The New York Times Building
Structural Design Challenges

Presented by:
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December 17, 2007
Birth of a building

- NYT wanted a building representative of their stature in the world
  - Represent journalistic ideals of communication and openness
  - Reflect their connection to the city and the neighborhood
  - Improve work efficiency/environment

- Partnered with Forest City Ratner Companies
Birth of a building

- Design Competition in 2000
  - Featured proposals from today’s most renowned architects
- Italian architect Renzo Piano won the competition
  - Partnered with FXFOWLE ARCHITECTS NYC office
Primary design features

- Transparency
  - Newsroom
  - Façade system
  - Exposed structural steel
  - Lobby
- Sustainability
- Technology
Choice of site

- Large footprint
- 52-story tower
- 5-story podium
- Houses entire newsroom
- Western expansion of Times Square redevelopment
Choice of layout

- 52 stories, 744’ to rooftop, 1048’ to tip of mast
- NY Times to occupy lower half of building
  - Fulfills Piano’s vision of connecting the newspaper to its city’s streets
- FCRC to develop upper half of building
  - Premium views from offices
Choice of layout

- Interior architect on board in early schematic design
  - Dimensions of core and shell influenced by Interiors layout
- Corner notches
  - Also help to engage the city sidewalk with the building
Exterior Wall

- Façade system
  - Ultra-transparent glass inner layer
  - Outer skin of closely spaced ceramic tubes to act as sun shade
- Daylighting
  - Blends transparency, sustainability, and technology

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Exposed Steel

- Columns in four corner notches are brought outside of building envelope
- Building is so transparent you can see its skeleton
- Also maximizes useable space
Overview of structural design

- Foundations
- Floor system
- Lateral system
Overview of structural design

- FOUNDATIONS

- Primarily supported on spread footings over 40 ton rock

- Test borings found 8 ton rock seam under tower

- Redesign of several tower columns with drilled caissons
Overview of structural design

- FLOOR SYSTEM

- Steel framing
- 2 ½” NW composite slab on 3” metal deck
- 40’ typical spans to optimize interior layout
Overview of structural design

- LATERAL SYSTEM
- Core braced frame
  - Concentric braces behind elevator shafts
  - Eccentric braces at elevator lobby entrances
Overview of structural design

- LATERAL SYSTEM
- Outriggers at two levels
  - All columns of tower are engaged in lateral system
  - Located at mid-height and top level mechanical rooms
Structural Design Challenges

- Efficient design of lateral system
- Design of exposed structure
- Detailing of exposed structure
- Resistance to building movements due to thermal differentials
- Cantilevered bay system
- Roof screen walls
- Mast
Efficient design of lateral system

- Core braced frame with outriggers
  - Sufficient for strength
  - Large deflections and accelerations (> 40 milli-g) do not satisfy comfort criteria

Outriggers

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Efficient design of lateral system

Traditional solution

- Increase member sizes of lateral system to meet comfort criteria
- Members sized beyond what is required for strength
Efficient design of lateral system

Actual solution

- Utilize expressed structure to engage additional gravity columns
- Provides ‘bonus’ redundancy for extreme loading conditions
Efficient design of lateral system

Actual solution

- Exposed X-brace system consists of pairs of high-strength rods (vary from 2.5” to 4” diameter)
- No fireproofing required because rods are not required for strength
Efficient design of lateral system

SUMMARY

- Ability to utilize exoskeleton made structure more efficient
- Minimized size of core columns, allowing for more efficient architectural layout
Exposed columns are built-up box columns

- Web plate was varied to provide additional area for strength/stiffness without compromising overall profile
Design of exposed structure

X-Braces

Typical challenges of X-braces

- Design of compression element
- Rod intersection at midheight
Design of exposed structure
X-Braces

- To eliminate bulky compression member, prestress rods so they remain in tension under wind
Design of exposed structure
X-Braces

- Used pairs of rods
-Eliminates center node and load sharing
- Eliminates eccentricities at column
- Makes structure appear lighter (two small rods instead of one large rod)
Design of exposed structure

Dog-leg beams

- Interior steel beams supporting slab penetrate through façade to frame to exposed column
- Wrapped with insulation to prevent heat transfer
Design of exposed structure
Dog-leg beams

- Raised floor system pushes structural slab 16” below top of finished floor
  - Also pushes slab below spandrel panel
- Solution – make beam ‘dog-leg’ at end connection
Design of exposed structure
Exposed outriggers

- To fully engage exterior bracing lines, outriggers are required
- Used built-up wide flanges to maximize area but minimize width/depth
- Box column interrupted by node to minimize gusset plates
Design of exposed structure
Exposed outriggers

- Interior outriggers need to penetrate façade to reach outer column
- Required coping of member to limit width of penetration
  - Three-plate laminate at end
Design of exposed structure

SUMMARY

- Overall architectural proportion was achieved by varying web plate thickness
- Utilized prestressing to keep exposed members light to maintain transparency of building
- Developed details where members penetrate façade to limit overall size
Detailing of exposed structure

- Exposed exoskeleton is one of primary aesthetic features of building
Detailing of exposed structure

- Use of major structural columns as exposed structural steel
  - Design team specified stringent requirements on Contract Documents
    - All exposed welds ground smooth
    - Steel tolerances to be half of AISC requirements
    - Fully detailed size and shape of gusset plates
    - Intumescent paint required to fireproof building columns
    - Bolt orientation
Detailing of exposed structure

- Knuckle connection
  - Rods frame into ‘bridge’ plates that span between two vertical gusset plates
- Horizontal strut bolted to knuckle as end plate
  - Cover plate welded in field to seal box after bolts installed

Bridge plates
Gusset plates
Detailing of exposed structure

- Knuckle mockup
  - Became part of the Contract Documents
  - Steel subcontractor bound to achieve same quality as mockup
  - Also used as mockup of intumescent paint application
Detailing of exposed structure

- Cooperation between design and construction team was critical to achieve architectural vision

- Architects, in addition to engineers, reviewed each exposed connection on site
Detailing of exposed structure

**SUMMARY**

- Specific requirements outlined on Contract Documents
  - All parties understood quality that was expected
- Developing constructible details that met architect’s standard of proportion
- Cooperation between design and construction team
Thermal differentials

- Interior steel members are maintained at room temperature
- Exposed members undergo extreme temperature changes
  - Can range from 130°C to -10°C F
Thermal differentials

- Exposed columns undergo temperature deformation and interior columns do not.
- Results in significant differential deflection at upper floors exceeding L/100.
Thermal differentials

- Utilized outrigger trusses to even out differential deflections
- Added thermal trusses along east and west faces
- Limited deflection to L/300 max
- Provides ‘bonus’ redundancy

THERMAL CONTRACTION

OUTSIDE BUILDING (T = -10 F)
INSIDE BUILDING (T = 72 F)
OUTSIDE BUILDING (T = -10 F)
Thermal differentials

SUMMARY

- Accommodated use of exposed structural steel within acceptable serviceability limits
- Structural systems resisting thermal differential movements located within mechanical levels
Cantilevered bays

- No outer columns at north and south bays that form the corner notches

No outer columns
Cantilevered bays

- Architectural vision
- No columns interrupting transparent storefront
- Structure above appears to float above the light storefront

No column from Ground to 2nd floor
Cantilevered bays

- Classical solutions
  - Transfer column at 2nd floor
    - Would have introduced large truss where transparency is most important
  - Cantilever girders on each floor
    - 20’ span requires deep member or diagonal brace for deflection/vibration
  - Cantilever series of beams
    - Huge tonnage premium
  - Hang floors from above
    - Erection sequence issues
Cantilevered bays

Actual solution
- Combination of systems
- Outer edges of bay supported on exposed cantilever
  - Sized for strength
- Single 2” diameter rod to control deflection (no fireproofing)
Cantilevered bays

- Middle line of bay is ladder Vierendeel system
- Moment connected beams to columns
- Ran numerous construction sequence models to specify method of construction
Cantilevered bays

- At outrigger levels, large brace ties middle line back to the core through outrigger trusses
- Provides redundant load path for extreme loading conditions
Cantilevered bays

- System not very stiff when only few floors are moment connected
  - Would deflect considerably
- Use of temporary diagonal
  - Resists deflection until enough floors have been constructed for frame action to take over
- Able to be removed when first outrigger installed
Cantilevered bays

**SUMMARY**
- Met architectural vision of column-free storefront
- Supported long cantilevers without diagonals through office space
- Kept member sizes at minimum due to presence of rod for deflection control
Roof screen walls

- Façade screens continue beyond roof
  - Illusion that they disappear into the sky
- Highest screen extends 75’ above roof
Roof screen walls

- Roof screen columns are tapered built-up wide flanges (4’-0” deep at base)
- Took advantage of upper mechanical level
  - Extended screen columns to 51st floor to create propped cantilever
  - Avoided kickers at rooftop
Roof screen walls

- Resists lateral force as horizontal couple over two stories
- Simplified connection back to primary structure
Mast

- Completes final transition of building to sky
- 300’ from top of roof
- Extends down to 51st floor similar to roof screen to achieve propped cantilever effect
Mast

- Steel pipe tapers from 8’-0” diameter at base to 8” at top
- Rolled in half pipes and welded together in shop
- Fatigue sensitive details
Mast

- Erected in three segments (bolted splice connections)
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Thank you!
Learning Objectives

- Understand the process with which an engineer can achieve the desired aesthetic of a building
- Learn different solutions to some of the challenges presented in this project
This concludes the American Institute of Architects
Continuing Education System Program

Questions

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