CONTINUING EDUCATION

CAST STEEL STRUCTURAL CONNECTIONS
AN ELEGANT SOLUTION FOR ARCHITECTURALLY EXPOSED STRUCTURAL STEEL THAT CAN ALSO PROVIDE COST SAVINGS.

By Peter J. Arsenault, FAIA, NCARB, LEED-AP

Structural steel has been a material of choice for a wide variety of building projects for over a hundred years due to its comparatively light weight and excellent structural capabilities. The industry surrounding the production of structural steel sections and the fabrication and erection of steel buildings has evolved in this time and created a fairly sophisticated and easily accessed network of companies, organizations, and individuals. Architects have embraced the benefits of this material and its industry since it allows a certain amount of design flexibility and freedom while often helping construction budgets. This has led to an increasing trend in building design to use structural steel as an exposed design element. Such a design approach requires special attention to make the steel look acceptable not only along the body of the exposed members, but particularly at the connection points. Those connections can often be characterized by an array of bolts, stiffener plates, welds, and other structurally necessary elements which produces an aesthetic that, if left unspecified, is more utilitarian than artistic. Happily, that is no longer the case when the decision is made to use cast steel components. Standardized or custom cast connectors are readily available which provide dramatic geometric freedom in structural steel shapes, thereby enabling artistic designs to be realized.

THE METAL CASTING PROCESS
Casting molten metal into a form is a common process that has been used historically for many metals including bronze, copper, and steel. In

LEARNING OBJECTIVES

At the end of this program, participants will be able to:
1. Investigate the design potential and innovative opportunities that steel castings can contribute to architecturally exposed structural steel (AESS) applications.
2. Identify and recognize the various steps involved in the casting manufacturing process including industrial design, detailing, tooling, casting and machining, and to understand and accommodate the lead times associated with custom castings.
3. Differentiate between the various common types of cast steel connections and their appropriate uses in different settings.
4. Assess through case studies how steel castings have been used in structural design to maximize architectural benefits, simplify fabrication and speed erection.

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innovative components for inspired designs
fact, all structural steel starts its life being cast into an ingot or other industrial shape. That steel is then hot rolled or cold formed into the final shape of the structural steel members. We are more familiar with such as wide flange sections, angles, channels, hollow structural sections, etc. This rolling/forming process works well for continuous or linear shapes, but not for other, non-linear, custom shapes. Hence, the creation of such specialty steel components relies on using a mold to pour molten metal into thus forming the desired shape without rolling or forming.

A common misconception regarding steel castings is that they are brittle because they are sometimes confused with cast iron. This is not the case in cast steel products which are just as ductile as rolled structural steel products, if not more so. The main difference between standard rolled structural steel shapes and steel castings is the production process which results in their final yield strength. Hot-rolled or cold-formed products attain their yield strength through the rolling or forming processes, whereas steel castings are heat treated after they are cast to attain the desired mechanical properties. In a normalized condition, low alloy steel castings can be readily produced with yield strengths in the range of 30 to 40 ksi. By introducing quenchanting and tempering processes, yield strengths of 50 ksi and greater can be attained. In Europe, a process called secondary heat-treatment is now being used to attain yield strengths as high as 150 ksi in castings to be used in special structural applications.

The typical process for the creation of all cast steel products occurs at a metal foundry and is essentially the same regardless of the size or complexity of the casting. The process starts once a particular shape is designed and analyzed for structural integrity. Then a full size, three dimensional rigid replica or pattern is made of the component out of cut wood, plastic, or similar material using a computer numerical control (CNC) process. Next, chemically-treated sand is placed around the finished pattern in two halves. When the sand has cured and stiffened, the pattern is removed by opening and then re-closing the halves, thus leaving a hollow, stiff sand mold that replicates the pattern exactly. In preparation for casting, the surfaces of the sand mold are treated with a ceramic-based coating. The sand and ceramic coatings are selected by the foundry for their ability to withstand the high temperatures of molten metal.

With the mold readied and secured in place, the specified metal is heated in a furnace until it reaches its molten state. It is then carefully poured into the sand mold and allowed to cool until it solidifies into shape. After the cooling is complete, the casting is removed from the sand mold by breaking away the sand. This means that the mold is destroyed in the process but the original pattern remains which can be reused to make multiple identical molds. Hence the process can be repeated as often as needed to make as many identical products as desired.

Using this common and time proven process, cast metal products are readily produced in virtually any size from very small to very large. Further, the shape and complexity is limited only by the imagination of the designer and the limits of the materials being used. There are of course certain design parameters that make for a better casting than others, but those are fairly well known and understood within the industry. Small, simple cast steel products include things like small cable connectors or cast hardware or decorative elements. Large, complex ones include multi-angle, multi-force custom structural elements for buildings.

**CAST STEEL STRUCTURAL CONNECTIONS**

Cast steel has been in use for quite some time in a variety of applications. Railroads use cast steel couplers for connecting freight cars to locomotives. Industrial equipment such as mining trucks use steel castings to make different parts including the entire load bearing frame for improved durability and resistance to impact loads. When it comes to buildings, steel castings have been commonly used for valves and fittings.

The use of cast steel as part of a structural system first occurred in the late 1970's in the construction of offshore oil platforms. These platforms consist of a complex framework of tubular steel members that commonly used welded connections. Problems arise, however, since the structures and their welded member connections are subjected to strong wind and wave action at sea. Given the constant loading and the complexity of the welded joints between the members (anywhere from 2 to 8 members intersect and must be connected to transfer forces), these connections are susceptible to fatigue failure. In response, the concept of a rigid “cast steel node” was developed. This alternative employed casting manufacturing to handle the complex geometry of the junction point thereby smoothing out the stress concentrations in the connection and moving the welded joint away from the region of geometric complexity. Further, the geometric freedom afforded through casting enables thickening the metal where necessary, as opposed to welded fabrication whereby connections are built up from plates. The use of cast steel nodes in this way improves the high-cycle fatigue performance of these connections by more than an order of magnitude. Although these nodes are purely functional, the smooth, more organic and sweeping appearance of these junctures made them a prime candidate to eventually be applied in architectural construction on land.

One of the first architects to make substantial use of steel castings in the design and construction of an onshore building structure was the firm of Renzo Piano and Richard Rogers. In the mid 1970’s they designed the Centre Pompidou in the Beaubourg area of Paris, France. The intentionally exposed structure created a post-modern, high tech design style with structural steel cast elements used to tie different structural elements and portions together. These castings were used as much for the structural integrity of the building as they were for the desired aesthetic. Since
The Pompideau Centre in Paris, France was one of the first buildings in Europe to use architecturally exposed structural steel incorporating cast steel components. Photos courtesy of Terri Meyer Boake

then, cast steel structural connections have become common in architecturally exposed structural steel (AESS) designs throughout Europe. In North America, however, their use has lagged behind primarily due to the historical focus of US-based steel foundries on mass production rather than “jobbing” customized production. However, the recent advent of various standardized cast steel components meant for use in building construction has led to an interest by the US foundry industry to support the architectural community in providing both standardized and custom designed steel castings.

Some of the beneficial characteristics of cast steel connections that have been realized in buildings include a dramatic increase in geometric and aesthetic freedom compared to conventionally fabricated connections. Structurally, they provide improved connection stiffness, strength, and fatigue resistance. During construction, they provide simplified fit up, fabrication, and erection. Given all of this, when does it make sense to consider cast steel connections in a building design? Their characteristics make them a preferred choice whenever architecturally exposed structural steel (AESS) is part of the design, particularly if round Hollow Structural Section (HSS) members are the primary structural members being used. They also work quite well for connections in exposed timber frame construction. There are several other building design conditions that also make cast steel connections a preferred choice to solve and simplify loading and connection issues, such as:

- When the building design requires complex connections due to complex geometry (i.e. many members framing together at a single location and/or at sharp angles where weld access would be an issue)
- For arduously loaded connections or when increased connection stiffness is needed
- When material fatigue is a critical connection criterion
- When the connection has to satisfy a special performance requirement, like blast or seismic resistance

In the process of reviewing how the cast connections join with the main structural elements, it is important to avoid the misconception that steel castings are not weldable. Again, this comes from incorrectly drawn parallels to cast iron. The reality is that cast steel grades can be selected for any number of mechanical properties, including weldability. In fact, welding is the primary and most common means for joining a cast connection piece to an AESS element since the joint can be ground smooth and finished to appear as a continuous member. In particular, The American Institute of Steel Construction (AISC) publishes standards and guidelines such as AISC 360-10 which lists ASTM A216 Grade WCB as a cast steel grade useful for steel structures. However, there are currently no cast steel grades listed as prequalified base metals in standard welding guidelines so welding procedure specifications must be qualified accordingly. In particular, preheating is required for welding very thick castings and common good welding practices should be exercised.

TYPES OF CAST STEEL CONNECTIONS

While all cast steel connections will share the attributes and production process already discussed, different types of connectors are made for different building design conditions. The four most common types are universal pin connectors, architectural tapers, high strength connectors, and custom cast connectors.
UNIVERSAL PIN CONNECTORS (UPC)

In many cases, the ideal structural connection from an architectural perspective is not a welded or bolted plate, rather it is a “true-pin” connection. While that ideal shape is difficult to achieve with flat or rolled steel, it is easily achieved with cast steel. Hence, universal pin connectors (UPCs) have become readily available in many sizes as standard, off-the-shelf cast connectors for AESS. They have become popular in a number of design schemes because they allow for a final appearance that provides elegance, simplicity and consistency.

The primary benefit of a true pin connection is that it allows for any geometric angle of connection which is particularly useful in cross bracing or other angular structure situations. And since the pin rotates freely until secured in place, field adjustment of the pin and angle is easily accommodated. On a broader basis, UPCs are readily used at the ends of any structural element carrying tension and/or compression, meaning that they are suitable for use at the ends of columns, braces, struts, ties, or any other common structural element where a true pin load connection is desired. They have often been used as part of the overall structural system for entrance canopies, to connect web members of large trusses, as support connectors in specialty stairs, and at the ends of exposed braces that are part of the building’s primary lateral force resistance system.

SPONSOR INFORMATION

CAST CONNEX is the leading designer and supplier of cast steel components for use in buildings and bridges. Their components simplify the design and enhance the performance of structures. They take pride in collaborating in the creation of safer, innovative, and more beautiful built environments.

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Universal pin connectors are standardized cast products that are welded to the end of a hollow structural section (HSS). Photos Courtesy of CAST CONNEX and Terri Meyer Boake

QUIZ

1. The creation of specialty steel cast components relies on:
   a. hot rolling steel into the desired shape
   b. cold forming flat steel
   c. an initial ingot of formed steel
   d. a mold to pour molten metal into thus forming the desired shape

2. All of the following are true about cast steel products EXCEPT:
   a. they are heat treated to attain their desired properties
   b. they are brittle
   c. they can have yield strengths between 30—150 ksi
   d. they are as ductile as rolled shapes, if not more so

3. Off shore oil rigs use cast connections instead of welded connections to overcome:
   a. fatigue failure
   b. welding out at sea
   c. complex geometry
   d. none of the above

4. The characteristics of cast steel connectors make them an excellent choice whenever which of the following are used:
   a. architecturally exposed structural steel (AESS)
   b. Hollow Structural Section (HSS) members
   c. exposed timber frame construction
   d. All of the above

5. True or False: In the process of reviewing how the cast connections join with the main structural elements, it is important to remember that steel castings are not weldable.

6. The primary benefit of a true pin connection is that:
   a. it allows for any geometric angle of connection
   b. it provides a rigid fixed in place angle pre-determined in fabrication
   c. it is only fabricated according to custom design specifications
   d. it uses only one piece to form a connection

7. All of the following apply to cast architectural tapers EXCEPT:
   a. they are easily welded to the end of round HSS tubes
   b. joints can be ground smooth to create an elegant finished structural element
   c. it involves cold or hot forming/bending flat plate into a conical shape
   d. they create an aesthetic where the overall HSS member appears to be more slender

8. True or False: Cast steel high strength connectors are standardized brace end connectors that accommodate a bolted double-shear connection between round HSS braces and a typical corner gusset plate

9. The best cast connection solution for complex connections subjected to arduous loading from a variety of structural members aligned in different directions is:
   a. a Universal Pin Connector
   b. an architectural taper
   c. a high strength connector
   d. a custom designed connector

10. True or False: An experienced casting designer typically assumes full engineering responsibility for the castings and may even procure the castings.
Cast UPCs are commonly sleek, clevis-type standardized fittings designed to connect to hollow structural section (HSS) elements. The connectors are generally carefully sculpted to provide a smooth transitional geometry that reflects the natural idealized flow of structural forces. The use of cast UPCs welded to HSS elements allows for a true pin connection and overcomes the inherent difficulty of trying to do so directly within the HSS element alone. Where aesthetics are a particular concern, the use of UPCs greatly simplifies the design, detailing, and fabrication of architecturally exposed structural connections while significantly improving the aesthetic appearance of the finished assembly. A complete UPC connection will require some additional hardware beyond just the cast portion. Specifically, they will need the associated carbon steel or stainless steel pins that insert through the connector and a base element. To work properly and hold the pin in place, stainless steel washers, cap plates, and cap screws are all generally required as well. Manufacturers have recognized this need and commonly supply all of this related hardware for a complete connection.

Some of the advantages of using UPCs include an aesthetic that provides elegant, smooth, curving transitions from every viewpoint. Properly designed, they can provide eye-catching end connections with a known cost, unlike traditional AESS connections which have been known to escalate in cost, even after the bid is awarded. Part of the cost improvement comes from dramatically simplified fabrication and a fraction of the grinding that typically accompanies AESS. Whether standard or custom UPCs are used, the casting process yields duplicate identical pieces to provide a consistent and reliable architectural appearance. And to make structural calculations and sizing easier, common connection details have been analyzed by manufacturers who can provide tabulated connection capacities.

**CAST ARCHITECTURAL TAPERS**

Cast architectural tapers are conical, hollowed, cast structural steel members that are tapered in shape. They are designed to connect to the end of round HSS members, typically those acting in compression, for use in architecturally exposed structural steel applications. Cast architectural tapers can be used, for example, at the ends of exposed steel columns in a building’s atrium. By combining universal pin connectors with architectural tapers, an aesthetic can be realized where the overall HSS member appears more slender. The smaller end condition also allows for a smaller UPC to be used.

Conventional fabrication of hollow conical steel tapers is difficult at best since it involves cold or hot forming/bending flat plate into a conical shape. Often steel fabricators and contractors will shy away from projects calling for such details if they don’t feel comfortable carrying out the fabrication. By contrast, cast architectural tapers are easily welded to the end of round HSS tubes by steel fabricators and installers. Once assembled and welded, the joints can be ground smooth to create an elegant finished structural element. Due to the relative ease of fabrication and installation, cast architectural tapers have become readily available and cost effective. They are typically consistent in appearance and quality by virtue of the casting of standardized pieces.

**HIGH STRENGTH CONNECTORS (HSC)**

Not all structural loading conditions call for the use of pin connections. Some require a fully rigid connection that is tolerant of a variety of forces which may include seismic, particularly in concentric braced structural frames. The conventional manner of addressing this need is to engineer detailed connections that often require connection reinforcement and the field welding of cross bracing to gusset plates which have been fabricated onto steel beams and columns. Such field welding requires skilled labor and an independent special inspection of the completed welds. All of this makes such conventionally-fabricated connections rather complex and costly.
By comparison, cast steel connection products have been developed that are simpler, work better, and create a lower cost connection overall.

Cast steel high strength connectors are standardized brace end connectors that accommodate a bolted double-shear connection between round HSS braces and a typical corner gusset plate. They are available in different standard sizes and capacities to suit a range of loading conditions. The modular design of these connectors minimizes detailing and accelerates fabrication of the steel structure. They are available as pre-designed and detailed connections which dramatically reduces engineering time and effort. During construction, the cast HSCs eliminate the need to field weld braces to the frame, hence they significantly speed erection and reduce the cost of special inspections. Because they are fully engineered connections, they can readily demonstrate conformance to code-listed connections that meet all of the requirements of AISC standards and guidelines to provide high strength, functional connections for earthquake resistant braced frame buildings.

Perhaps most significantly, cast HSCs are typically designed to eliminate shear lag in the connection. The AISC defines shear lag as behavior at an end connection of a tension member where some but not all of the cross-sectional elements are connected thus the area that is effective in resisting tension may be less than the full calculated net area. Cast HSCs are intended to have a full penetration shop-welded joint between the connector and tubular brace member which thus assures that the full cross-sectional area is available to resist all forces, thus eliminating the shear lag effect. This means that no connection reinforcement is required and the common iterative design process for determining reinforcement plates is eliminated. Overall the final joint provides improved reliability and a simplified connection design using standardized, pre-engineered cast steel pieces.

Although intended to be functional, cast HSCs also offer a unique aesthetic, which can be suitable for use in some AESS applications. Although the bolted connection is visible, it is a consistent, compact connection which is consistent with a high tech or utilitarian aesthetic without all of the visual clutter or variations found in conventional connections. HSCs also provide a compact gusset connection which reduces the likelihood of interferences with non-structural elements of the building.

**CUSTOM CASTINGS**

Thus far we have reviewed mostly standard types of cast connections that are commonly available. As design teams are faced with bigger challenges or simply choose to get more creative about exposed structures, it is important to know that it is entirely possible to create completely custom steel cast connections that allow the realization of a design vision in freeform architecturally exposed structural steel. In some cases, the custom castings may be variations on the UPCs or HSCs already discussed. In others, design conditions may suggest completely custom castings giving designers the ability to create unique and even iconic structures. Custom castings are appropriately considered for architecturally exposed connections, particularly for connecting HSS elements or to mate between various materials (i.e. steel to timber). They are also the best solution for complex connections subjected to arduous loading from a variety of structural members aligned in different directions. Structurally, they can be excellent solutions where increased connection stiffness is required, where fatigue critical connections are involved, or where advanced components provide specific performance or function (i.e. rockers, couplers, dissipaters, etc.)

If it is determined that custom castings offer the best design solution, then it will be critically important to work throughout the design process with a firm or manufacturer that can provide complete design or design-build services for custom cast steel components. Such a company will need to provide services that are not commonly performed by conventional architecture and engineering firms, namely, 3-dimensional industrial design and modeling of cast elements, finite element stress analysis for the components, steel connection design, casting detailing, non-destructive examination specification writing, and in some cases, even destructive structural testing of full-scale components and assemblages. It will also be important that they are able to provide custom steel production and assessment with a full understanding of steel casting technologies. Foundries don’t typically have the people on staff to undertake structural engineering and design work, since they are mostly staffed with process engineers and metallurgists who understand how to make the castings but not how to design buildings that use them. Instead, a company needs to be chosen that can work as part of the design team for custom cast steel components to ensure that they provide the desired aesthetic appearance, carry loads safely and efficiently, integrate with the structural steel framing of the building, are capable of being cast using best practices, and remain economical.
The first step in the process is to properly identify and understand the structural loading and flow of forces through the structural members in order to create structurally appropriate cast connections. This is where the three dimensional computer modeling and structural analysis becomes important. By assessing the forces and capabilities of the steel, the shape and thicknesses of the castings can be optimized by reviewing alternatives that meet all of the design requirements of the project. This process also allows for elegant and sweeping forms that follow the natural flow of forces. As an alternative, the connection can be sculpted in different ways purely for aesthetic reasons while still being assessed for proper structural performance. Either way, the end result will be a designed connection that cleanly and smoothly carries the imposed loads while allowing full control of the final appearance.

Once the preferred connection shape and size are finalized, the full industrial design & detailed engineering of the custom casting will need to be undertaken. The actual casting may include features that are needed for the casting or installation process such as fins or lifting lugs that are ultimately removed after the full structure is in place. This will tie directly into the engineering that goes on in the foundry to create the patterns and molds that will be used for the custom casting. Once all of those details are worked out, a cast of the “first article” needs to be undertaken to determine its full suitability and quality. First article castings are subjected to rigorous non-destructive (and sometimes even destructive) examination to prove out the production process. If anything is not up to par, then changes can be made to the pattern or the feeding and gating system for the casting to produce a casting that passes muster. If the first article is found to adequately meet specifications, then the original pattern becomes the basis for all subsequent castings.

By now it should be clear that there is some necessary lead time that needs to be built in to a design and construction schedule to allow for the full engineering, molding, and first article testing of custom cast products. Further, there will be some time needed to produce the quantity of custom castings that are ultimately needed for a particular design project. That means any given project needs to work within the overall production schedule of the selected foundry that will be providing the cast products. The overall actual production time will vary of course based on things like the size and complexity of the castings, the quantity needed, and the other schedule commitments of the foundry. Hence, all the more reason to engage with casting professionals earlier rather than later to assure that they can be made and shipped to the construction site when needed. In the end, the results will likely be very worthwhile, but proper planning and time scheduling will keep expectations in line and help maintain positive relationships between all parties.

SPECIFYING CAST STEEL CONNECTIONS

Based on everything that we have covered thus far, you may have decided to use cast steel connections on a project because of an appreciation that standard steel fabrication may not or cannot achieve what casting can. You also understand that custom castings generally require a longer lead-time than conventional fabrication and have allowed for that in the project schedule. While you may know all of this, you also need everyone working on the project to know it too. As a designer, the principal tool for communicating with the contractors and fabricators are the contract documents prepared by your firm. Drawings which show the castings with some general, overall dimensions and maybe some 3D images are appropriate to convey intent and make it clear to bidders that castings are required.

But beyond that, the specifications will generally dictate the details of casting requirements. Since most architectural and general structural engineering offices don't have direct experience in casting design and production, either a specialized casting designer is added to the design team as discussed above, or performance specifications are used that delegate appropriate responsibilities to a suitably experienced party. Such specifications spell out the key architectural features and governing load-cases (i.e. the performance criteria) which must be met such that the casting designer can satisfy architectural, structural, and castability requirements, simultaneously. Including these items within the performance specification can help ensure that the design team and ultimately the client gets what is intended. It will allow the casting designer the flexibility (even creativity) in satisfying the architectural and structural requirements, but promote productive communication between all parties. Requirements for deliverables including a casting design report, shop drawing submittals, and production documentation (chemical and physical test reports for each cast heat and non-destructive examination reports for each casting produced) are also typically included in the performance specification. The goal of having these deliverables is to allow the casting designer the freedom to develop an economical casting design but to still allow the project architect and engineer to retain control over design intent.

The casting designer will thus be required to engineer the castings to meet these performance requirements and will prepare the required detailed casting specifications and shop drawings for review by the architect and structural engineer. An experienced casting designer typically assumes full engineering responsibility for the castings and may even procure the castings. Remember that
foundries obviously have casting expertise but most will not assume design responsibility or assess whether a component they produce is fit for any specific purpose or use. Most foundries won’t assist in the production of 3-dimensional models or shop drawings, either.

A detailed casting specification prepared by an experienced casting design firm typically covers a number of key items including:

- Foundry qualifications in terms of capability and capacity to produce the type and size of castings being specified.
- Quality control and assurance standards for production.
- Metal material grade based on industry standards.
- Non-destructive examination (NDE) requirements for both the first article and all subsequent production components.
- Surface finish quality requirements.
- Dimensional tolerances.
- Machining requirements (if any) for the finished cast pieces.
- Notes on handling and integration of the cast steel elements into the structural steel framing.

CONCLUSION

Architects and engineers have the opportunity and freedom to create architecturally exposed steel structures that yield new aesthetics, exceptional performance, and economical buildings. Cast steel connections provide an exciting outlet for creativity in design and can be a key to achieving successful end results by helping to produce designs that are structurally adequate, architecturally appropriate, and readily constructed. By working with professionals in this field preferably in the design process but certainly in the construction process, choices can be made that result in economical yet elegant casting designs that enhance the full building.

Cast steel connections provide an exciting outlet for creativity in design and can be a key to achieving successful end results by helping to produce designs that are structurally adequate, architecturally appropriate, and readily constructed.

Photos courtesy of CAST CONNEX and Terri Meyer Boake

Project Case Study #1: Universal Pin Connectors at the Whitney Museum of American Art, New York, NY

Universal Pin Connectors used in architecturally exposed X-braces

Owner: Whitney Museum  Construction Manager: Turner Construction
Architects: Renzo Piano Building Workshop and Steel Fabricator: Banker Steel Company
Cooper, Robertson & Partners  Casting supplier: CAST CONNEX
Structural Engineers: Robert Silman Associates

The new Whitney building is a 200,000-square-foot building in downtown Manhattan. Located on Gansevoort Street between West Street and the High Line, it will include more than 50,000 square feet of indoor galleries and 13,000 square feet of outdoor exhibition space on a series of rooftops facing the High Line. The dramatically cantilevered entrance along Gansevoort Street will shelter an 8,500-square-foot outdoor plaza. Universal Pin Connectors were selected by the architectural team for the first floor exposed steel braces in keeping with the artistic nature of the surroundings.
### Project Case Study #2: High Strength Connectors at UMASS Amherst Press and Sky Box, Amherst, MA

**High Strength Connectors used in Architecturally Exposed Support Frames**

**Owner:** University of Massachusetts Amherst  
**Architects:** Perkins+Will  
**Associate Architect:** HOK  
**Structural Engineers:** LeMessurier Consultants  
**General Contractor:** Consigli Construction  
**Steel Fabricator:** Beauce Atlas  
**Casting Supplier:** CAST CONNEX

High strength connectors are featured predominantly in the architecturally exposed structural steel (AESS) support frames for the Martin and Richard Jacobson Football Press and Skybox Complex at University of Massachusetts Amherst. Though the press box extends over the stands, the complex is structurally independent from the existing Stadium. The AESS—including the braces, struts, and ties fitted with high strength connectors—is galvanized. Smooth tension control (TC) bolts are used in conjunction with the connectors for an improved aesthetic.

### Project Case Study #3: Custom Cast Nodes at Queen Richmond Centre West, Toronto, ON

**Cast Steel Nodes for Architecturally Exposed Delta Frames Supporting a Multi-Story Building**

**Owner:** Allied Properties REIT  
**Architects:** Sweeny &Co Architects  
**Structural Engineers:** Stephenson Engineering  
**Construction Manager / General Contractor:** Eastern Construction  
**Steel Fabricator / Erector:** Walters  
**Custom casting engineering, detailing, and supply:** CAST CONNEX

This world-class development includes both the modernization of an existing historic Toronto building and the construction of a new multi-story, reinforced concrete office building perched atop three, 70-foot tall, architecturally exposed structural steel “delta frames”. The cast steel manufacturer provided design-build services for the unique 35,000 pound cast steel nodes that form the central kernel points of the delta frames. The three delta frames are primary elements in the gravity and lateral force resisting systems for the building, with each cast steel node carrying well over 20-million pounds of force. The Queen Richmond Centre West, received a Citation in the 2015 ARCHITECT Magazine R+D Awards.

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Photos courtesy of CAST CONNEX, Perkins+Will, and LeMessurier Consultants

Photos courtesy of CAST CONNEX and Marcus Mitnis