



# The Art of *Exposing* Structural Steel

BY MICHAEL BRACK, P.E.

Whether “architecturally exposed” or just “exposed to view,” here are some thoughts—big and small—about the collaborative role structural engineers play in creating beautiful steel structures.

James E. Langford

**STRUCTURAL STEEL** is an incredibly versatile material for designing exposed structures in architectural applications. Sometimes it is larger than life and heroic, while other times it is sleek and understated. Sometimes it is whimsical, and sometimes, in those inspired structures that move us deeply, it's hard to tell where the structure stops and where the architecture begins.

Precisely because it remains a visible element after the completion of the structure, the appearance of exposed steel is important. Here are a few things we have learned to keep in mind when designing in exposed steel.

### Not all exposed steel is created equal.

It's important to know when to pull the trigger on specifying Architecturally Exposed Structural Steel (AESS). Just because a steel structural element is exposed to view does not mean it needs to be AESS. Specifying AESS triggers a broad range of fabrication and erection tolerances, as well as a host of finish requirements, that often simply are not needed. There are real costs in fabrication, erection, finishing and time associated with AESS, so make sure you need it before you specify it. Sometimes only some selected improvements over the standard steel requirements are all that you really need. Or perhaps the design should feature the look of steel as fabricated and erected. AISC offers several AESS-related resources at [www.aisc.org](http://www.aisc.org), including Section 10 of the AISC *Code of Standard Practice*. Also, a 16-page guide to AESS from the May 2003 issue of *MSC*, including photos and a sample specification, is available as a free download at [www.modernsteel.com/backissues](http://www.modernsteel.com/backissues).

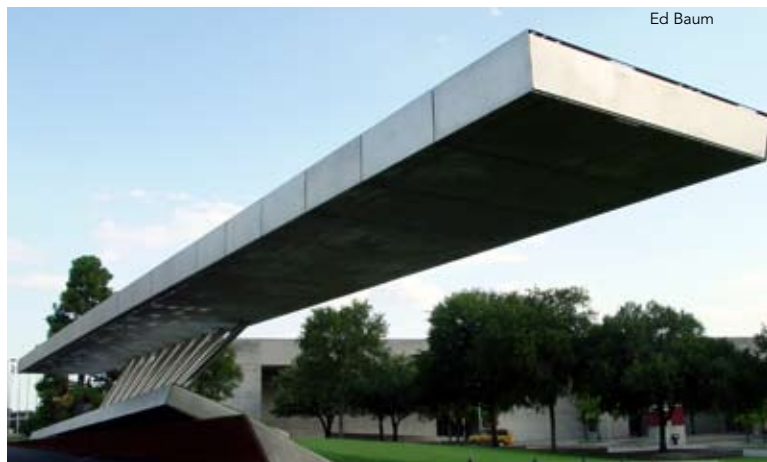
### Context matters.

The intimate scale of smaller projects or spaces requires an especially careful attention to detail, triggering an AESS spec and designation. Weld marks, mill stamps and other characteristics of typical steel construction will be even more apparent when viewed from close range next to a custom wood cabinet or stair. The same level of craftsmanship displayed in those finished materials may be expected of the structure. The sizes used are often the smaller wide-flanges and channels. Therefore, typical detailing that is common to W8 and larger members often doesn't work. In other cases, the exposed face of a steel perimeter beam may be serving as the exterior skin, and a connection that completely seals all gaps may be required. Welds need to be worked and ground to look good. Residential and other smaller projects often have a mix of structural materials, which creates challenges for detailing the steel to work with the other systems, as well as choosing compatible sizes. For example, the sizes of steel members may need to be increased to look appropriate when supporting wood framing.

### Be clear about what is and isn't AESS.

Rarely is all the steel on a project AESS. On a recent addition to the Briscoe Museum in San Antonio, Texas, we clearly noted on our plans which elements were to be AESS and which were not. For fabrication and erection details designated AESS, elements were shop coated with white paint. The remainder of the steel was shop painted with red primer to distinguish between the two in both the shop and field.

◀ A specialty steel erector was enlisted to erect the tensegrity tension tie element at this chapel in Dallas.



Ed Baum

- ▲ Using 7-in.-diameter solid stainless steel rods as columns maintained an honest, clean expression of the structure on the Dallas Police Memorial.
- ▼ Steel designated AESS was painted white in the shop so it was easily distinguishable by anyone working on the Briscoe Museum project.



Mat Wallace, courtesy of Lake Flato

*Michael Brack, P.E., is president of Datum Engineers, Inc., ([www.datumengineers.com](http://www.datumengineers.com)), a Texas-based firm practicing "The Art of Structural Engineering."*



Frank Orms, courtesy of Lake | Flato



▲ Exposed steel often requires stricter tolerances to fit up well with integrated architectural elements and finishes, as shown in the photograph of LC Ranch in Montana.

▲ The 300-ft-long roof trusses of the Irving (Texas) Convention Center are backlit by the glow of the interior space.

### Is it really going to be exposed?

Sometimes exposed steel framing requires intumescent paint to meet the code-required fire rating. Intumescent paint has a thickness and texture that can affect the desired look of the element. For example, on the Business Leadership Building at the University of North Texas, Denton, Texas, the architect (Polshak, now Ennead) specified custom tapered exposed steel columns to support the second and third floors at the perimeter. These columns were key architectural elements. The proportions and detailing of the connector plates at the base of the columns had to be tweaked and simplified because the approximately ¼-in.-thick paint coating significantly affected the desired look of the connection. Thus, a ½-in. plate looked more like a 1-in. plate, and a ⅜-in. groove detail was deleted because it would disappear once the paint was applied.

### Sometimes, it's not about the most efficient section.

Rangers Ballpark in Arlington, Texas, designed with HKS and David M. Schwarz, is a modern-day expression of a vintage baseball venue. Exposed steel was used extensively throughout the concourse areas and the bleacher overhangs to create this look and feel. It would have been easy to span 40 ft over the concourse areas with a simple W21 beam. However, we saw this as an opportunity to use steel to help evoke a sense of place in keeping with the retro design. So instead, we created arched trusses with bolted connections designed to mimic riveted construction. The star and circle at the center of the truss (reminiscent of those worn by the legendary law officer Texas Rangers) was so well received that it became the logo of the baseball team for more than 10 years.

### Think big.

The steel arches of the Dallas Convention Center we designed with HKS created a 400-ft by 600-ft column-free exhibit space, and became the iconic identity of the facility. The 425-ft-long bent pipe arches soar over the flat roof of steel trusses 40 ft above the exhibit floor, and are a recognizable part of the downtown skyline.

### Iterate, and then iterate again.

On the Irving Convention Center in Las Colinas, Texas, the architect (RMJM) used perforated copper paneling on the massive 300-ft-square upper box of the facility. The copper panels were set out from the enclosed space, acting as shade screens during the day, and allowing the interior lighting to glow through at night. The 60-ft-deep perimeter roof trusses are also the armature that support this skin, and consequently are visible in silhouette through the perforated panels. We laid out several options to coordinate the look of the trusses with the evolving shape of the irregular upper box during the design phase. In each iteration of the design process, the architect and structural engineer worked closely to refine and improve the layout of the truss members to be rational and appropriate for the look of the building.

### Get the right people for the job.

For a beautiful and elegant chapel for the Episcopal School of Dallas, designed by architect Jim Langford, we saw an opportunity to use AESS to create an interesting and exciting feature for the students' worship space. Rather than using a simple tension tie rod to resist the spreading forces of the gable roof, we used tension cables that run through a series of sculptural "tensegrity" structures. We recognized that the tensegrity structures were more specialty orna-



▲ Connections of built-up steel columns at the UNT Business Leadership Building had to be adjusted to account for the thickness of intumescent paint.

▲ The Children's Medical Center bridge features crisscrossed cable supports hanging from an arched pipe, with a three-layer connection to accommodate all the cables.

mental steel than typical structural steel. They would take longer to erect and require special protection during construction, adding cost and time to the overall project. To counter this, we specified temporary standard steel tie rods and turnbuckles to be installed by the primary steel erector. Later a specialty steel fabricator and erector, whose work we knew from previous experience, was selected to delicately replace the tie rods with the tensegrity sculpture.

### Great connections are critical.

How many times have we seen nice clean steel framing with ugly connections? Connections in exposed steel buildings are often easily seen, so detailing of visible connections is critical to an exposed steel structure. Each connection's design and detailing must be consistent with the architect's concept while also balancing the design requirements, the fabricator's needs, the erector's needs, and project cost. Input from an experienced fabricator during the project design is helpful and can minimize the risk of providing details that are overly complicated and/or difficult to construct. Exposed connections become even more important at complex connections such as space trusses, where multiple members come together from various angles. Datum, along with architect Lake | Flato, successfully addressed this issue on the Cutting Horse Ranch project, a project which included several architecturally exposed steel barns. As a general strategy, the more heavily loaded members took precedence in their positioning over more lightly loaded members. Not only is this more efficient, but it looks more coherent in the final product, as the hierarchy of members is consistent with the work they are doing. A number of good images of the Cutting Horse Ranch project, which was a National Award Winner in AISC's 2011 IDEAS<sup>2</sup> program, can be viewed online at <http://bit.ly/qcKQUO>.

### Think in 3D.

The Dallas Children's Medical Center Bridge utilizes crisscrossed steel cables to hang the deck supports from large arched pipes. The structure weaves pipes, plates, cables, and pins together with an aesthetic geometry set collaboratively between architect FKP and Datum to create a 3D topography that is visually compelling and unique to this bridge. To avoid conflicts between crossing cables, the cables are positioned in three layers. The larger, more heavily loaded cables remain centered on the arch and tie beam while the outer two layers of smaller cables are offset.

### To weld or not to weld?

For steel exposed to weather, hot-dip galvanizing is often the finish of choice for its long-term durability and low maintenance. Detailing of the connections is critical to the long-term performance of the coating. Erection, construction sequence, and tolerances should be carefully considered and details developed to avoid field welding. Where welding is done after galvanizing, the zinc coating is removed by grinding or "burning" off the zinc before the welding process. Repair typically involves grinding and cleaning the weld and coating it with a zinc-rich paint, commonly referred to as "cold galvanizing." The coating is often not a good color or texture match with the hot-dip galvanizing. Plus, these touch-up repairs almost always exhibit some rust over time, as it is difficult to properly prepare the welded area to provide a smooth uniform substrate for the repair coating. The resulting roughness due to grinding, weld spatter and weld surface irregularity may create thin spots and gaps in the coating which often rust over time. Extra attention paid in detailing to use bolted field connections can pay dividends in the appearance and long-term durability of the exposed construction.



◀ The iconic 425-ft-long trusses of the Dallas Convention Center stand out in the Dallas skyline.

### I can't find that at Home Depot.

Sometimes small amounts of very expensive materials can be used to great effect. On the Dallas Police Memorial, Ed Baum and the Oglesby Group's sculptural concept called for a single line of nine beam-columns to support one edge of a 93-ft-long cantilevered stainless steel "slab." The columns wanted to be as elegant as possible, and the common notion of encasing conventional steel columns within a stainless steel cladding with seams would have detracted from the architectural strength of the concept. We used 7-in.-diameter solid stock stainless steel rods instead. You can't find these listed in the *AISC Manual*, but sometimes a little research can unveil a broader spectrum of possibilities. Don't confine your thinking to off-the-shelf solutions.

### Mock-ups can be critical.

To make sure everyone gets the look and feel they want in the end, a mock-up can be an invaluable tool. These can range from mock-ups of isolated pieces or elements to consider the look of welds and finishes, to full-scale slices of a particular system. We have even used full-size mock-ups during the design process to learn fabrication and erection lessons that impact our detailing and even member selection. In one such instance, we switched from nested pipes to nested HSS because the sizes matched up better and tighter, eliminating the need for hundreds of spacers and grommets.

Of course none of these beautiful structures happen as the result of one person's efforts. The close collaborative relationship between the architect and the structural engineer is at the heart of it all. A great structure has to be responsive to, and respectful of, the designer's vision for the project. The collaborative effort at work within the structural team is also critical to our success, as ideas are developed and refined over time with the input of many people. The concepts and projects in this article were developed by several of Datum's own team members, including Thomas Taylor, Robert Fry, Stephen Price, Marty Sloan, Rodolfo d'Arlach, Scott Williamson, and Greg Diana. **MSC**



◀ Using trusses instead of simple beams helps create a sense of place at Rangers Ballpark.



### **Architects and AESS**

We asked our clients the question, "What do you like most about designing with exposed structural steel?" Here are a few of their responses.

"Steel can combine many small and light members working together to make efficient and strong structures. From a simple scaffolding to a complex geodesic dome, we love the practicality and poetic potential of steel's 'communal effort,' its ability to convey strength with assurance and lightness."

—*Juan Miró, Miró Rivera Architects,  
Austin, Texas*

"Buckminster Fuller coined an appropriate phrase, 'Doing more with less.' Structural steel provides wonderful opportunities to create economic and highly sustainable building structures that not only provide the design team with opportunities to create wonderful building forms and magnificent spaces but a building skeleton that reveals and celebrates the load transfers with elegance and precision."

—*James Andrews, Overland Partners,  
San Antonio, Texas*

"Designing with exposed structural steel adds a muscular, visceral quality to buildings. They feel more tangible and have a greater physicality and presence than buildings where structure is concealed. People relate to that and can see a parallel between the bones and muscles of the building and their own bodies. There also is an intrinsic elegance in steel construction. The great strength of the material allows it to do the structural job with both power and grace. Expressing that gives the architect one more tool for authentic expression in the architecture rather than having to rely on superficial glitz."

—*Larry Speck, Page Southerland Page,  
Austin, Texas*

