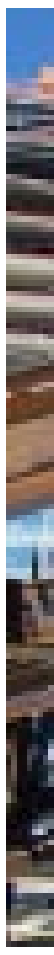


Erecting Crystals

BY PATRICK M. HASSETT, S.E.

How engineering the dynamics of erection led to structural stability.

THE BUILDING GEOMETRY of the Crystals retail and entertainment district at CityCenter in Las Vegas features a one-of-a-kind roof structure consisting of 19 distinct and challenging shapes. The steel fabricator and erector, Phoenix-based Schuff Steel Company, planned out the detailing of column and truss assemblies and their connections, to work with the anticipated general sequence of erection. However, even that was no easy task because the erection of this structure would be highly complex. Schuff engaged Hassett Engineering Inc., Castro Valley, Calif., to engineer the step-by-step erection scheme for the project.

Sequencing and Shoring

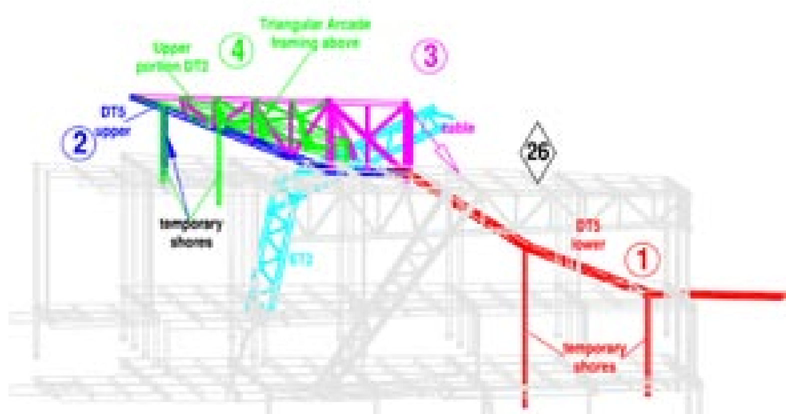
The intricacy of the roof arcade systems was incredible. In many cases, one area to be erected was dependent on the next area for support. With clever sequencing, the need for shoring could be minimized. Nevertheless, four shoring towers and many individual temporary members were designed, detailed, fabricated, and erected. Schuff had established the conceptual sequences, which we were to verify and adjust by working out the details.

The construction management of this job allowed the use of the structural engineer's structural SAP model for the erection engineering. The model was broken down by taking the entire model and deleting the areas yet to be erected. Thus, an erection "sequence" could be modeled and analyzed to determine the problems with strength and stability of each sequence. Once a particular sequence of steel was analyzed and resolved, the next significant sequence was added to the model and the process was run through again.

The shoring towers and temporary members were designed and modeled by inserting members into the SAP model that were sized to provide lateral stiffness for the system due to the rather large P-Delta affects. If the towers were stiff enough, the ironworkers would be able to use the platforms on the shoring frames to push, pull and jack the roof trusses into position within the acceptable tolerance.

Coordinates of physical members were measured by 3D GPS targets that were marked on members in the shop.

Close coordination with the detailer was needed for the temporary member and shoring designs. Using export files from the SAP models, 3D images were conveyed to the detailers, as well as to the superintendent. In return, detailers forwarded their model, developed using Tekla Stuctures, for our review and verification of detailed geometry of our temporary members. That model was used extensively by us, as well as by the superintendent in the field, to visualize the puzzle that we were tasked with assembling.



Erection plan drawings were generated by working with individual pieces and assemblies from the 3D model. Note the inclusion of temporary shores and cable attachment requirements.

This article is the basis of a presentation the author will make at The Steel Conference, May 12-15 in Orlando, Fla. Learn more about The Steel Conference at **www.aisc.org/nascc**.

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Extra tabs and attachment points had to be provided for the variety of cables that stabilized structural elements throughout the steel erection.

Lifting devices engineered to allow the crane to hold members at the proper skew and slope reduced the brute force required of the ironworkers in making connections.

Lifting and Stability

Trusses and column assemblies were strategically detailed and built up in the shop and shipped to the field for erection. Assemblies that were too large to ship were built up on site and hoisted into place. We engineered lifting devices to support members as they were lifted, while orienting the member in its final skew and slope to which it would match up with the support members. Because most of the beams and trusses were canted and skewed, and most columns were sloped, the erector benefited greatly from the members hanging correctly during the lift. That enabled crews to swing members into position with little need to force them by twisting and leveraging them against their own weight.

Many trusses and beams were on the borderline of instability for the practical purposes of steel erection, and were clearly identified on our erection plan ("EP") drawings. Guying requirements, and/or tie-in members were noted to be installed prior to release from the crane. Due to the leaning columns and the sloped and canted trusses, many were noted to have the end connections completely bolted prior to release from the crane.

Logistics and Communication

To add to the complexity of this project, the site was extremely congested. Due to a tight schedule coordinated by the general contractor, multiple trades found themselves working closely amongst each other. Therefore, the site logistics had a big influence on the sequences of member erection and the measures that were necessary for stability.

As with any erection operation, the erection engineering procedure must start with an understanding of the capabilities and regular practice of the erection crews. Level of stability and lateral strength during erection are based on the available manpower for plumb-up, bolting and welding. On this job Schuff's superintendent kept the bolting and welding crews close behind the erection. Completed bolted connections provided integrity of the partial structure, for which this type of erection was essential.

A job as challenging as this was bound to have special cases and changes of sequence. Regular site visits, and communications with the superintendent on a daily basis, kept our engineering on track with the practicalities and the special conditions on this job and adjustments to the erection plan were made as required. This ongoing communication contributed significantly to the successful erection of this extreme structure. MSC

Design Architect for the Crystals
Studio Daniel Libeskind, New York

Architect of Record for the Crystals
Adamson-Associates, Toronto

Structural Engineer
Halcrow Yolles, Las Vegas (AISC Member)

Steel Fabricator and Erector
Schuff Steel Company, Phoenix (AISC Member)

Steel Erection Engineering
Hassett Engineering, Inc., Castro Valley, Calif. (AISC Member)

Steel Detailer
BDS Steel Detailers, Tempe, Ariz./ South Brisbane, Australia (AISC Member)

General Contractor for CityCenter
Perini Building Company, Las Vegas