



Source: Foster + Partners

# 30 St Mary Axe

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ARCH 631 | Prof. Nichols

# Project

- Location - London, United Kingdom
- Completed construction in 2003, opened in 2004
- Client: Swiss Re Insurance Co.
- Architect: Foster and Partners
- Structural Engineer: ARUP
- Project Manager: RWG Associates
- Contractor: Skanska
- Building Services Engineer: Hilson Moran Partnership
- Cost Consultant: Gardiner & Theobald





# Project Background

- Previous building damaged in 1992 from IRA bombing
- Has won many awards that include:
  - London Architectural Biennale Best Building Award
  - LDSA Built in Quality Awards – Winner Innovation Category
  - Emporis Skyscraper Award 2003
  - RIBA Stirling Prize
  - The International Highrise Award – Honourable Mention
  - Dutch Steel Award – Category A



# Site Analysis

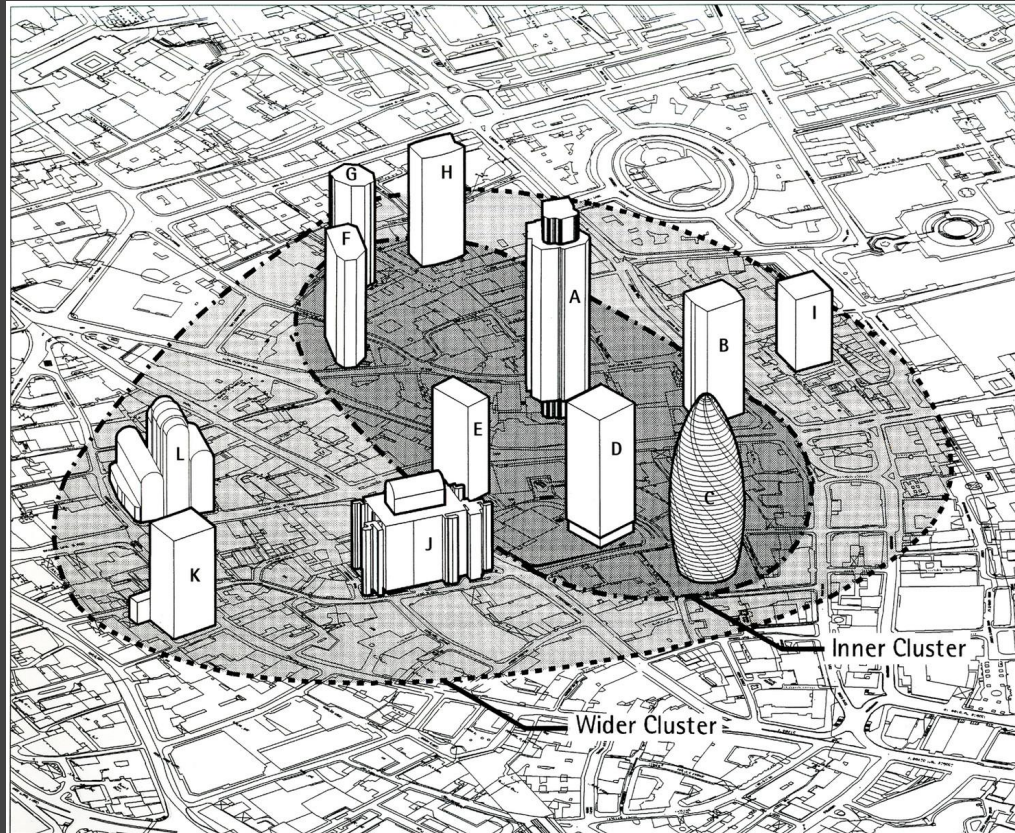
## Urban Context

- 1.4 Acre Site in the Financial District
- Less than  $\frac{1}{2}$  mile to London Bridge
- $\frac{3}{4}$  mile to St. Paul's Cathedral
- .2 miles to Underground Stop

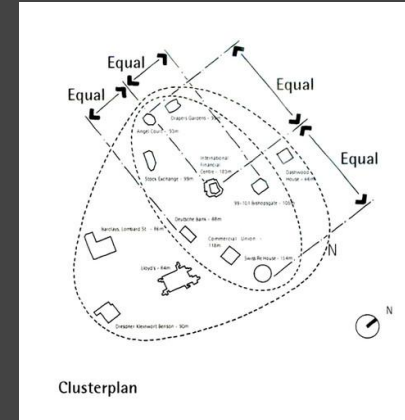


Source: Foster + Partners

# Consolidation of City Cluster of High Rise Buildings



Source: Archdaily



Source: Archdaily

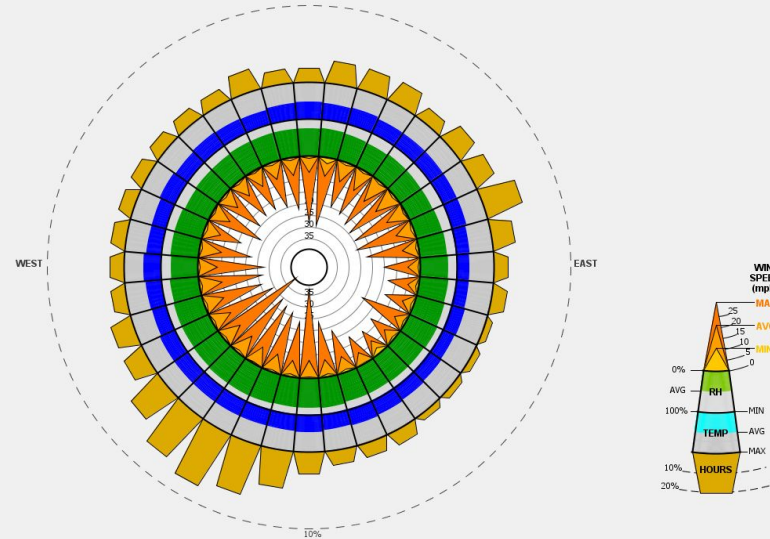
- A International Financial Centre - 183m
- B 99-101 Bishopsgate - 105m
- C Swiss Re House - 154m
- D Commercial Union - 118m
- E Deutsche Bank - 88m
- F Stock Exchange - 99m
- G Angel Court - 93m
- H Drapers Gardens - 99m
- I Dashwood House - 66m
- J Lloyd's - 84m
- K Dresdner Kleinwort Benson - 90m
- L Barclays, Lombard St. - 86m

Source: Archdaily



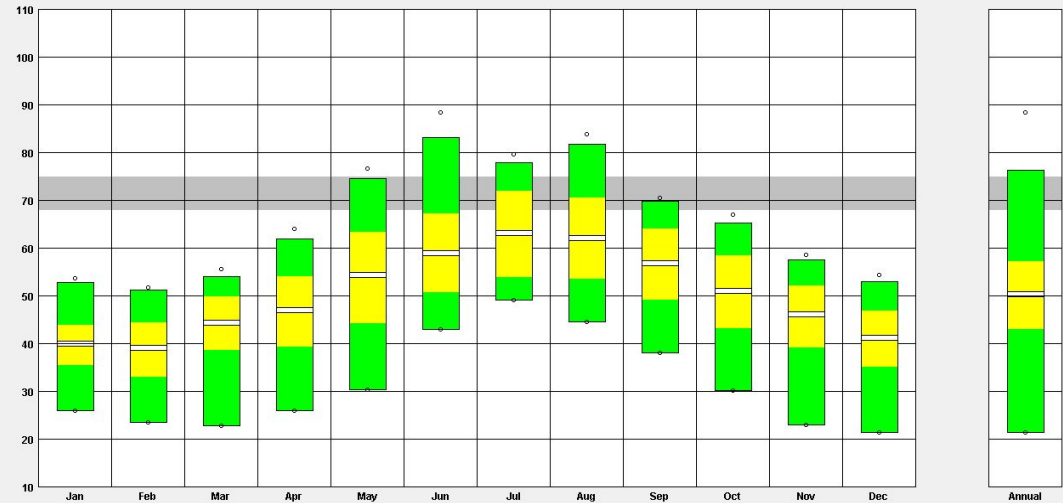
# Wind + Temperature

## Annual Wind Pattern



Max 25 mph

## Temperature Range °F

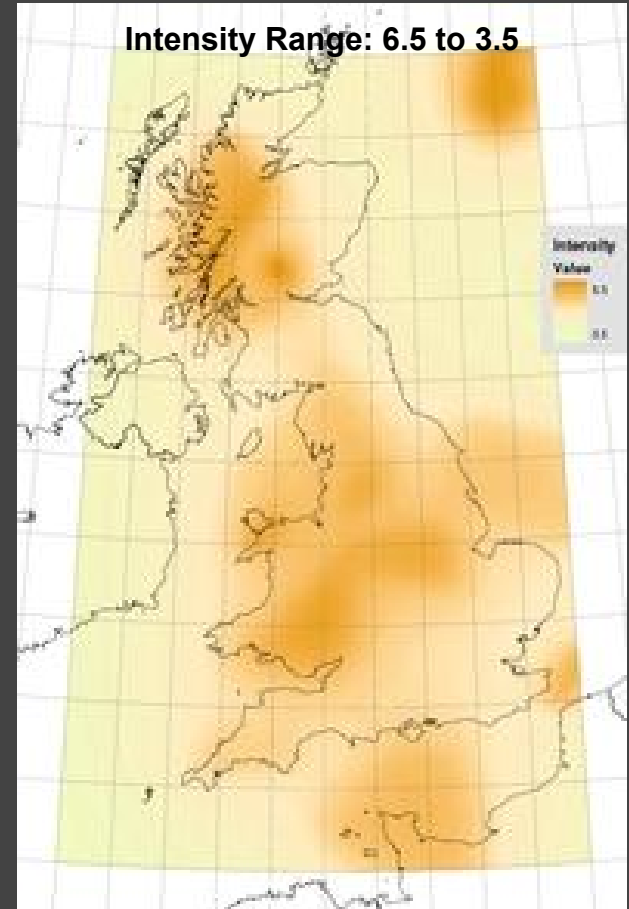


Average Temp. 52 °F

Source: Climate Consultant

# Seismic Hazards

- Large seismic events are rare
- The most powerful earthquake recorded in the UK occurred in the North Sea off the coast of Yorkshire in 1931. Magnitude 6.1
- Last time people were killed due to seismic activity was in 1580; it damaged numerous buildings and caused two fatalities
- Areas of Seismic Hazard:
  - Highest: West of Scotland, North and South Wales
  - Lowest: Northern Ireland and Northeast Scotland
  - Southeast England has a low probability of experiencing a major seismic event.

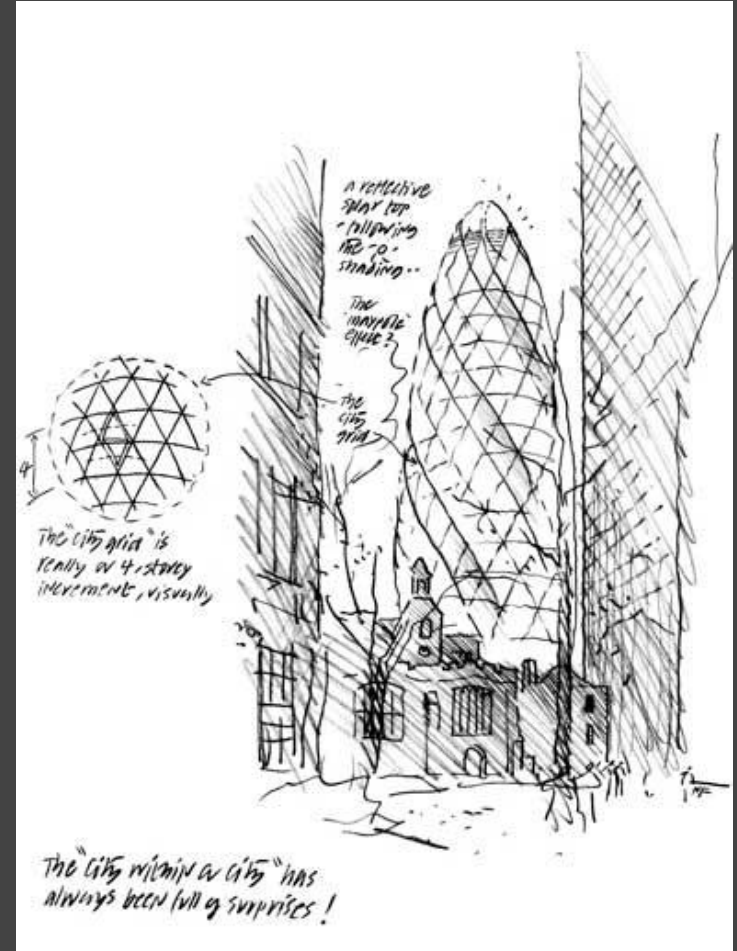


Source: <http://www.earthquakes.bgs.ac.uk/hazard/UKhazard.html>

# Design Concept

Norman Foster designed an aerodynamic shape to allow windflow around the building and its facade, rather than redirecting the wind to the ground

- The enhancement of the public environment at street level, opening up new views across the site to the frontages of the adjacent buildings and allowing good access to and around the new development.
- Maximum use of public transport for the occupants of the building.
- Flexibly serviced, high specification 'user-friendly' column free office spaces with maximum primary space adjacent to natural light.
- Good physical and visual interconnectivity between floors.
- Reduced energy consumption by use of natural ventilation whenever suitable, low façade heat gain and smart building control systems.

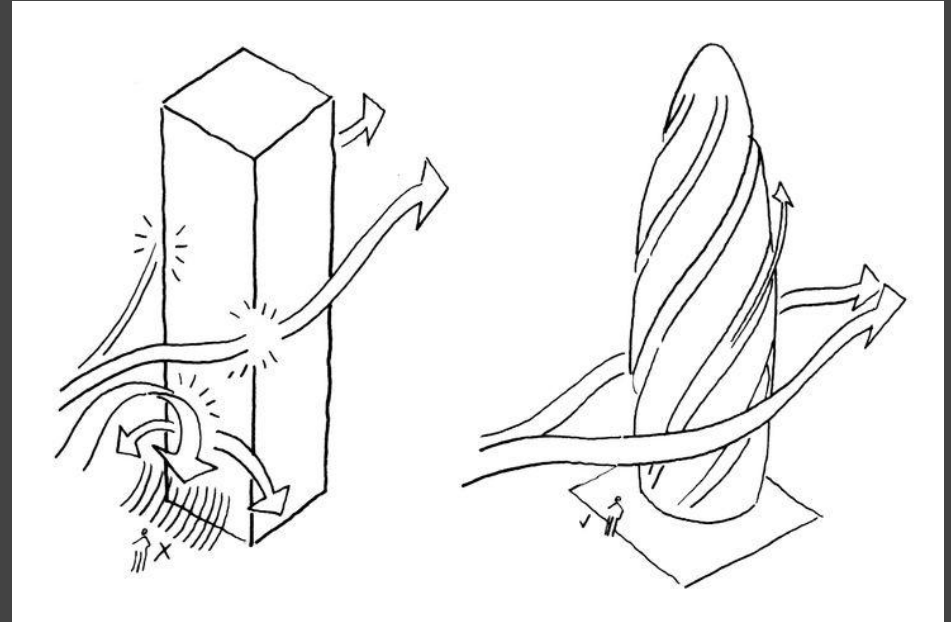




# Design Concept

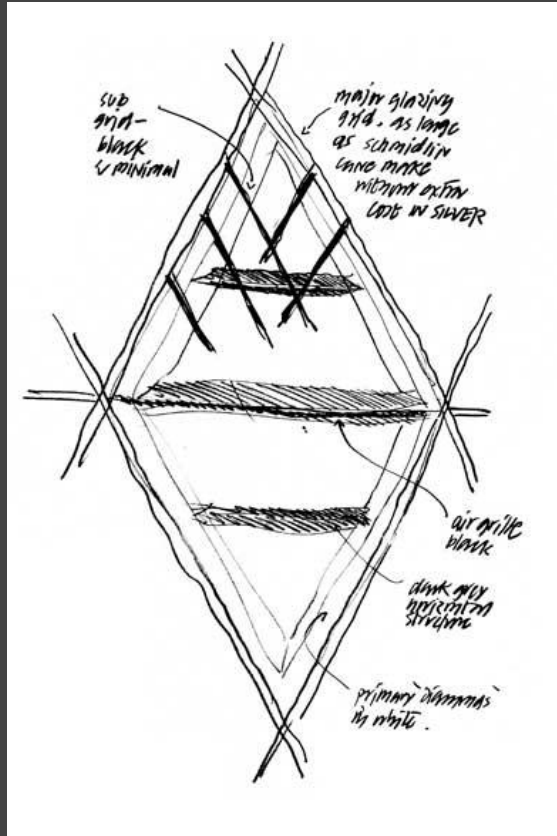
## Shape

- More air flows around the cylindrical structure than a traditional rectangular building.
- The smooth flow of wind around the building was one of the main considerations.
- The shape of the tower is influenced by the physical environment of the city.
  - In a traditional skyscraper, two-thirds of the wind is directed down to the street

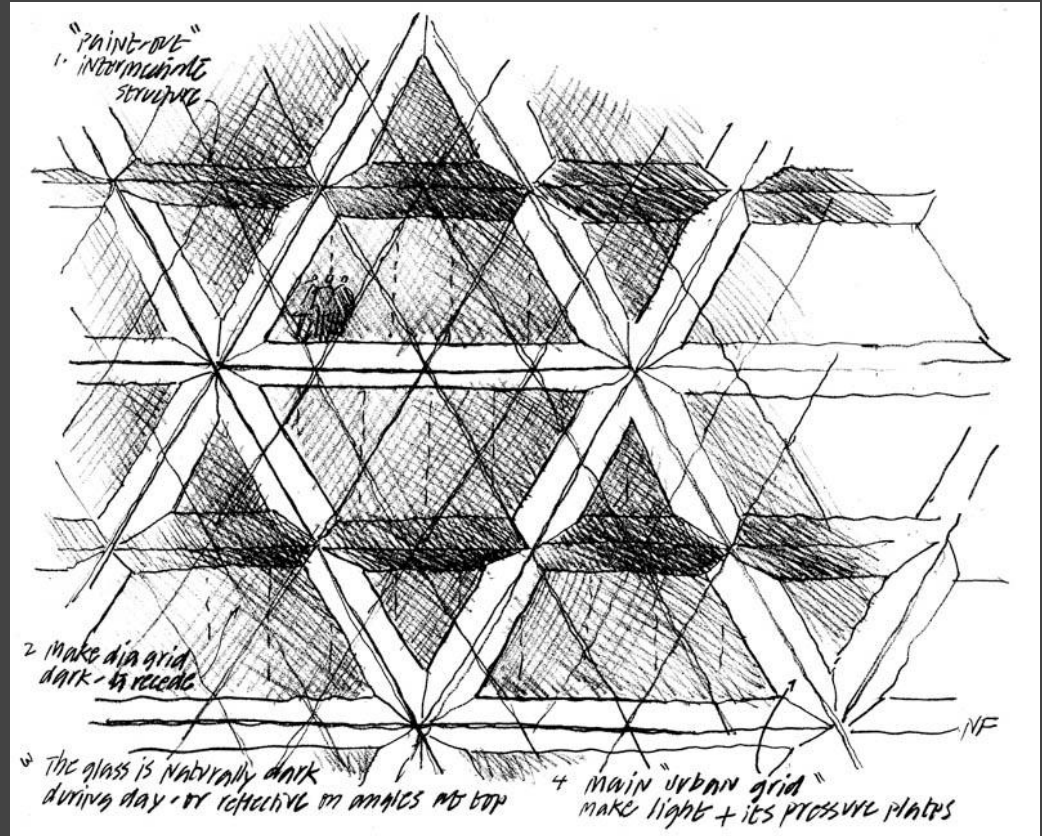


Source: Foster + Partners

# Concept Sketches - Diagrid System

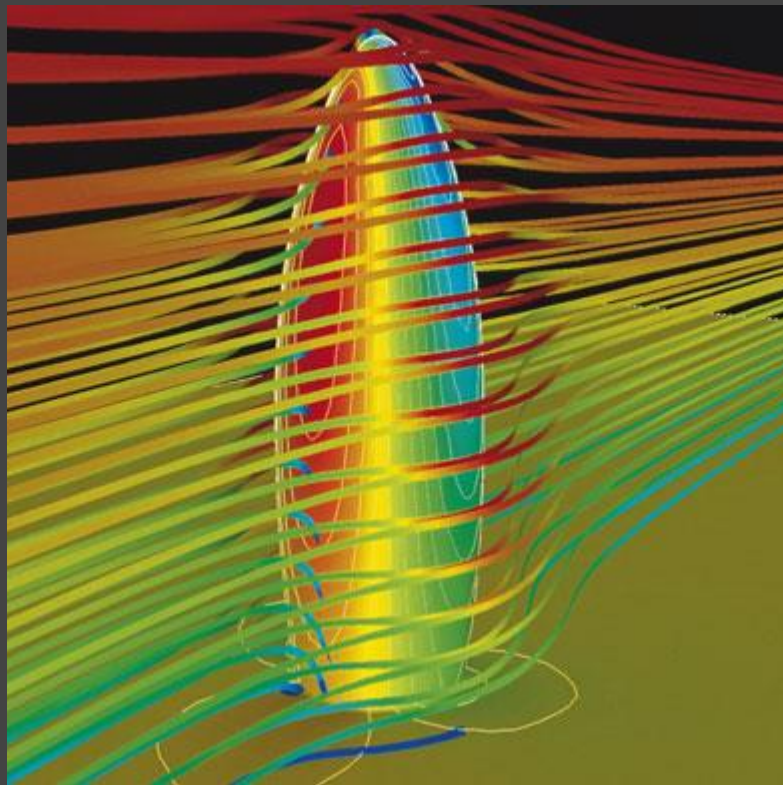


Source: Foster + Partners

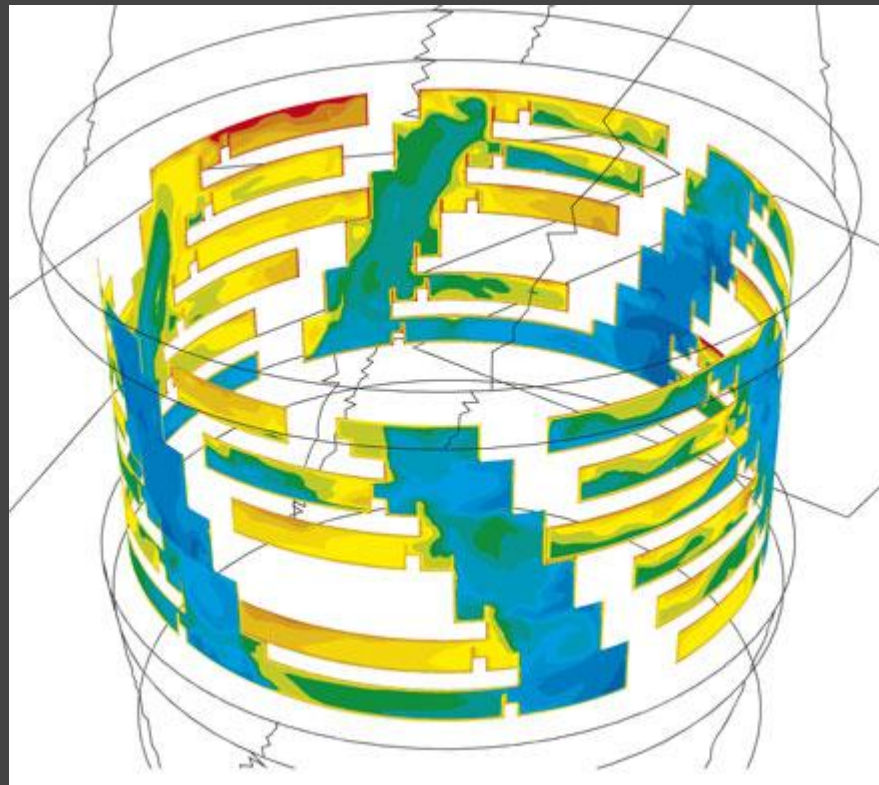


Source: Foster + Partners

# Wind Simulation



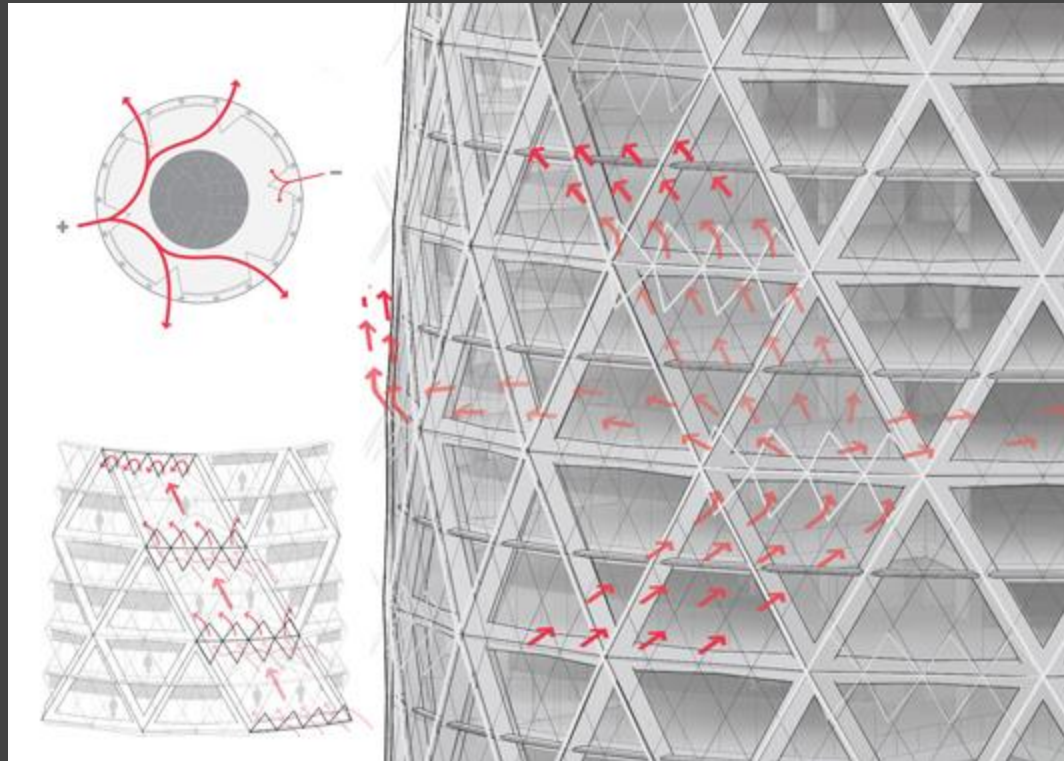
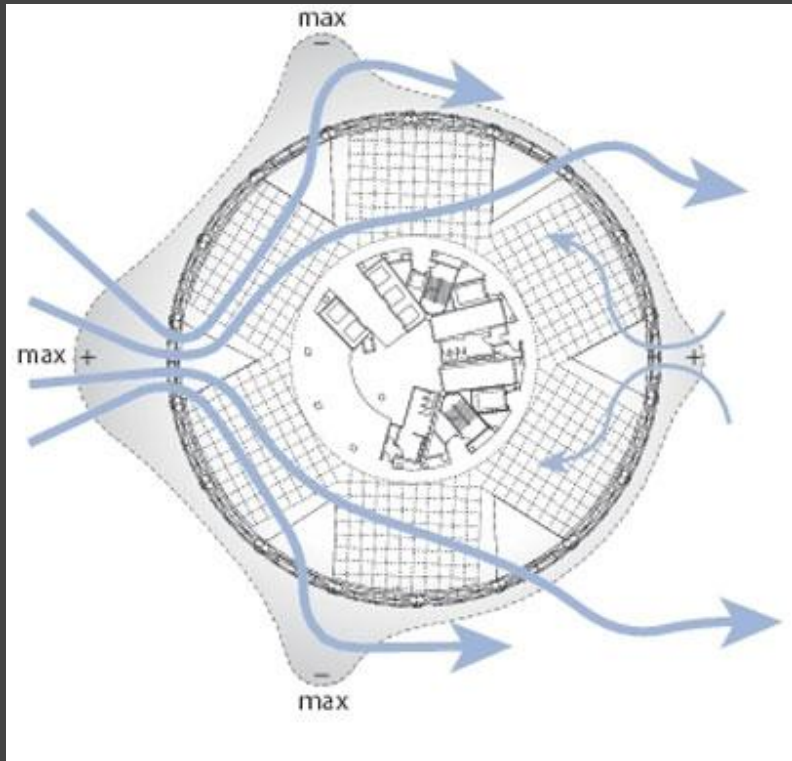
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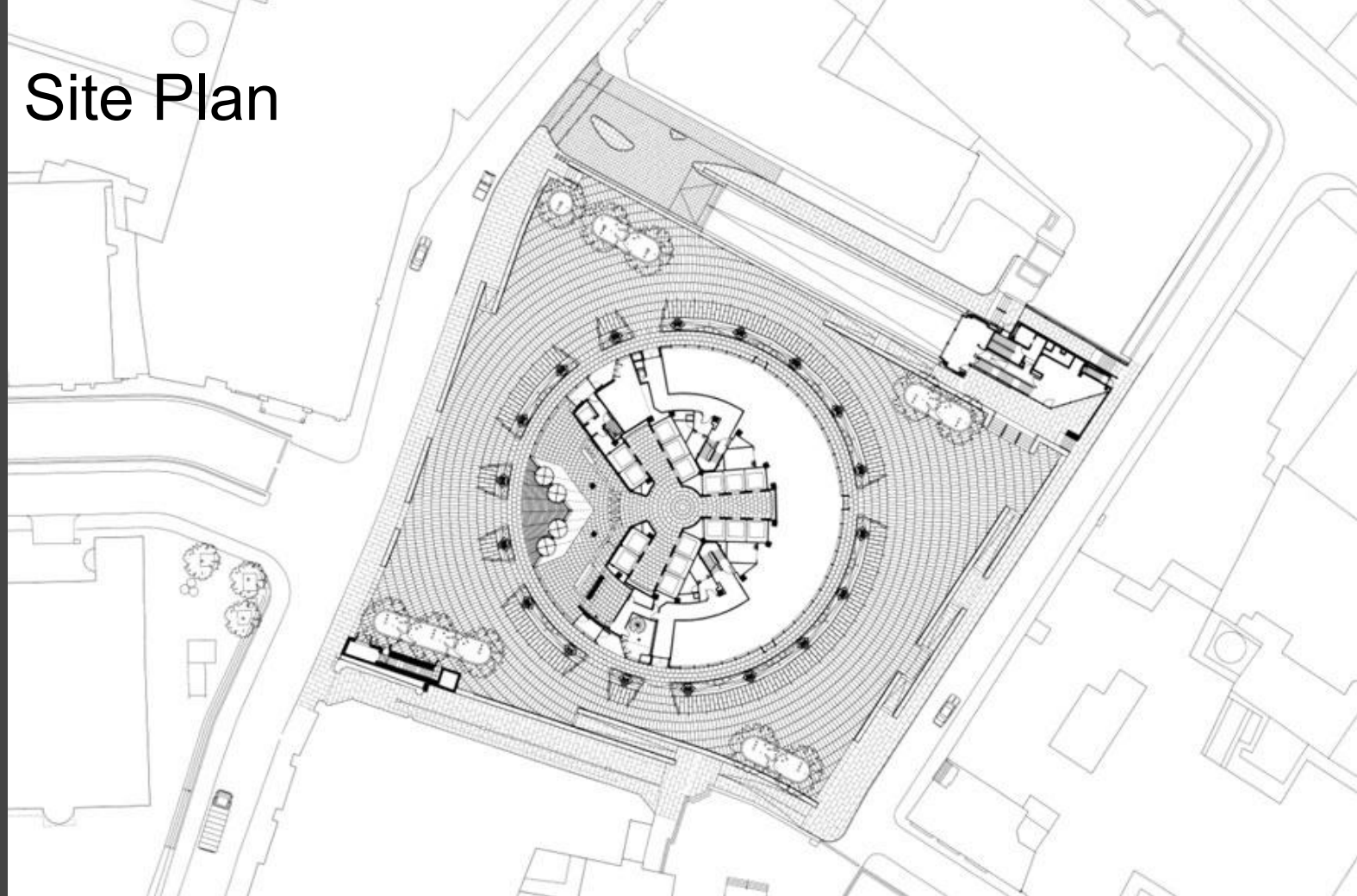
Source: Foster + Partners



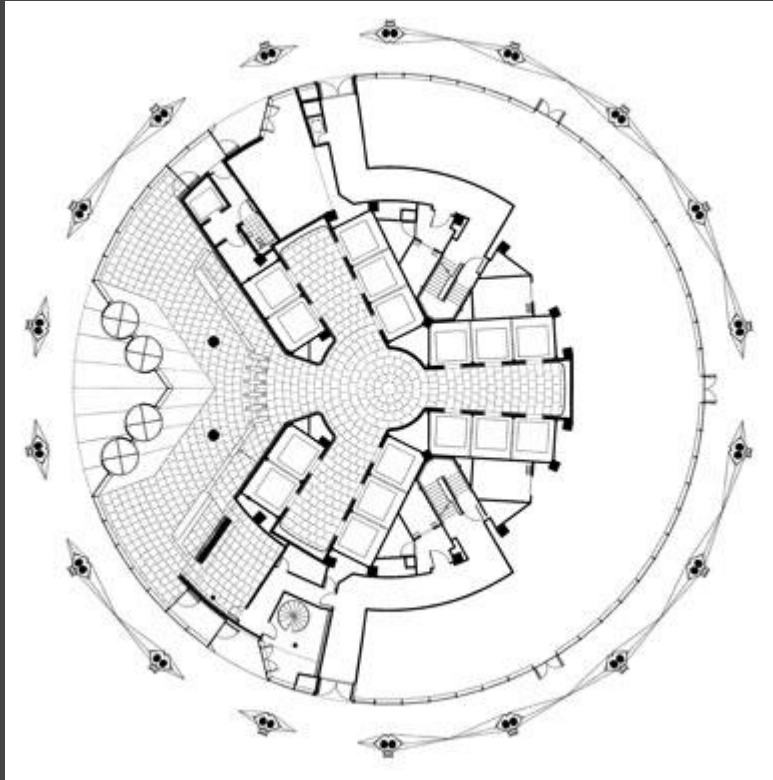
# Wind Effect



# Site Plan

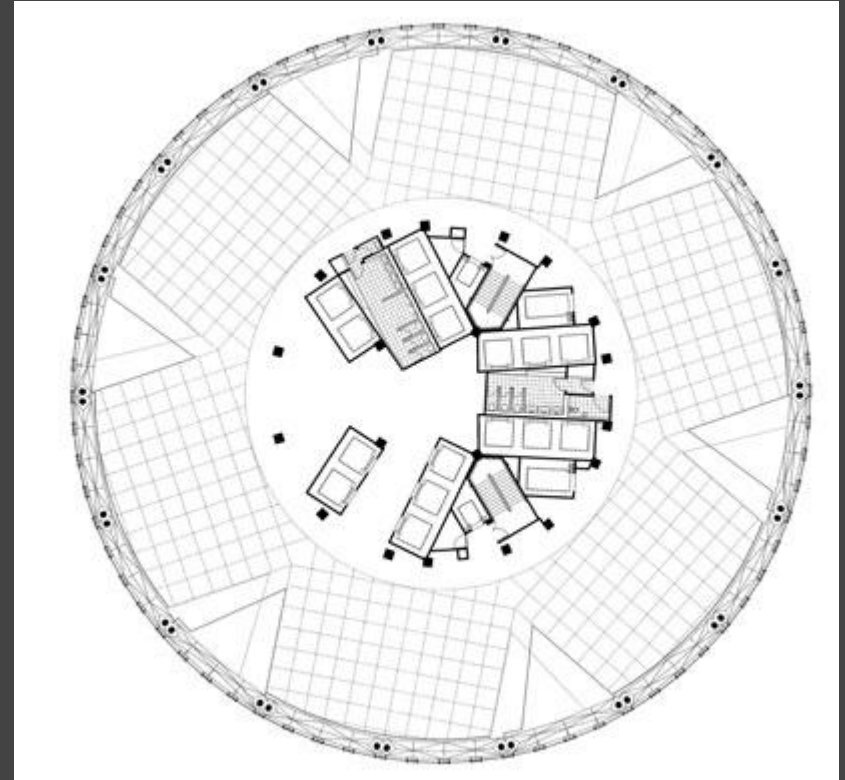


# Floor Plans



Ground Floor

Source: Foster + Partners

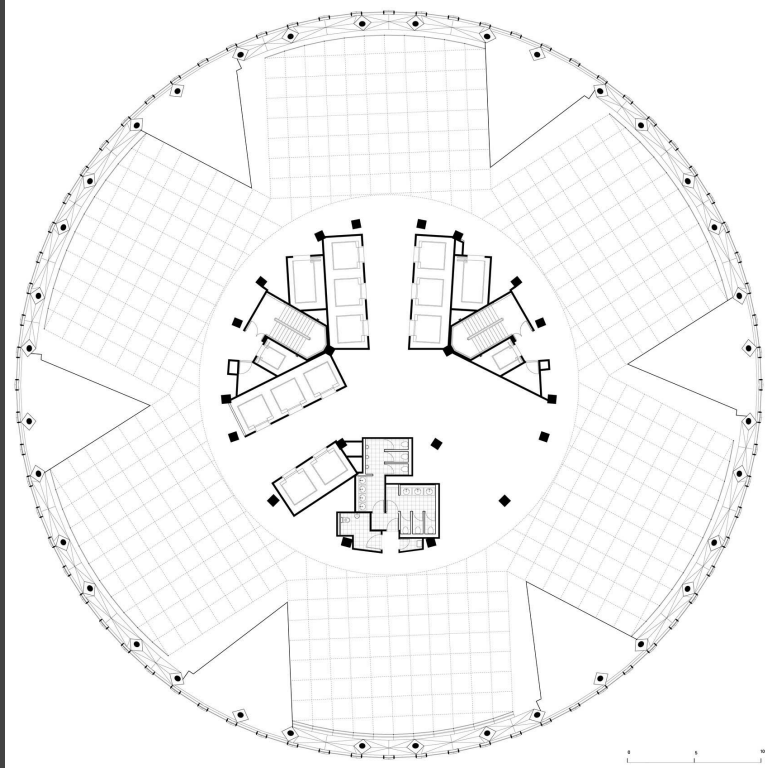


6th Floor

Source: Foster + Partners

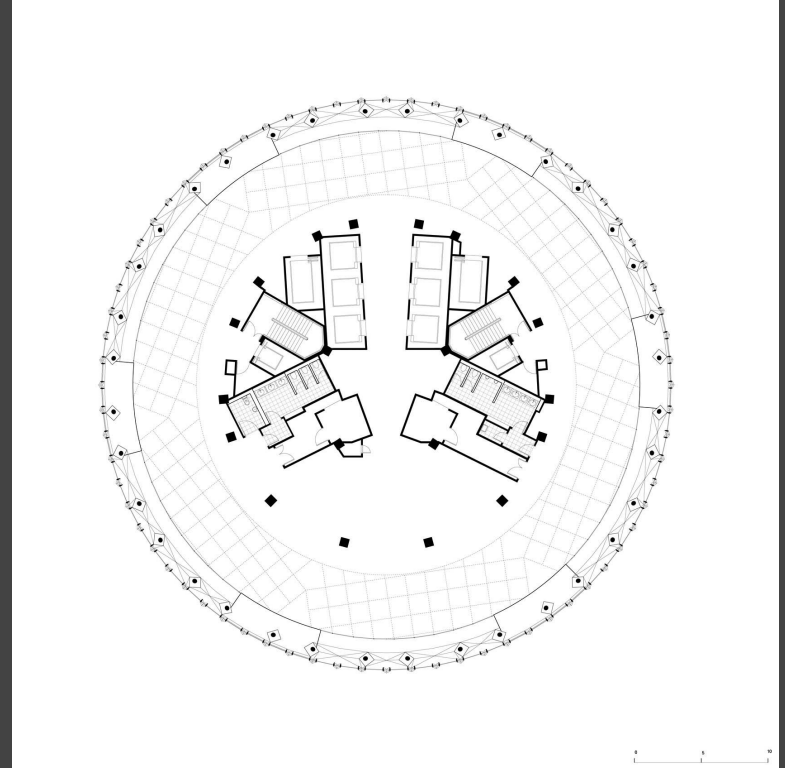


# Floor Plans



Source: Foster + Partners

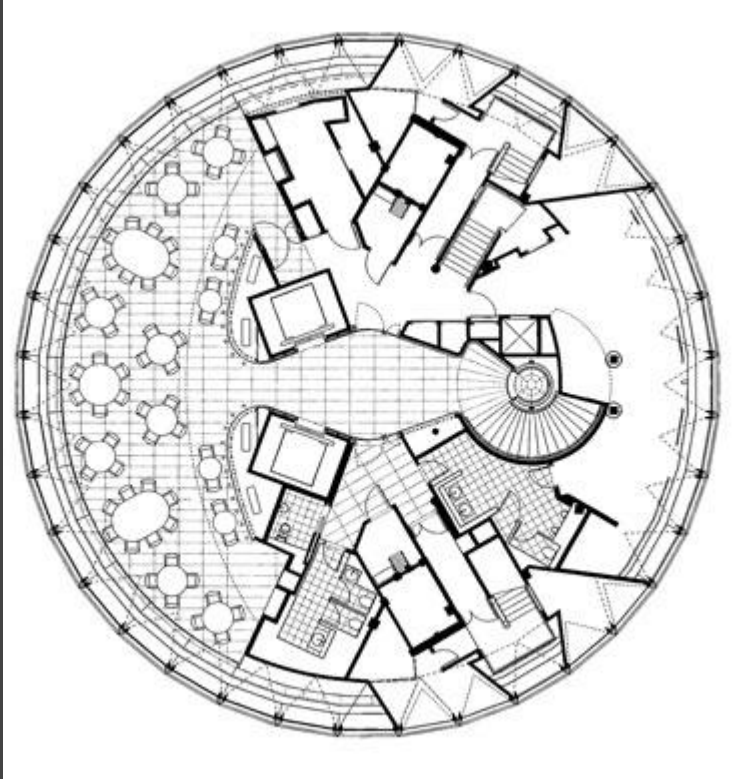
21st Floor



Source: Foster + Partners

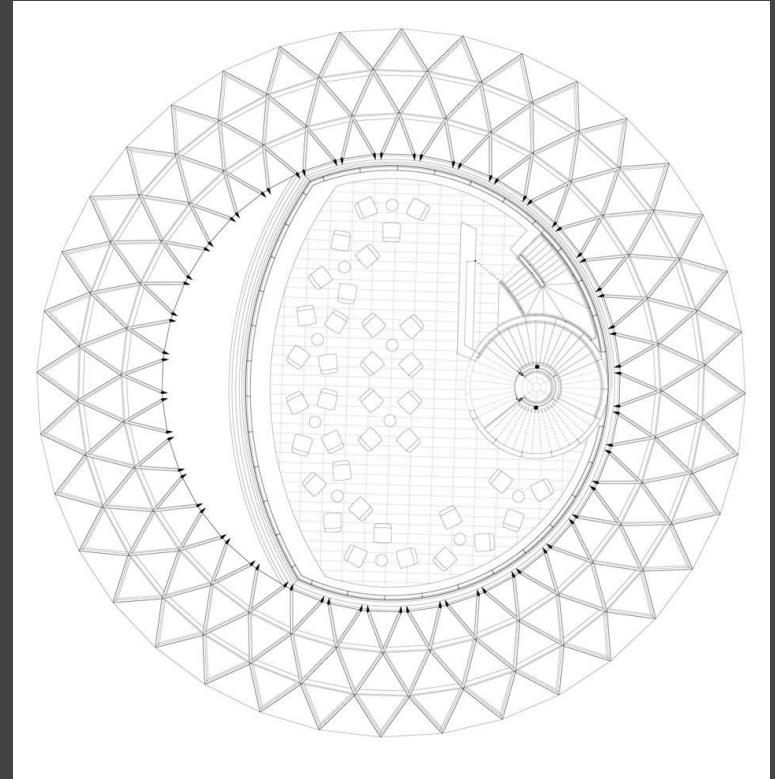
33rd Floor

# Floor Plans



Source: Foster + Partners

39th Floor



Source: Foster + Partners

40th Floor

# Soils

- Built on London Clay
- Soil has low bearing capacity
  - More piles required
  - Piles must be driven deeper
- Poor horizontal shear strength
- Organic material in the soil
- Susceptible to settling



Source: London's Natural Signatures: The London Landscape Framework / January 2011



# Foundation

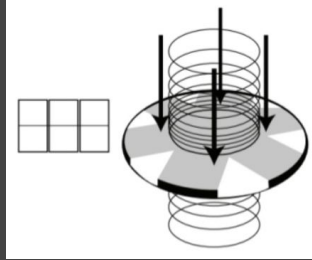
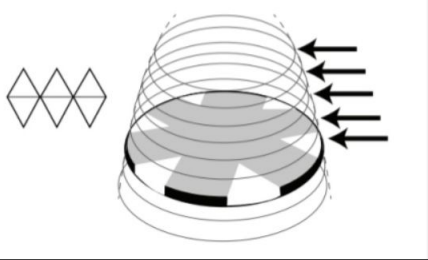
- Core column maximum design load: 33,266 kN
- 750mm diameter concrete piles into London Clay
- Number of piles: 333
- Average length of piles: 27 m
- Total length of piles: 9 km
- Total design capacity: 117,000 Tonnes



# General Structure

## Two Primary Structural Systems

- Diagrid - Resists horizontal and gravity loads
- Core - Resists gravity loads





# Structural Core

- The core is the primary system for transferring vertical gravity loads to the foundation system.
- It is a rigid frame made up of moment connected steel members.
- The core also ensures that the horizontal hoop system does not splay outward by acting as a tie back from the diagrid.
- The core's central, symmetrical placement within the building does not allow torsion as an effect from lateral loading.
- High structural stiffness is advantageous when dealing with loose soil types





# Structural Diagrid

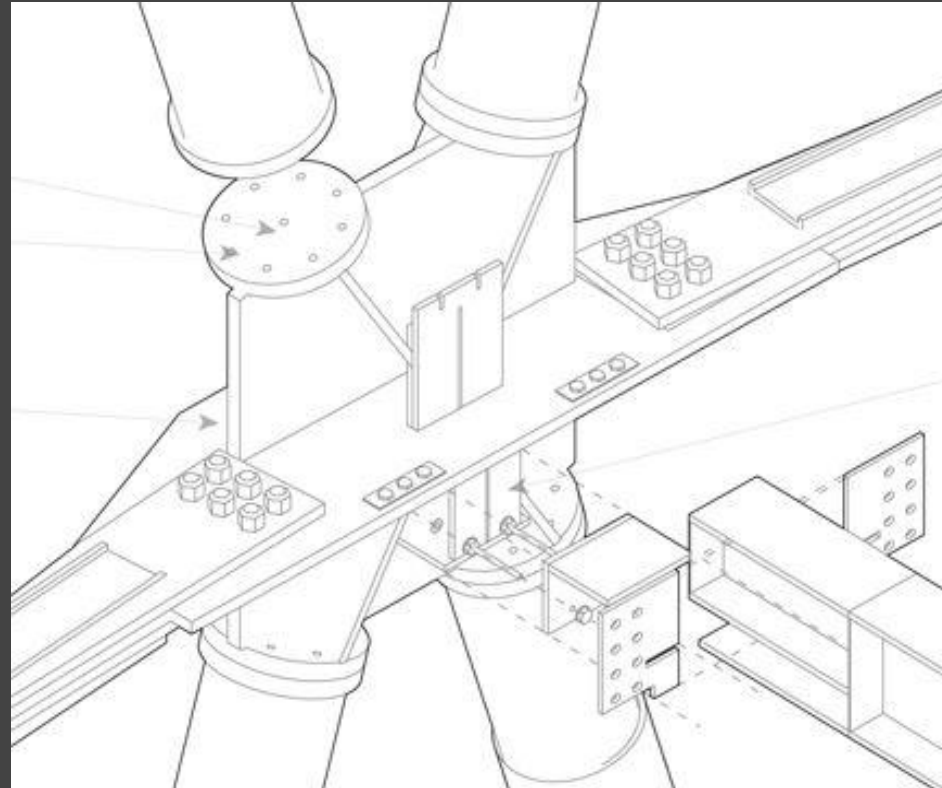
- The diagrid provides vertical support to the floors while allowing for a column free interior space.
- Implementation of the diagrid system allows the radical form.
- When coupled together, the structure and form are the ideal solution to dealing with wind loads.
- Combination of HSS steel members and rigid node connectors
- Diagrid column sizes vary throughout - larger towards the base
- There are 19 hoop structures that prevent the diagrid from splaying out



Source: Foster + Partners

# Nodes

- 360 total nodes
- The nodes transfer loads both horizontally and vertically
- The node itself is composed of three welded steel plates
- The plates are oriented at oblique angles in order to facilitate the complex geometry of the structure
- HSS - round sections bolted to the plates in order to facilitate the diagrid structure



Source: <https://sites.google.com/site/diagrid390a/limitations-of-the-system>

# Construction Process





# Construction Process





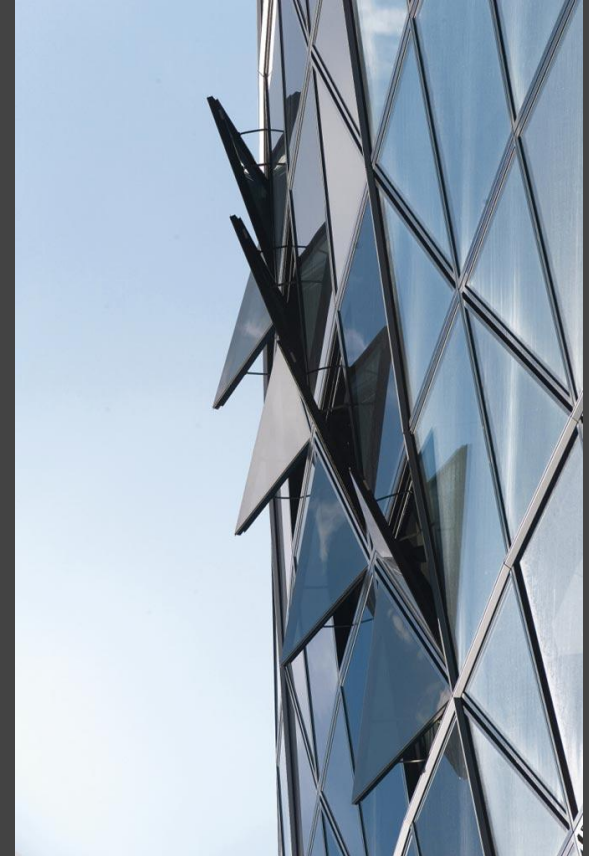
# Sustainability

## Natural Ventilation

- Windows opened 40% of the year
- Six light wells act as buffer zone to collect fresh air and control the speed and temperature as it flows through the building

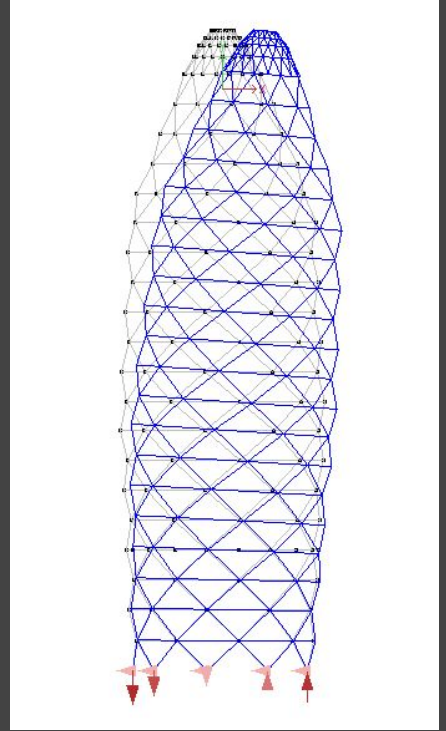
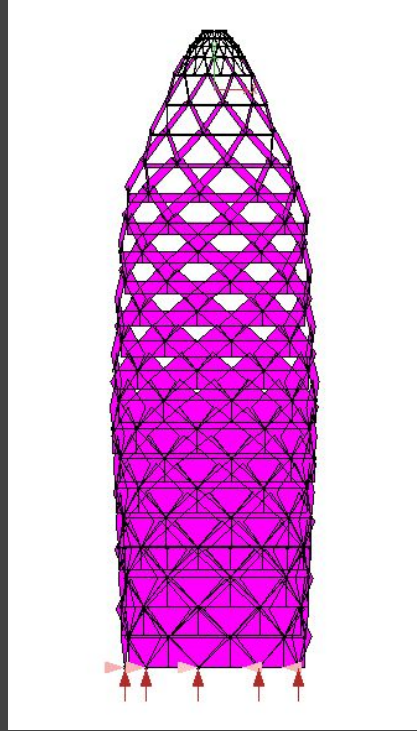
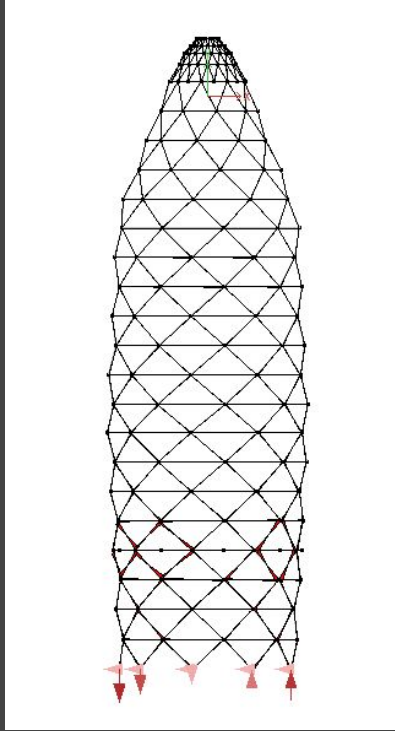
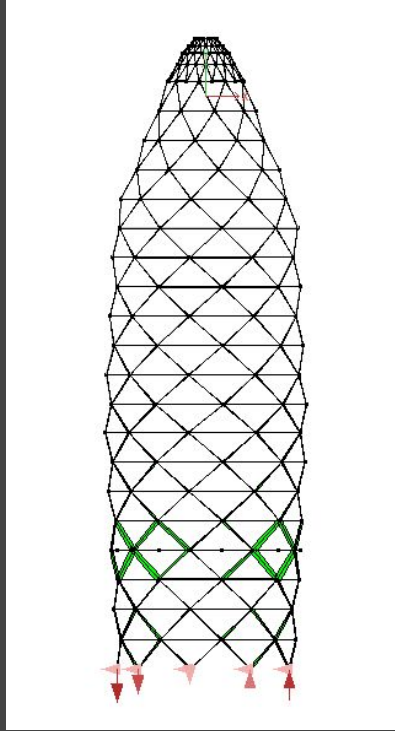


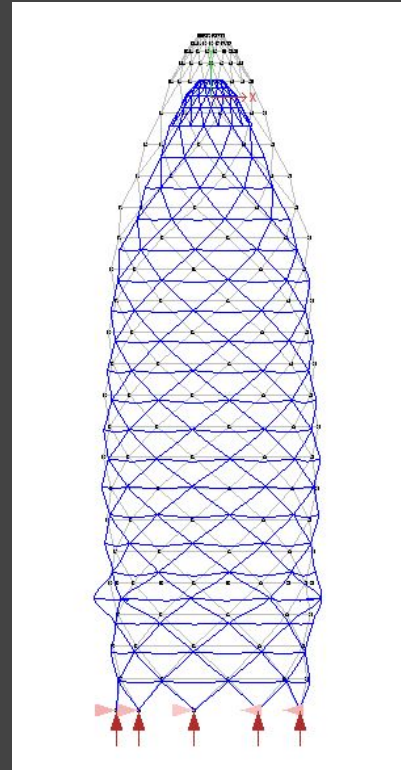
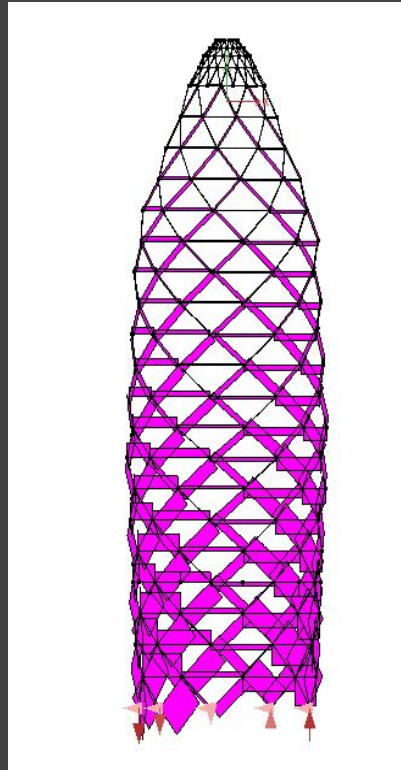
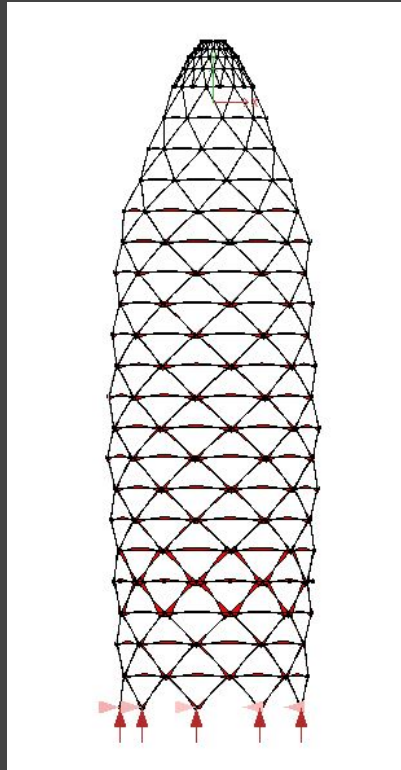
Source: Foster + Partners



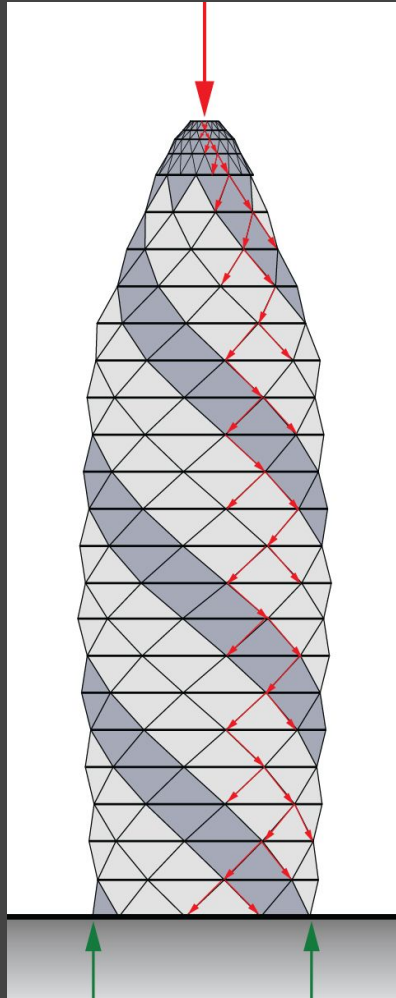
Source: Foster + Partners

# Wind Load





# Load Tracing





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