Taking the COMPLEXITY out of Complex Erection

BY THOMAS P. GETSCHMAN, PE

Unique steel structures sometimes require complex steel erection bracing, and successful bracing requires successful strategizing.

THE KEY to complex erection bracing projects is not unique, "one-off" bracing *schemes* used past on projects, but rather the *strategies* used to overcome complex erection bracing issues.

Here, we'll discuss some of the the strategies that erectors and erection engineers can use to help them achieve success on complex steel erection bracing projects.

Acknowledge Roles

The first strategy is more of a philosophy that should be considered for any erection bracing project. I recently had an informal conversation with the safety director for a client who stressed this point to me in a way that I hadn't previously thought of. His comments focused on the role of the erector in the design/construction process. From the owner to the architect to the engineer to the steel fabricator and detailer, the last person in the process that will have the final influence on the steel structure is the erector. The erector will ultimately have the final contribution to the steel structure as to how the structure will look as envisioned by the architect, perform as designed by the engineer, fit as produced by the fabricator and succeed as envisioned by the owner—and because of that the erector has the final say in the overall process. It is all the more reason for the erector to be engaged in the design/construction process and for the other project team members to understand and accept the role of the erector as influential to the overall success of the project.

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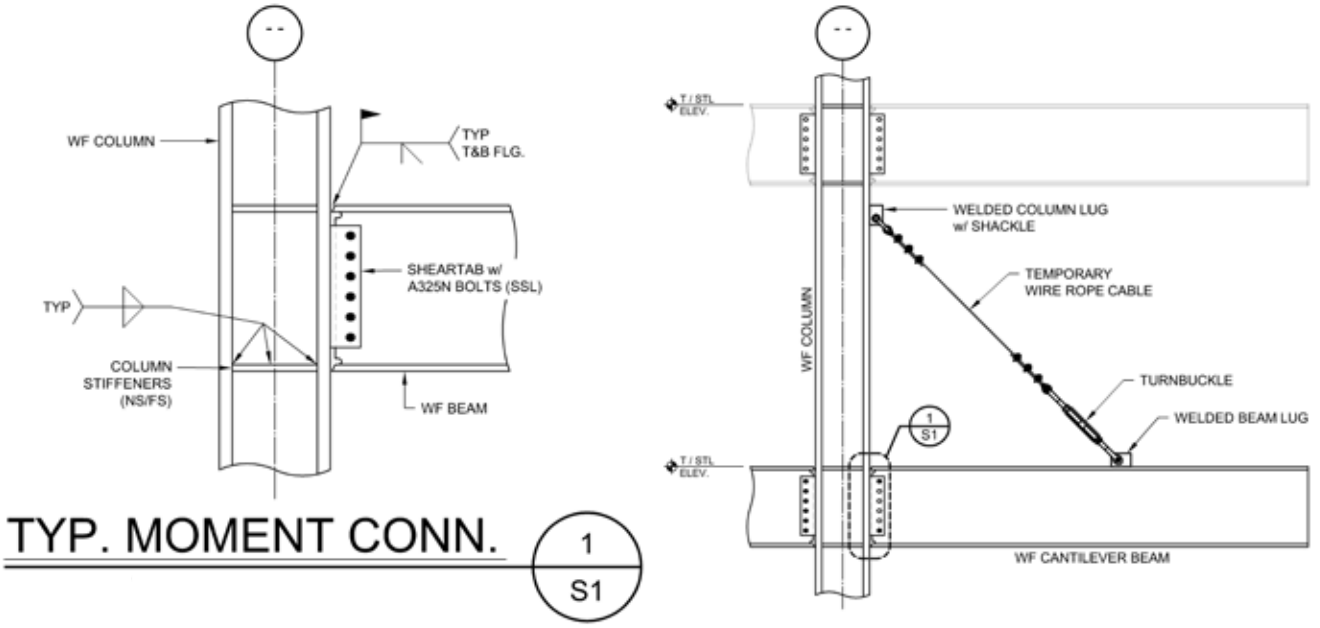
Get Involved

The influence of the erector in the construction process would logically lead to the erector's influence in the design process. The erector should get involved in the design process as early as possible, certainly as soon as contractually obligated if not sooner. Efforts that are put forth by the erector in the pre-bid phase will give them a leg up in the proposal and selection process and will allow them to influence the design before it gets to the detailer. Any decisions made by the owner or design and construction team, that will have a significant impact on the structural steel erection, should incorporate the erector.

One of the most significant groups of decisions that drives the structural steel erection plan and stability bracing of the structure centers on crane size, crane type, quantity and lo-



Any connections that participate in the lateral load resisting system of the structure, along with "typical" connections (like the above) that could be applied to atypical connection locations, should be carefully reviewed.

cation. Complex structures usually involve large and heavy structural elements. This will influence the erection sequence, lift limitations, shoring requirements and long-span truss design. During the crane logistic planning between the erector and general contractor (GC), ground preparation and review of existing buried utilities should be addressed. Whenever possible, engage the geotechnical engineer for crane ground preparation recommendations.

In conjunction with crane logistics, the final design of long-span heavy trusses should be reviewed by the erector. The engineer-designed truss lateral bracing may not be present when long-span trusses are set, which may require changes to truss design or the need for additional temporary bracing. Understanding the engineer's truss design and then suggesting alternate splice locations, chord orientations or increased member sizes will facilitate the truss erection and help maintain stability during construction. Once the conceptual connection designs are being developed, the erector needs to provide guidance to the design team to ensure that the connections have erectability in mind. Any connections that participate in the lateral load resisting system (LLRS) of the structure, along with "typical" connections that could be applied to atypical connection locations, should be carefully reviewed. For instance, while a field-welded moment connection can be thought of as "typical," if it is detailed at a cantilever situation, the complexity of erecting that member increases dramatically.

Therefore, any unique connection situations with atypical connection design should be addressed by the erector in the connection design phase. Any large connections/nodes that require extensive field welding need to have erection aids detailed and fabricated into the connection design, to ensure fit-up and erectability.

Understand the Structure

The next strategy for the erector to succeed on complex erection bracing projects is for them to completely understand the structure and the structural design of the engineer. This strategy goes hand in hand with engaging an erection engineer, which will be addressed in the next section. As stated in the AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303), available at **www.aisc.org/standards**, it is the responsibility of the design engineer to indicate on the drawings to the erector and GC what the LLRS of the structure is. Additionally, they must indicate if any structural elements in that system are not structural steel. Unfortunately, any logical description of the LLRS on these very large and complex structures is not easily generated.

Often, going above and beyond the *Code* is required, and the erector and erection engineer should have an open line of communication to exchange information about the structure and the intended erection plan. For these parties, understanding the structure will allow for an erection plan that can efficiently use the design engineer's intended load path and minimize the need for additional erection bracing. Establishing alternate load paths for both lateral and gravity loading may still be required by using temporary bracing, using reserve capacity within the designed LLRS and sequencing the steel erection to minimize loads on the partially erected structure.

Engage Your Erection Engineer

The most fundamental strategy for success, which all the other strategies are impacted by, is the relationship between the erector and the erection engineer. The design engineer has vast knowledge of the steel structure and the erector has tremendous knowledge of how to erect steel structures, but it is the erection engineer that acts as the bridge between the two. It is also important for the erector to communicate their needs, wants and concerns to the erection engineer so that the latter can provide an erection plan to meet the former's schedule, budget and logistical constraints. An open exchange of information between the two will allow for an erection plan that is easy to understand, reasonable to implement, works within the

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An ExxonMobil facility in Houston involved a challenging erection sequence for an assembly called "the Cube." The assembly was built on top of temporary jacking assemblies, them permanently rested on pot bearings following substantial erection. (See "Focusing Energy" in the June 2015 issue for more.)

fabrication/erection sequence, clearly identifies critical erection sequences and provides safe "stable points" for the erector. Equally important to the erection engineer, the erection plan should present a clear and evident load path for each sequence of construction, be consistent with the expected duration and provide the flexibilty for field modifications.

Understand the Erection Plan

It is critical that the erector can easily understand and implement the erection plan provided by the erection engineer. A "top-down" approach by the erector in implementing the erection plan will ensure that the plan is followed correctly and most efficiently. The estimating department will need to know the crane requirements to support the erection plan and an order of magnitude as to the amount of temporary bracing/shoring towers to budget. The overall project schedule will need to be reflected in the erection plan.

The project managers and superintendents are the on-site eyes and ears for the erection engineer. They will need to coordinate with the GC and other trades so that the erection plan developed by the erection engineer can be implemented correctly. Lastly, the "boots on the ground" ironworker is the final person that will have influence on the steel structure and ultimately needs to understand the work flow of the erection plan. The ironworker is responsible for implementing the detailed step-by-step erection sequences that are included in the plan, measuring and communicating the as-built field conditions and being the first to recognize realize inconsistencies between the erection plan and the structure. Every level of personnel will have a significant impact on the outcome of a project, and therefore understanding the erection plan will increase the rate of success.

Simplify the Complex Problem

Simplifying the erection plan on complex steel erection projects will create a safer and more economical approach to the structural steel erection. Identify the source of the complexity. Is it the design, logistics, construction constraint, architect or engineer that increases the degree of complexity? Whatever the answer, develop simple solutions to address those sources of complexity. When it comes to erection bracing for complex steel structures, I prefer to substitute safe in lieu of stupid when using the K.I.S.S. concept (keep it simple and safe). There is nothing stupid in erecting structural steel, but safety is always a concern. For the erector to tackle the complexity of these modern-day engineering projects safely, they need to have knowledge on par with the design engineer to create and execute the erection plan developed by the erection engineer. At the end of the day, from the owner to the erector, safety should be a priority.

Although there is no simple solution or typical situation, using these strategies on complex steel erection projects should help overcome the challenges that arise and allow for successful completion of complex projects. ■

This article is based on Session R7 "Complex Erection Bracing," which was presented at NASCC: The Steel Conference this past March in San Antonio. You can view a PowerPoint presentation of the session, including a recording of the audio, at ***www.aisc.org/2017nascconline****.*