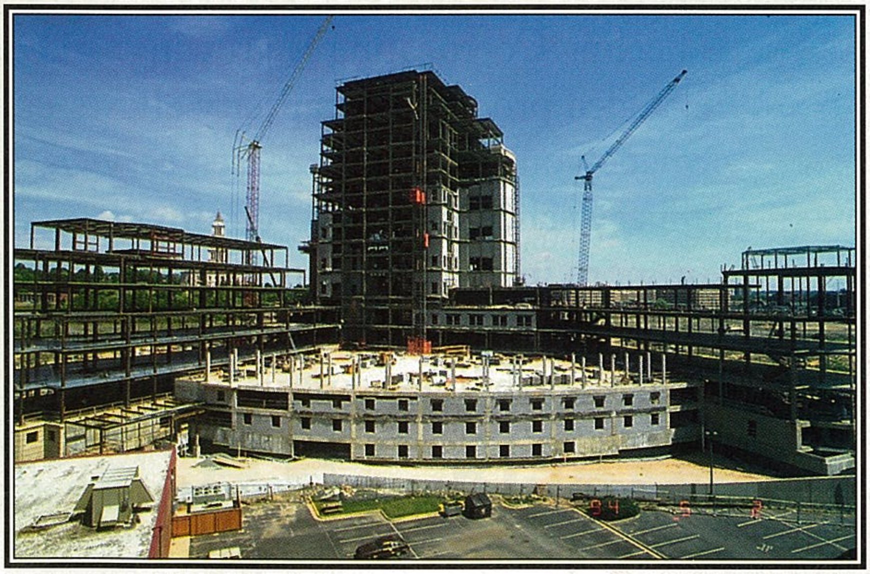
Steel Judged Best For New Courthouse

Steel's suitability for irregular bays and long spans made it the material of choice for a new courthouse in Northern Virginia



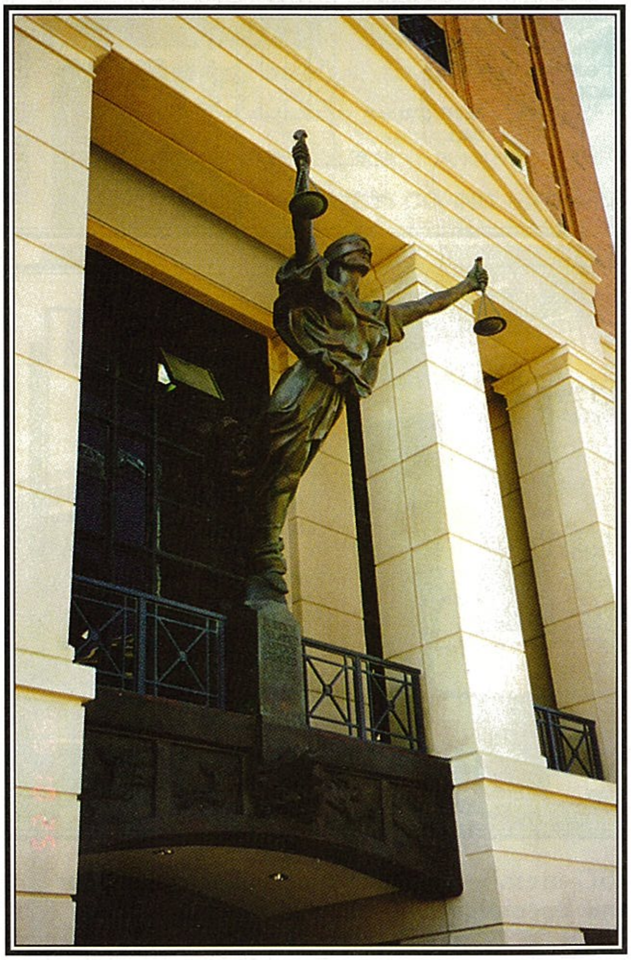
By Larry J. Willis, P.E.

WHILE IT'S NOT UNUSUAL FOR A DEVELOPER TO USE A THEATER OR A BIG-NAME RETAILER to anchor a new development, in a unique twist, a resourceful developer in Northern Virginia used a new federal courthouse to spur additional development.

The new United States Courthouse in Alexandria, VA, a close neighbor of Washington, DC, is the centerpiece of an 80-acre mixed-use development situated near Interstate 95. The landowners and developers, Carr-Norfolk Southern (CNS), deeded the courthouse's trapezoidal-shaped parcel to the federal government with the hope that the new courts building would anchor the development and attract additional commercial, retail and residential ventures. CNS further agreed to provide soil remediation, which was necessitated by hydrocarbon contamination from an old landfill that had occupied the site years before.

The 510,000-sq.-ft. facility is divided by expansion joints into four separate structures: an 11-story tower containing 15 courtrooms and judges chambers; a five-story wing for the U.S. Attorneys; a three-story wing for court support and administrative functions; and a two-story cast-in-place concrete parking structure topped with a landscaped plaza that infills the space between the tower and the two wings. The entire project footprint is underlain by two levels of cast-in-place concrete below-grade parking. Structural engineer on the project was Hankins and Anderson Consulting Engineers of Richmond, VA, and the architect was Spillis Candela/Warneke of Washington, DC.

The architectural design of the building was guided by a desire to express the dignity and spirit of the administration of justice, to reflect the character of nearby historic Old Town Alexandria, and to follow the guidelines of the development master plan, which called for an urban design emphasizing pedestrian scale and environment. The result is a stately building with a brick facade, numerous setbacks and terraces and large architectural precast cornice and parapet panels.



A beautifully executed statue showing the scales of justice rises above the main entrance to the new United States Courthouse in Alexandira, VA.

DESIGN STUDIES

During the concept studies, a comparative cost analysis of both concrete and steel gravity framing systems was performed on the tower portion of the building. Composite steel framing was compared to a one-way concrete pan joist system and evaluated on first cost, speed of construction and effect on the foundation. The steel solution was preferred on all three counts.

Speed of construction was particularly critical since the construction schedule required the shell of the tower to be constructed as quickly as possible in order to allow sufficient time for the extensive architectural finish work required in the 15 courtrooms and lobbies. The composite steel scheme also was judged to be better suited to the irregular column spacing throughout the tower and the 42-ft. spans over the courtrooms. The same framing scheme was used in the more regular low-rise wings for consistency and uniformity.

The selected gravity framing system was a 5¼-in. lightweight concrete slab on 2-in. composite deck with a maximum beam spacing of 10-ft.-6-in. Beams and columns are A572 Grade 50, except at drift-controlled wind braces and frames where A36 steel was used. The typical floor-to-floor height in the tower is 22-ft.-4-in. to accommodate the 20-ft.-high ceilings required in the courtrooms, which resulted in larger-than-normal column sections for the 11-story, 210-ft.-tall structure. Typical floor-to-floor height in the three- and five-story wings is 14-ft. A total of 3,100 tons of structural steel was

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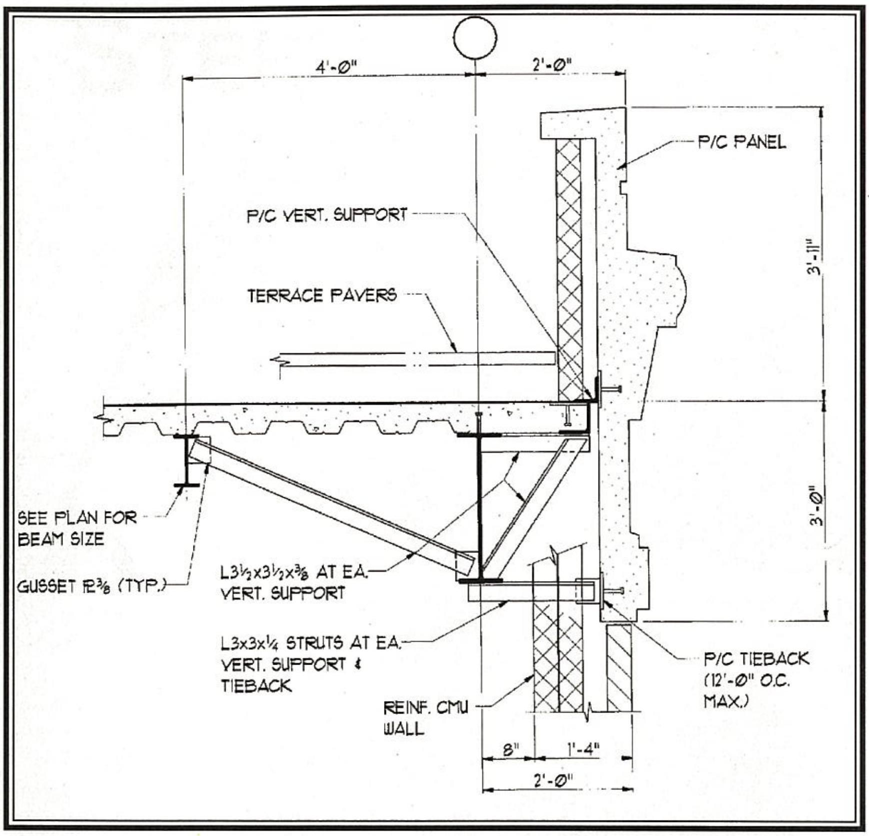

fabricated by AISC-member Lynchburg Steel and Specialty Co. and erected by L.R. Wilson Co. of Gambrills, MD. The heaviest lift on the project was a W14x500 column section weighing about 27,000 lbs. General contractor on the project was Charles H. Tompkins Co. of Washington, DC.

A lateral analysis concluded that wind loads governed for the tower, while seismic loads controlled for the long, narrow wings. Steel K-braces at elevator cores were used for the lateral system in the tower, with some floor requiring eccentric or single diagonal braces due to door interferences. Architectural constraints limited the maximum permissible width of the diagonals to 6-in., so 6-in.-wide rectangular tube sections were used to efficiently resist the axial wind forces. The tubes were slotted at the ends for gusset plate connections to the beams. At the lowest level of two of the tower K-braces, the tubes were coverplated on the top and bottom to increase their capacity while maintaining the maximum 6-in. width.

In the two wings, a desire for future flexibility in space layout led to the selection of rigid frames for the lateral force resisting system. Only two broad-face and two narrow-face frames were used in each building, which minimized the amount of field welding and concentrated the resistance into a fewer number of heavy columns and beams.

Exterior Cladding

The exterior skin of all buildings consists of 8-in. or 6-in. reinforced CMU and face brick with numerous offsets, jogs and recesses in the fenestration. Because of the 22-ft. floor heights in the tower, an intermediate girt line was required between floors to provide lateral support for the CMU walls. The perimeter columns were therefore designed for axial as well as bending loads caused by reactions of the rotated wide-flange girts. The brick is relieved at each floor of the tower, and at every other floor in the three- and five-story wings.

Because the main passenger elevator and stair shafts in the tower are located on an exterior wall, the absence of a slab required the use of side-by-side perimeter tubes to support the changing profile of brick and block. The heavy masonry skin and tall floor heights in the tower added significant load to the perimeter beams and girders and dictated strict attention to deflections in order to preclude cracking of the brick facade. The RAMSTEEL floor framing analysis and design program greatly simplified the deflection design with its feature allowing multiple user-defined deflection limits and assignment of various criteria to individual members.

The space above the lower ceilings in areas adjacent to the vaulted courtrooms was utilized for interstitial mechanical rooms whose elevations between floors coincide with the intermediate girt line of the perimeter walls. Situating the mechanical rooms between levels required relatively simple steel framing and eliminated the need to commit valuable square footage on the main floors, while facilitating acoustic isolation of the mechanical equipment.

Large architectural precast concrete cornice and parapet panels, nominally 5-in. thick, accent the brick facade at the various setbacks and roof levels. The panels, some as deep as 10 ft., are supported by the perimeter steel beams and cantilevered slab edges. Attachment of the precast panels was easily coordinated between trades, requiring only the placement of weld plates in the elevated slabs during the concrete pours and attachment of the bottom flange struts to prevent rotation of the steel beams.

The main entrance to the courts building is faced by large precast wall panels and four foot square column covers extending from the first floor to the fourth floor, all topped by a 45-ft.-long curved precast panel, backed up and supported by a steel bowstring truss. On a second floor balcony directly over this public entance stands a 3,500-lb. Bronze statue of Lady Justice, cantilevering over the entrance and greeting visitors passing through the monumental portal.

Transfer Girders

In the tower, building setbacks at the fourth floor significantly impacted the gravity framing by creating building columns that could not, for architectural reasons, extend to the first floor. Instead, eight transfer girders, with a maximum 42-ft.

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span, were used to support the eight-story-tall perimeter columns above—most of which, in addition to floor loads, support 160 vertical feet of exterior brick and block. Steel plate girders were chosen for the task and were designed to support either one column at midspan or two columns at approximately third points. Plate girder depths varied from 62-in. to 89-in., with some members controlled by stress and others by the deflection criteria of brick-supporting members. Most of the plate girders are composed of A36 steel, though two of them required A572 Grade 50. The heaviest weighed more than 17,000 lbs.

In two locations at the third floor, transfer girders supporting nine-story columns were situated over areas where required ceiling heights limited the members to wide flange beam depths. The 30-ft. span transfer girders were therefore designed as W36 beams with top and bottom cover plates. For connection to the columns at each end, the side-by-side beams were spaced to allow the webs to just pass by—and connect to—the outside face of both column flanges.

Foundation System

The presence of the old landfill on the site dictated the selection of a steel H-pile foundation system. The H-pile's ability to drive through underground debris from the landfill, and its capacity to develop both end-bearing and friction strengths in the soil, were important considerations. Sixty-ton piles were used under the two wings and the parking structure, while deeper piles were driven under the tower to achieve 80-ton strengths. Numerous piles were driven on a 1:3 batter to resist lateral loads at the base of the structure, which, in addition to wind and seismic loads, included as much as two full basement levels of unbalanced earth pressures. Approximately 2,100 HP 12x74 piles—a total of 84,000 linear feet—were driven on the project. To speed construction, the foundation design was released as an early bid package while the superstructure was still in the design development stage.

The high and variable water table at the site created design hydrostatic uplift pressures of 425 psf at the lowest level of underground parking, requiring a thick structural base slab and tension piles for anchorage. The large surface area of the H-piles provided adequate soil skin friction, and the natural tensile capacity of the steel pile itself left only a simple tension anchorage detail at the 12-in.-thick base slab to complete the load path resisting the large buoyant forces on the building.

Although reinforced concrete buildings predominate in the Washington, DC, metro area, steel proved to be well suited to the irregular bays and long spans in this project. In addition, it permitted rapid erection and was the low-cost alternative.

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