An industrial facility downsizes its roof trusses to meet new interior clearance requirements.

Making Room

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▲ Virtual 3D model (Revit elements inside the point cloud).

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COMPLETED IN 1956, the Ford Sterling Plant in Sterling Heights, Mich., was originally constructed to house the production of chassis and drive shafts.

After more than 50 years in operation, it recently required an upgrade to its heat treating operations with the installation of an acetylene-powered furnace—which would require a reconfiguration of the vertical space.

The building is steel-framed with a roof structure composed of steel beams (purlins) and trusses supported by steel columns. The typical bay has jack (or girder) trusses spanning 50 ft and carry trusses spanning 45 ft, with two intermediate trusses per bay; the carry truss and jack truss depths are 6 ft, 2 in. and 6 ft, 10 in., respectively, and the clear height to the bottom chord is 18 ft. The furnace is approximately 40 ft long, 20 ft wide and 16 ft high and required a one-ton overhead bridge crane used for burner tube replacement. As such, the furnace and crane clearances could not fit into the 18-ft clear height.

➤ Shoring of the truss to be modified.

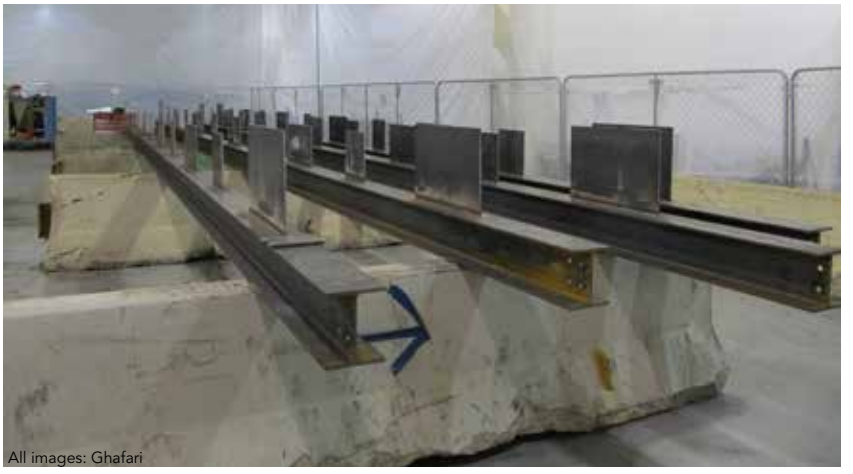
Historically for situations like this, the engineering solution has been to raise the entire roof framing system to provide sufficient clearance. This solution, however, has its shortcomings, including exposure of the construction area to external elements and the creation of snow drift loading on the surrounding roof, which requires additional reinforcing costs. Structural engineer Ghafari Associates would need to come up with an alternate solution that would increase the interior headroom without raising the roof.

Existing Conditions

But before any structural design started, a high-definition laser scan of the area was performed to obtain a virtual 3D image of the existing conditions. After the scan was completed, the data was imported as a "point cloud" and then modeled in Revit. NavisWorks was used to integrate the existing structure, furnace crane and duct-work layouts. This integrated file was used for "what-if" space planning, during which the Ghafari team tried a few different solutions and layouts to determine exactly how much clearance would be needed. The team concluded that the most effective and economical solution would be to modify the depth of five carry trusses and raise the bottom chord height by 2 ft.

The existing carry trusses are Pratt-type trusses, divided into six internal panels. All truss members were made of double angles in A9 steel with riveted and bolted connections. The plan was to replace the double-angle bottom chord with a wide-flange member (W8x28, 45 ft long) at the raised bottom chord height. The truss web members would then be cut to length and reconnected to the new bottom chord. The reworked truss would essentially be a hybrid Vierendeel truss in which web members and their connections would be modified for moment resistance resulting from the new configuration (the Ghafari team performed the analysis using RAM Elements).

▲ Truss with the bottom chord removed.



➤ New bottom chord members with gusset plates, ready to be installed.

All images: Ghafari

Installation of the new bottom chord.

The specific sequence of construction was essential to the structural design approach, especially the jacking procedure, and after all roof live loads and collateral loads were removed from the area of influence, the jacking was performed in two phases. The jacking frames were located at each truss top chord panel point. The first phase was to support the truss in the original position without lifting the truss. In this position the truss was fully shored at the top chord such that the bottom chord could be safely removed. The second phase was to engage the jacks to provide top chord camber meeting the original truss top chord design profile plus additional camber to account for the truss self-weight. In this position the truss was reworked with all necessary steel reinforcements along with the installation of a new wide-flange bottom chord. The bottom chord at this point was still not fully fastened to the jack trusses and the columns, in order to avoid stressing the jack truss verticals and the columns in bending once the jacks were released. After all the steel work was completed, the jacks were released and the truss deflected under the self-weight into the original design shape. At this time the bottom chord was fully fastened to the jack truss verticals and the columns. Once all the trusses were reworked, the bottom chord bracing was installed to complete the construction.

The project was performed entirely by in-house Ford skilled trades. In the end, the solution saved approximately $700,000 compared to the traditional method of raising the entire roof structure, which would have been roughly $850,000. The truss modification construction took approximately six weeks to complete, keeping Ford's scheduled furnace installation on track. MSC

All five trusses are completed.

Completed construction.

Owner
Ford Motor Company, Sterling Heights, Mich.

Construction Manager
Walbridge, Detroit

Structural Engineer
Ghafari Associates, LLC, Dearborn, Mich.