One World Trade Center

David Creamer, Lindsey Dusek, Lacey Masters, Alyssa Mayfield, Mildred Trevino & Carmen A Torres

"The tower is an open, welcoming building that both radiates light and is filled with light. Our design team has achieved our goal of creating a great urban place -- a building that serves the people who work in it, welcomes those who visit it, and plays an integral and vibrant role in the city that surrounds it."

- David M. Childs, One World Trade Center Architect

WORLD TRADE CENTER
REBORN

WORLD TRADE CENTER TIMELINE

1968-1971
CONSTRUCTION

1971-2001
WTC SITE

2001-2006
POST-9/11

2006-2011
REBUILDING

2011-
THE NEW WTC

Project Data

Completion Date: 2013

Height to Architectural Top: 1,776 feet

Total Area: 3,501,274 square feet

Cost: US $3.9 billion

Primary Use: Office

Project Developer: The Port Authority of New York & New Jersey

Architect: Skidmore Owings & Merrill LLP

Structural Engineer: Sclaich Bergermann und Partner; WSP Cantor Seinuk; Leslie E. Robertson Associates

MEP Engineer: Jaros, Baum & Bolles

Main Contractor: Tishman Construction

Project Manager: The Port Authority of New York & New Jersey

Wind Consultant: RWDI

Elevator Consultant: Jaros, Baum & Bolles

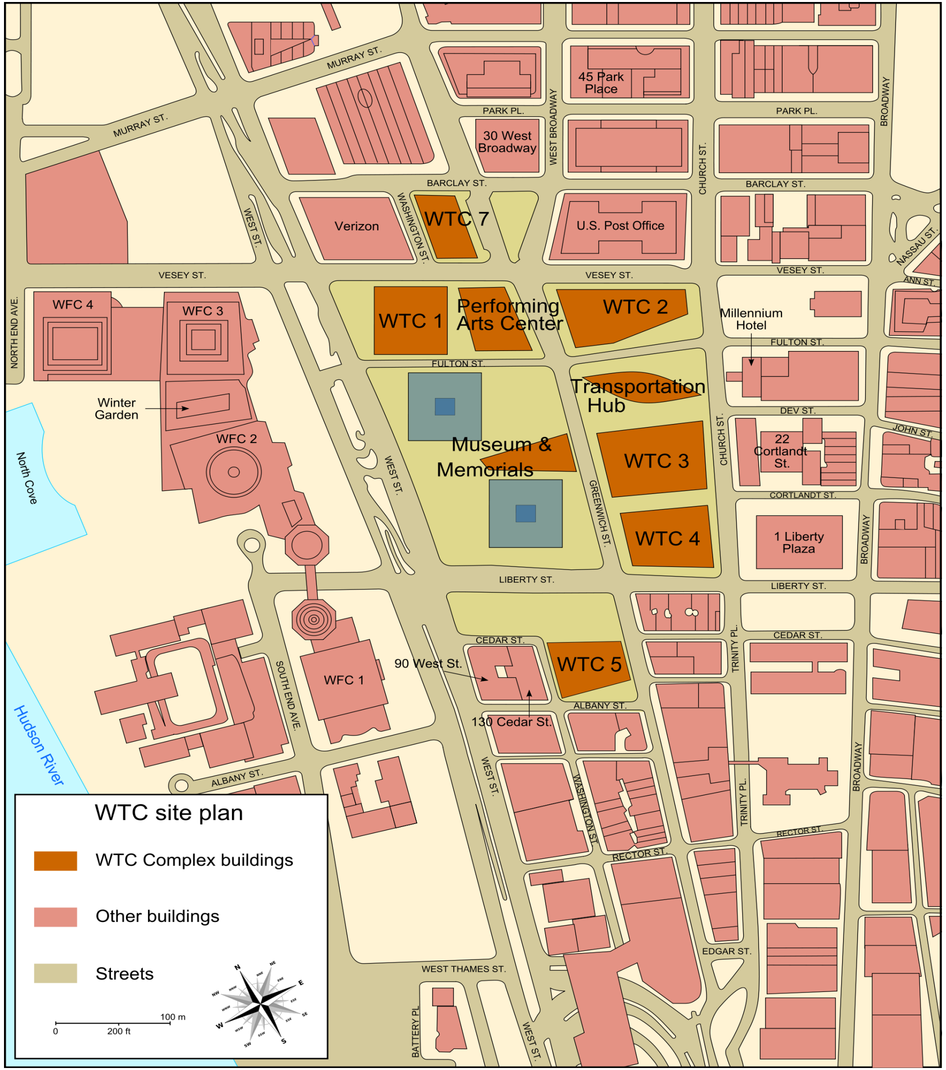
History

9/11 terrorist attacks

Controversy arose

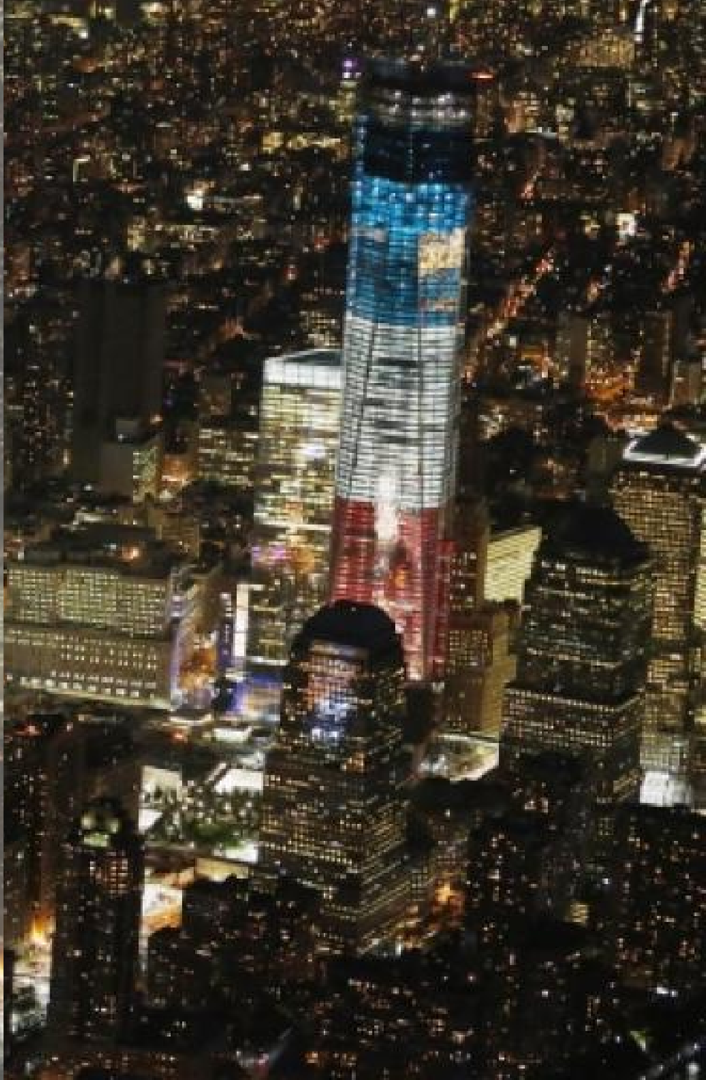
People questioned whether to rebuild the towers as they were, whether they should come up with a new design, or whether any skyscraper should be built in the first place.

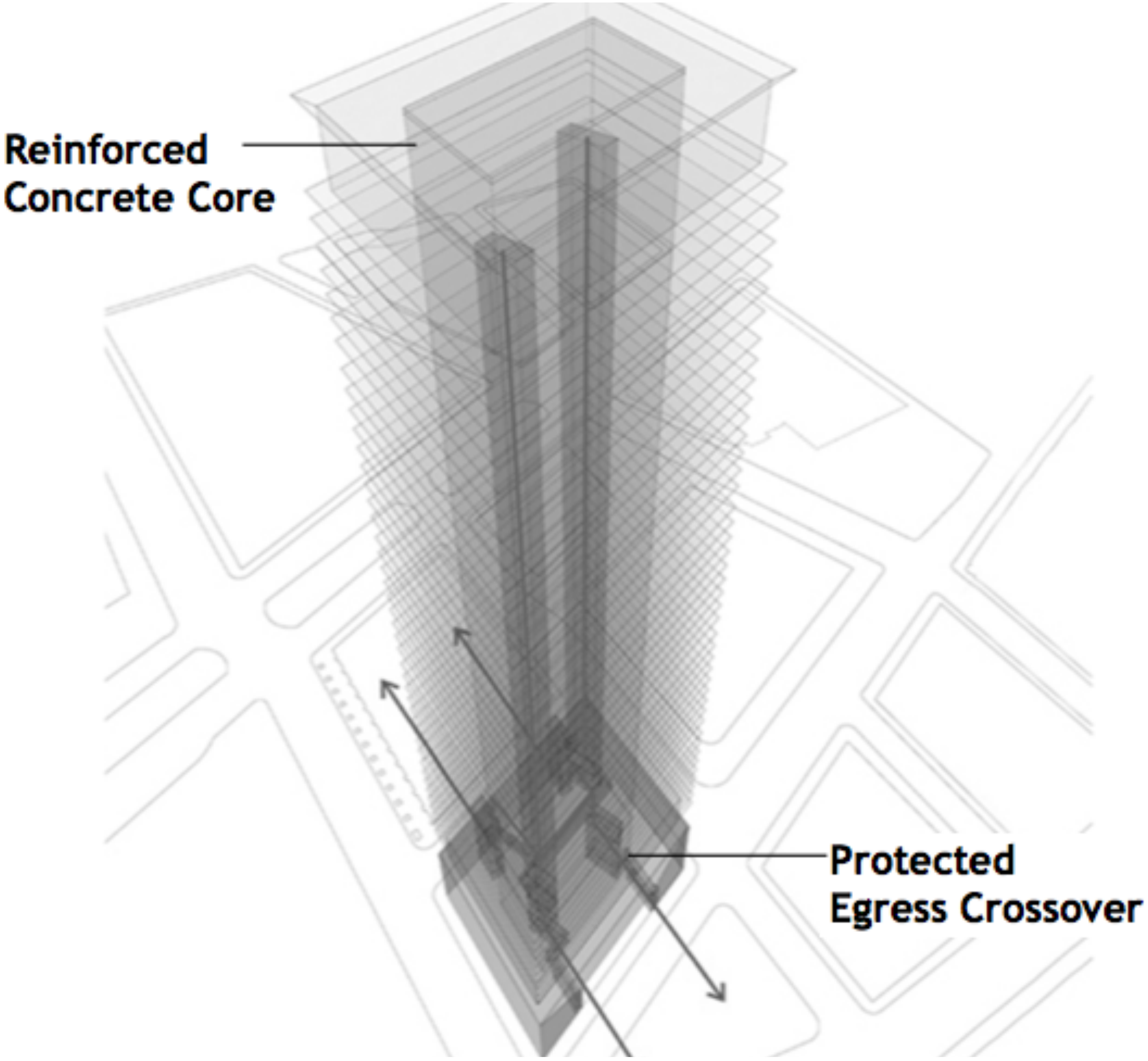
- World Trade Center site in New York City, NY



Concept

- Having previously been a target for terrorist attacks, architect David Childs felt it was necessary to make the skyscraper **feel safe**
  - Extra wide pressurized Stairs
  - Structural redundancy
  - Dense fireproofing
  - Biochemical filters
  - Backup emergency lighting
  - Concrete protection for sprinkler systems
  - Core wall
  - Increased impact resistance
  - Ultra strength concrete
  - Pressurized to keep smoke out
  - Enhanced elevators



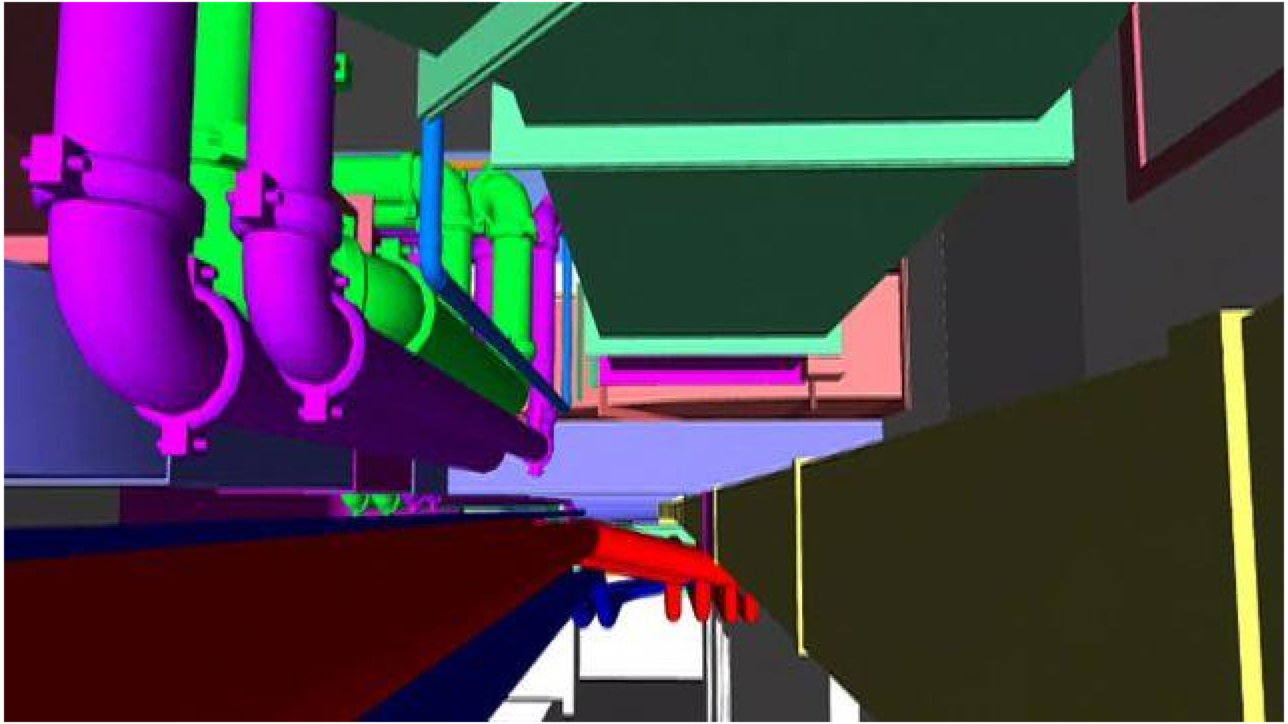

Reinforced
Concrete Core
Protected
Egress Crossover

BIM

“The project’s Structural Engineer used a combination of Revit Building and AutoCAD to model the Tower’s foundations, buttress slabs, core walls and columns”

-(AEC Mag)

- One of the first times that BIM was being used in a project of this scale and complexity
- Skidmore, Owings and Merrill (SOM) is famously known to work with advanced BIM technology since the late 80s
- A combination of Revit, 3DS Max, and AutoCAD were used to produce the complex plans and renderings required to express the design



- Helped implement MEP engineering into the model
- Decreased RFIs

Materials

Concrete core

Steel Frame

Prismatic glass around structural podium

Curtain Wall Glass for the tower

Concrete

“We believe that it sets a new standard for New York City construction.”

14,000 psi concrete for podium and base

12,000 psi concrete for the structural core above podium

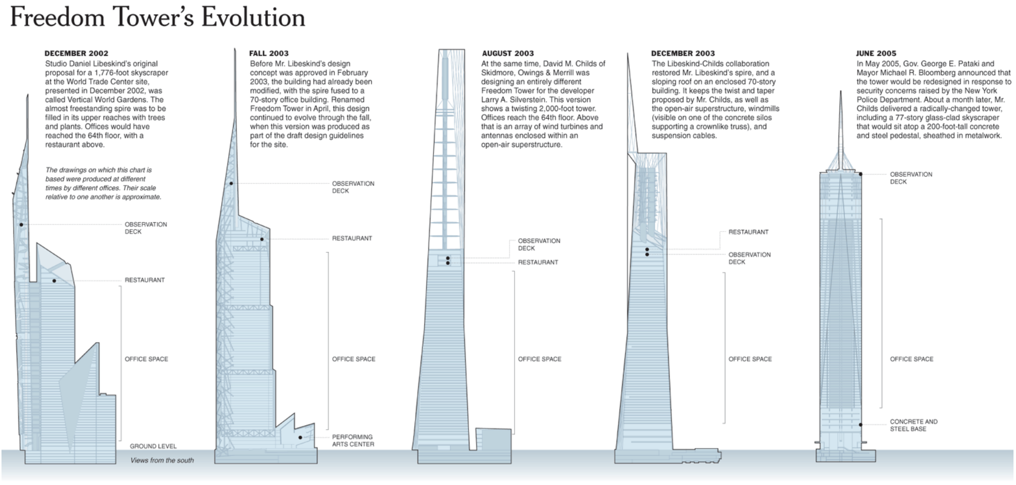
Prismatic Glass

Prismatic glass around structural podium meant to make the concrete "fortress" seem more inviting.

Emanates light because of the way the prism reflect light

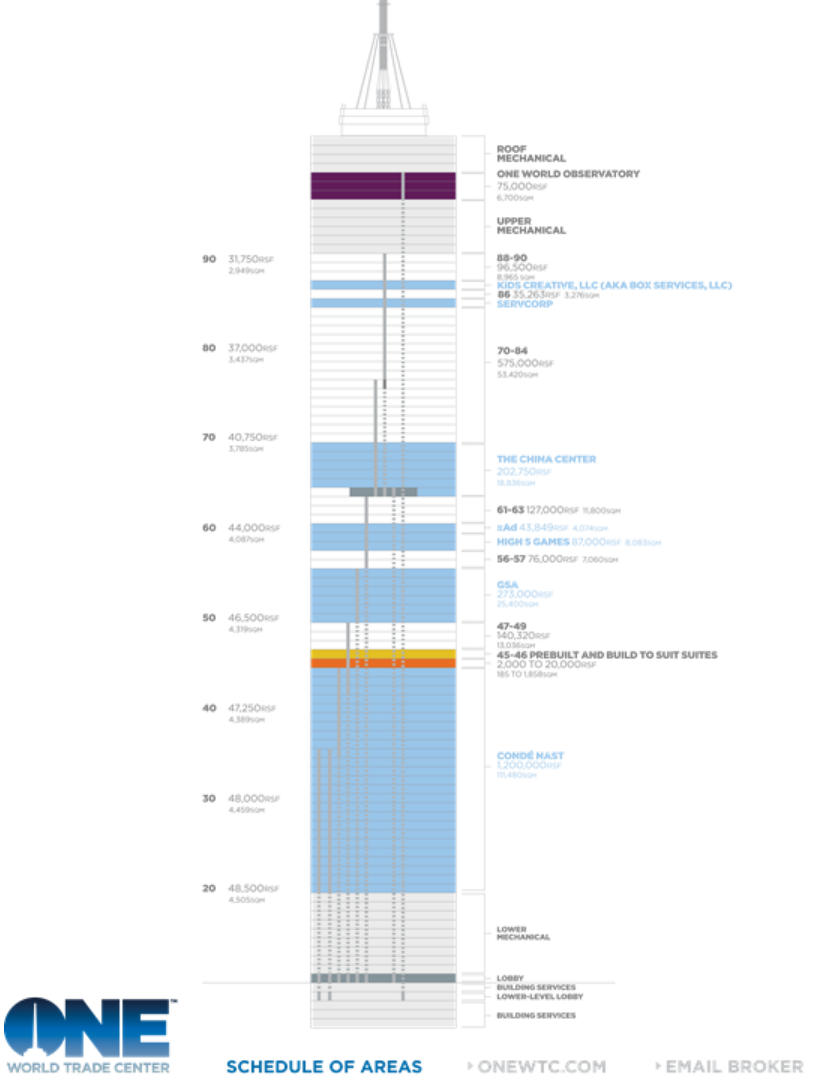
Background Architect

1 WTC” (Freedom Tower) iterations
Daniel Libeskind 1,776 spire Before approved,modified
Larry Silverstein David Childs
Childs different design turbines
A hybrid of spire and turbines
NY Police altered
SOM took over radically changed today.



Building Layout

- 104 Floors total; 5 below grade; 71 office floors
- The 1st floor contains the Lobby with a 55ft high ceiling
- Floors 2-19 are lower mechanical
- Floors 20-90 are office space
- The below grade floors will be used for building services, retail, restaurants, and public transportation access.



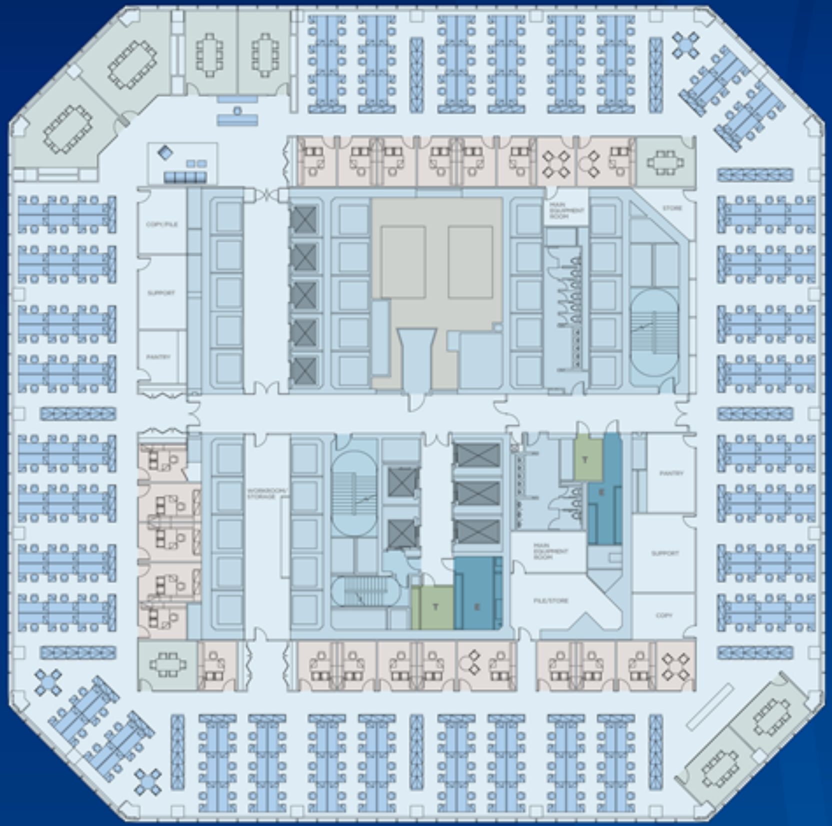
FLOOR 45 FINANCIAL FIRM

47,358RSF 4,400SQM

TYPE	QTY.
OFFICE (180SF)	2
OFFICE (150SF)	3
OFFICE (120SF)	16
BENCHING (38SF)	196
TOTAL SEATS	**217**
RATIO	**10% / 90%**
12P CONF.	2
8P CONF.	4
6P CONF.	2
4P CONF.	2
TOTAL SEATS	**76**
SEATS/PP	1:2.9
RSF	**47,358**
RSF/PP	**218**
MAXIMUM OCCUPANCY:	320 PP

KEY

- OFFICE
- CORE
- VERTICAL TRANSPORTATION
- HVAC/MECHANICAL
- TELECOMMUNICATIONS
- ELECTRICAL

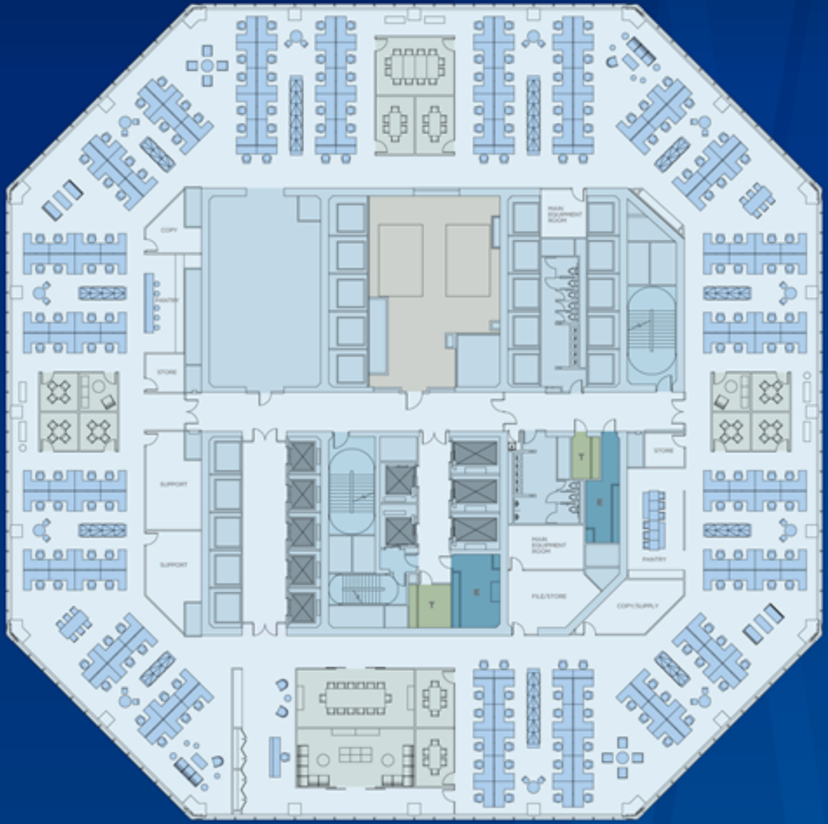


FLOOR 60
CREATIVE AGENCY

43,849RSF 4,074SQM

TYPE	QTY.
OFFICE (120SF)	0
WORKSTATION (33SF)	172
TOUCHDOWN (25SF)	12
TOTAL SEATS	**184**
RATIO	**0% / 100%**
14P CONF.	1
12P CONF.	2
6P CONF.	4
4P CONF.	8
TOTAL SEATS	**94**
SEATS/PP	1:2
OPEN COLLABORATION	58
TOTAL SEATS	**58**
SEATS/PP (CONF + OPEN COLLABORATION)	1:1.3
RSF	**43,849**
RSF/PP	**238**
MAXIMUM OCCUPANCY:	280 PP

KEY
- OFFICE
- CORE
- VERTICAL TRANSPORTATION
- HVAC/MECHANICAL
- TELECOMMUNICATIONS
- ELECTRICAL



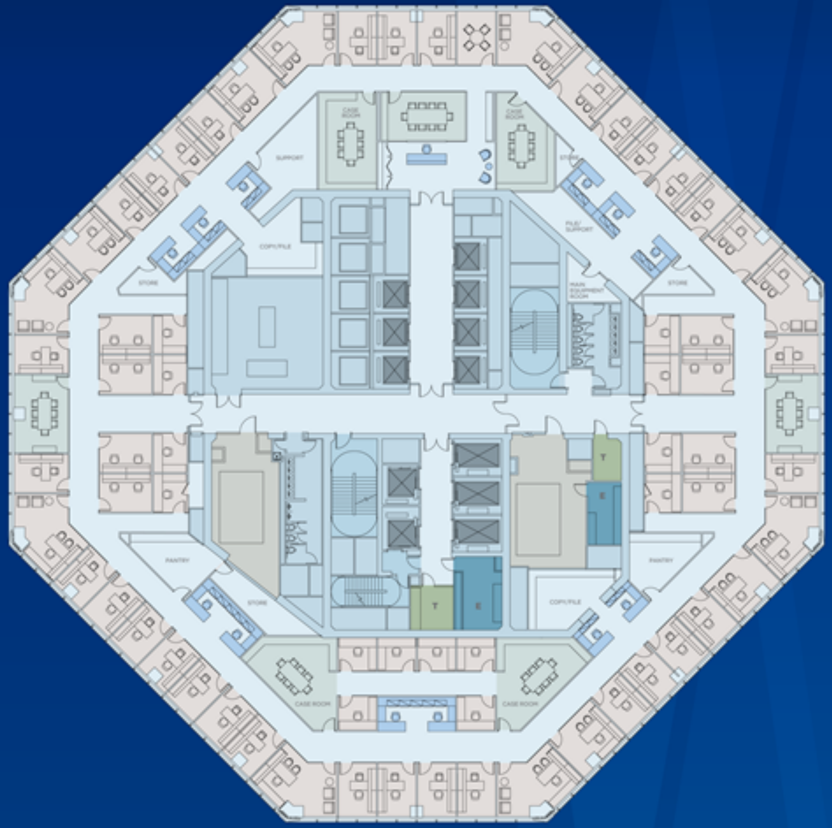
FLOOR 80
LAW FIRM

36,993RSF 3,437SQM

TYPE	QTY.
PARTNER (250SF)	8
PARTNER (190SF)	6
ASSOCIATE (130SF)	30
DBL ASSOCIATE (130SF)	8
TOTAL ATTYS	**60**
PARALEGAL	14
SECRETARY	12
TOTAL SEATS	**86**
CASE ROOMS	4
10P CONF.	1
8P CONF.	2
4P CONF.	1
TOTAL SEATS	**30**
RSF	**36,993**
RSF/ATTY	**616**
RSF/PP	**430**
MAXIMUM OCCUPANCY:	280 PP

KEY

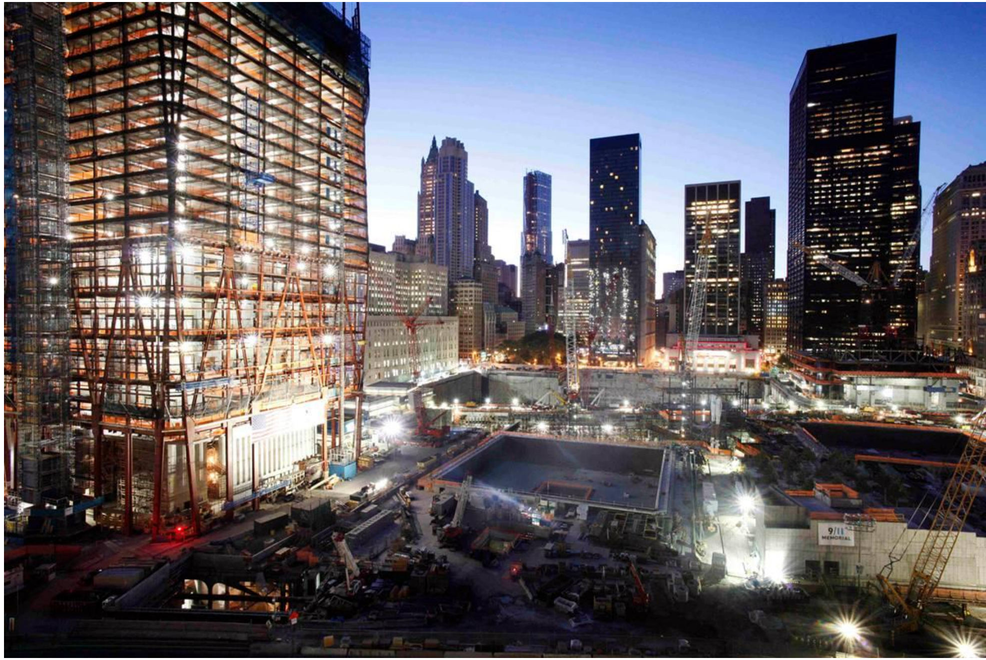
- OFFICE
- CORE
- VERTICAL TRANSPORTATION
- HVAC/MECHANICAL
- TELECOMMUNICATIONS
- ELECTRICAL



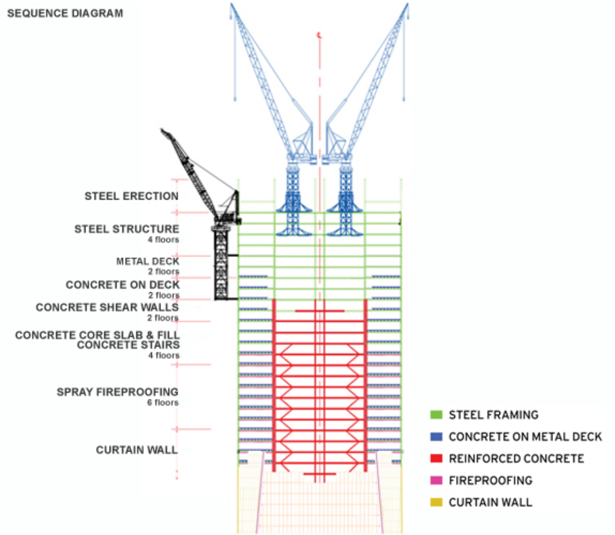
Site

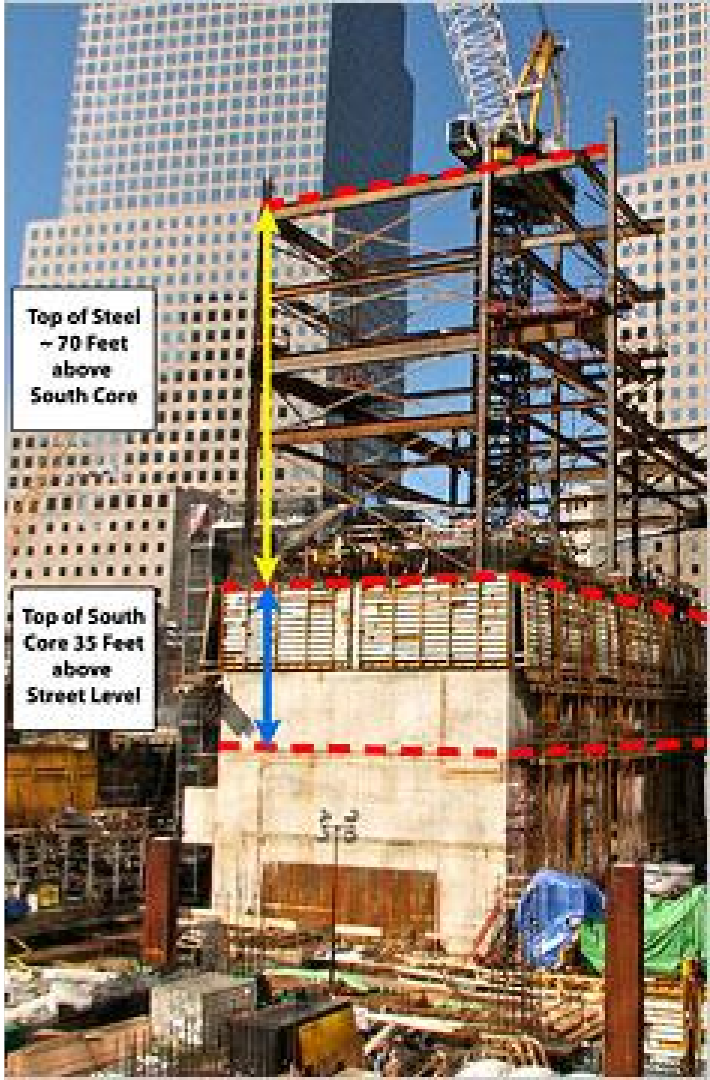
challenges in term of site:

- Existing obstacles in terrain
- Subway vibrations
- Subway network and new hub
- Services must remain operational
- Partnership between disciplines
- Shear wall that runs the height of the building and down below grade must avoid complex veins of train lines.



Structural Design

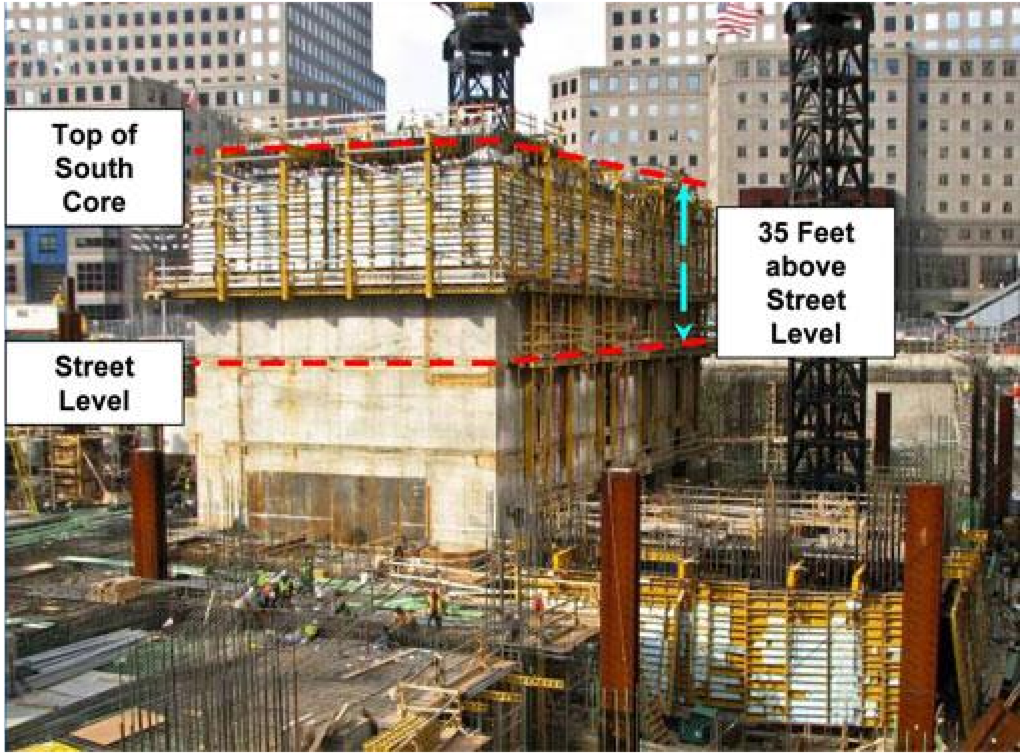




- Hybrid System combining a concrete core with a steel moment frame.
  - BASE
  - STEEL WORK
  - CONCRETE CORE

Base

- Stretches 20 stories high and is referred to as the podium.
- Dimensions are 200’ x 200’, the same as the original Twin Towers
- Blast Walls at the base fortify against truck bombings
- Can withstand 14,000 pounds per square inch of pressure.



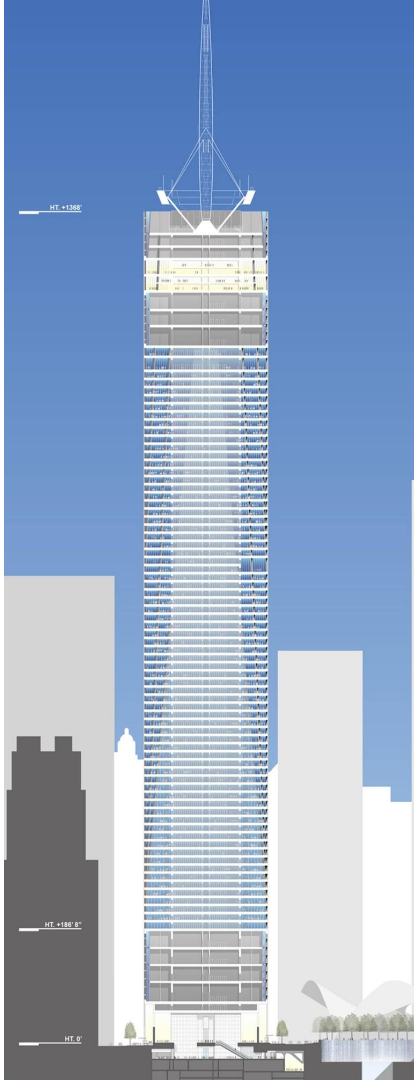
Steel Work

- The Tower contains more than 40,000 metric tons of structural steel

- Steel moment framing rises up from the solid base of the building
  - The moment frame wraps around all vertical and sloped perimeters, forming a tube system.
  - It resists lateral loads through bending of the frame elements. Paired with the concrete-core shear wall, the moment frame gives the building rigidity and redundancy while providing a column-free interior.

Concrete Core

- Provides support for gravitational loads as well as resistance to wind and seismic forces
- Houses mechanical rooms and all means of egress.
- Required 150,000 cubic meters of concrete
- Floor system within the core is a cast-in-place concrete beam and flat slab system.
- Uses high strength concrete to meet the demands imposed by the height and slenderness of the structure.



Spire

-Design

408 ft antenna

Consists of mast and communication platform ringa

Beacon at top sends out light beam

-What does it do?

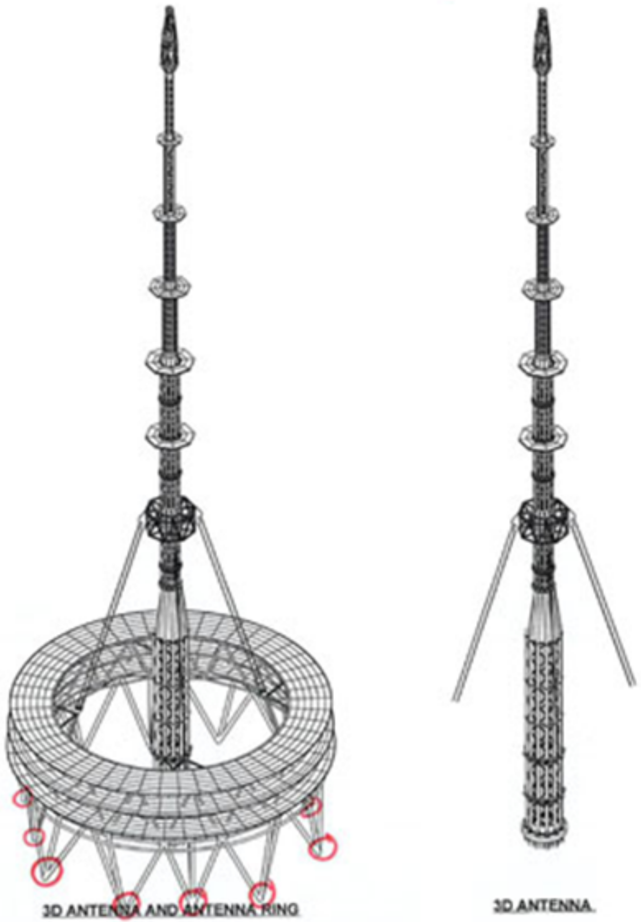
The spire is used for broadcasting and digital communication

-The different structural components

The mast is protected by a fiberglass panel that resists wind load.

Tetrahedral lattice ring supports media transmission equipment and braces eight radio frequency Kevlar guy cables that support the mast.

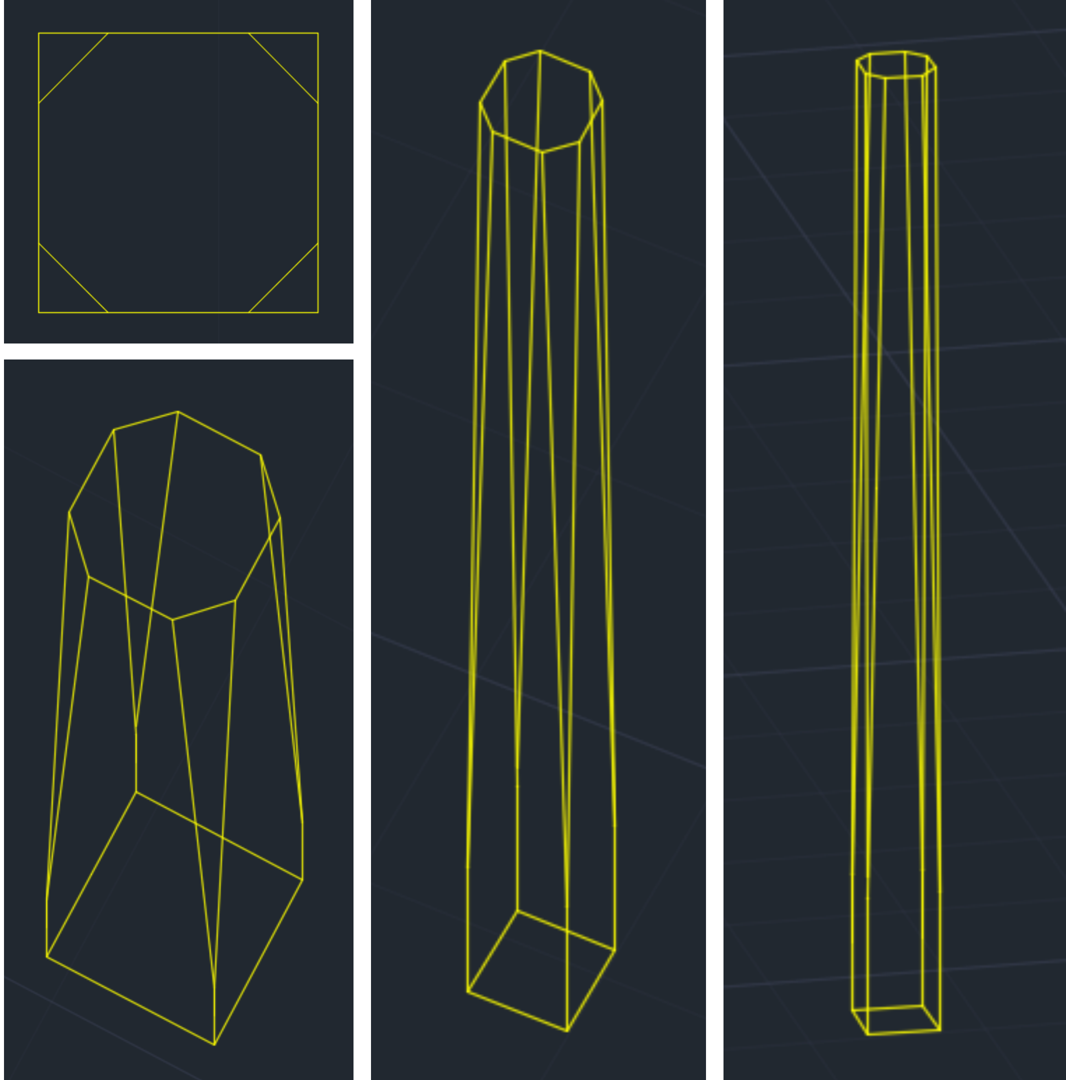
1WTC ANTENNA



"NODES" circled in red

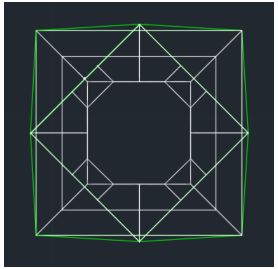
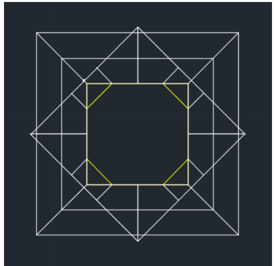
Model Making: Interior Core

- Rigid Core
- High strength concrete
- Gravitational Loads
- Wind and Seismic Loads



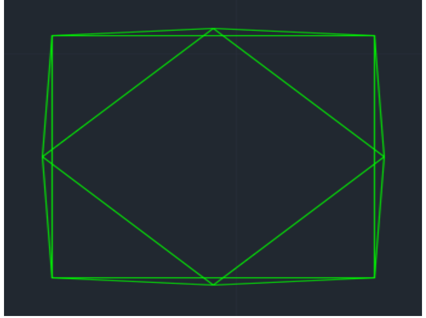
Model Making: Floor Plates

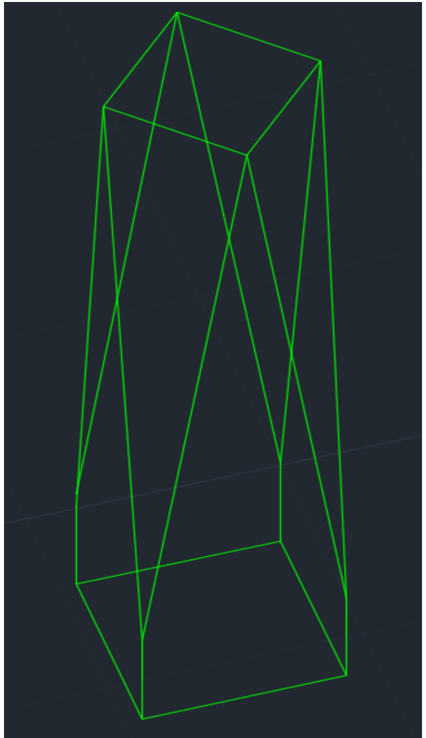
- Moment Connection Frame to Interior Core (above base)
- Floor plates and columns (exterior)
- Tube System
- Resists Lateral Loads

Model Making: Exterior

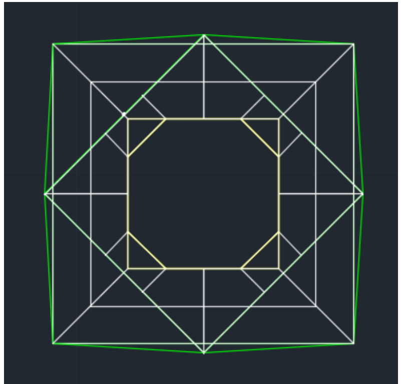
- Square Base: 200’ x 200’
- Square Top: 150’x150’, rotated 45*
- Base = 20 stories, Shear & Curtain Wall
- Above = Steel Metal Moment Frame
- Rigid Whole





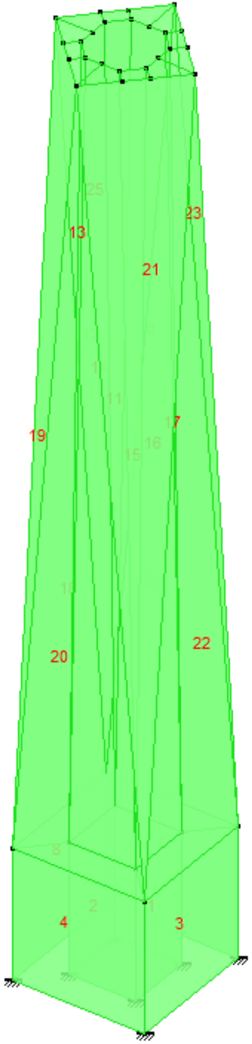
Model Making: As a Whole

- Rigid Core
- Rigid Exterior
- Moment Frame connecting to core



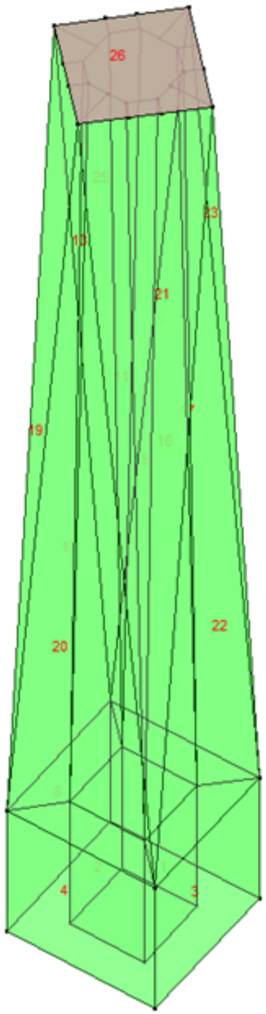
Multiframe: Start-Up

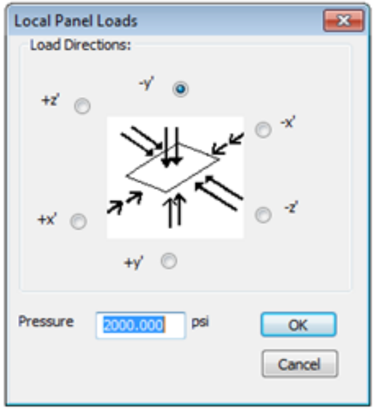
- Assign Member information
- All joints = Rigid
- Ground Points = Fixed
- Create Panels

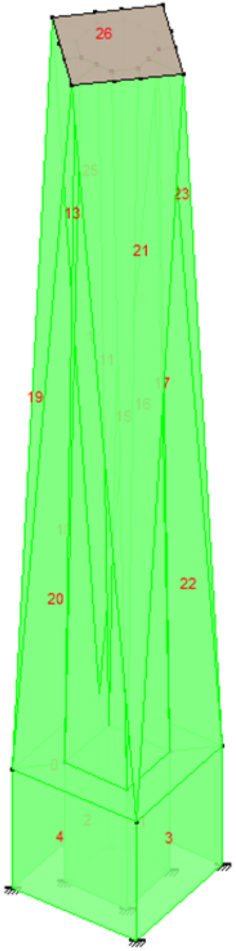


Multiframe: **Gravitational** Loads on Model

- Picked Top Panel of Exterior
- Chose Local Panel Loads
- Gravitational Load Representation





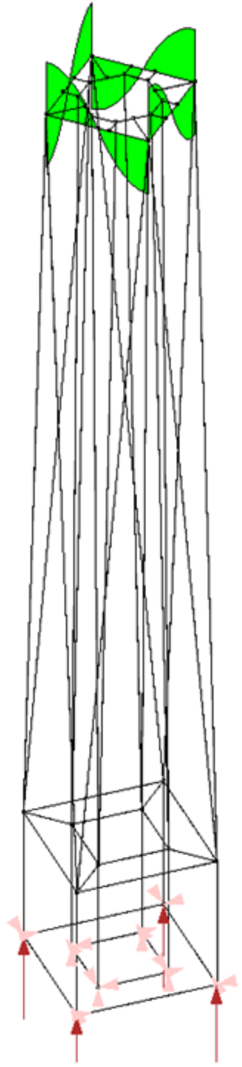


Multiframe: **Analysis, Axial Loads**

- Load Tracing - Floor Plate to Frame
- Rigid frame transfers load to Base
- Base load transfers to foundation / ground

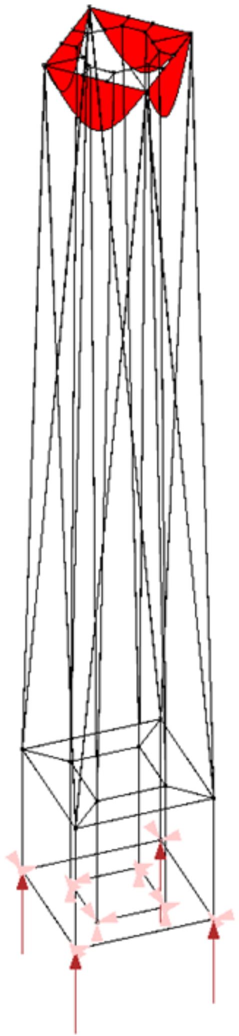
Multiframe: **Analysis, Shear**

- High Shear at Exterior Connection of Floor Plates to Rigid Frame
  - Moments Connections
  - Beam meets Column

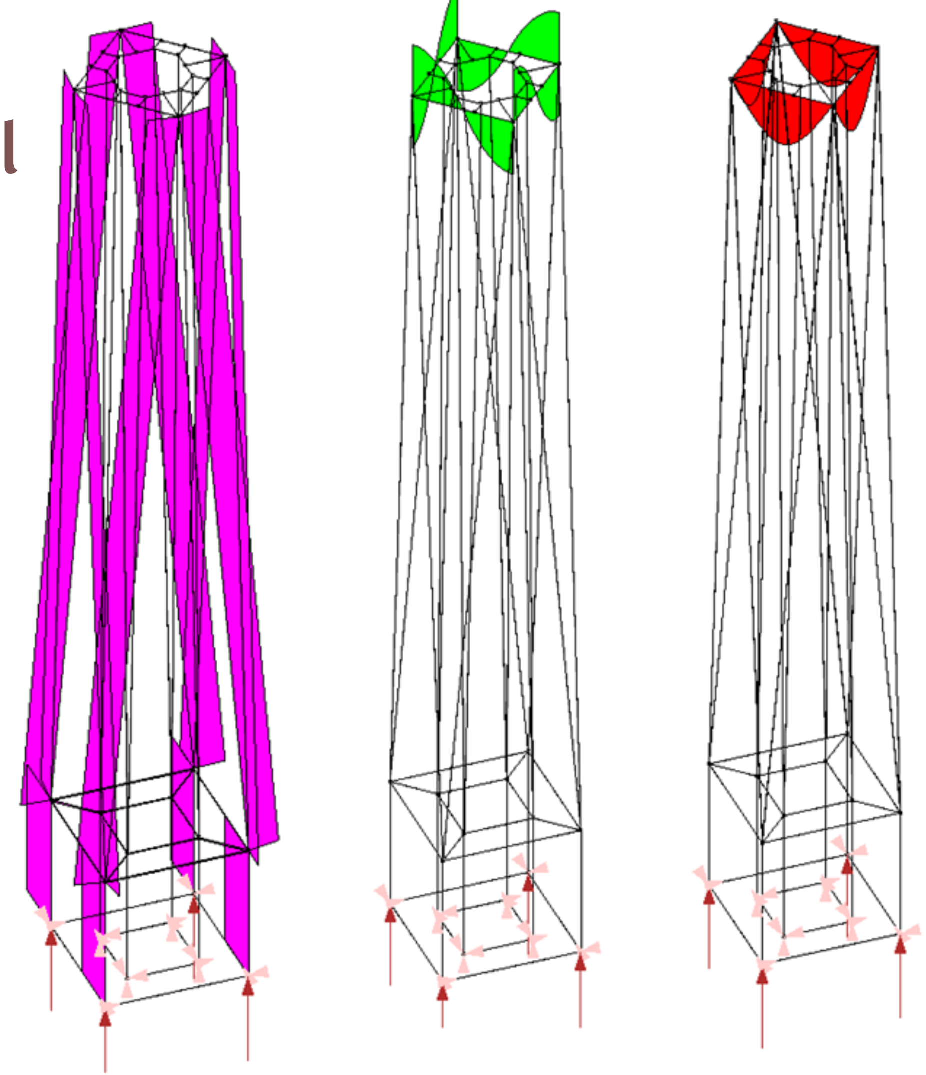


Multiframe: **Analysis, Moment**

- High Moment Relates to High Shear
  - Moments Connections cause High Moment at Mid-Beam Span

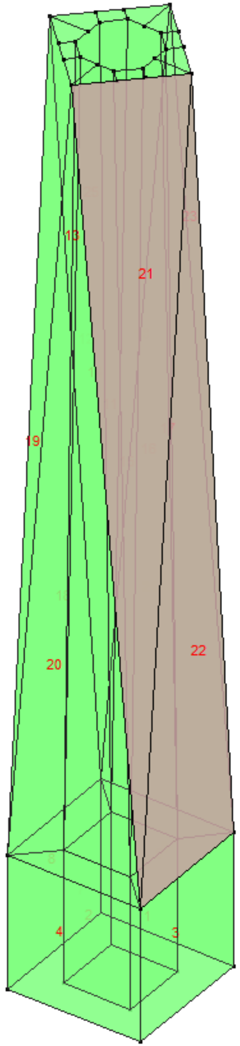


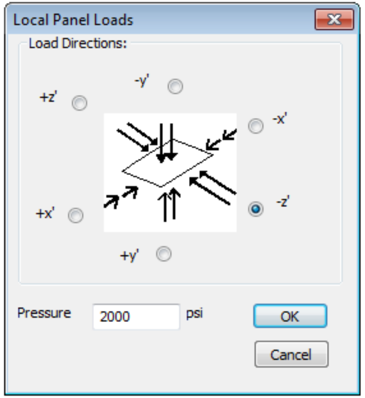
Multiframe: **Gravitational Loads Analysis**



Multiframe: Wind Loads on Model

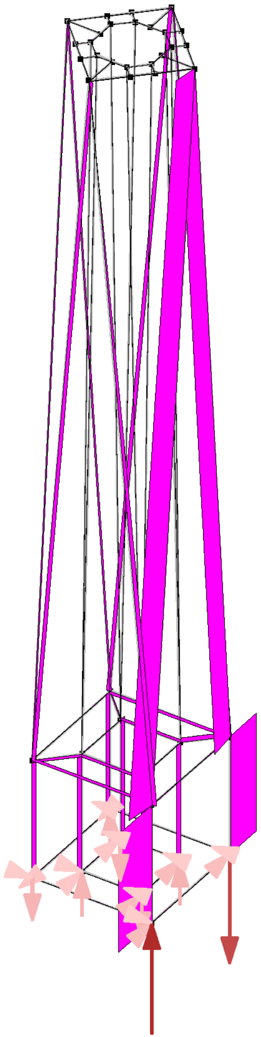
- Picked 2 upper panels of Exterior
- Chose Local Panel Loads
- Wind Representation
- Tower to resist 100+ mph winds
- 2000 psi loads for model





Multiframe: Analysis, Axial Load

- Rigid frame transfers load to floor plates
- Floor Plates / Rigid frame transfers load to Base
- Base load transfers to foundation / ground

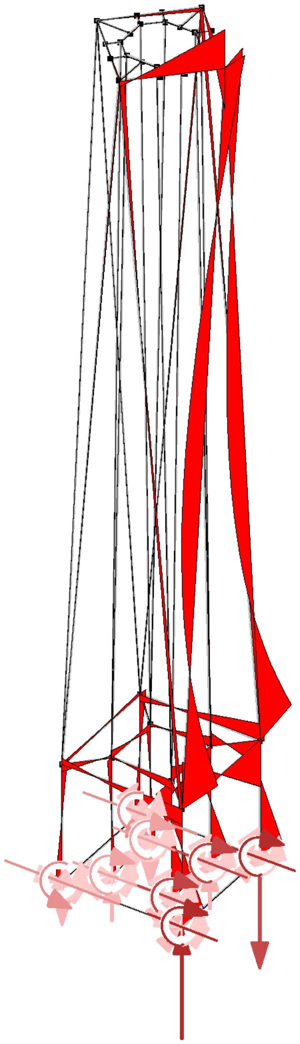


Multiframe: Analysis, Shear

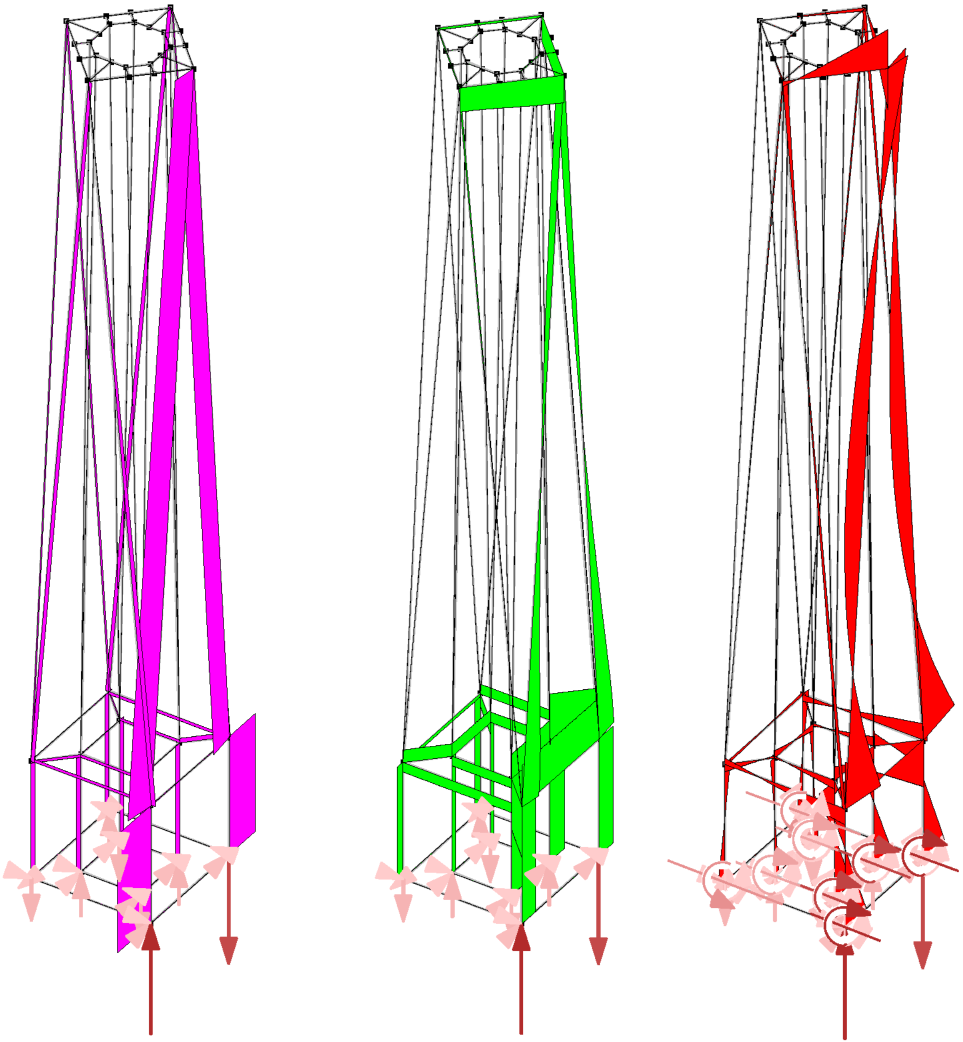
- Rigid frame, Interior, Exterior
- High Shear:
    - Exterior Connection for Floor Plates (Rigid Frame)
    - Rigid Frame meets Shear Base
    - Floor Plates and Columns in lower part of building

Multiframe: Analysis, Moment

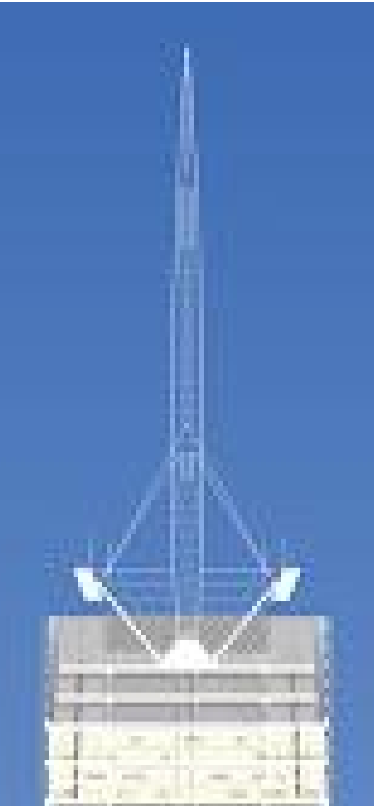
- High Moment Relates to High Shear
    - Exterior Connection for Floor Plates (Rigid Frame)
    - Rigid Frame meets Shear Base
    - Columns in lower part of building / Base

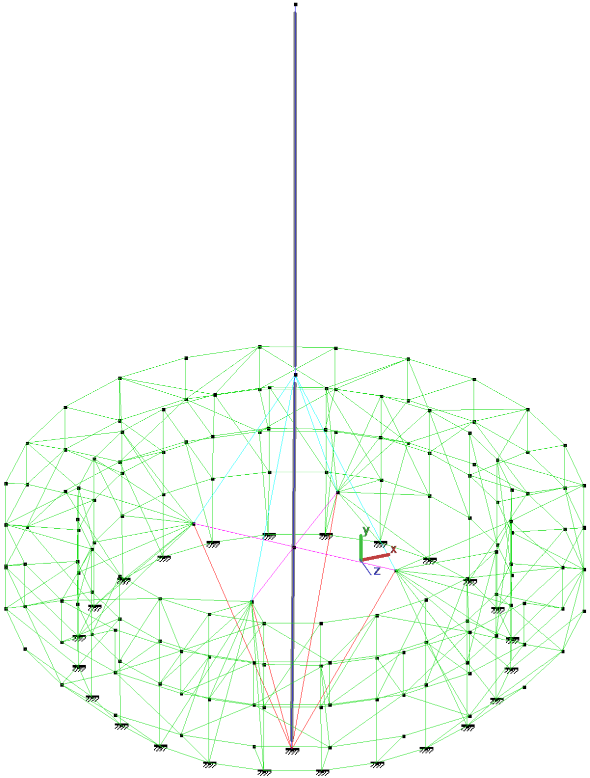


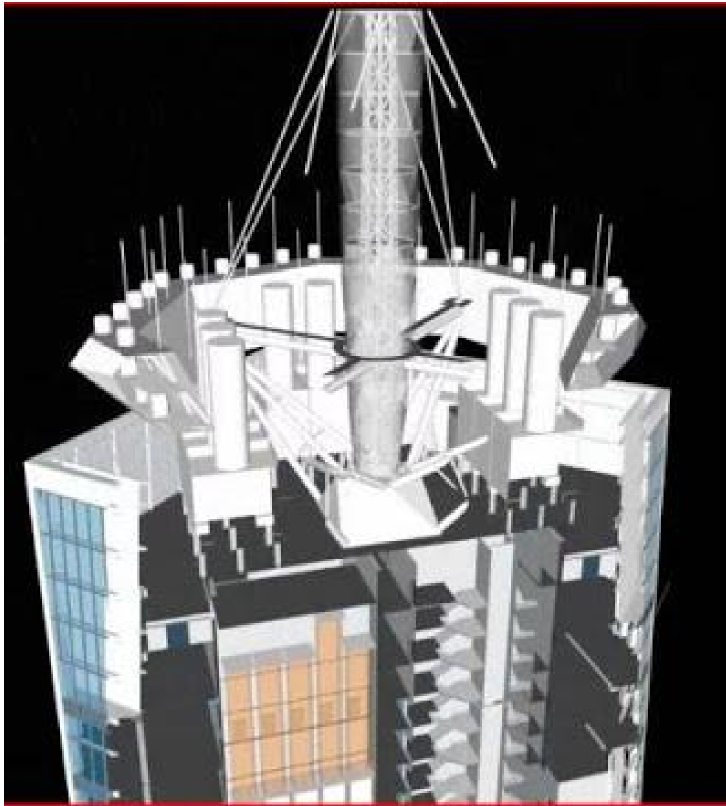
Multiframe: Lateral Loa(



Multiframe: Spire Analysis

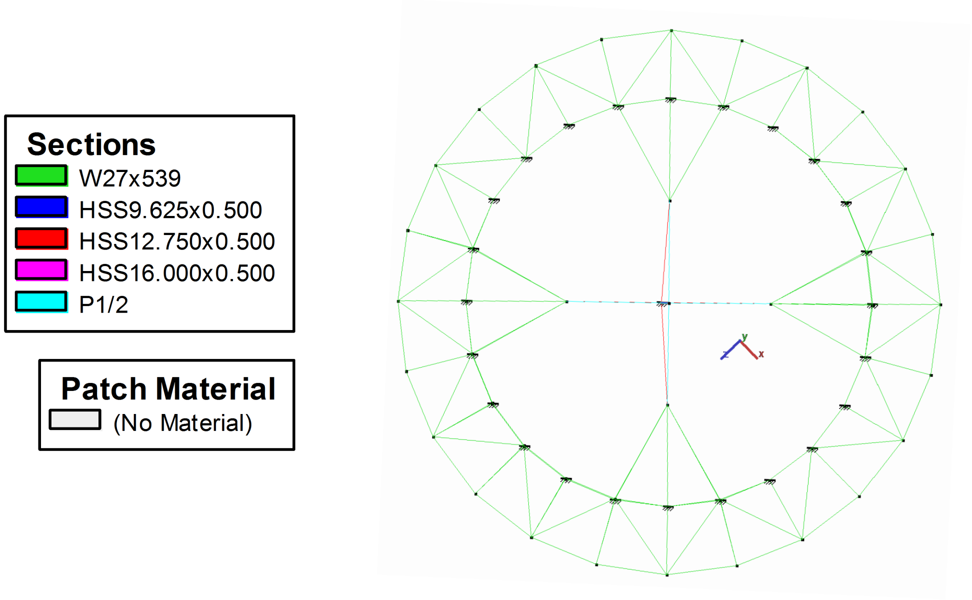


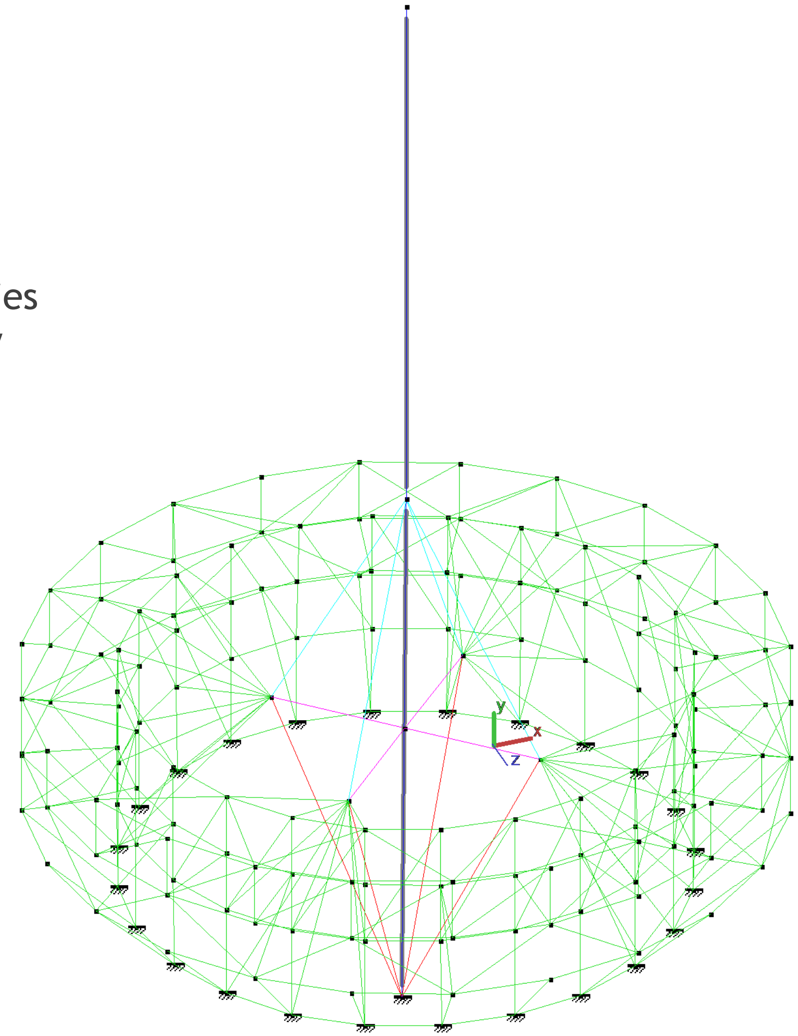




Multiframe: **Spire** Analysis

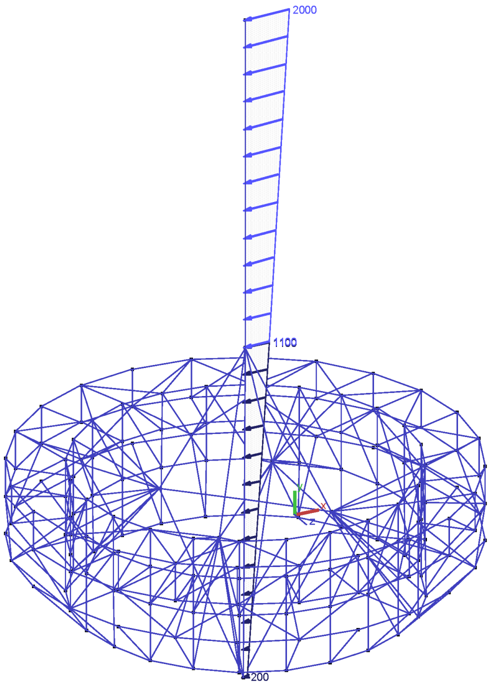
- Circumferencing Leasable Space - Own Structure
- Spire, Cable Guides, Rigid Anchors; various properties
- Spire load transfers to own base then to core below

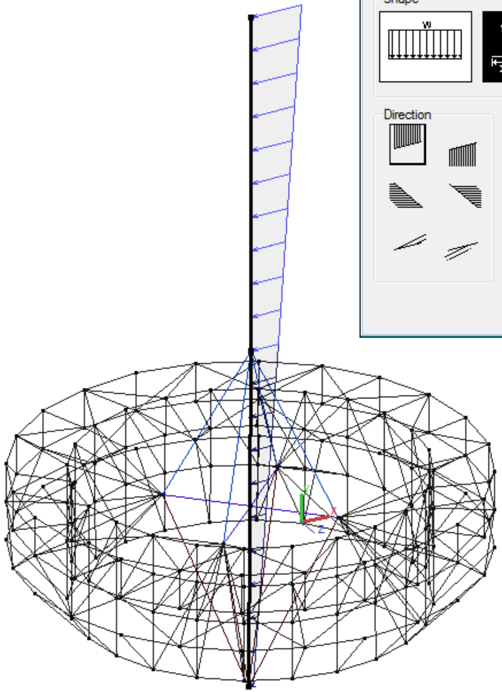


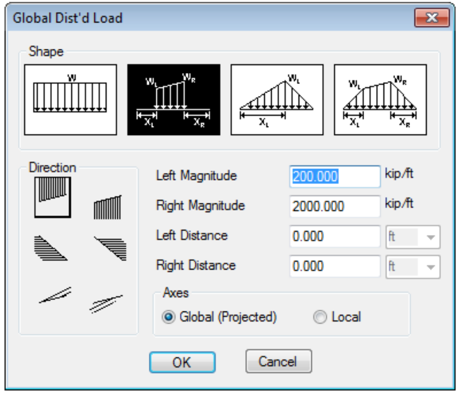


Multiframe: **Spire** Analysis

- Simulated Wind Load
- Tapering distributed load on Spire
- 200 - 2000 Kip-ft

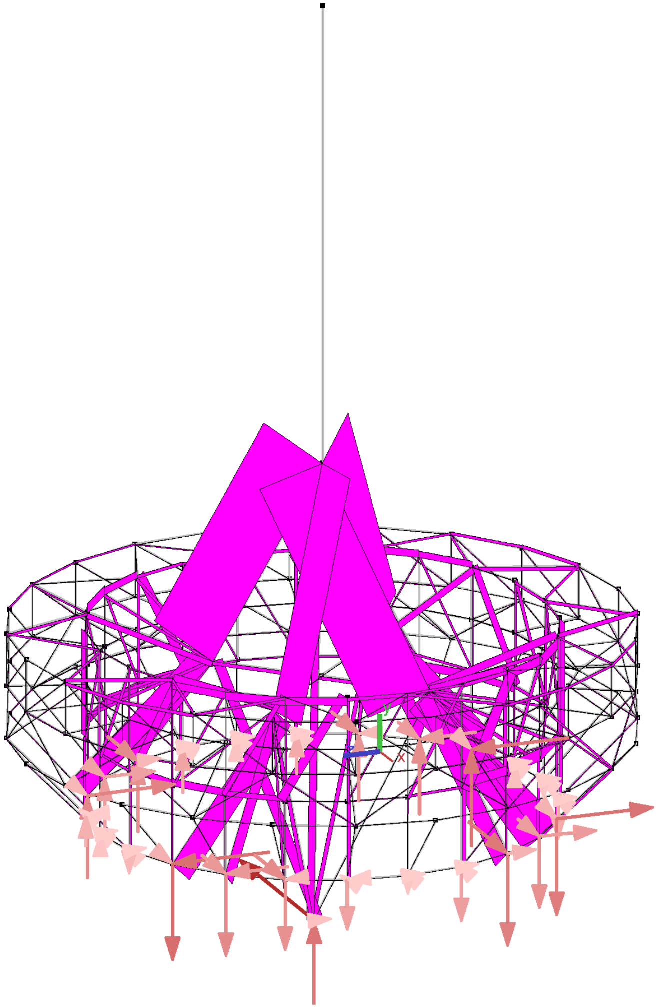






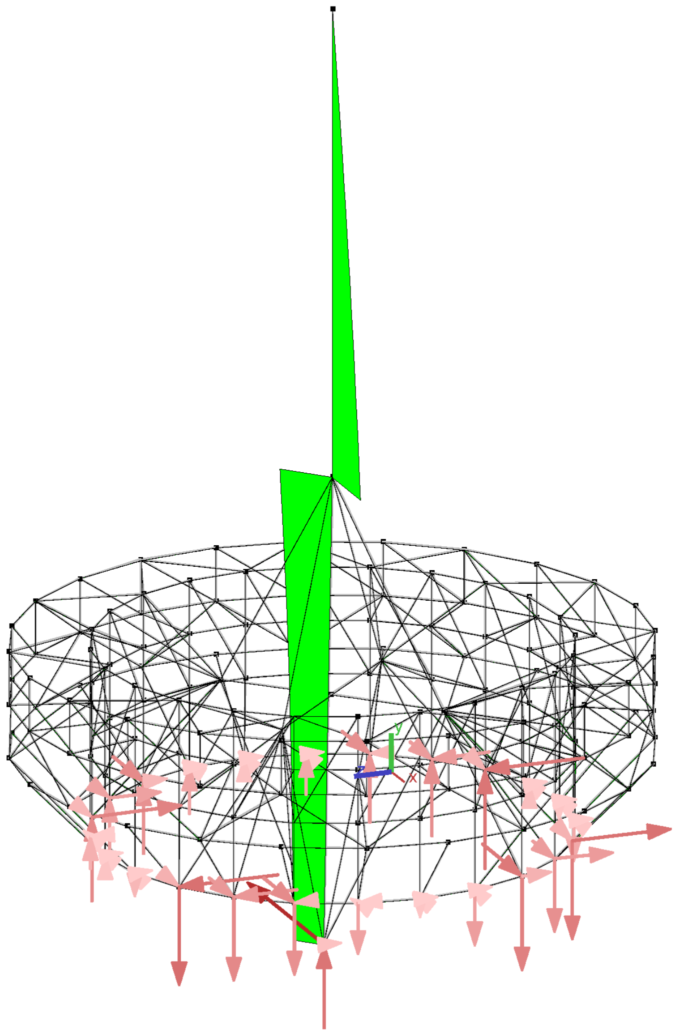
Multiframe: **Spire** Analysis

- Axial Load -
  - Cable Guides see large axial loads
  - Loads transfer to Members beneath
  - Loads transfer to Core beneath



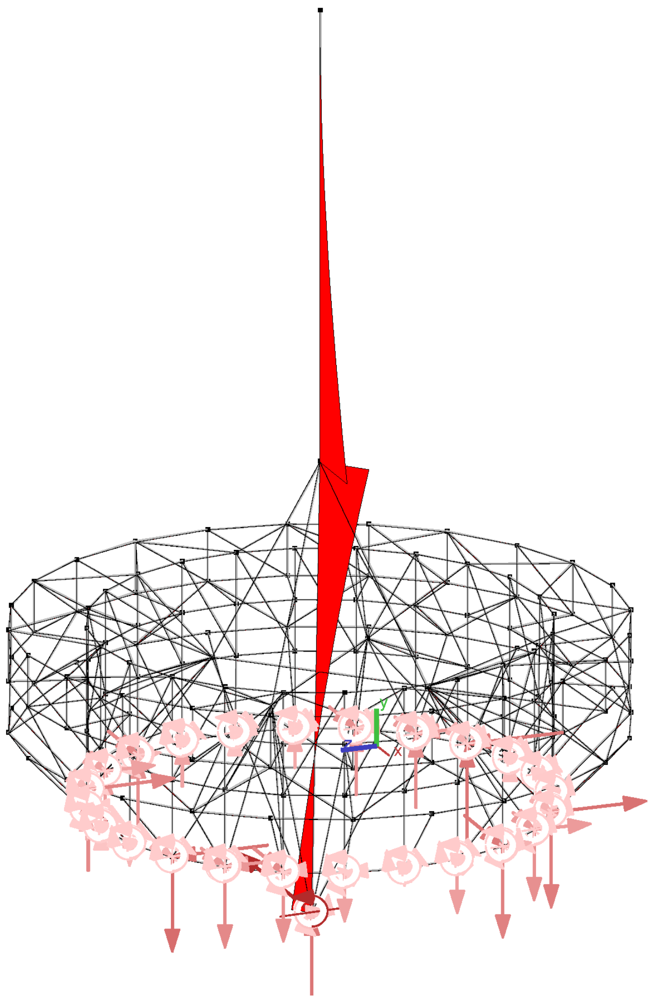
Multiframe: **Spire** Analysis

- Shear Loads
  - High shear where extra structure begins
  - From bend or “give” of Spire to where the Cable guides pick up the loads

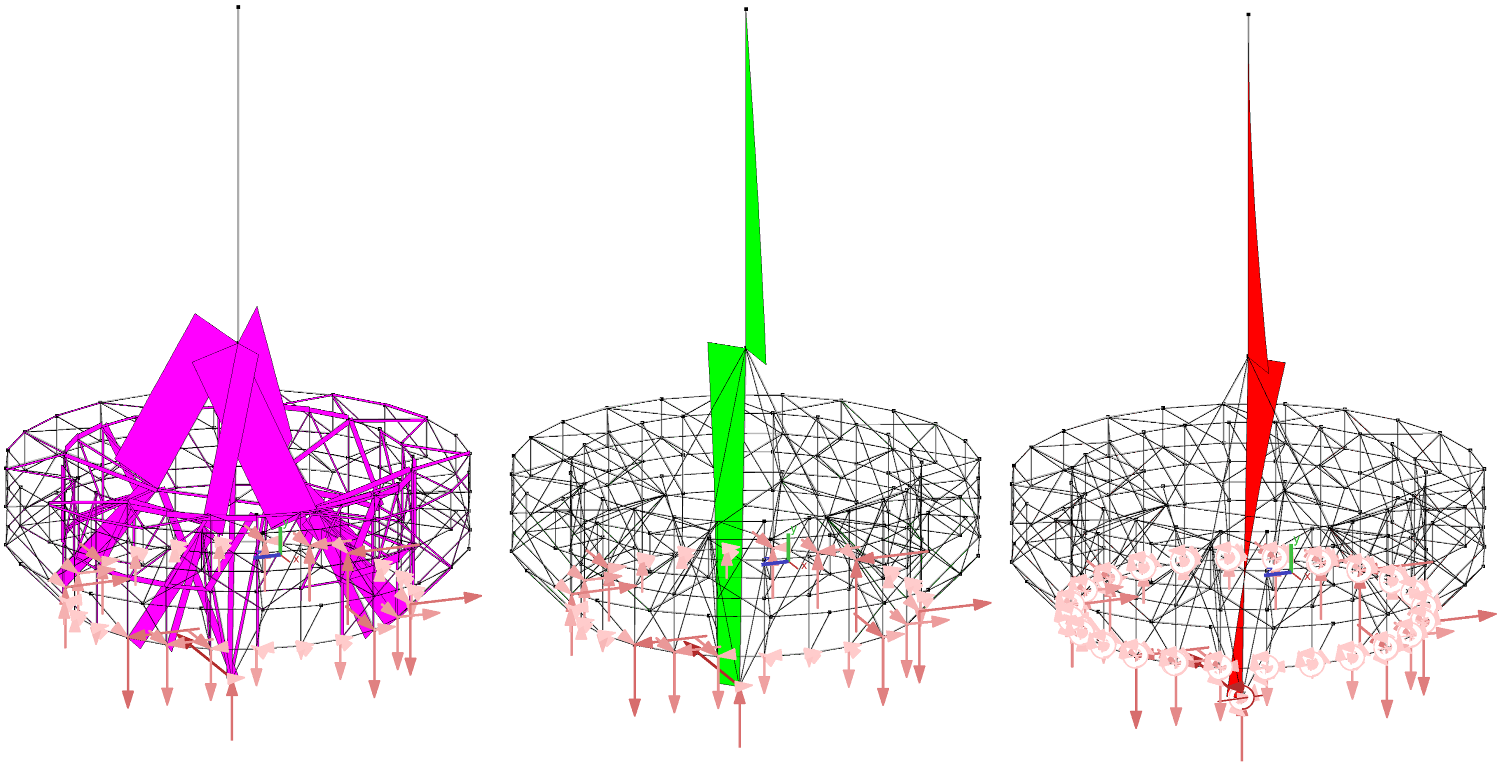


Multiframe: **Spire** Analysis

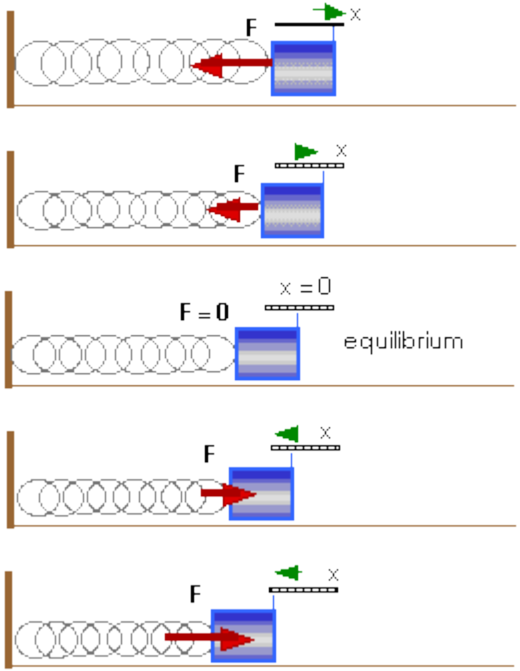
- Moment Loads
  - Highest moment correlates to highest shear
  - Where spire structure is supplemented with extra structure
  - Additionally, increase in moment where structure meets the core
  - Reactions at bottom of structure



Multiframe: **Spire** Analysis



Summary- Remember Hooke's Law



F= *k*(Total Displacement)

the displacement or size of the deformation is directly proportional to the deforming force or load.

Design Goal Minimum Displacement	=	DL+LL Force
		k Stiffness Skyscraper design