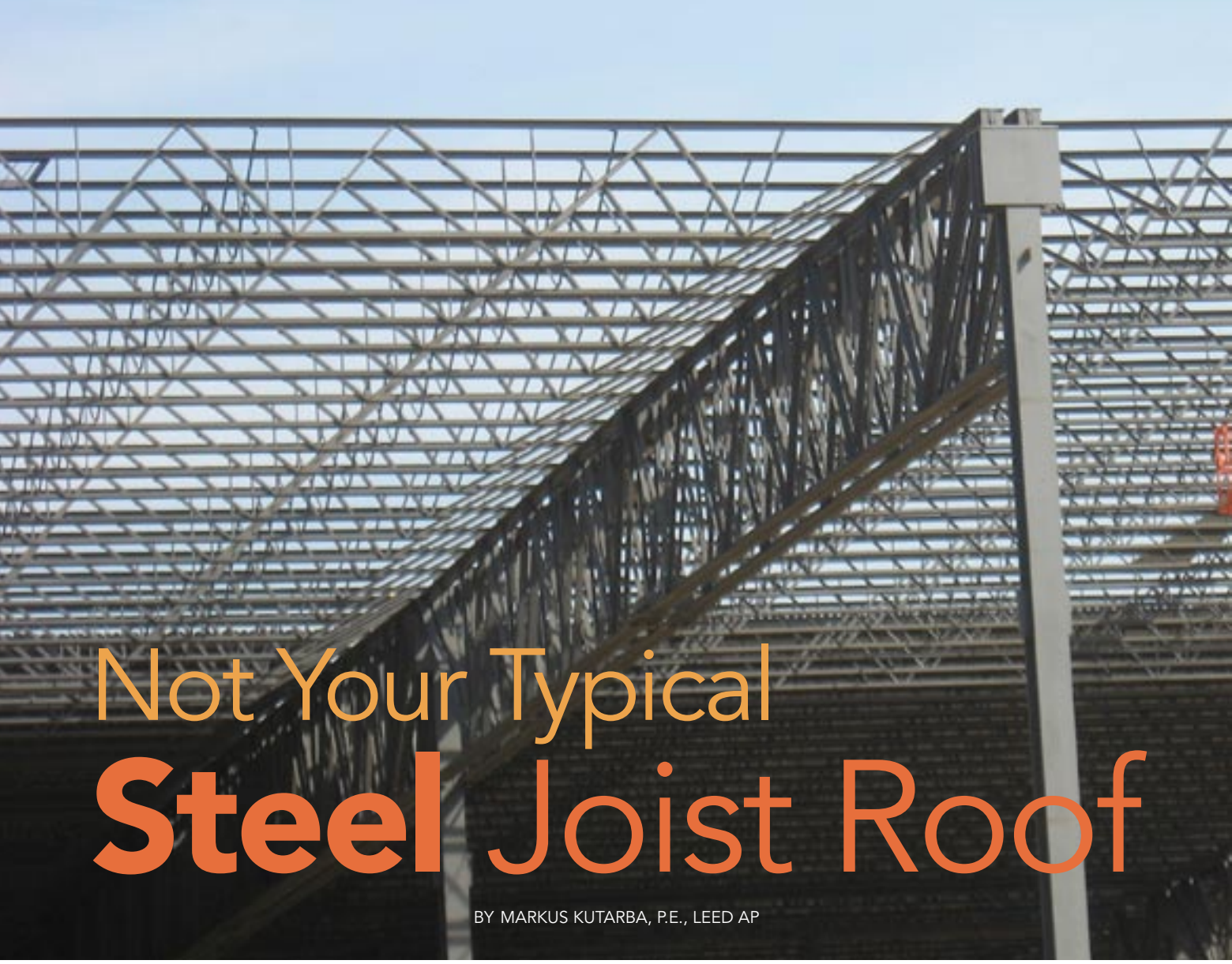

Not Your Typical **Steel** Joist Roof

BY MARKUS KUTARBA, P.E., LEED AP

Using long-span open-web steel joists helps minimize column requirements and maximize clear space.

WHILE LONG SPAN trusses seemed like the obvious way to frame the large roof expanse of a new North Carolina manufacturing facility, the design-build team instead relied on a more economical bar joist system.

The facility was designed by the Haskell Company in Jacksonville, Fla., as a 15-month fast-track project. It was built specifically to accommodate the manufacture of huge aircraft fuselage sections found in today's largest airplanes.

The project is a 585,000-sq.-ft structural steel-framed building with an insulated metal panel envelope. The fully environmentally controlled facility consists of 150,000 sq. ft of Class 100K-ISO8 clean room environments, 170,000 sq. ft of fabrication and assembly rooms, a specialized room for one of the world's largest autoclave units as well as tooling maintenance and prep areas. Most of these areas are covered by overhead crane zones. The single largest crane zone covers 65,000 sq. ft. Overall the factory measures 1,070 ft by 718 ft. Because of the very large size of the components being manufactured, all rooms were required to either be column-free or have as few interior columns as possible.

Because of the tight time constraints, it was critical that standard, readily available steel shapes were utilized in the design and construction. Part of Haskell's integrated delivery model includes its own steel fabrication shop whose staff researched warehouse and steel mill inventories to determine what shapes were available. At that time the largest column available was a W14x311 and the steel shop immediately placed an order for that material.

Next, the parameters for the overall design were established. The project's scope was to provide two manufacturing areas connected by a transportation core. The first area consists of two clean rooms in which large composite aircraft parts will be manufactured. Once fabricated, these parts will be taken to the autoclave for curing and then to the last two fabrication rooms for the finishing work. The clean rooms measure 300 ft by 310 ft and 370 ft by 175ft. Each fabrication room is 520 ft by 130 ft and the transportation core is 670 ft by 82 ft. For comparison, the field for NFL football measures 300 ft by 160 ft, which makes this facility larger than 12 football fields.

Two types of roof framing systems were considered for this facility, a bar joist/joist girder system and a traditional steel truss solution. The

▲ The new manufacturing facility includes two very large clean rooms, which are side by side in the left portion of the facility shown in the photo; a 670-ft-long central transportation core; and two fabrication rooms, each of which is larger than a football field.

▼ The "Oversized Load" flatbed tractor trailer being unloaded gives some perspective on the expansiveness of clean room No. 1, which is about the size of two football fields side by side.

▲ Eight of the ten joist girders in the clean rooms were installed as closely spaced double joists in order to maintain deflection limits in crane zones.

➤ Clean room No. 2 provides a clear space 300 ft long and 175 ft wide served by three 10-ton cranes suspended from the roof structure.

latter was dismissed due to its cost and the extended field assembly schedule it would have required. At that point the Vulcraft Group, Florence, S.C., was engaged to assist with the design process.

The plans called for a 42-ft-high ceiling suspended from joists in clean room No. 1 with a joist bearing height of 65 ft at the high point and 59 ft, 3 in. at the low point. In addition to dead load and live load, the roof members were required to allow maintenance personnel to walk on the clean room ceiling for service work and to support 15-ton cranes with the crane typical deflection limit of $\frac{1}{600}$. The final design in clean room No. 1 used 132-ft-long, 5-ft, 8-in.-deep LH joists at 5 ft, 6 in. on center and ten special joist girders, all supported on four interior columns.

The special joist girders were roughly 100 ft long, up to 10 ft deep and had tapered top chords in order to achieve the required 7-ft clearance for maintenance work above the ceiling. Eight of the ten joist girders were installed as closely spaced double joists in order to maintain deflection limits in crane zones. Due to the large spans,

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In the fabrication room two 10-ton cranes are suspended from the joists.

each of the four interior columns is supporting about 25,000 sq. ft of roof and walkable ceiling area. Because that exceeded the load carrying capacity of a 60-ft-tall W14×311 column and larger columns were not available, 1½-in.-thick flange plates were added to increase the load carrying capacity.

Clean room No. 2 was slightly smaller and therefore the design team decided to use 175-ft-long, 12-ft, 2-in.-deep joist girders at 30 ft on center with K-joist spanning in between to provide a column-free space. A walkable ceiling and three 10-ton cranes were suspended from the roof structure in this clean room. Due to the building geometry, an expansion joint was required at the north end of this room. Haskell's engineers accomplished this by placing all joist girders on slide bearing plates.

The fabrication rooms are similar to the clean room with 10-ft-deep joist girders spanning 130 ft spaced at 50 ft on center supporting LH joists between them. Crane coverage was provided by suspending multiple rails 20 ft below the roof structure for two underslung 10-ton cranes.

While the transportation core is somewhat smaller than other areas, its design was no less complicated. The architect required an 80-ft-wide column-free traffic space at the ground level with a full-length equipment floor above. The Haskell engineers, in collaboration with Vulcraft, designed the roof of the transportation core using 12-ft-tall by 82-ft-long bowstring joists with the bottom chord bearing at 60 ft above the ground level. LH joists spaced at 7 ft, 6 in. were used to construct the composite floor system which accommodated the long span. In addition, to provide lateral stability, some of the joists were designed to act as 82-ft-wide by 60-ft-high, two-story moment frames through the addition of diagonal kickers between the bowstring and composite floor joists and columns.

Overall, 3,500 tons of joists, 600 tons of roof deck and 4,000 tons of structural steel were erected in approximately three months. The entire building envelope was completed in six months. Only six interior columns are used to support the roof structure; all other columns are hidden in walls.

Key to the project's success was the decision to use all joists to their maximum capabilities. For example, some of the roof joists in

Crane rail hangers being installed in the clean room.

The 585,000-sq.-ft structural steel-framed building is fully environmentally controlled and is large enough to allow the manufacture of sizeable composite aircraft components, such as sections of the fuselage.

➤ The ground level of the transportation core features an 80-ft-wide column-free traffic space with a full-length equipment floor above.

▲ The second floor mechanical room under construction.

➤ For this second floor mechanical room in the transportation core, LH joists support the composite floor while 12-ft-deep bowstring joists support the roof above.

this facility are supporting a combination of roof dead and live loads, loading from the walkable ceilings and crane loads of up to 35,000 lb. MSC

Design-Build Contractor and Steel Fabricator
The Haskell Company, Jacksonville, Fla.

Joist Supplier
Nucor Vulcraft Group, Florence, S.C.
(AISC Member)

Steel Erector
Summit Erectors, Inc., Jacksonville, Fla.
(IMPACT and SEAA Member)