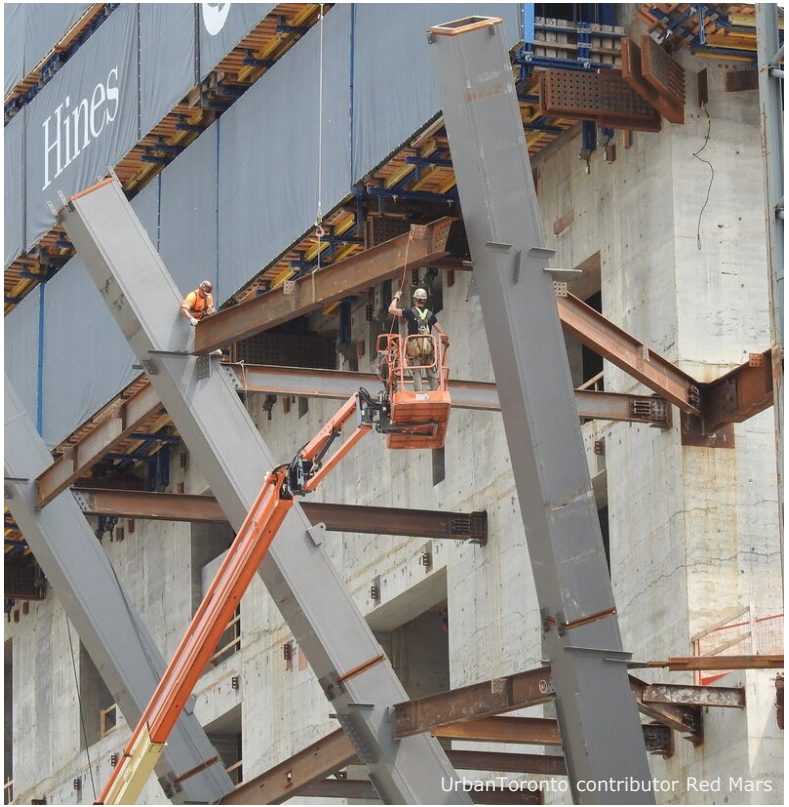
Cast steel nodes

Cast steel nodes

Sloping columns





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Sloping columns

SuperMetal

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Construction progress

David Ruggiero

Construction progress

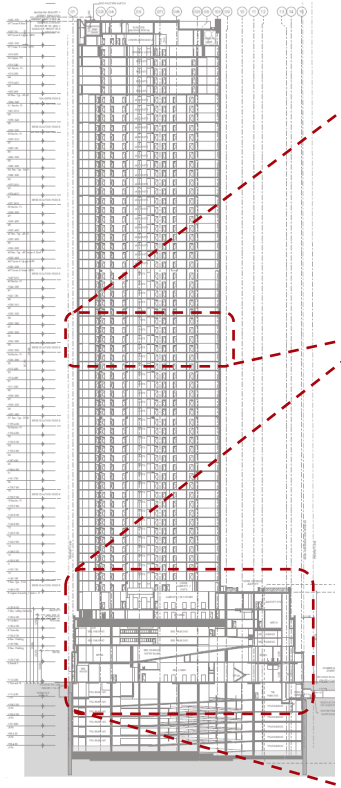
David Ruggiero

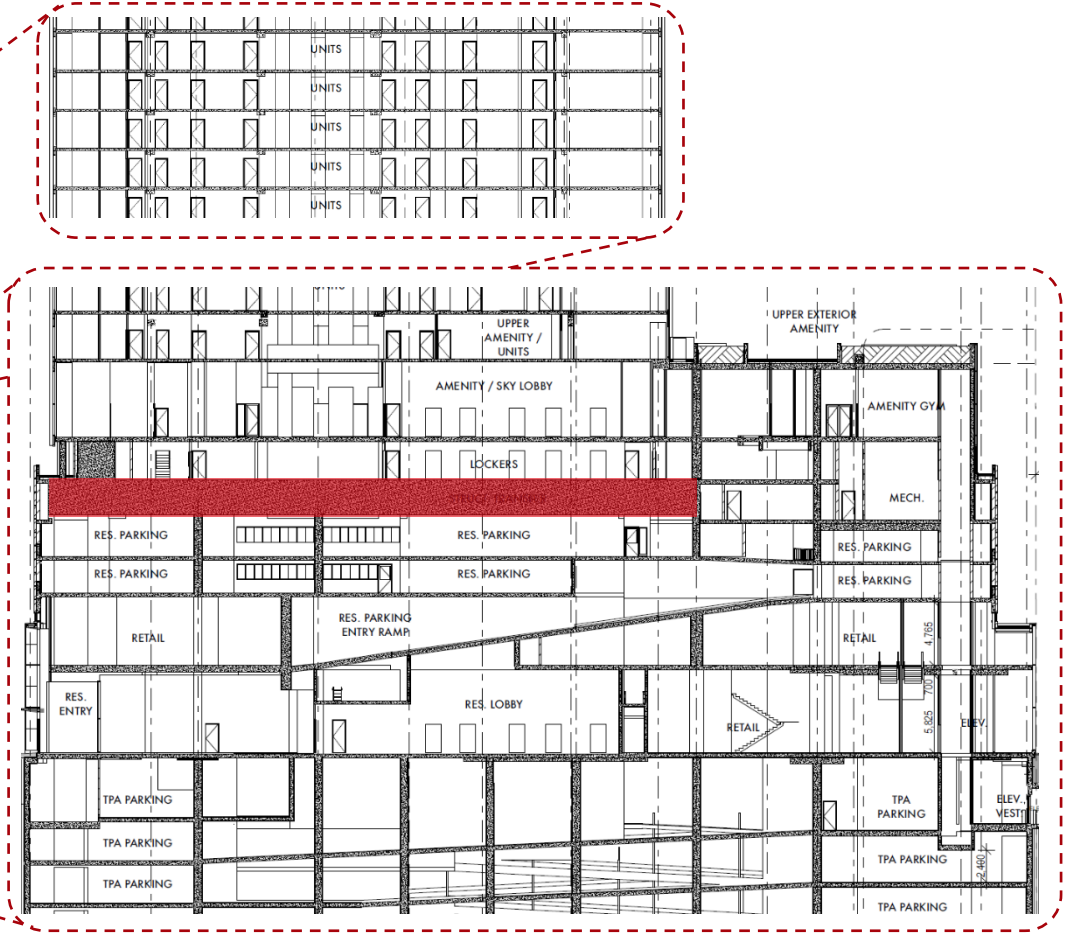
flickr: Drone Alone

215 m-tall residential

Pemberton

Cross-section





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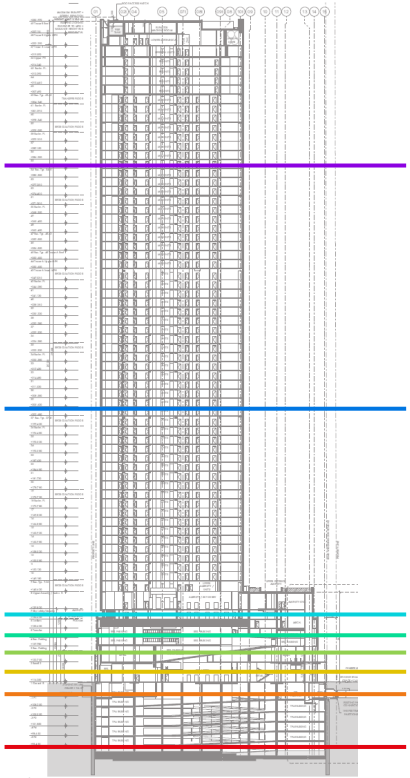
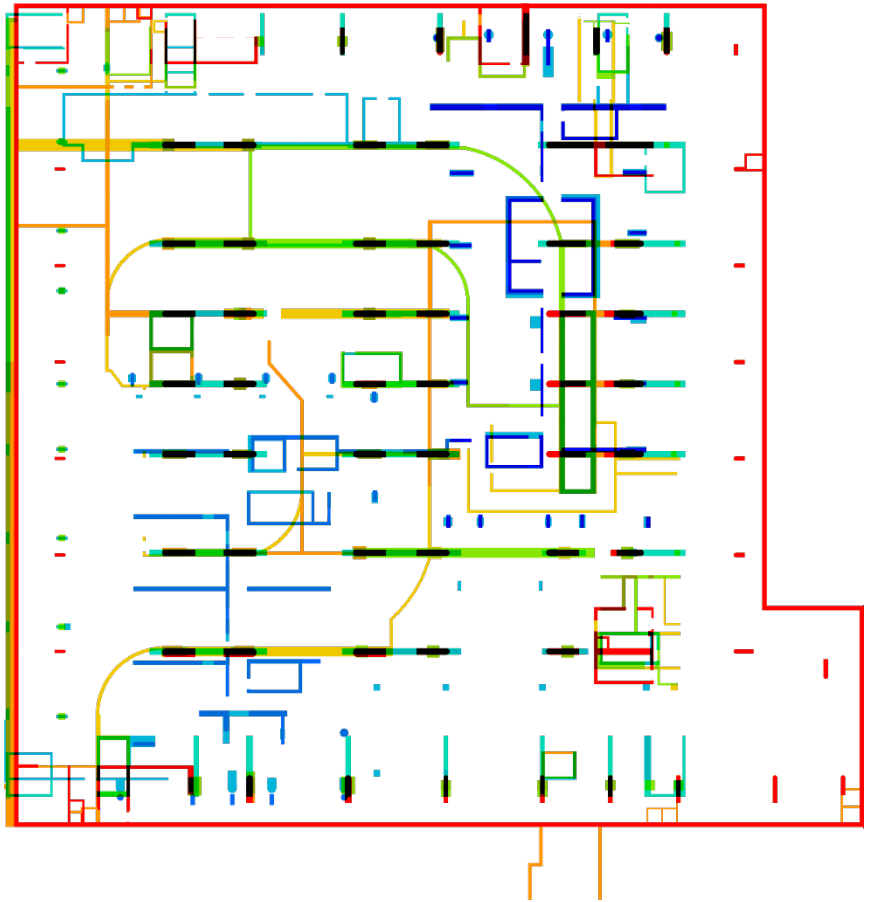
Floorplans





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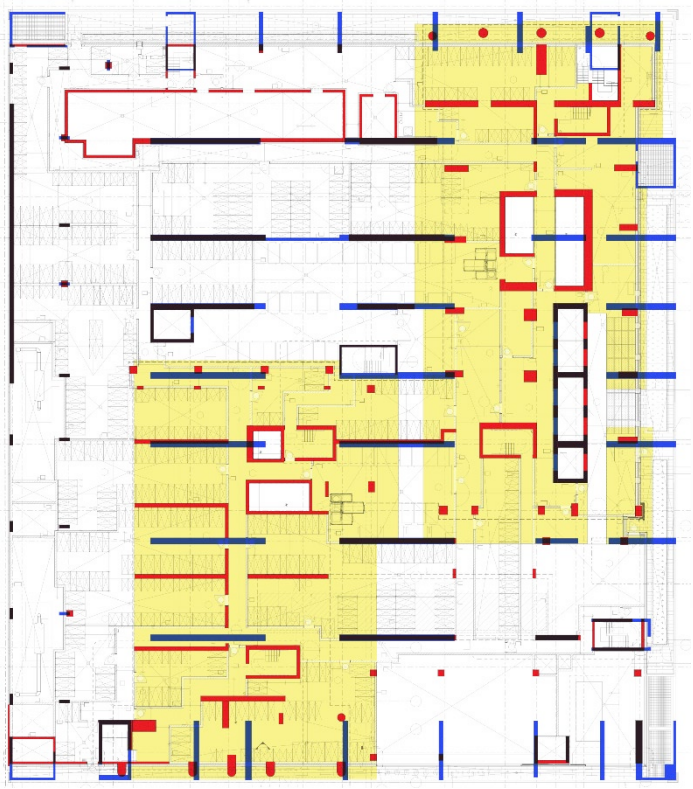
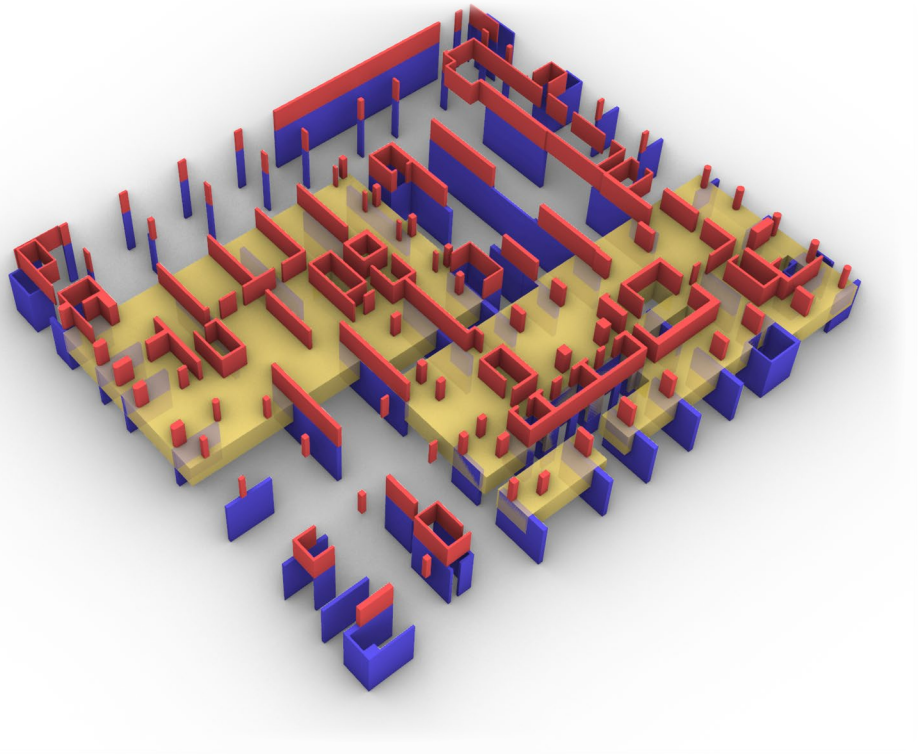
Transfer slabs

Transfer slabs





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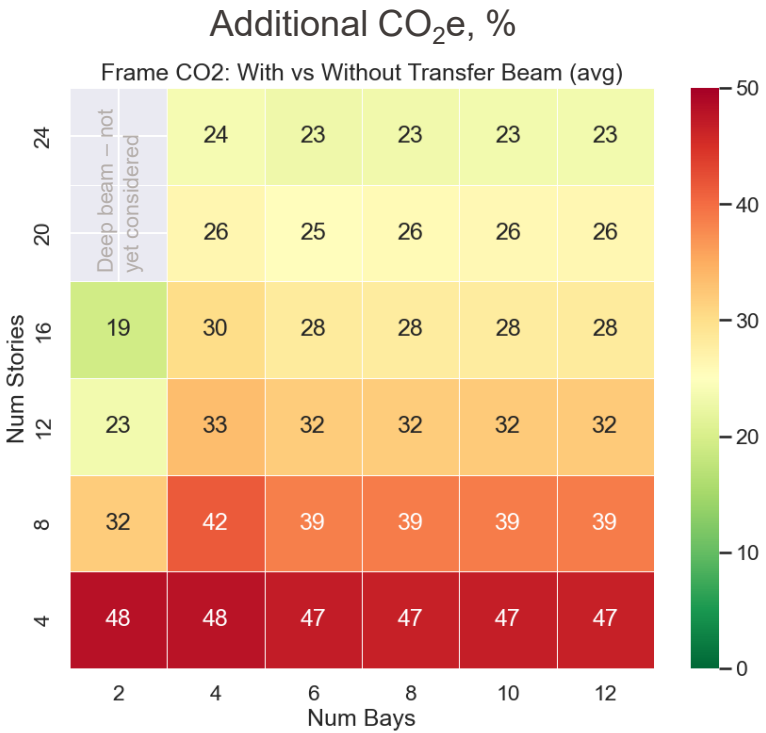
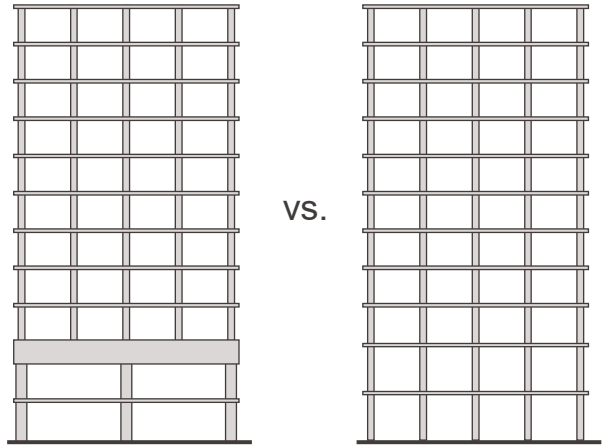
Transfer slabs

Carbon cost of transfers





Source: Enrico Pinelli (MSc project)

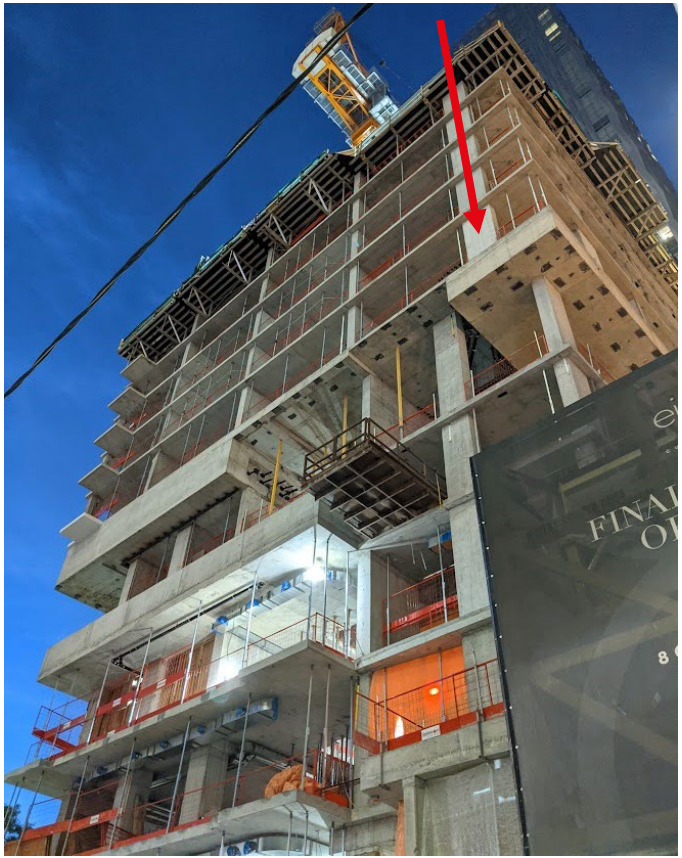
The new normal

UrbanToronto contributor Rascacielo


UrbanToronto contributor Red Mars

The new normal

45 STOREYS



The new normal

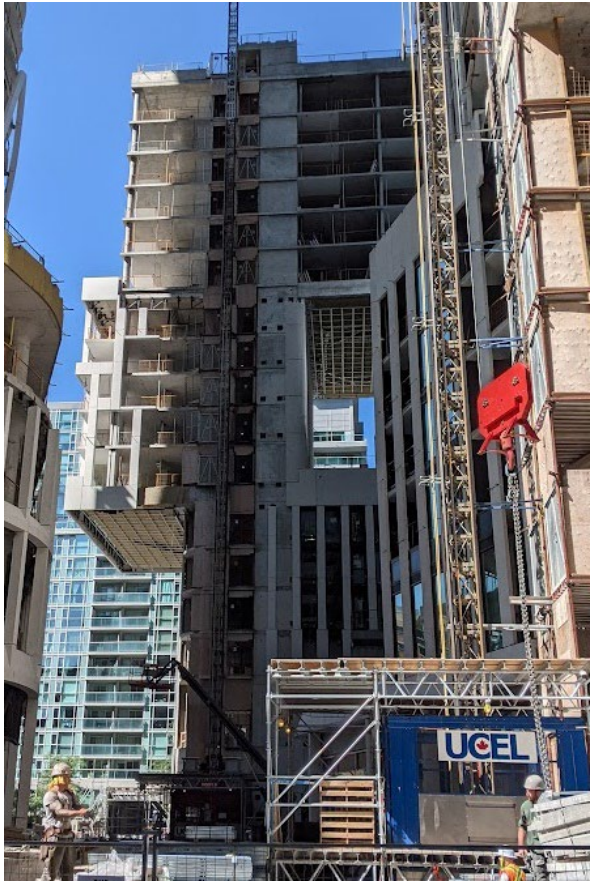
UrbanToronto contributor Solaris

David Ruggiero

The new normal

The new normal

The new normal



UrbanToronto contributor Red Mars

David Ruggiero

The new normal

The new normal

Phil Quach

The new normal

Phil Quach

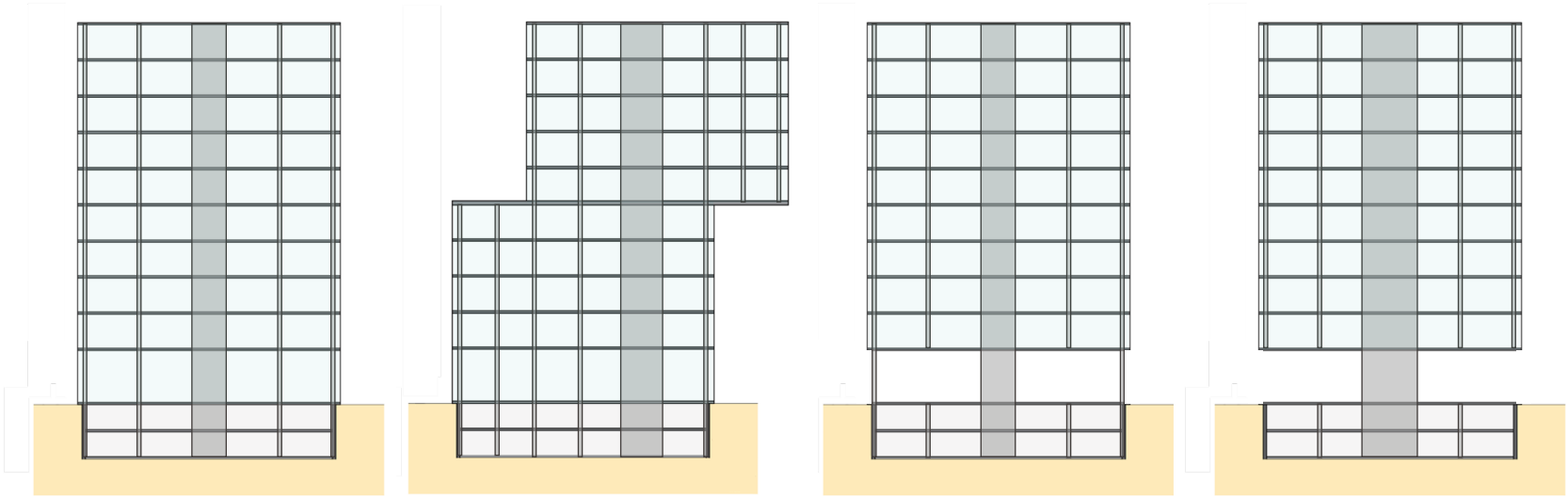
David Ruggiero

The new normal

The new normal

The new normal

Carbon cost of irregularity



~138 $kgCO_2e/m^2$

(8 designs)

~154 $kgCO_2e/m^2$

(4 designs)

+11%

~189 $kgCO_2e/m^2$

(1 design)

+37%

~291 $kgCO_2e/m^2$

(1 design)

+110%

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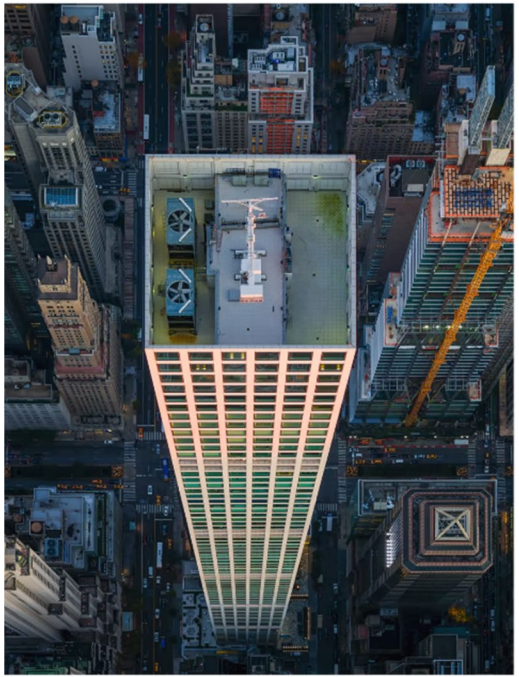
How tall is too tall?



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

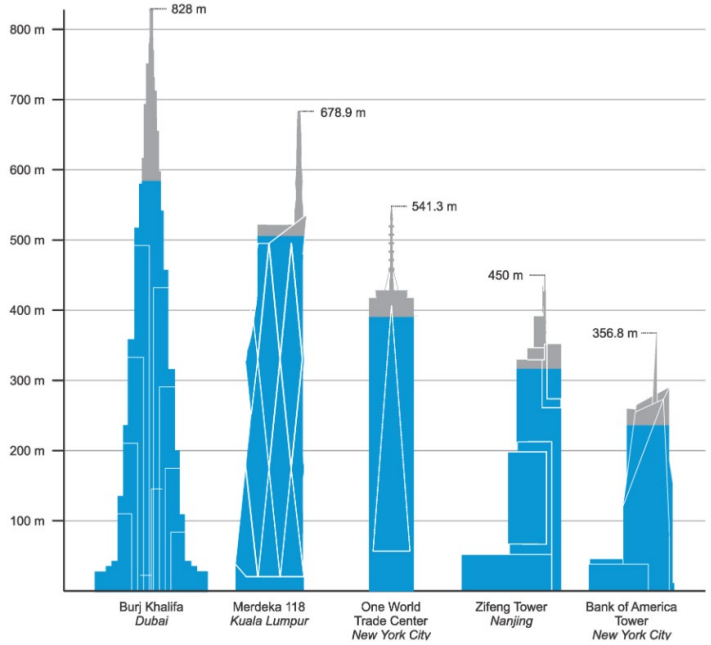
January/February 2023 Issue

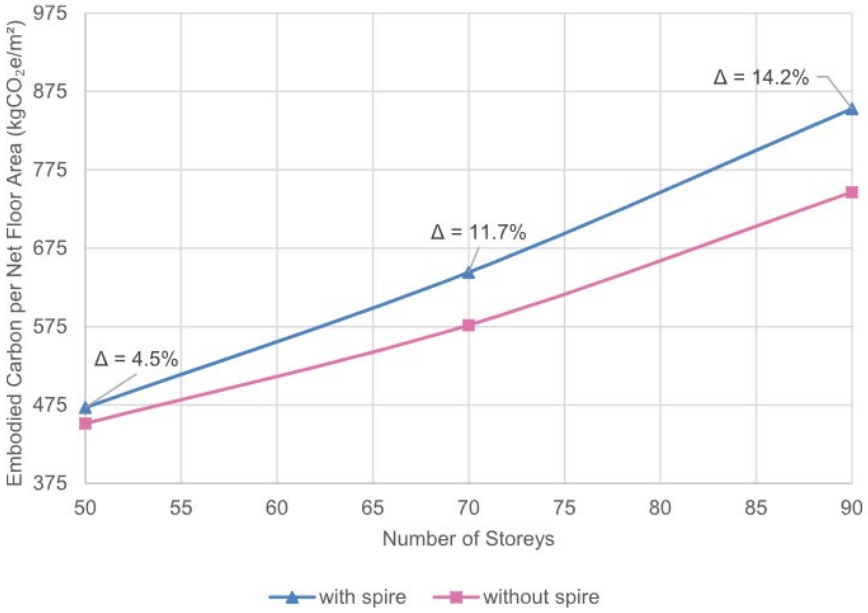
David Ruggiero

Vanity projects – 11th century

Vanity projects – 21st century

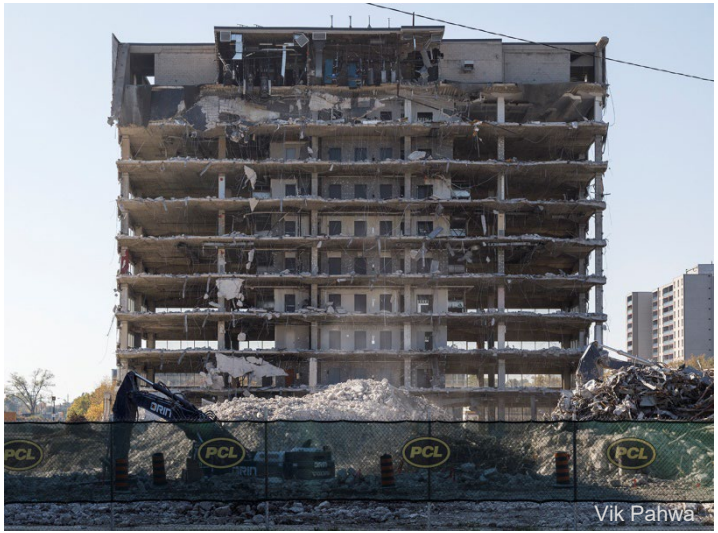
Carbon cost of vanity spires





Helal, James, Dario Trabucco, and Dalibor Savovic. 2024. 'Embodied Carbon Premium for Vanity Height: A Case for the Exclusion of Decorative Spires in the Design of Tall Buildings'. Journal of Cleaner Production 456 (June):142334.

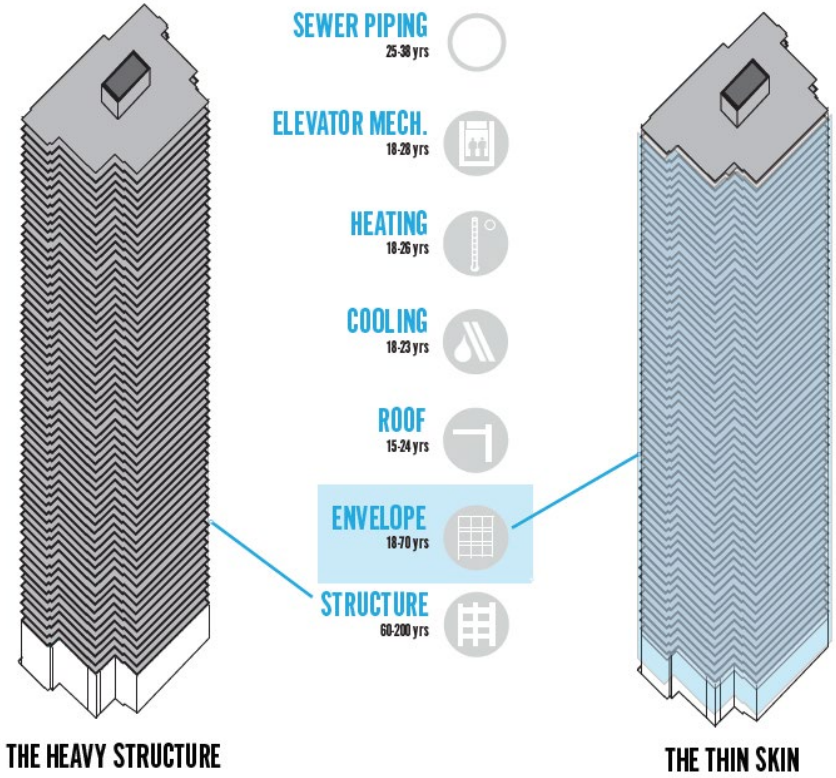
Life-cycle



39 years old

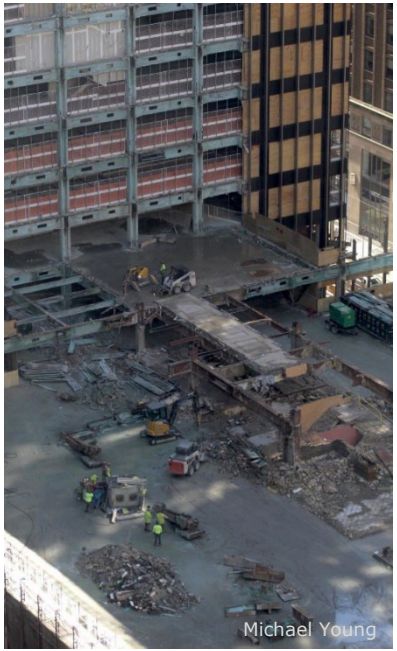
1900 years old

Life-cycle



Building resilience in condoland, SPACING magazine

Skyscraper demolition



270 Park Avenue, New York City – 215 m – Built 1960, demolished 2021

David Ruggiero

Skyscraper demolition

AXA Tower, Singapore – 235 m – Built 1986, demolished 2023

Skyscraper demolition

[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 (CTBUH)

Questions?