Puerta de Europa

ARCH 631

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BACKGROUND

Puerta de Europa or the "Gate of Europe" 1989-1996

- Twin office towers that defy the typical conventions of skyscraper design
- Situated on prime real estate and straddle one of Madrid's most important boulevards – the Paseo de la Castellana
- Towers measure 115 meters tall with 26 floors and tilt towards each other at a 15° slant
- Gross Floor Area: 1,130,000 sf / 105,000 sm
- Also marks the Northern end of Madrid's business district
- Define the entry to a central transportation and pedestrian hub
- Awards: First Prize Award for Engineering Excellence, 1996

ARCHITECTS

PHILIP JOHNSON (right):

- born in 1906 in Cleveland, Ohio
- American architect, also studied history and philosophy
- Studied at Harvard University School of Design
- Director of the Museum of Modern Art
- Awarded the first Pritzker Architecture Prize and an American Institute of Architects Gold Medal in 1979

JOHN BURGEE (left):

- Partner of Philip Johnson from 1967-1991
- American architect noted for contributions to Postmodern architecture
- Studied at University of Notre Dame School of Architecture
- President of the Institute for Architecture and Urban Studies

STRUCTURAL ENGINEERS

LESLIE E. ROBERTSON ASSOCIATES

LERA
Leslie E. Robertson Associates
STRUCTURAL ENGINEERS

- Established in 1923
- Experience ranges in scale from small renovations to the design of multi-block urban developments
- Other services offered: value engineering, peer review/structural audit, expert witness testimony, and technical research projects

MATERIALS

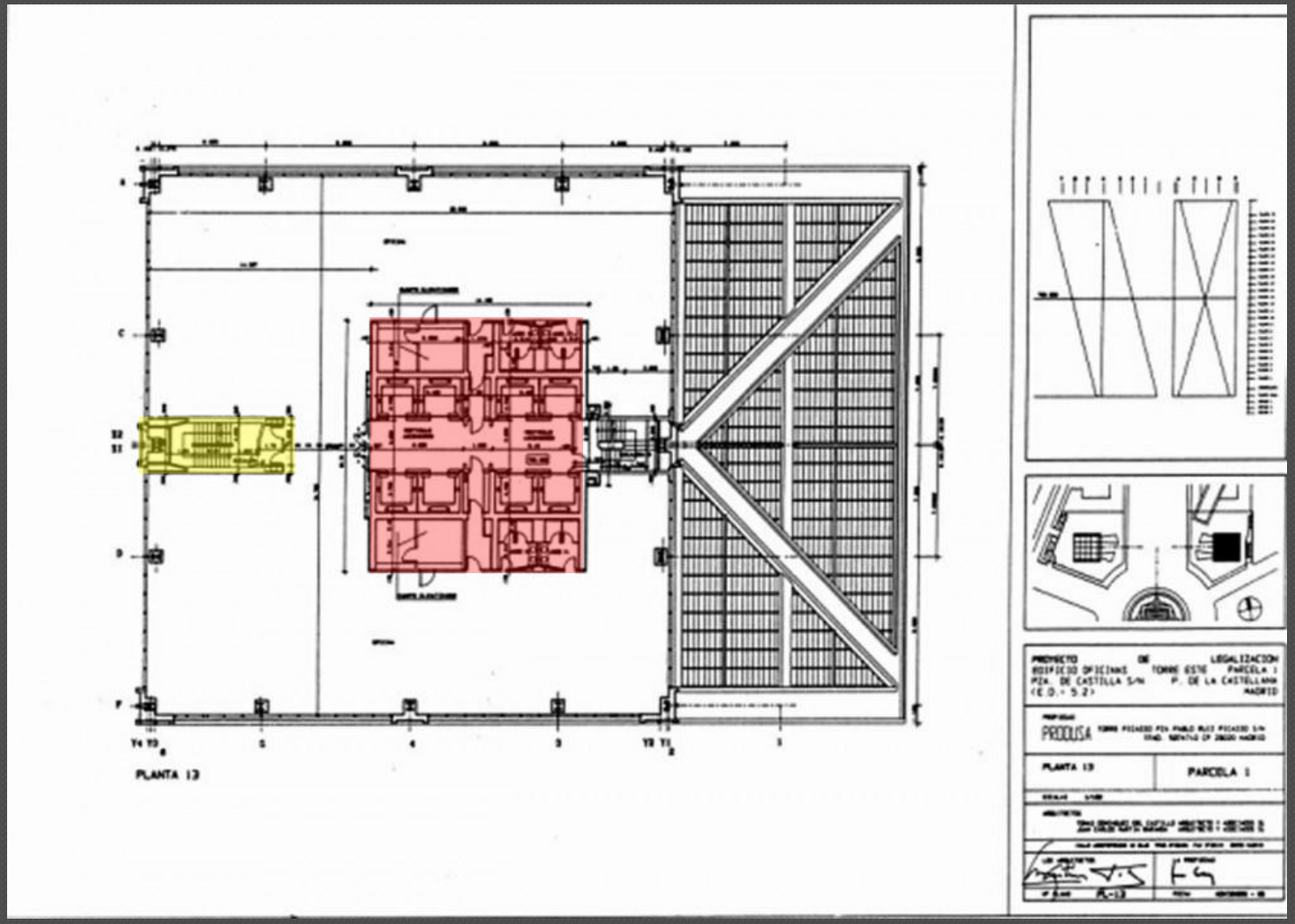
- Steel
- Glass
- Stainless steel
- Architectural style:
  structural expressionism
- Façade colors:
  - Black
  - Light gray
  - Dark red

DESIGN CONCEPT

"We must end the right angle if we do not want to die of boredom. The skyscraper is over; we can forget it."

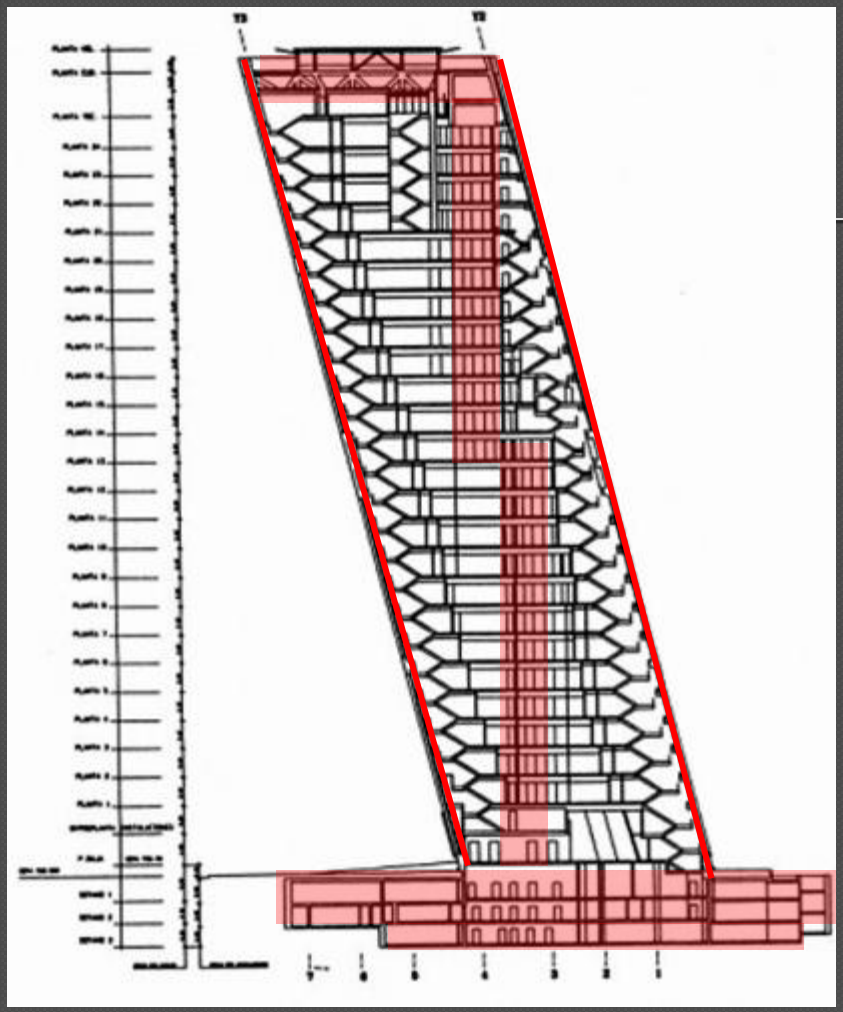
- Philip Johnson

BUILDING LAYOUT



MAIN STRUCTURAL SYSTEM

- Steel Wireframe
- Concrete Core
- Glass Curtain Walls
- Concrete Ballast



COMPONENTS

Steel Wireframe
- The fifteen degree angle of the buildings is achieved through the use of a steel frame
- Steel is post-tensioned

Glass Curtain Wall
- Exterior facades are composed of glass in a curtain wall system

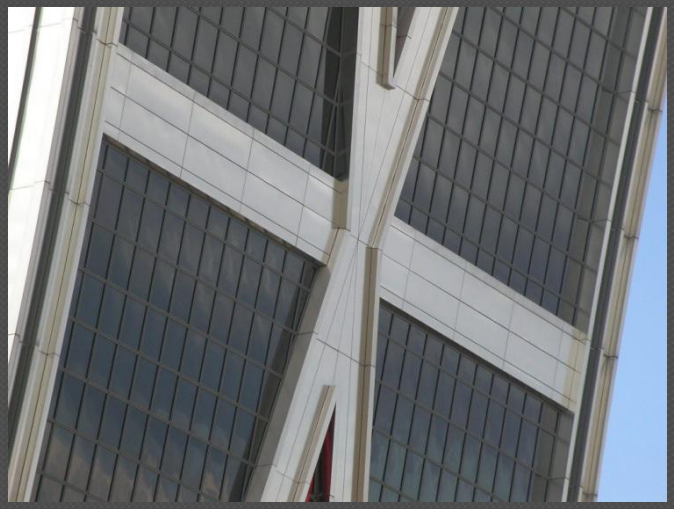
Concrete Core
- Interior floors are stabilized with a concrete core through the center
- Surrounds the circulation elements

Underground Ballast (Counterweight)
- 165 feet long, 41 feet wide, 32 feet deep
- Weighs 15,400 tons

CONNECTIONS

STEEL STRANDS FOR POST-TENSIONING

- Both the steel and concrete were post tensioned, which strengthened both and allowed for the steel members to be smaller and more economical



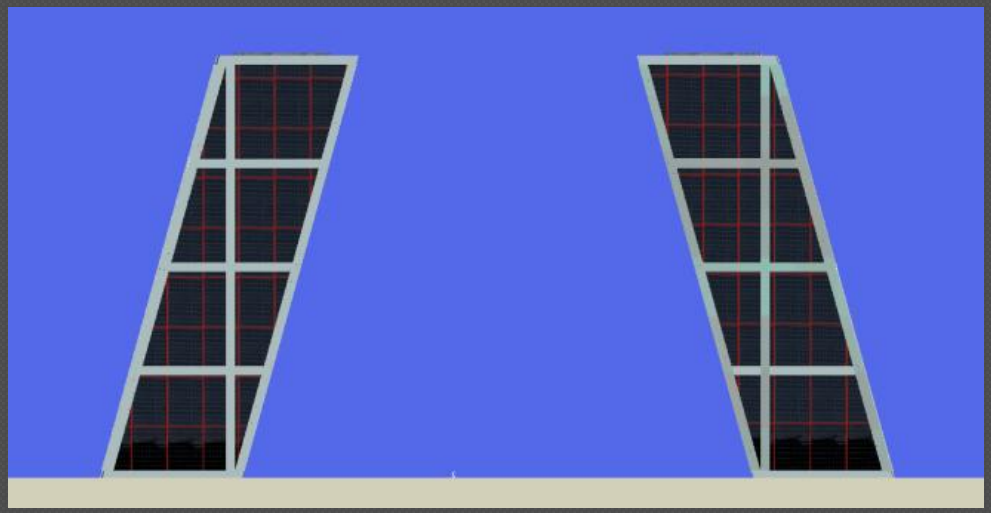
TYPICAL STRAND ANCHOR

SYSTEMS

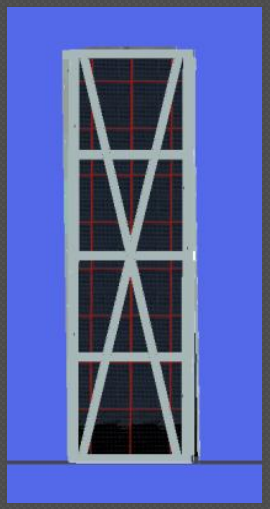
SYSTEMS:

- HVAC and other systems had to be considered with the building's structure due to the building's unusual shape
- Steel was chosen for the members so that notches could be made in the steel for mechanical space

LATERAL RESISTING SYSTEM



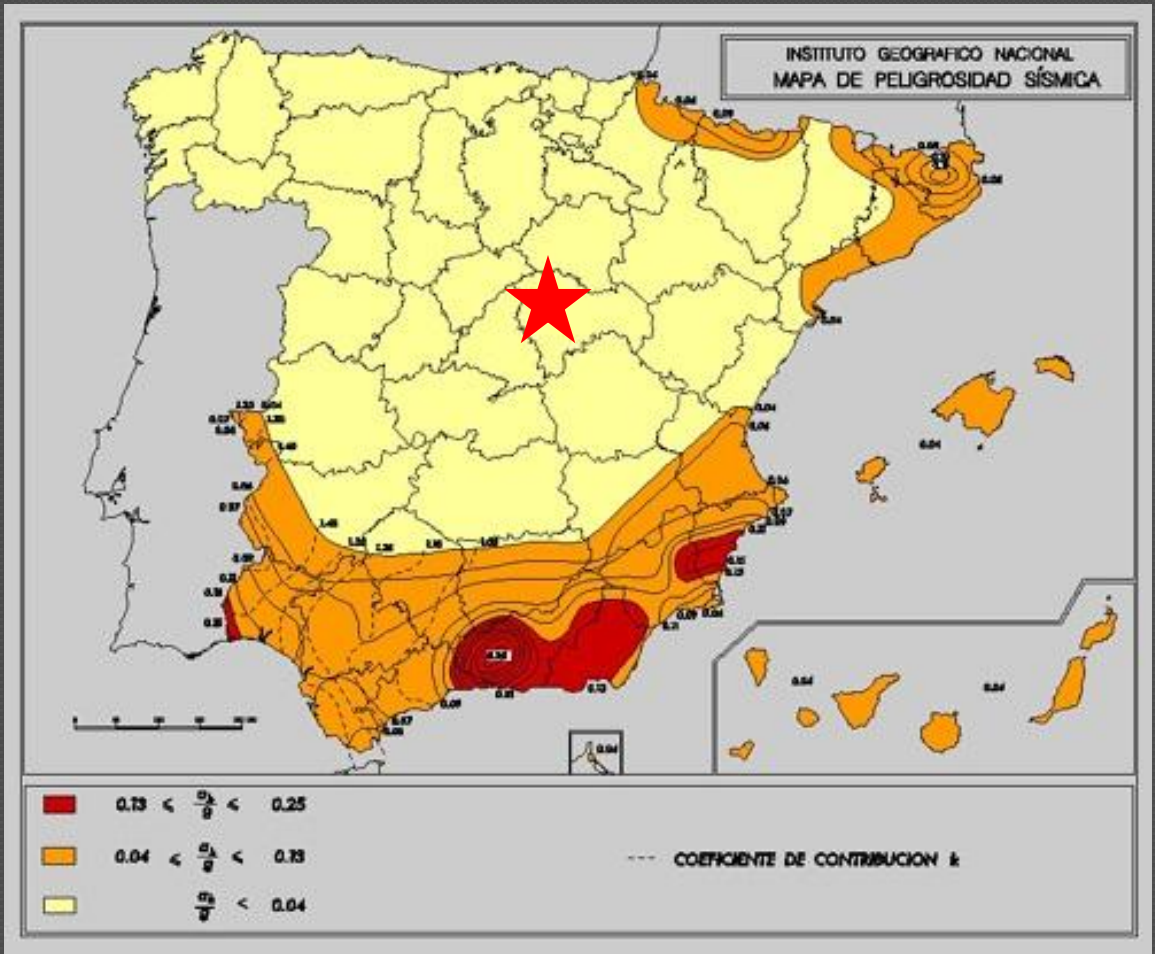
NORTH-SOUTH ELEVATION



EAST-WEST ELEVATION

- Primary structural system is the diagrid of structural steel around the perimeter of the building

LOAD DESCRIPTION

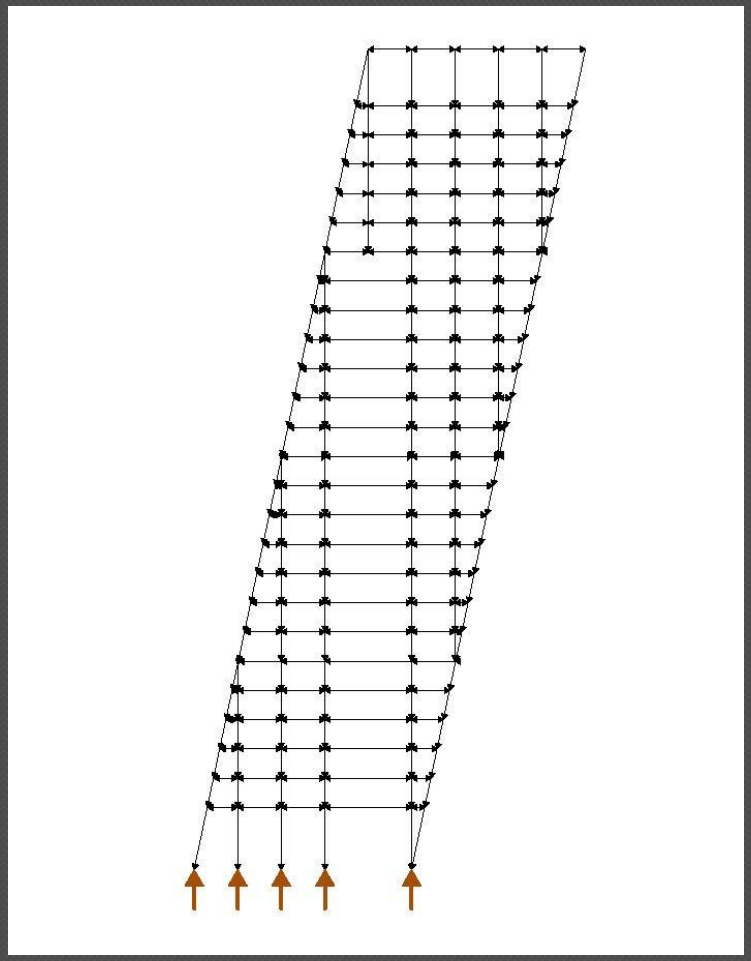


LOADS:

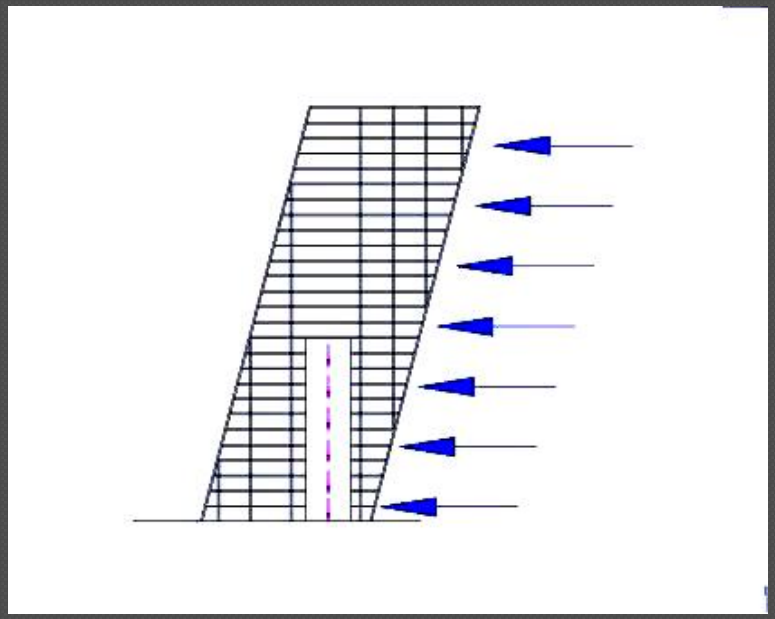
- Constant forces such as the wind and gravity had to be considered
- Seismic load was a consideration as well

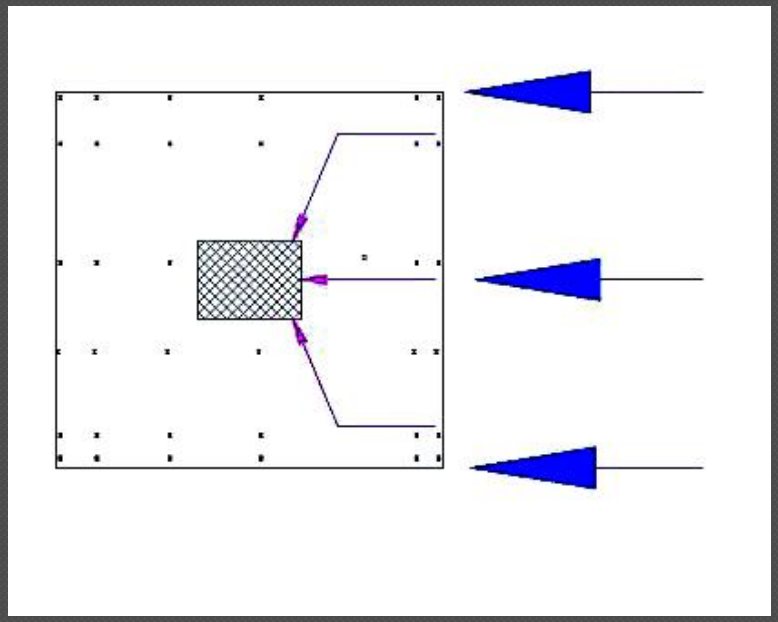
LOAD TRANSFER PATH

- The vertical loads transfer through the beams and girders and are then carried to the ground by the concrete core and columns



LATERAL LOADING BEHAVIOR

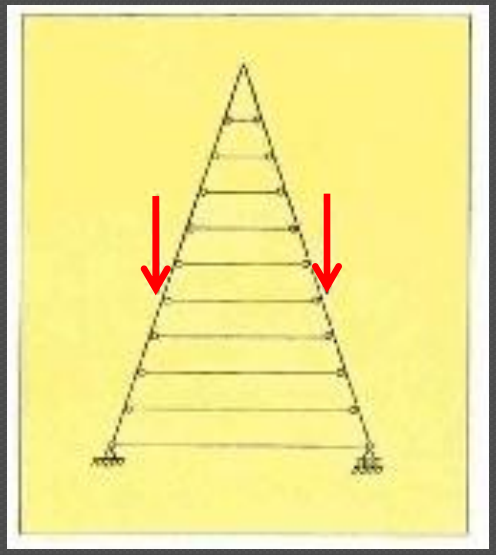


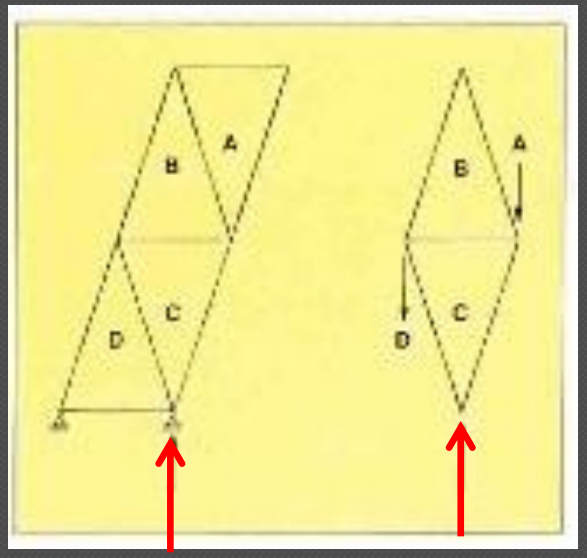


WIND LOAD:

- In section and plan, the blue arrows represent the wind load
- The purple arrows indicate the load transfer path the wind takes which is directed to the center concrete core and then carried to the ground

LATERAL LOADING BEHAVIOR CONT.

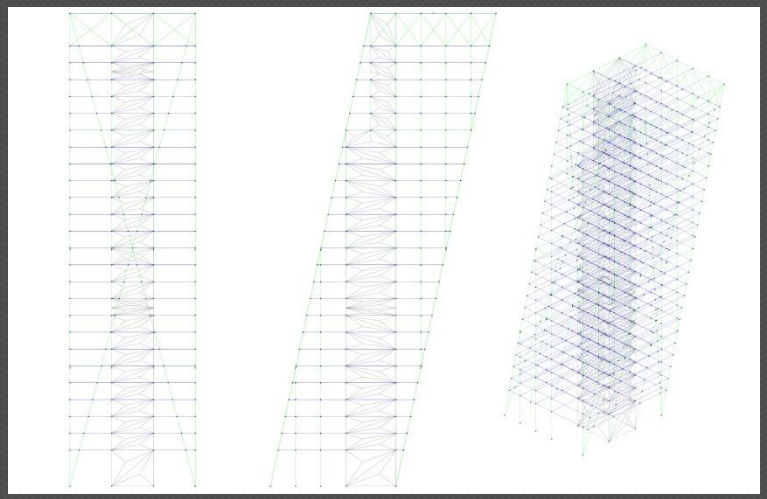




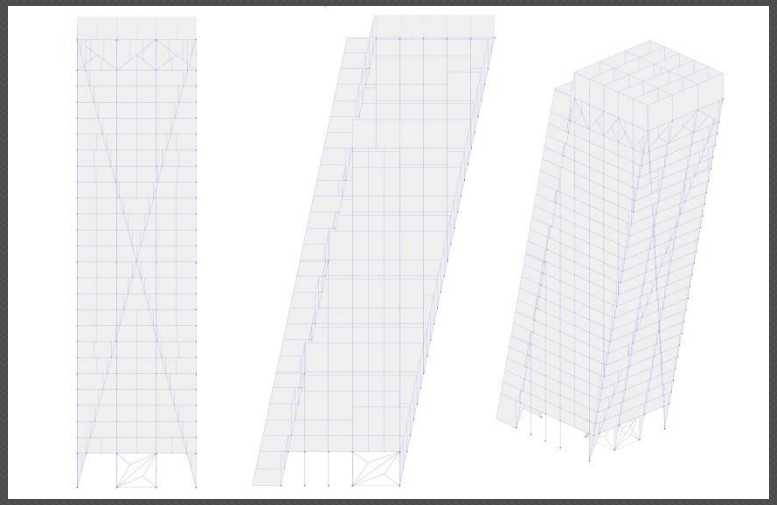
SYMMETRICAL VERTICAL LOADS:

- The image to the left shows the basic triangular building block and how the symmetrical vertical loads are evenly distributed on a vertical cantilever without bending
- The image on the right shows how a system of combined basic triangular building blocks transfers the gravity load safely to the buildings base preventing lateral deflection and uplift in the foundation

MULTIFRAME

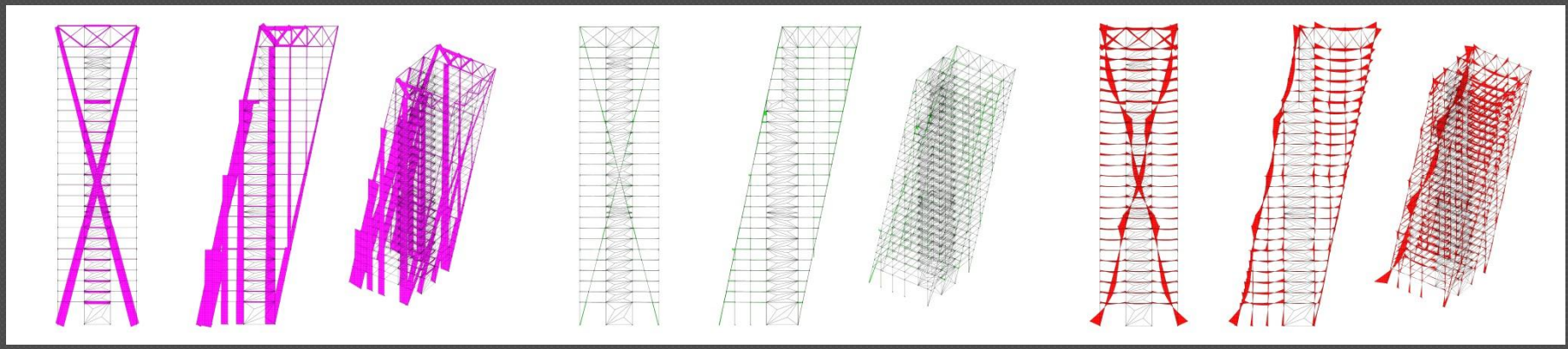


STRUCTURAL MEMBERS



STRUCTURAL MEMBER LOADING

MULTIFRAME



AXIAL ANALYSIS

SHEAR ANALYSIS

MOMENT ANALYSIS

FOUNDATION AND SOIL

FORCES:

- This image illustrates how the cables counteract the overturning moment