The New York Times Building exemplifies the idea of transparency in reporting by wearing part of its structural frame on the outside.

Inside Out

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ARCHITECT RENZO PIANO MADE HIS MARK, along with his partner Richard Rodgers, in the design of the renowned Pompidou Centre in Paris. By turning the building inside-out and putting means of egress and mechanical systems on the outside of the building, Piano helped create a structure that both celebrates the systems that compose a building and provide visitors with an amazingly open space to enjoy. These same trends are present in Piano's latest design, The New York Times Building, except that in this case, the building is turned inside-out by exposing its structure. The use of exposed structure complements Piano's vision of creating a transparent building as well as creating numerous efficiencies in the design of the steel structure.

Located a few blocks away from the Times' original home in Times Square, the new 52-story building

Photo: David Sundberg/ESTO

stands 744 ft from the sidewalk to the roof. The façade extends above the roof in a marriage between form and function, completing the concept of a transparent building disappearing into the sky, while also hiding rooftop mechanical equipment. A 300-ft-high steel mast extends above the roof, topping the overall structure out at 1,048 ft and making it the third tallest building in New York City at the time of its completion. The New York Times Company occupies the lower 27 floors, while business partner Forest City Ratner Companies developed the upper floors of the building.

The footprint of the building exhibits an elongated cruciform shape in plan. The steel braced-frame core of the building is 65 ft in the east-west direction by 90 ft in the north-south direction. The tight layout of the core allowed for wide 40-ft spans on the west and east sides of the building. At the mid-level and upper-level mechanical floors, double-story outrigger diagonal braces extend from the core to the perimeter columns, allowing all columns to participate in the lateral stiffness of the building.

Four Corners

In each of the four corner notches of the tower, the two columns on the north and south notch faces are brought outside of the building envelope. These columns are 30-in.-wide by 30-in.-deep box columns built from steel Grade 50 or Grade 42 plate. After initial sizing of the columns for stress, structural engineer Thornton Tomasetti worked with Renzo Piano Building Workshop (RPBW) and FXFOWLE Architects to establish a hierarchy of exposed steel sizes. Part of the architect's vision was for the building to get lighter as it approaches with the sky, which worked well with the desire to maintain an efficient structure. Exposed members changed sizes in five levels of hierarchy along the height of the building. For the box columns, the flange thickness was varied, from 4 in. at the base of the building to 2 in. at the top levels. To achieve the required area for strength and stiffness, Thornton Tomasetti varied the thickness of the web plate, allowing for structural efficiency that did not affect the aesthetics of the building. The web plates were also inset 3 in. from the toes of the flange, creating both an aesthetic reveal and a means for welding the plate together with simpler fillet welds rather than penetration welds.

One unique aspect of the project is that it was a break from the traditional fast-track design of many high-rise buildings built by developers. Because of the owner's desire to create a technologically savvy and world-class building, the design team was afforded a flexible design schedule, and the owners pushed them to come up with multiple solutions and understand the positives and negatives of each. This resulted in many instances where the best interests of the architect, engineer, and owner were all satisfied by the final solution. One example of this is the exposed bracing system. In the desire to expose the structure aesthetically, the architect envisioned an elegant vertical bracing system on the outside of the building. Structurally, this was ideal, as additional bracing lines outside of the steel braced-frame core helped spread out the building's lateral stiffness to multiple columns that were already sized for gravity.

Maximum Exposure

Given the amount of exposed steel in the building, one of the principal concerns was the amount of exposed fireproofing that would be required. The columns were fireproofed using intumescent paint for both aesthetics and durability. To avoid the additional fireproofing requirements on the vertical bracing, the exposed bracing lines were only used to limit building drift and accelerations, which governed the building's design. Because the braces themselves were not fireproofed, the core had to be designed to resist lateral loads for strength, assuming the exterior system was not present. In a more typical high-rise, additional steel tonnage would have been required to limit the accelerations of the building to levels deemed acceptable for human comfort. By using the exposed bracing system, less steel was required to be added, as the steel area used to resist gravity loads on the exterior could now also be used as additional axial stiffness to resist building movement. The use of these exterior bracing lines, in addition to the typical outrigger system of the building, allowed all 30 tower columns to participate in the lateral system of the building.

Pretensioned, high-strength (65 ksi) steel rods were used in a two-story-high X-braced system to keep the exposed bracing light and elegant. The rods were pretensioned to overcome any future compression due to differential axial shortening of columns, differential temperatures in exposed steel members, and wind or seismic loads. To maintain a sense of proportion with the columns at each of the five hierarchical levels, the rods decrease in diameter as they go up the building, with 4-in.-diameter rods at the base and 2.5-in. rods at the upper levels.


Thornton Tomasetti, Inc.

above: Outrigger diagonal braces on the 28th floor.

Thornton Tomasetti, Inc.

above: New building, same classic font.

below: Structural elements are brought outside of the building envelope at the four corner notches of the tower.


David Sundberg/ESTO

One of the typical pitfalls of X-braces is how to handle the middle of the bay where the braces intersect. Creating a node at this location results in a bulky connection, and many different load paths need to be evaluated. The braces can also be offset so they run by each other, resulting in eccentric connections at the columns. To solve these issues, pairs of rods were used in lieu of single braces. This allowed one set of rods to be aligned horizontally and the other pair to be aligned vertically and pass between the two horizontal rods. In addition, each of the rod pairs would maintain concentric alignment with the center line of the columns. At every other floor level, a horizontal strut connects between the columns to resist the compression component from the rod tension force. This strut is a 22-in.-deep built-up I-shape and its flange thicknesses step in the same five levels of hierarchy (from 2 in. at base to 1 in. at top) as the box columns.

By bringing the columns outside of the building envelope, one issue that arose was how to handle the interior girders that frame to these columns. In the lower 28 floors of the building, a raised floor system was incorporated, meaning that the structural slab was 1 ft, 4 in. lower than the top of finished floor. This put the steel supporting this slab low with respect to the center-line of the spandrel panel, which the architect required all horizontal steel framing into the columns to be centered upon. To maintain this requirement, the girders framing into exterior columns dog-leg at the end to allow their elevation to change before penetrating through the building façade. This was achieved by transitioning the beam's depth and elevation over a 3-ft zone. The beam was wrapped with insulation where it penetrates through the façade, and stiffener plates were welded between the beam flanges to provide a seal point to disrupt outside air from getting into the building.

One of the other principal structural challenges of the building was the north and south cantilevered bays. These 65-ft-wide by 20-ft-deep bays form the north and south stems of the cruciform in plan. The architects envisioned that the building would float above the elegant glass storefront beneath these bays without any building columns running through. Thornton Tomasetti investigated several options including transfer trusses and girders, hanging systems, and cantilevering out from each floor. The final system was a hybrid of these options. At the east and west faces of the bay, the structure is supported by large exposed, built-up cantilevered beams. These beams taper from 22 in. deep at the column to 18 in. at the tip, and the end moment is transferred directly into the box columns. These cantilevered beams match the flange thickness of the horizontal struts from the X-braced system. A single 2.25-in.-diameter diagonal rod is used to control the deflection of the cantilevered beam, allowing the beam to be sized only for strength. Similar to the X-braced system, the rod did not have to be fireproofed because it only serves a role of serviceability. Back-to-back vertical channels connect between the tips of the cantilevered beams between each level to smooth out any differential deflections between floors to limit the strain on the exterior wall system.

The inner column line of the cantilevered bay was more complicated to support, as it was not desired to have a diagonal brace interrupting the floor plan. Instead, the girders were moment connected between the inner column and an outer column, which only extended to the second floor, creating a ladder vierendeel truss. A temporary diagonal was installed between the second and third floors to resist gravity load during construction until enough floors of the moment connections were completed, in order for frame action of the vierendeel truss to provide sufficient support.

Knuckles

Piano's focus on the proportioning of the exposed steel did not limit itself to the design of the built-up members themselves. The connection details of the exposed members were also critical to maintain the sense of lightness of the building's exoskeleton. The primary exposed connection was the "knuckle" connection, where the exposed rods from above and below and the horizontal strut frame into the built-up box column. Early discussions of casting the knuckle were quickly shelved due to cost. Instead, the team developed an extremely compact built-up knuckle that had a similar appearance to a steel casting, but with much less cost.

The knuckle extends off of the "flange" of the box column. Two 3-ft-high vertical gusset plates extend off the column, with the outer face of these gussets aligning with the recessed web plate of the column. The gusset plates gently curve above and below the horizontal strut to create a profile that thins as it meets the plane of the rods. A "bridge plate" in the plane of the diagonal rods is nestled between the two vertical gussets. This bridge plate receives the pin-ended connections of the rods and spans between the two gusset plates. Because the rods are configured in two separate planes to allow them to pass by each other, two different configurations of the bridge plate were required. In the "fork" configuration, the two rods are aligned horizontally and each rod comes fitted with a fork at each end. In this configuration, the bridge plate has two holes side by side to which the forks connect. In the "spade" configuration, the rods are oriented vertically and each rod has a spade at its end. The spades frame in above and below a single hole in the bridge plate, and a single pin connects both spades to the plate. Similar to the gusset plate, the bridge plates were also curved to enhance the aesthetic appearance of the connection and maintain the connection's proper proportion to the structural members.

Between the two bridge plates that meet the rods from above and below, a built-up stub of the horizontal strut was connected between the vertical gusset plates. The horizontal strut was connected to the built-up stub portion of the knuckle by means of a bolted end-plate connection. After the bolted connection was complete, a thin closure plate was field welded between the flange toes of the built-up stub to conceal the bolts and give the knuckle the appearance of a single casting.

The same extreme care that was taken in the design of these connections was also desired in the fabrication and erection of the steel. The design team provided specific guidelines on the structural drawings outlining all the tolerance and finish requirements for the exposed steel. While this steel is not technically classified as architecturally exposed structural steel, many of the requirements of AESS steel were

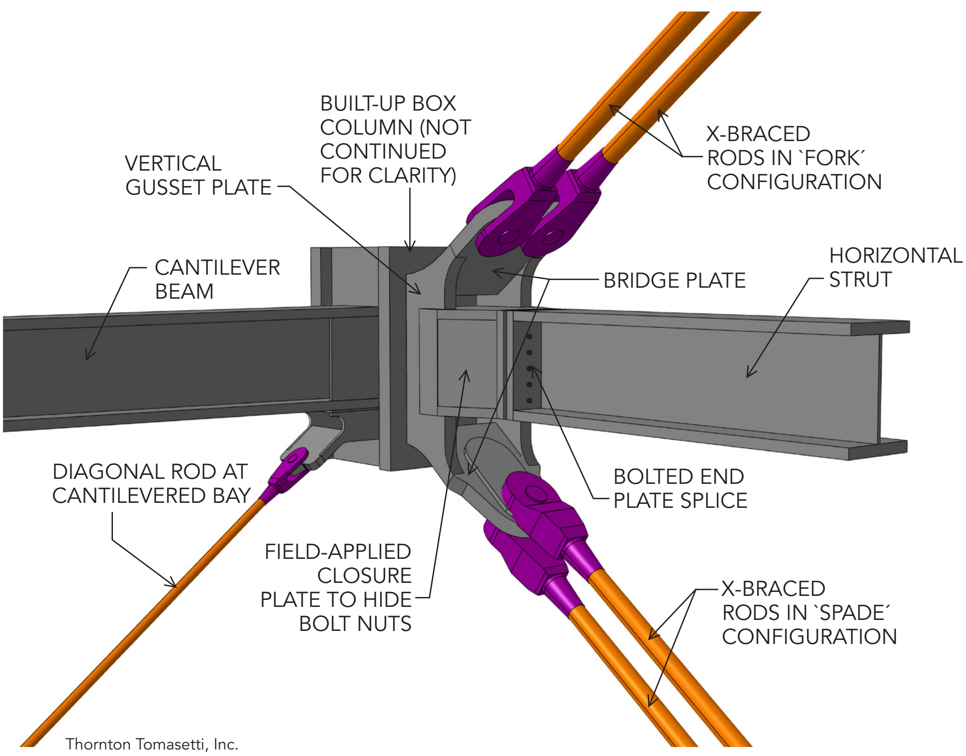
Transparency

Piano's principal objective in the design of the New York Times Building was to reflect the ideals of journalists in being open and transparent to the world on which they report. Piano envisioned a light, transparent building in which the outside world could watch the newsroom at work and the building's inhabitants could connect—and share natural light—with the city. The building's curtain wall system is a primary component in achieving this vision. The system consists of an inner clear glass wall that allows abundant natural light to imbue the workspace. An outer screen wall of closely spaced ceramic rods helps diffuse the light efficiently by eliminating excess heat and glare. In concert with the transparent curtain wall system, the steel superstructure is exposed in four corners of the building, giving the impression that the building is so transparent that its skeleton is visible.

Temperature Differentials

One of the principal design challenges of designing with exterior steel is handling the thermal differentials between steel on the outside and the inside of the building. All interior steel is constantly conditioned at room temperature, whereas the exposed steel undergoes continual temperature changes. Using recommendations from the National Building Code of Canada and a report produced by specialty consulting engineering firm Rowan Williams Davies and Irwin, Inc. (RWDI) summarizing recorded temperature history for New York City, the team developed a temperature range of -80 °F to 70 °F to evaluate stresses and movements caused by the differential temperature. Thirty different thermal load combinations were applied to evaluate the effects of one side of the building having more differential temperatures than the other sides. These combinations also reflected a potential difference in temperatures between large, heavy steel members like the box columns and the light steel members such as the rods.

In the initial thermal studies, the analysis showed that the outrigger braces at the top of the building were successfully limiting the differential deflections between the exposed perimeter columns and the adjacent interior columns. At the east and west faces of the building, however, no outriggers were present, and thus the anticipated differential vertical deflection at the top of the building at these faces was approximately L/120 in the initial analysis. This movement was deemed to be too significant for serviceability issues such as floor levelness and compatibility with the façade system. To reduce the deflection on these faces, thermal belt trusses were provided on each face, which limited the differential movement to a more reasonable L/300.



A diagram of the "knuckle" connection, the primary exposed connection used throughout the New York Times Building project.

incorporated into the exterior steel notes on the drawings. Notably, all tolerances for exposed steel had to be one-half of typical AISC tolerances. The design team provided a corrective fix detail on the contract documents for column splices that were out of tolerance, that involved field welding thin tapered plates to visually smooth out the step in the two column shafts. The fabricator and erector both agreed that this was a very expensive detail and initially took special care to get the alignment of columns within tolerance. An on-site representative from Renzo Piano Building Workshop's office visually inspected every exposed splice before welding and, after a few slight adjustments, all columns met the required tolerance without the need to perform the corrective detail. In addition to tolerance requirements, the drawings noted that all penetration welds were to be ground smooth and seal welds were required at all joints between exposed plates. Special Charpy V-Notch requirements were applied for exposed steel to ensure ductile behavior of the steel undergoing continual temperature changes.

The owner and design team also commissioned a full-size mockup of the knuckle to be completed before the steel structure was sent out for bid. This mockup helped take the fear factor out of the bidders by showing that the connection was constructible within the tolerances indicated on the drawings. It became part of the contract documents as an example of the quality of work expected in the final product. MSC

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