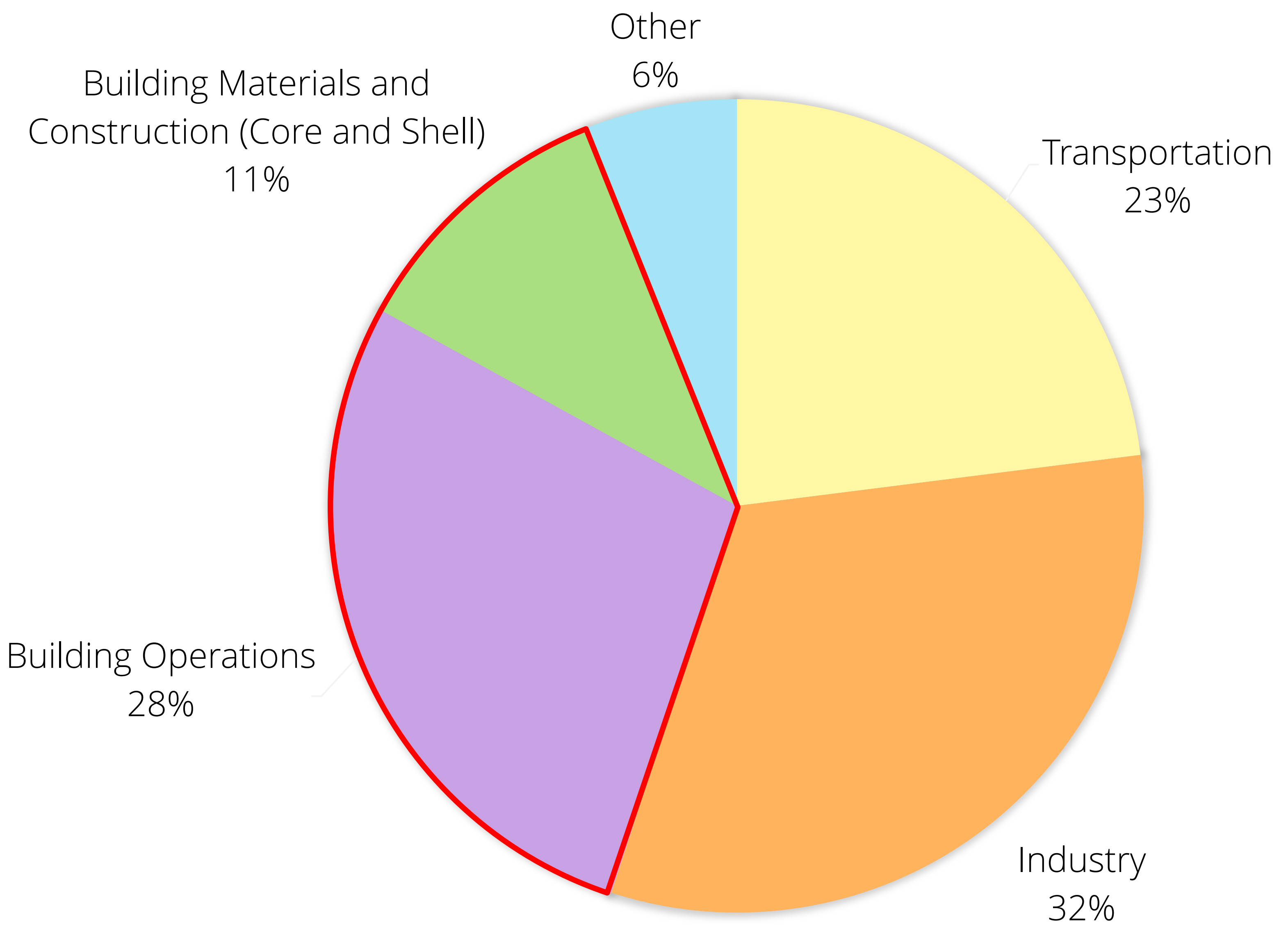
Foster + Partners

The Future of Tall Buildings

Roger Ridsdill Smith

Global CO_2 Emissions



Source : Global Alliance for Buildings and Construction
2018 Global Status Report

The Future of Tall Buildings

- History
- Technology
- Sustainability
- The Future

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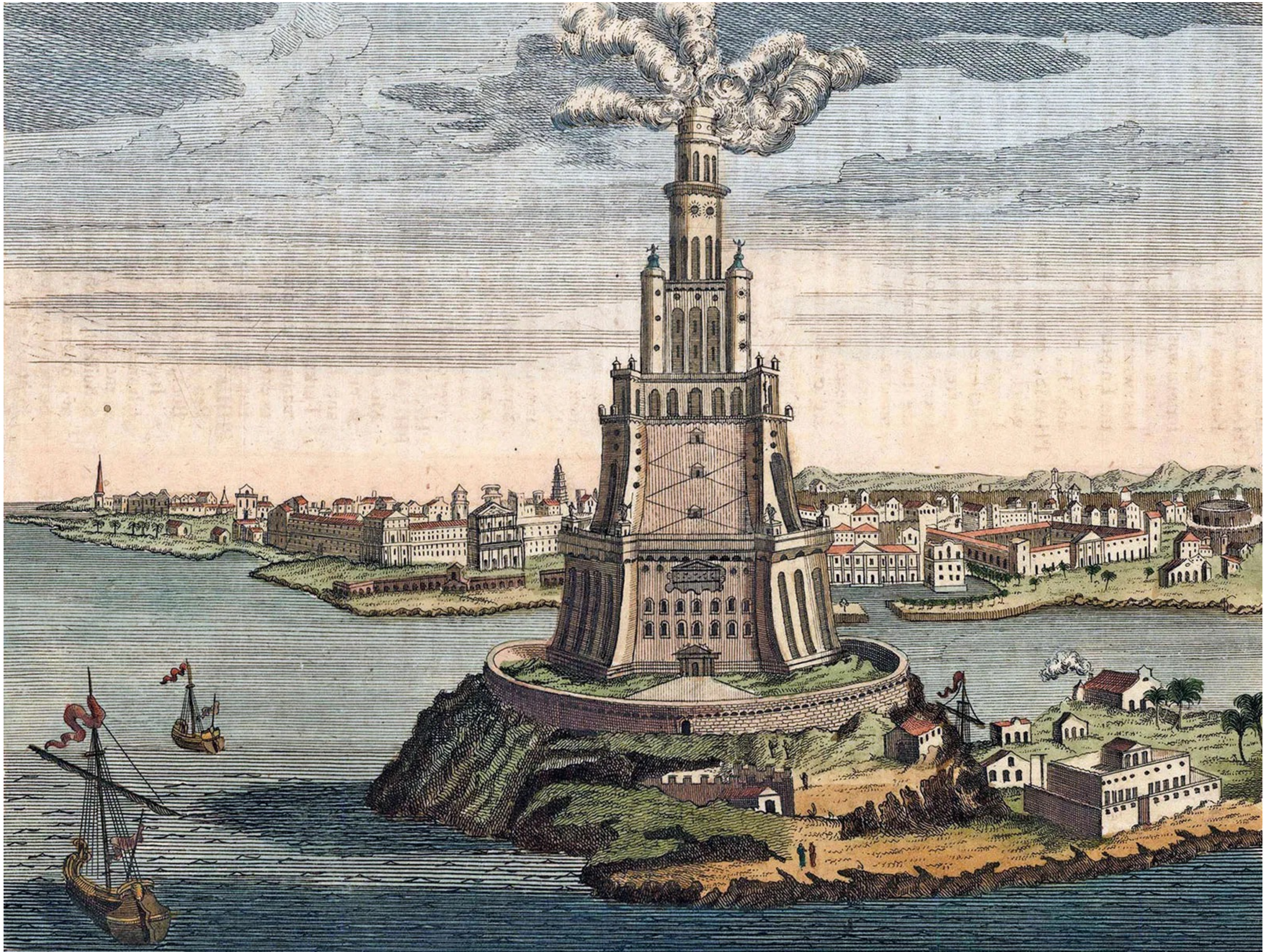
Giza Pyramids | 2600 BC | 146m

Alexandria lighthouse | 247 BC | 120m



Lincoln Cathedral | 1311 | 160m

Cathedrals

Strasbourg Cathedral | 1439 | 142m

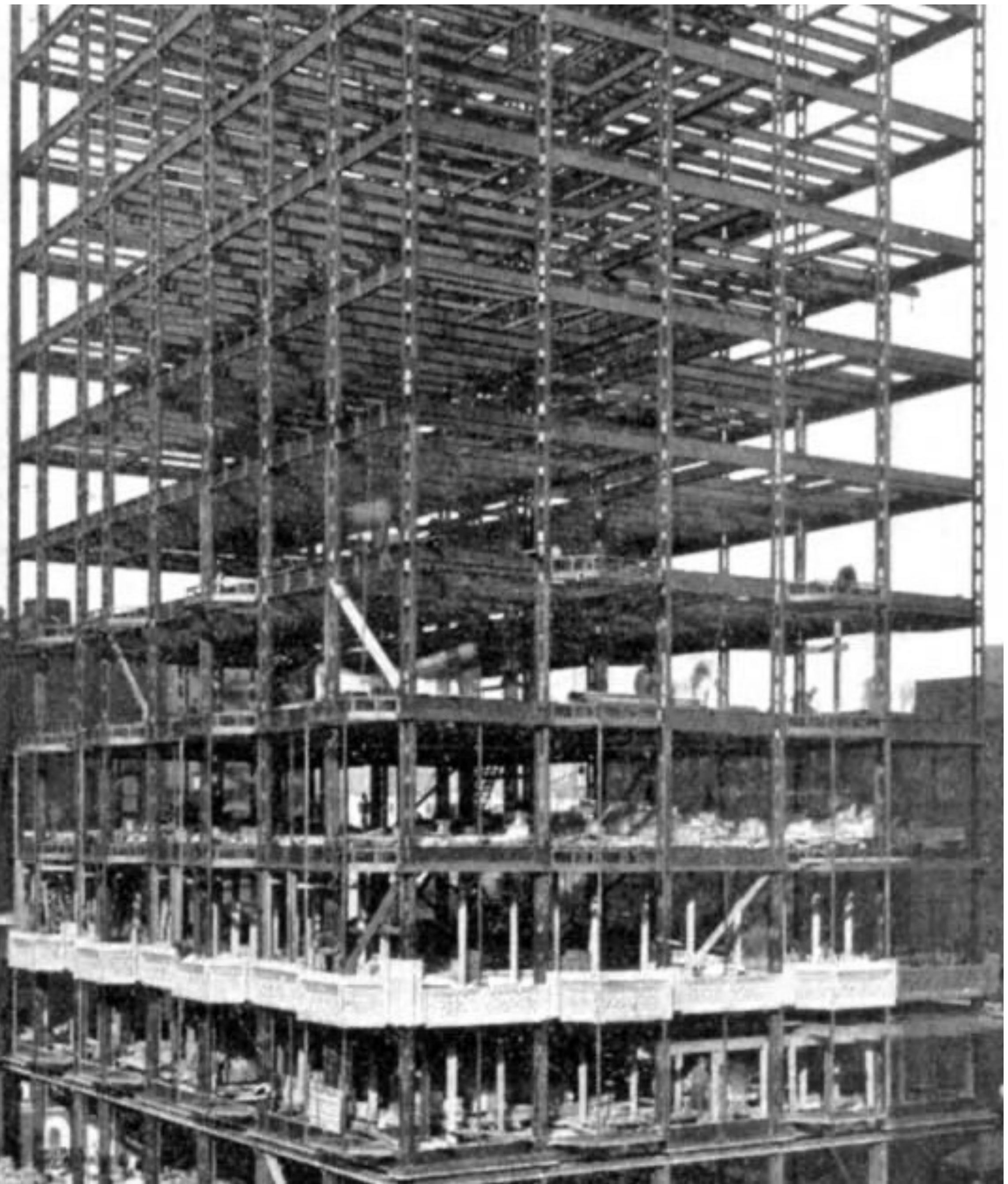
Cologne Cathedral | 1880 | 157m

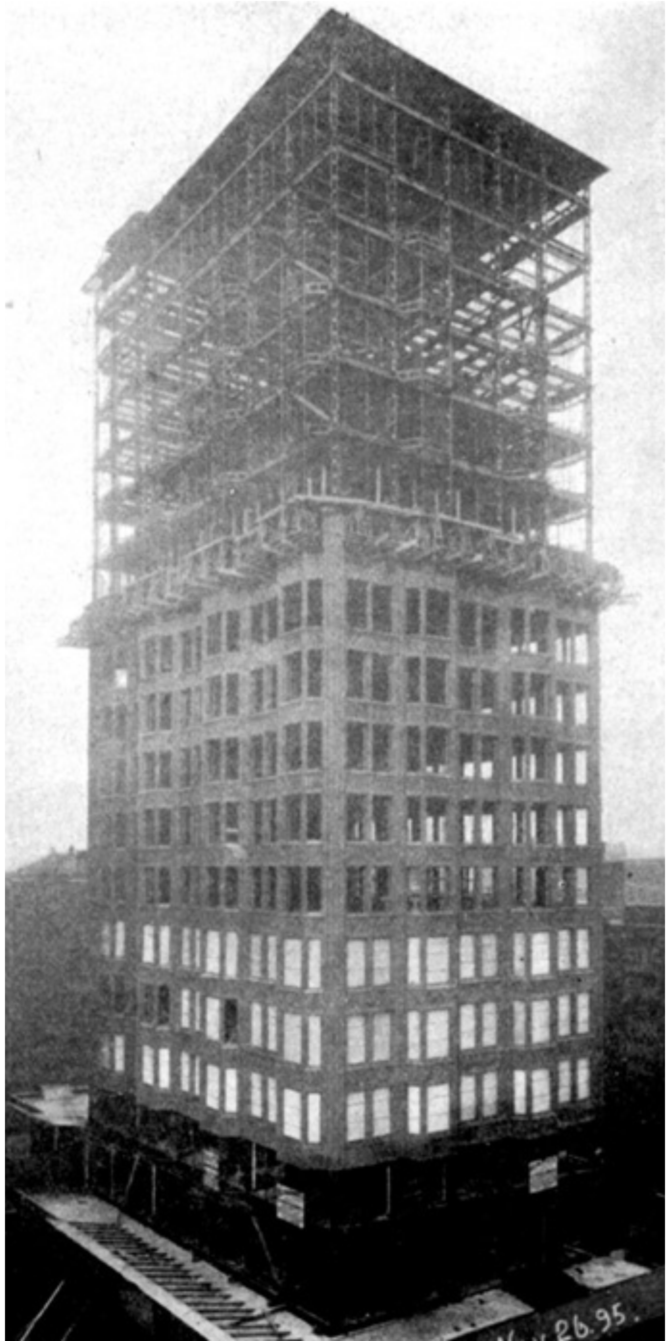
Otis Safety Elevator | 1854

Bessemer Converter | 1856

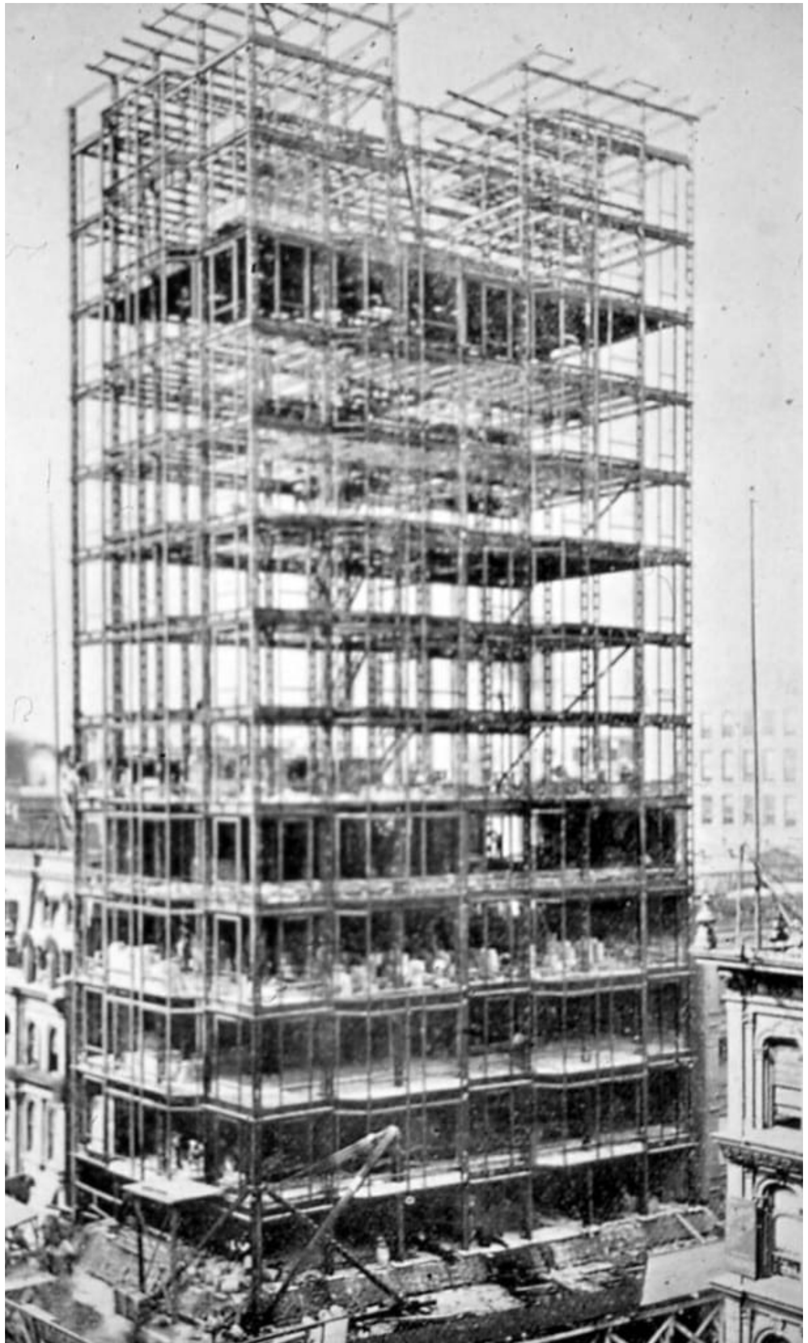
Home Insurance Building | 1891 Architect : William Le Baron Jenney | Height : 42m

Fisher Building, Chicago | 1896 Architect : D H Burnham and Co. | Height : 84m





Reliance Building, Chicago | 1894 Architect : CB Atwood of Burnham and Co. | Height : 62m



Louis Sullivan | The Tall Building Artistically Considered 1896

seems ever as though the life and the form were absolutely one and inseparable, so adequate is the sense of fulfilment.

Whether it be the sweeping eagle in his flight, or the open apple-blossom, the toiling work-horse, the blithe swan, the branching oak, the winding stream at its base, the drifting clouds, over all the coursing sun, *form ever follows function*, and this is the law. Where function does not change, form does not change. The granite rocks, the ever-brooding hills, remain for ages; the lightning lives, comes into shape, and dies, in a twinkling.

It is the pervading law of all things organic and inorganic, of all things physical and metaphysical, of all things human and all things superhuman, of all true manifestations of the head, of the heart, of the soul, that the life is recognizable in its expression, that form ever follows function. *This is the law.*

Shall we, then, daily violate this law in our art? Are we so de-

Chicago | 1927

Manhattan, New York | 1931

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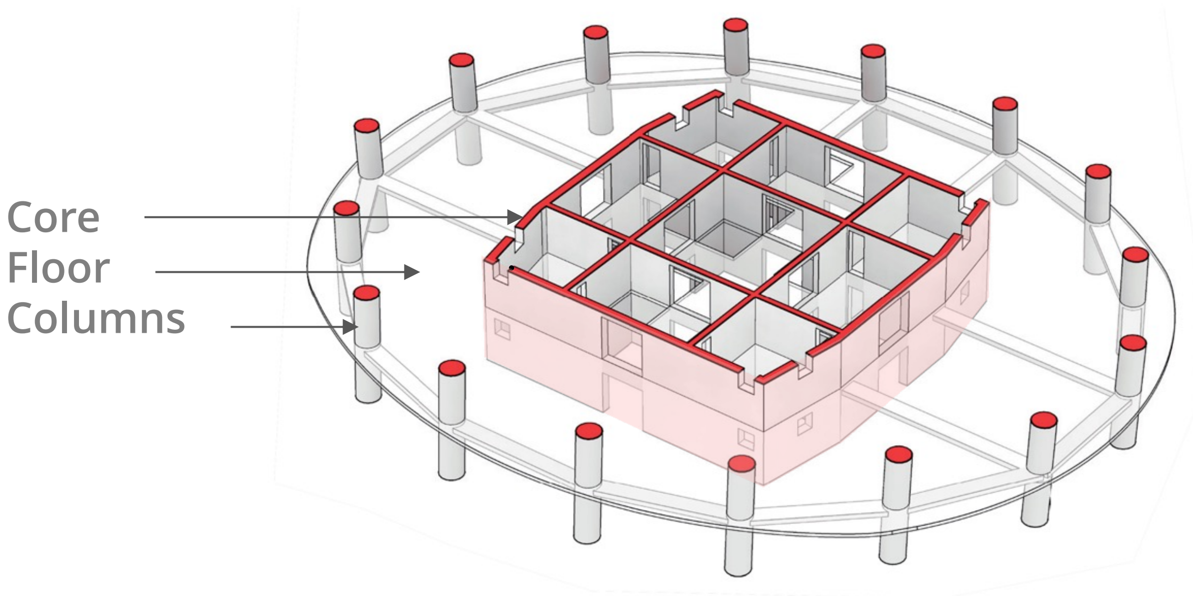
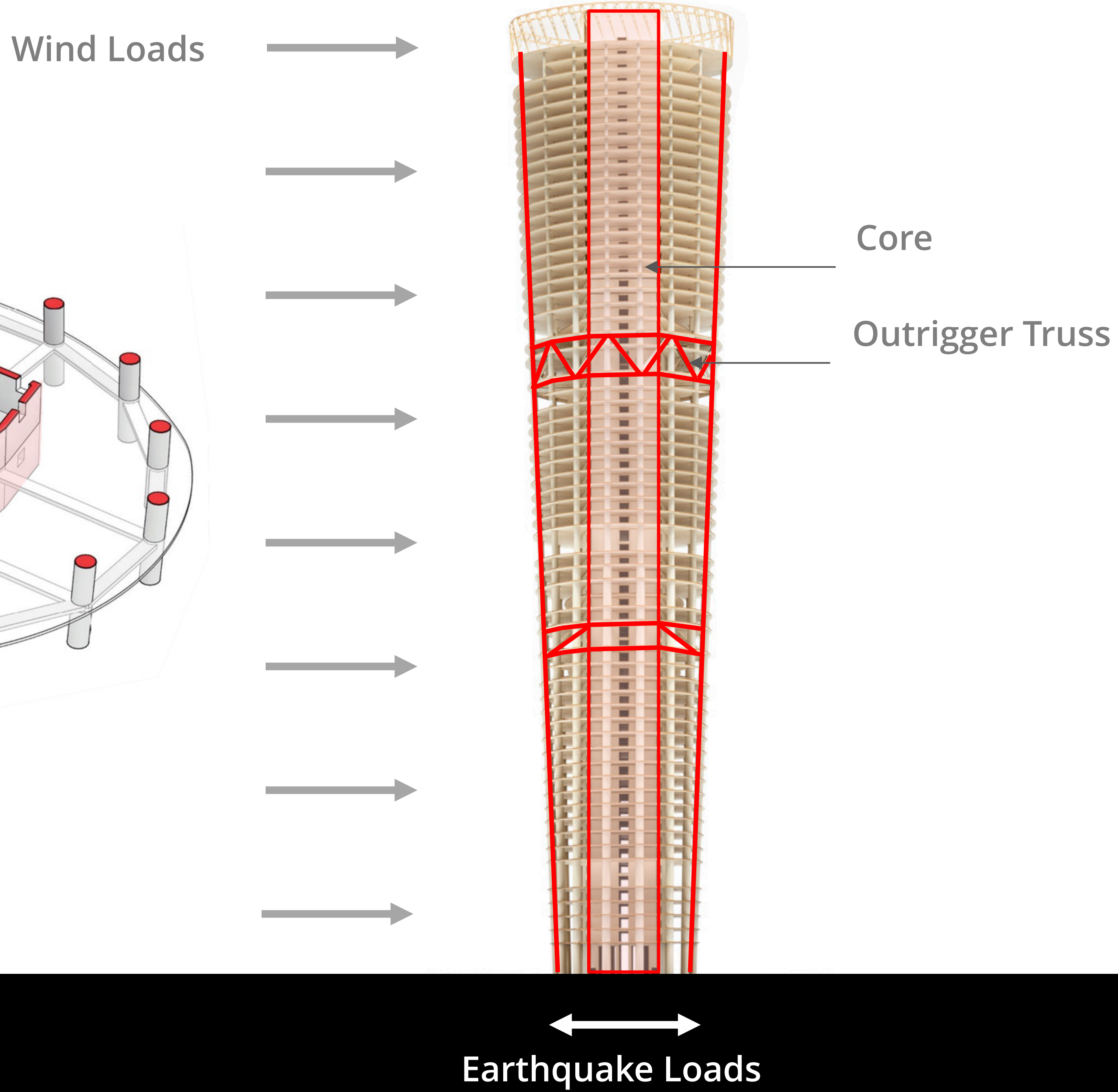
Foster + Partners | Structures | Recent Tall Buildings

Lusail Towers, Doha| Foster + Partners | 4 towers Height : 257 and 300m

Lusail Towers Structural Model

Lusail Towers Structural Principles





Lusail Towers | Construction

Lusail Towers | Construction

Reinforced concrete core

Outrigger floor with perimeter truss

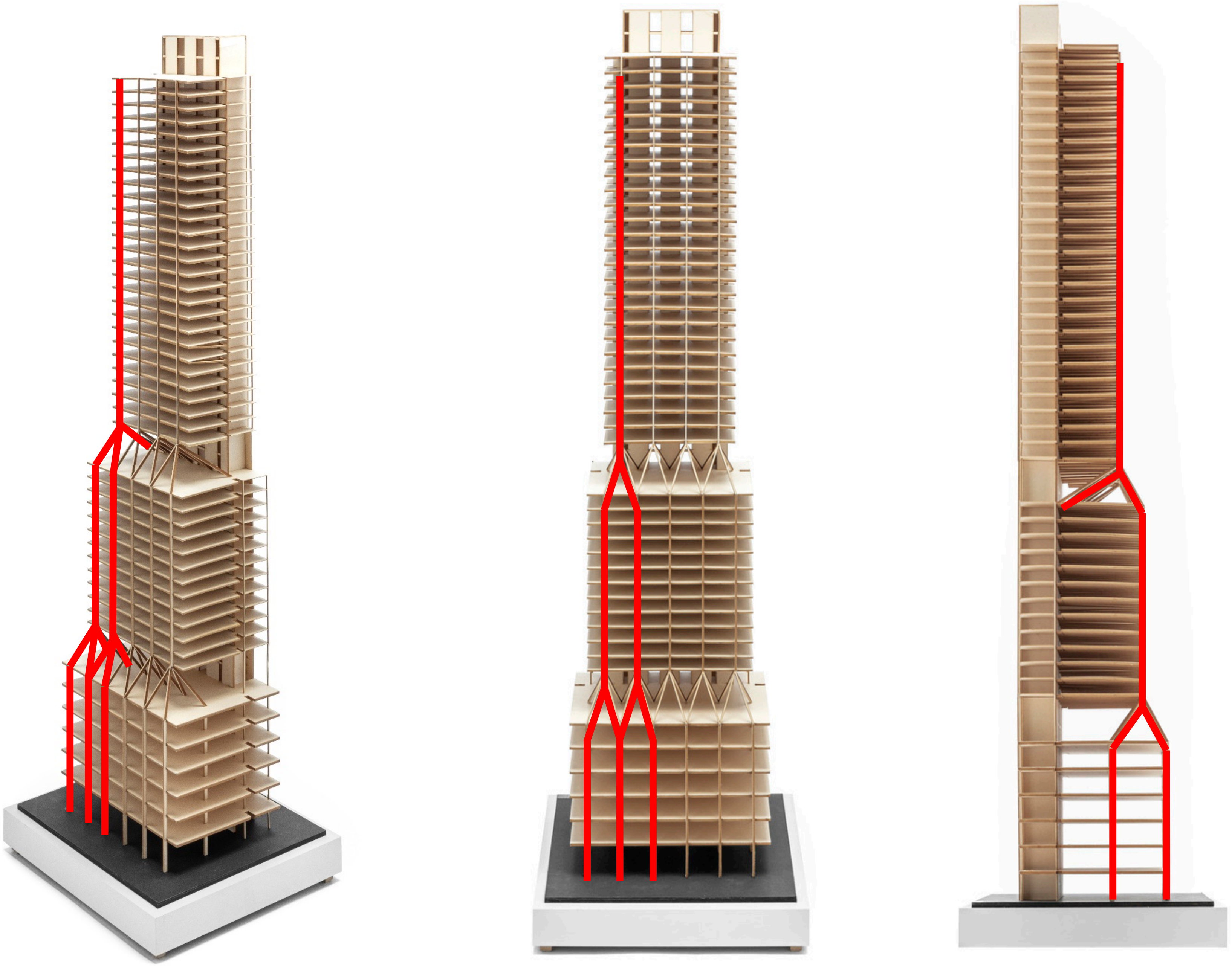
Lusail Towers

425 Park Avenue, New York | Foster + Partners | Height : 254m

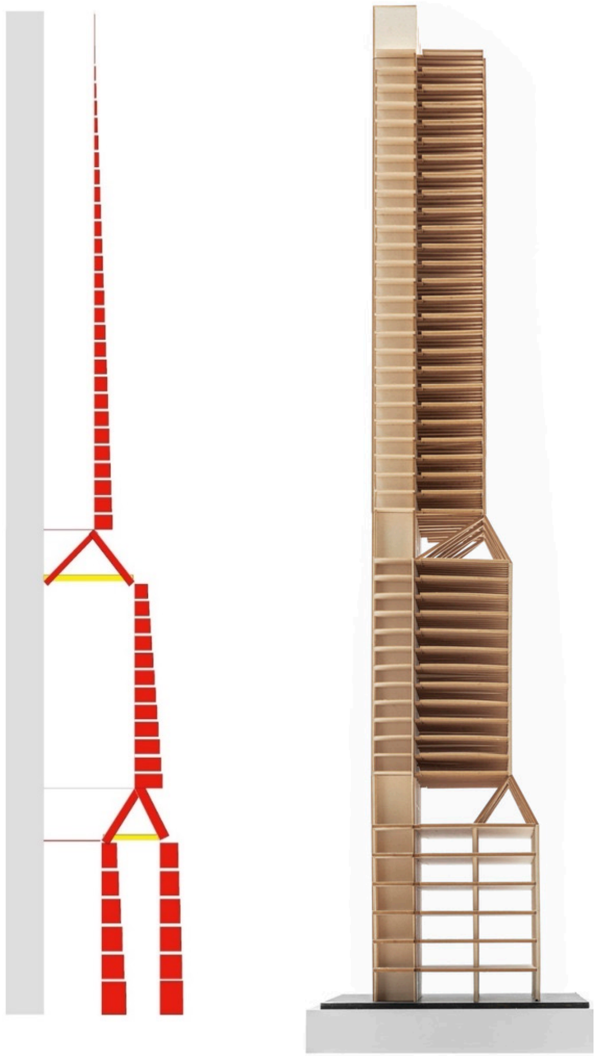
425 Park Avenue | Foster + Partners

- New York
- 254m tall
- Competition 2012

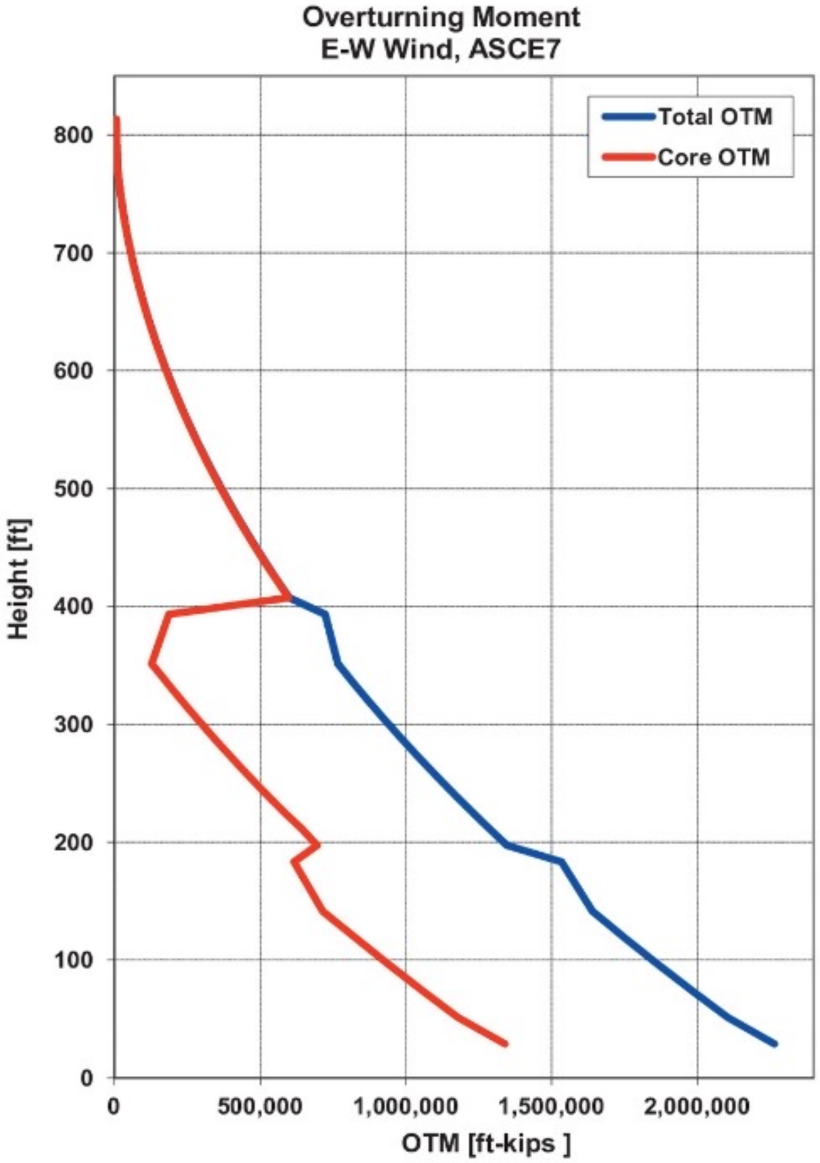
425 Park Avenue | Foster + Partners Structural Principles



425 Park Avenue | Foster + Partners Structural Principles



Structural forces
under vertical loads



Bending moment under wind load

425 Park Avenue | Foster + Partners

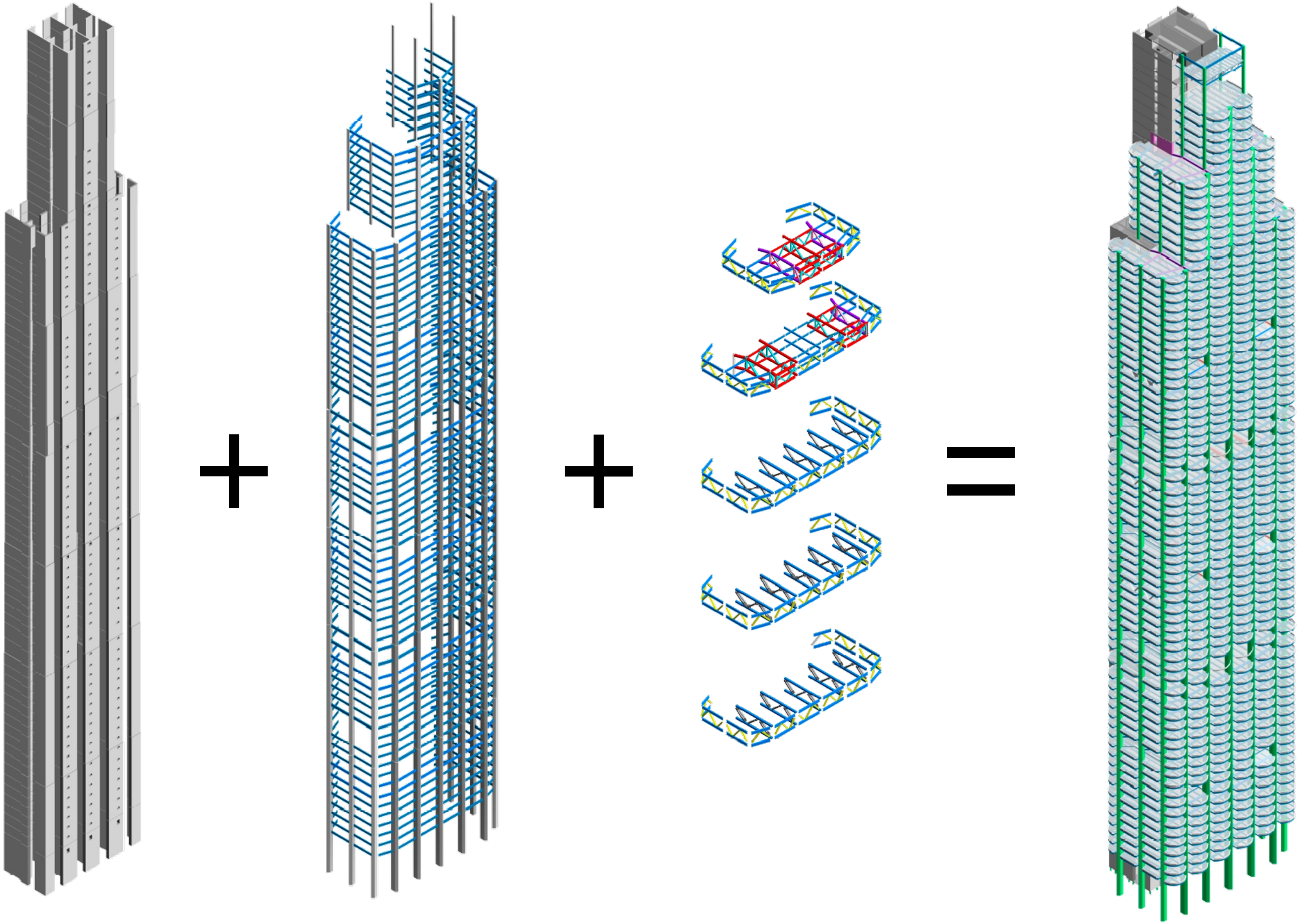
China Merchants Bank Tower, Shenzhen | Foster + Partners | Height : 388m

China Merchants Bank tower | Foster + Partners

- Shenzhen
- 388m tall

China Merchants Bank Tower | Foster + Partners Structural Principles

- Side core
- 20m span column-free office space
- Fire water tank on the roof used as a Tuned Liquid Damper to reduce wind-induced motion
- Performance-based seismic design



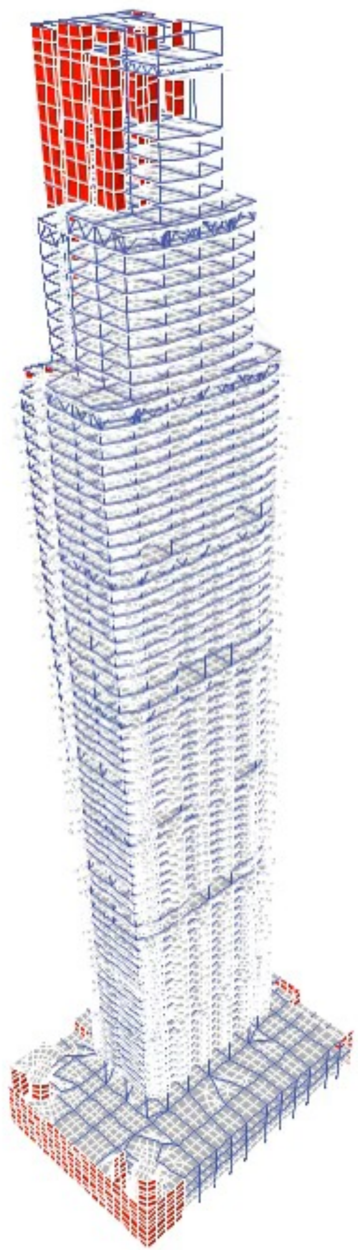
Concrete side core

Perimeter Composite moment frame

Steel outriggers, belt truss and transfer truss

Lateral force resisting system of the HQ tower

China Merchants Bank Tower | Foster + Partners Earthquake Timeline



China Merchants Bank Tower | Foster + Partners | Construction

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What is Embodied Carbon?

Carbon dioxide equivalent (CO_2**e**):

A measurement used to compare the emissions from various greenhouse gases on the basis of the global warming potential (GWP)

Symbol	Name	Common sources	Atmospheric lifetime (years)*	Global warming potential	% of US emissions
CO_2	Carbon dioxide	Fossil fuel combustion, forest clearing, cement production, etc.	50-200	1	79.9
CH_4	Methane	Landfills, production and distribution of natural gas and petroleum, fermentation from the digestive system of livestock, rice cultivation, fossil fuel combustion, etc.	12	21X	9.5
N_2O	Nitrous oxide	Fossil fuel combustion, fertilisers, nylon production, manure, etc.	150	310X	5.8
HFCs	Hydrofluoro-carbons	Refrigeration gases, aluminium smelting, semiconductor manufacturing, etc.	264	Up to 11,700X	1.8
PFCs	Perfluoro-carbons	Aluminium production, semiconductor industry, etc.	10,000	Up to 9200X	
SF_6	Sulphur hexafluoride	Electrical transmission and distribution systems, circuit breakers, magnesium production, etc.	3,200	Up to 23,900X	

*Standard industry classification

(Source: Energy Information Administration, (1998); IPCC, (2001))[180]

Carbon Measurement

Whole Life Carbon
Emissions from all lifecycle phases

=

Embodied Carbon
Emissions associated with materials and construction processes throughout the whole lifecycle of a building

+

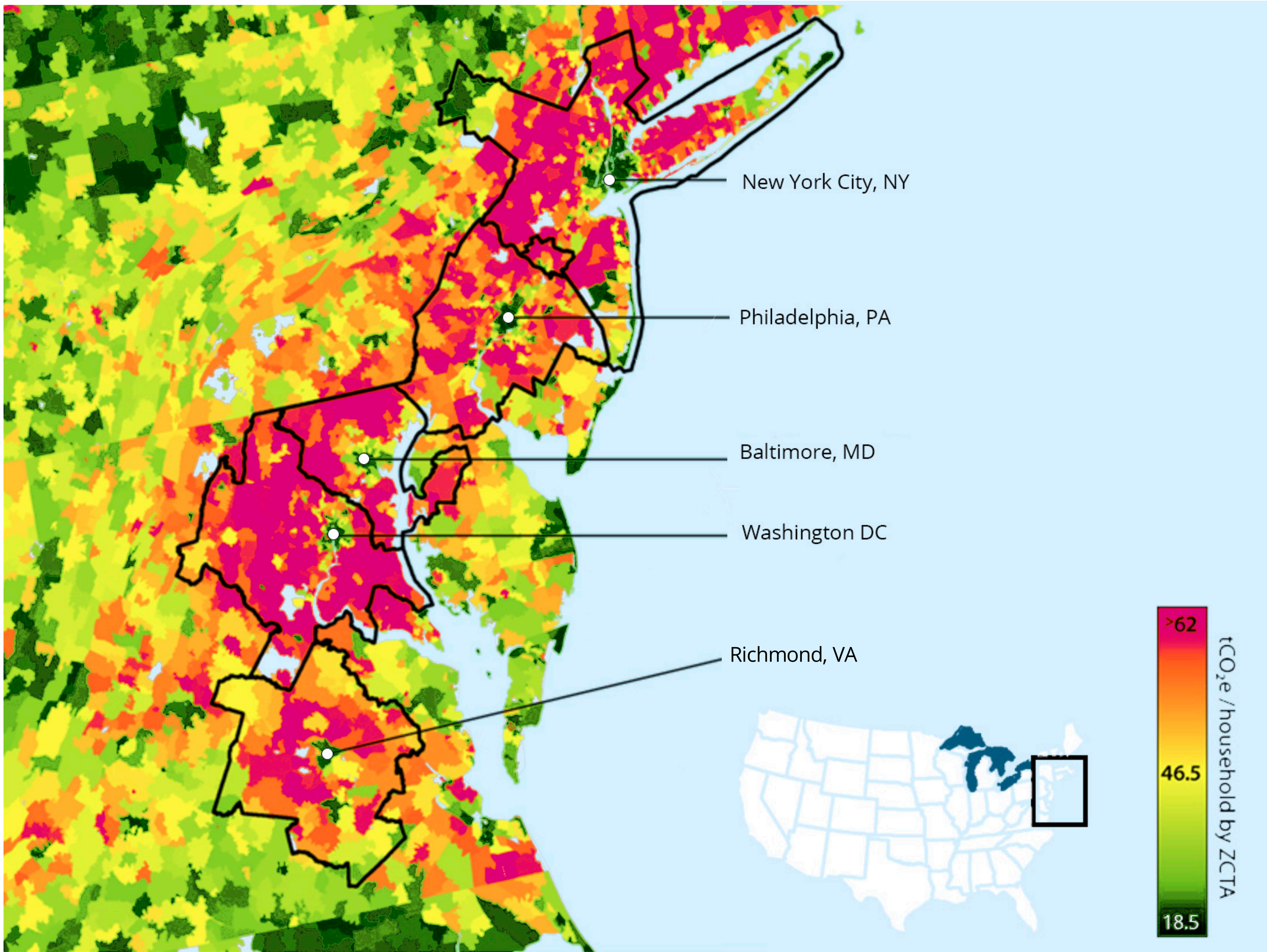
Operational Carbon
The emissions associated with the energy used to operate the building

Household Carbon Footprint

=

Greenhouse gas emissions from purchase and use of motor vehicles, public transit, air travel, household energy, food, water, consumer goods and services

Household Carbon Footprints | United States East Coast

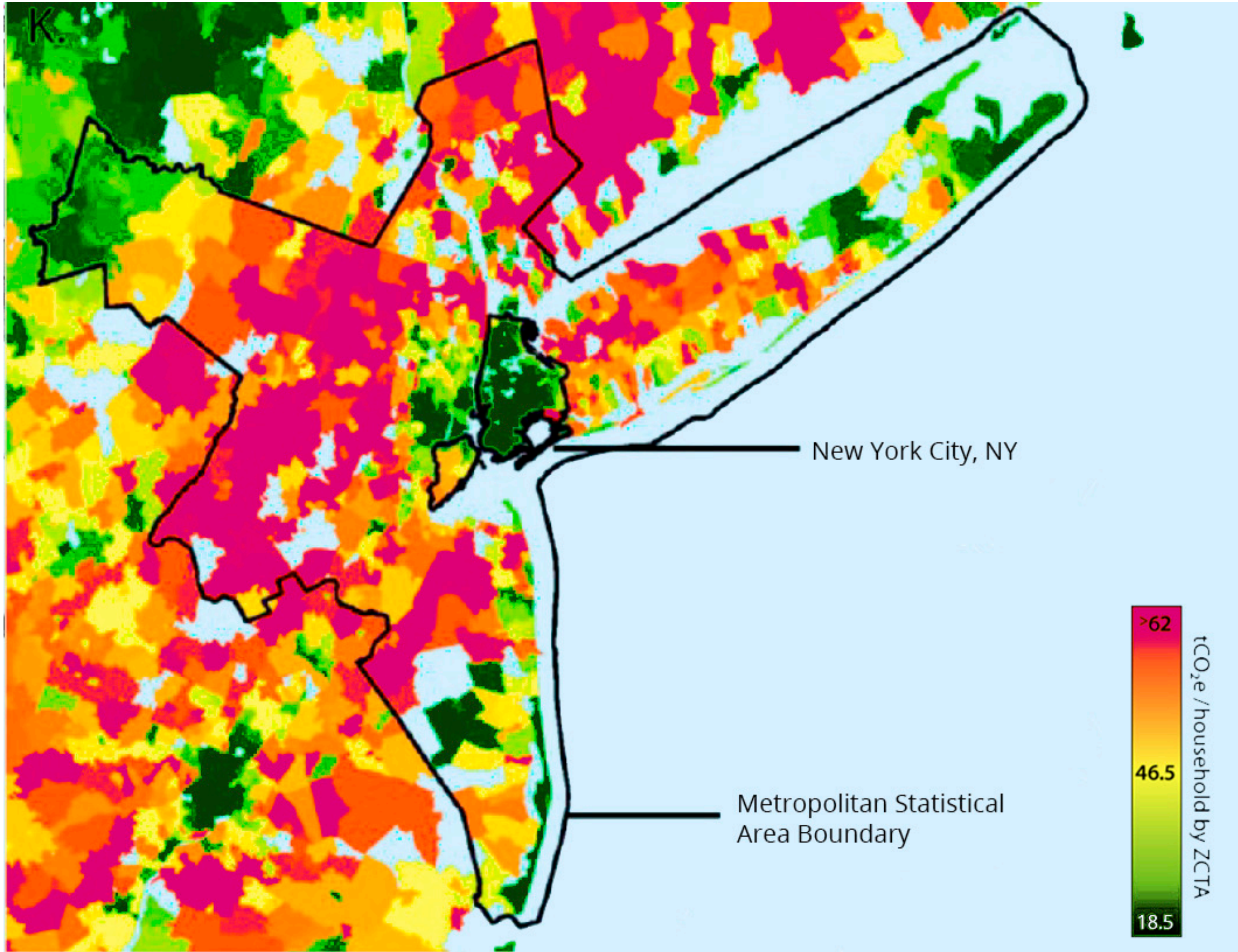


Source :

- Jones and Kammen, Spatial Distribution of US household Carbon Footprints reveals suburbanisation undermines greenhouse gas benefits of urban population density, *Environmental Science and Technology, 2013*

- UC Berkeley CoolClimate Network, Carbon footprints profiles of all U.S. zip codes, cities, counties and states, *https://coolclimate.berkeley.edu*

Household Carbon Footprints | New York



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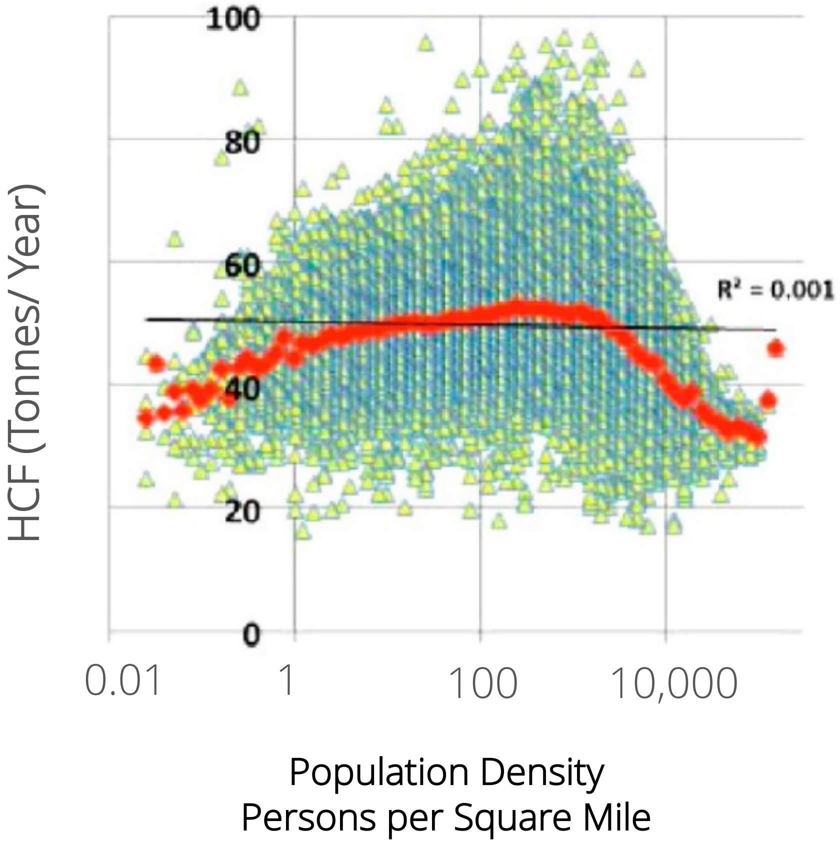
- UC Berkeley CoolClimate Network, Carbon footprints profiles of all U.S. zip codes, cities, counties and states, *https://coolclimate.berkeley.edu*

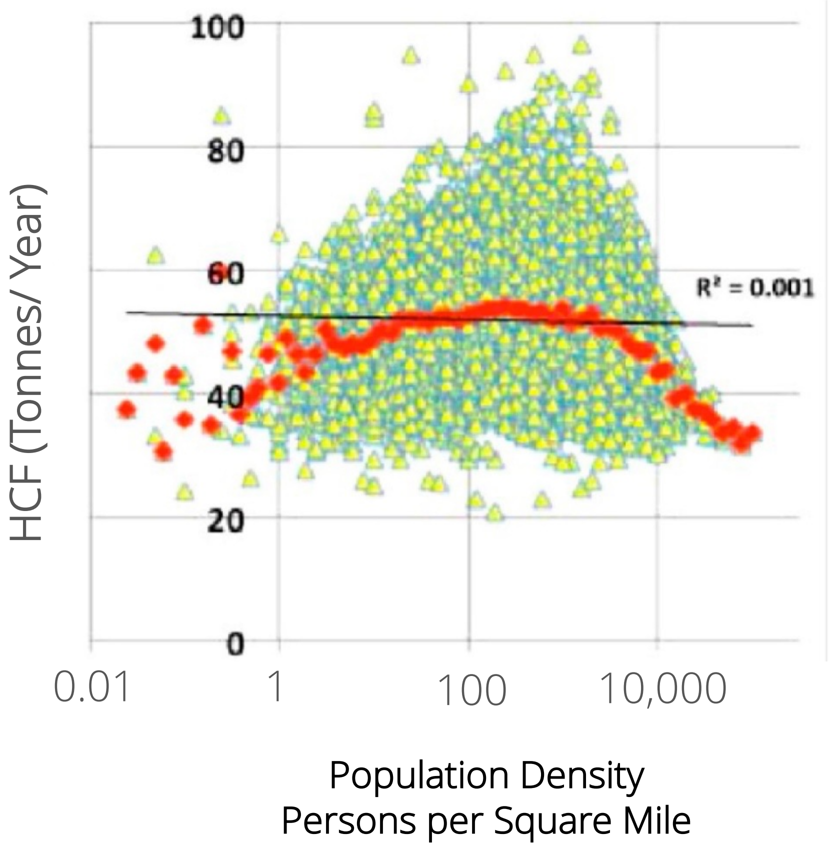
USA | Average Household Carbon Footprint (HCF)

The red line in each figure is the mean of all HCF for that population density.

31531 Zip Codes



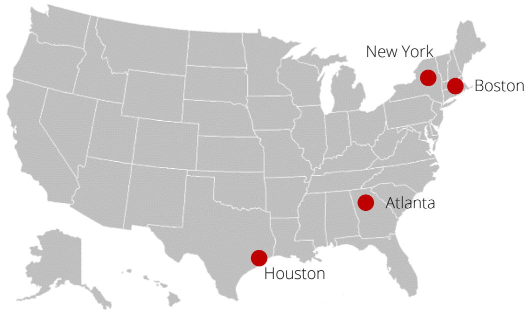
10093 US Cities and Towns



Source : Jones and Kammen, Spatial Distribution of US household Carbon Footprints reveals suburbanisation undermines greenhouse gas benefits of Urban Population Density, 2013

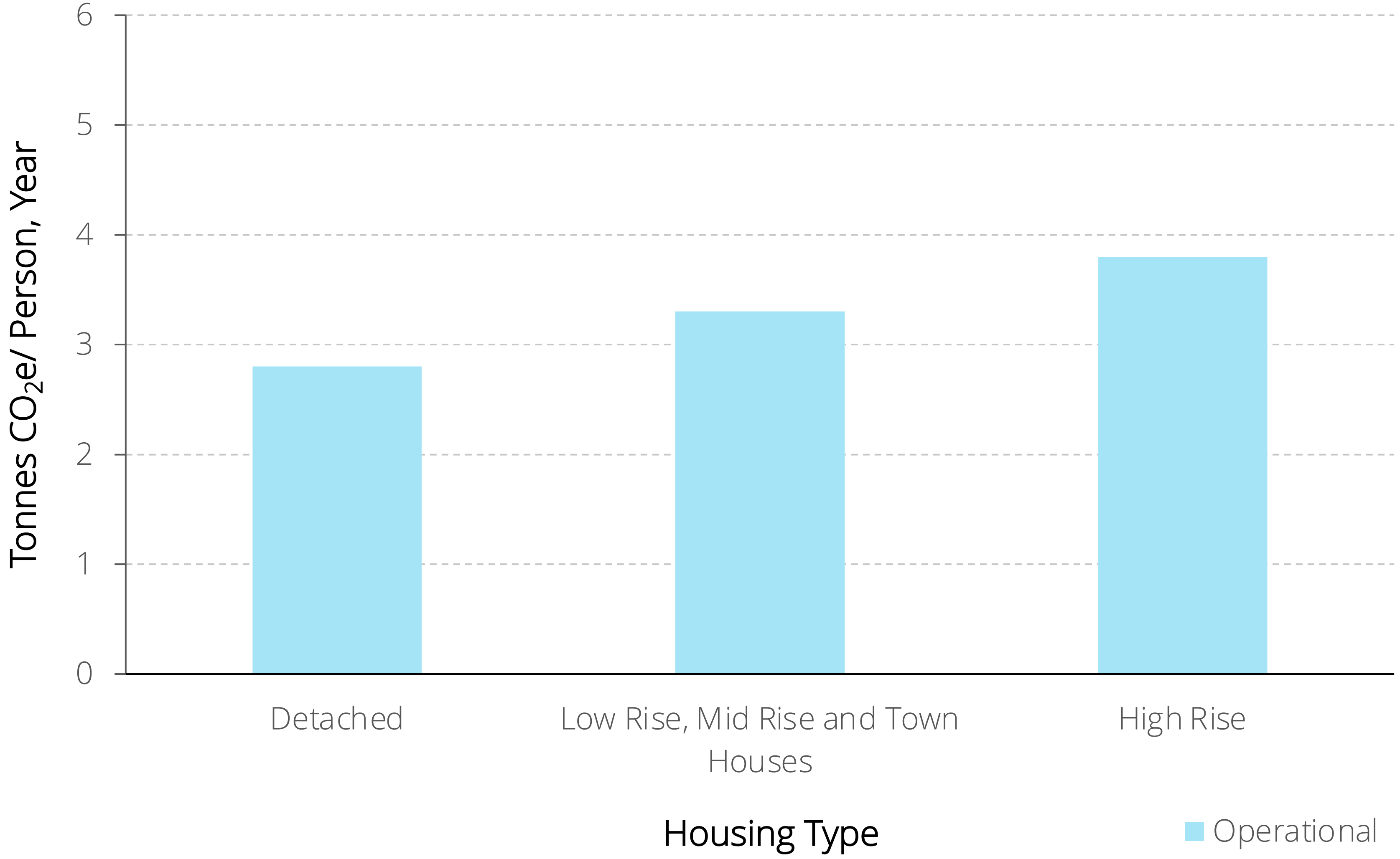
USA | Suburb – City Difference in Emissions

Carbon Emissions are lower for people living in central cities than suburbs



Source: Green Cities, Brown suburbs, City Journal, Glaeser, 2009

Sydney | Emissions for Housing Types



Source: The Density Trade-off: Colin Beattie, Peter Newman
Curtin University Sustainability Policy (CUSP) Institute, Fremantle, WA, Australia, 2011

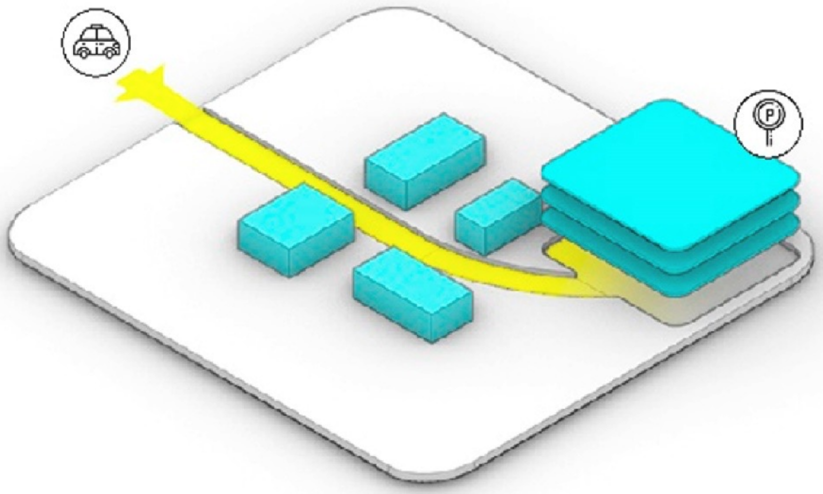
Sydney | Emissions for Housing Types

Source: The Density Trade-off: Colin Beattie, Peter Newman
Curtin University Sustainability Policy (CUSP) Institute, Fremantle, WA, Australia, 2011

Whole Life Carbon| Tall Buildings vs Suburbs

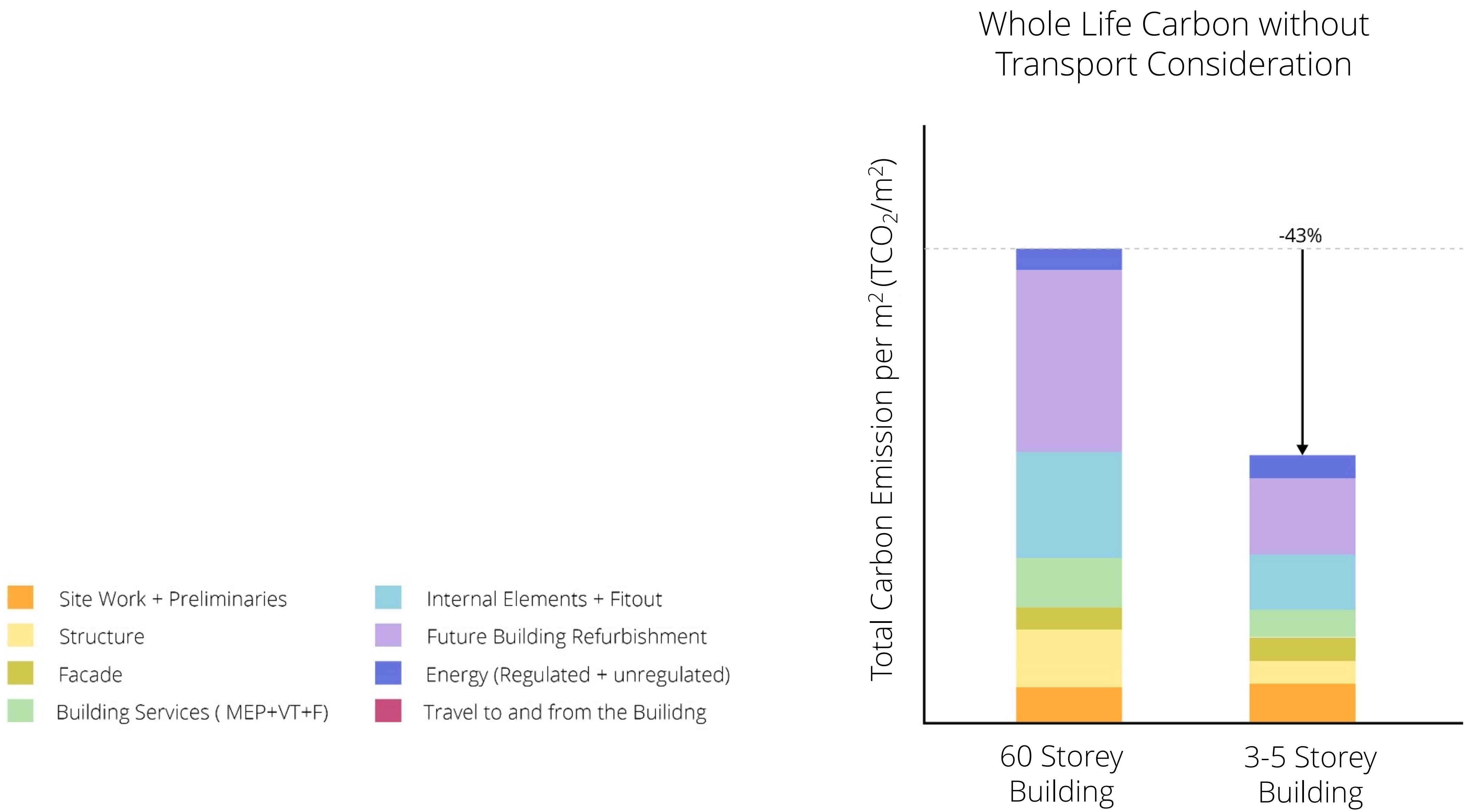
60 storey building in dense city

3 to 5 storey building in suburb with minimal infrastructure



Source : Transitioning to an integrated whole life approach to sustainability in the built environment
World Green Building Council/Chris Trott, Foster + Partners

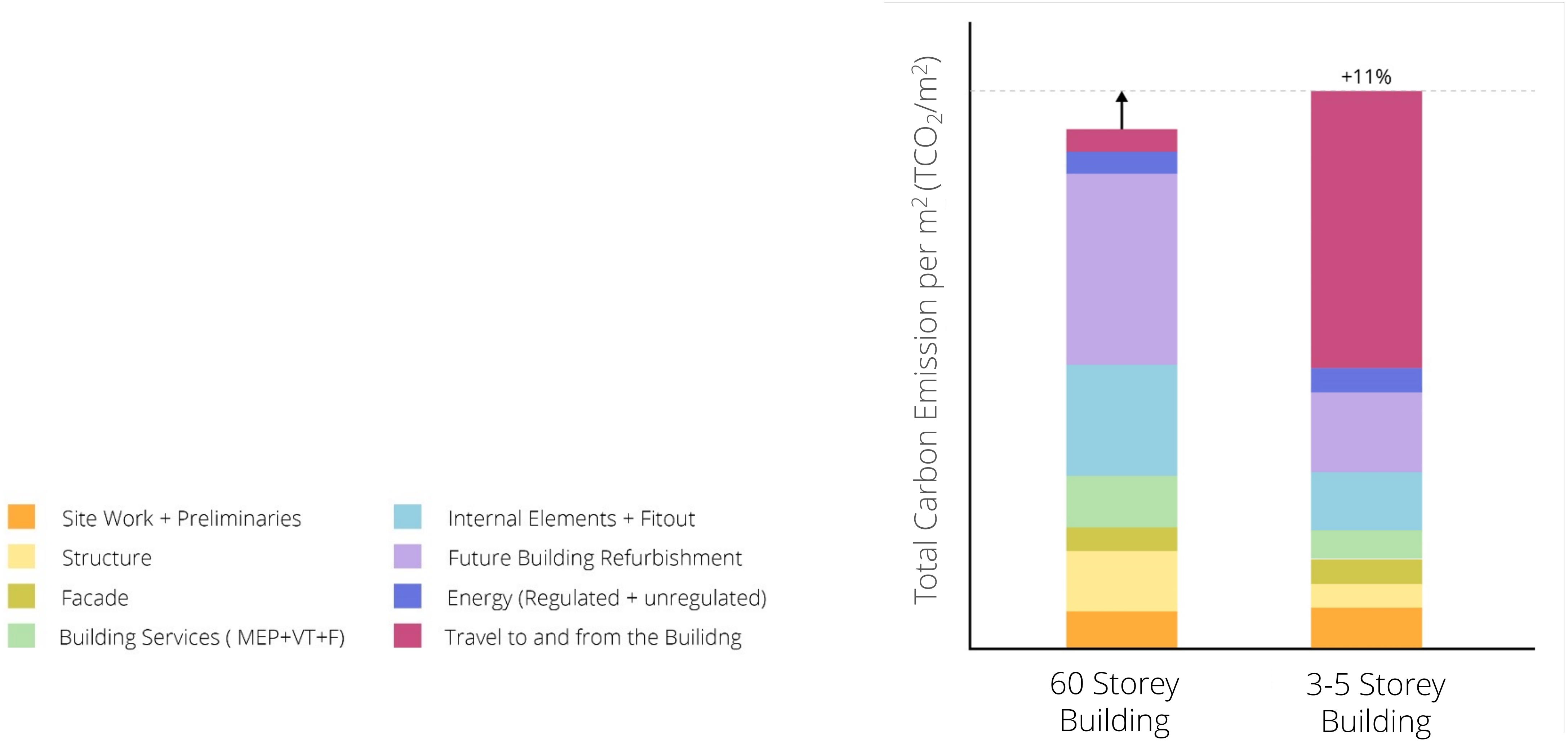
Whole Life Carbon| Tall Buildings vs Suburbs



Source : Transitioning to an integrated whole life approach to sustainability in the built environment
World Green Building Council/Chris Trott, Foster + Partners

Whole Life Carbon| Tall Buildings vs Suburbs

Whole Life Carbon with Transport Consideration



Source : Transitioning to an integrated whole life approach to sustainability in the built environment
World Green Building Council/Chris Trott, Foster + Partners

Tall Buildings vs Suburbs

Los Angeles

1901

2001

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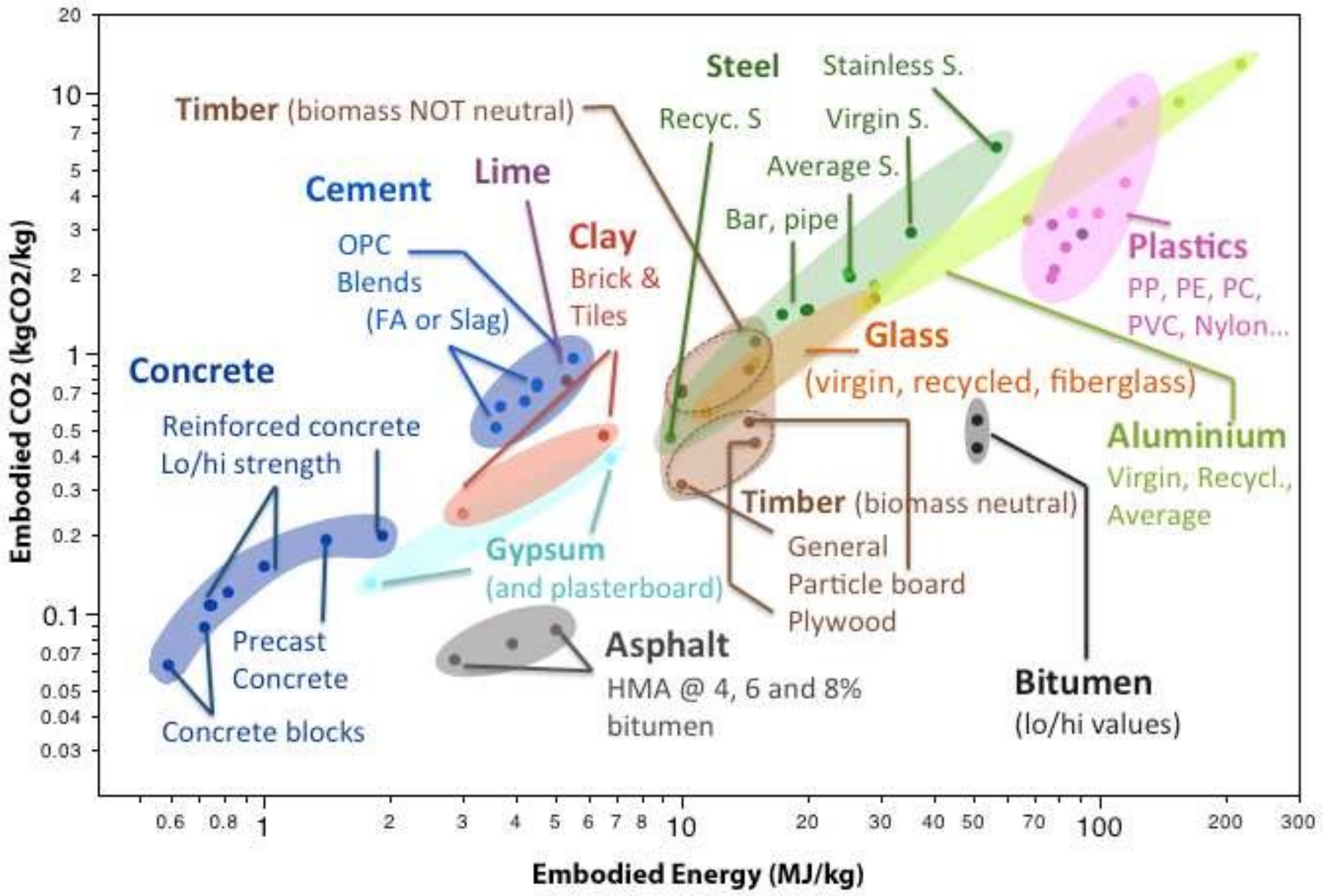
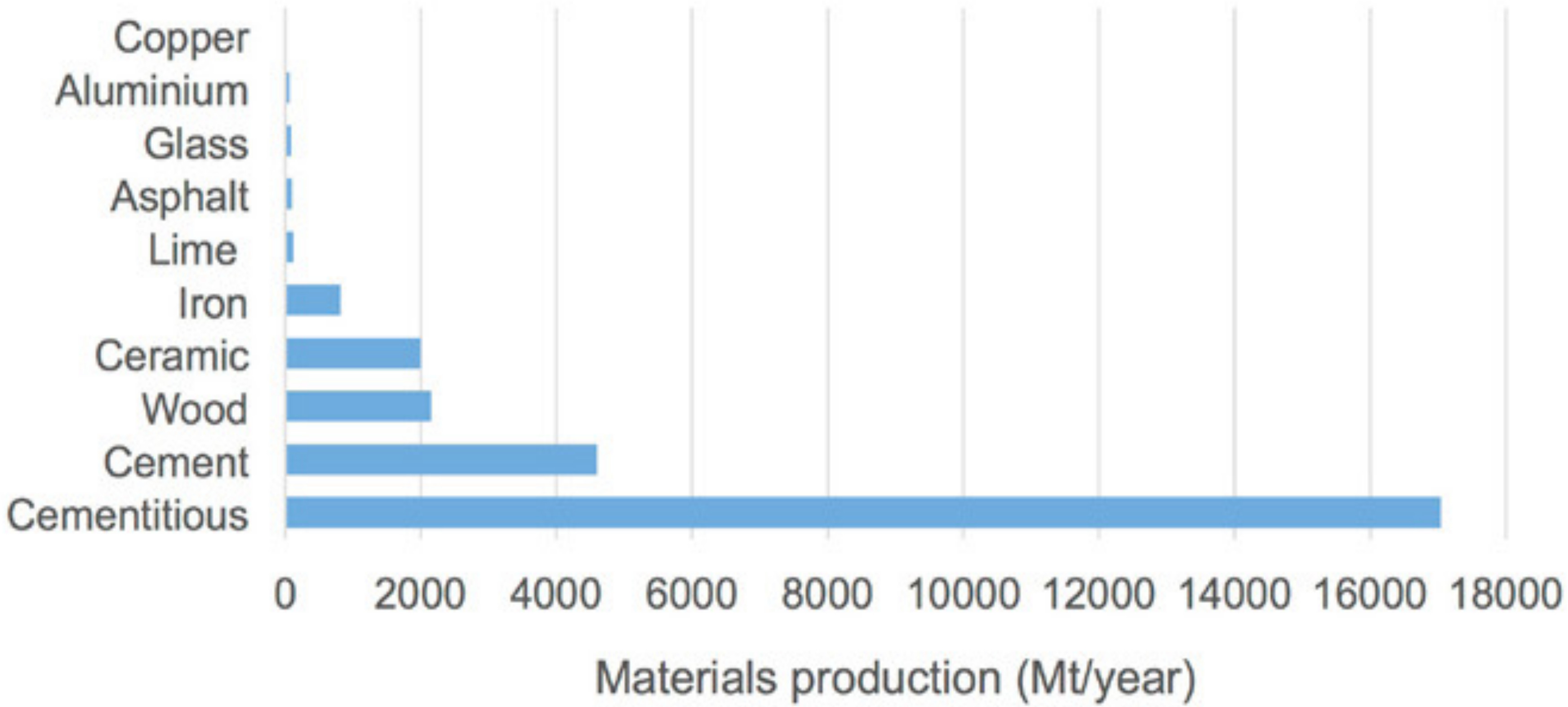
Correlation Between Embodied Carbon and Embodied Energy

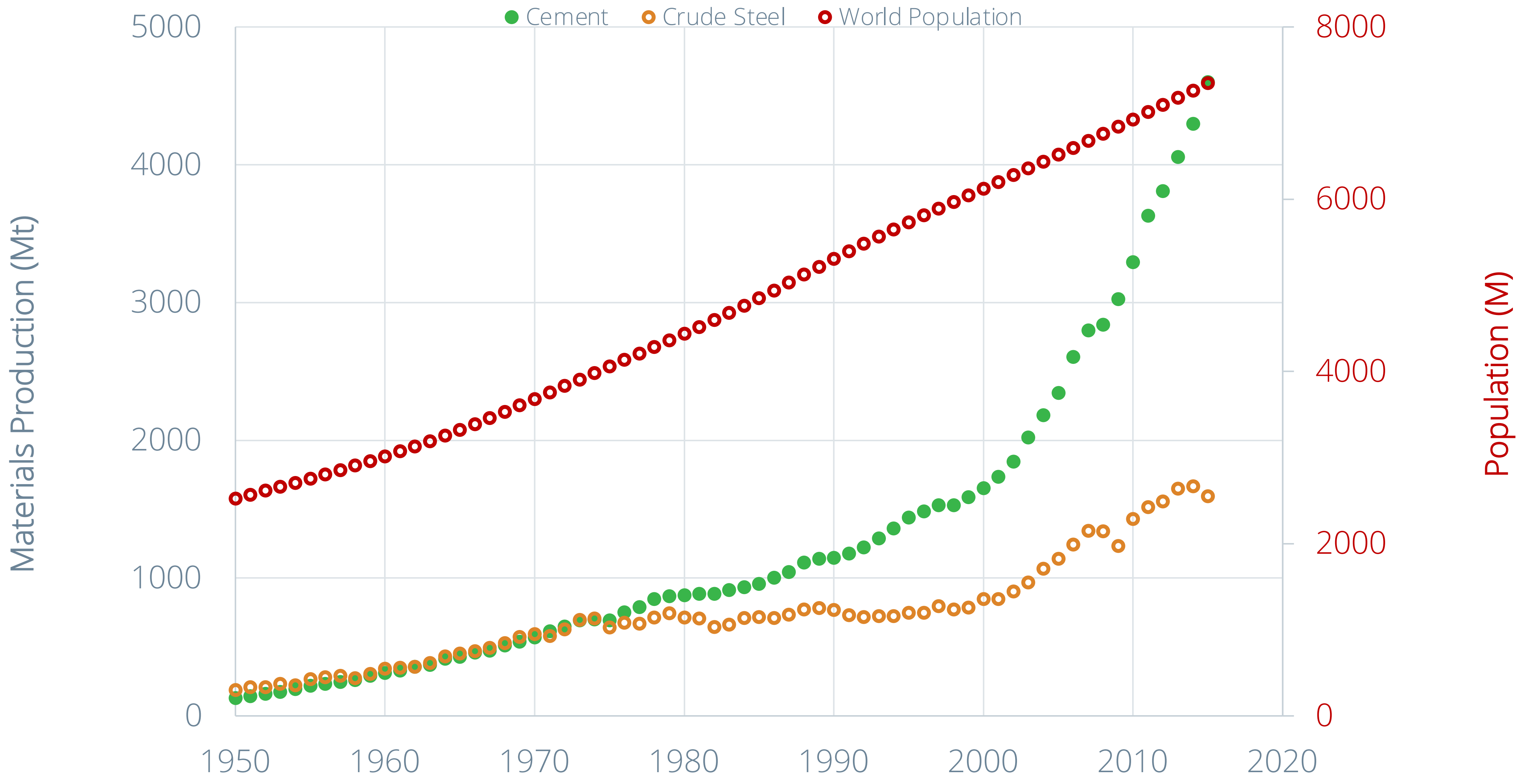


Estimated Annual Material Consumption| 2002 – 2005



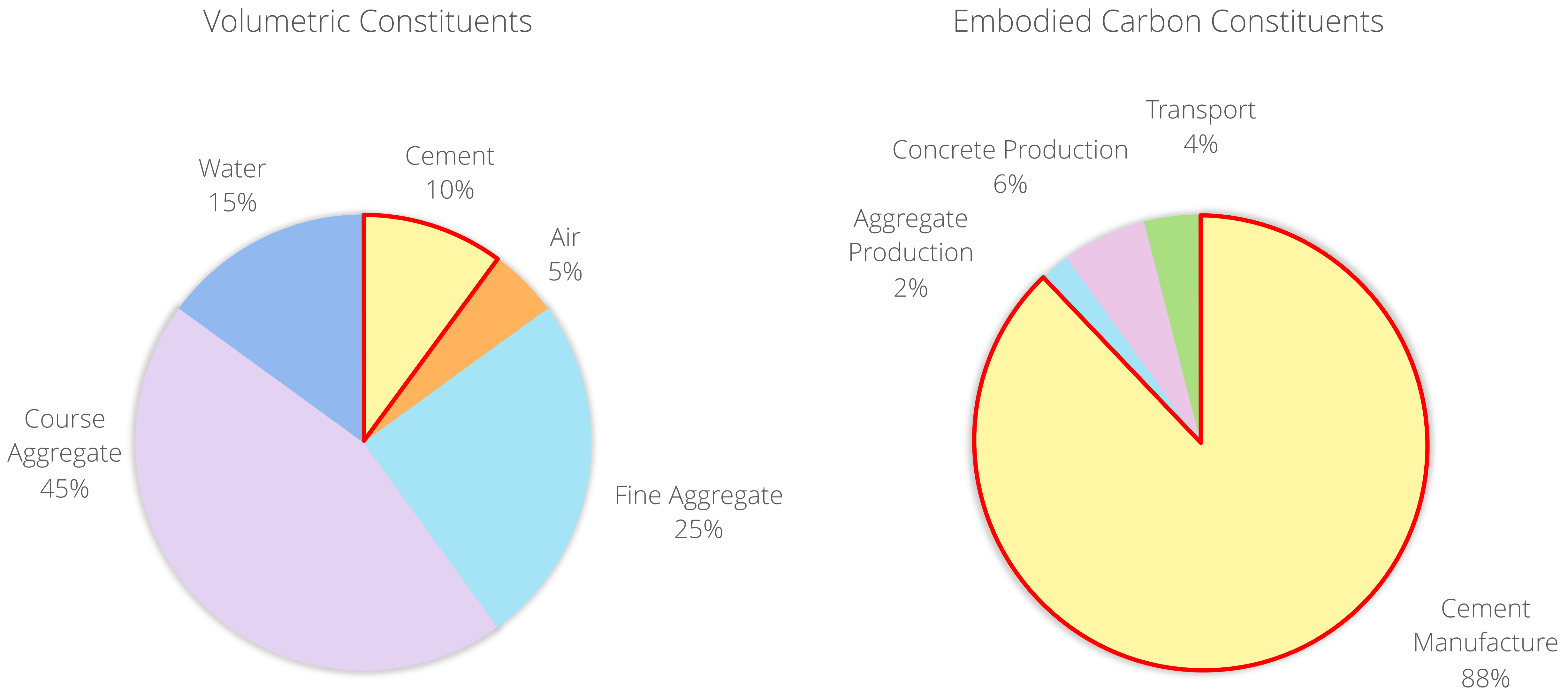
Eco – efficient cements UNEP report 2017

Annual Steel and Cement Production



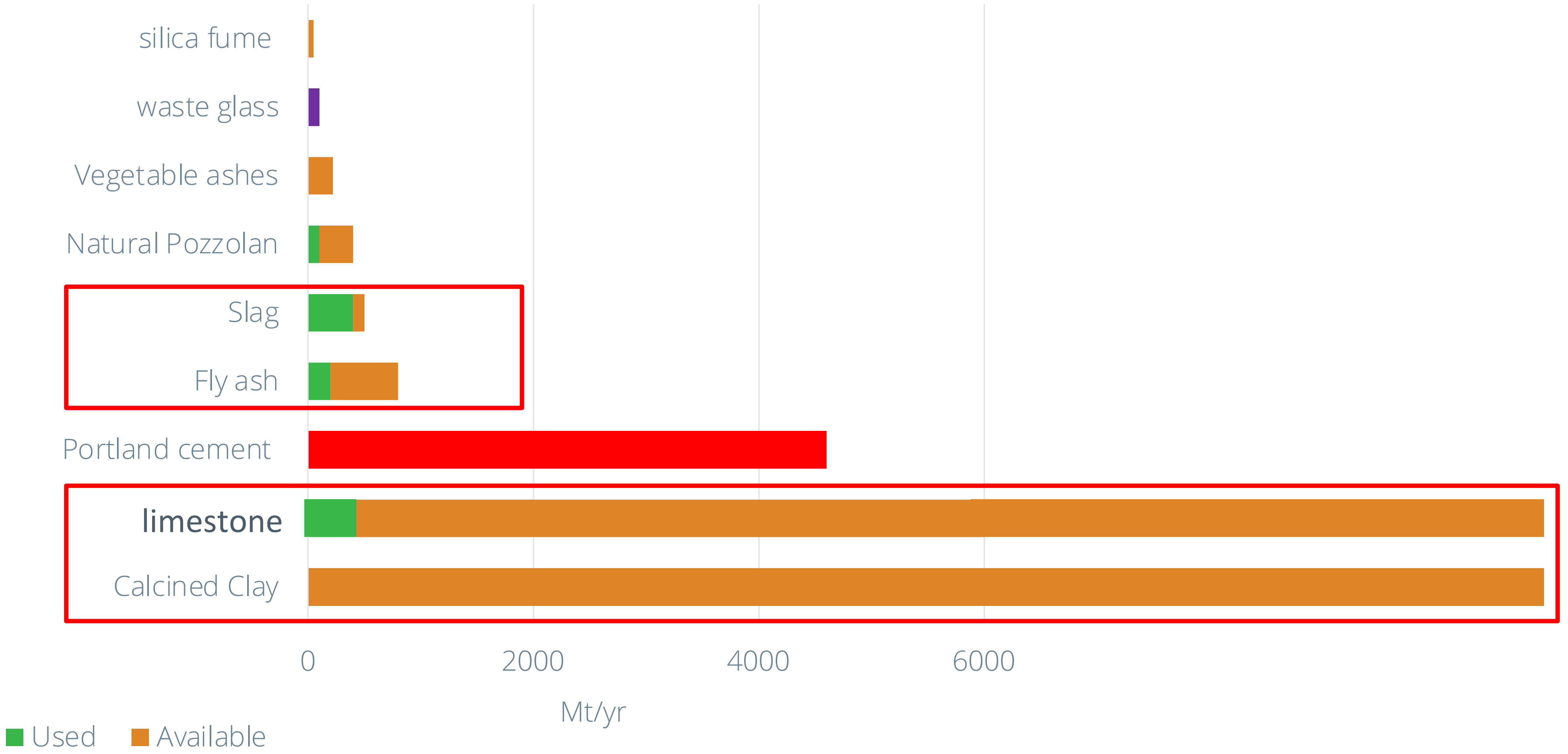
Eco – efficient cements UNEP report 2017

Concrete


Volumetric Constituents
Water
15%
Cement
10%
Air
5%
Course
Aggregate
45%
Fine Aggregate
25%
Embodied Carbon Constituents
Transport
4%
Concrete Production
6%
Aggregate
Production
2%
Cement
Manufacture
88%

Availability of Secondary Cementitious Materials

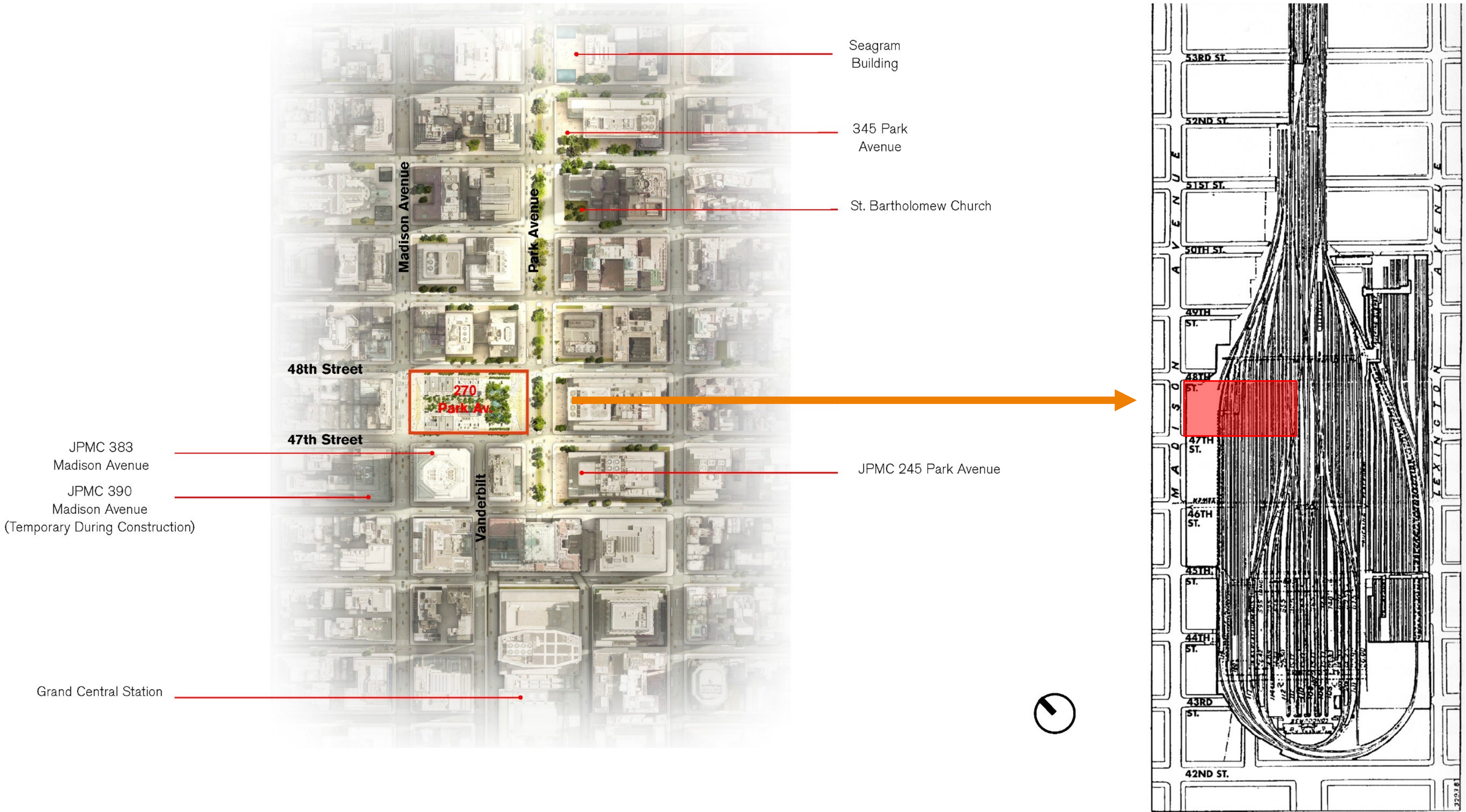
Classic SCMs – fly ash and slag are only around 15% of current cement production, will drop to < 10% in near future



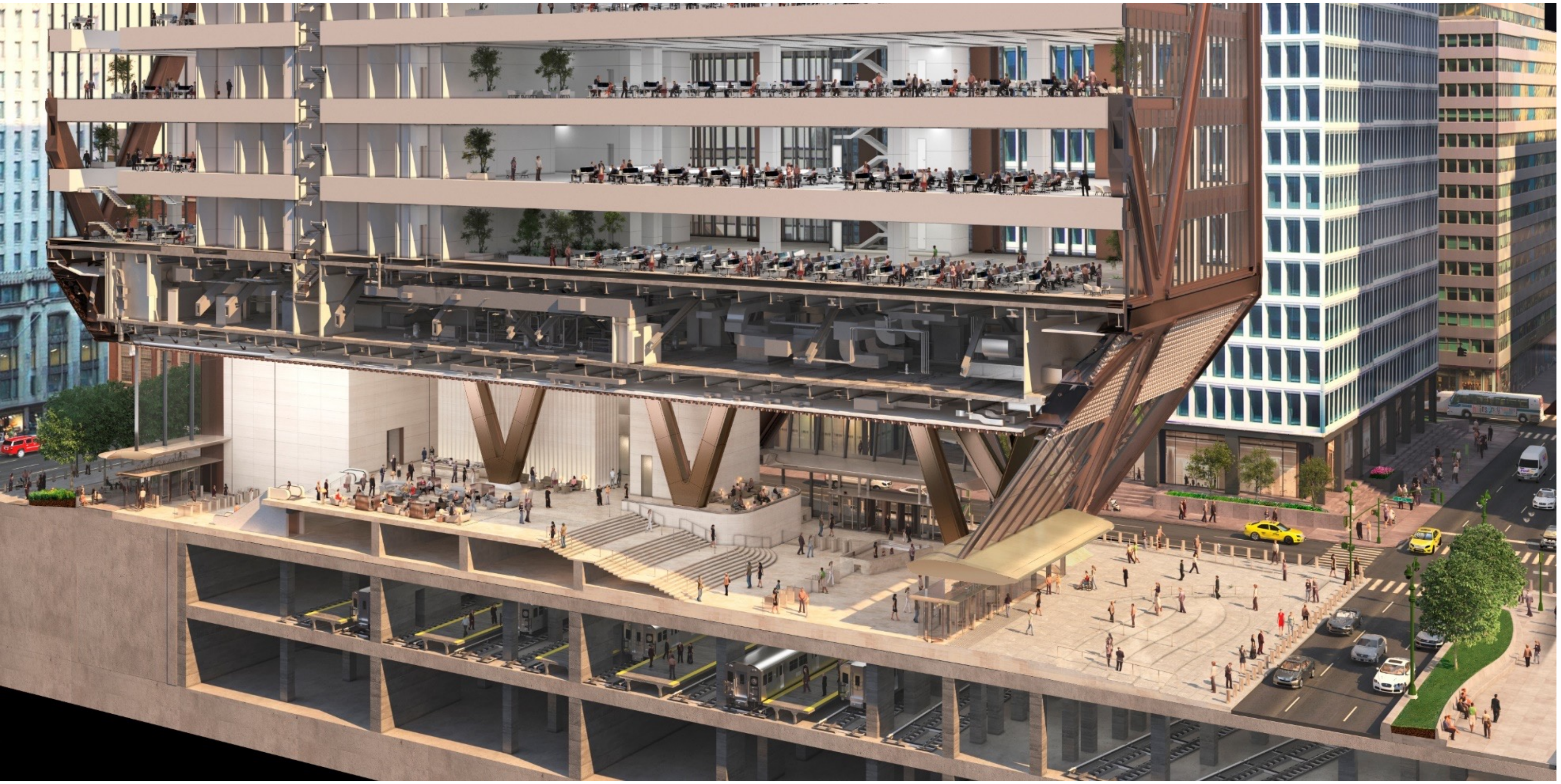
Source: Professor Karen Scrivener, Ecole Polytechnique de Lausanne, 2022

270 Park Avenue, New York| Foster + Partners Height : 426m

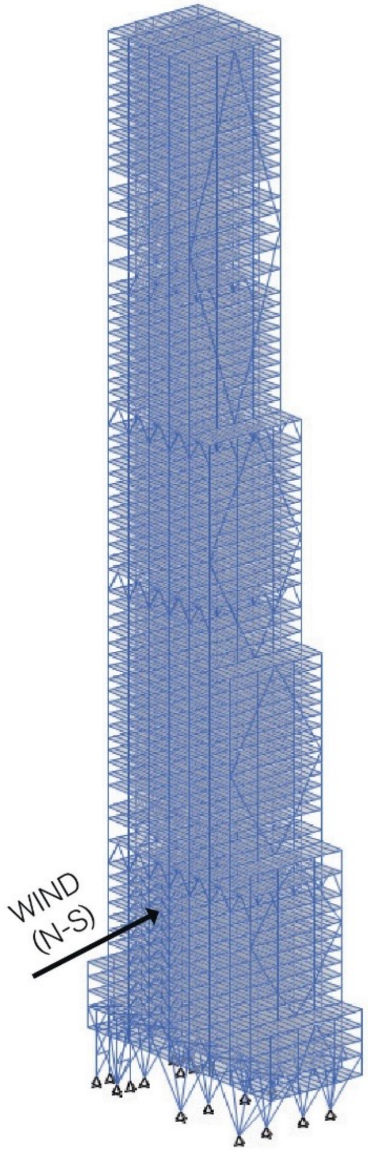
270 Park Avenue | Foster + Partners | Site location over underground railways



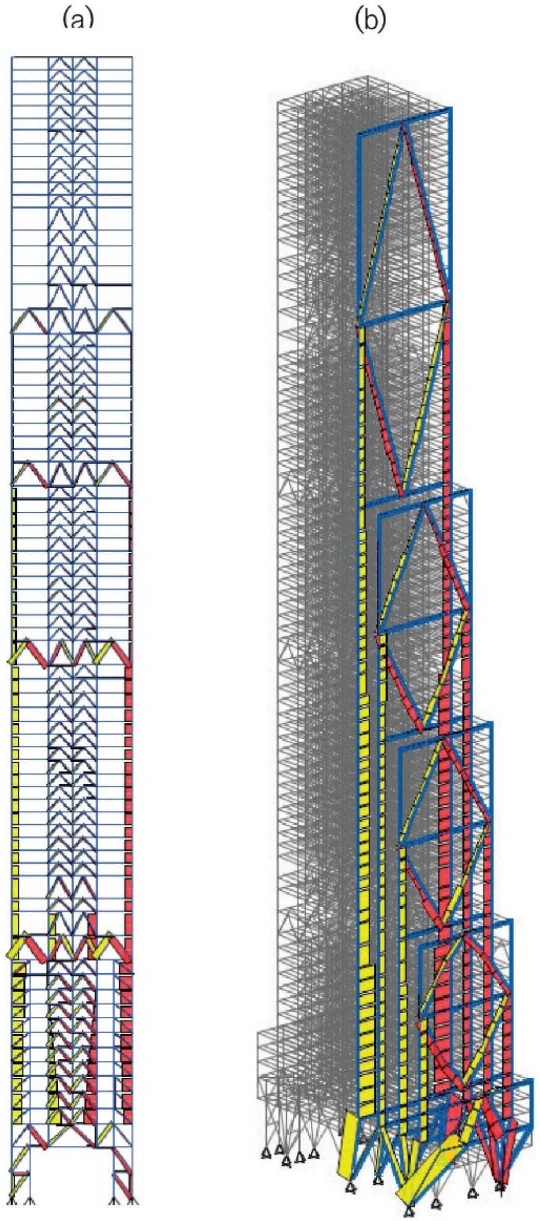
270 Park Avenue | Foster + Partners | Ground Level Structure



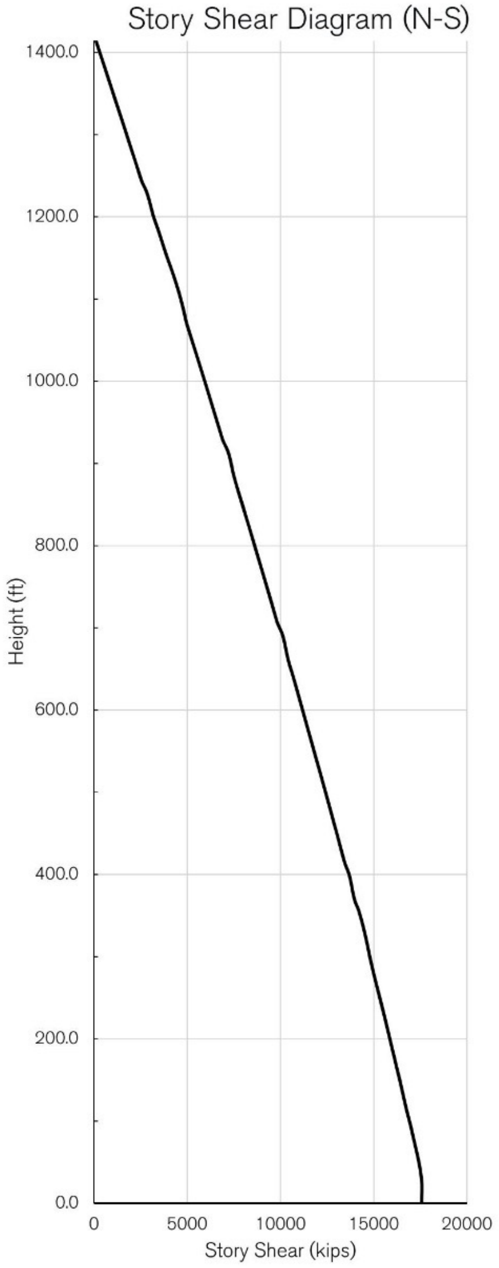
270 Park Avenue | Foster + Partners Competition Structural Analysis

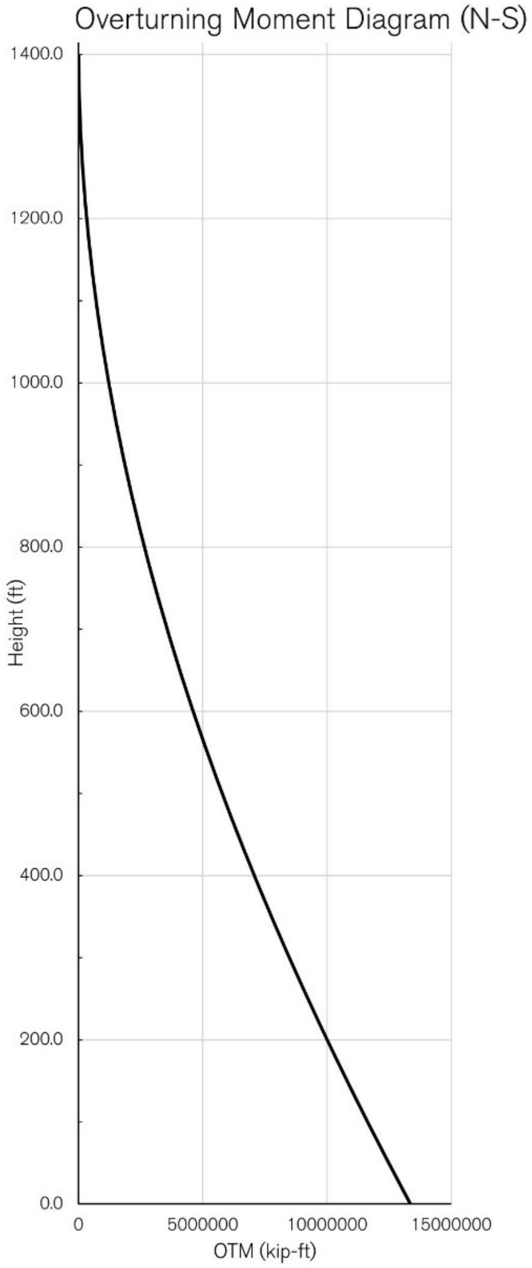


Loading direction

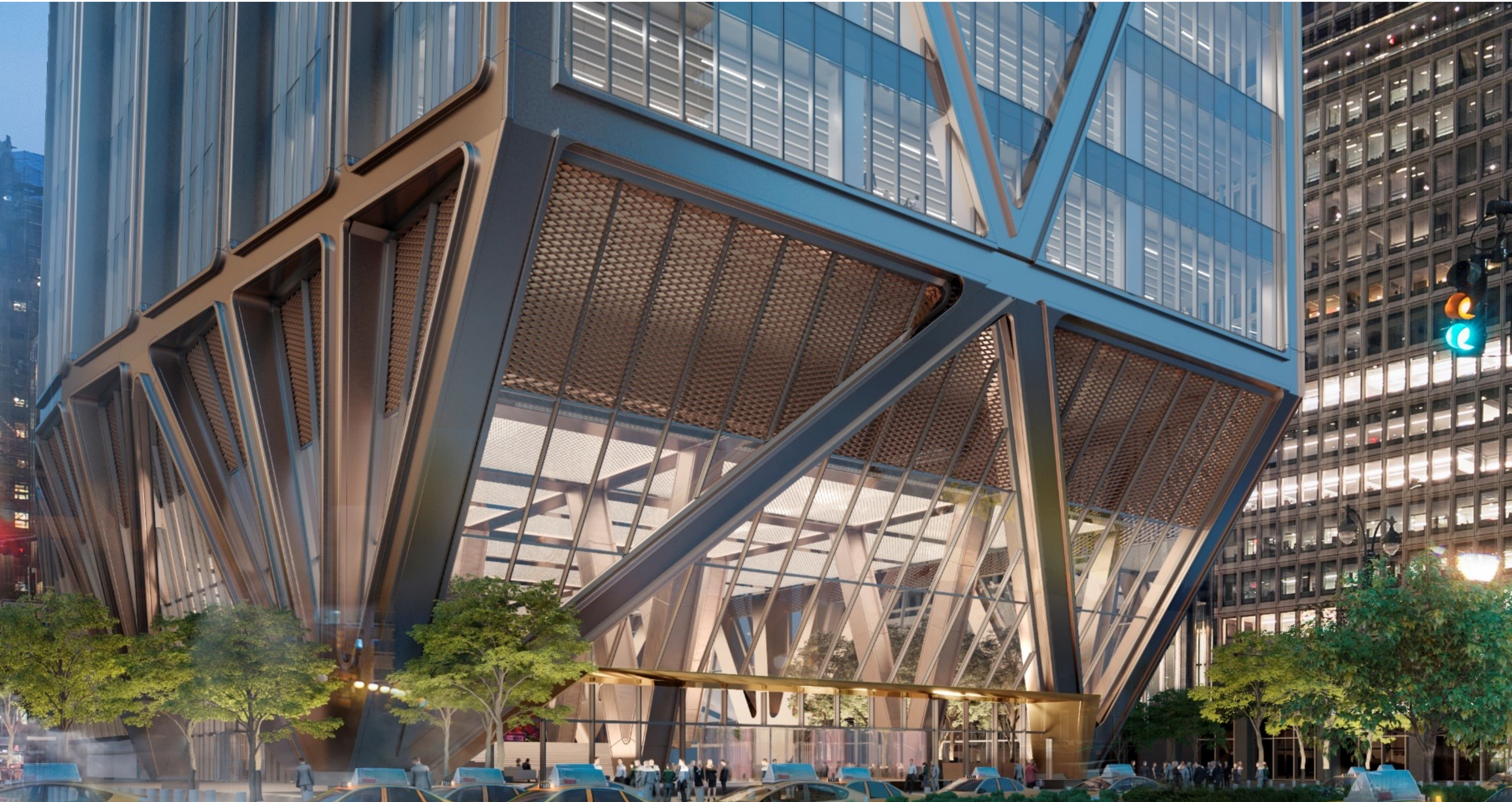


Axial force diagram at section through core (a) and East face bracing (b) due to N-S wind only



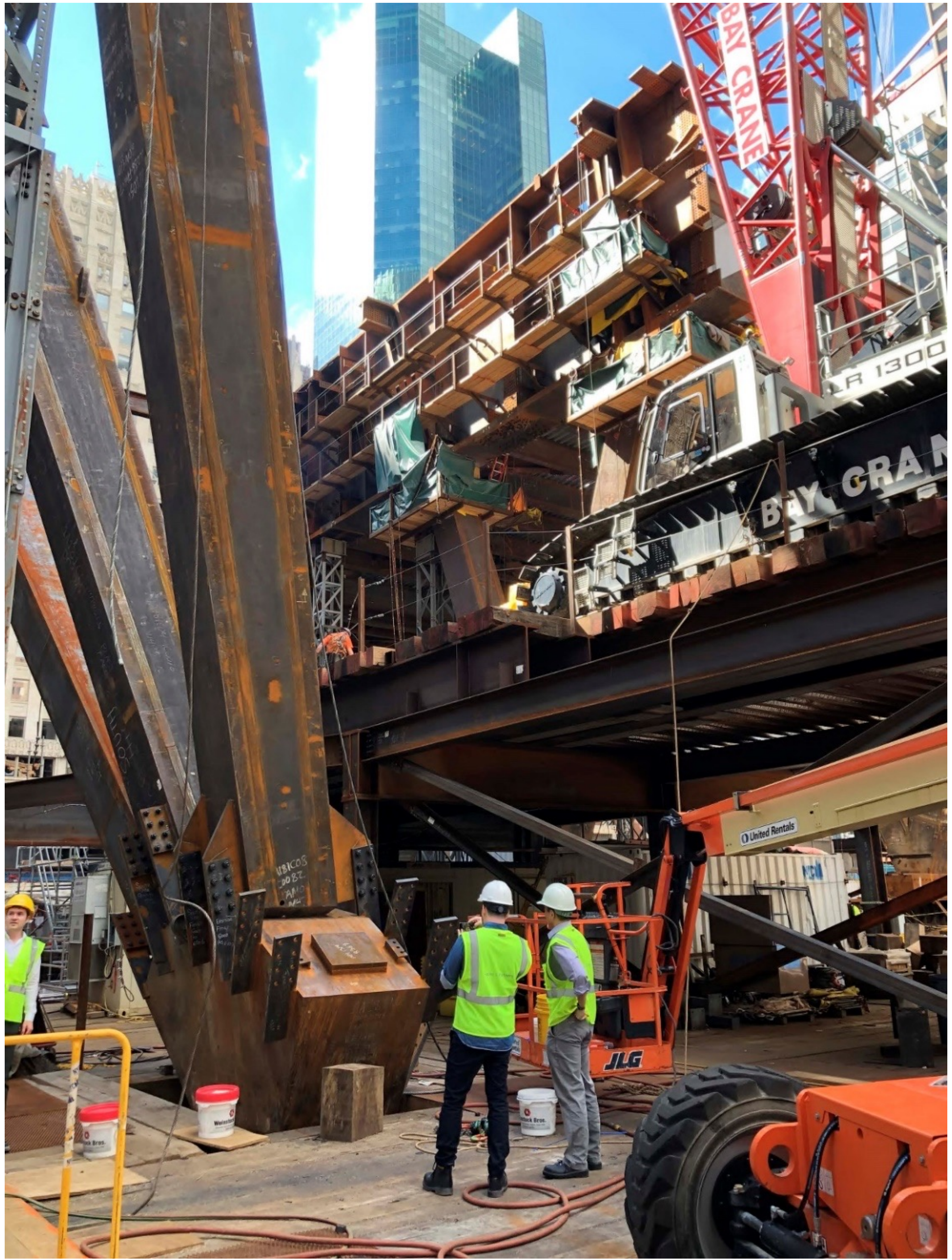


270 Park Avenue | Foster + Partners



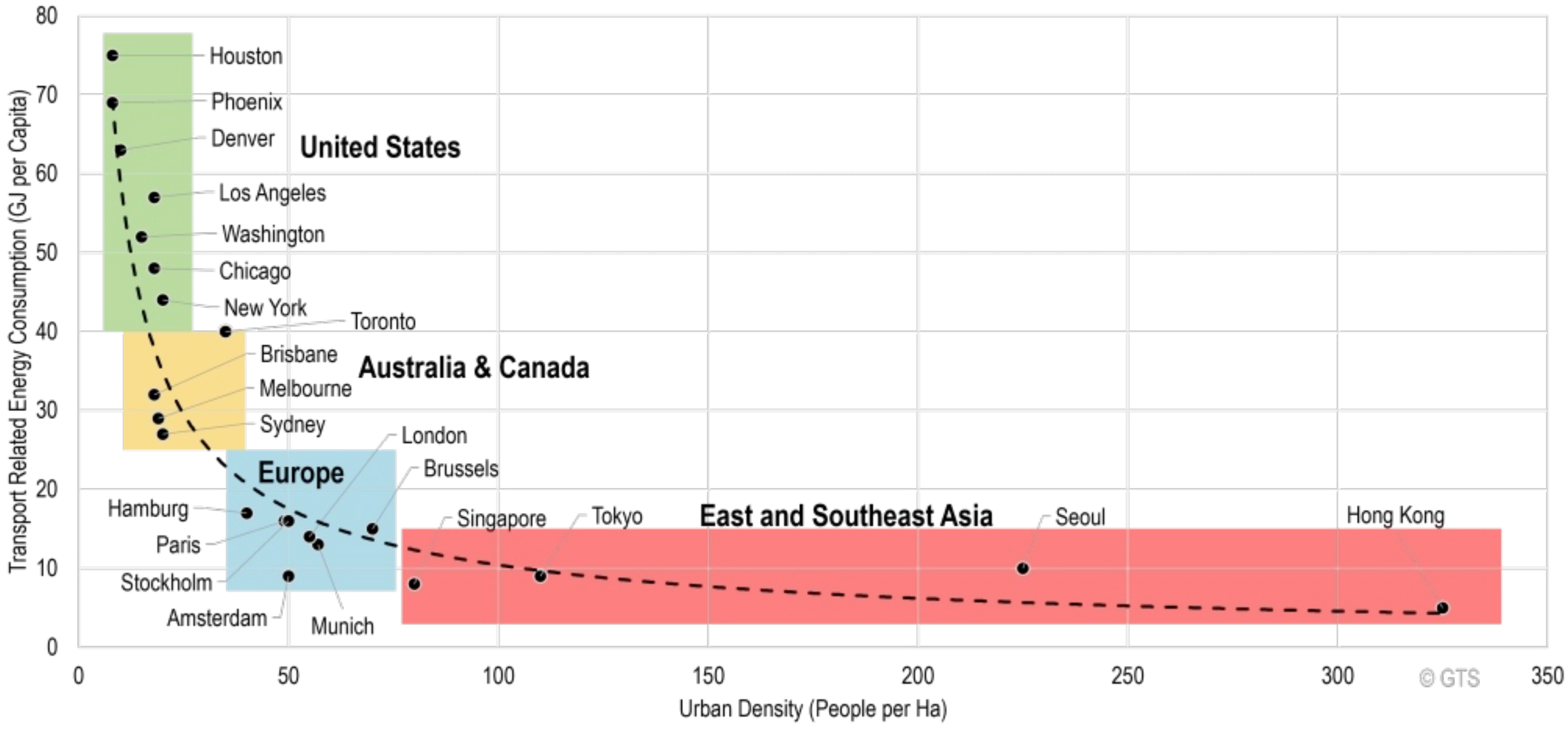
270 Park Avenue | Foster + Partners Construction

270 Park Avenue | Foster + Partners Construction



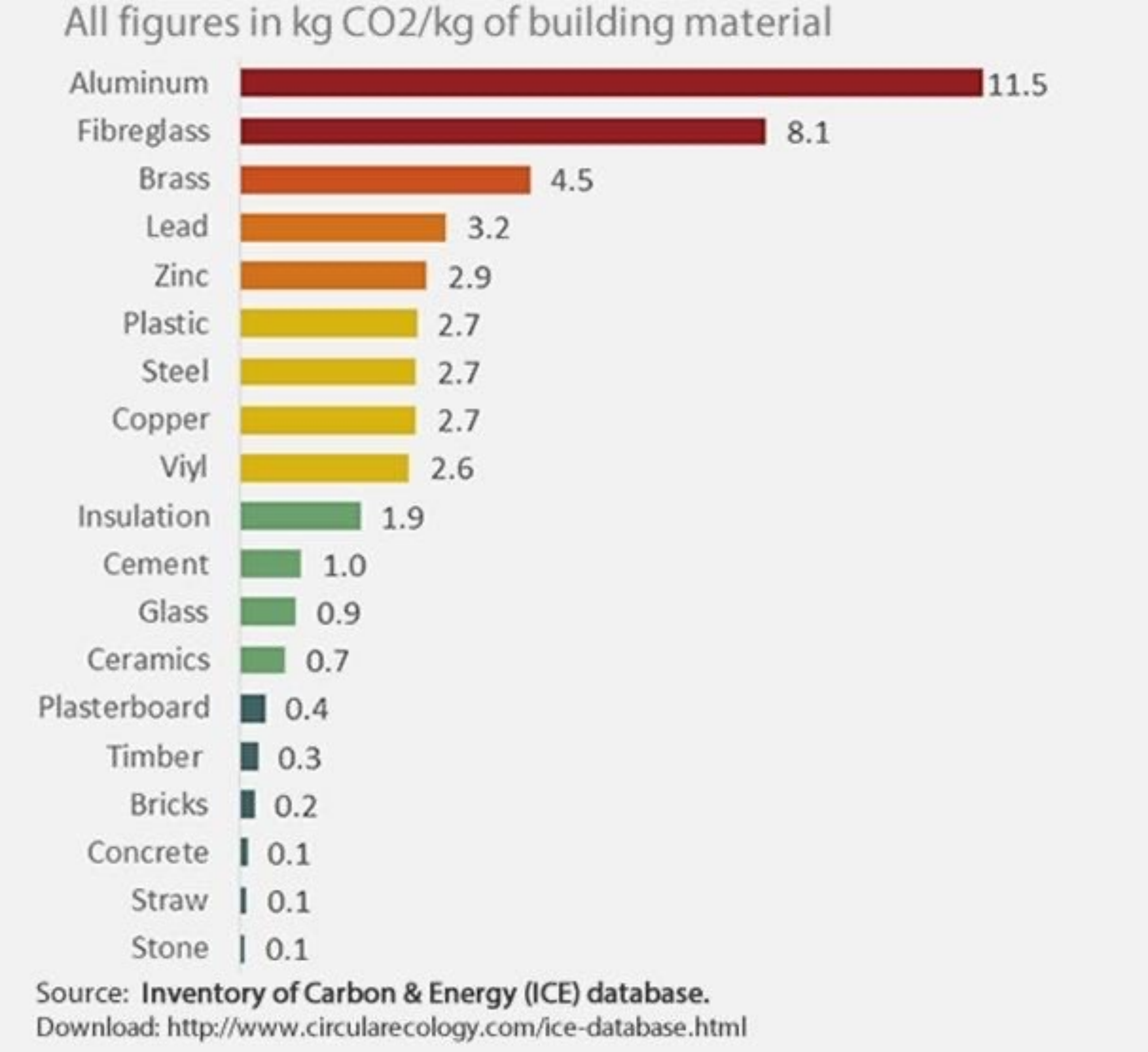
270 Park Avenue | Foster + Partners

Urban Density and Energy Consumption



Source: adapted from Newman, P. and J. Kenworthy (1999) Sustainability and Cities: Overcoming Automobile Dependence, New York: Island Press.

Embodied Carbon Typical Values



97%

of Demolition Waste diverted* away from Landfill

**reused, recycled, or upcycled material streams*

	Interior “Soft” Demolition	Exterior Demolition	Structural Demolition	Below Grade Demolition
% Diverted from Landfill	90.9%	97.4%	97.8%	96.7%
% Landfilled	9.1%	2.6%	2.2%	3.3%
% Overall Diverted from Landfill	**97.0%**			


HOME FEDERAL SAV
YORKS

Builder : George A. Fuller


GAS OFFICE.
LANQUIST & ILLSLEY CO.
CONTRACTORS
MAR.15.10