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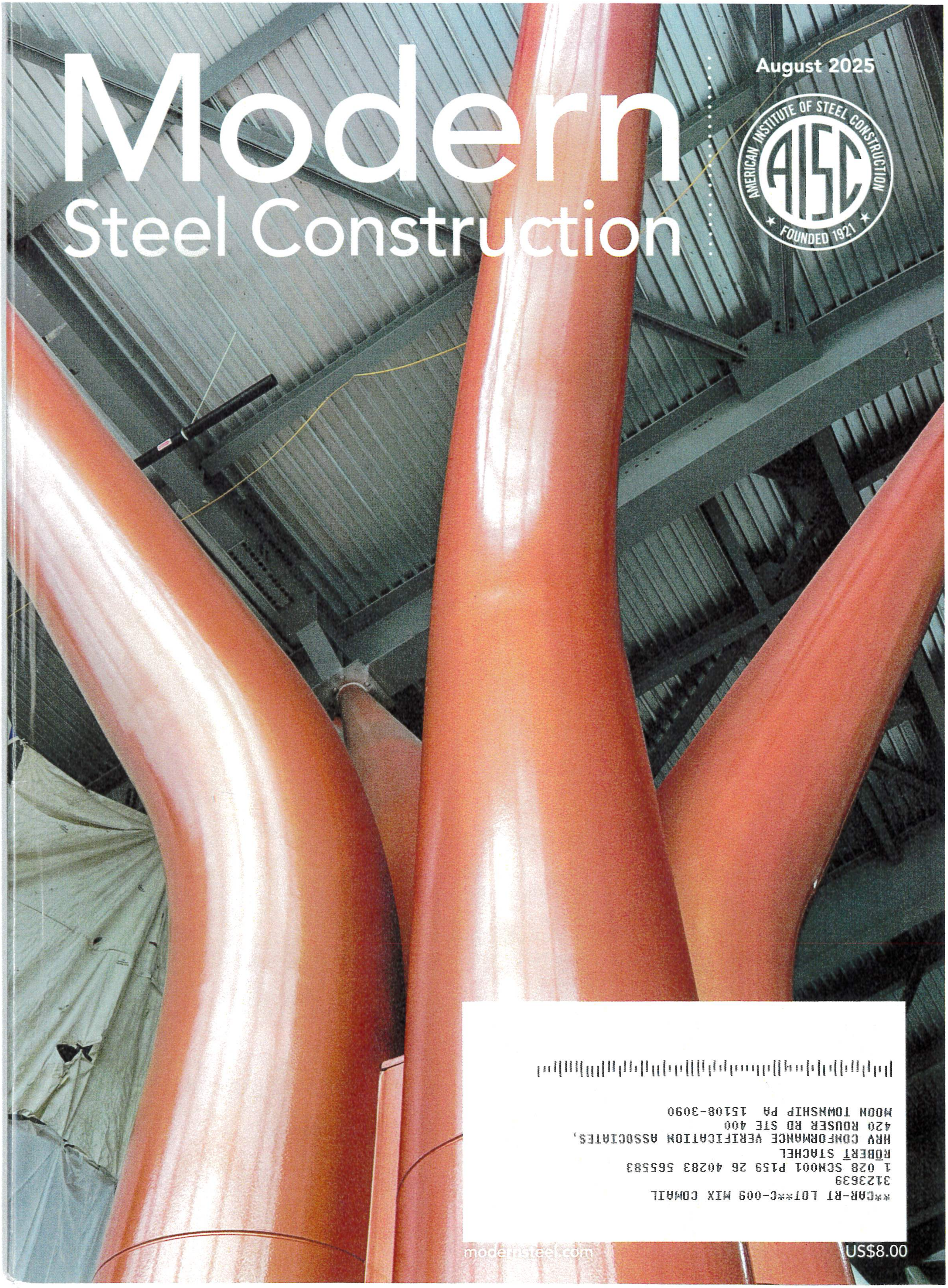

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Tree columns and an organically formed roof are the steel backbone of Pittsburgh's new airport terminal that will transform passenger experience.

Rooted in Innovation

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Gensler and HDR in association with luis vidal + architects

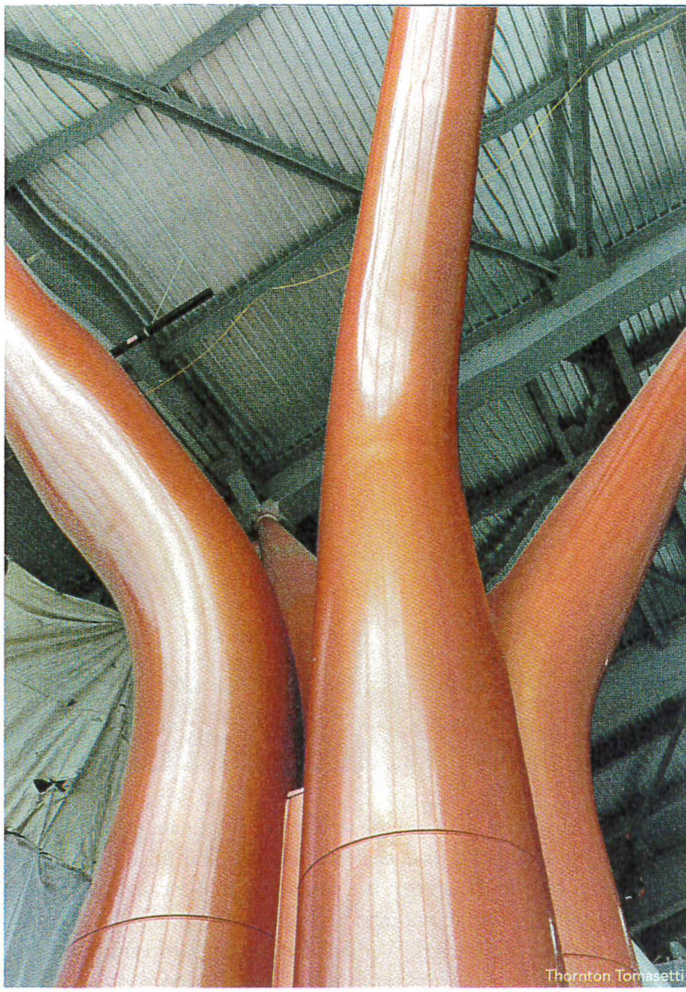
PITTSBURGH IS SOON TO WELCOME a striking addition: a new terminal at Pittsburgh International Airport. With its exposed steel tree columns, unique architectural roof form, and challenging site conditions over active tunnels, the 800,000-sq.-ft, three-story steel structure showcases how collaborative design and innovative thinking can deliver elegance and efficiency on even the most challenging of projects.

The new terminal is an architectural statement and a crucial efficiency boost for the airport that meets the market's current needs. The $1.7 billion project consists of a new pre-security building and a multi-modal complex focused on the Pittsburgh passenger rather than a single airline. It replaces the old landside terminal, which is located a half-mile from the passenger gates and connected to them by an automated people mover (APM). The new building is immediately adjacent to the existing concourses, providing better connectivity for passengers and eliminating the APM. The Allegheny County Airport Authority estimates the project is generating about $2.5 billion in economic activity for the region, including more than 14,00 jobs.

The terminal's distinctive rolling roofline is inspired by the region's topography. The roof is supported by 38 architecturally exposed structural steel (AESS) Category 1 tree columns spaced up to 120 ft apart, creating a vast entry point for travelers (learn more about AESS at **aisc.org/AESS**). The roof cantilevers roughly 60 ft beyond the building façade, sheltering the curbside drop-off area and visually linking the structure to the adjacent landscape. The new terminal includes four outdoor terraces—two landside and two airside, a rarity for U.S. airports—offering further views of the surrounding topography.

Building Above Constraints

The new terminal presented a major design challenge with its location directly above the APM and utility tunnels. These tunnels are critical to the current function of the airport and were required

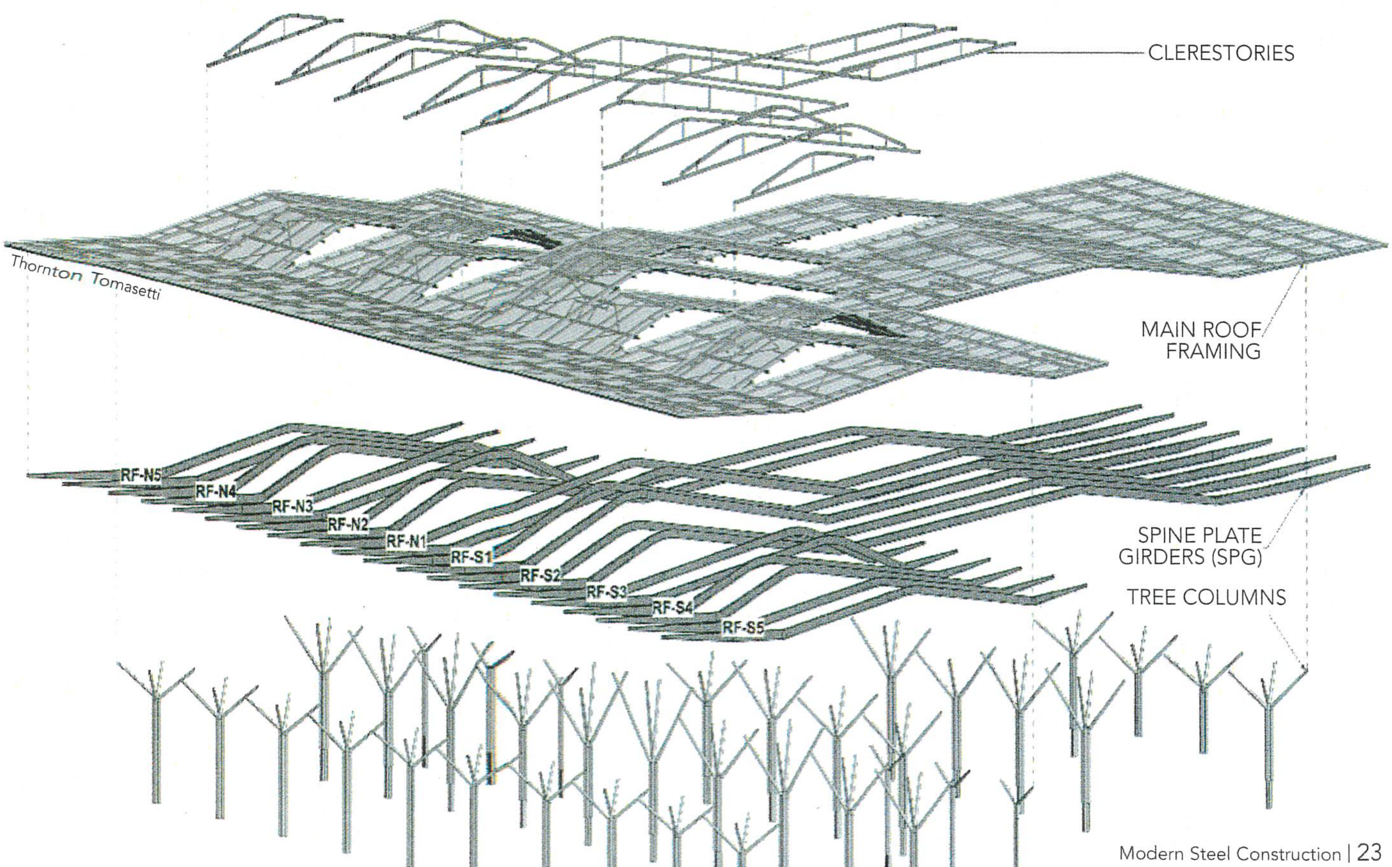


left: A tree column with a finished coating.

below: The tree columns are spaced as far as 120 ft apart.

opposite page: A rendering showing the terminal roof and the AESS Category 1 tree columns that support it.

below: HSS tree columns support custom plate girder spine elements. Both create moment frames in the east-west direction. The spine elements support conventional roof framing.




The roof cantilevers 60 ft over the road and is inspired by the region's topography.

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to remain fully operational during construction. The design solution to accommodate the tunnels is a structural slab at grade supported by a series of long-span grade beams—extending as long as 70 ft—that in turn support the loads from the grade level and serve as transfer girders for the building columns above.

Due to the heavy column loads and limited depth between the top-of-tunnel and top-of-slab elevation, up to 5-ft-deep embedded 50 ksi wide-flange steel plate girders were introduced at many locations. These plate girders were designed compositely with the surrounding concrete to maximize their efficiency.

The size and length of the plate material required for the plate girders, up to 4 in. thick and 52 in. wide, necessitated the introduction of splices. Several of the girders were multi-span members to take advantage of continuity and enhance structural performance. The Thornton Tomasetti design team and steel fabricator, Sippel Steel Fab in Ambridge, Pa., collaborated to determine splice locations that would minimize demand to allow the splices as bolted connections rather than field-welded connections. The resulting connections used 1⅛ in. A490-SC-B bolts in double shear.

Consistency Among Variation

The sculptural and structural tree columns are composed of four 20-in. round steel sections, press-brake formed from 1½ in. plate and bundled into a trunk that is 44 in. by 44 in. out-to-out. These sections then diverge to form four branches that taper from 20-in. to 14-in. diameter sections. However, the tree columns' key component is the transition "elbow." Although the tree columns' geometries are unique from location to location and branch to branch, this small "elbow" segment is made up of the same 20-in. round section, which is bent at a constant 5-ft radius. The length is then dictated by the distance needed to achieve the intended angle of each specific location. This repetition enabled efficient fabrication while preserving the organic visual.

Fire protection of these columns was achieved not through traditional prescriptive approaches, but via performance-based fire engineering. In this approach, fire conditions are simulated to evaluate the actual structural performance in the event of a fire.

Provisions were made so the structure can remain stable under fire conditions. In this case, each tree column was filled with concrete up to the roof such that the concrete could act together with the steel to carry the temporary loading condition, should the fire reduce the steel's strength. Varying levels of reinforcement were provided within the trunk and some branches of the columns, depending on the degree of loading. In some of the heaviest loaded cases, small W10 built up wide-flange sections are embedded within the round sections to provide additional strength.

The structural concrete methodology allowed for a smooth paint finish in lieu of the orange peel appearance typically associated with intumescent coatings. Not only does this provide an architecturally pleasing aesthetic, but eliminating intumescent paint saved more than $1 million in construction costs.

Procurement and fabrication of the tree columns involved an elaborate supply chain, which included multiple vendors and unique challenges at each step. One example is the joint preparation at the elbow-to-trunk CJP weld. The induction bending process for the elbows creates wall thickening at the intrados and wall thinning at the extrados. A uniform wall thickness is required to fit backing for the CJP weld. To address the varying wall thickness, the internal surface at the extrados was face welded after bending and the entire elbow was sent to a machine shop, where the ends were face-milled and backing groove-cut using a CNC controlled five-axis machining center.

Assembling the tree columns was a multi-step process, starting with CJP welding the trunk section to the elbow. Afterward, any rebar or embedded wide-flange material was installed. Next, two of these "hockey stick" sections, made up of one trunk section connected to one elbow section, were connected with a stitch plate into "dumbells." Electrical conduits were then placed in the inner void to allow for lighting to be installed after erection was complete. The last step in the shop was to assemble two "dumbells" together and complete all AESS requirements. The branches, formed using a press brake and flat trapezoidal plates, were attached to the lower column section in the field. This approach of field-attaching the branches helped with shipping and ensuring proper positioning within construction tolerances.

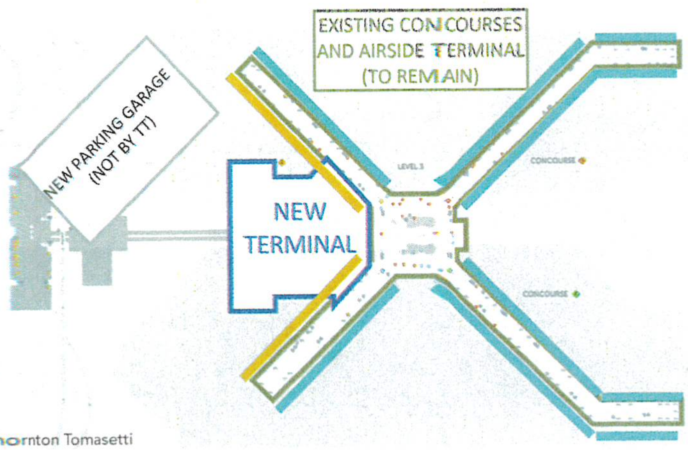
A Hierarchy of Elements

Like the columns, the roof system is built around efficiency and repetition. Primary 5-ft-deep "spine" plate girders—spanning up to 120 ft—rest on the branch tips, which have a 30 ft spread. They support conventional wide-flange framing and double angle diaphragm bracing, which is strategically oriented to coincide with the roof curvature.

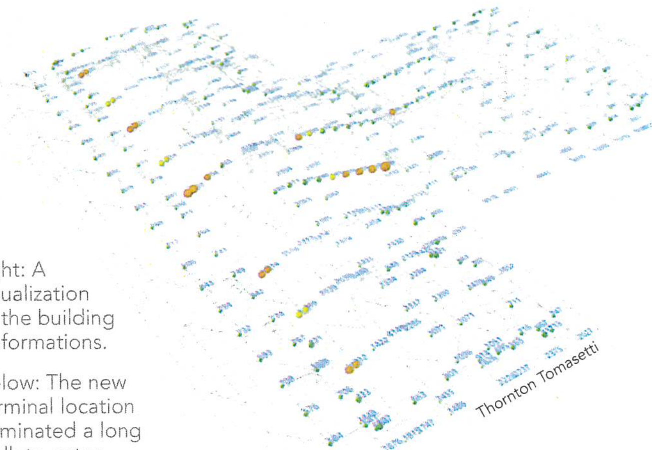
Each pair of spine girders over a given roof column (a ribbon) works as a moment frame for lateral support in the east-west direction, transferring lateral forces to lower-level braced frames. Similarly, in the north-south direction, moment frame action is used in areas where ribbons run coplanar. In other cases where the ribbons separate to form clerestories, each tree column works as a cantilever column.

Because the diaphragm is discontinuous at clerestories, special attention was given to ensure allowable drifts were achieved. A custom Grasshopper script automated the drift process due to the number of unique areas. Additionally, where ribbons crossed and intersected, special detailing allowed load transfer and ensured geometric compatibility.

Parametric tools and automation aided in many aspects of the design of this project, including generation of the roof framing layout. With the framing strategy defined, the roof framing was generated by starting with an architectural roof surface defined in Rhino. A Grasshopper script then applied the structural layout onto the architectural profile. The resulting configuration was converted via Konstru into a structural analysis model and then pushed to Revit for documentation.

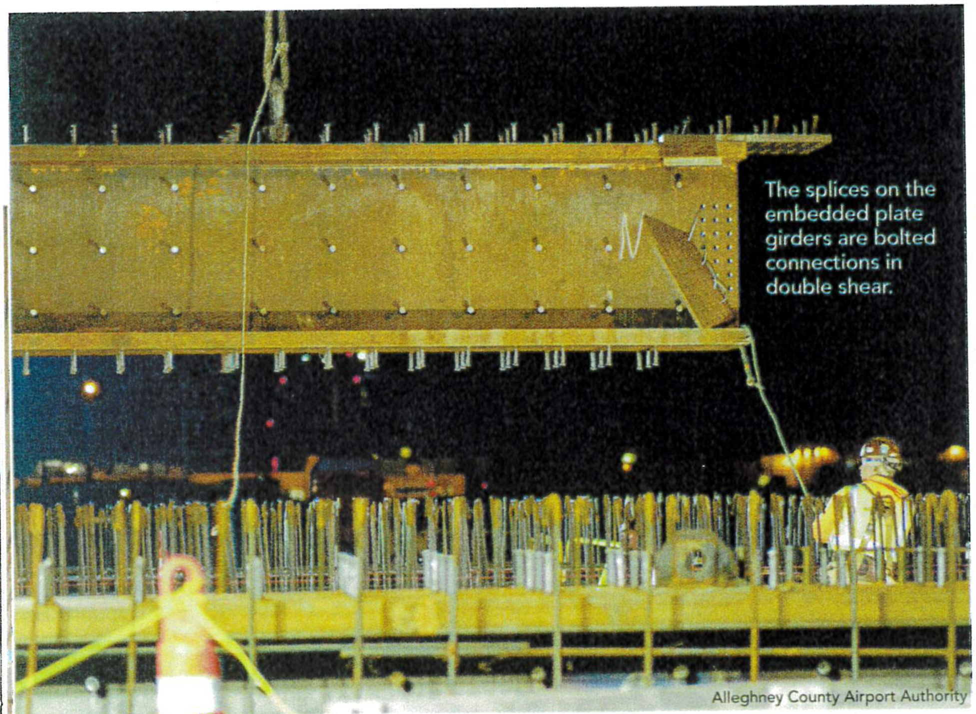


Thornton Tomasetti



right: A visualization of the building deformations.

below: The new terminal location eliminated a long walk to gates.


The splices on the embedded plate girders are bolted connections in double shear.

Allegheny County Airport Authority

Using parametric modeling methods allowed for rapid iteration during early design phases and enabled the design team to generate a Tekla model of the building, which was delivered with 100% construction documents. Creating the Tekla model ensured proper communication of the complex 3D structural geometry rather than solely relying on 2D drawings.

Erection Process

The erection procedure needed to address multiple competing objectives. The position tolerance and the erection sequence required by the structural design necessitated adjustment of the bearing elevations after roof erection and prior to welding the branch to the elbow. The elbow-to-branch CJP joint required close control of the final joint geometry.

These considerations were addressed by using a steel falsework system that provided


An embedded 50 ksi plate girder being set into place.

Allegheny County Airport Authority

The project uses 15,200 tons of structural steel.

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safe temporary support of the branches while permitting for field adjustment of the top-of-branch elevation. Roof girders and beams were pre-assembled on the ground and installed on branches supported by the shoring system. After completing the roof erection on the shoring system—prior to tensioning the bolted connections and completing the field welds—the top-of-branch elevations were surveyed and adjusted.

The branch sections of the tree columns were field-spliced to the trunk section at the elbow by all-around CJP welds. The finished weld was exposed to view and was subject to AESS Category 1 requirements. Due to the weld quality, productivity, and aesthetic challenges, the erector elected to use a shielded flux core welding system that required tenting of intersections to provide a controlled welding environment.

After the shoring system was removed, the actual building deflections at specified control points were surveyed. These deflections were compared to deformations predicted by the structural analysis to confirm the performance of the completed structure.

The terminal project cost $1.7 billion and used 15,200 tons of structural steel. When it opens in fall 2025, the new terminal will offer passengers an improved experience and a more efficient journey to and from their gates. It is more than a functional upgrade, though. It's a display of innovative and thoughtful structural design realized through creative thinking, technology-driven workflows, and close collaboration across the entire design and construction teams. ■

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