

One World Trade Center

An aerial photograph of New York City, centered on the One World Trade Center. The building is a tall, blue-tinted skyscraper with a spire at the top. The surrounding city is densely packed with buildings of various heights. In the foreground, there are yellow geometric shapes: a downward-pointing triangle at the top, and two overlapping diamonds below it, all centered on the building. The sky is a mix of blue and grey, suggesting an overcast day.

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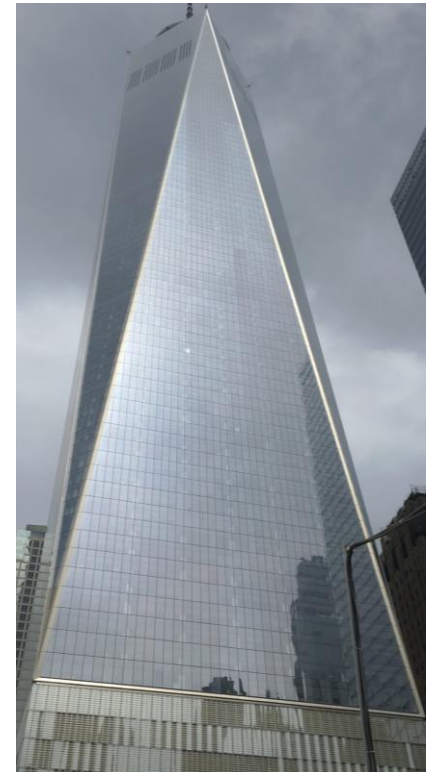


Introduction And Design

- Overview
- History
- Design Concept
- Architect Background
- Site Challenges
- Project Requirements



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

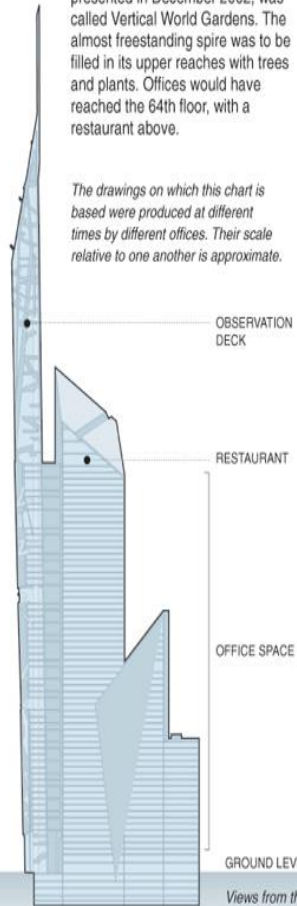


Freedom Tower's Evolution

DECEMBER 2002

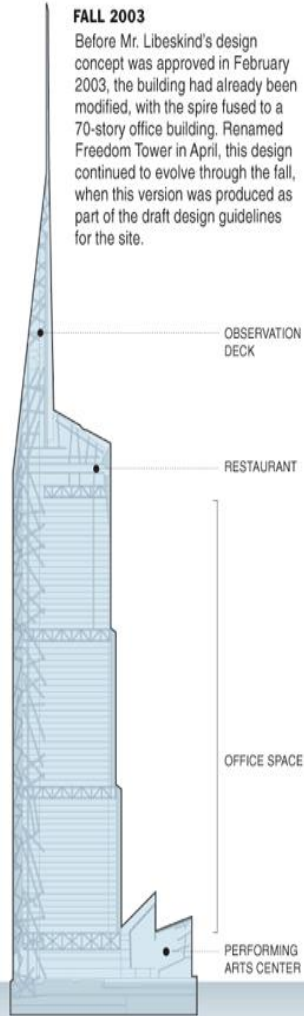
Studio Daniel Libeskind's original proposal for a 1,776-foot skyscraper at the World Trade Center site, presented in December 2002, was called Vertical World Gardens. The almost freestanding spire was to be filled in its upper reaches with trees and plants. Offices would have reached the 64th floor, with a restaurant above.

The drawings on which this chart is based were produced at different times by different offices. Their scale relative to one another is approximate.



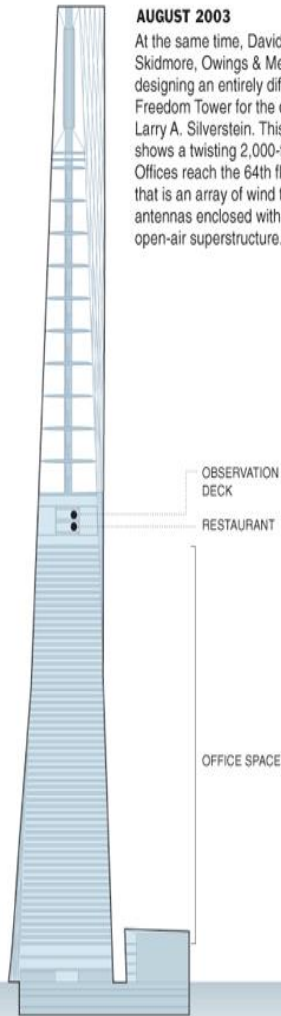
FALL 2003

Before Mr. Libeskind's design concept was approved in February 2003, the building had already been modified, with the spire fused to a 70-story office building. Renamed Freedom Tower in April, this design continued to evolve through the fall, when this version was produced as part of the draft design guidelines for the site.



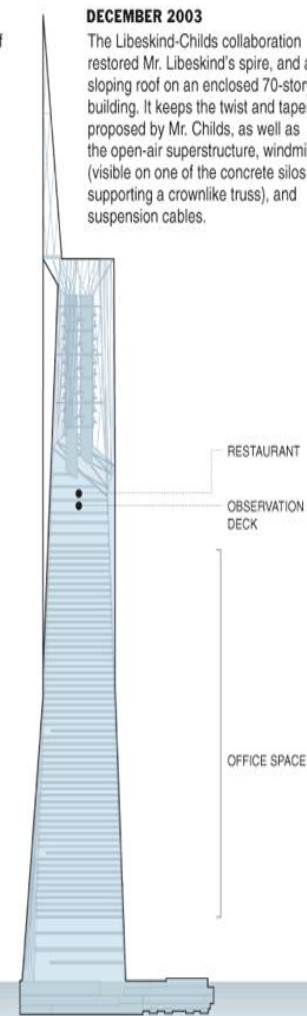
AUGUST 2003

At the same time, David M. Childs of Skidmore, Owings & Merrill was designing an entirely different Freedom Tower for the developer Larry A. Silverstein. This version shows a twisting 2,000-foot tower. Offices reach the 64th floor. Above that is an array of wind turbines and antennas enclosed within an open-air superstructure.



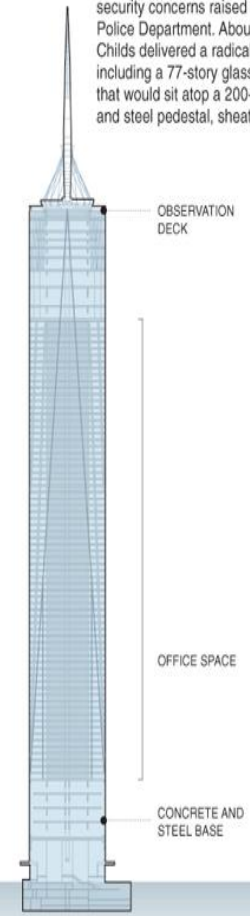
DECEMBER 2003

The Libeskind-Childs collaboration restored Mr. Libeskind's spire, and a sloping roof on an enclosed 70-story building. It keeps the twist and taper proposed by Mr. Childs, as well as the open-air superstructure, windmills (visible on one of the concrete silos supporting a crownlike truss), and suspension cables.



JUNE 2005

In May 2005, Gov. George E. Pataki and Mayor Michael R. Bloomberg announced that the tower would be redesigned in response to security concerns raised by the New York Police Department. About a month later, Mr. Childs delivered a radically-changed tower, including a 77-story glass-clad skyscraper that would sit atop a 200-foot-tall concrete and steel pedestal, sheathed in metalwork.



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 fact that the tower tapers as it rises and combined with the chamfered corners forms an aerodynamic and structurally efficient shape.

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 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



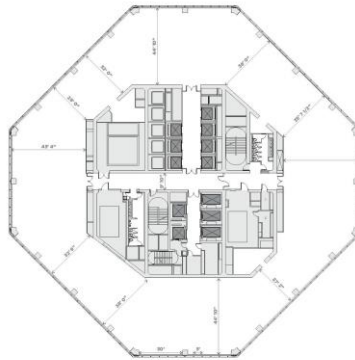
Floors

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

FLOORS 80-89

TYPICAL FLOOR:
 32,995 - 36,948 RSF
 3,058 - 3,437 SQM

KEY:
 ○ AVAILABLE
 ○ MECHANICAL
 ● ELEVATORS



INDICATIVE FLOORPLANS

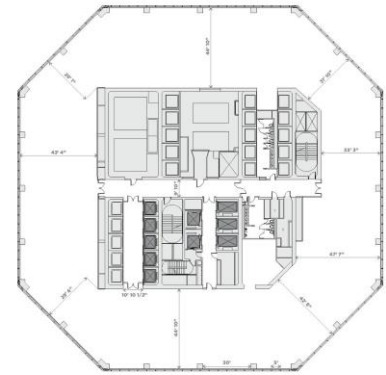
▶ ONEWTC.COM

▶ EMAIL BROKER

FLOORS 60-63

TYPICAL FLOOR:
 41,588 - 43,850 RSF
 3,864 - 4,074 SQM

KEY:
 ○ AVAILABLE
 ○ MECHANICAL
 ● ELEVATORS



INDICATIVE FLOORPLANS

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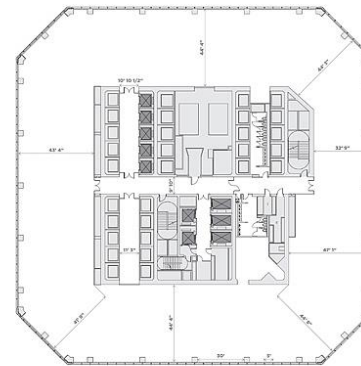
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Top Floor

FLOORS 45-49

TYPICAL FLOOR:
 46,539 - 47,840 RSF
 4,324 - 4,398 SQM

KEY:
 ○ AVAILABLE
 ○ MECHANICAL
 ● ELEVATORS



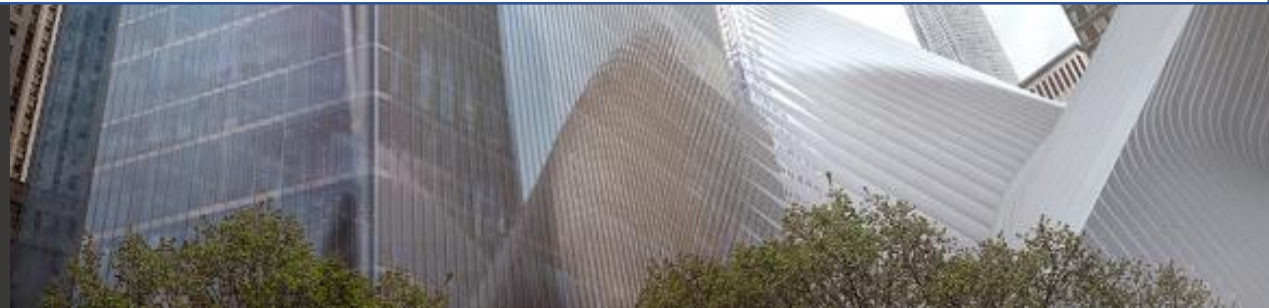
INDICATIVE FLOORPLANS

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Middle Floor

Bottom Floor





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

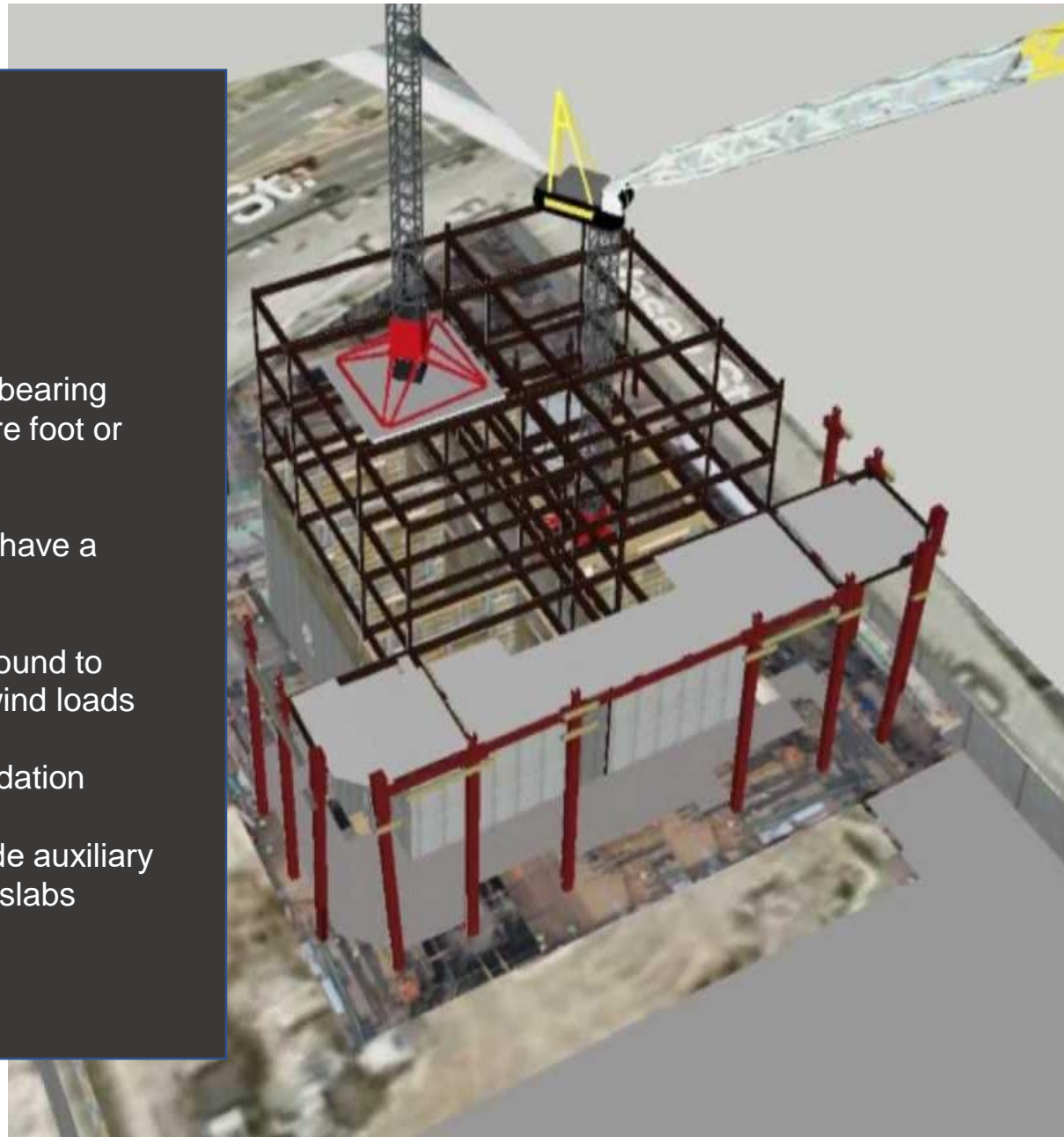
Spread and strip footings with bearing capacities of 60 tons per square foot or better

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





Building

Materials



Base Podium

The cubic base upon which One World Trade Center 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

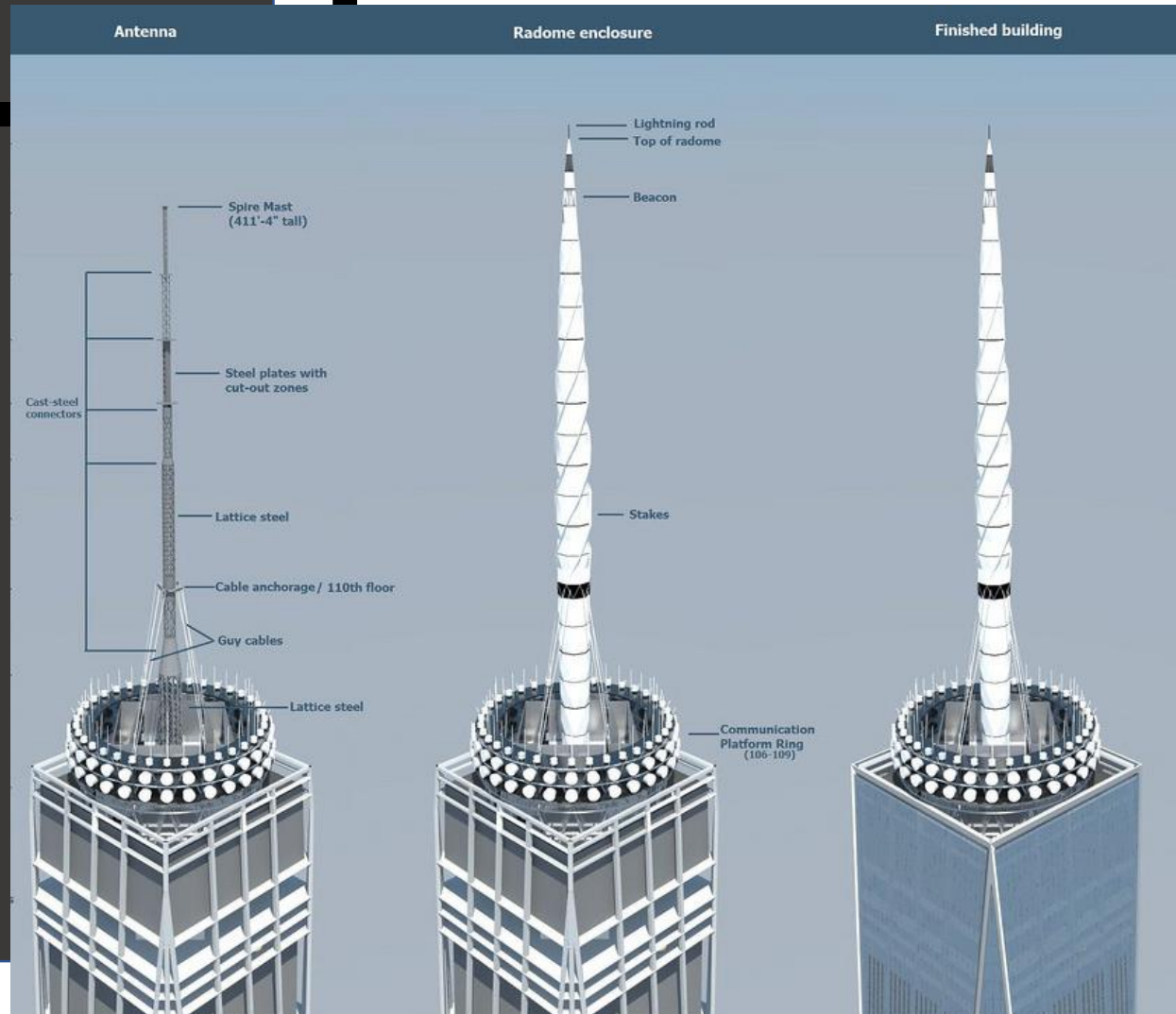
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LIVE LOAD RANGES FOR BUILDING OCCUPANCIES

OCCUPANCY	Light Loads		Medium Loads		Heavy Loads	Very Heavy Loads
	20 psf 1.0 kPa	60 psf 2.9 kPa	100 psf 4.8 kPa	150 psf 7.2 kPa	250 psf 12.0 kPa	
Assembly Areas		Fixed seats Movable seats				
Building Corridors		Private	Stage areas Public			
Garages		Passenger cars		Trucks and buses		
Hospitals		Private rooms	Operating rooms Laboratories			
Hotels and Multifamily Housing		Private rooms	Public rooms			
Libraries			Reading rooms	Stacks		
Manufacturing				Light	Heavy	
Office Buildings		Offices	Lobbies			
One- and Two-Family Dwellings	Attics	Bedrooms Living spaces				
Outdoor Areas				Pedestrian	Vehicular	
Roof Loads	No snow	Moderate snow	Heavy snow	Extreme snow		
Storage Areas		Green roofs	Pedestrian	Light	Heavy	
Schools		Classrooms	Assembly	Shops		

,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

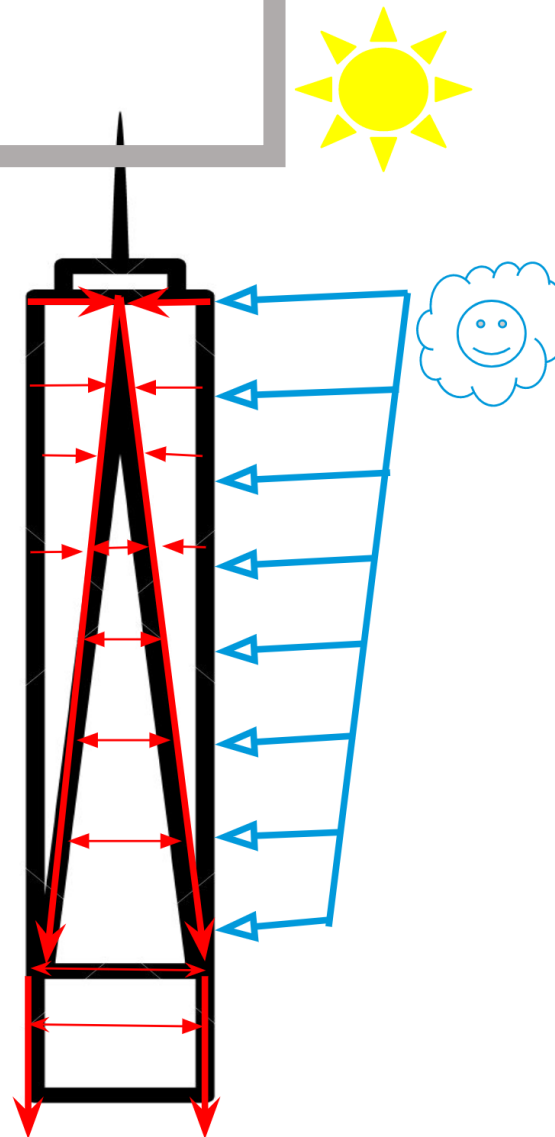
Aerodynamics is important because of the height

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



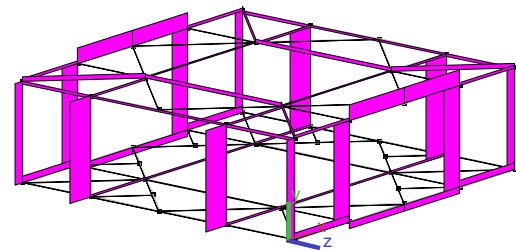
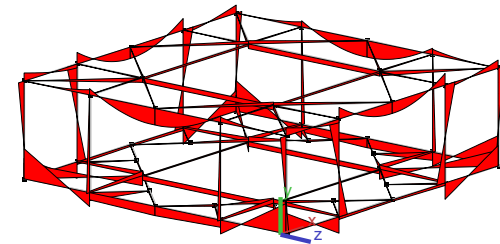
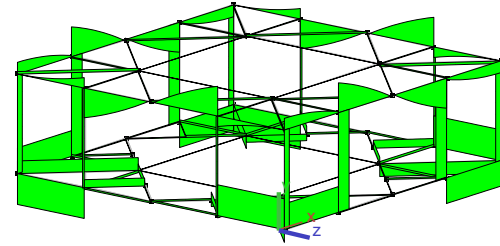
Wind (MPH)	Load (PSF)
25	1.63
50	6.52
75	14.66
100	26.07
125	40.73
150	58.65
175	79.84
200	104.28

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

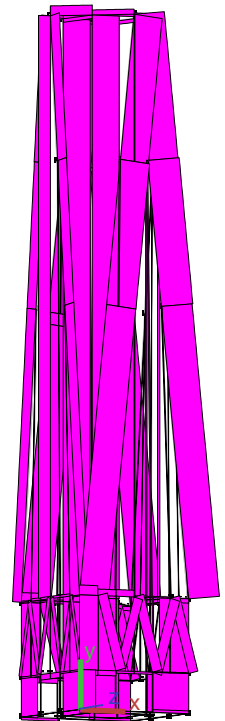
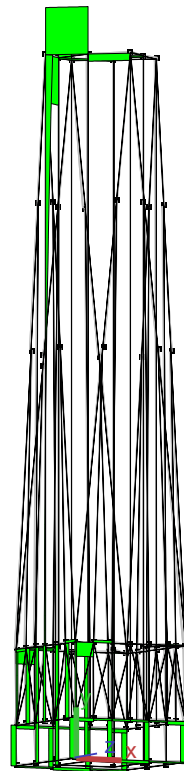
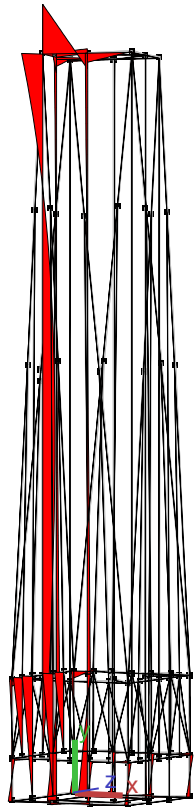
High shear forces occur at the corners



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



Work Cited

<https://www.thoughtco.com/one-world-trade-design-4065225>

<http://time.com/world-trade-center/>

<https://www.archdaily.com/795277/one-world-trade-center-som>

http://www.som.com/projects/one_world_trade_center

<http://www.structuremag.org/?p=1885>

<https://www.wsp.com/en-GL/projects/one-world-trade-center#Services>

<http://www.structuremag.org/wp-content/uploads/F-WTC-Nov121.pdf>

<https://www.thoughtco.com/one-world-trade-design-4065225>

[https://en.wikipedia.org/wiki/World_Trade_Center_station_\(PATH\)](https://en.wikipedia.org/wiki/World_Trade_Center_station_(PATH))

https://www.youtube.com/watch?v=_YLxhgLe-do



That's all Folks!