



STEEL

Architecturally
Exposed
Structural Steel

Connections

Helmut Jahn

Munich Airport Center | Munich, Germany



STEEL

Rogers Stirk Harbour + Partners

Heathrow T5 | London, UK

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Objectives

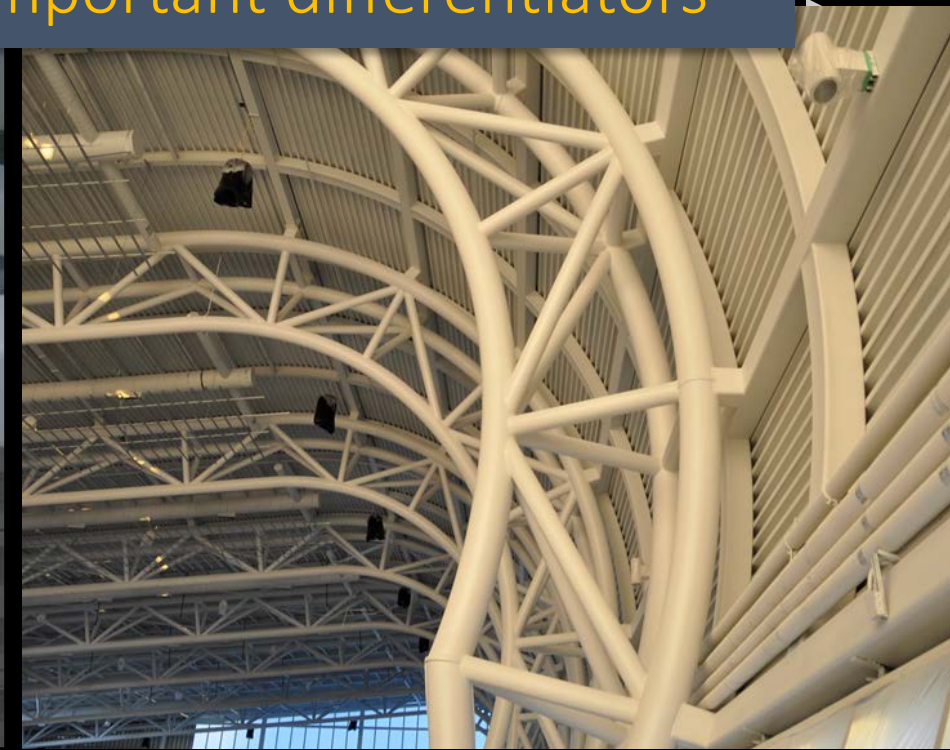
- Understand when bolted connections work with the AESS category.
- Understand when welded connections best serve the AESS category.
- Understand the limits on the practice of grinding of welds
- Understand the use of custom plate steel to achieve an AESS 4 category.
- Various approaches to making similar connections

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
- Proper application of the Category System will assist to make a smoother design and construction experience



Connection types are important differentiators



AESS: Primary Factors of influence

- Distance. Visibility.
- Connections mostly bolted or welded
- Tolerances required at fabrication and erection
- Access to detail to perform required finish

- Degree of expression
- Size and shape of structural elements

- Interior or exterior setting
- Paint finish, corrosion resistance, fire protection

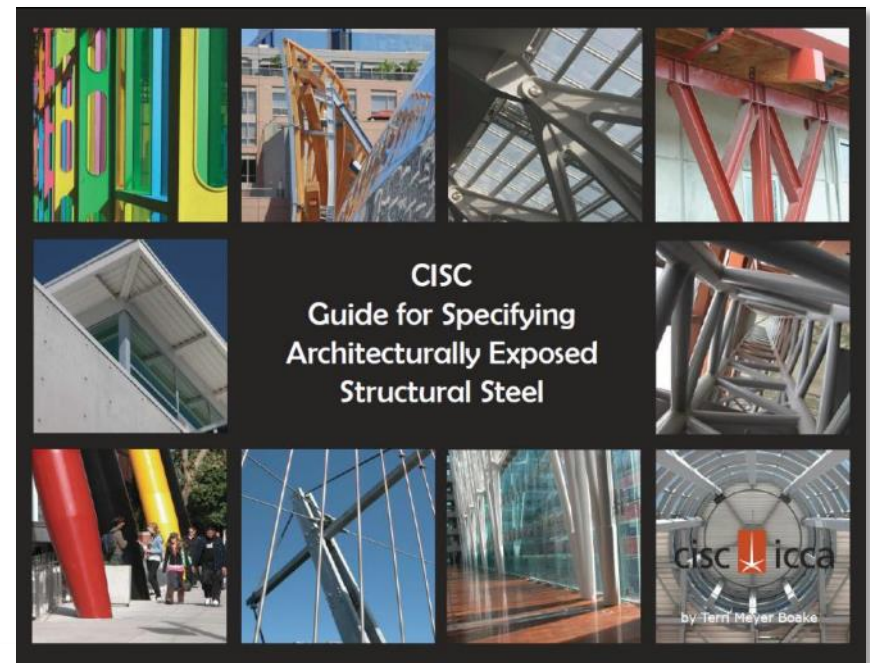
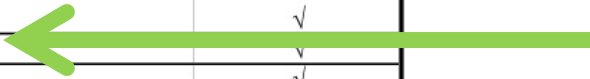


Table 1 - AESS Category Matrix

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

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



Grinding permitted \$\$

No Grinding!!

Defintions

- **Member** refers to the discrete sections of steel, such as wide-flange (Universal) sections, hollow structural sections (HSS), angles, channels, rods or cables.
- **Element** references the larger agglomerated pieces of a building. This includes trusses, beams and columns as they extend from one external connection point to the other. A small or uncomplicated element may be constituted simply by one steel member. In many AESS projects the additional complexity will require the assemblage of larger elements from a number of members.

Connection Types

Connections are of three basic types by virtue of their location and purpose:

- *Internal connections* are those by which the members are joined to create a larger element. These are most normally the result of shop fabrication.
- *External connections* connect elements to each other. These are most often completed on site. This includes, for example, the connection of a truss to its supporting column or a beam to a truss.
- *Splices* are to be found when elements are too large to ship in one piece. These are often completed on site, either on the ground prior to lifting or in the air as erection proceeds.

Expressed or discreet

- Connections located **within** an AESS element tend to be done in ways that **suppress** the evidence of the connection.
- Connections **between** AESS elements will **choose the level and nature** of the expression of the connection.
- Splices are special connections that discreetly happen within sections of elements where the act of connecting is intended to be hidden.
- Splices often arise as a result of the inability to transport oversized members, hence requiring the element to be fabricated in smaller sections that are aggregated on site.

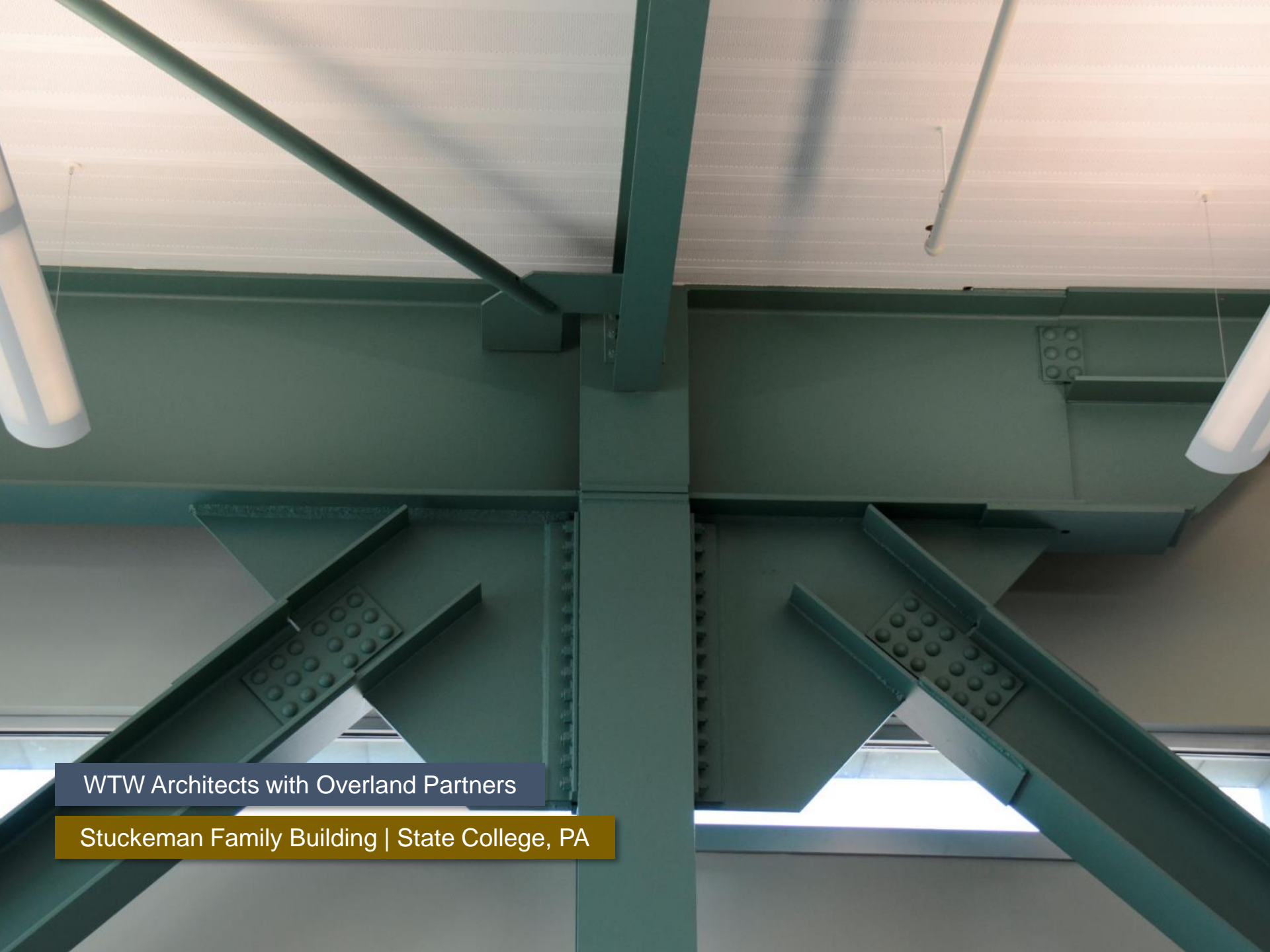
Shop or site?

- Welded connections will have the best results if fabricated in the shop
 - Climate controlled environment
 - Ease of access for welding operations
 - Crane assist for abilities to turn and manipulate the pieces
- Bolted connections are best suited to site situations
 - Quick to do
 - Shortest time on the crane
 - Weather independent
 - Less requirements for scaffolding and temporary shoring

Bolted Connections







WTW Architects with Overland Partners

Stuckeman Family Building | State College, PA



Antoine Predock

Canadian Museum for Human Rights | Winnipeg, Canada









Frank Gehry

Pritzker Pavilion | Chicago, IL







XXX

Arboretum | Penn State University

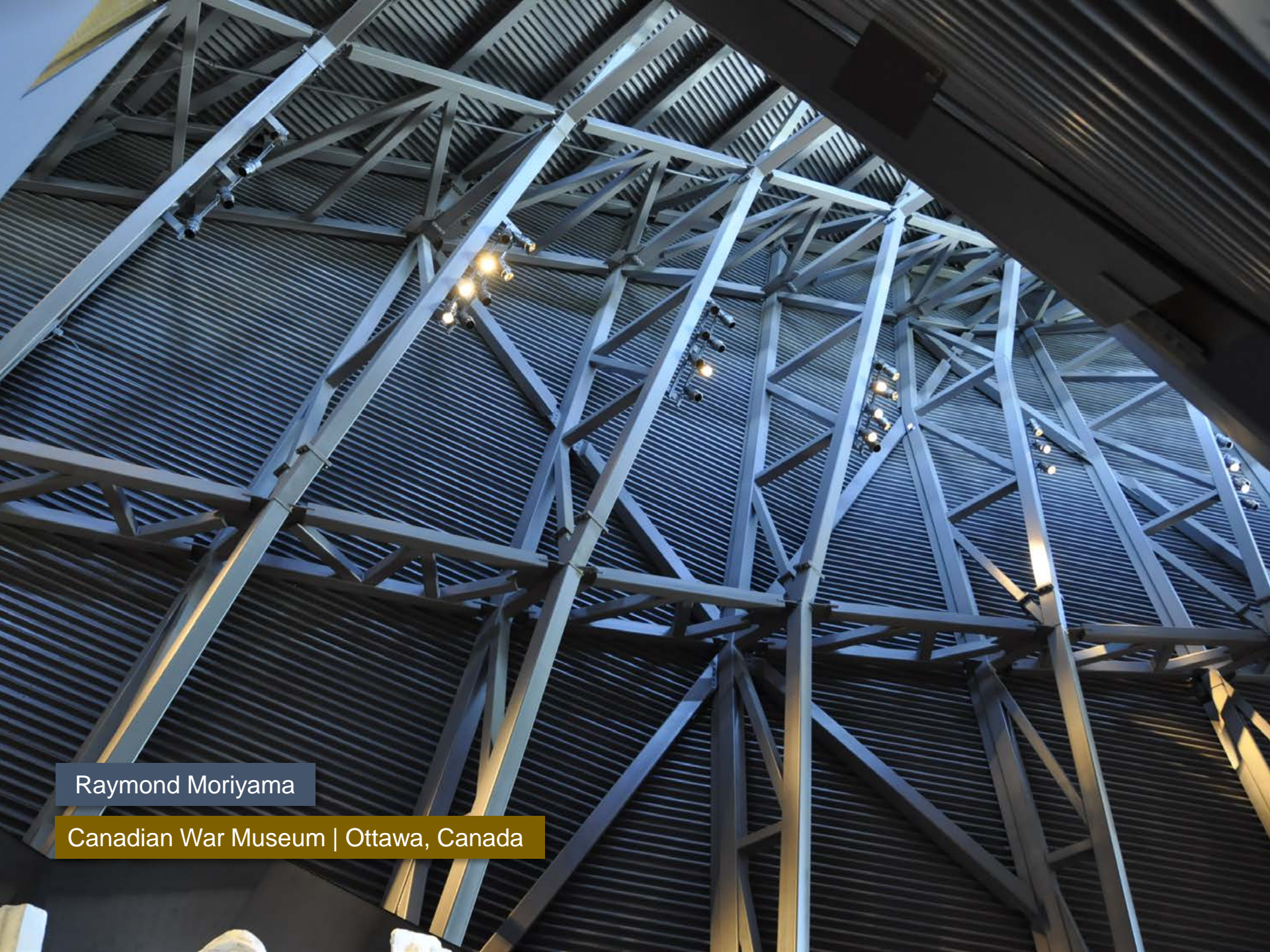




A.Form Architecture pc

Bank of America Pavilion | Boston, MA





Raymond Moriyama

Canadian War Museum | Ottawa, Canada





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Lillis School of Business | Eugene, OR







Pelli Clarke Pelli

National Airport | Washington, DC



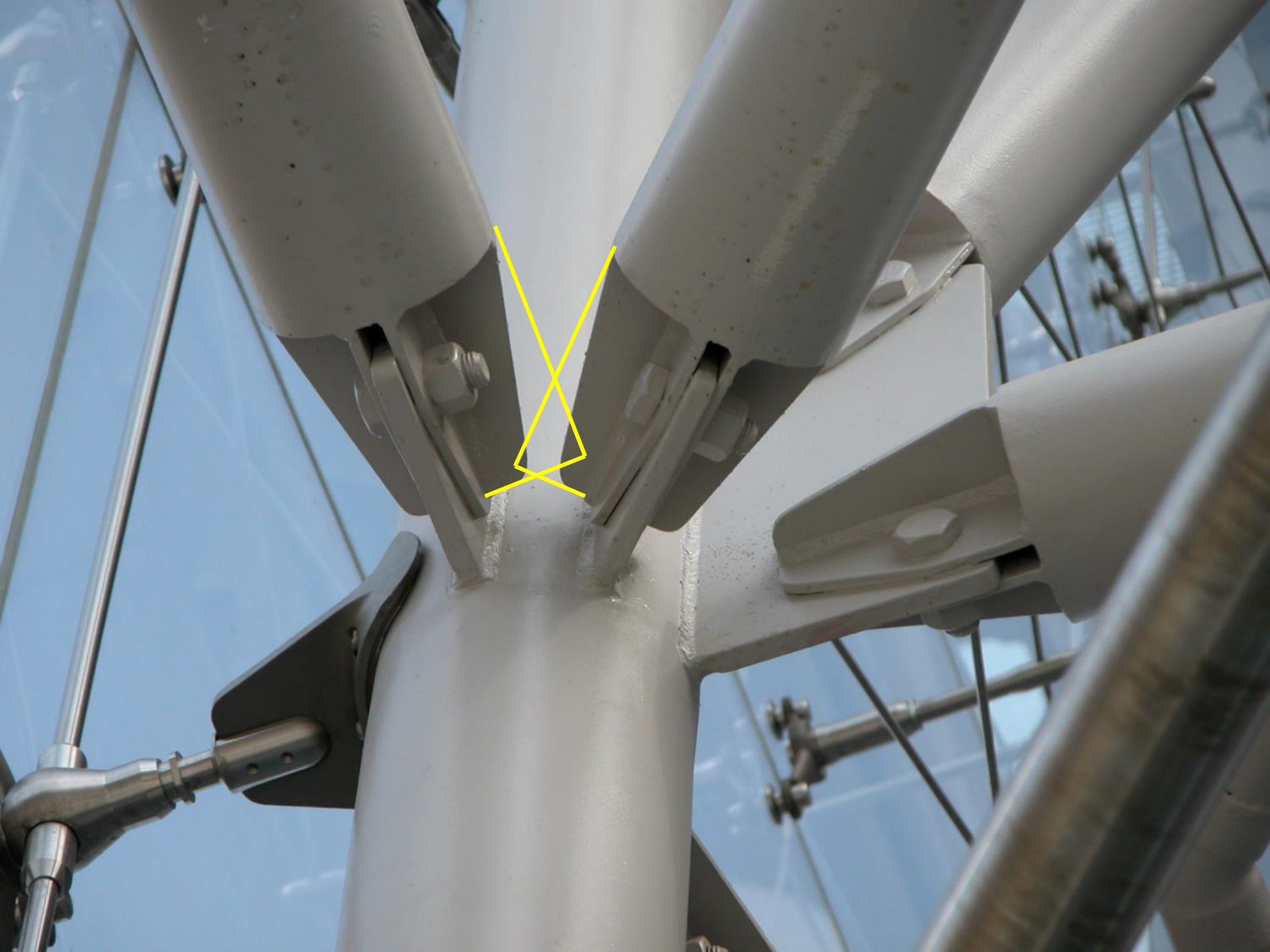




Ennead Architects

Rose Center for Space | New York, NY





Discreet Connections



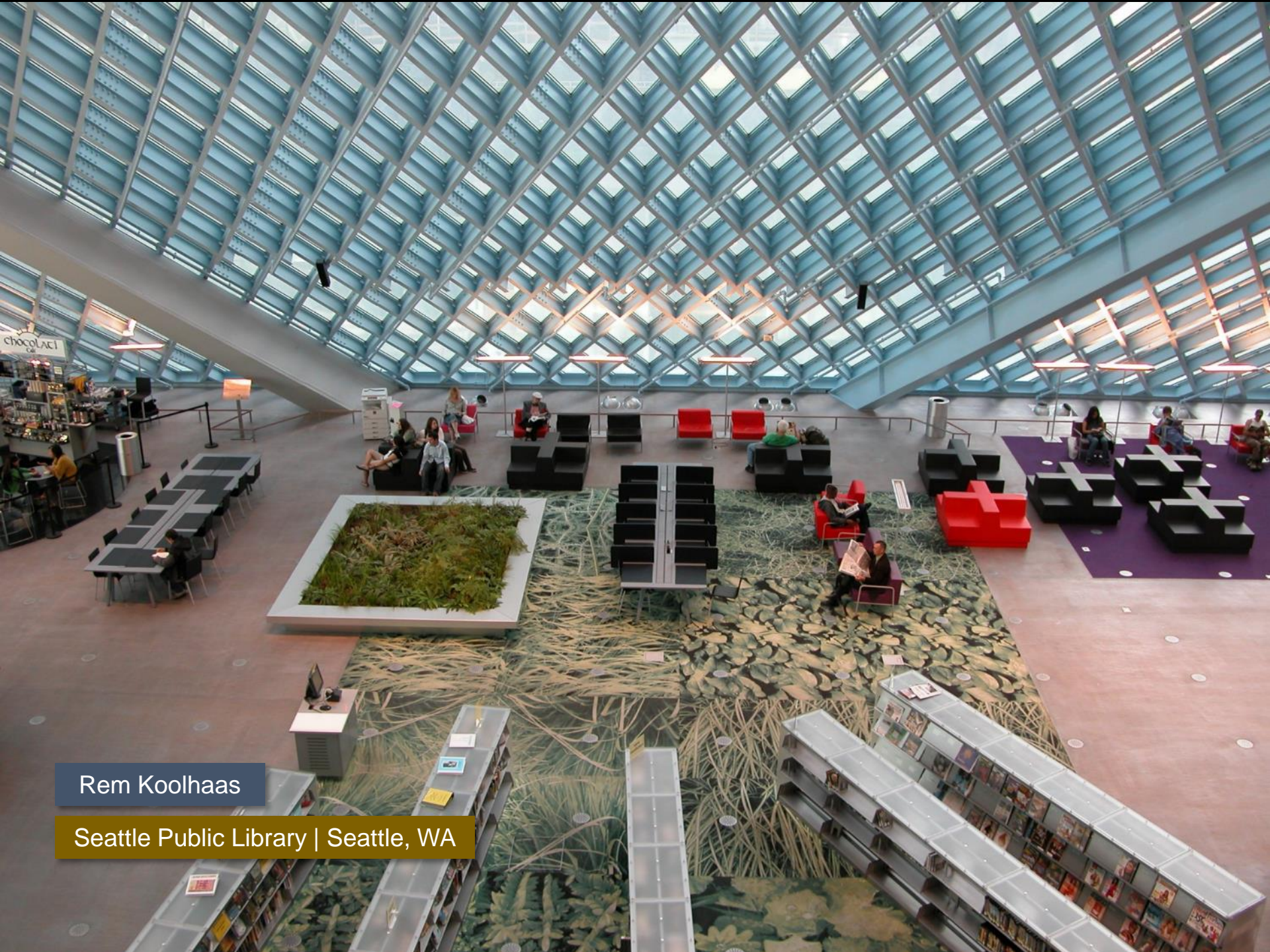
SOM, URS, AECOM

Baltimore Washington International Airport | Baltimore, MD









Rem Koolhaas

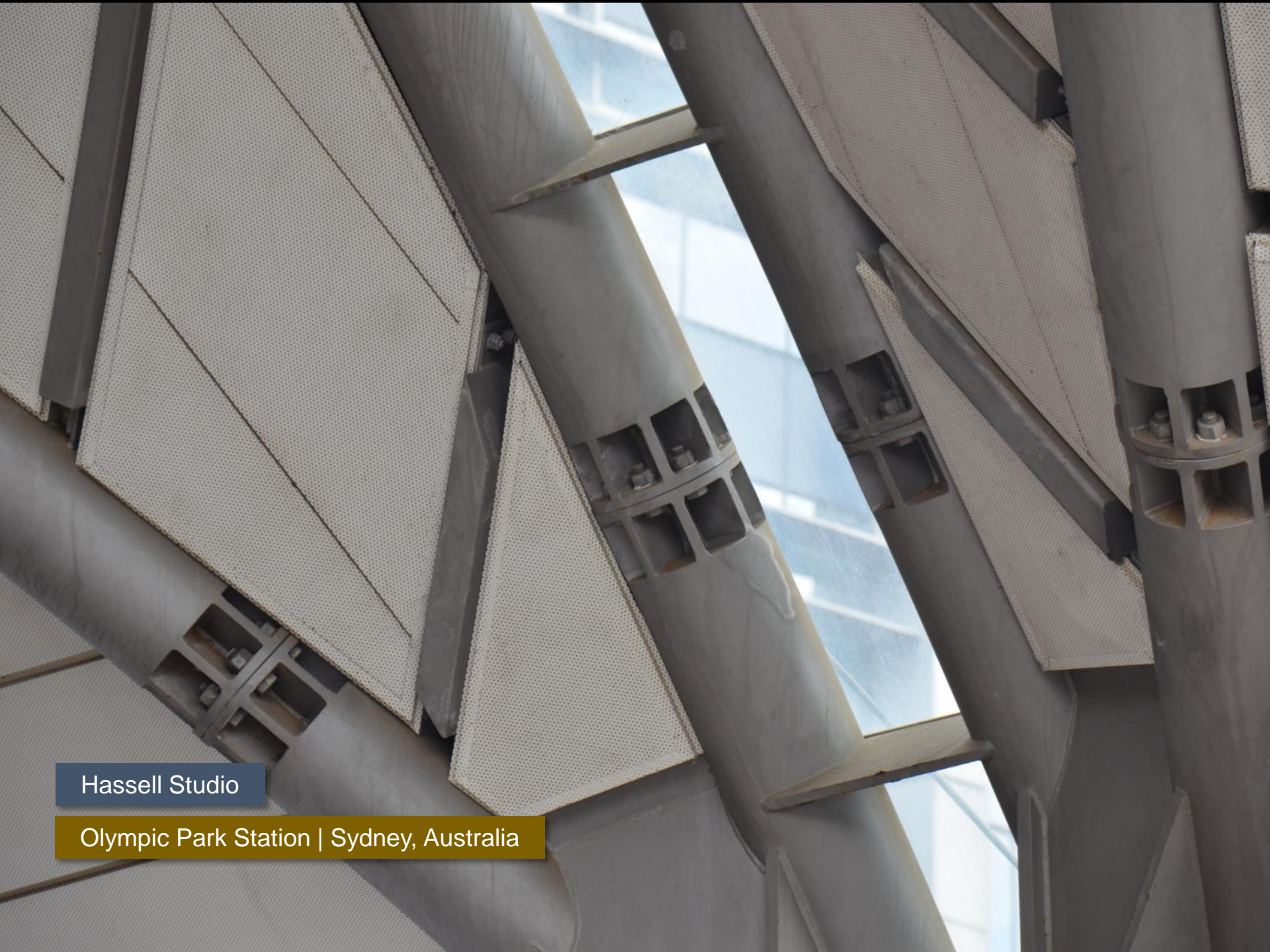
Seattle Public Library | Seattle, WA





Hassell Studio

Olympic Park Station | Sydney, Australia



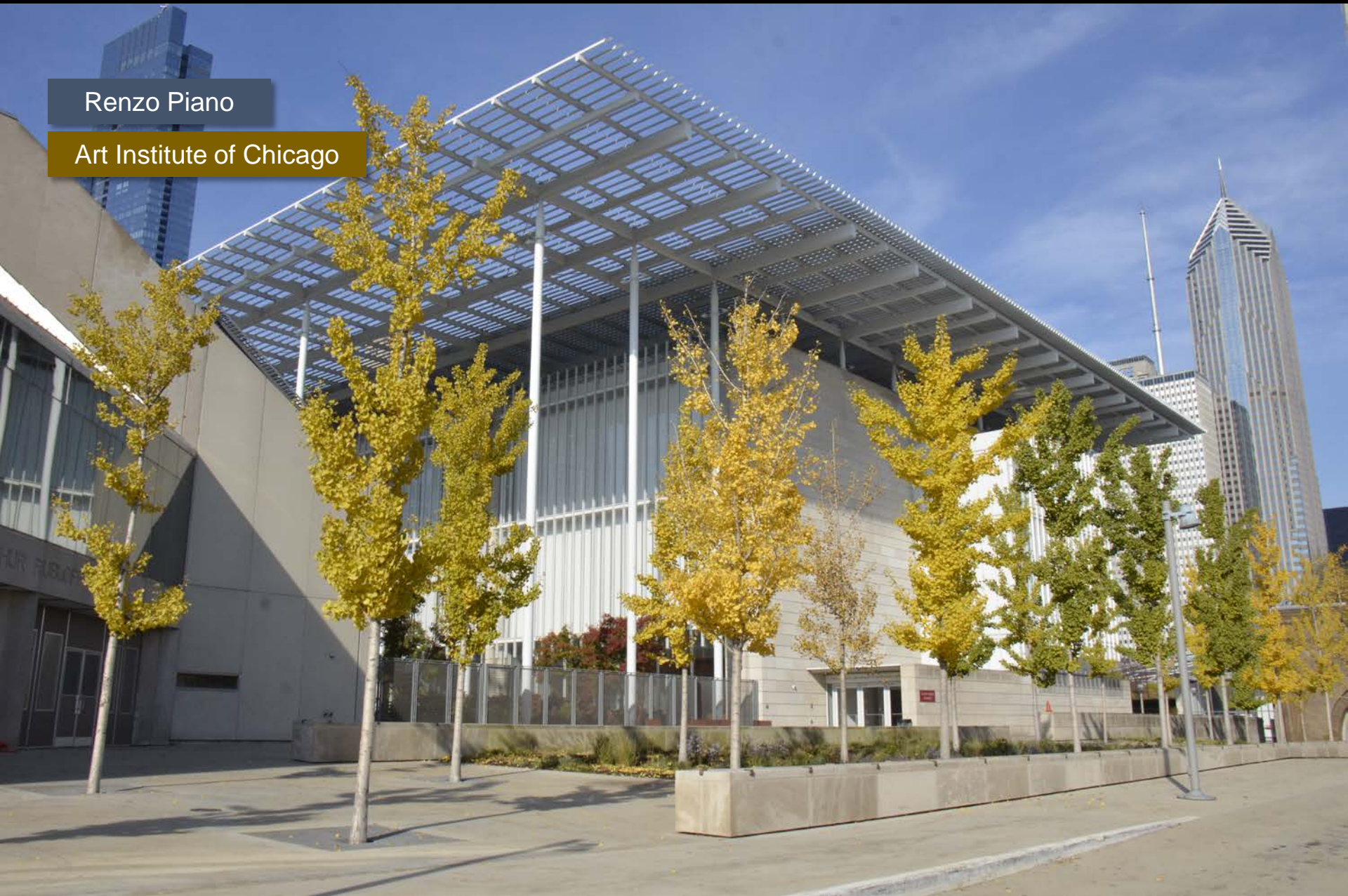
Hassell Studio

Olympic Park Station | Sydney, Australia



Renzo Piano

Art Institute of Chicago







Richard Rogers

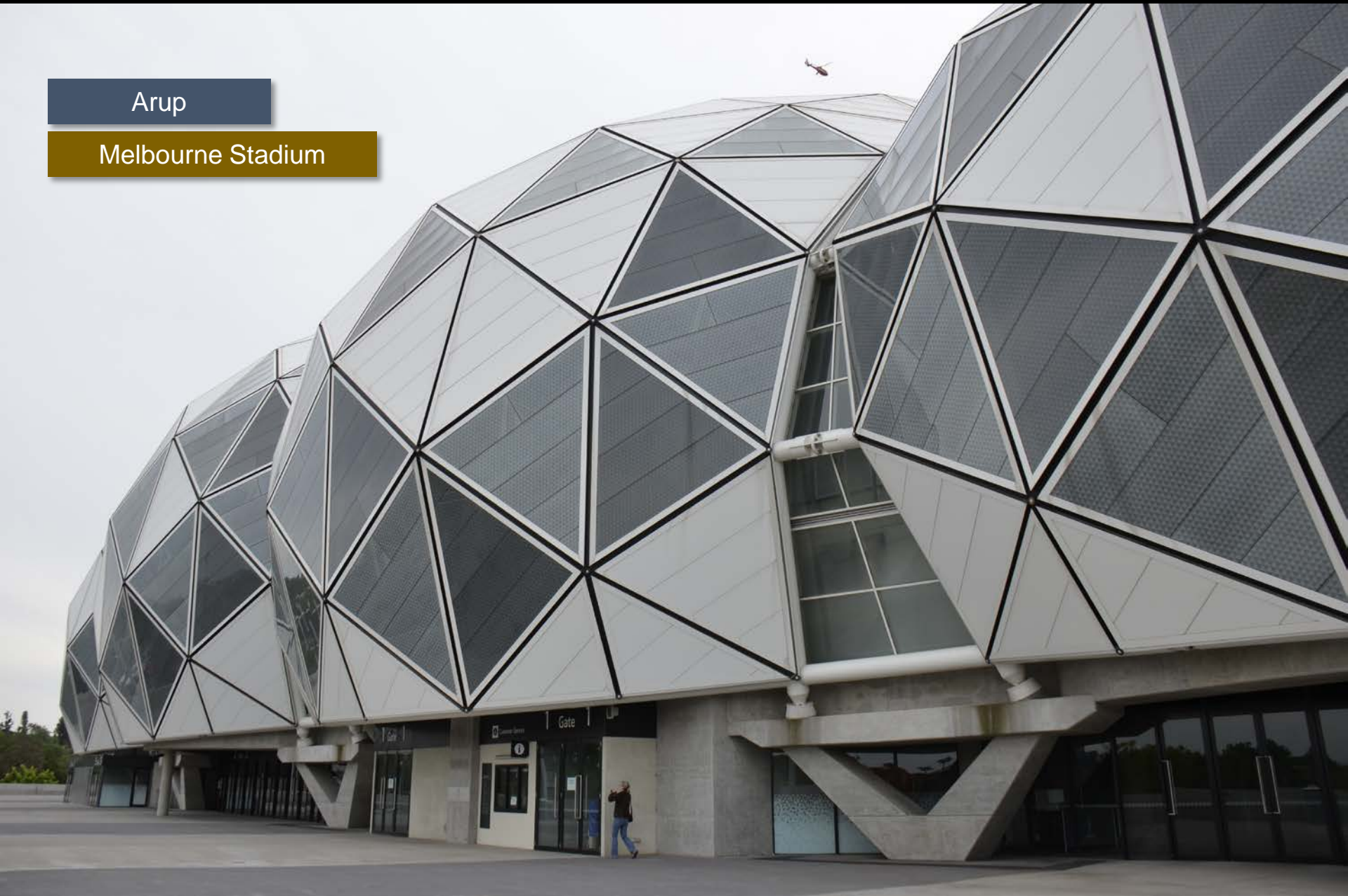
Office Building at Potsdamer Platz | Berlin, Germany





Arup

Melbourne Stadium









Grimshaw

Southern Railway Station | Melbourne





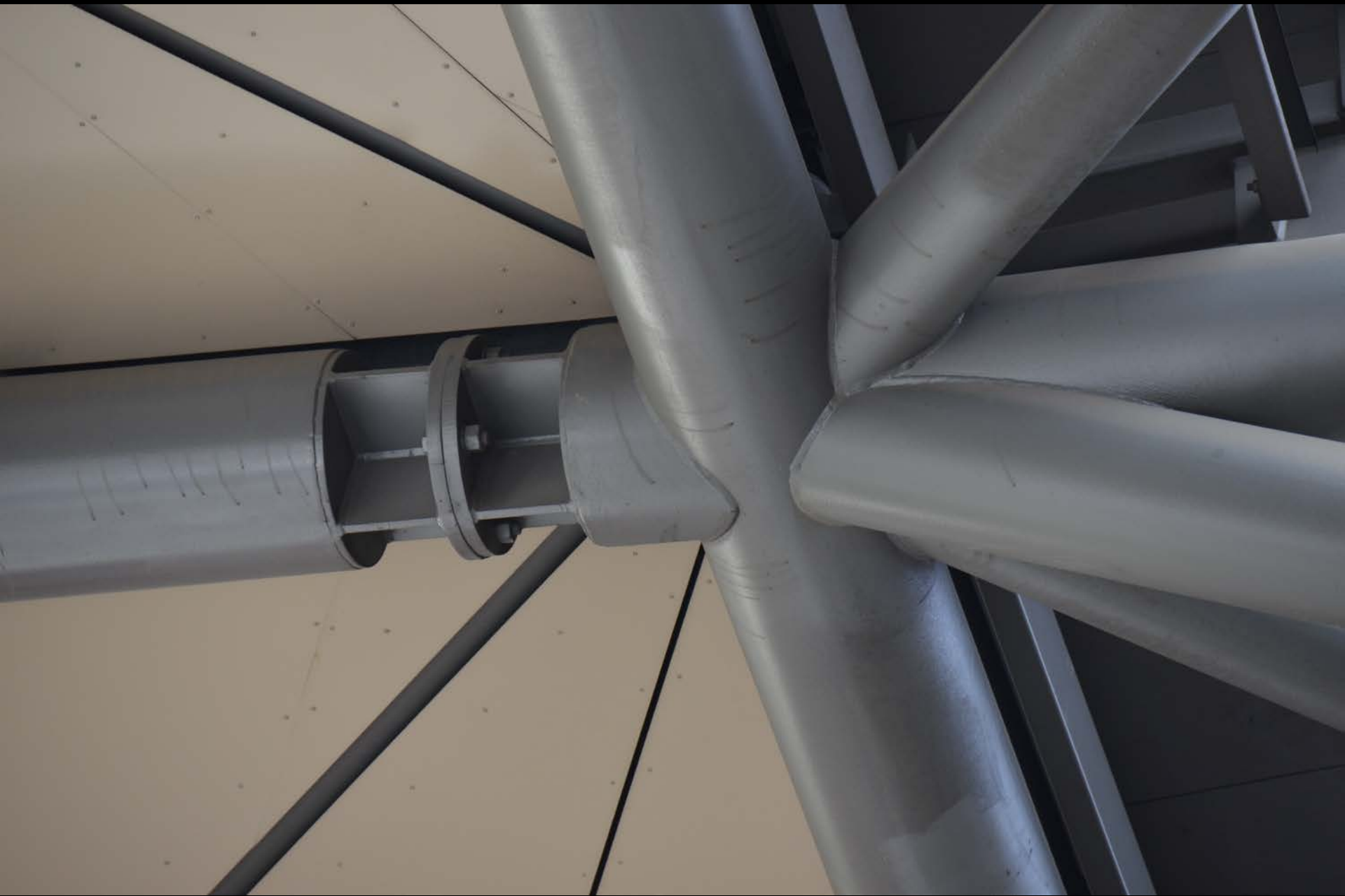


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Ateliers Jean Nouvel

100 Eleventh Avenue | New York, NY





Bates Smart Architects

Federation Square | Melbourne, Australia

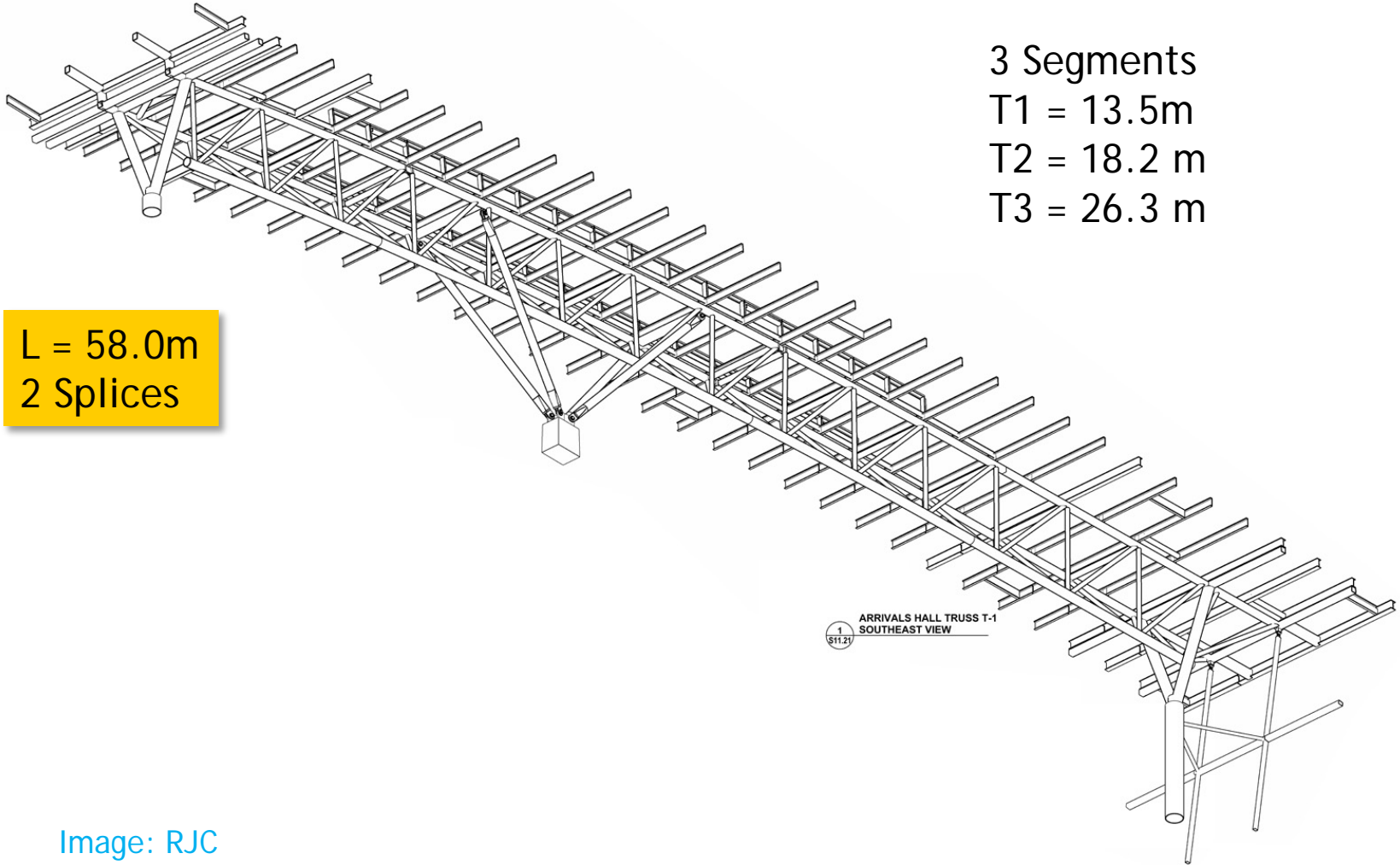


Hidden Connections

The image shows the interior of a large, modern airport terminal under construction. The most prominent feature is the ceiling, which consists of a complex, white, truss-like steel structure. The ceiling is supported by a series of white columns. On the left side, there is a large, curved glass wall that allows natural light to enter the space. The floor is a polished, light-colored material, possibly concrete or stone, and is partially covered with blue protective tarps. In the background, there are various construction elements, including scaffolding and equipment, indicating that the terminal is still under development. The overall atmosphere is one of a large, open, and modern architectural space.

DIALOG

Calgary International Airport | Calgary, Canada



3 Segments

T1 = 13.5m

T2 = 18.2 m

T3 = 26.3 m

L = 58.0m
2 Splices

ARRIVALS HALL TRUSS T-1
SOUTHEAST VIEW
1
S11.21

Image: RJC







Sydney Olympic Stadium





Welded Connections



John McAslan and Partners

Kings Cross Station | London, UK

Weld Remediation

- This is the BIGGEST question!
- The AESS level determines whether or not you are permitted to grind welds
- AESS 1 and 2 – no weld grinding permitted due to use and distance factors
- AESS 3 and 4 – grinding permitted, but...
 - THINK CAREFULLY ABOUT THE DETAILS TO DECIDE IF IT IS ACTUALLY NECESSARY
 - Neatly done welds can often be left “as is”
 - Grinding should be essential to the creation of smooth curves and not considered routine
 - Grinding requires the construction of safe working platforms and ease of access on site







Arthur Erickson

Roy Thomson Hall | Toronto, Canada





SRG Partnership

Seattle Museum of Flight | Seattle, WA





Eppstein Uhen Architects

Intermodal Terminal | Milwaukee, WI











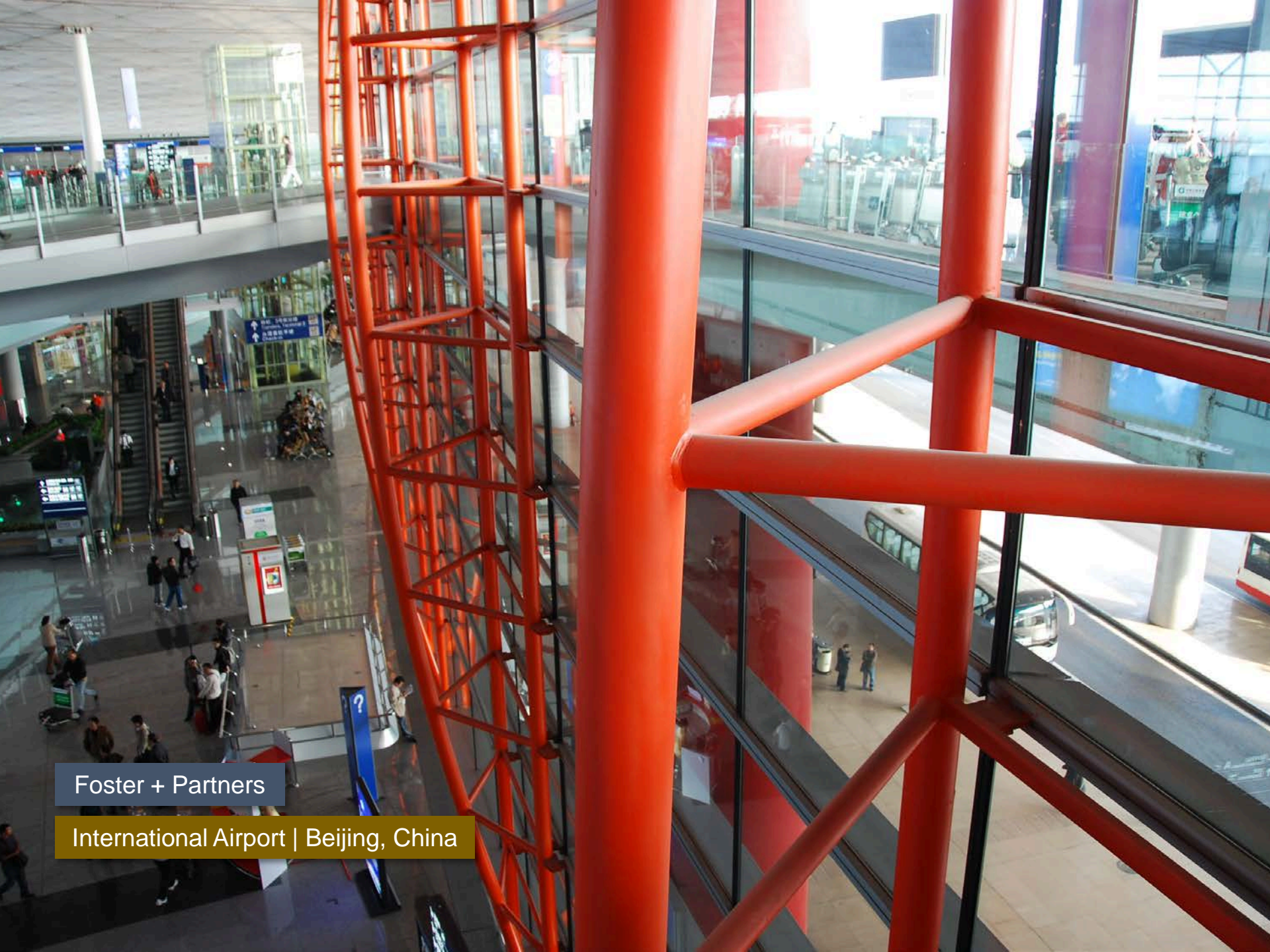






Jasmax Architects

Pedestrian Bridge | Auckland, NZ



Foster + Partners

International Airport | Beijing, China

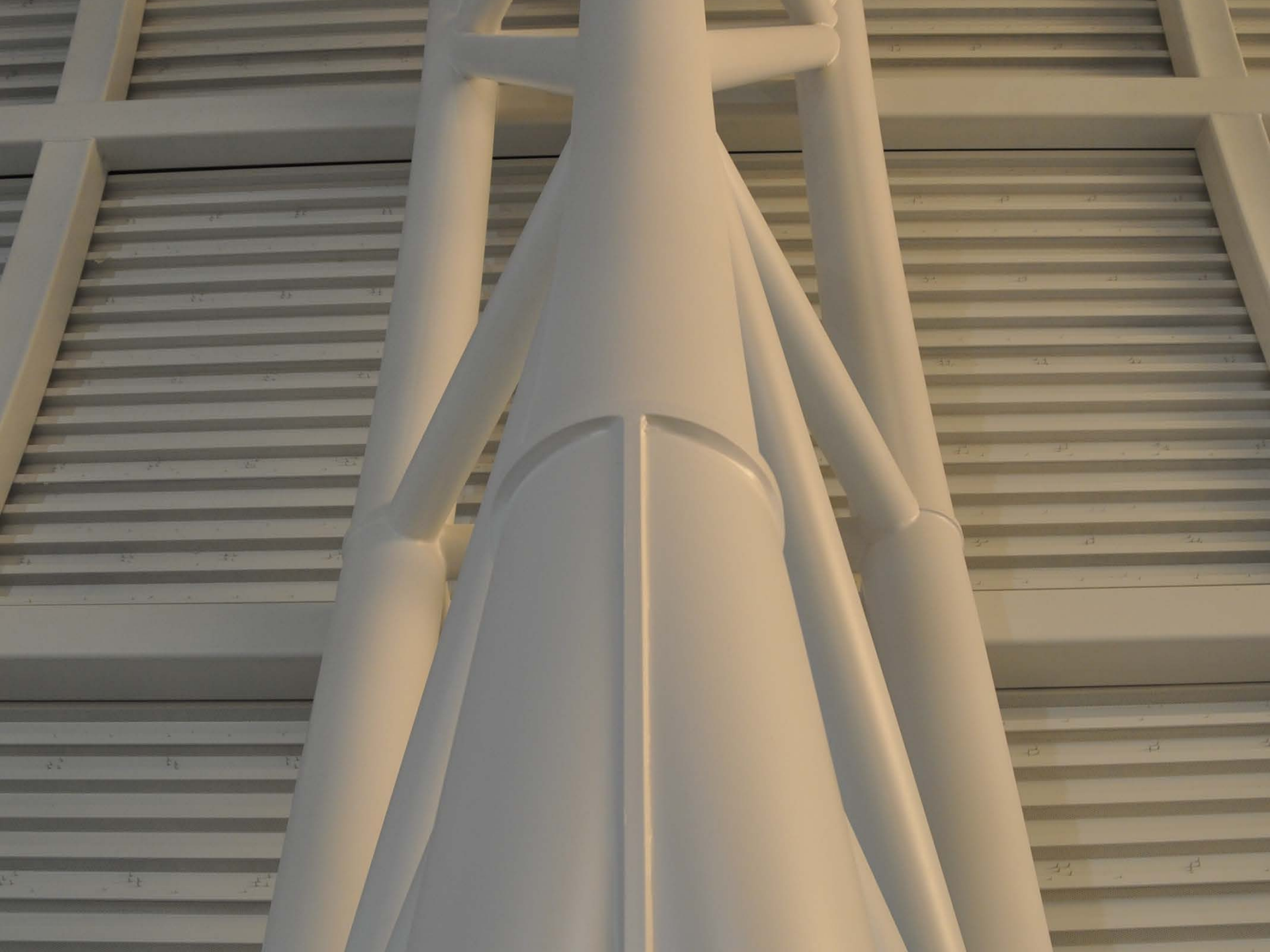


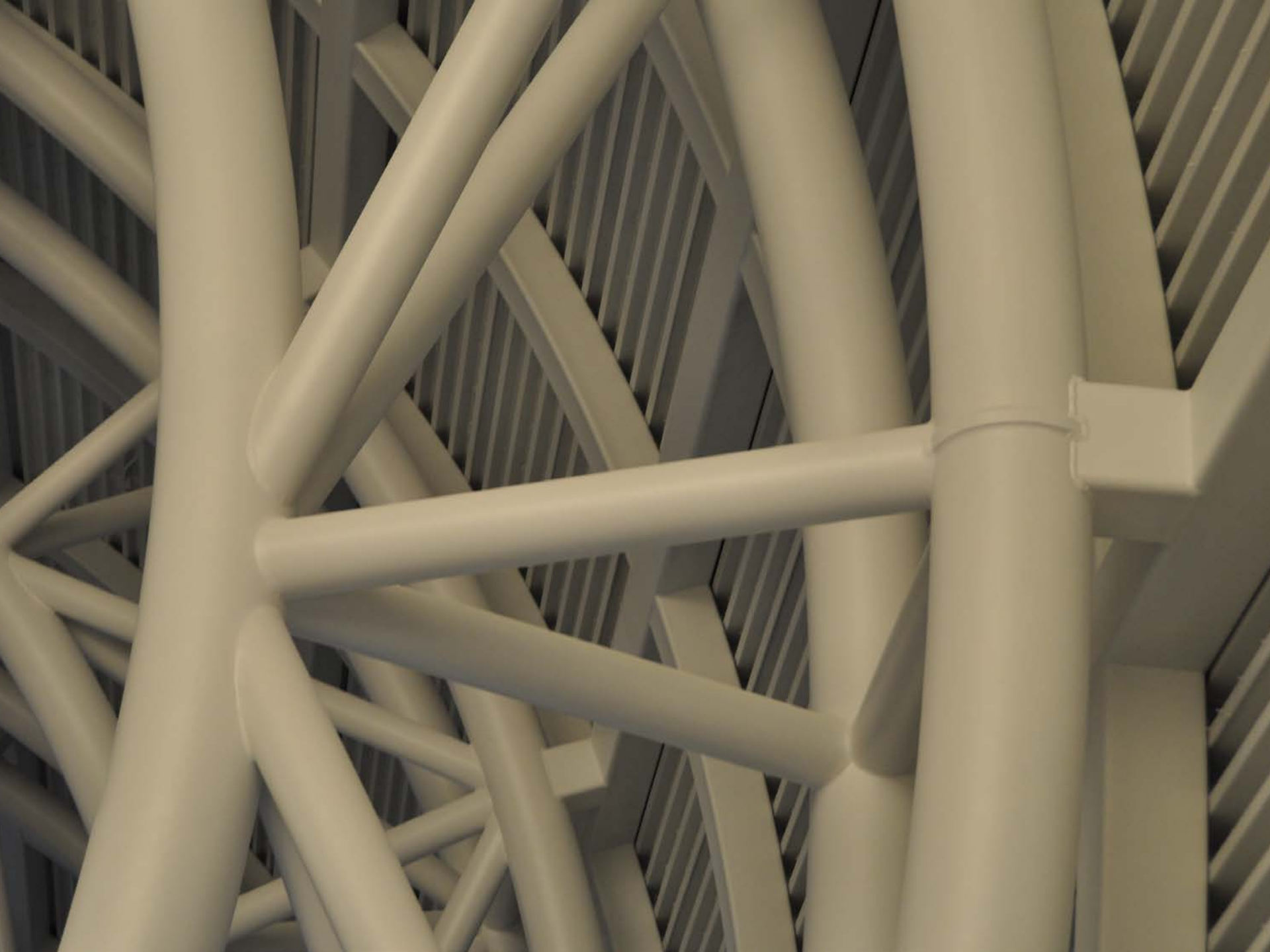




B+H Architects

Abilities Center | Whitby, Canada







DIALOG

Calgary International Airport | Calgary, Canada





Making Splices

- Usually done between sections of larger elements
- Usually the result of transportation limitations
- Usually intended to be as unobtrusive as possible
- *Downplay the connection*
- Three normal ways when dealing with HSS:
 - COMPLETELY REMEDIATED SPLICE BY WELDING TO THE POINT OF INVISIBILITY
 - HIDDEN CONNECTION USING BOLTS AND A COVER PLATE
 - DISCREET CONNECTION WITH EXPOSED BOLTS





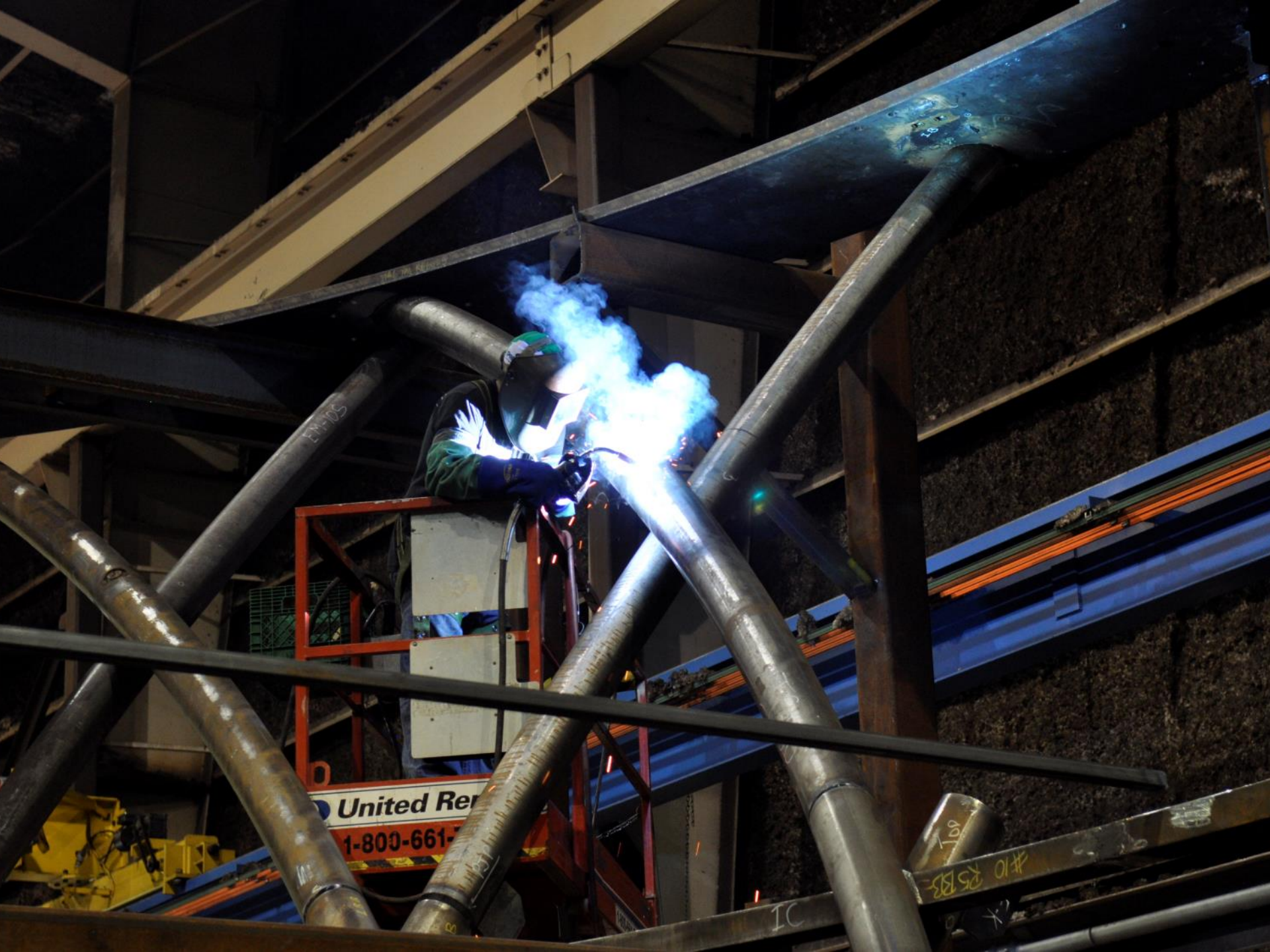






Pelli Clarke Pelli Architects

World Financial Center Entry Pavilion | New York City, NY



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STEEL

AESS 4

Custom Steel

TFP Farrells

Railway Station | Guangzhou, China



Santiago Calatrava

Oriente Station | Lisbon, Portugal



VIAGENS TÁMEGA

SANTOS











Wilkinson Eyre Architects

Siemens Crystal | London, UK





Renzo Piano

The Shard | London, UK







Renzo Piano

New York Times | New York, USA





Rogers Stirk Harbour + Partners

Leadenhall Building | London, UK









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Ennead Architects

Newseum | Washington, DC









Foggo Associates

Cannon Street Station | London, UK













TFP Farrells

South Railway Station | Guangzhou, China





Aranguren + Gallegos Arquitectos

ABC Museum | Madrid, Spain



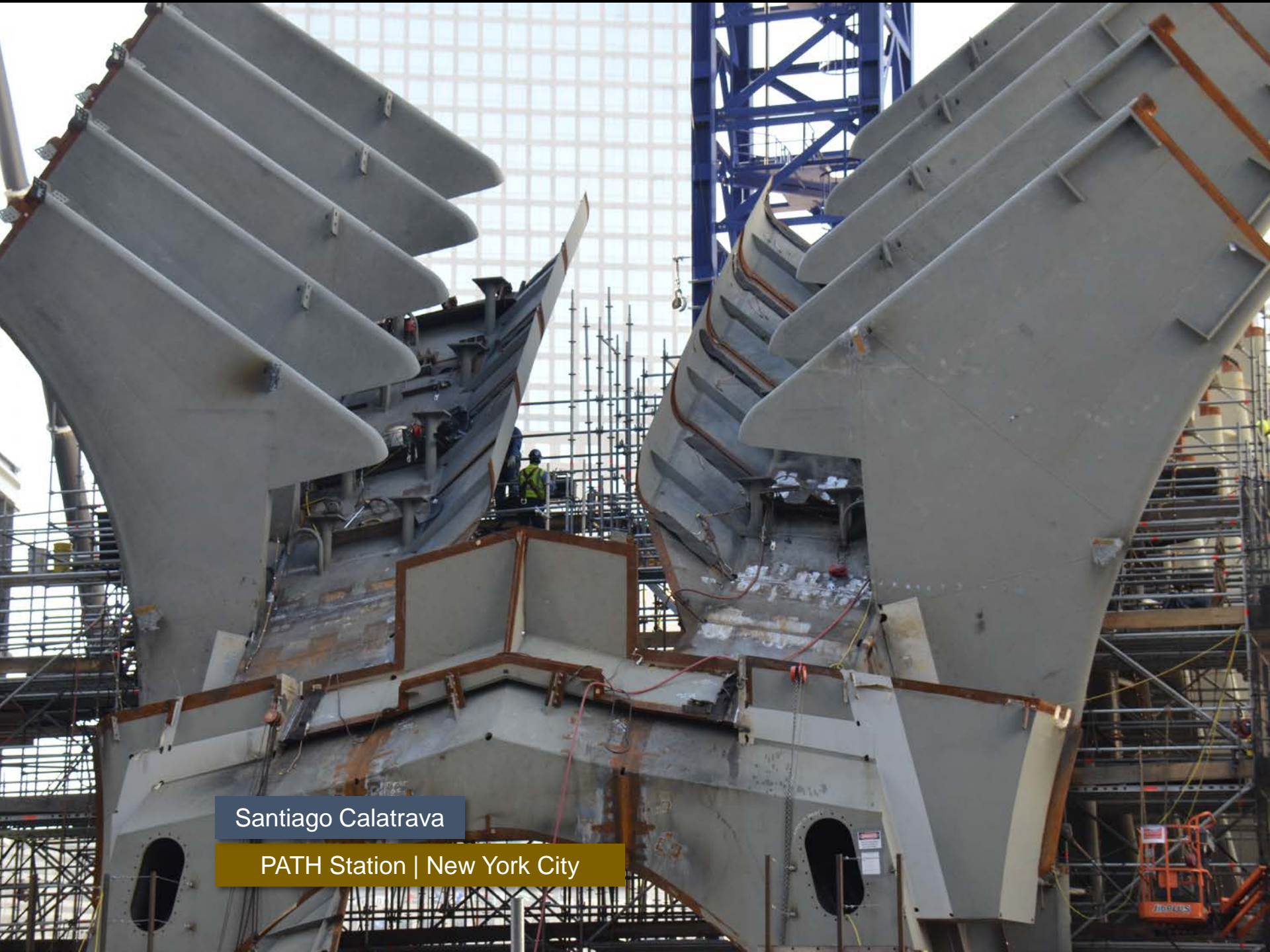


Dominique Perrault

Arganzuela Bridge | Madrid, Spain







Santiago Calatrava

PATH Station | New York City



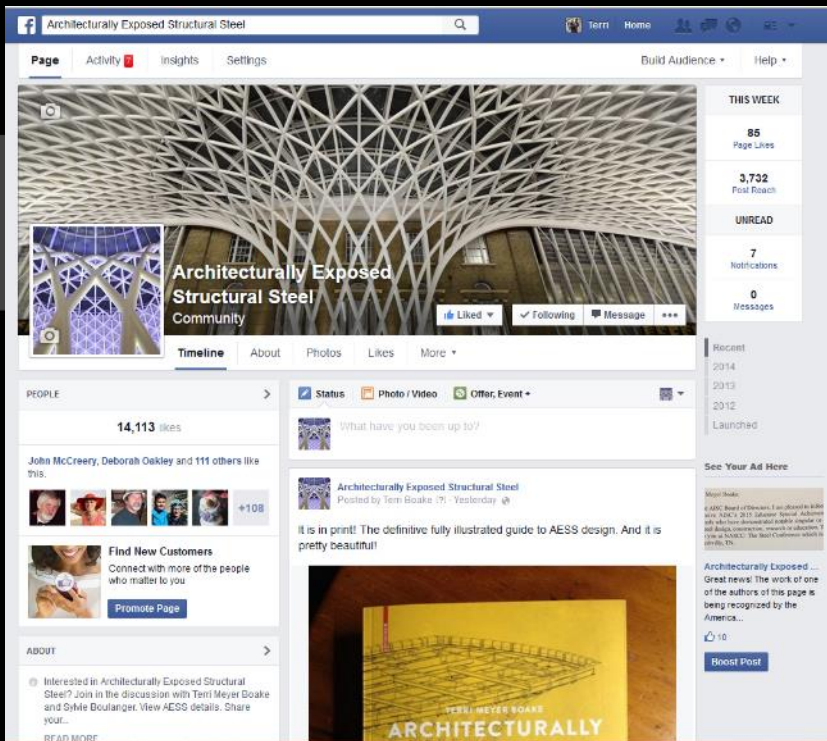






WORLD TRADE CENTER

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STEEL

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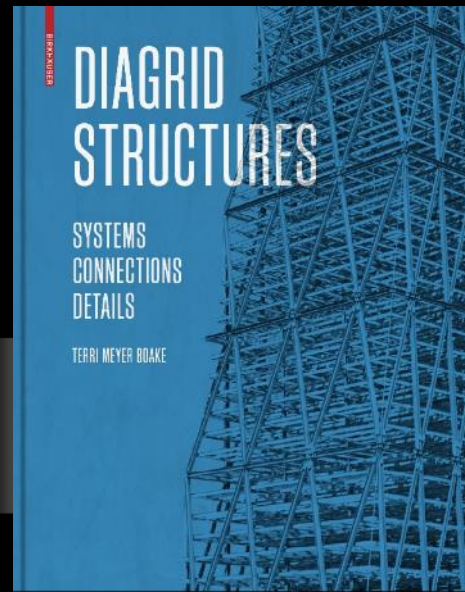
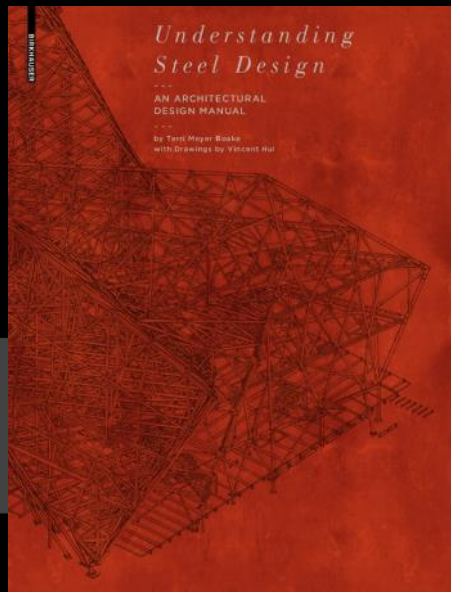
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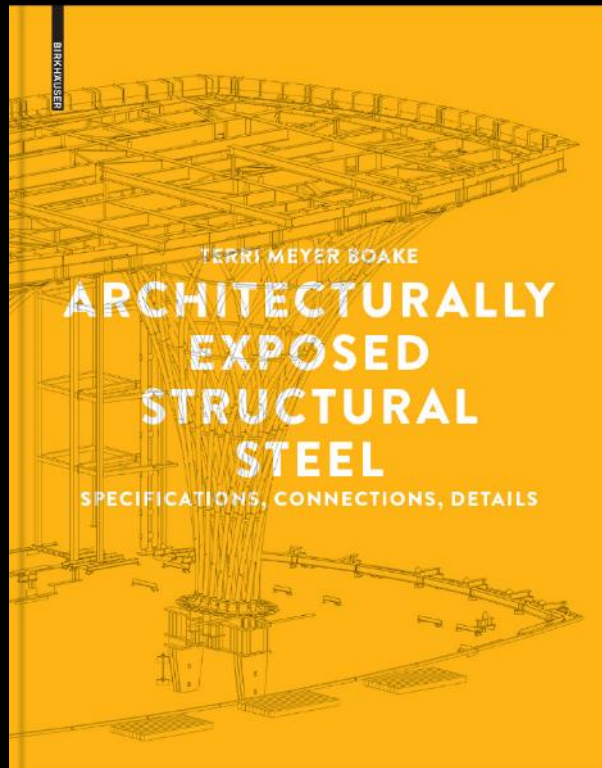
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