# One World Trade Center

Shelly Damo, Megan Dorsey,
Shelby Dittrich,
Hector Escalante, Luis
Cabrera, Andres Vela,

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# Introduction And Design

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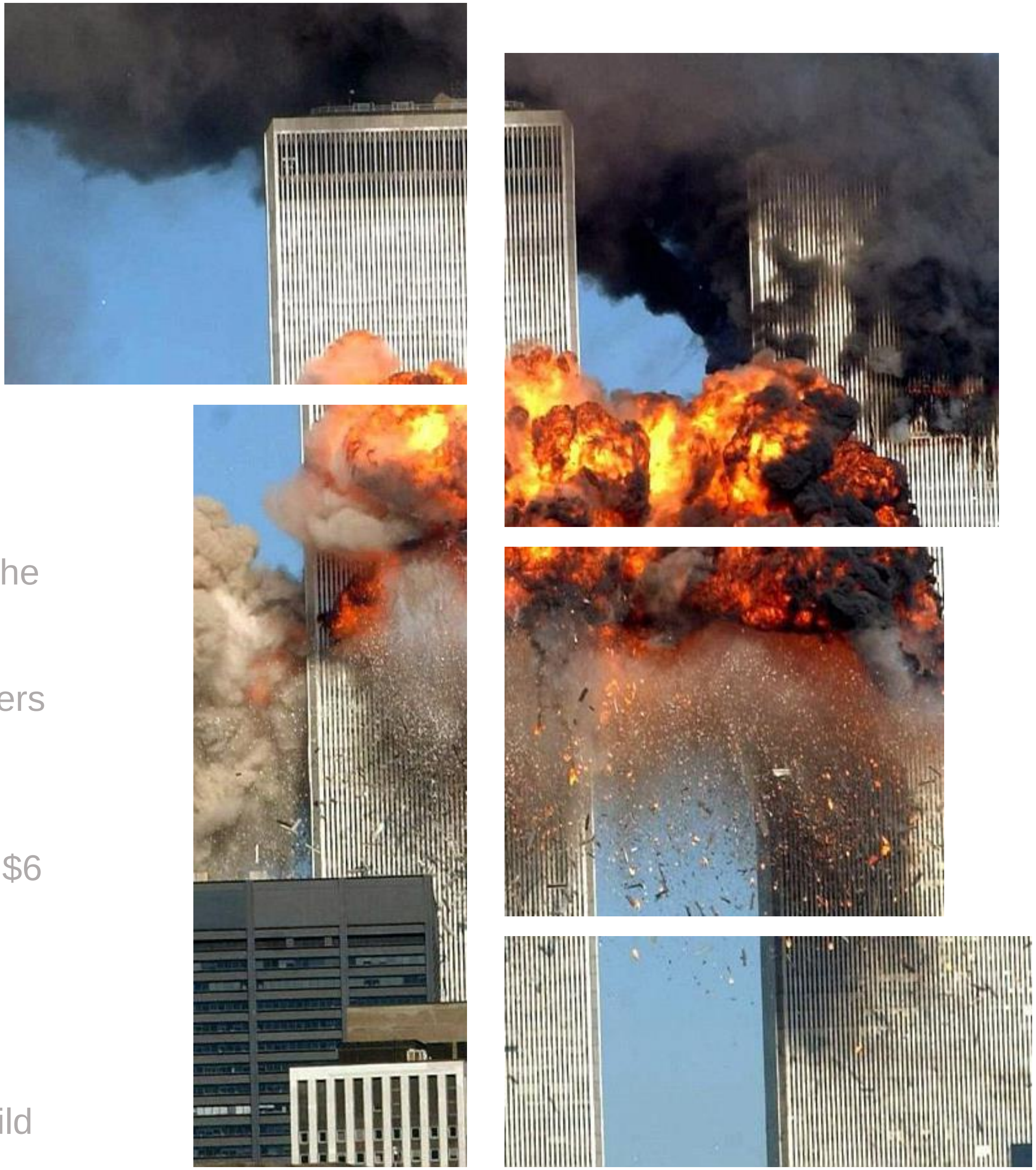
# Overview

•Location: New York City, New York
•Opened: October 2014
•Owner: Port Authority of New York and New Jersey
•Architect: Skidmore, Owings & Merrill (David M. Childs)
•Structural Engineer: WSP Cantor Seinuk
•MEP Engineers:Jaros Baum & Bolles, Inc.
•Height: 104 Stories / 1776 feet high
•Square Footage: 3.4 Million

Cost: $3.8 billion

# History



1939: New York World Fair and the World Trade Center Exhibit

1959: David Rockefeller decides to revive the World Trade Center Concept

1967: Construction began on the Twin Towers

1970: Construction was completed

1993: Bombing of the World Trade Center; $6 Million in damage, 6 killed, 1,000 injured. Reopened 20 days later.

2001: Collapse of the Twin Towers

2002- 2011: Clean up, Planning, and Rebuild

2014: One World Trade Center Opens

# Libeskind Goal

•Memory of the tragedy
•Foster vibrant working neighborhood
•Sustainable, high-tech office towers
•Re-connecting the historic street-grid
•Reinvigorating the streetscape with above-ground retail
•Reshaping the underground transit concourses
•Finding room for two major new public facilities: an iconic new transportation station and a performing arts center.
•1776 - America's Independence

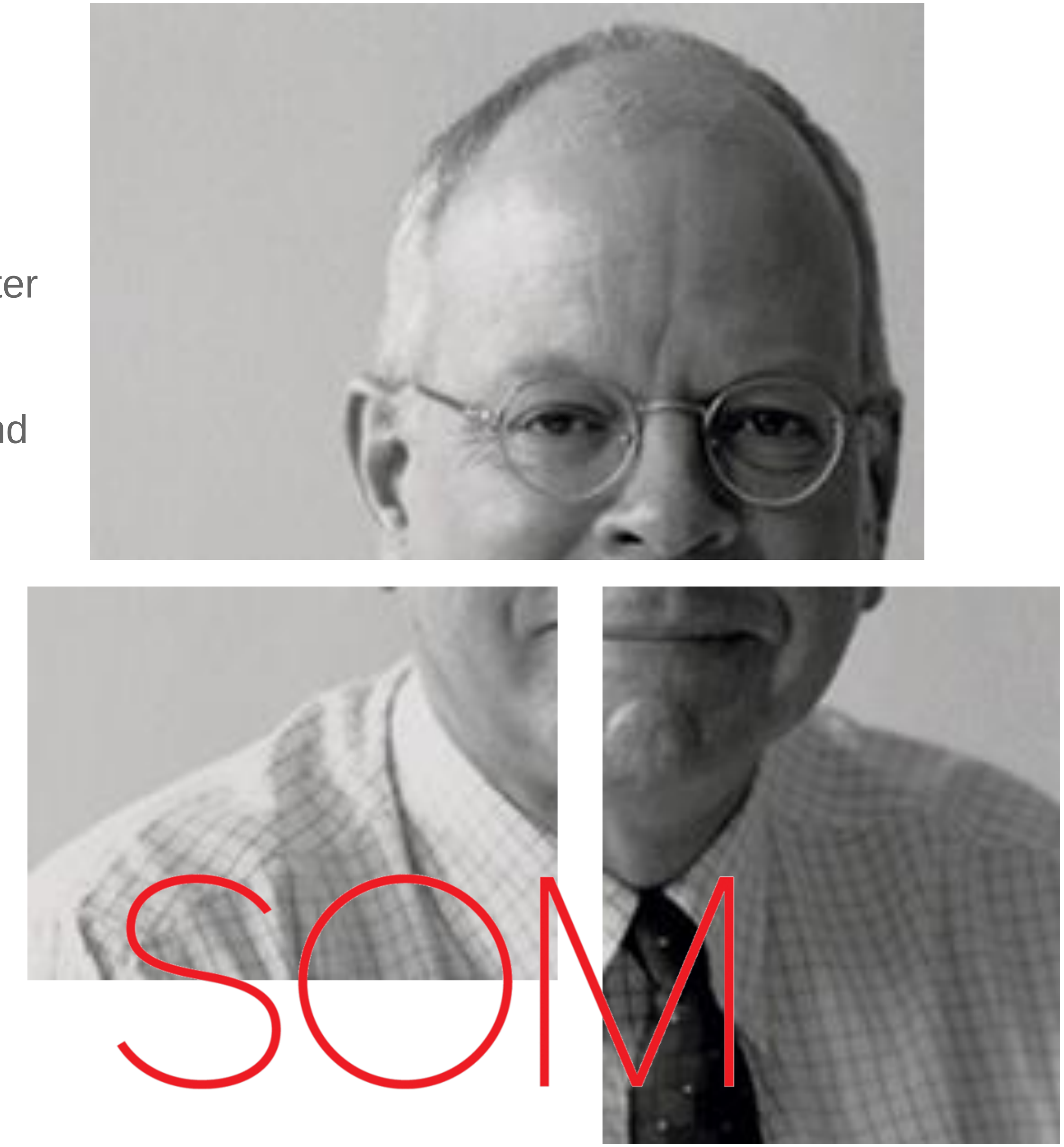
"A space for the people, not just organizations."

# Childs' Goals:

Soften concrete base
Design elegance while maintaining strength
Minimize internal columns
Security measures

"[Create a] ...dynamic, shimmering surface."

•Daniel Libeskind's proposed master plan won the redevelopment competition in 2003
•Developer Larry Silverstein wanted SOM to design the new building because he liked 7 World Trade Center
•David Childs and Libeskind worked together to create a design that retained the original ideas of Libeskind but with more office space



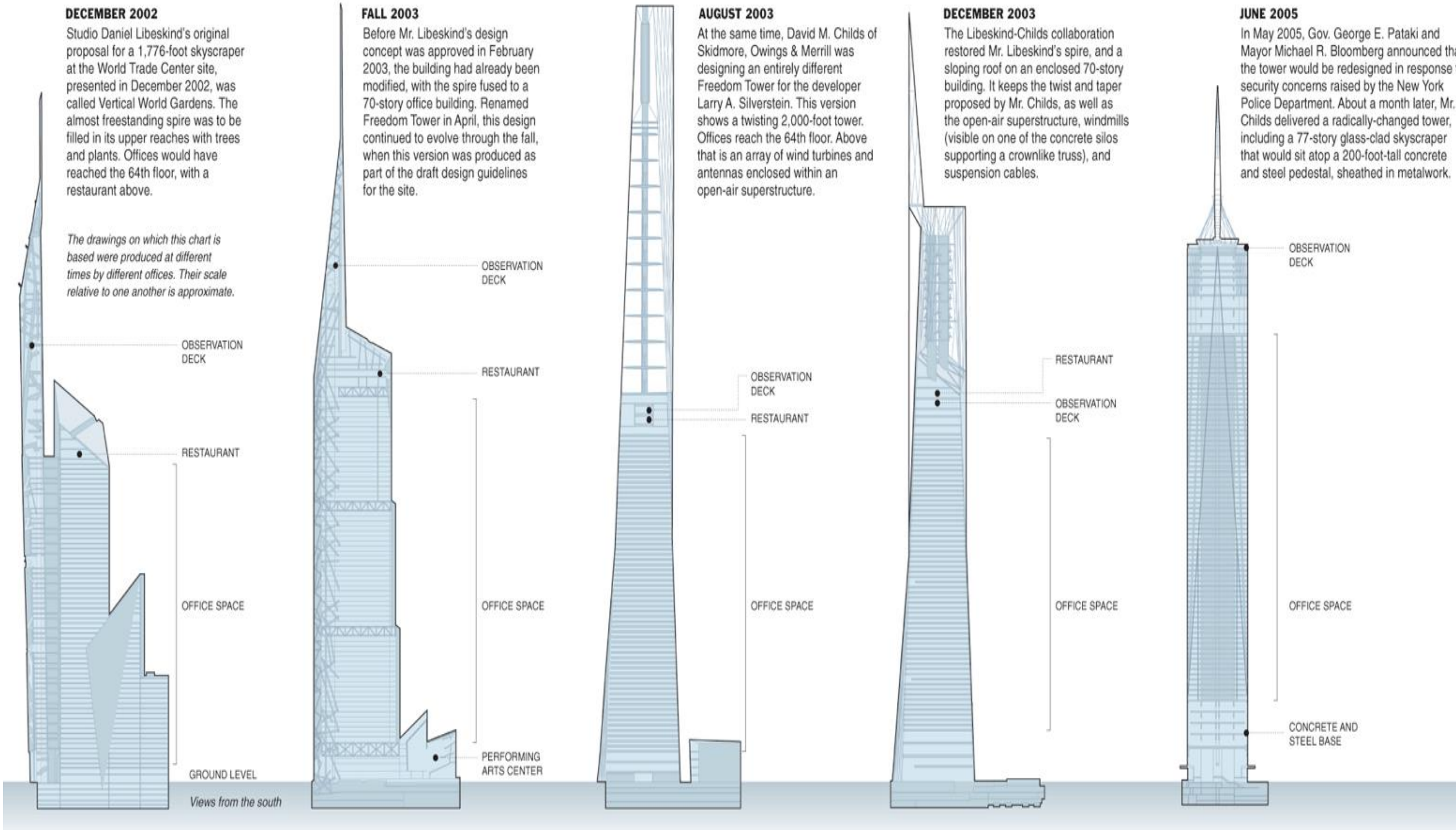

**David Childs**

•Graduate of Yale College and the Yale School of Art and Architecture
•Joined SOM in 1971; relocated to New York (1984)
•Completed Projects:

- Worldwide Plaza on Eighth Avenue
- The New York Mercantile Exchange
- The JFK International Arrivals Building
- The Bear Stearns Headquarters
- The Stuyvesant School Bridge in Tribeca

•Also designed 7 World Trade Center

# Freedom Tower's Evolution



# Site Challenges

- Bridge existing subways tracks
- New network development accommodations
- Train services were to remain operational
- Existing structures had to be preserved
- “ In order to comply, we designed a steel structure that bridges over the tracks, which supported the wet concrete loads during construction and was eventually integrated into the permanent structure.” Yoram Eilon - Vice President at WSP Cantor Seinuk

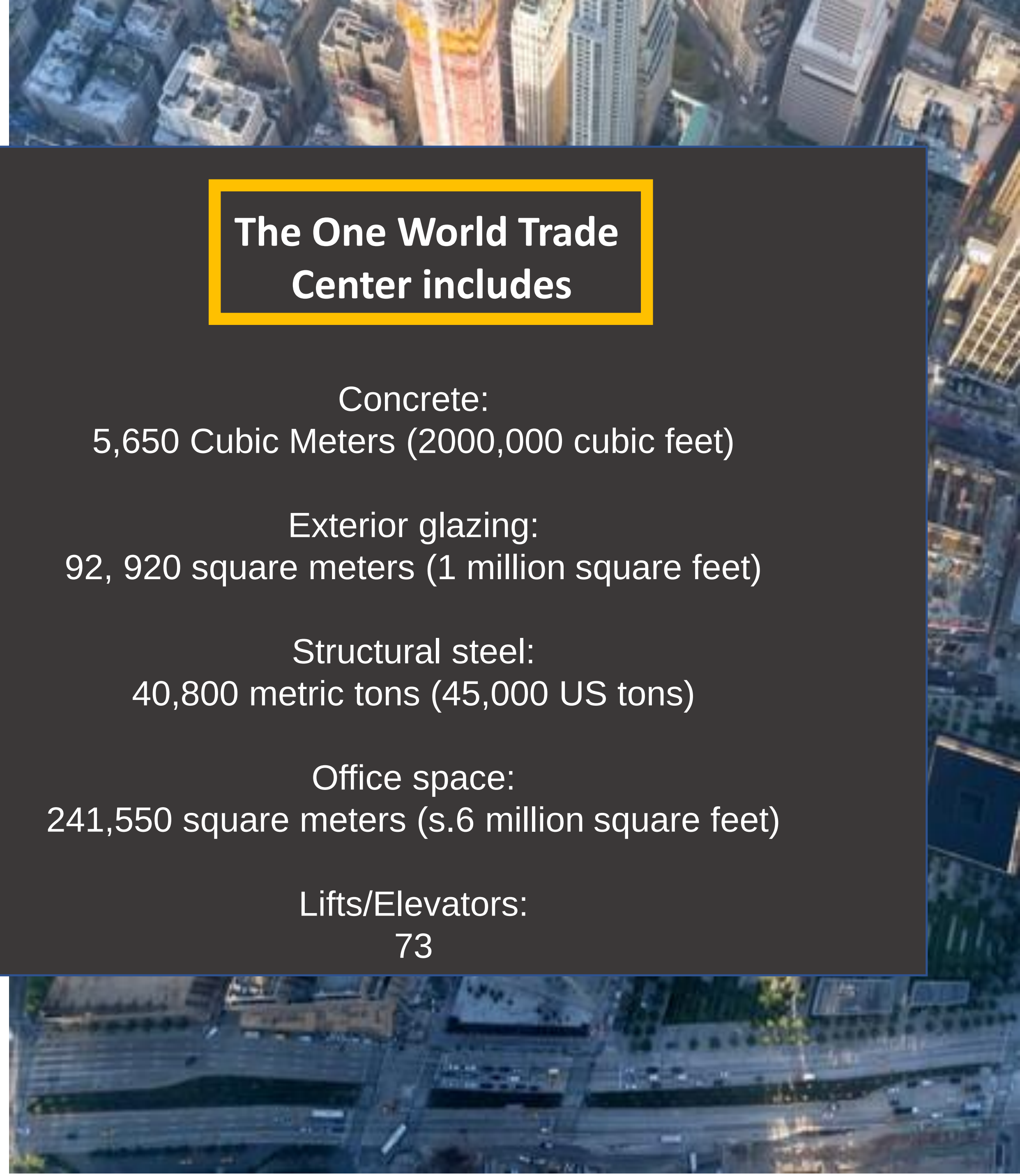
# Main Structures

Overview

Main Structure

Precautionary Design

# Overview



**The One World Trade Center includes**

Concrete:
5,650 Cubic Meters (2000,000 cubic feet)

Exterior glazing:
92, 920 square meters (1 million square feet)

Structural steel:
40,800 metric tons (45,000 US tons)

Office space:
241,550 square meters (s.6 million square feet)

Lifts/Elevators:
73

# Precautionary Design

•Avoiding a “soft story” for the first 20 floors and constructing for blast resistance

- 70-ton steel beam base
- 200 x 200 ft base
- 2000 - 13 ft tall glass prisms of automotive safety glass

•Egress Stairs

- 50% wider than required
- Internally pressurized

•Core

- High psi concrete and considerable reinforcement

The One World Trade Center  is the first project in which 14,000 psi concrete has been used in a New York City project. It was used in the lower portion of the towers shear walls.

The efficiency of the structure is due to the use of a hybrid system of high strength concrete core and structural steel moment frame at the towers perimeter. Also due to the fact that the tower tapers as it rises and combined with the chamfered corners forms an aerodynamic and structurally efficient shape.

The geometrical shape of the tower reduces exposure to wind loads, as well as the amount of structural steel needed

# Main Structures

The tower's structural design is planned around a massive, redundant steel moment frame which consists of beams and columns that are connected by welding and bolting.

Two large Manitowoc cranes were used to position the columns and nodes, the largest weighed as much as 72.5 metric tons (80 US tons)

A massive concrete core shear wall and the moment frame allows the building structure to have substantial rigidity and redundancy. It also provides column-free interior spans for maximum flexibility.

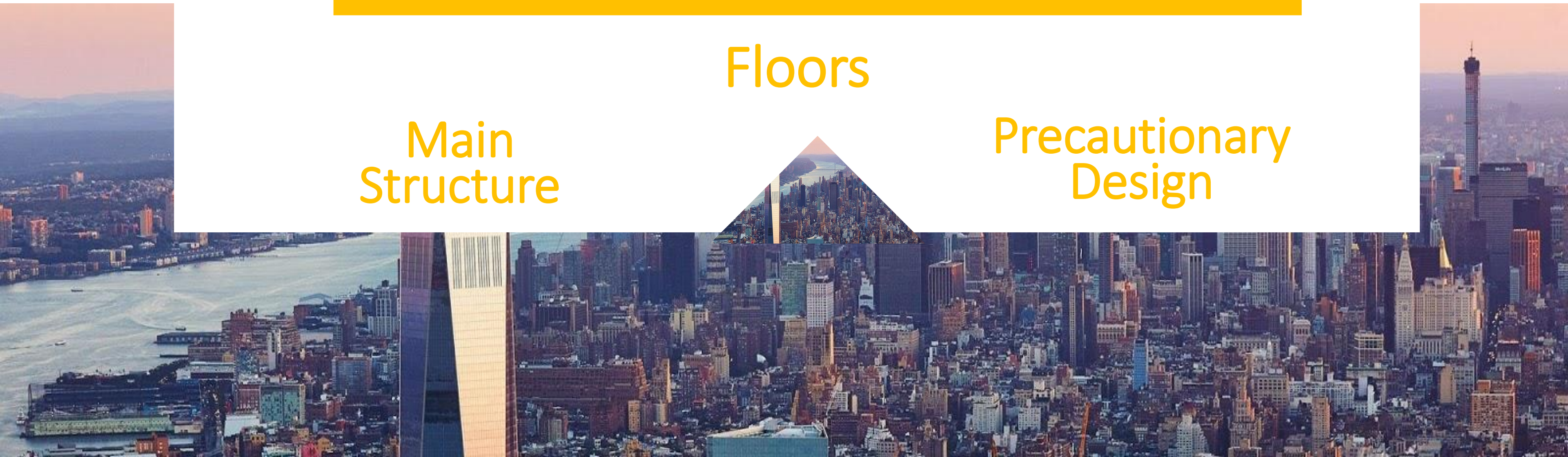
A self-jacking lift system is constructing the massive core walls.

# Components

Floors

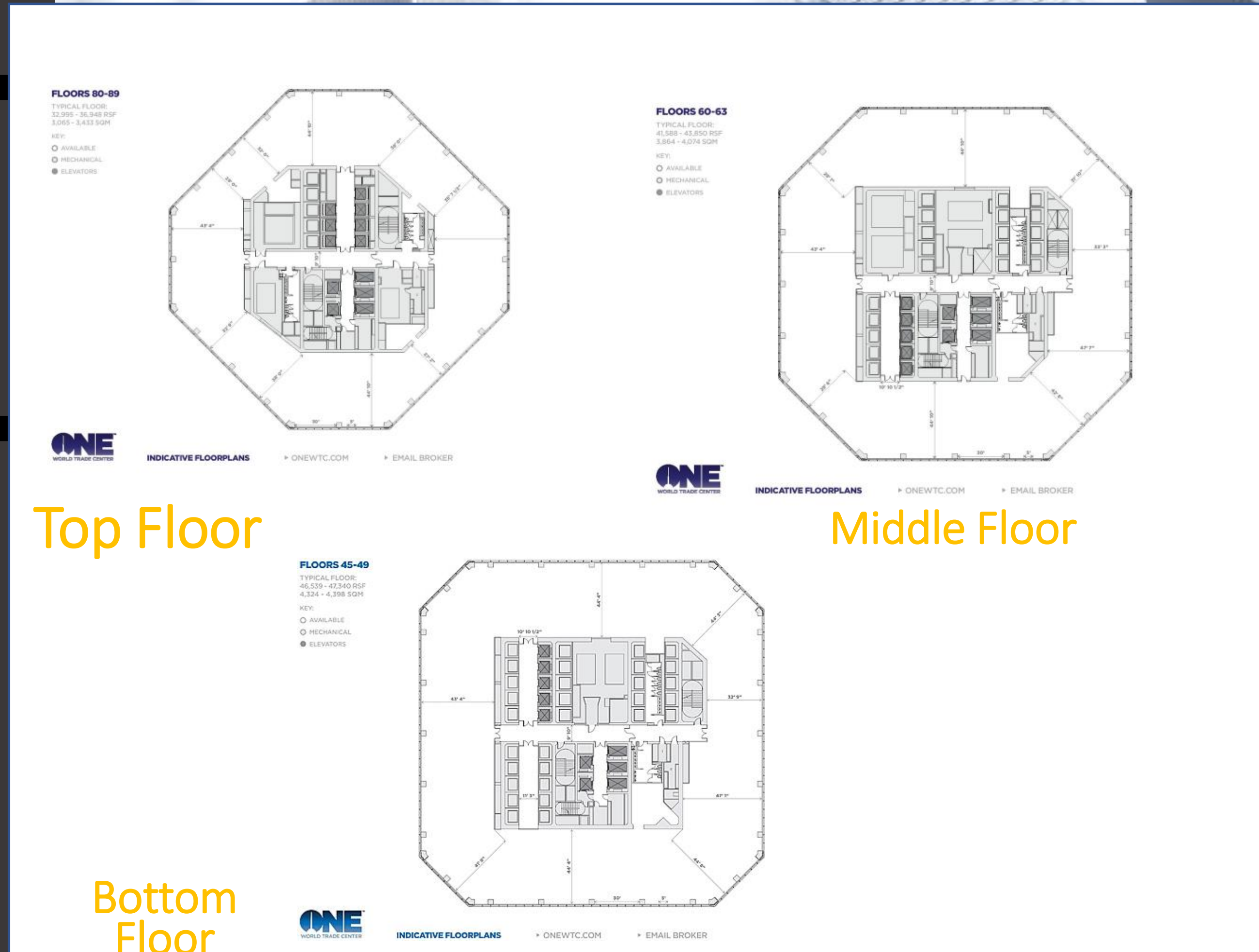
Main Structure

Precautionary Design



# Floors

Base: 19
Offices: 68
Mech: 13
Public Space: 4
Basement: 5
**Total: 109**



# Building Materials

# Components

Reinforced concrete core acts as main spine of the building.

Provides support for gravity loads and resistance to seismic and wind forces.

Concrete strength of 8,000 - 14,000 psi for foundation, columns, and core walls.

4,000 - 8,600 psi for slabs.

Floor systems feature cast in place concrete beam and slab system as well as concrete on a composite metal deck supported by steel.


# Steel Frame

45,000 US tons of structural steel

Ductile steel moment frame surrounds concrete core

Provides rigidity and column-free interiors

Shape of tower reduces wind loads and amount of structural steel

# Curtain Wall

Curtain walls begins at 20th floor and rises to the observation deck.

Based on 1.52m by 4.0m sq module

13,000 insulated panels

Panels run from floor to floor and each unit weighs up to 2720 kgs each.

Designed for LEED gold
Glazing covers 1 million sq feet
90% occupied space uses natural lighting
21% energy reduction
High performance curtain wall

# Foundation Design

Spread and strip footings with bearing capacities of 60 tons per square foot or better

Excavated deeper into rock to have a higher bearing capacity

Rock anchor tie 80 feet into ground to resist overturning effect from wind loads

Long span, deep flat slab foundation

“Bathtub” structure: below grade auxiliary shear walls, below grade floor slabs laterally brace slurry walls


# Base
# Podium

The cubic base upon which One World trade rests is comprised of a 65 foot high public lobby with a 200 ft by 200 ft square footprint.

Most striking feature of the interior is the cavernous lobby within the base portion of the building.

Features triple laminated, low iron glass fins, and embossed stainless steel slats.

Heavy reinforced concrete walls serve as a disguised security barrier.

Features four monumental entrances on the North and South sides


# Core

Supports gravitational loads, as well as wind and seismic loads.

Protects the exit routes, which was important especially after 9/11.

110-foot square

Four and a half feet thick walls at the base, slimming down to two feet.

Steel framing was built first, which is reverse from typical hybrid construction methods.

# Spire

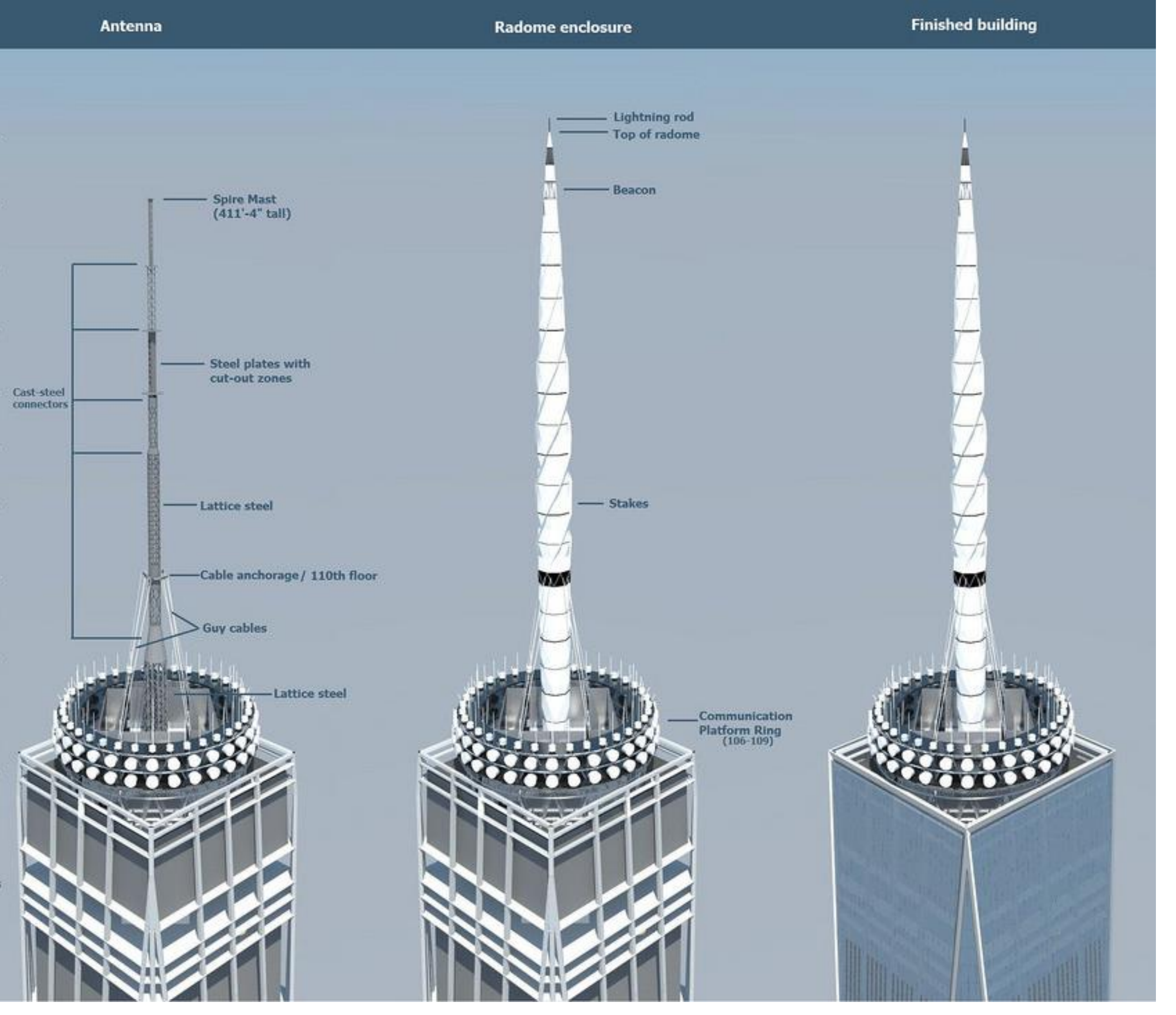
Spread and strip footings with bearing capacities of 60 tons per square foot or better

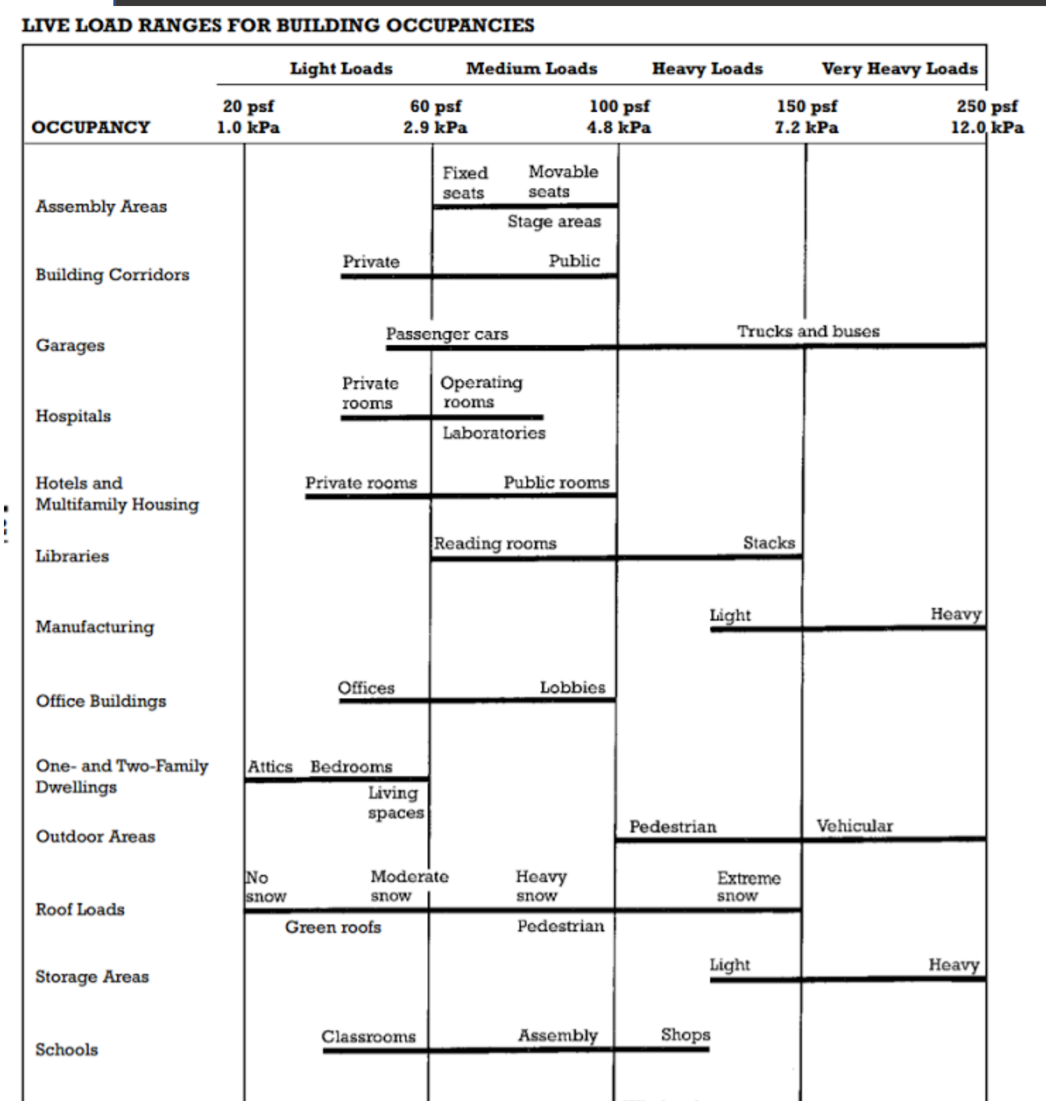
Excavated deeper into rock to have a higher bearing capacity

Rock anchor tie 80 feet into ground to resist overturning effect from wind loads

Long span, deep flat slab foundation

“Bathtub” structure: below grade auxiliary shear walls, below grade floor slabs laterally brace slurry walls






,650 cubic meters of concrete
X 2400 kg per cubic meter = 13,560,000 kg

40,800 metric tons of steel
X 1000 kg per metric ton = 40,800,000 kg

13,000 insulated glass panels
X 2,720 kg per panel = 35,360,000 kg

**Approx. dead load:**

89,720,000 kg = 89,720 metric tons

2.6 million square feet
X 100 lbs per square foot = 260,000,000 lbs
(1 lb = 0.453592 kg) = 117,933,920 kg

**Approx. live load:**

117,933,920 kg = 117,933.92 metric tons

*Approximate Gravitational Loads:*

*207,654 metric tons*

# Lateral Load

## Load tracing

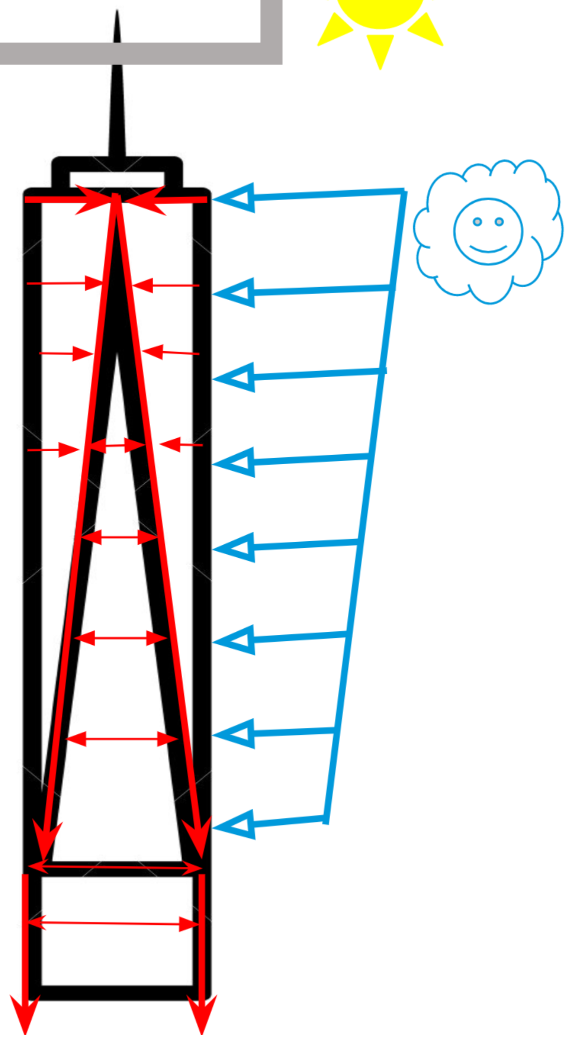
Aerodynamics is important because of the height

On a calm day, wind can be 50 mph at the top of the structure

Constant motion from wind loads

The turning and tapering of the structure allows it to deflect lateral loads from wind

Wind testing and human comfort criteria were analyzed in order to display how the building would react as well as



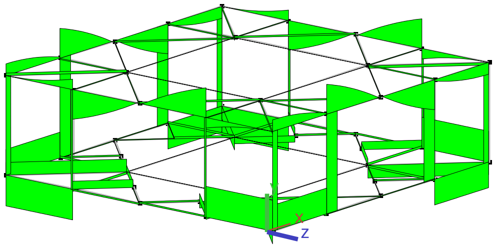
| Wind (MPH) | Load (PSF) |
|---|---|
| 25 | 1.63 |
| 50 | 6.52 |
| 75 | 14.66 |
| 100 | 26.07 |
| 125 | 40.73 |
| 150 | 58.65 |
| 175 | 79.84 |
| 200 | 104.28 |

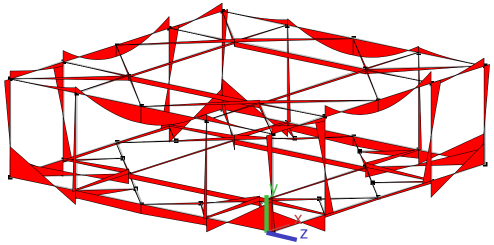
# Gravitational Loads Analysis

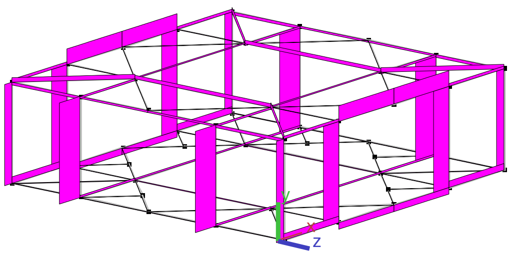
Gravitational loads are transferred outward by the floors to the steel frame

High moments occur in the middle of the edge members on all sides

High shear forces occur at the corners



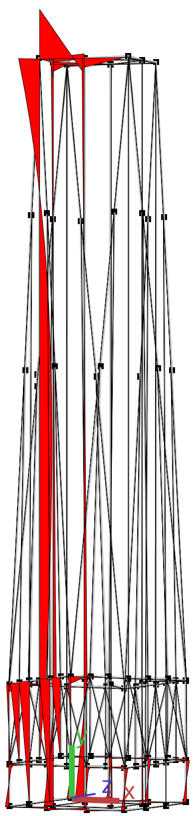


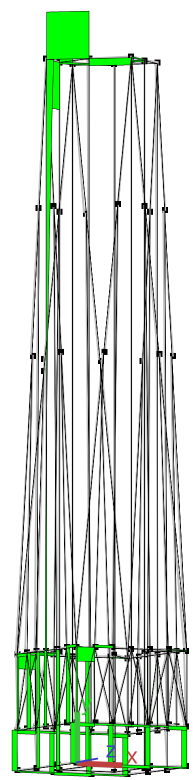


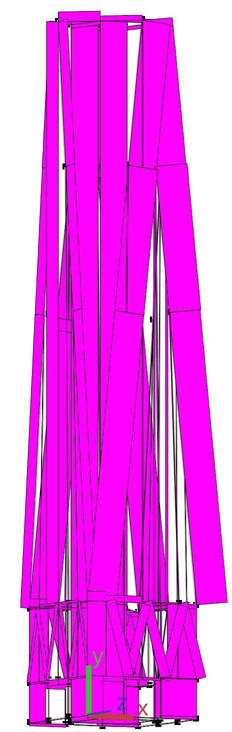
# Lateral Loads Analysis

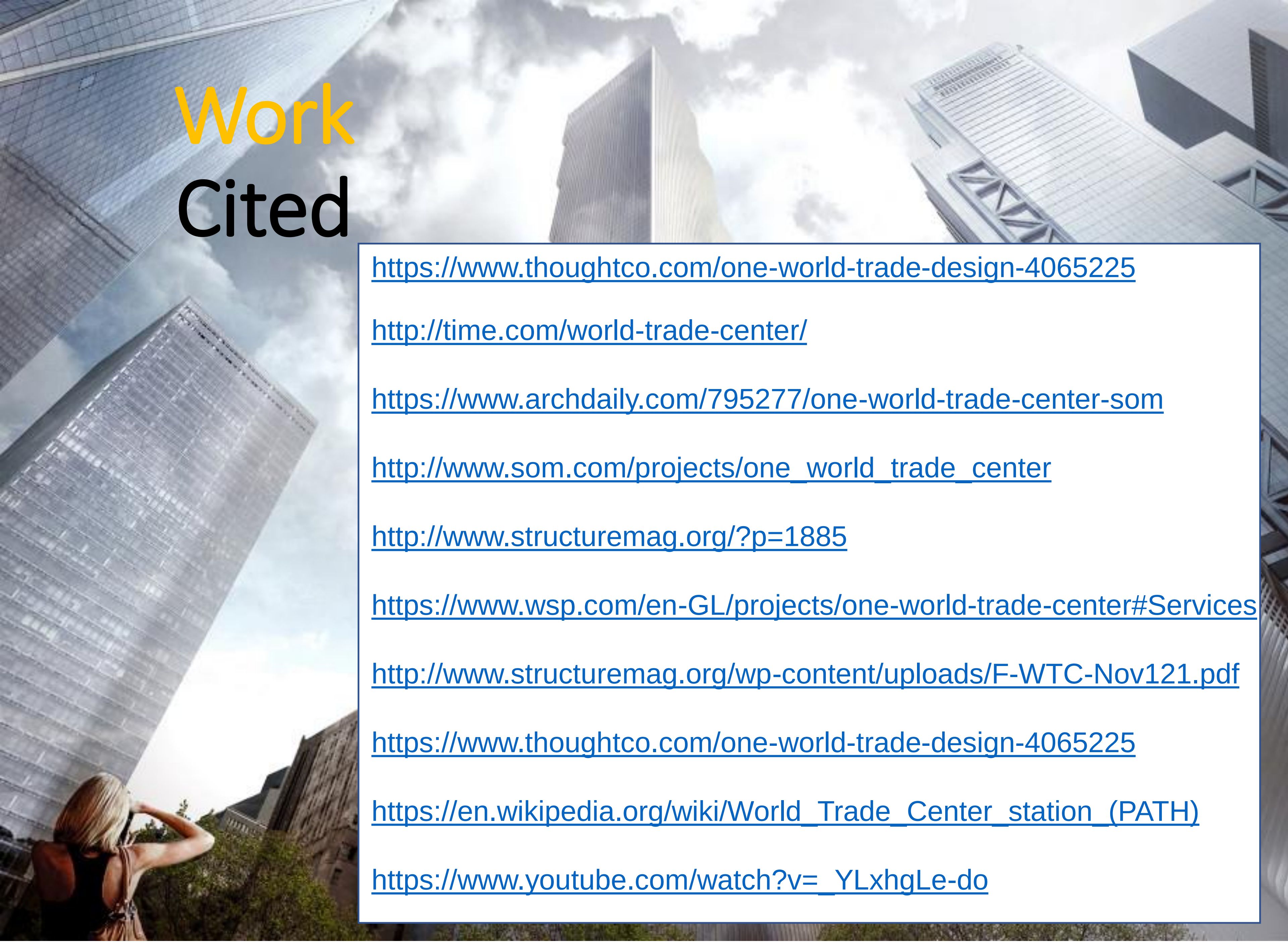
Rigid frame – Transfers lateral loads through the frame to the podium and into the ground

High shear and moment forces along the top where the top plate connects to the rigid frame









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That's all Folks!