AESS APPLIED

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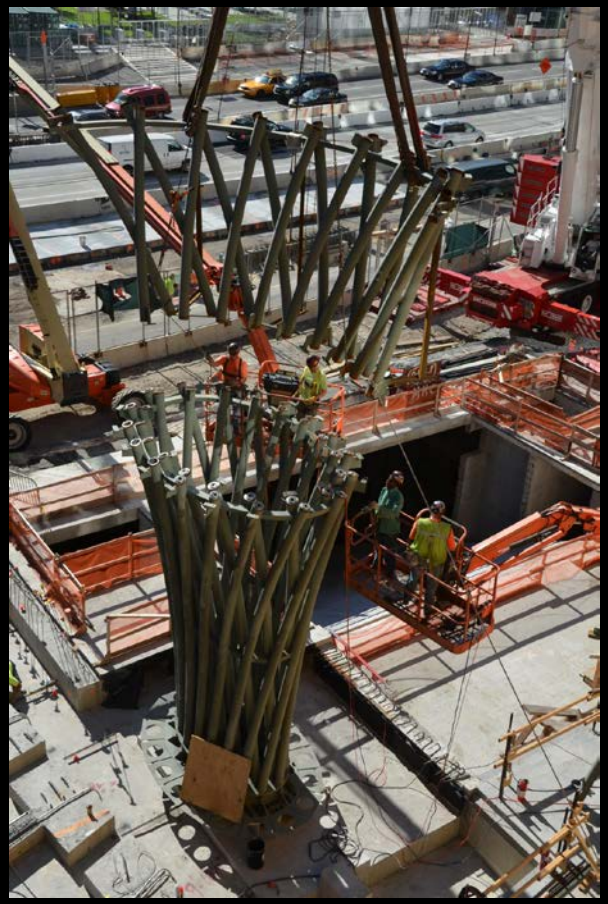
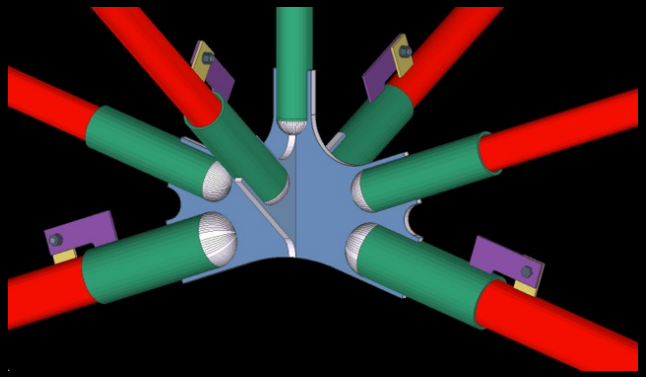
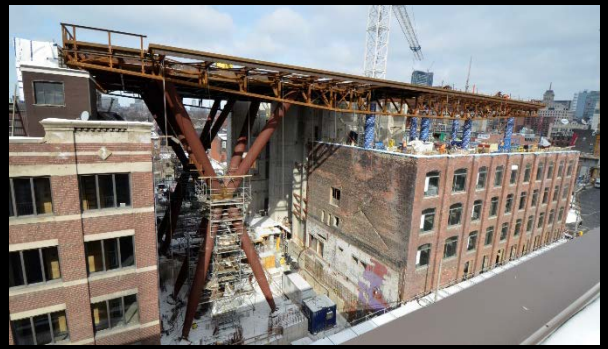
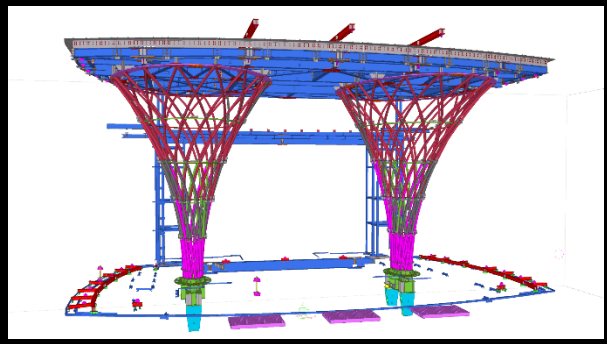
School of Architecture
University of Waterloo

cisc icca









What is AESS?

- Architecturally Exposed Structural Steel is steel that has been purposefully left exposed
- It must fulfill structural functions
- It is normally part of the Architectural aesthetic of the space
- It usually requires detailing, finish and handling that requires more attention and care than regular structural steel
- It adds to the cost of the contract

Table 1 - AESS Category Matrix

Id	Characteristics	AESS C *Custom Elements*	AESS 4 *Showcase Elements*	AESS 3 *Feature Elements* Viewed at a Distance ≤ 6 m	AESS 2 *Feature Elements* Viewed at a Distance > 6 m	AESS 1 *Basic Elements*	SSS *Standard Structural Steel* CSA S16
1.1	Surface preparation to SSPC-SP 6		√	√	√	√	
1.2	Sharp edges ground smooth		√	√	√	√	
1.3	Continuous weld appearance						
1.4	Standard structural bolts						
1.5	Weld spatters removed						
2.1	Visual Samples		optional	optional	optional		
2.2	One-half standard fabrication tolerances		√	√	√		
2.3	Fabrication marks not apparent		√	√	√		
2.4	Welds uniform and smooth		√	√	√		
3.1	Mill marks removed		√	√			
3.2	Butt and plug welds ground smooth and filled		√	√			
3.3	HSS weld seam oriented for reduced visibility		√	√			
3.4	Cross sectional abutting surface aligned		√	√			
3.5	Joint gap tolerances minimized		√	√			
3.6	All welded connections		optional	optional			
4.1	HSS seam not apparent		√				
4.2	Welds contoured and blended		√				
4.3	Surfaces filled and sanded		√				
4.4	Weld show-through minimized		√				
C.1							
C.2							
C.3							
C.4							
C.5							
	Sample Use:	Elements with special requirements	Showcase or dominant elements	Airports, shopping centres, hospitals, lobbies	Retail and architectural buildings viewed at a distance	Roof trusses for arenas, retail warehouses, canopies	
	Estimated Cost Premium:	Low to High (20-250%)	High (100-250%)	Moderate (60-150%)	Low to Moderate (40-100%)	Low (20-60%)	None 0%

Categories go from lowest at the right to highest at the left.

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1.3	Continuous weld appearance		√	√	√	√	
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	Estimated Cost Premium:	Low to High (20-250%)	High (100-250%)	Moderate (60-150%)	Low to Moderate (40-100%)	Low (20-60%)	None 0%

Viewing distance is noted as the differentiating factor between the high and low end AESS Categories.

Grinding permitted $$

No Grinding!!

Table 1 - AESS Category Matrix

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	Estimated Cost Premium:	Low to High (20-250%)	High (100-250%)	Moderate (60-150%)	Low to Moderate (40-100%)	Low (20-60%)	None 0%

Characteristics are listed from the most common/least expensive at the top to the more specialized at the bottom.

Table 1 - AESS Category Matrix

Id	Characteristics	AESS C *Custom Elements*	AESS 4 *Showcase Elements*	AESS 3 *Feature Elements* *Viewed at a Distance ≤ 6 m*	AESS 2 *Feature Elements* *Viewed at a Distance > 6 m*	AESS 1 *Basic Elements*	SSS *Standard Structural Steel* CSA S16
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C.5							

Estimated cost premiums over Standard Structural Steel are noted at the bottom.

	AESS C	AESS 4	AESS 3	AESS 2	AESS 1	SSS
Sample Use:	Elements with special requirements	Showcase or dominant elements	Airports, shopping centres, hospitals, lobbies	Retail and architectural buildings viewed at a distance	Roof trusses for arenas, retail warehouses, canopies	
Estimated Cost Premium:	Low to High (20-250%)	High (100-250%)	Moderate (60-150%)	Low to Moderate (40-100%)	Low (20-60%)	None 0%

Standard Structural Steel

- The initial point of technical reference is Standard Structural Steel as it is already an established and well-understood as a baseline in construction Specifications.

NOTE: Even if “non rectilinear steel” LOOKS like Standard Structural Steel, the TOLERANCES and FIT required are likely to be more in tune with AESS requirements!

Table 1 - AESS Category Matrix

AESS 1

Id	Characteristics	AESS C *Custom Elements*	AESS 4 *Showcase Elements*	AESS 3 *Feature Elements* Viewed at a Distance ≤ 6 m	AESS 2 *Feature Elements* Viewed at a Distance > 6 m	AESS 1 *Basic Elements*	SSS *Standard Structural Steel* CSA S16
1.1	Surface preparation to SSPC-SP 6		√	√	√	√	
1.2	Sharp edges ground smooth		√	√	√	√	
1.3	Continuous weld appearance		√	√	√	√	
1.4	Standard structural bolts		√	√	√	√	
1.5	Weld spatters removed		√	√	√	√	
2.1	Visual Samples		optional	optional	optional		
2.2	One-half standard fabrication tolerances		√	√	√		
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2.4	Welds uniform and smooth		√	√	√		
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Sample Use:		Elements with special requirements	Showcase or dominant elements	Airports, shopping centres, hospitals, lobbies	Retail and architectural buildings viewed at a distance	Roof trusses for arenas, retail warehouses, canopies	
Estimated Cost Premium:		Low to High (20-250%)	High (100-250%)	Moderate (60-150%)	Low to Moderate (40-100%)	Low (20-60%)	None 0%

Roof trusses for arenas, retail warehouses, canopies
Cost premium: Low (20-60%)

AESS 1 - Basic Elements

- the first step above Standard Structural Steel
- suitable for "basic" elements, which require enhanced workmanship
- should only require a low cost premium in the range of 20% to 60% due to its relatively large viewing distance as well as the lower profile nature of the architectural spaces in which it is used.

Table 1 - AESS Category Matrix

AESS 2

Id	Characteristics	AESS C *Custom Elements*	AESS 4 *Showcase Elements*	AESS 3 *Feature Elements* Viewed at a Distance ≤ 6 m	AESS 2 *Feature Elements* Viewed at a Distance > 6 m	AESS 1 *Basic Elements*	SSS *Standard Structural Steel* CSA S16
1.1	Surface preparation to SSPC-SP 6		√	√	√	√	
1.2	Sharp edges ground smooth		√	√	√	√	
1.3	Continuous weld appearance		√	√	√	√	
1.4	Standard structural bolts		√	√	√	√	
1.5	Weld spatters removed		√	√	√	√	
2.1	Visual Samples		optional	optional	optional		
2.2	One-half standard fabrication tolerances		√	√	√		
2.3	Fabrication marks not apparent		√	√	√		
2.4	Welds uniform and smooth		√	√	√		
3.1	Mill marks removed		√	√			
3.2	Butt and plug welds ground smooth and filled		√	√			
3.3	HSS weld seam oriented for reduced visibility		√	√			
3.4	Cross sectional abutting surface aligned		√	√			
3.5	Joint gap tolerances minimized		√	√			
3.6	All welded connections		optional	optional			
4.1	HSS seam not apparent		√				
4.2	Welds contoured and blended		√				
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C.1							
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C.5							
Sample Use:		Elements with special requirements	Showcase or dominant elements	Airports, shopping centres, hospitals, lobbies	Retail and architectural buildings viewed at a distance	Roof trusses for arenas, retail warehouses, canopies	
Estimated Cost Premium:		Low to High (20-250%)	High (100-250%)	Moderate (60-150%)	Low to Moderate (40-100%)	Low (20-60%)	None 0%

Retail and architectural bldgs viewed at a distance
Cost premium: Low to Moderate (40-100%)

AESS 2 - Feature Elements (> 6 m)

- **structure that is intended to be viewed at a distance > 6 m**
- The process requires basically good fabrication practices with enhanced treatment of welds, connection and fabrication details, tolerances for gaps, and copes
- might be found in retail and architectural applications where a low to moderate cost premium in the range of 40% to 100% over the cost of Standard Structural Steel would be expected.
- NO GRINDING

Although using fairly standard W and C sections, this AESS has incorporated castellated members

Table 1 - AESS Category Matrix

AESS 3

Id	Characteristics	AESS C *Custom Elements*	AESS 4 *Showcase Elements*	AESS 3 *Feature Elements*	AESS 2 *Feature Elements*	AESS 1 *Basic Elements*	SSS *Standard Structural Steel*
				Viewed at a Distance ≤ 6 m	*Viewed at a Distance > 6 m*		CSA S16
1.1	Surface preparation to SSPC-SP 6		√	√	√	√	
1.2	Sharp edges ground smooth		√	√	√	√	
1.3	Continuous weld appearance		√	√	√	√	
1.4	Standard structural bolts		√	√	√	√	
1.5	Weld spatters removed		√	√	√	√	
2.1	Visual Samples		optional	optional	optional		
2.2	One-half standard fabrication tolerances		√	√	√		
2.3	Fabrication marks not apparent		√	√	√		
2.4	Welds uniform and smooth		√	√	√		
3.1	Mill marks removed		√	√			
3.2	Butt and plug welds ground smooth and filled		√	√			
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3.4	Cross sectional abutting surface aligned		√	√			
3.5	Joint gap tolerances minimized		√	√			
3.6	All welded connections		optional	optional			
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4.2	Welds contoured and blended		√				
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C.5							
Sample Use:		Elements with special requirements	Showcase or dominant element	Airports, shopping centres, hospitals, lobbies	Retail and architectural buildings viewed at a distance	Roof trusses for arenas, retail warehouses, canopies	
Estimated Cost Premium:		Low to High (20-250%)	High (100-250%)	Moderate (60-150%)	Low to Moderate (40-100%)	Low (20-60%)	None 0%

Airports, shopping centres, hospitals, lobbies
Cost premium: Moderate (60-150%)

AESS 3 - Feature Elements (≤ 6m)

- **structures that will be viewed at a distance ≤ 6m**
- suitable for "feature" elements – where the designer is comfortable allowing the viewer to see the art of metalworking
- welds should be generally smooth but visible and some grind marks would be acceptable
- Welds can be ground if desired

- Tolerances must be tighter than normal standards. As this structure is normally viewed closer than six meters it might also frequently be subject to touch by the public, therefore warranting a smoother and more uniform finish and appearance.
- could be expected to incur a moderate cost premium that could range from 60% to 150% over Standard Structural Steel as a function of the complexity and level of final finish desired

Table 1 - AESS Category Matrix

AESS 4

Id	Characteristics	AESS C *Custom Elements*	**AESS 4** *Showcase Elements*	AESS 3 *Feature Elements* Viewed at a Distance ≤ 6 m	AESS 2 *Feature Elements* Viewed at a Distance > 6 m	AESS 1 *Basic Elements*	SSS *Standard Structural Steel* CSA S16
1.1	Surface preparation to SSPC-SP 6		√	√	√	√	
1.2	Sharp edges ground smooth		√	√	√	√	
1.3	Continuous weld appearance		√	√	√	√	
1.4	Standard structural bolts		√	√	√	√	
1.5	Weld spatters removed		√	√	√	√	
2.1	Visual Samples		optional	optional	optional		
2.2	One-half standard fabrication tolerances		√	√	√		
2.3	Fabrication marks not apparent		√	√	√		
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C.1							
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Showcase or dominant elements, sculptures
Cost premium: High (150-250%)

	AESS C	**AESS 4**	AESS 3	AESS 2	AESS 1	SSS
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Estimated Cost Premium:	Low to High (20-250%)	High (100-250%)	Moderate (60-150%)	Low to Moderate (40-100%)	Low (20-60%)	None 0%

AESS 4 - Showcase Elements

- used where the designer intends that the form is the only feature showing in an element
- All welds are ground and filled edges are ground square and true
- All surfaces are sanded and filled. Tolerances of these fabricated forms are more stringent, generally to half of standard tolerance for standard structural steel

- All of the surfaces would be "glove" smooth
- The cost premium of these elements would be high and could range from 100% to 250% over the cost of Standard Structural Steel – completely as a function of the nature of the details, complexity of construction and selected finishes.

Owner
Brookfield

Architects
Pelli Clarke Pelli Architects

Construction Manager
Plaza Construction

Steel Fabricator / Detailer / Erector
Walters Inc. Hamilton/Metropolitan Walters

Project Profile

WORLD FINANCIAL CENTRE ENTRY PAVILION
New York City, New York

Site access courtesy: Walters Inc.

The Architect's Concept

Image: Pelli Clarke Pelli Architects

Complex steel uses digital methods

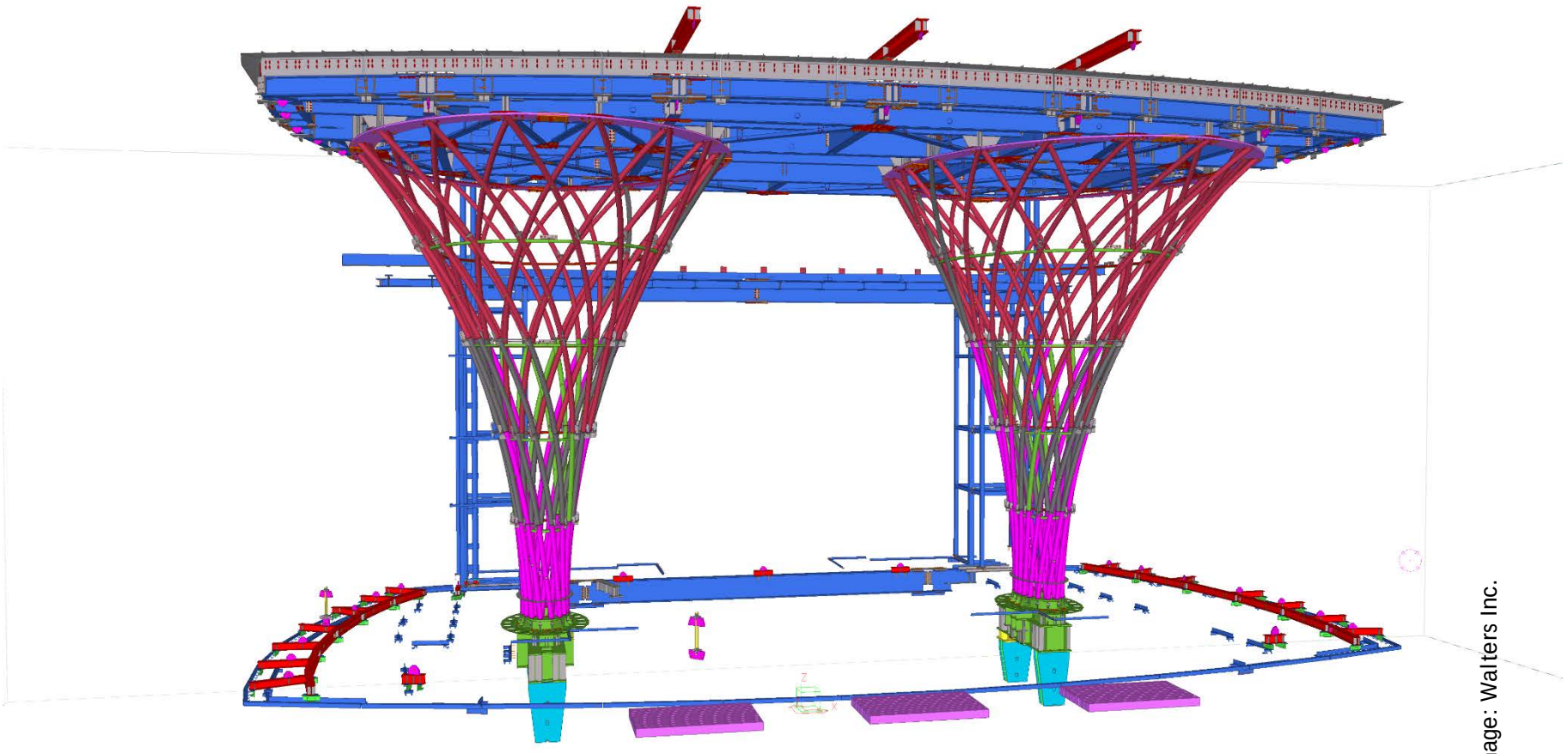


Image: Walters Inc.

Top view of plan

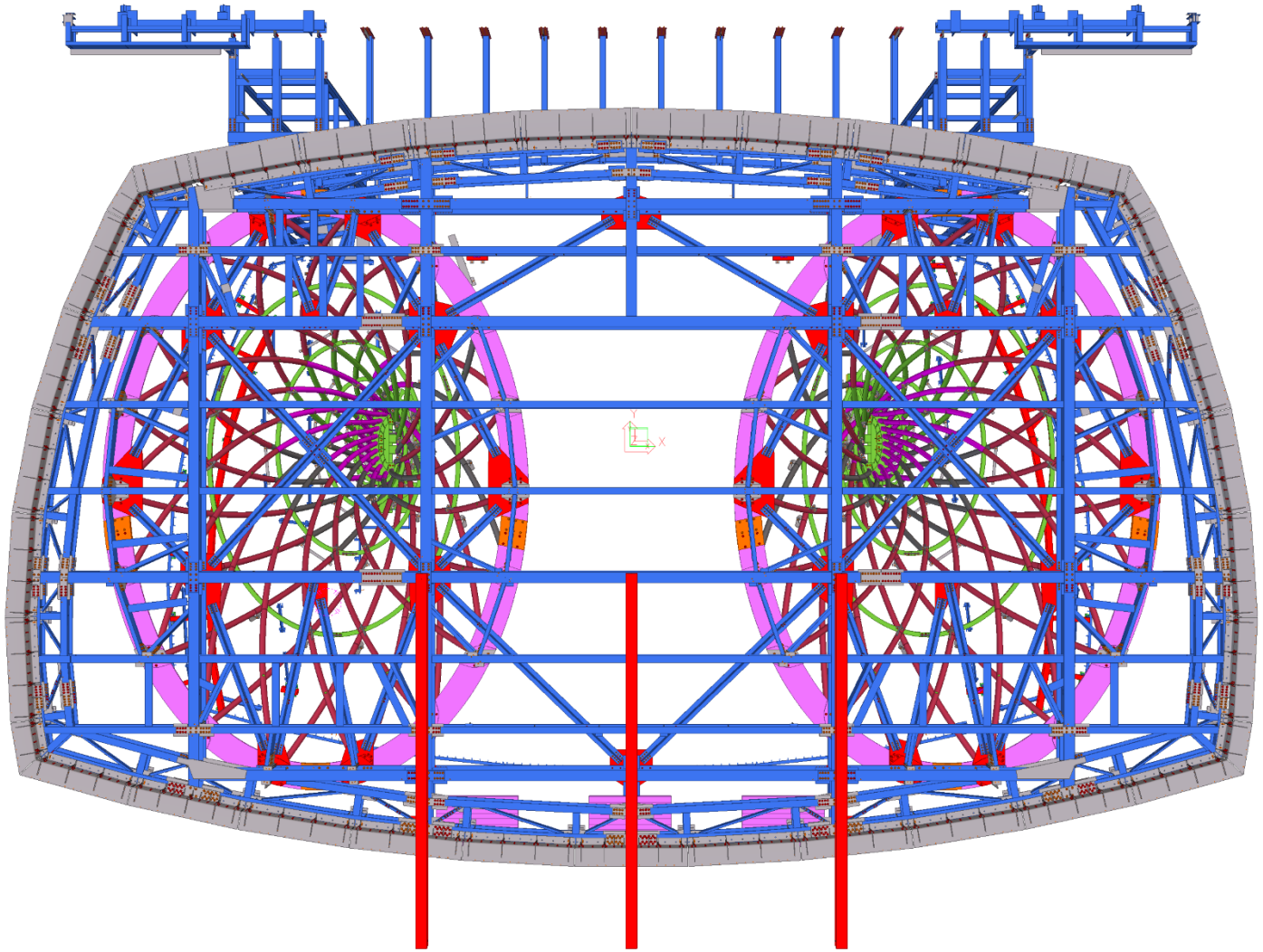


Image: Walters Inc.

Detailed view

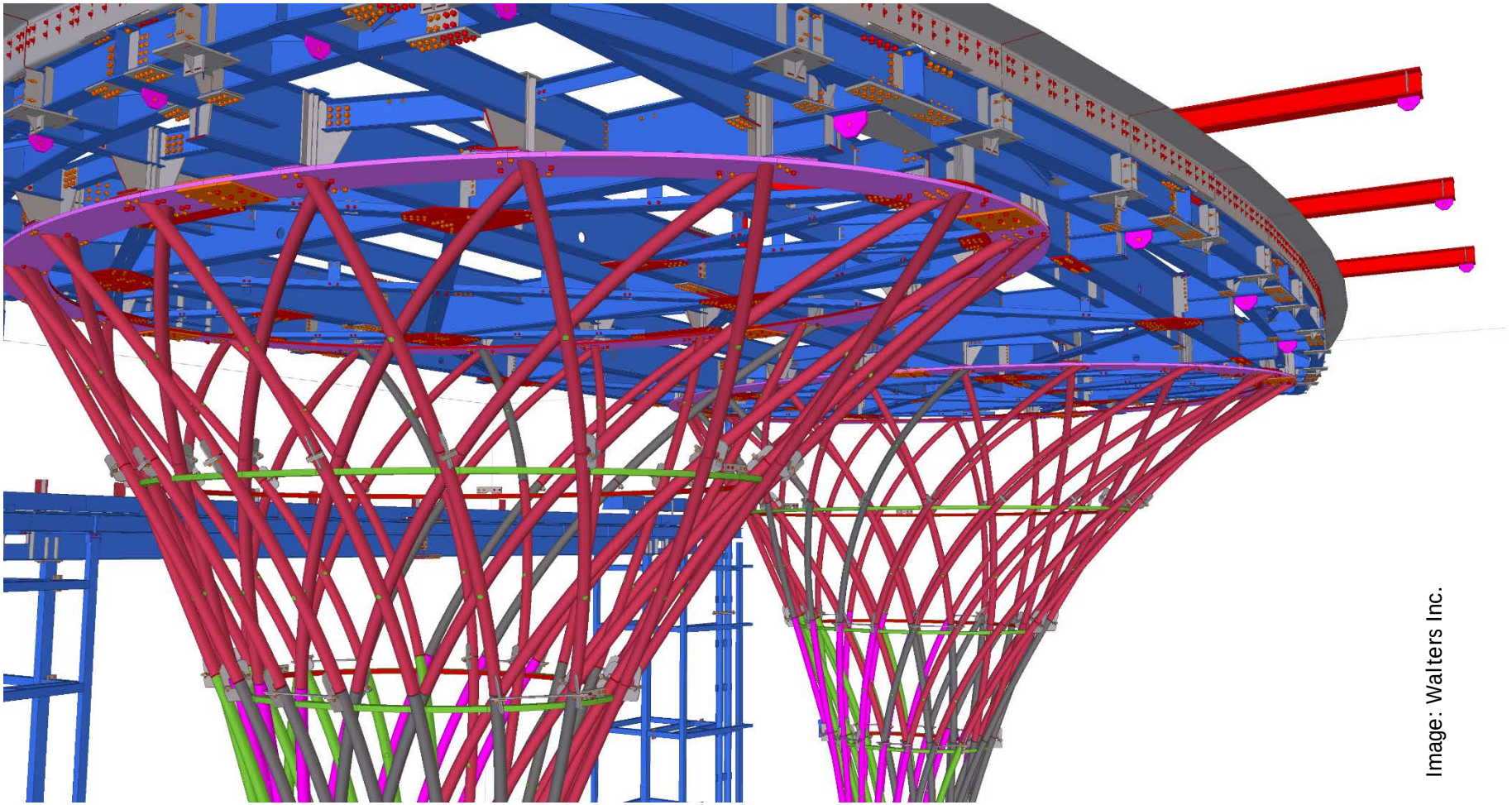
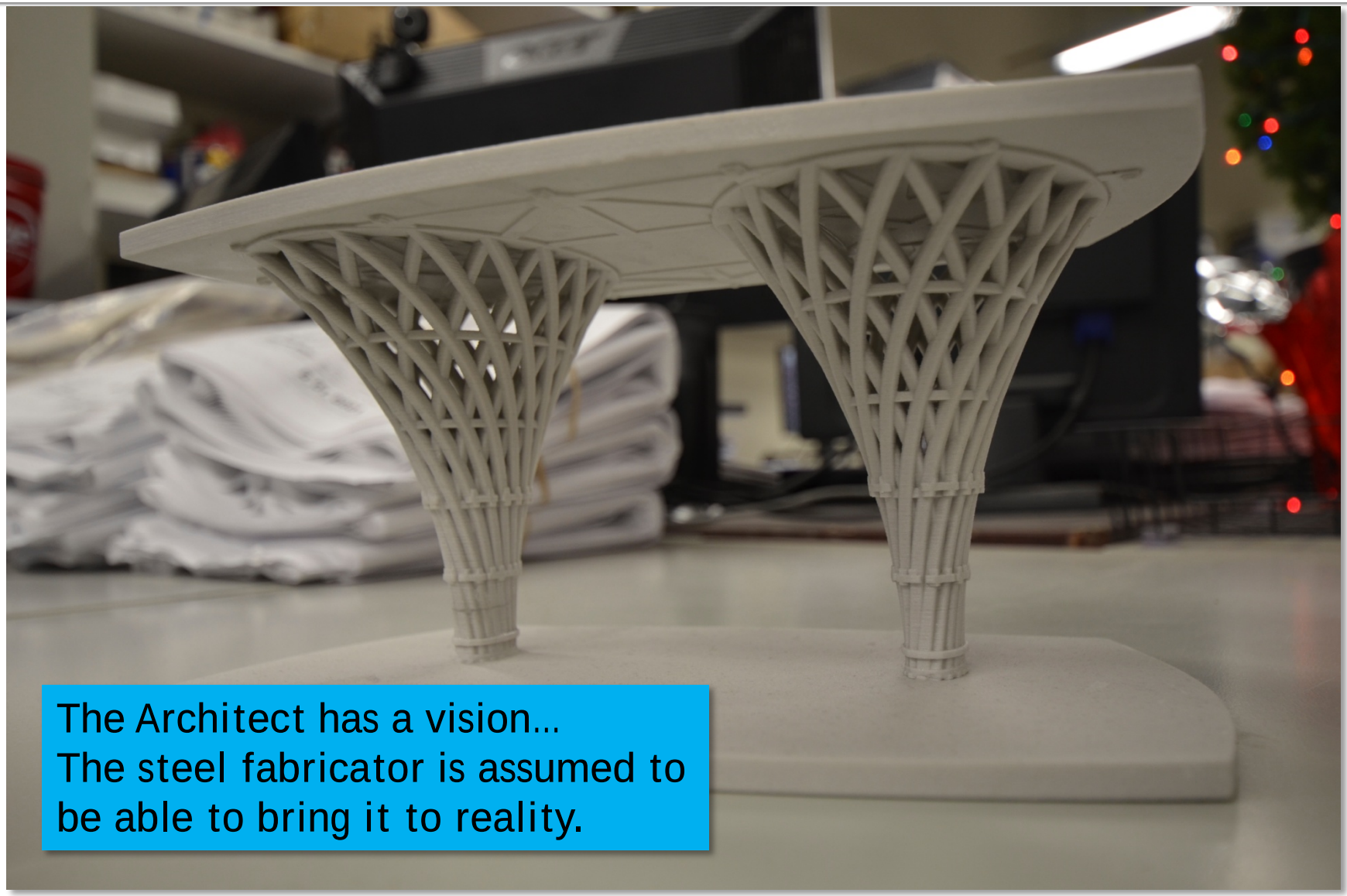
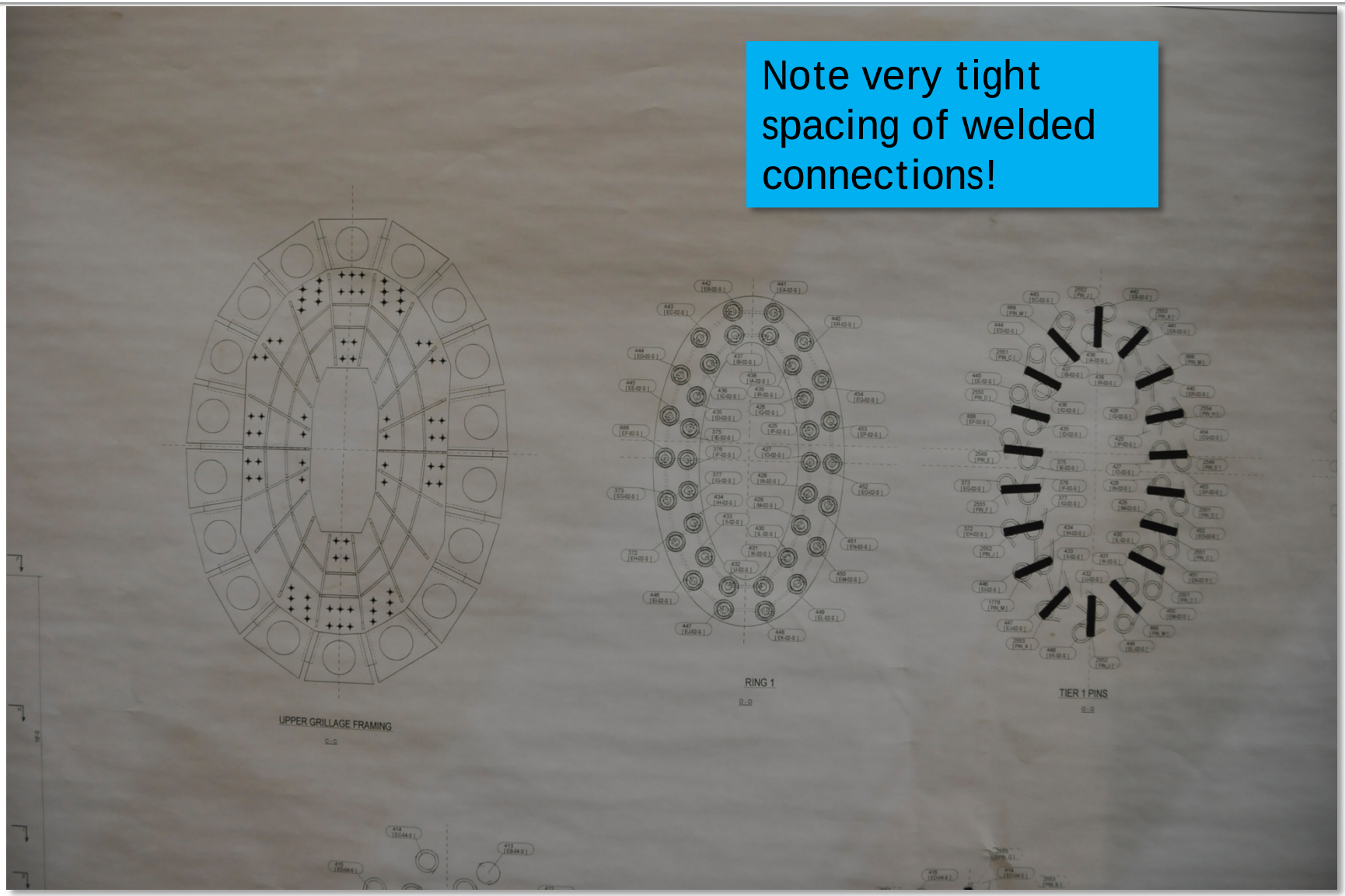


Image: Walters Inc.

The 3D Model


The Architect has a vision…
The steel fabricator is assumed to be able to bring it to reality.

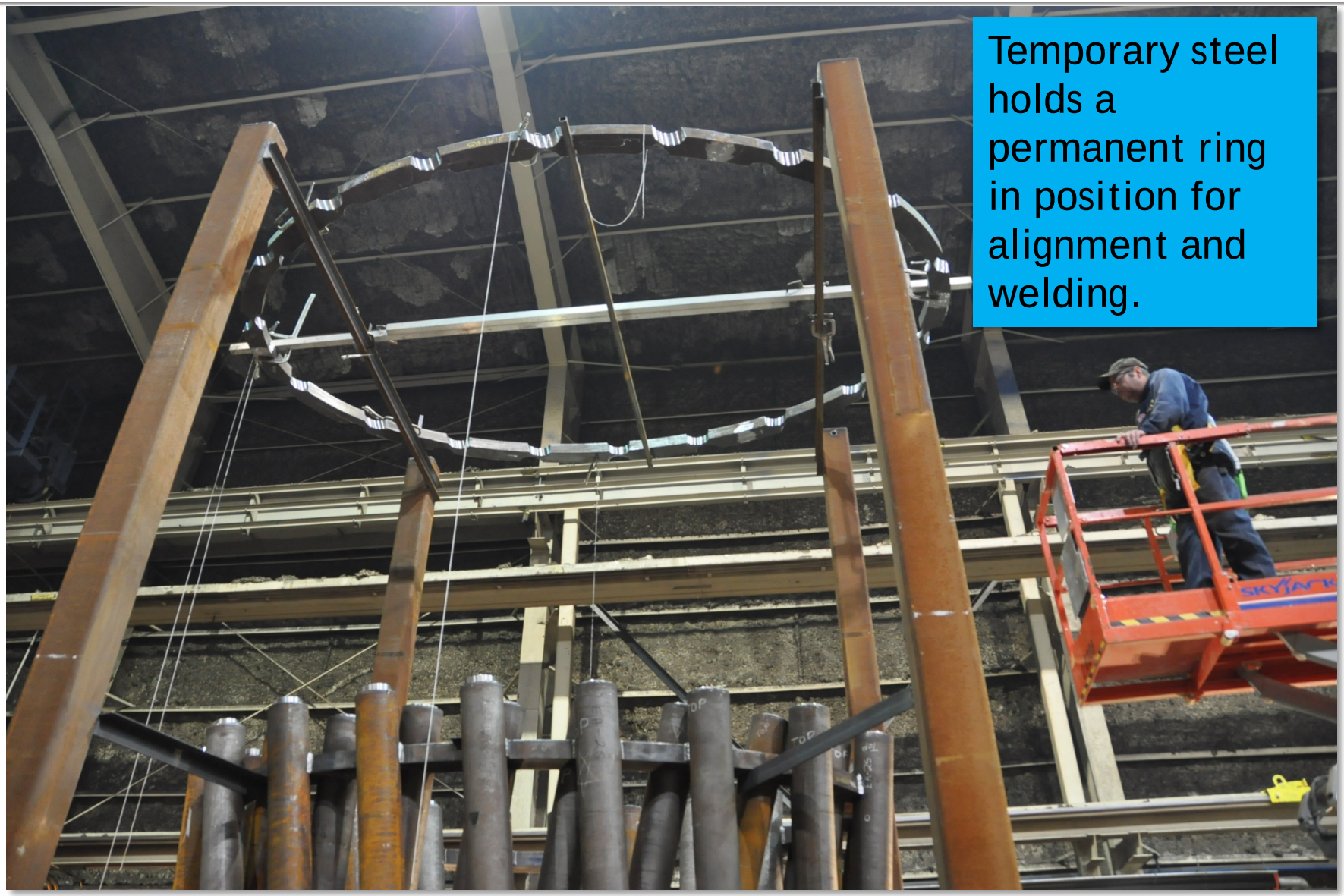
Planimetric drawings



Setting the jigs

- Two “baskets”
- 5 tiers each
- Fully welded AESS4
- Understand truck limitations
- Minimize site connections
- Transport to NYC from Hamilton

Maximizing the fabrication in shop



Curved tubular steel

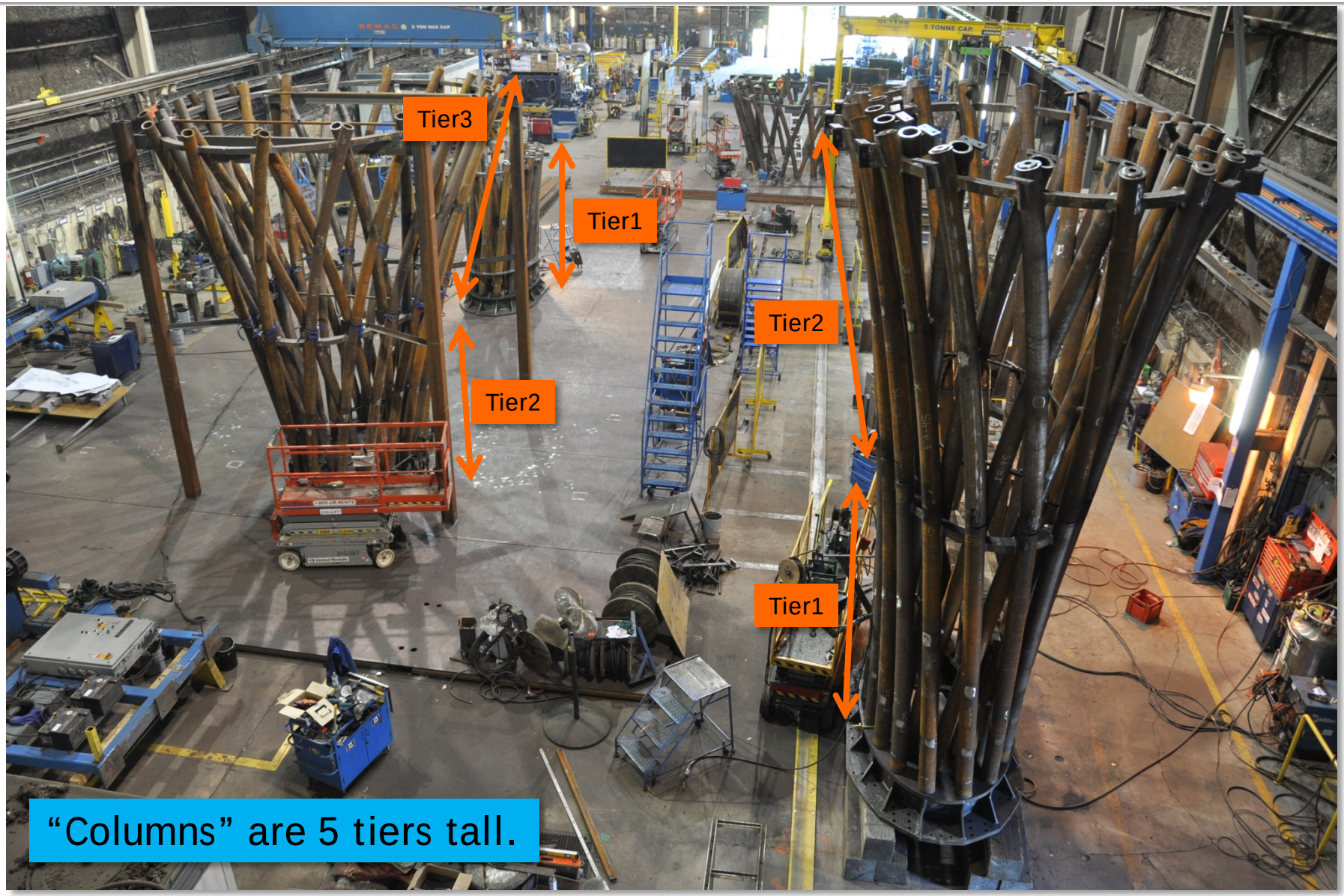
Issues with matching connecting curved pieces for seamless welded connections.

Solid connecting steel rods

For AESS4 these connections must be ground and filled and
'made to disappear'

Curves, overlaps and geometry

Shop space and pre-fitting

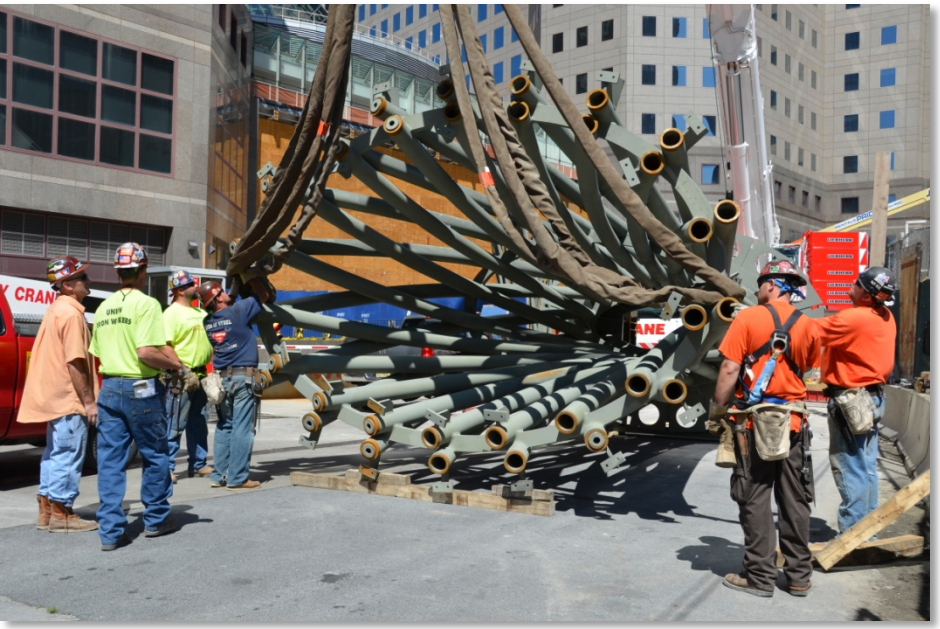


Aligning future site connections

Why shop weld?

Transportation

Handle with care



- Erection crew different from fabrication crew
- Lifting odd shapes difficult
- Steel is primed
- Surfaces must not be damaged

Lift off of the truck

Lift into place

- Site preparations must be accurate
- AESS requires precision
- Plumb element
- Remember this is structural steel

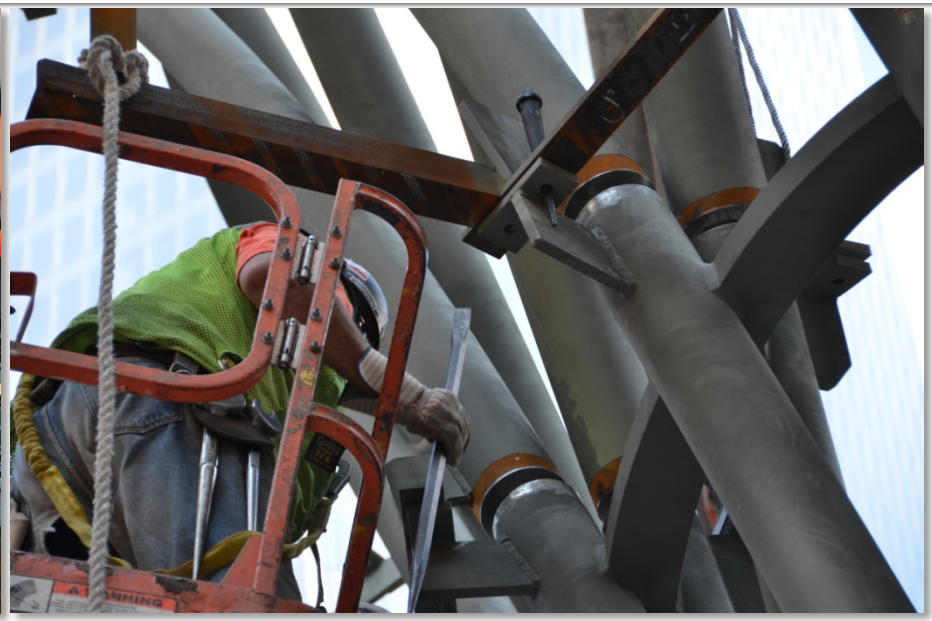
Access to complete connections

Staging and site issues

Sorting pieces

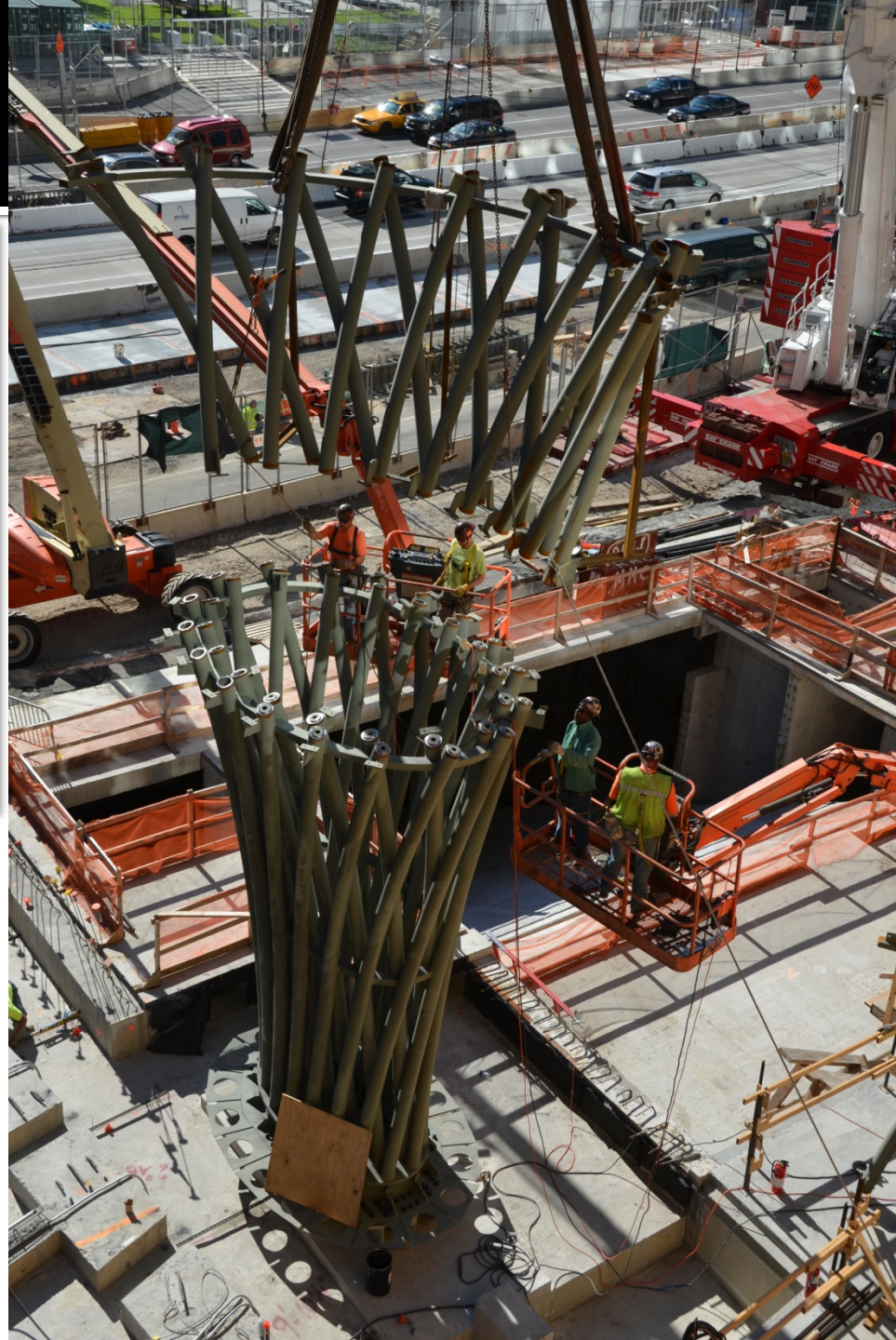
- Many pieces for a complex project
- Need to ensure adequate labeling to avoid confusion
- Upper tiers too large to be shipped assembled
- Subdivided into sections to fit shipping limitations

Access to perform work



Complex fit

- If it does not fit, it is a HUGE problem
- Precision at the shop AND precision at the site



3 months later…

Weld remediation

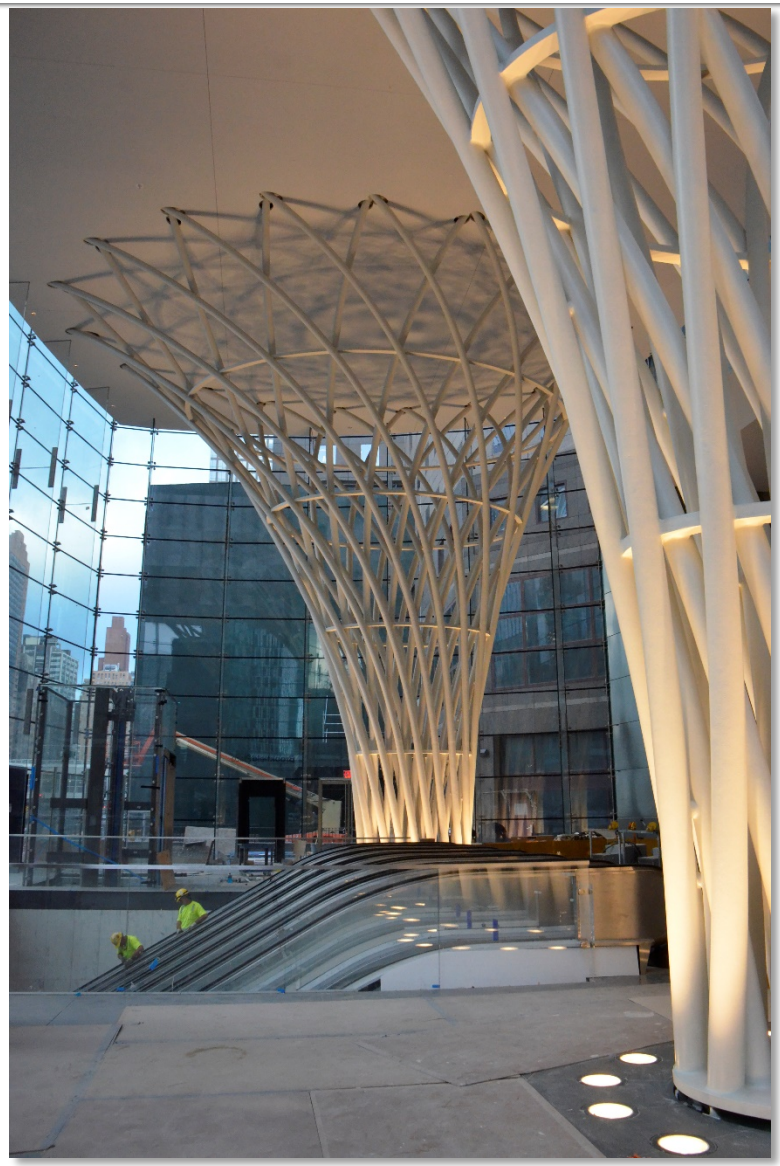
Installation of roof decking

This takes a long time...

Welding, erecting scaffolding and the sheer number of connections adds up.

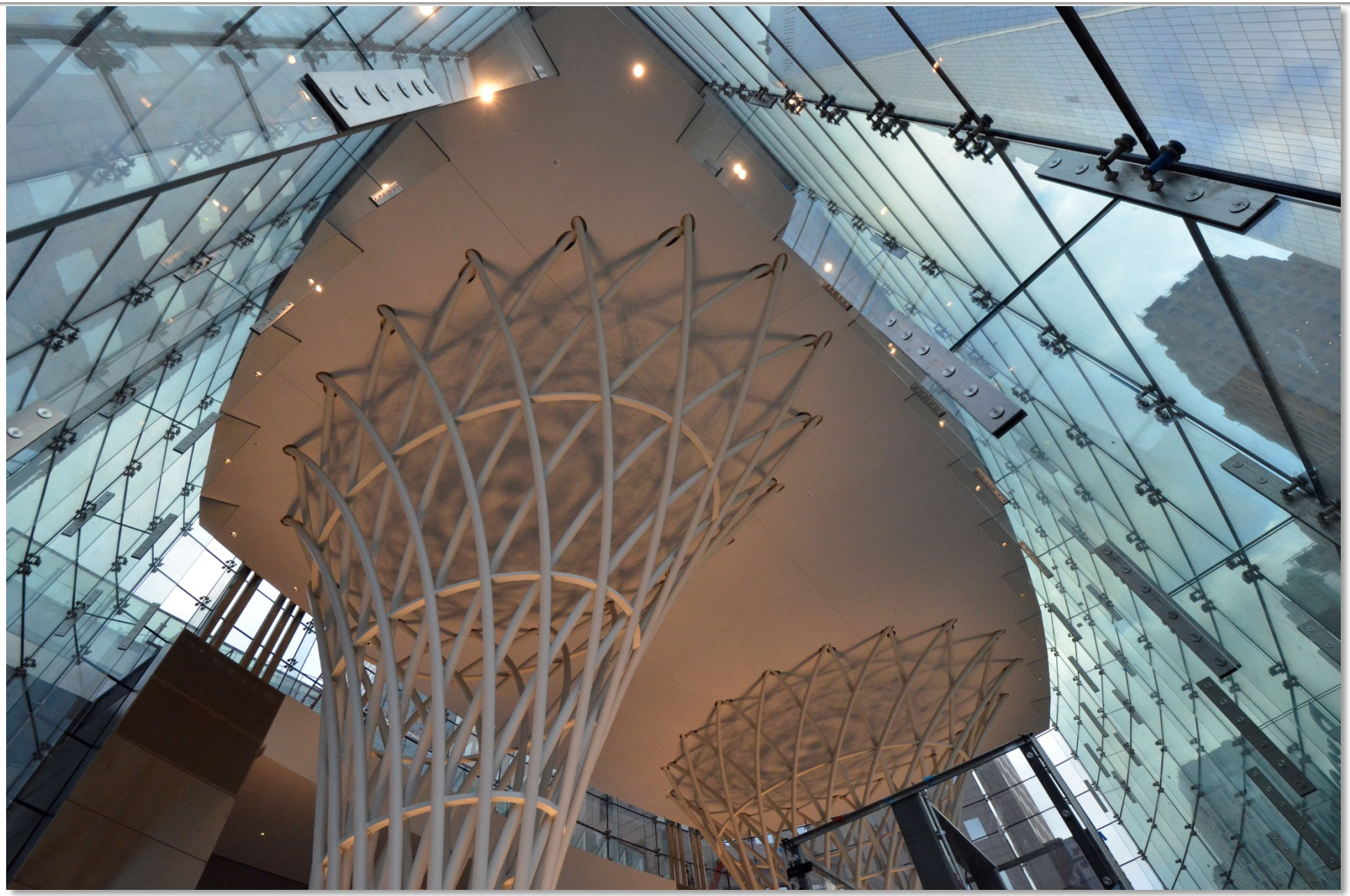
The Glass Box

Finished steel



Intumescent coating

Structural columns in glass box



Project Profile

EIGHTH AVENUE PLACE
WINTERGARDEN
Calgary, Alberta

Owner
Penny Lane II Limited Partnership

Development Manager
Hines Canada Management Co., ULC

Architects
Pickard Chilton International Design architect
Gibbs Gage Architects AOR
Kendall/Heaton Associates Inc. Production architect

Structural Engineers
Dr. P.V. Banavalkar, CBM Design engineer
Read Jones Christoffersen Ltd. EOR

Construction Manager
Ellis Don Construction Management Services

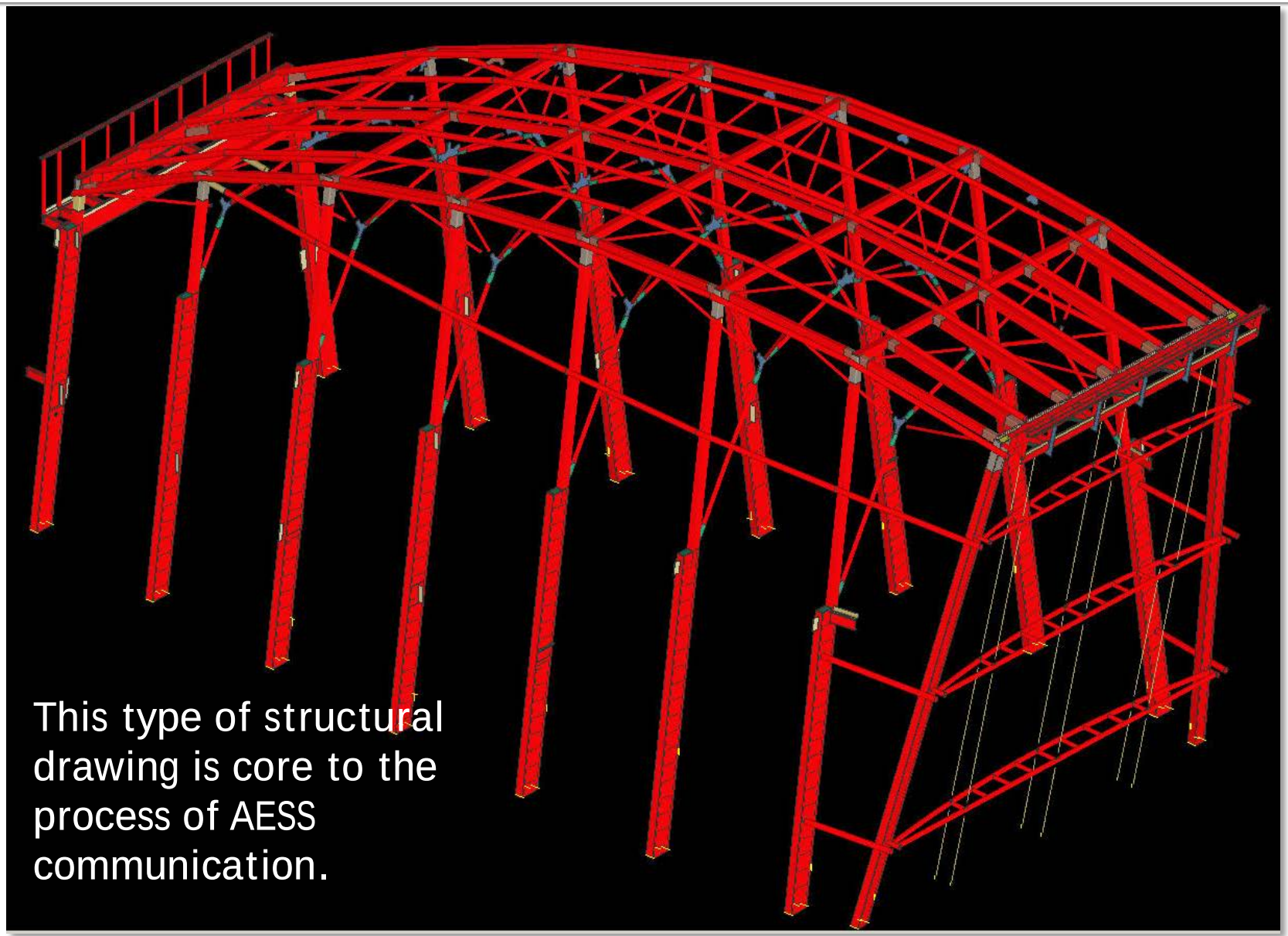
Steel Fabricator / Detailer / Erector
Supermétal

Photo credits this section: Supermétal
Content: Sylvie Boulanger, Vice President, Technical Marketing

Concept

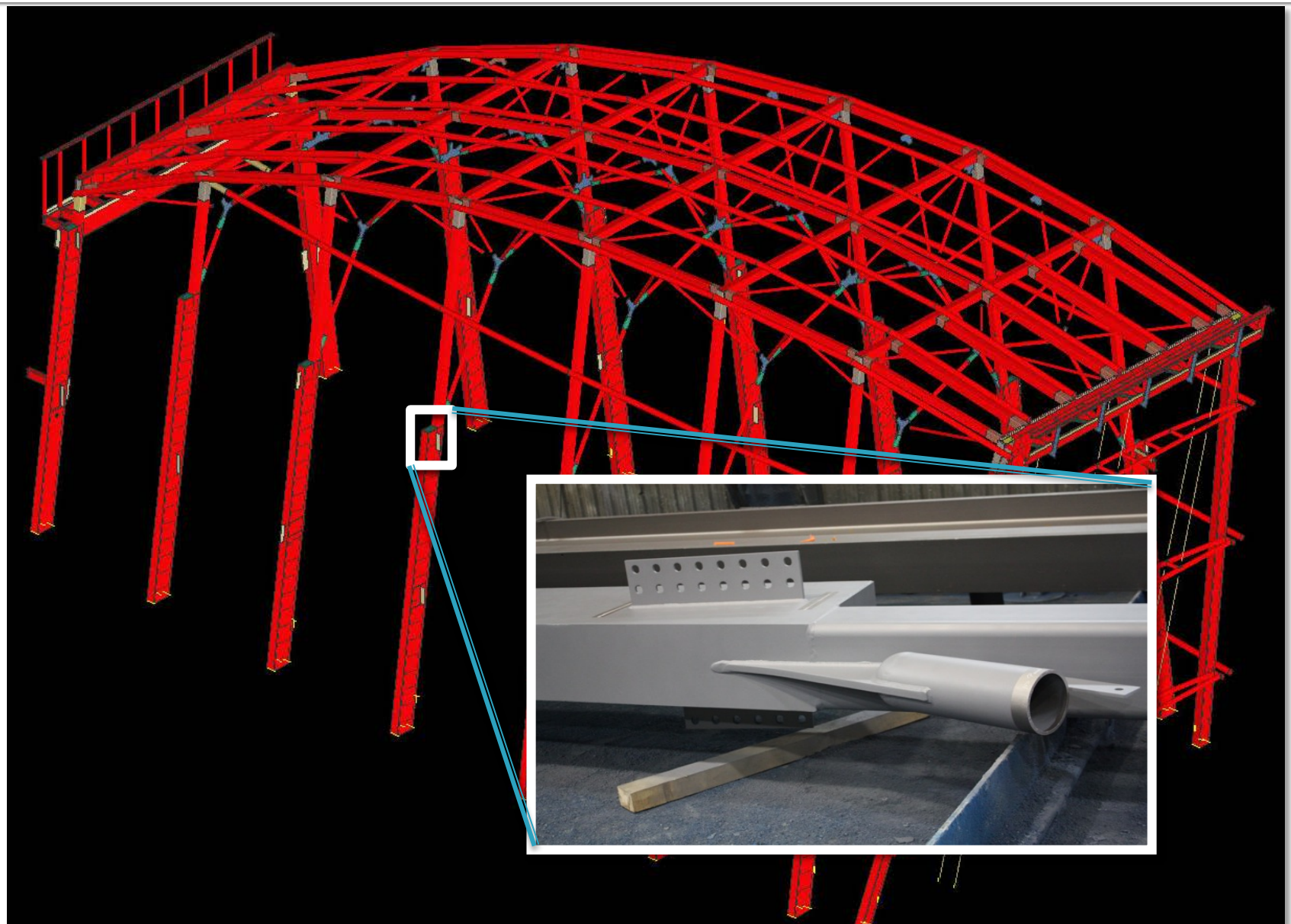
- The main structure comprises **eight large trapezoidal arches** connected by a web of smaller steel tubes, which form an interconnected three dimensional truss-frame.
- All of the **complex structural connections** between the steel arches and tubes were architecturally designed and engineered
- Specification approaches **CISC's AESS2 and AESS3** Categories, for 'far from view' and 'close to view' steel

Overall structural drawing

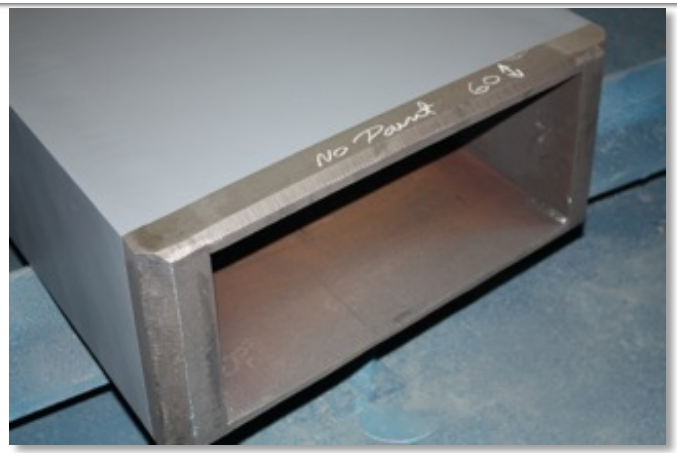


This type of structural drawing is core to the process of AESS communication.

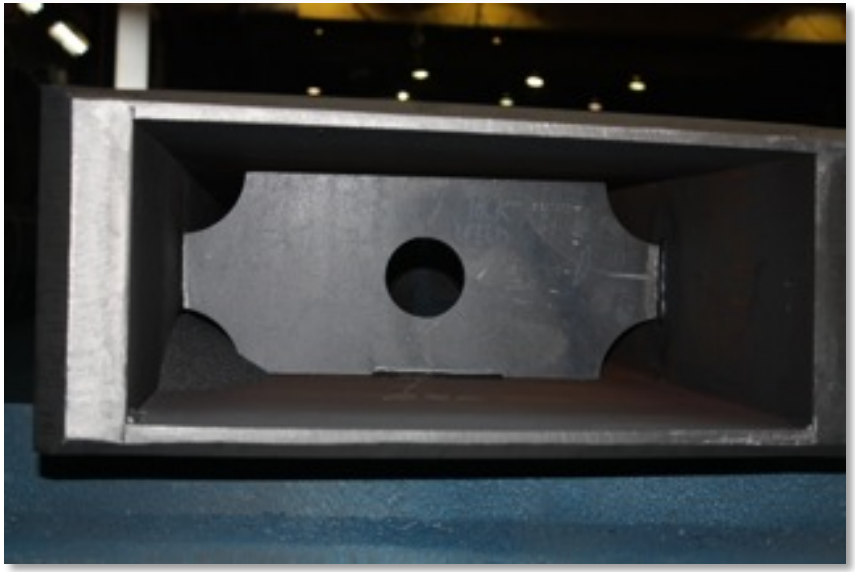
Haunch detail

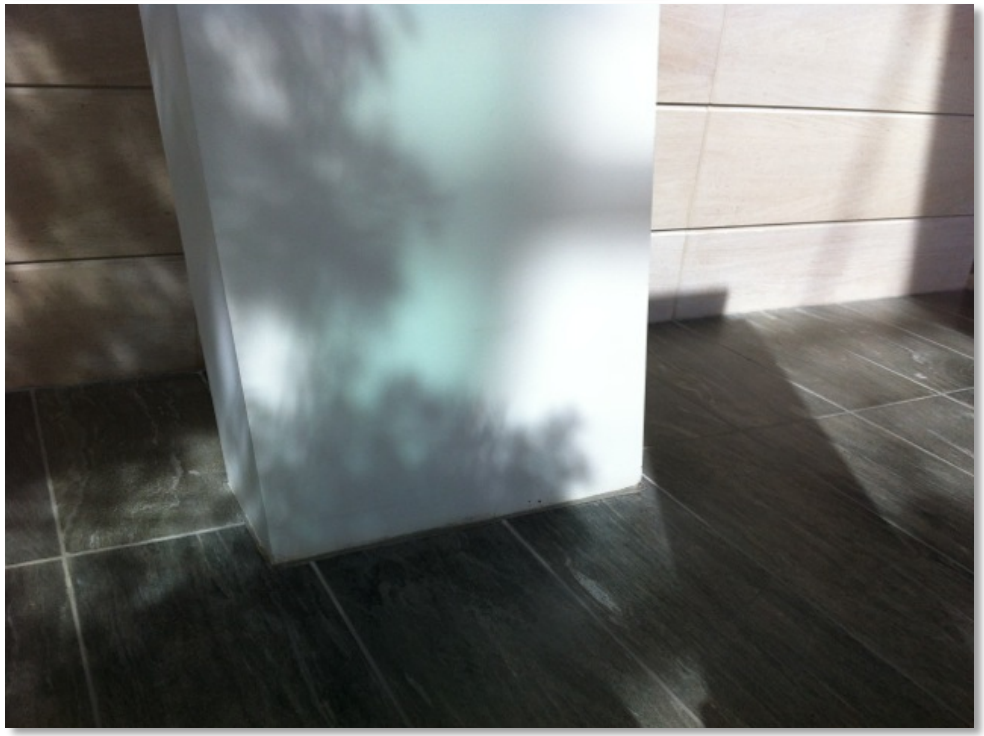


Column fabrication

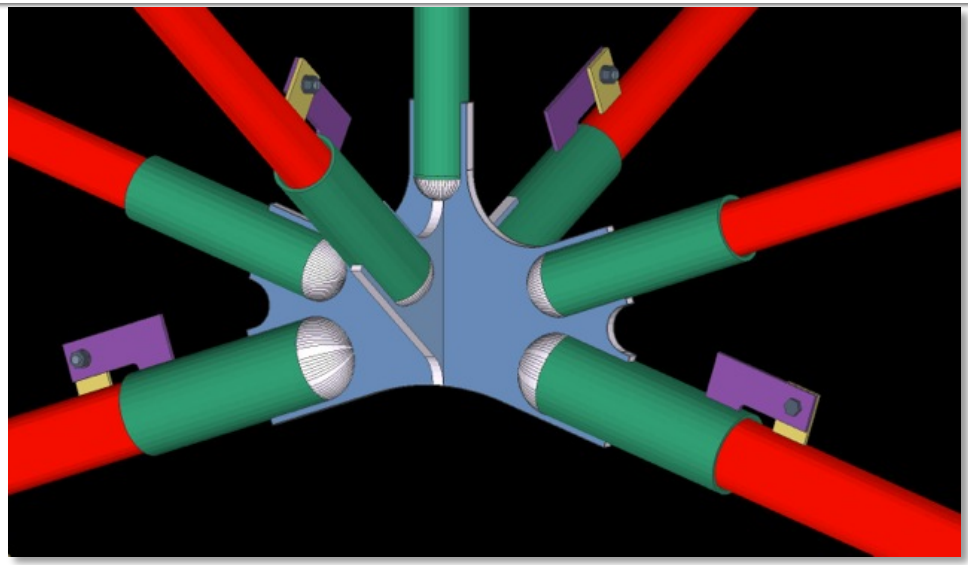


Custom plate columns with sharp corners are typical of high level AESS





Node connection



Steel erection

Last Arch erection

2nd Arch erection

Completed node

Completed Wintergarden

Details

Owner
Cityzen, Fernbrook Homes

Architects
architectsAlliance

Construction Manager

Steel Fabricator / Detailer / Erector
Walters Inc. Hamilton/Metropolitan Walters

Project Profile

PIER 27 RESIDENCES
Toronto, Ontario

Site access courtesy: Walters Inc.

Bridging with a diagrid ‘truss’

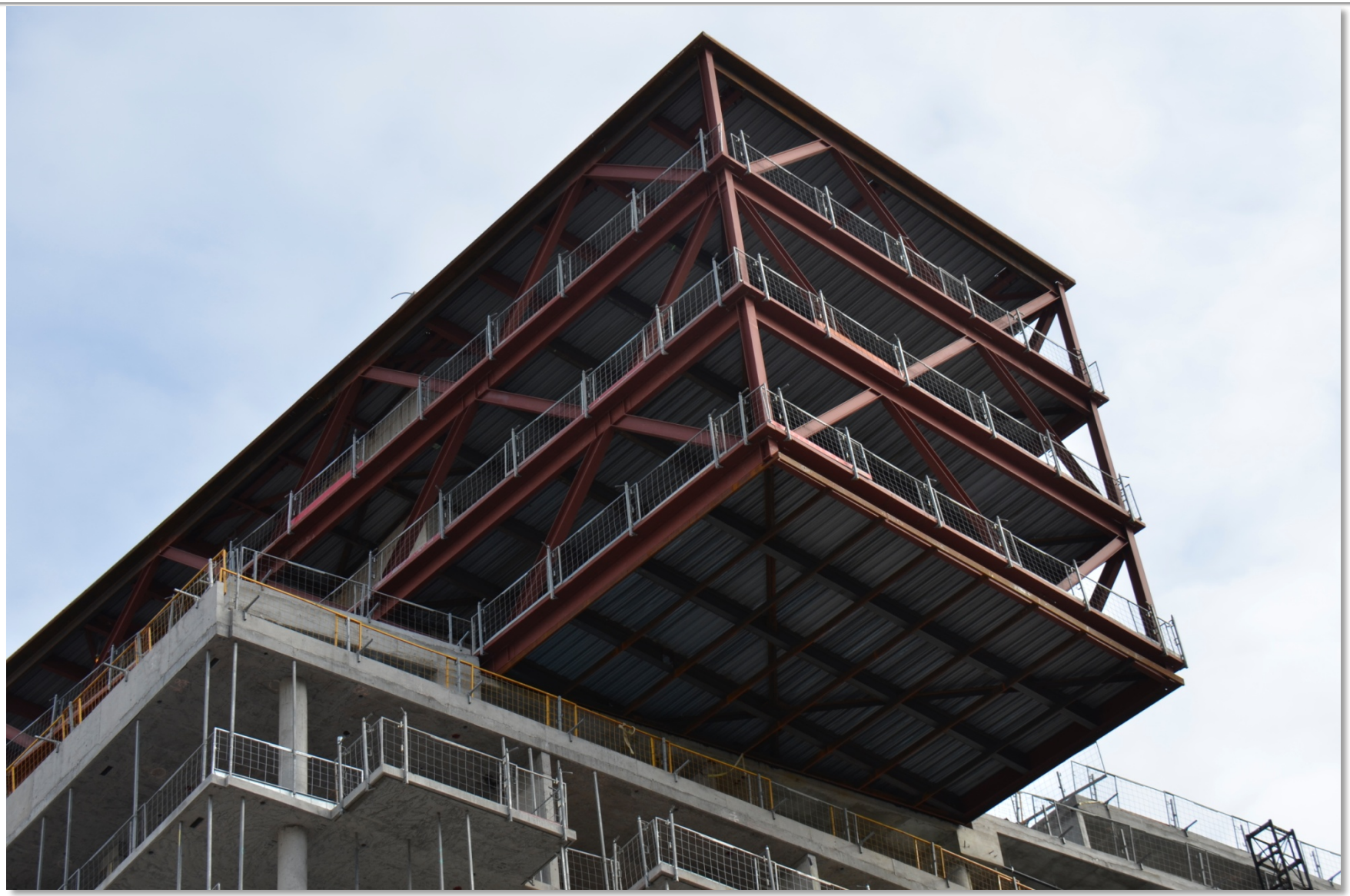
Prepping for a lift

Floor support element erected

Team accepting element

What is exposed? What is not?

Bracing in all planes



Intersections

Stiffness through structural choices

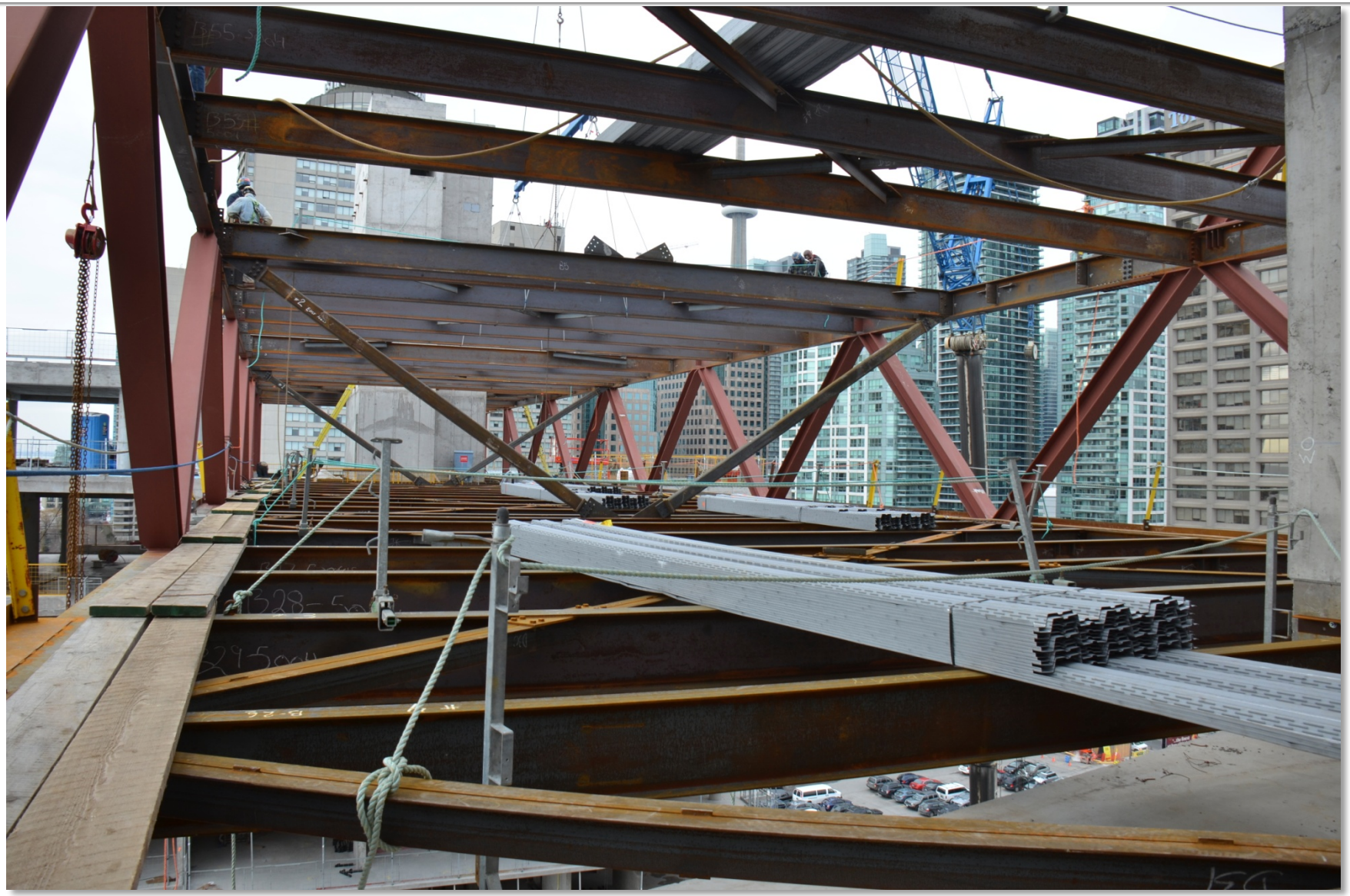
Steel to concrete issues

AESS vs structural components

Splice locations

Shipping restrictions

Temporary stabilization systems



Bridges and cantilevers

Diagrid as result

Subtle differentiation

Project Profile

PEMBINA HALL
University of Manitoba
Winnipeg, Manitoba

Owner
The University of Manitoba

Architects
Raymond S.C. Wan Architect

Structural Engineers
Crosier Kilgour & Partners Ltd.

SMS Engineering Ltd.

McGowan Russell Group

Stantec Engineering

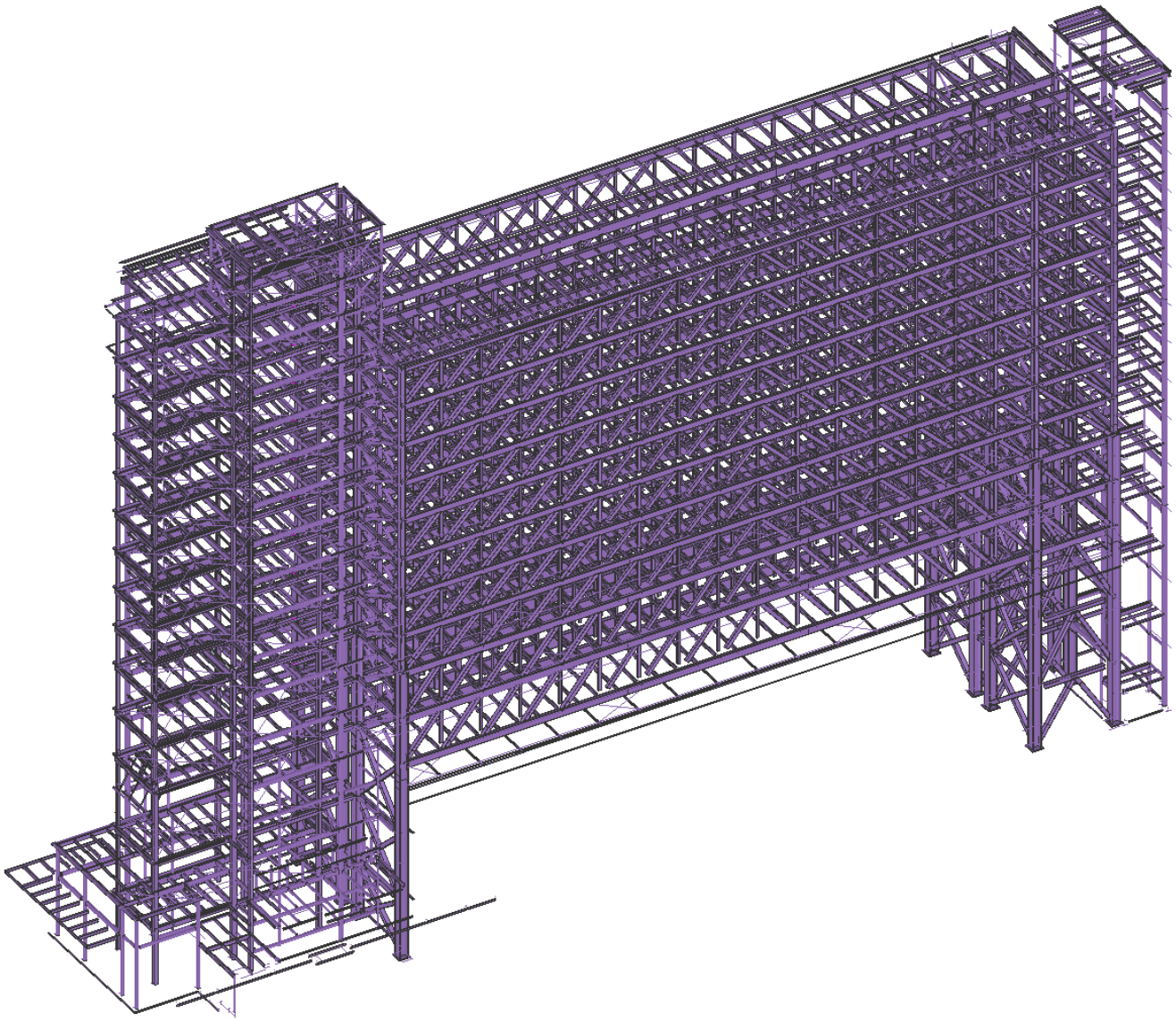
Dyregrov Robinson Inc.

Construction Manager
Bird Construction Company Ltd.

Steel Fabricator / Detailer / Erector
Supermétal

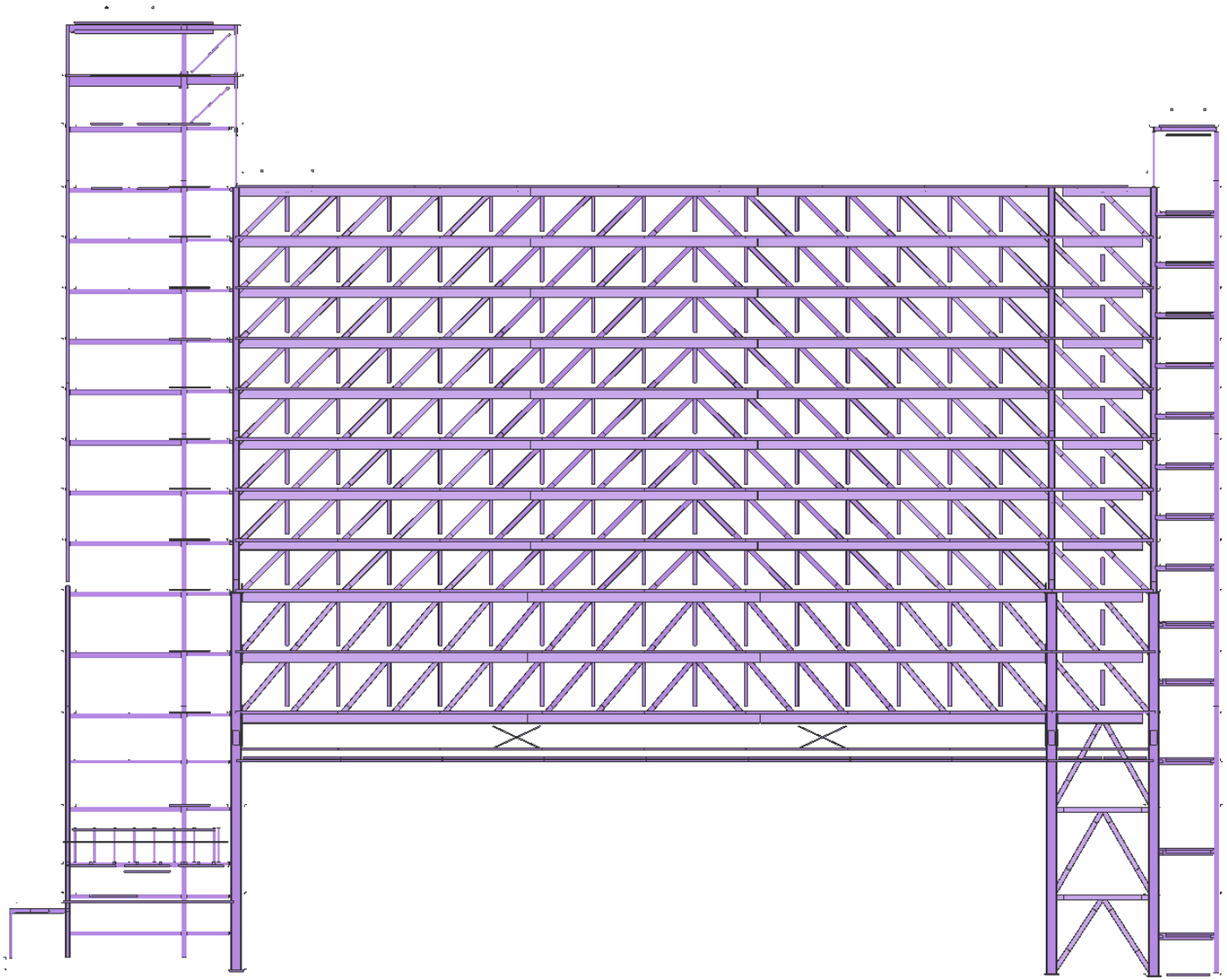
Photo credits this section: Supermétal
Content: Sylvie Boulanger, Vice President, Technical Marketing

Structural Isometric



This drawing type is useful for showing the extent of the steel in the project as it excludes other materials such as reinforced concrete from the view.

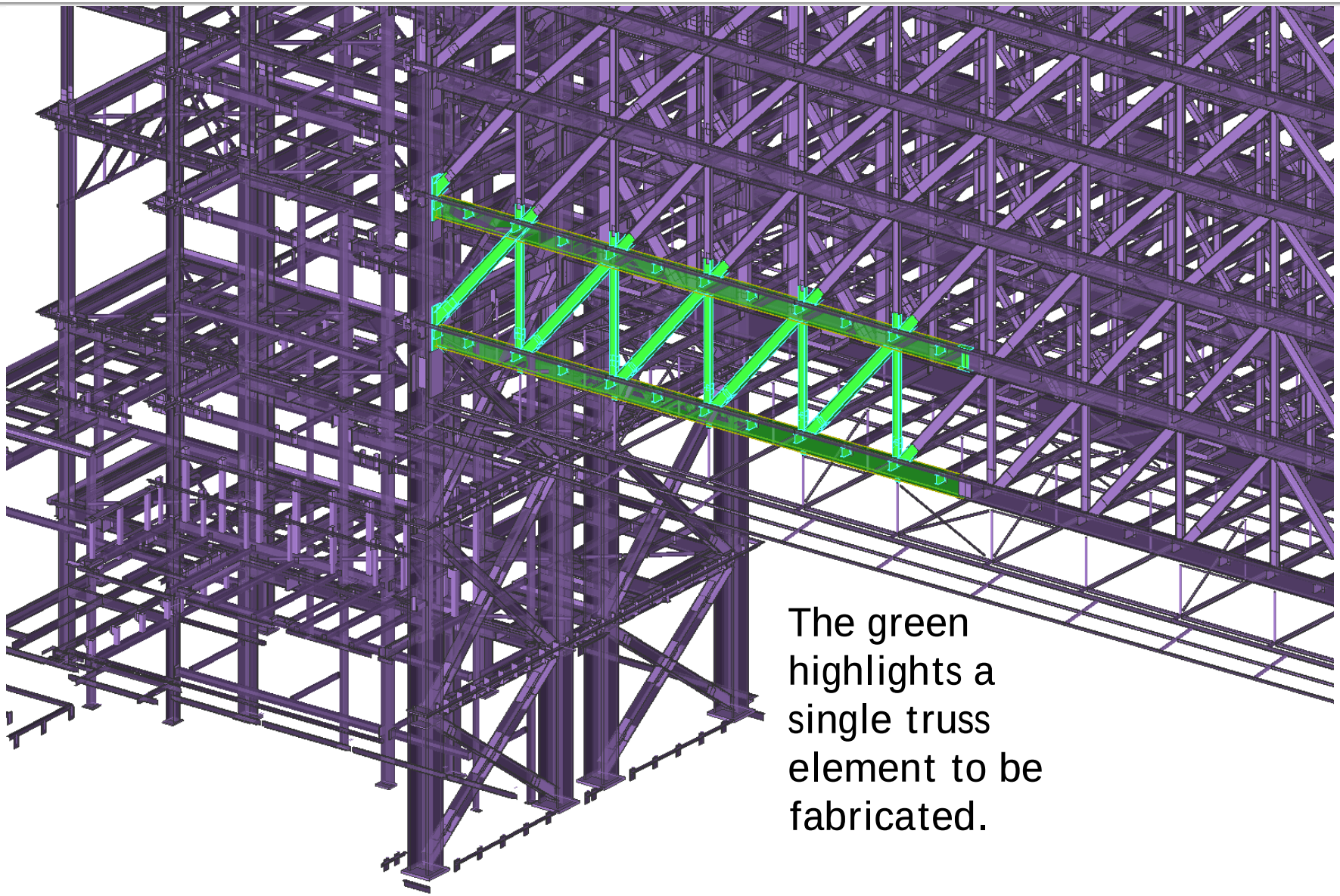
Elevation view of steel



The elevation view highlights that the main slab of student residences will be clear spanning between the tower elements.

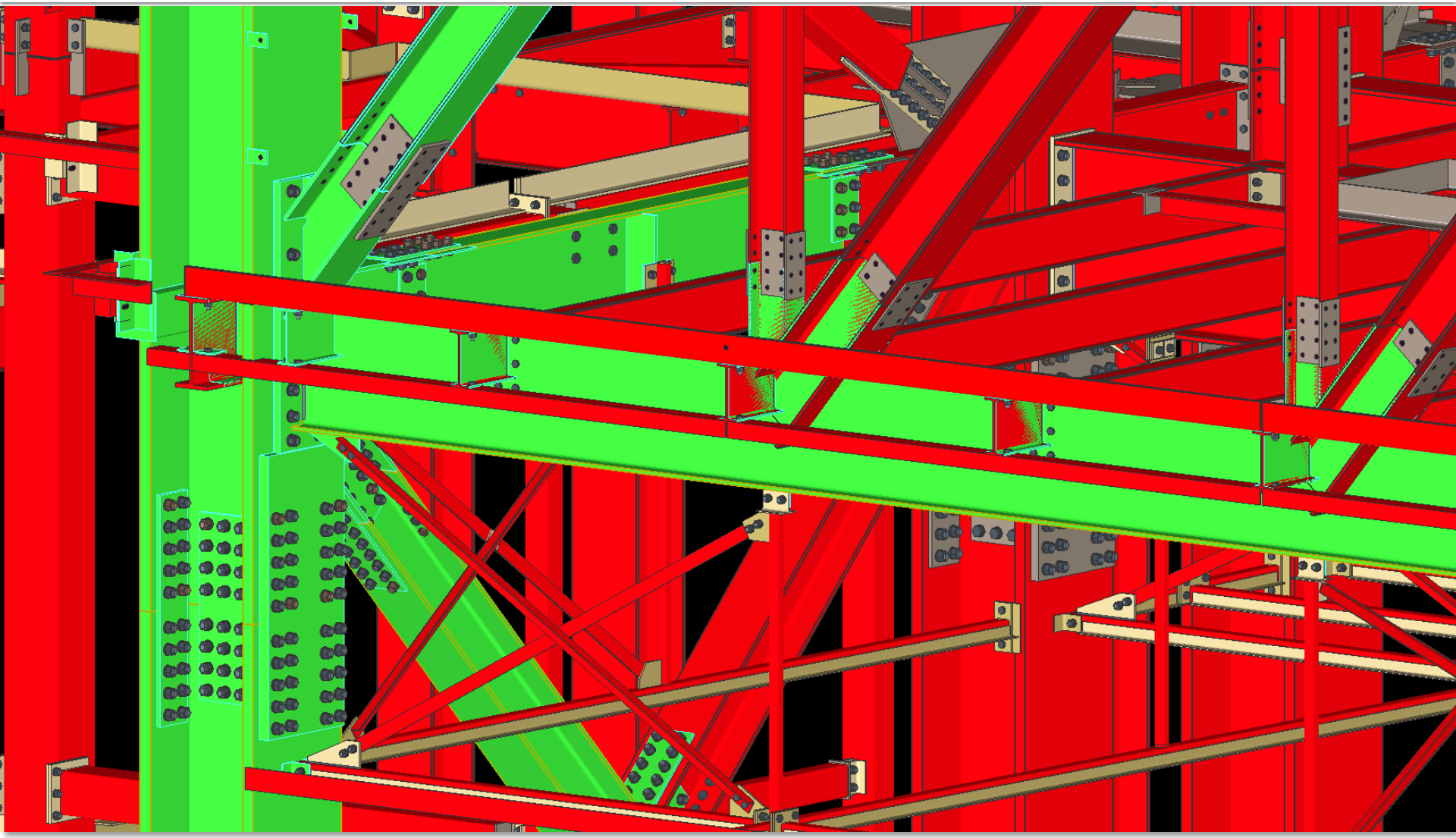
The direction of the diagonal chords was an aesthetic choice as it puts them in compression which is not optimal loading.

Truss element

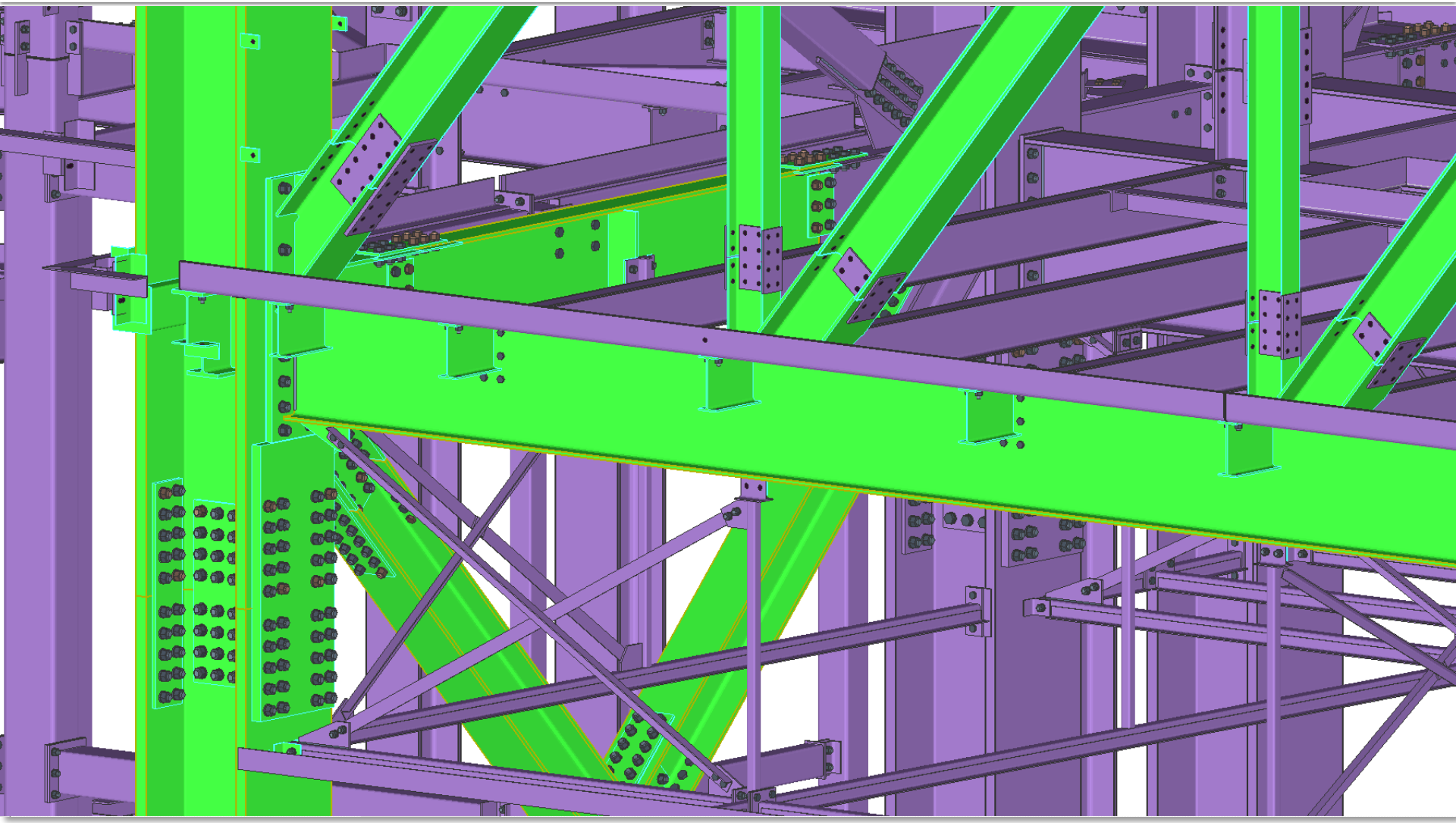


The green highlights a single truss element to be fabricated.

Connections and splices



Connections and splices



Site assembly of truss components

Lifting an assembled truss section

First truss in place

Site bolting

Semi finished structural frame

Project Profile

UNION STATION ATRIUM
Toronto, Ontario

Owner
Yolles (CH2M HILL) – lead for GO Transit / Metrolinx

Architects
Zeidler Partnership

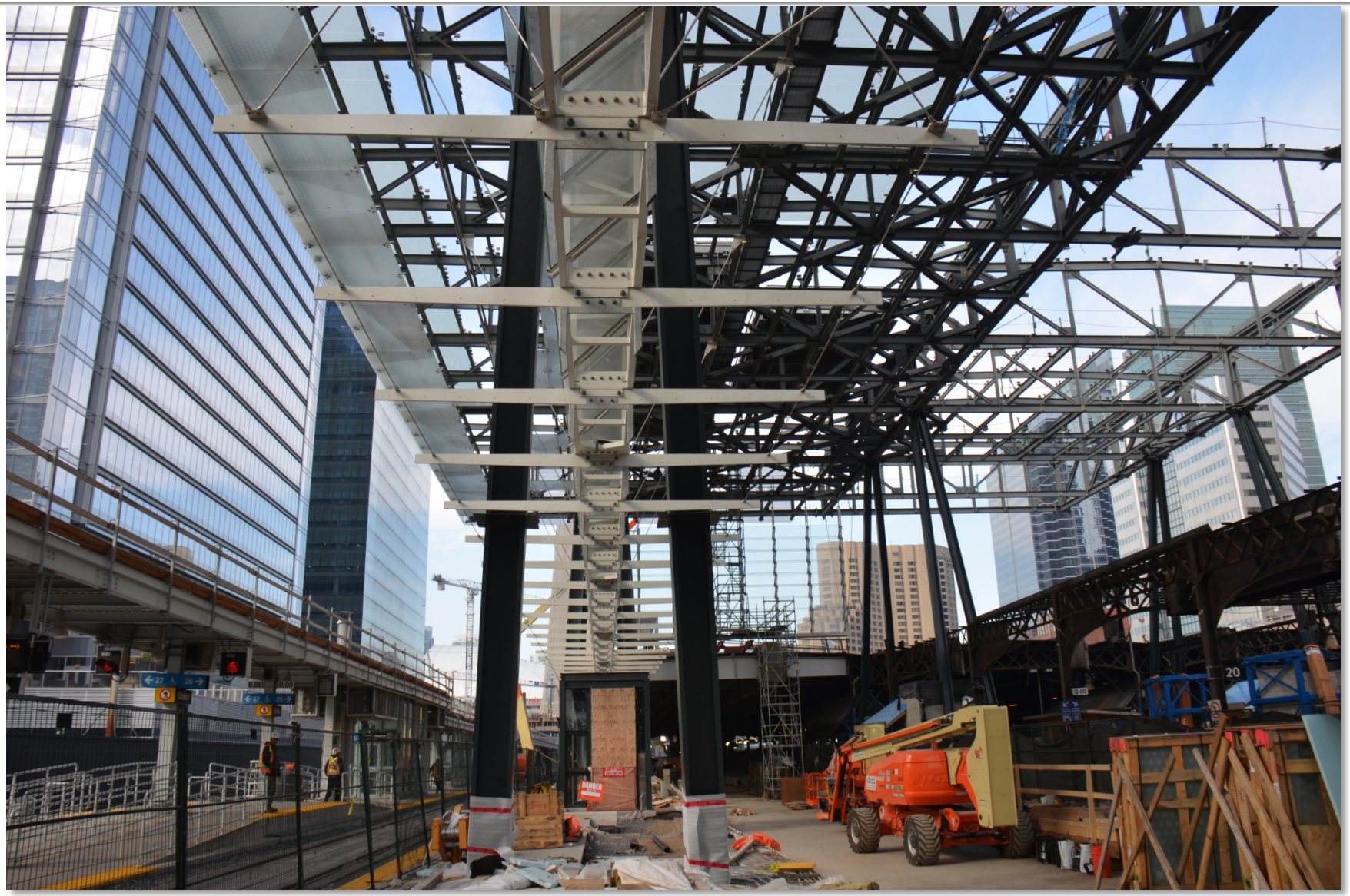
Construction Manager
Aecon

Structural Engineer
Yolles

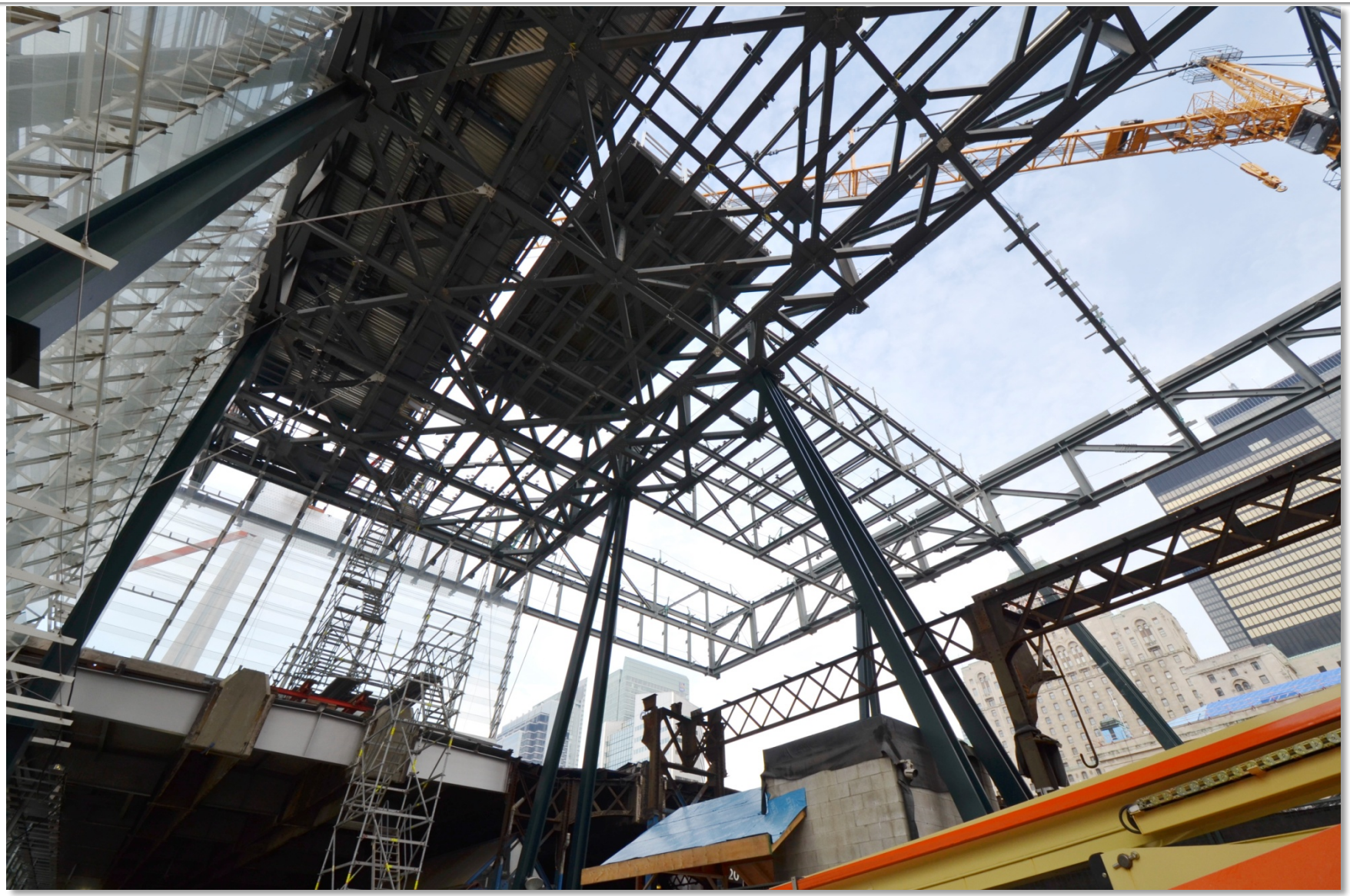
Steel Fabricator / Detailer / Erector
Walters Inc.

Site access courtesy: Walters Inc.

Union Station Train Shed

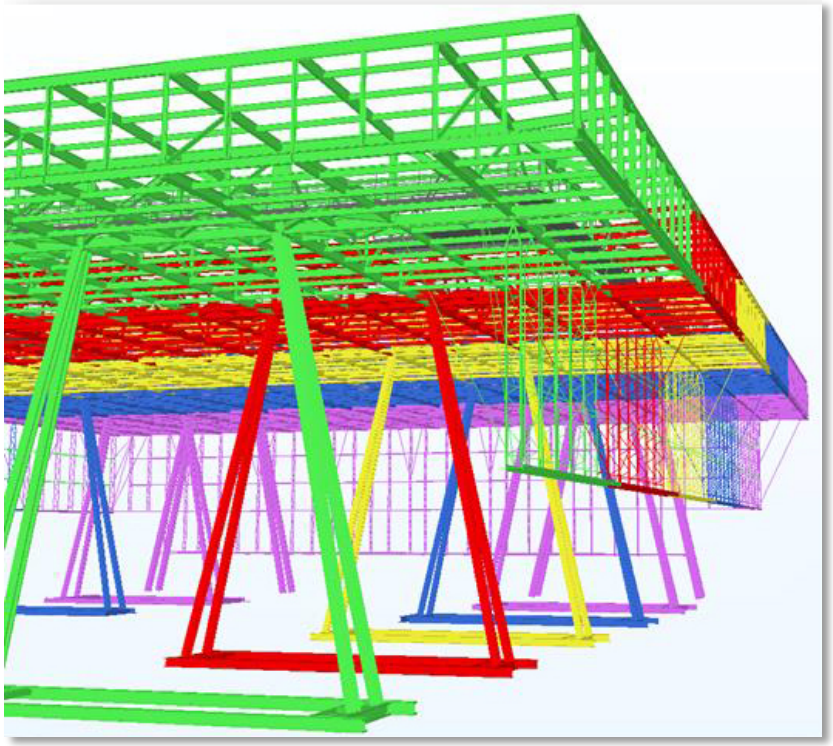


View towards roof

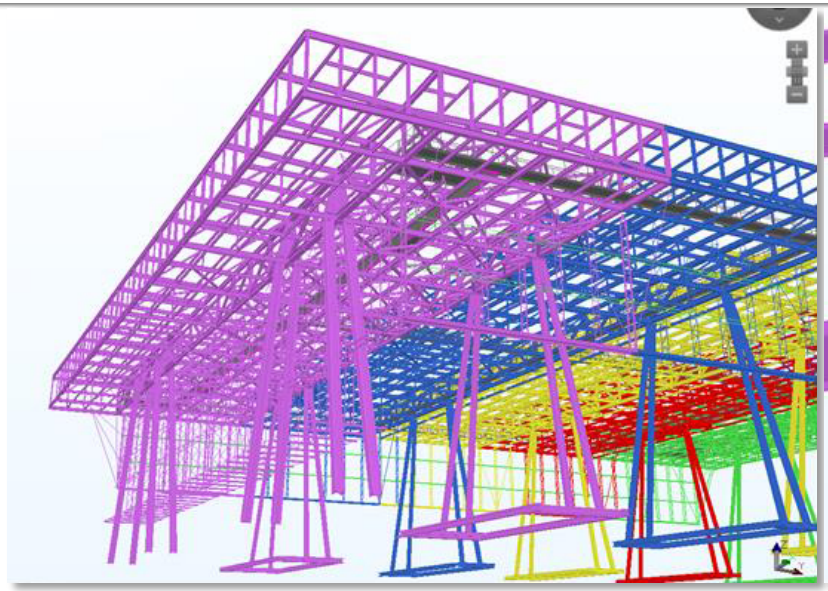


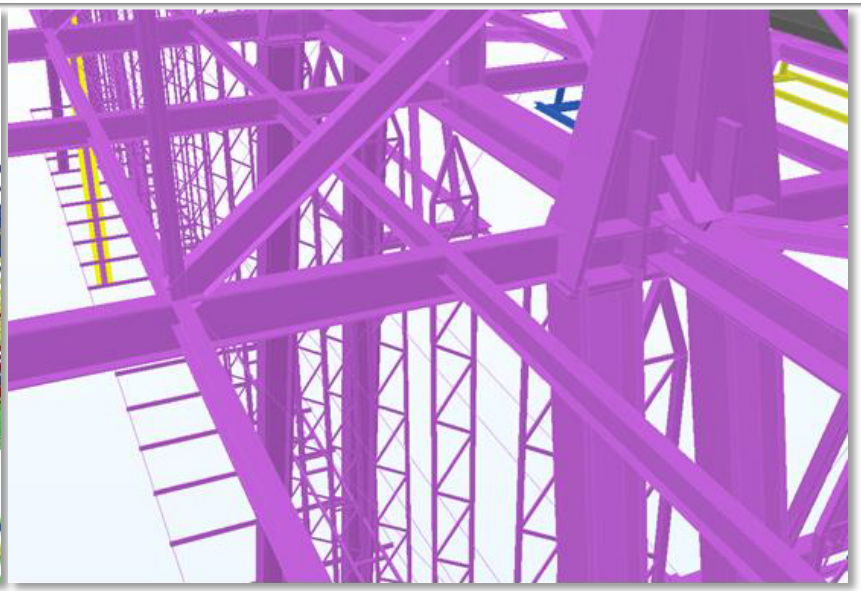
Construction phasing

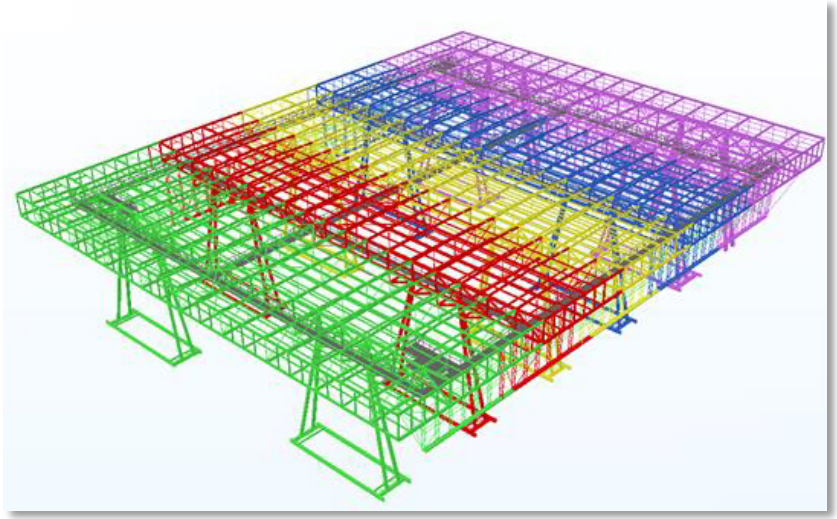
- The location provides many ‘issues’
- The tracks have to be kept open and operational
- The work has to be sequenced
- Major lifting that does require track closure can only occur at night
- This costs ‘extra’ given the time of day issues



Drawings





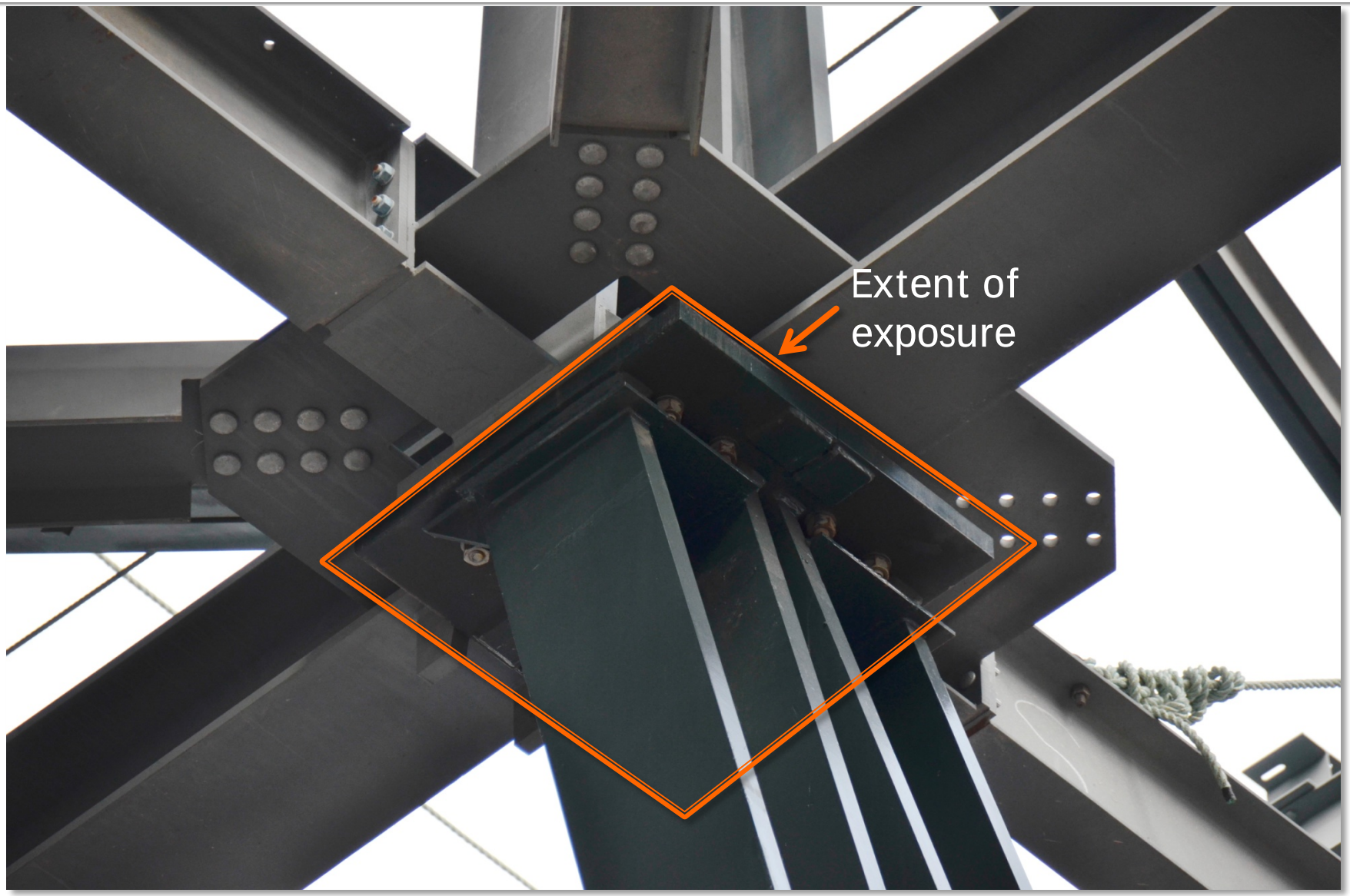


Detailing software allows the fabricator to design all of the connections as well as produce drawings for each element and for erection sequencing.

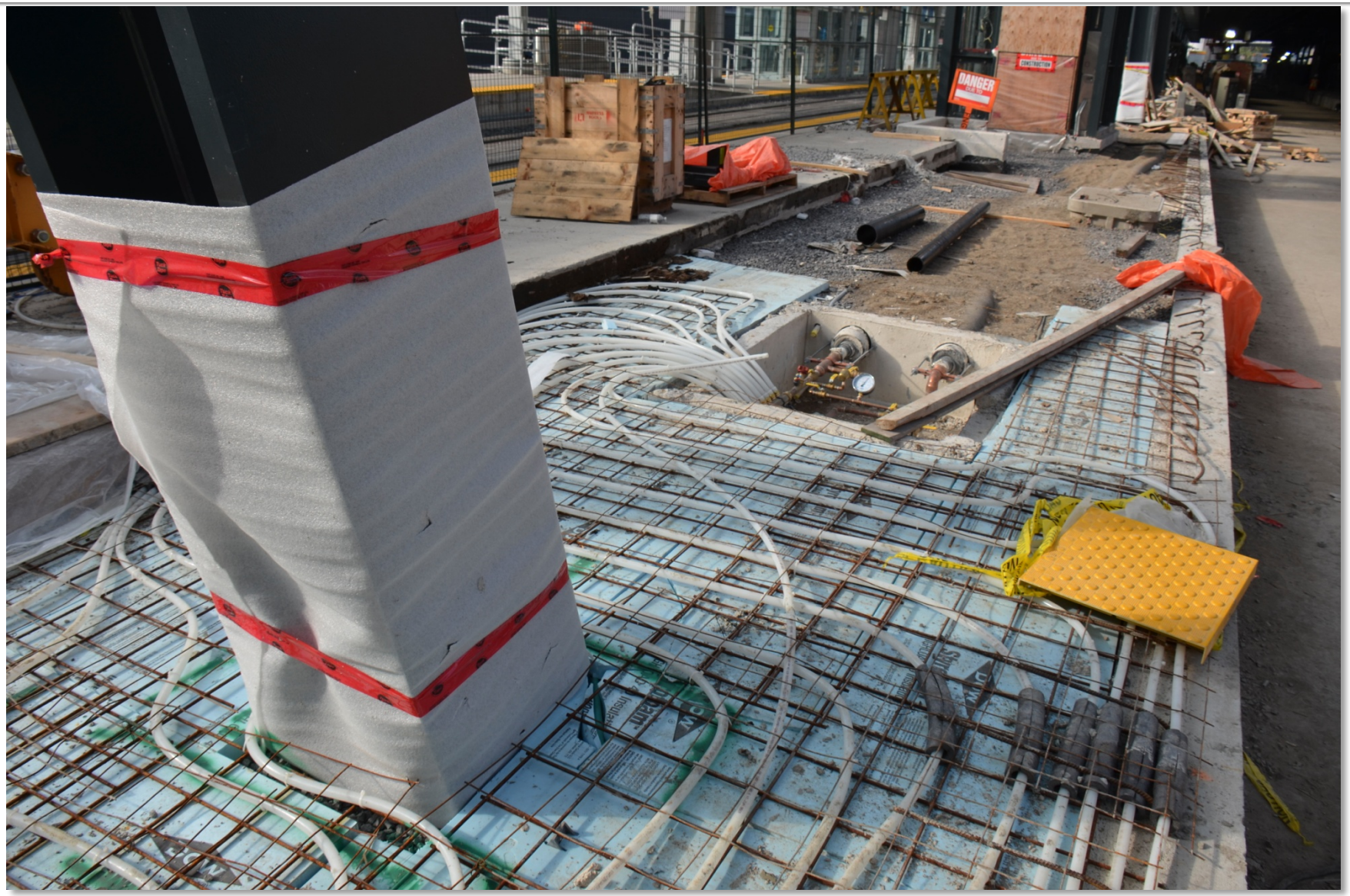
Images: Walters Inc.

Truss construction

Truss connecton



Column meets heated floor



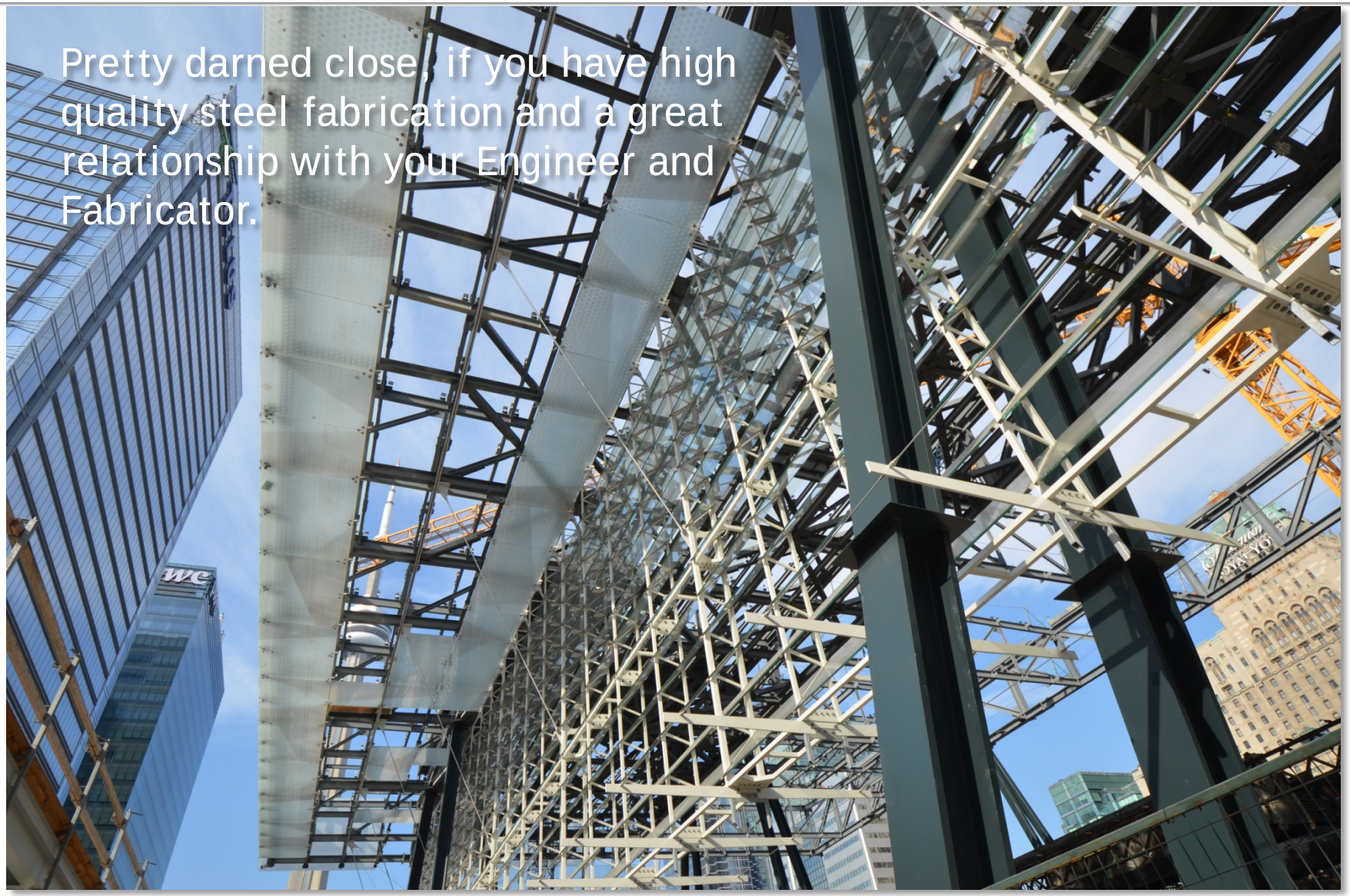
Exposure levels

- Not all steel is exposed
- Columns are AESS3
- Hanger system is fabricated to AESS standards but is not considered “structural” per se
- Fritted, translucent glazing on soffit obscures the steel trusses
- Stainless steel cables provide some tension support for the glazed wall

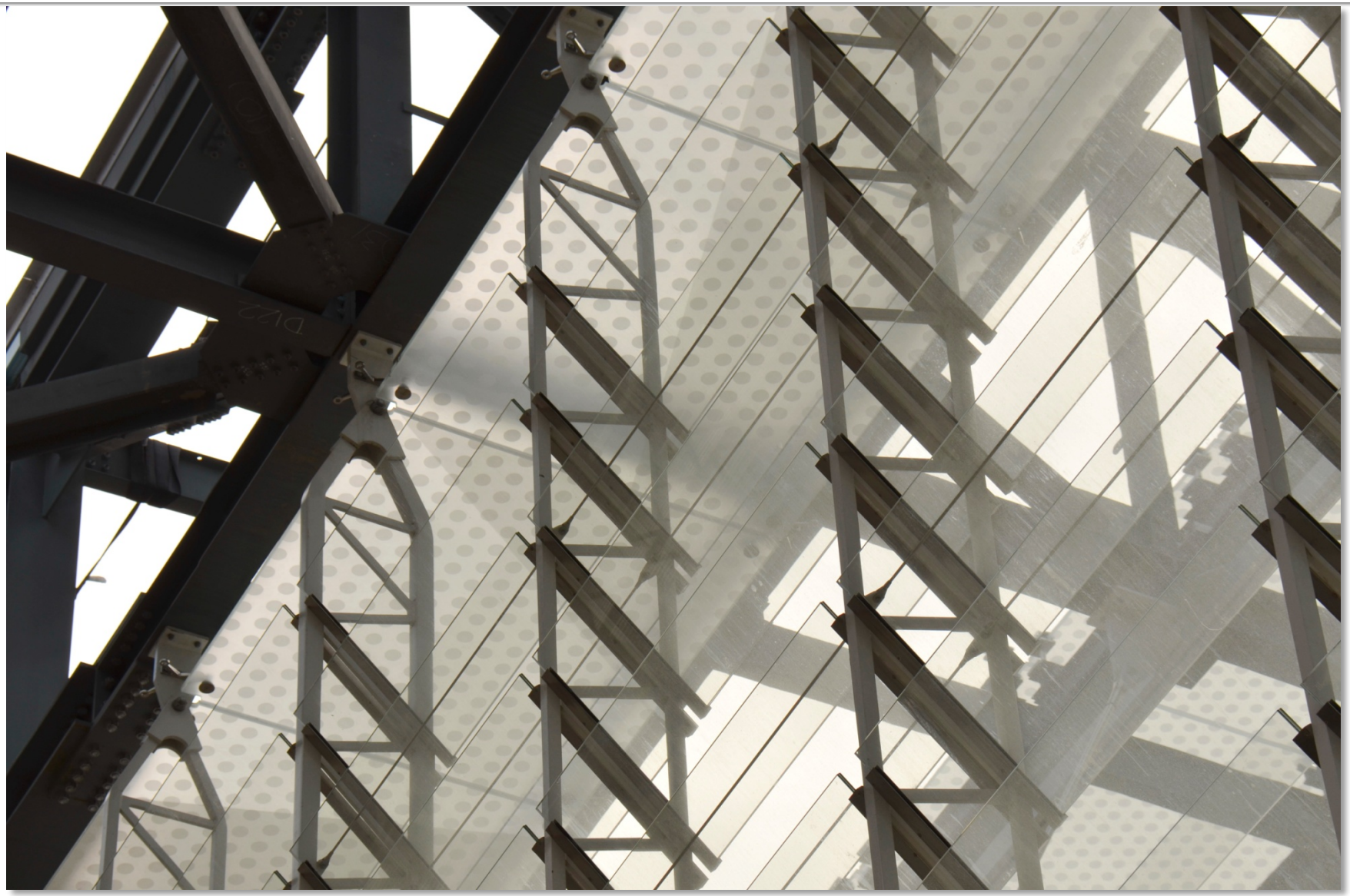
Quality fabrication brings projects to life

Image: Zeidler Partnership

Front elevation



Translucency



Support for venting glazing

Hanger connection for side glazing

Custom welded plate for columns

Fine support system for glazing

Obscured by glazing


UNION STATION
adidas

Project Profile

QUEEN RICHMOND WEST CENTRE
Toronto, Ontario

Owner
Allied Properties

Architects
&Co Architects

Construction Manager
Eastern Construction

Steel Fabricator / Detailer / Erector
Walters Inc. Hamilton/Metropolitan Walters

Castings
CastConnex

Site access courtesy: Walters Inc. and CastConnex

Special legs

Image: &Co Architects

- The ‘legs’ that will support the new office tower that sits over the older building at Queen and Richmond Streets in Toronto is set on very large legs created from hollow steel, connected with a large cast connector.
- Referred to as “delta frames” by the team.

Modeling to design

The decisions regarding the shape of the lower ‘legs’ were based on these models. The tapered ends were chosen.

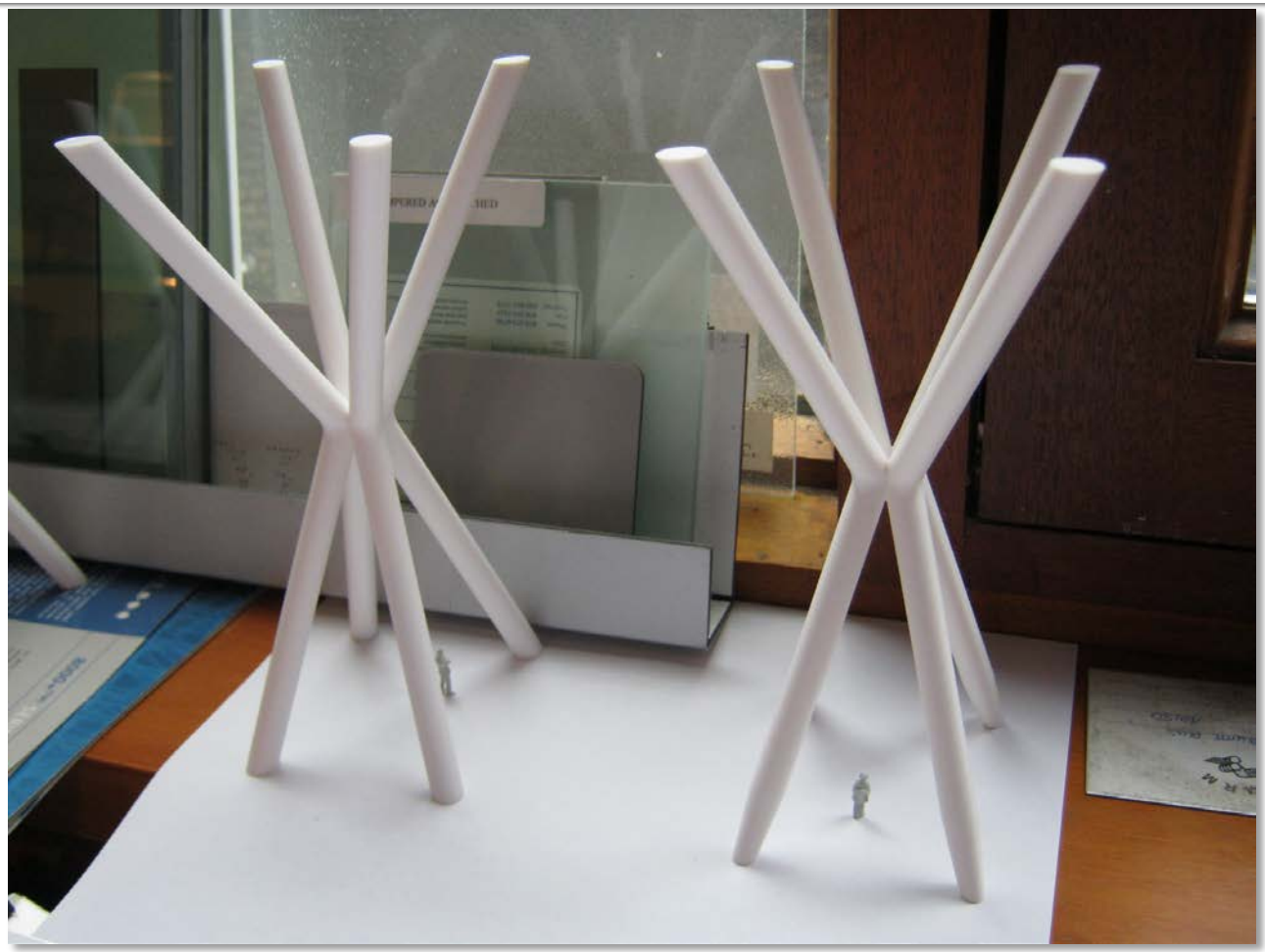


Image: CastConnex

Overall structural model

Tekla Structures was used to model the overall steel system. The software incorporates full structural requirements as well as detailing of connections.

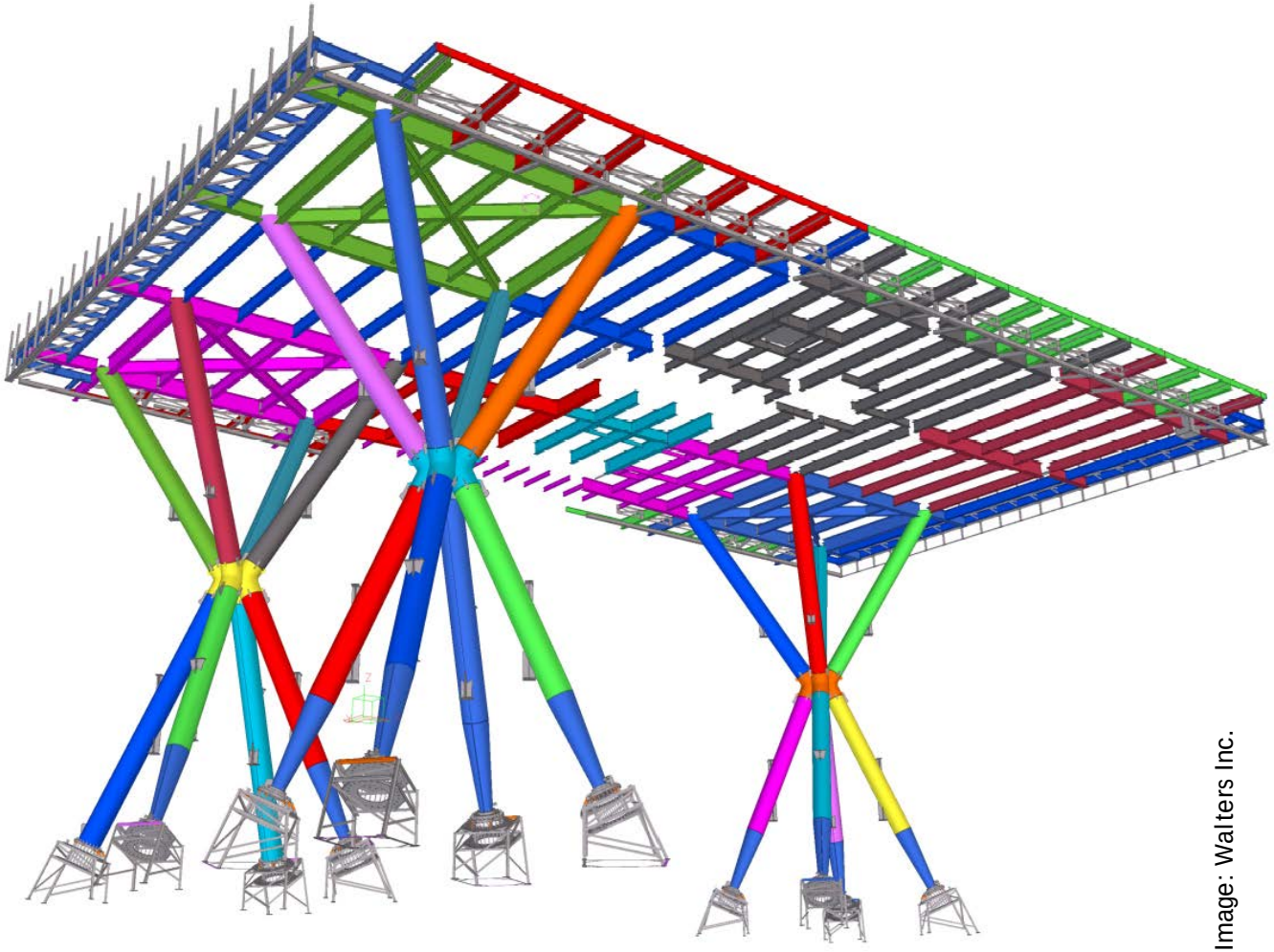
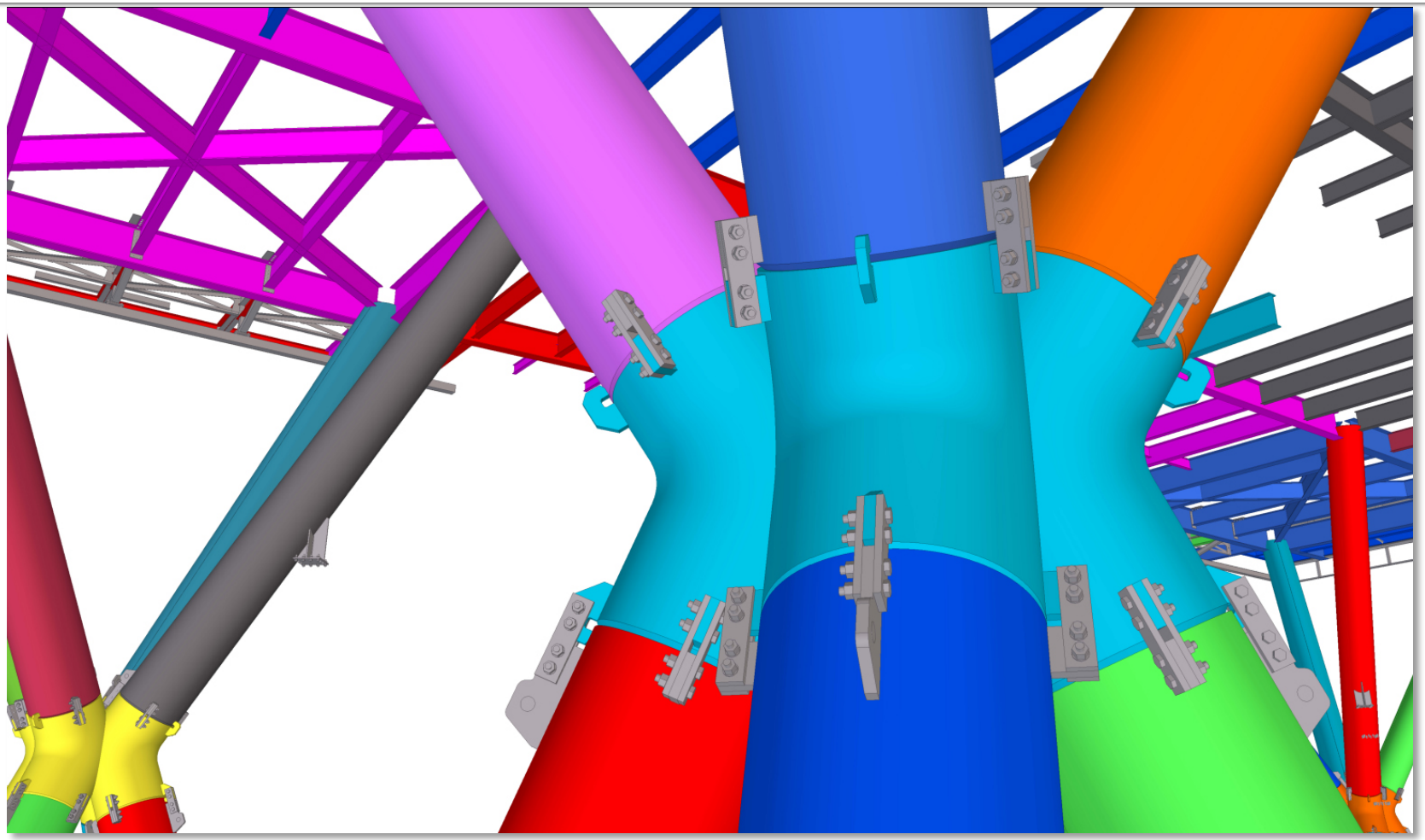


Image: Walters Inc.

Connection details



The Tekla model allows for a very detailed development of the connections. Shows temporary tabs for support during erection.

Resin model

A resin casting of the node allowed better visualization of the connection and its curvatures.

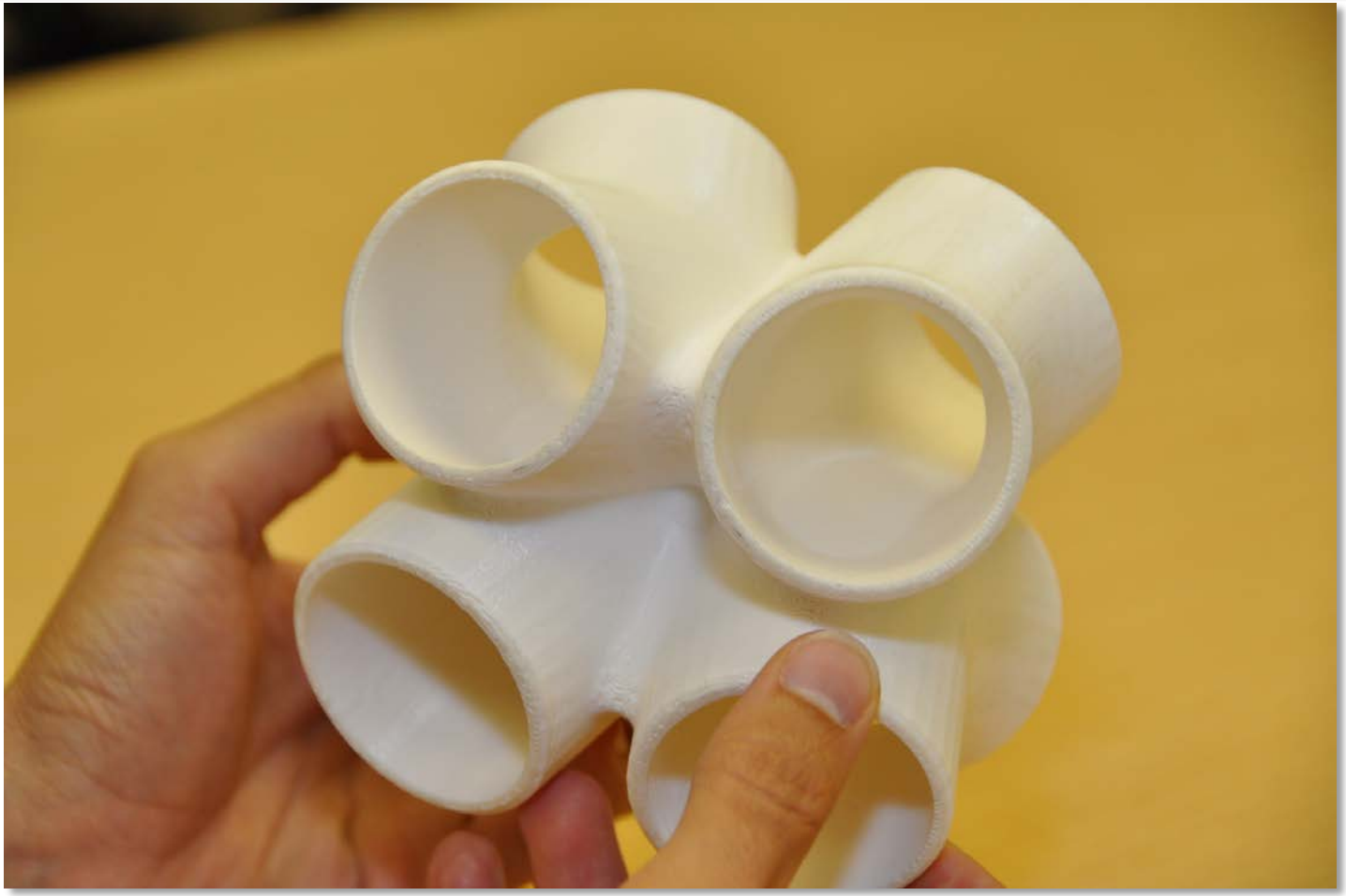


Image: CastConnex

Casting process

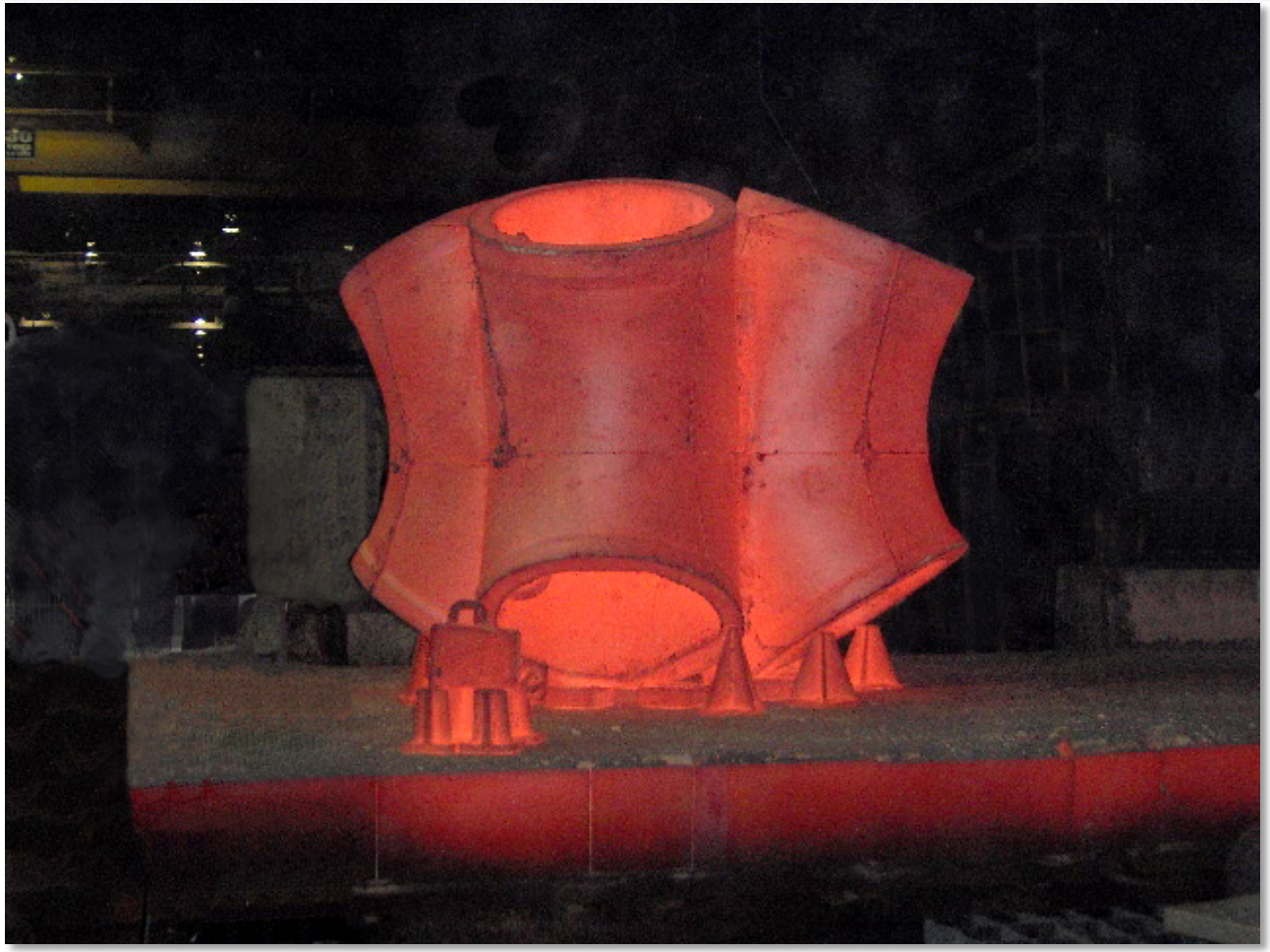


Image: CastConnex

The casting was done in Kansas as this facility offered the best quality and price.

This sort of node is created using an expendible mould. This means that it is broken in order to remove the casting. These are normally made from sand/resin casting.

Cleaned up

Once the casting is cooled, it is cleaned up and rough edges removed. These were shipped from Kansas to Walters Inc. in Hamilton for further work and preparation for attachment to the legs.

Image: CastConnex

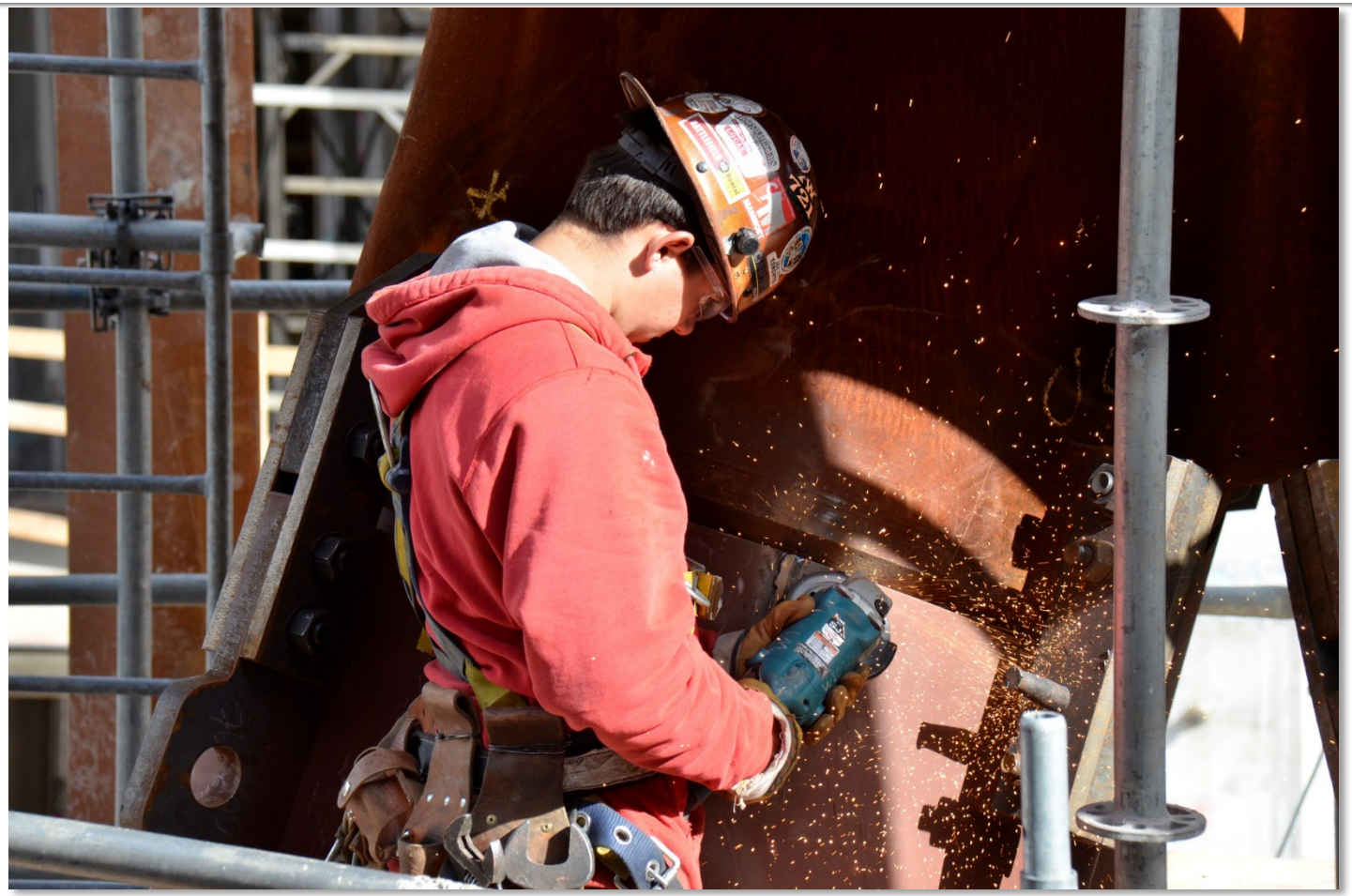
Pre fit the legs to the node

The large tubular legs were fabricated and pre-fit to the node. The system will be filled with concrete to create the required structural strength.

Coordination

Lifting a 31,500 pound cast node requires lot of precision and planning.

Grinding



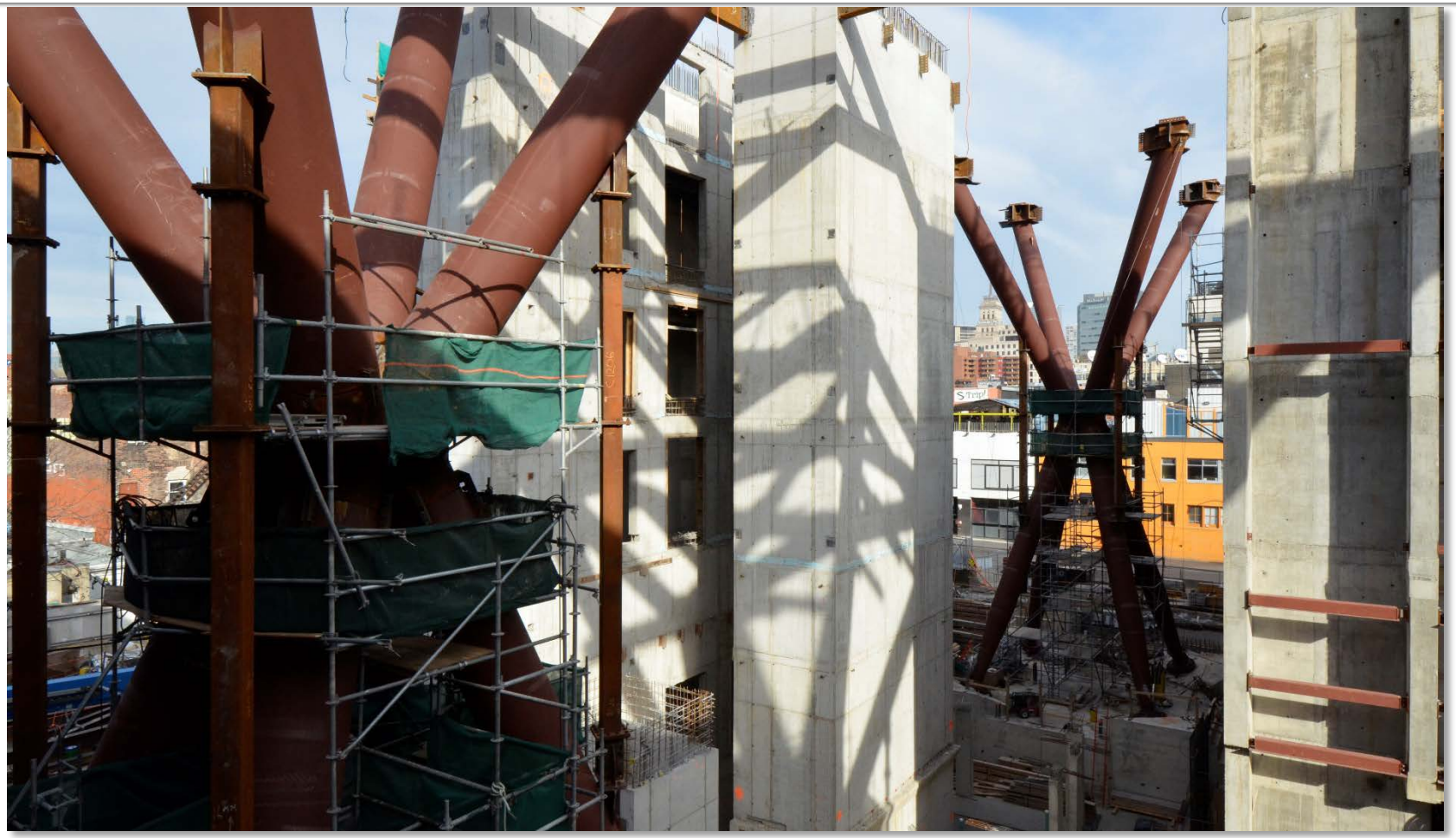
AESS 3 and 4 are the only categories that permit grinding. Here some of the temporary tabs are being removed prior to welding the join.

Appreciation of logistics

Erectors will need to work out temporary support systems for geometries that are incapable of stability due to eccentric loading during construction.

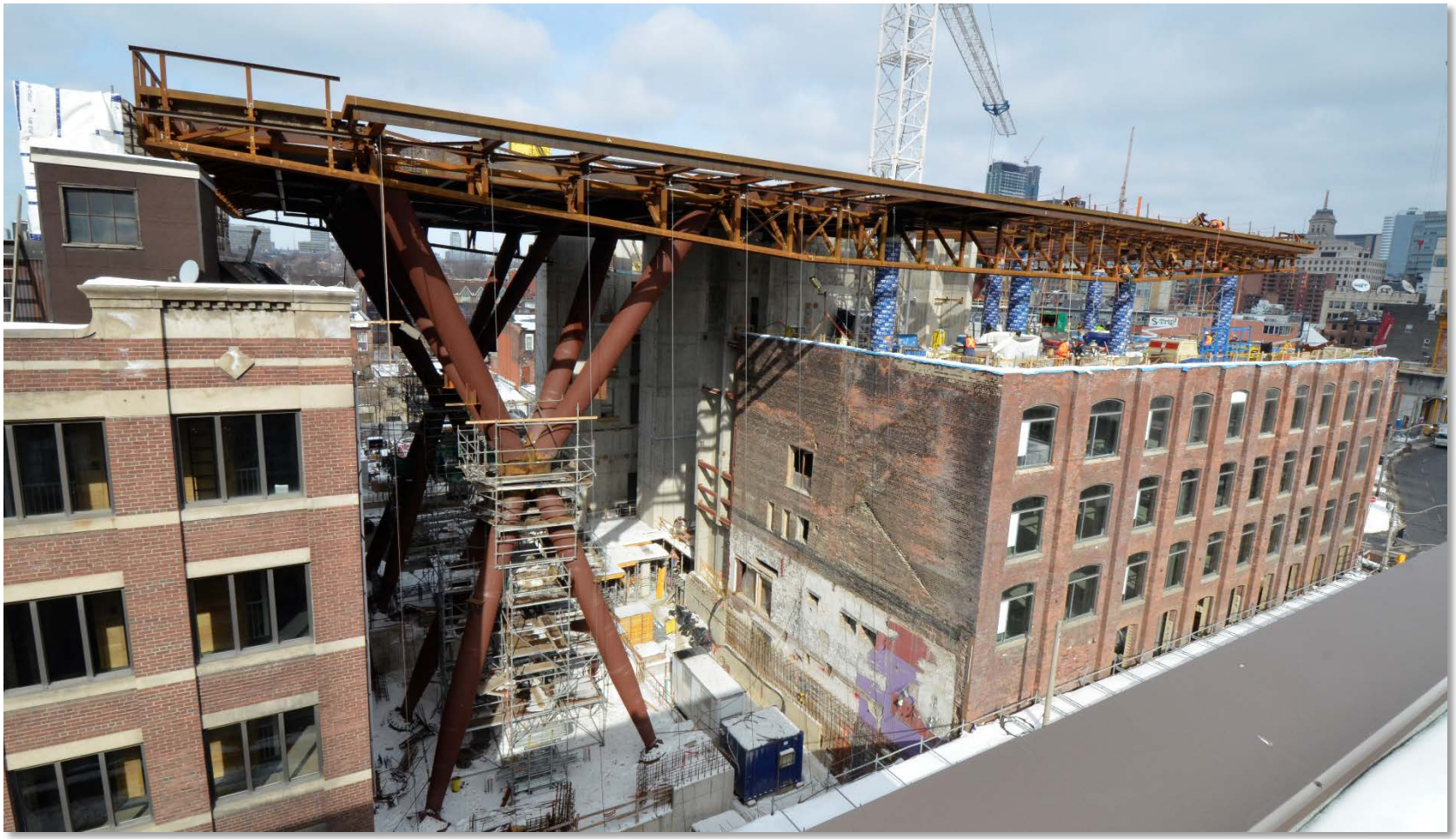
The bottom of the leg is a tapered tube. Fabricated via break forming with fully ground welds. AESS4 quality.

Staging of erection



Timing needed to account for the pouring of the concrete to catch up to the steel which is faster to erect.

Support system



The three delta frames support a steel platform that will in turn be used to support the multiple floors of office above.

Weld finishing

AESS LESSONS

Design process implications

- Architects and engineers have to **talk** to decide on **AESS Categories**.
- **AESS Categories** need to **appear** on all contract documents as per Spec.
- We typically expect that there will be **2 Categories** specified per structure
  - ex. AESS 2 upper portion of atrium, AESS 3 for the lower portion
- There are certain “styles” of members that automatically require welding, hence determining the AESS Category
- Fabricators to **bid** on Engineering documents and the Categories specified.

Fabrication and Erection Implications

- Categories specified infer sequencing, cost and constructability issues.
- Higher **level of care** as provided for in the Code for Fabricators.
- AESS Categories to **appear** on all Shop and Erection drawings.

Positive outcomes

- AESS system standardizes basic design and fabrication issues
- Eliminates many ‘routine’ issues through the Category System
- Very important NOT to change AESS Categories
- If you want something different, pick CUSTOM
- Allows team to concentrate efforts on more particular issues for the project

Credits

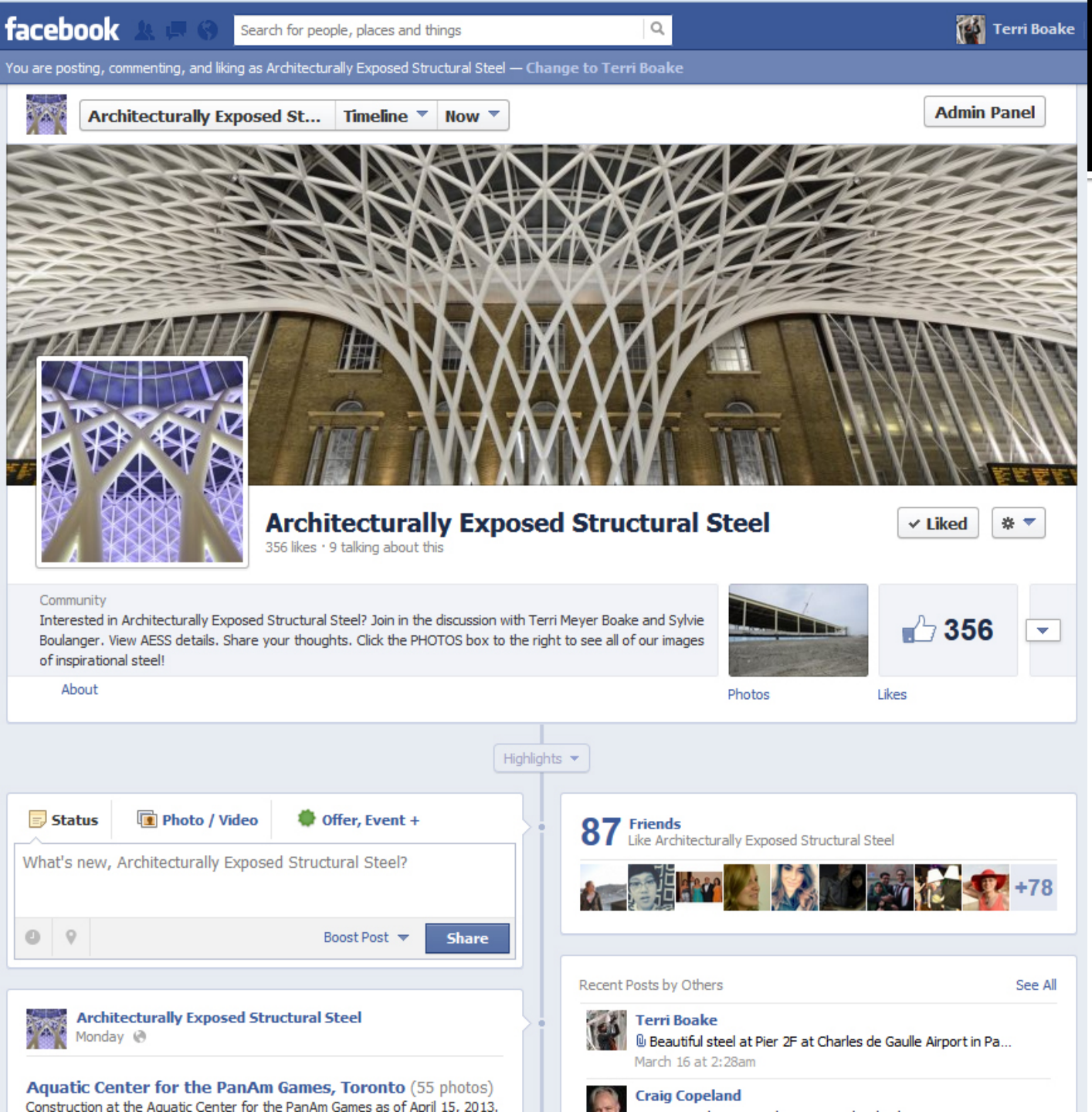
- Sylvie Boulanger, Supermétal, Vice President, Technical Marketing
  (for images, project content and the original work on the development of the CISC AESS Documents and System)

- Walters Inc.
  (for providing site access and documentation for their projects)

- CastConnex (for site access and images)

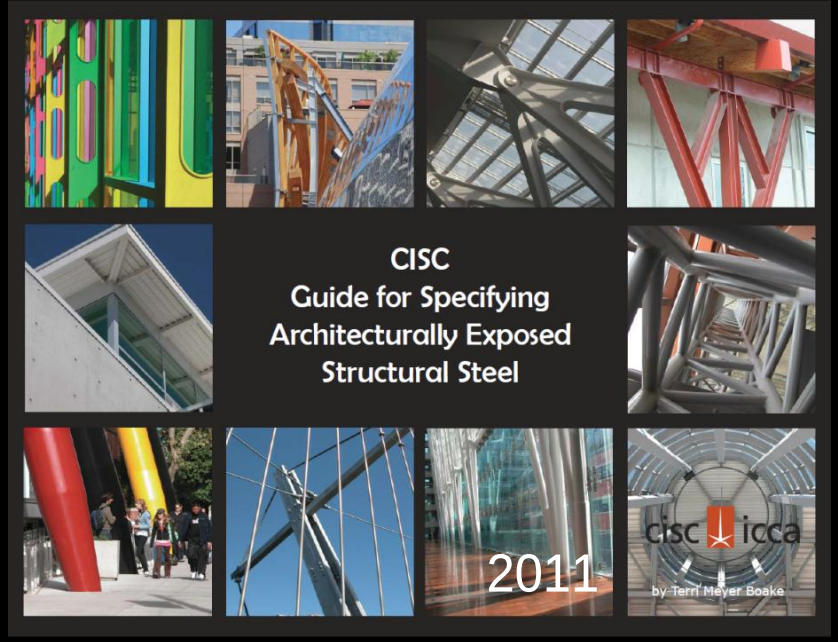
CISC AESS Documents

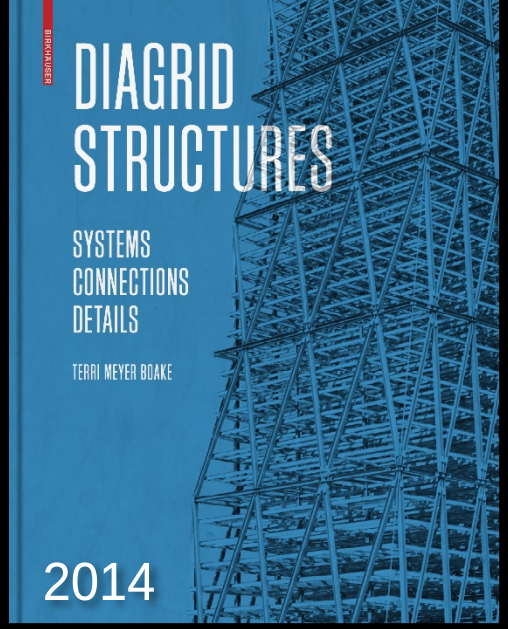
- Available for purchase and download:
  - CISC Guide for Specifying Architecturally Exposed Structural Steel
- Available for download at http://www.cisc-icca.ca/solutions-centre/aess
  - Sample Specification
  - Code of Practice for Fabricators
  - Matrix

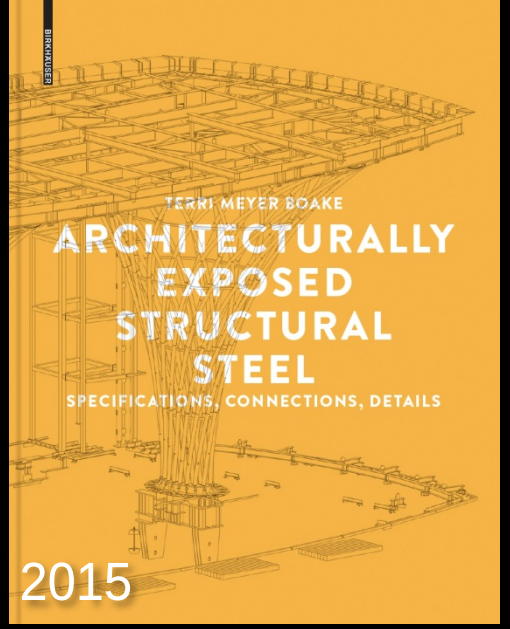


Check out our AESS Facebook Page!

facebook.com/aess4u







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School of Architecture
University of Waterloo

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Content development credit:
Sylvie Boulanger, Supermétal