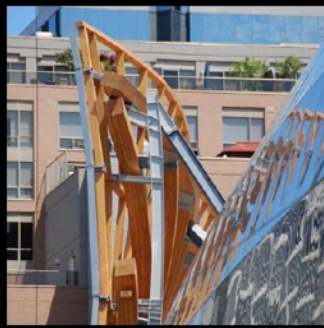




# Modern Steel Construction

Arch 173: Building Construction 2  
Winter 2025

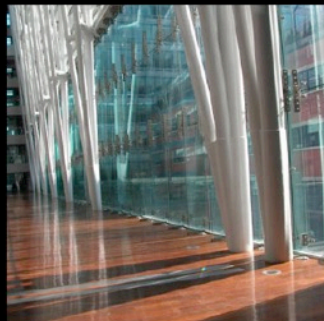
Terri Meyer Boake



# Canadian Institute of Steel Construction Guide for Specifying Architecturally Exposed Structural Steel



by Terri Meyer Boake





BIRKHAUSER

*Understanding  
Steel Design*

---  
AN ARCHITECTURAL  
DESIGN MANUAL

---  
by Terri Meyer Boake  
with Drawings by Vincent Hui

BIRKHAUSER

DIAGRID  
STRUCTURES

SYSTEMS  
CONNECTIONS  
DETAILS

TERRI MEYER BOAKE



BIRKHAUSER

TERRI MEYER BOAKE

# ARCHITECTURALLY EXPOSED STRUCTURAL STEEL

SPECIFICATIONS, CONNECTIONS, DETAILS

BIRKHAUSER

TERRI MEYER BOAKE

# COMPLEX STEEL STRUCTURES

NON-ORTHOGONAL  
GEOMETRIES IN  
BUILDING WITH STEEL

## Types of steel:

- Regular carbon
- High strength
  
- Weathering steel (aka Corten)
- Stainless steel



















GE Plaza



YOU  
COCA-COLA  
Canada

Canada

CAFE

Canada Pacific Gateway








BRITISH  
COLUMBIA

The Best Place on Earth









Galvanizing is NOT a type of steel.  
It is a dipping process in hot zinc  
for corrosion protection

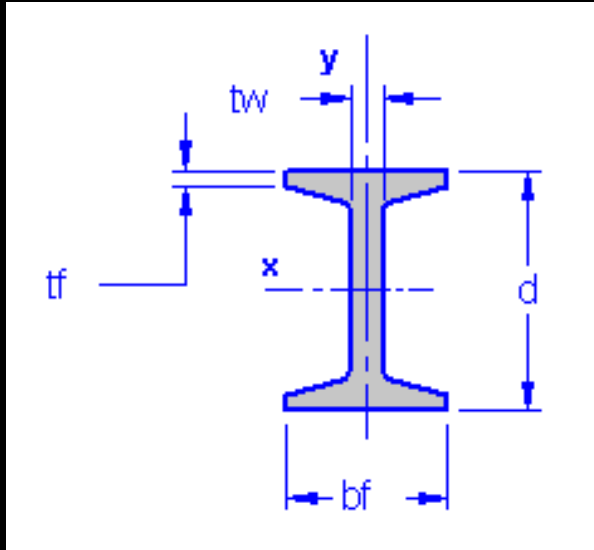


## Structural Steel Shapes

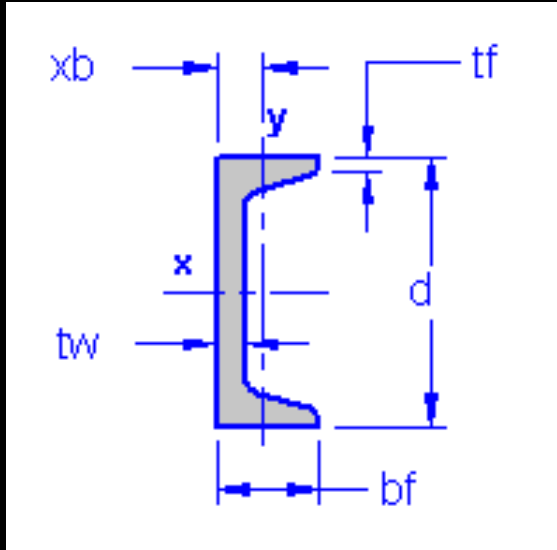
Shapes are either hot rolled  
or

Formed from plate material and  
bent, formed into shapes

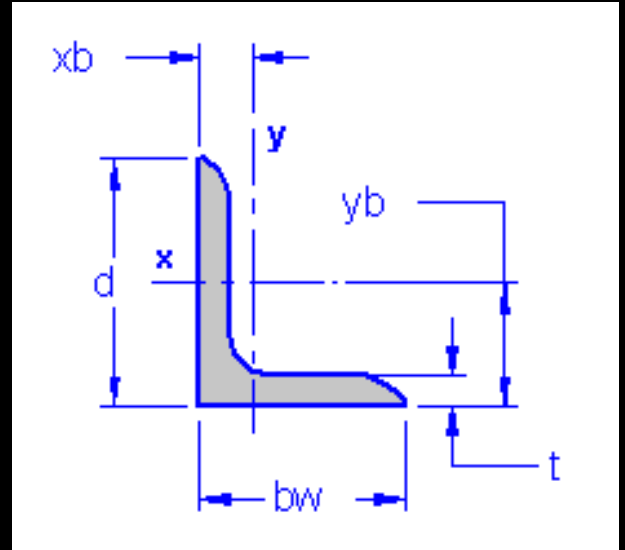




Wide Flange

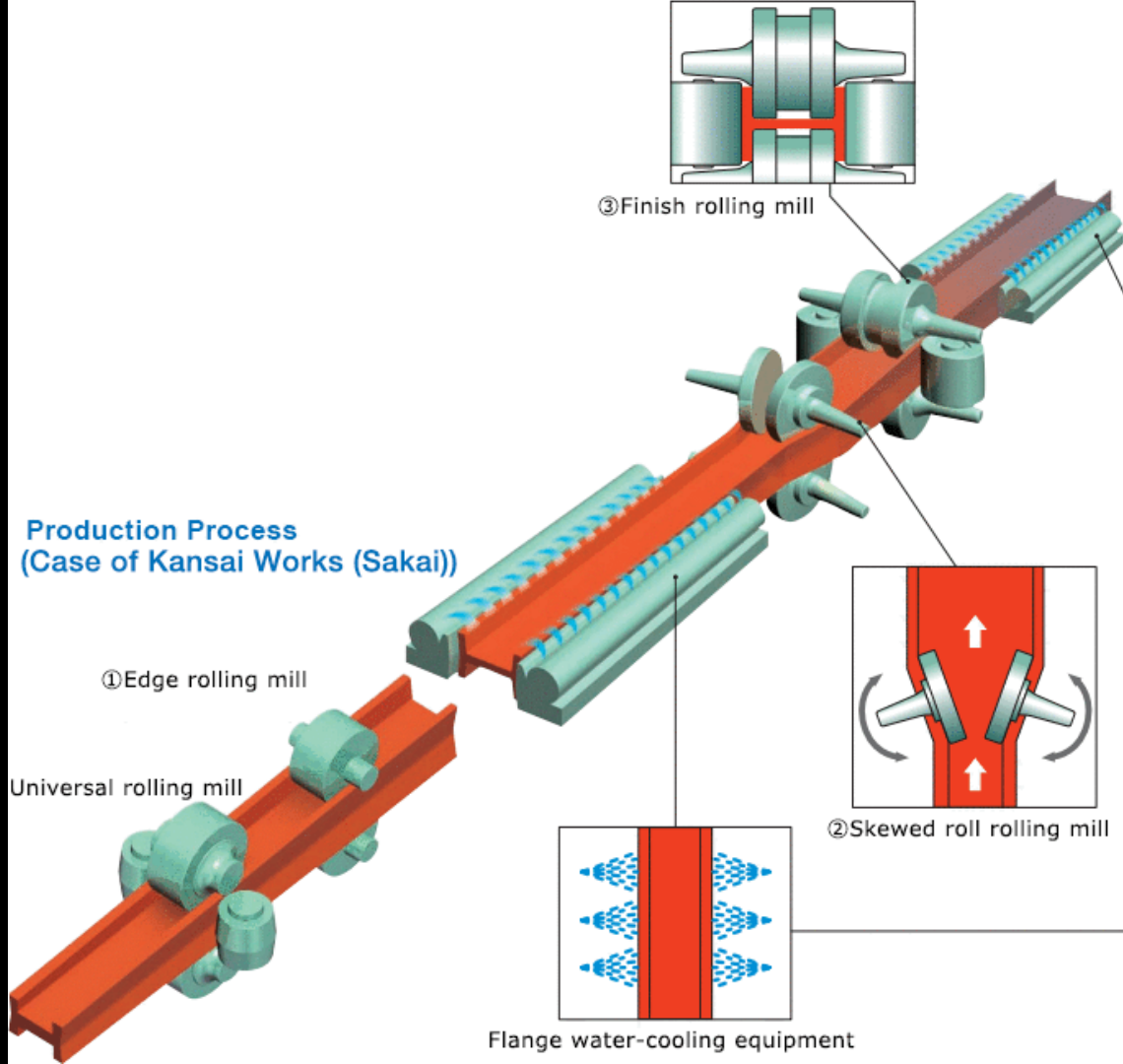


Channel



Angle

**Production Process  
(Case of Kansai Works (Sakai))**









Q235 Q235 Q235  
1-7977 1-7977 1-7977

Q235  
Q235

Q235 Q235  
1-7983 1-7983

Q235 Q235  
1-7926 1-7926

ZIBO-SINO

2004 9 25





12 pcs 6x6x5/8x45

6x6x2 1/2x9  
#125

6x6x3 1/2x9  
#125





HW 0216  
33  
10x6  
10x6

10x6x500  
33  
HW 0216  
10x6x500  
33'

HW 0216

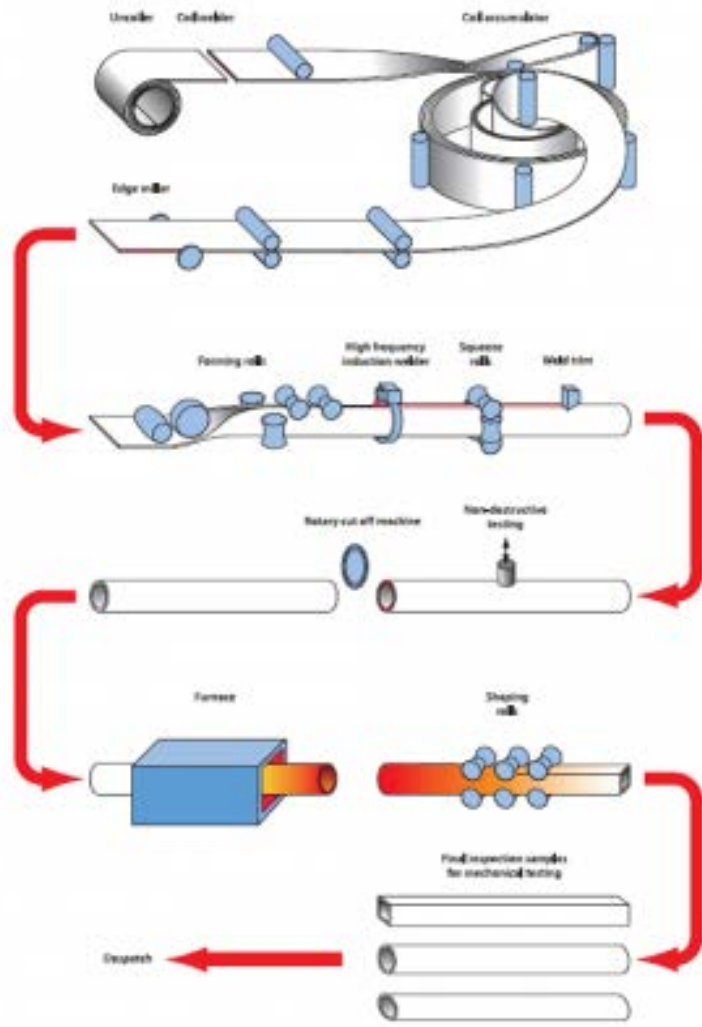
HW 0216  
33  
10x6

HW 0216  
33  
10x6

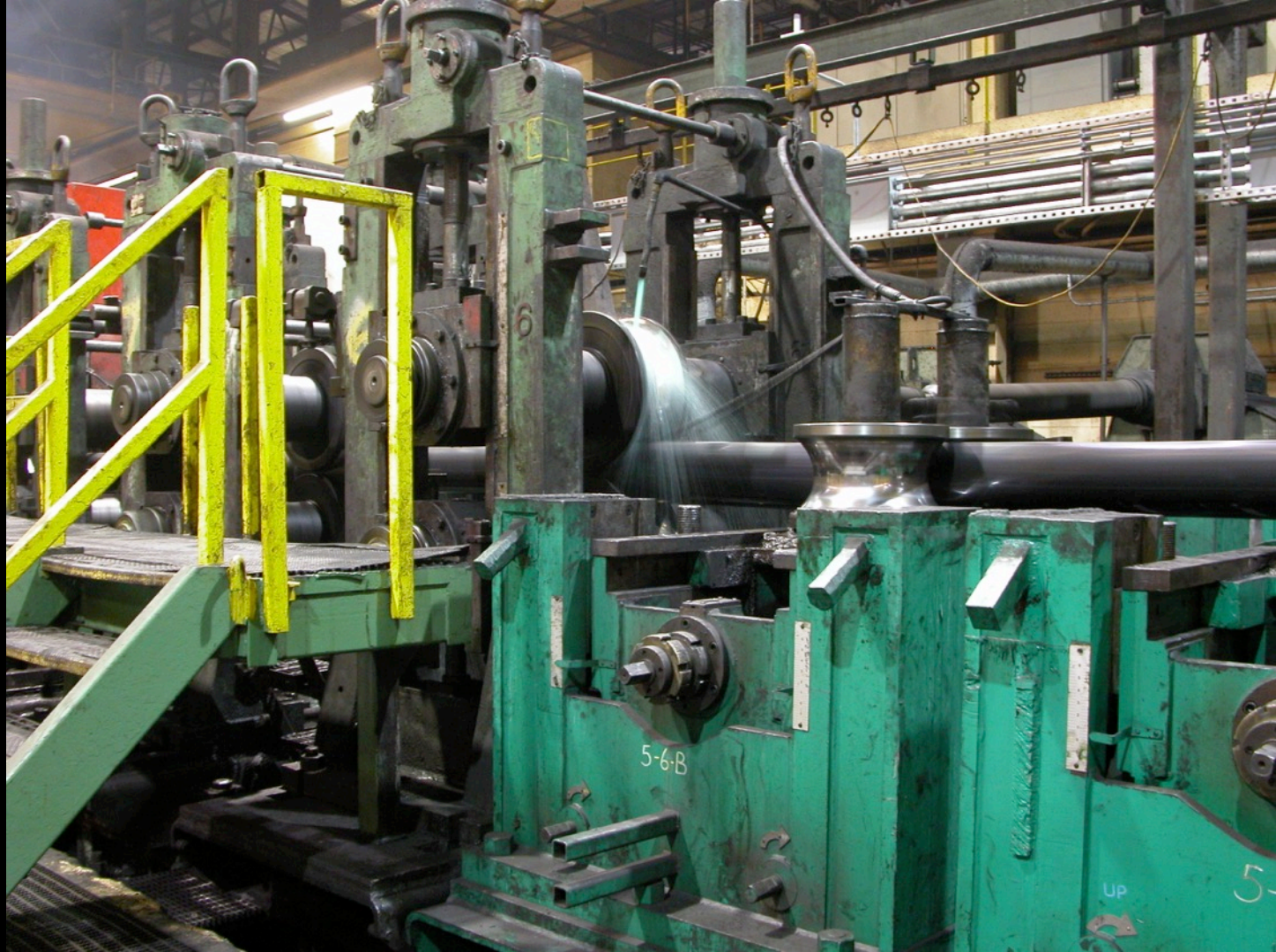




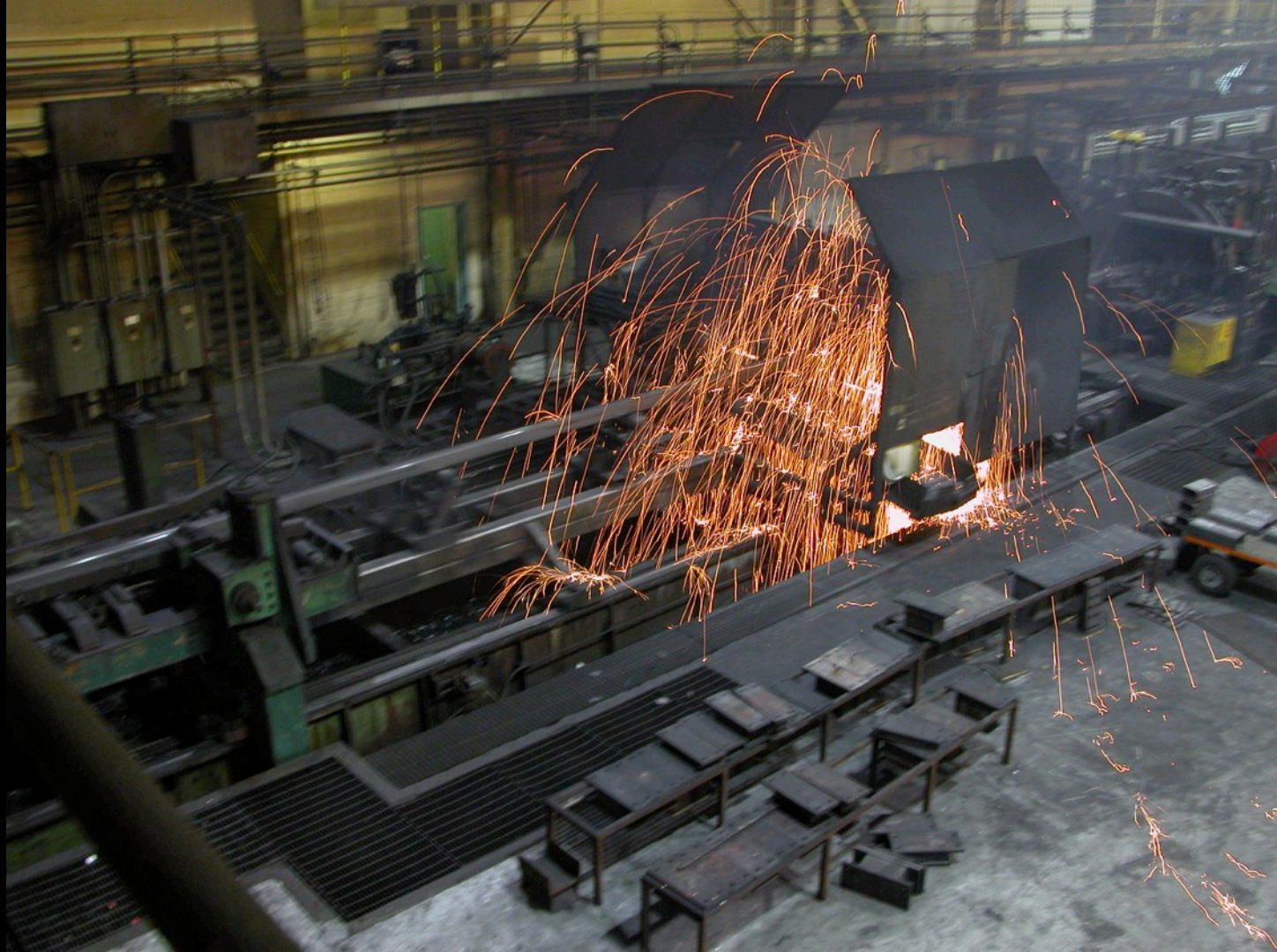
Hollow Structural Sections  
AKA HSS

















STKR600 SIZE: 300x200x1200 11110 HEATNO. 20050705  
STKR600 SIZE: 300x200x1200 11110 HEATNO. 20050705  
STKR600 SIZE: 300x200x1200 11110 HEATNO. 20050705

SHANGHAI METAL CO. LTD  
NO. 1000000000  
SPEC. STKR600  
SIZE: 300x200x1200  
HEAT NO. 20050705

SHANGHAI METAL CO. LTD  
NO. 1000000000  
SPEC. STKR600  
SIZE: 300x200x1200  
HEAT NO. 20050705

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HEAT NO. 20050705

SHANGHAI METAL CO. LTD  
NO. 1000000000  
SPEC. STKR600  
SIZE: 300x200x1200  
HEAT NO. 20050705

2005 1 12





2005 8 7







Because the HSS is bent formed into shape the corners are rounded.

How rounded depends on the thickness of the steel plate.

HSS come:

Square, rectangular, circular and in Europe, elliptical

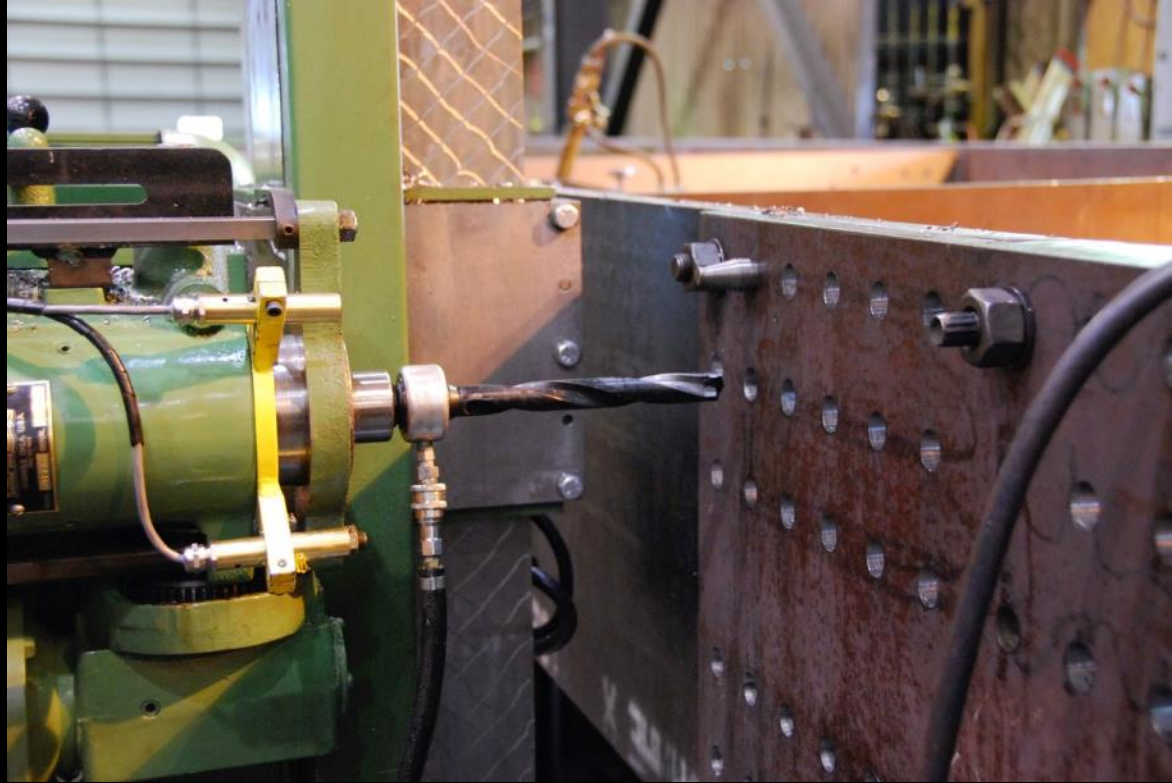




# Fabrication Processes

































# Principles of Connection



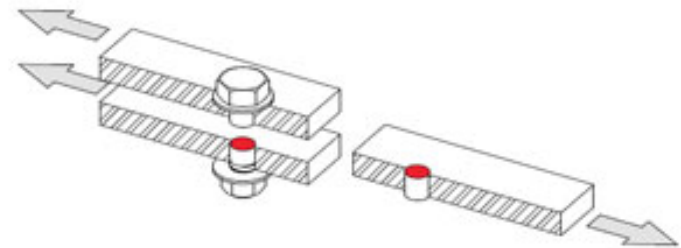
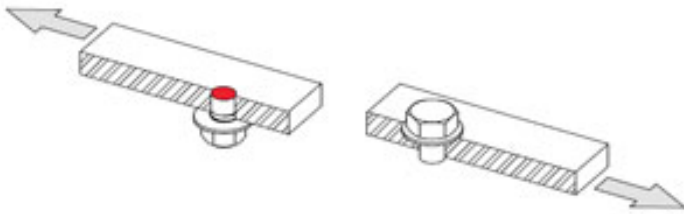
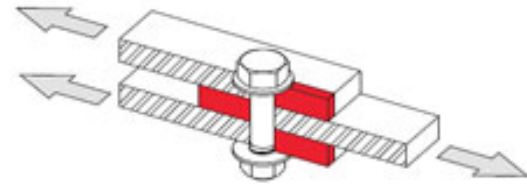
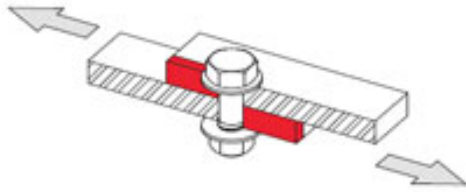
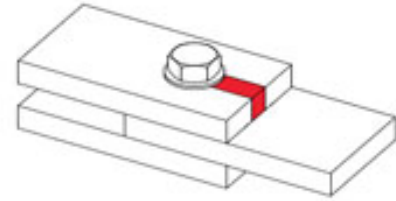
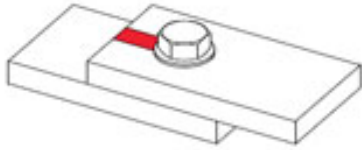
Hex Head Bolt



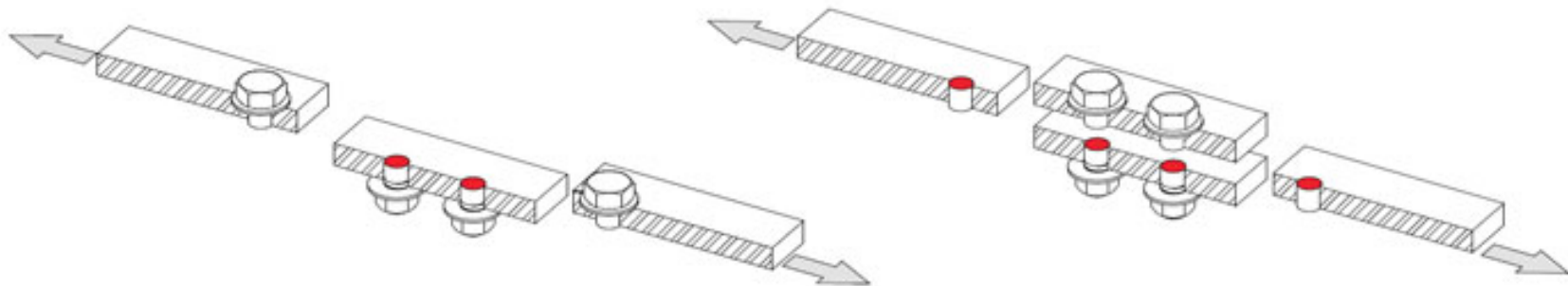
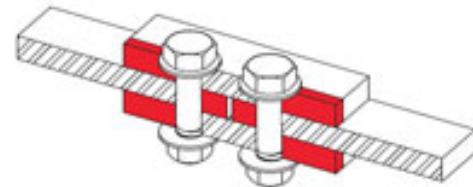
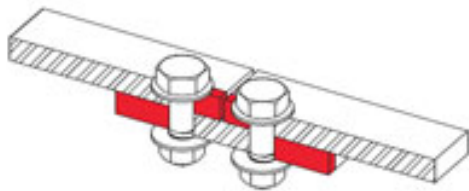
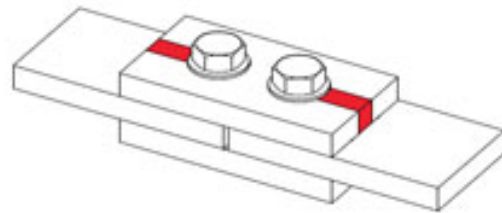
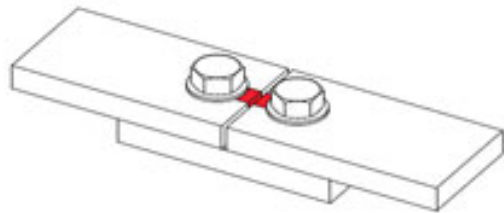
TC (Tension Control) Bolt



# Lap Joints



# Butt Joints

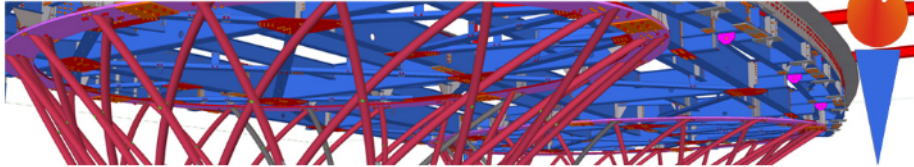




# IMPORTANT RESOURCES!

## Fun is in the Details: Innovation in Steel Connections

[CISC](#) [Home](#) [Basic Connections](#) [Steel Framing](#) [AESS](#) [Innovative Connections](#) [Historic Projects](#) [Contemporary Projects](#) [Finishes](#)



## Fun is in the Details: Innovation in Steel Connections A Curriculum Materials Project

Welcome to "Fun is in the Details: Innovation in Steel Connections"! This curriculum materials project has been funded by the **Steel Structures Education Foundation** the former educational arm of the **Canadian Institute of Steel Construction** ([CISC](#)).

The web site is structured into *SEVEN primary sections on CONNECTION DESIGN* that will take you through the understanding and development of steel connections. Navigation is accessible at the top of each page, with subheadings for each section available in the left sidebar or through the pull down menu at the top.

### HOME SUB MENU

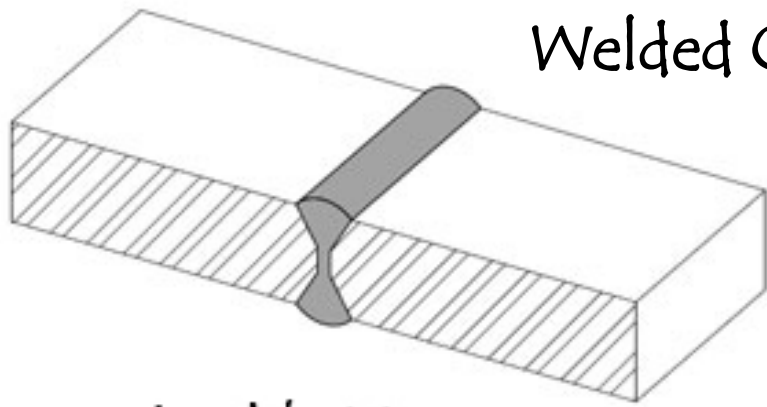
[Project Introduction](#)  
[Using the 3D PDFs](#)  
[About the Authors](#)  
[References and Links](#)  
[Site Index](#)  
[Legal Disclaimer](#)



This web based project is designed to increasing the understanding of connection design in steel structures to better assist students of architecture and engineering in creating more convincing and compelling structures. The project looks at how to take basic methods of creating connections and transform them into innovative connections, using similar principles. Although Standard Structural Steel connections will be included, the emphasis will be on an exploration of Architecturally Exposed Structural Steel (AESS). The project will reference the new CISC AESS documents, in particular the "Category Matrix" and "CISC Guide for Specifying Architecturally Exposed Structural Steel".

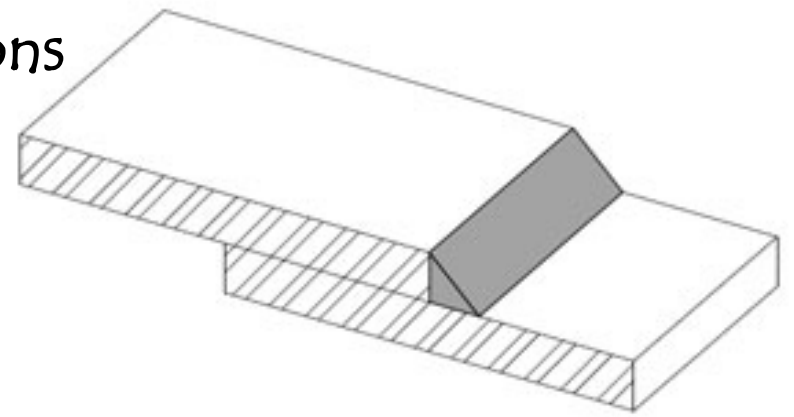
Please check out my [Facebook page for AESS](#) . Many more projects there!

# Welded Connections



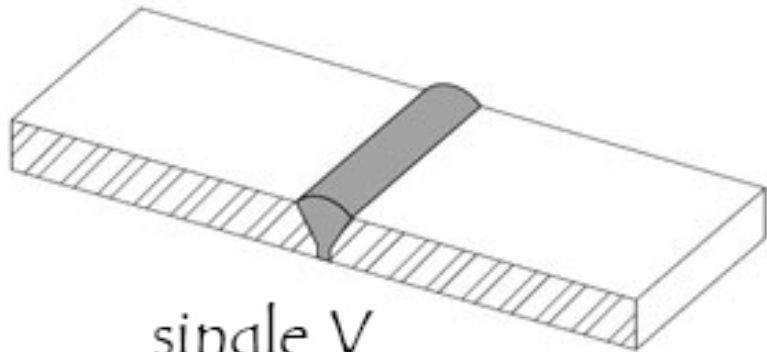
double V

BUTT

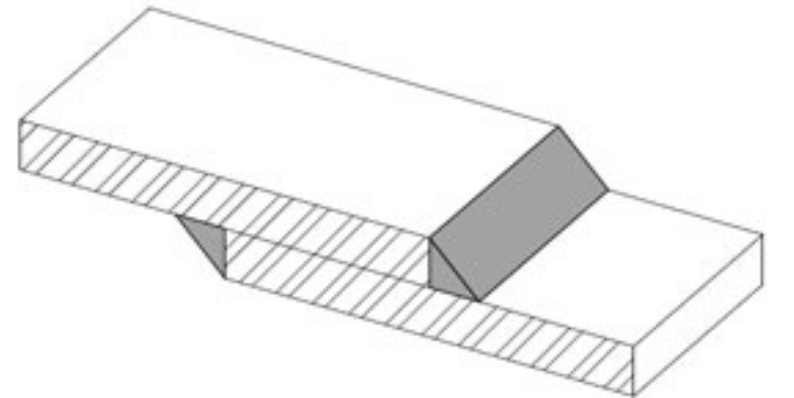


LAPPED

fillet weld

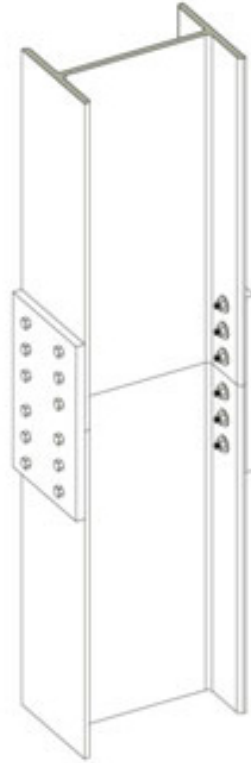


single V





# Column Splices

















5

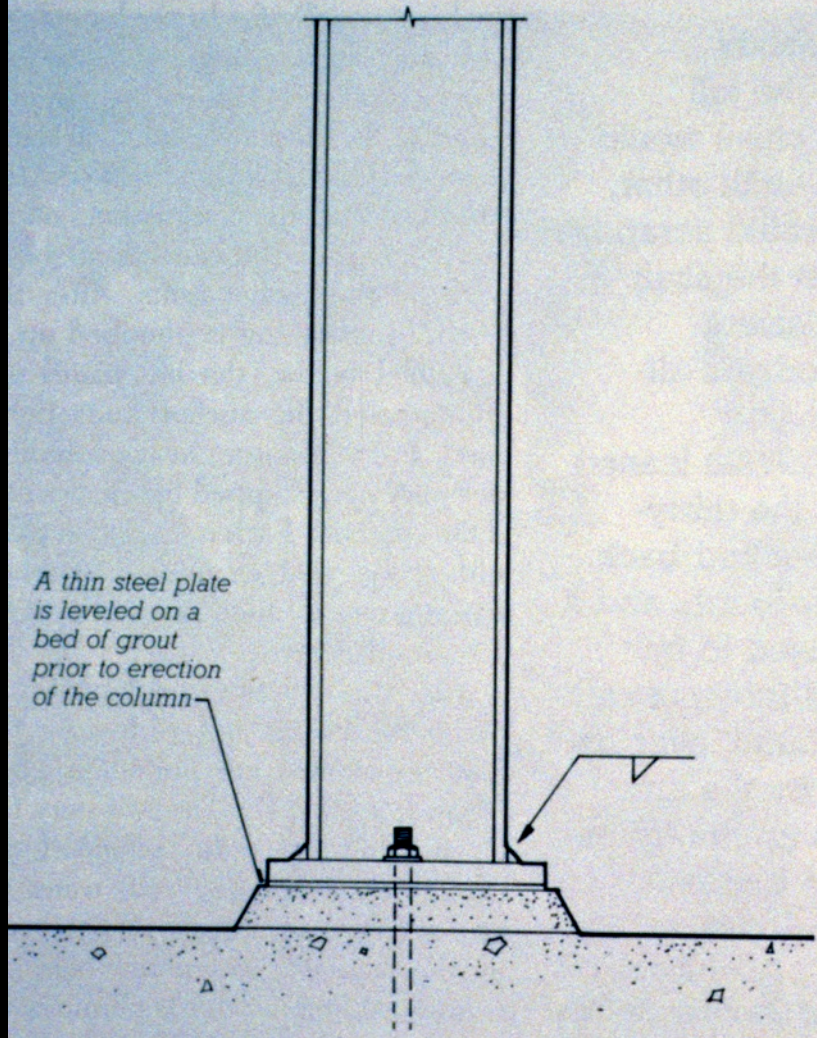
✓ PREP 13mm  
28 f

0999 99

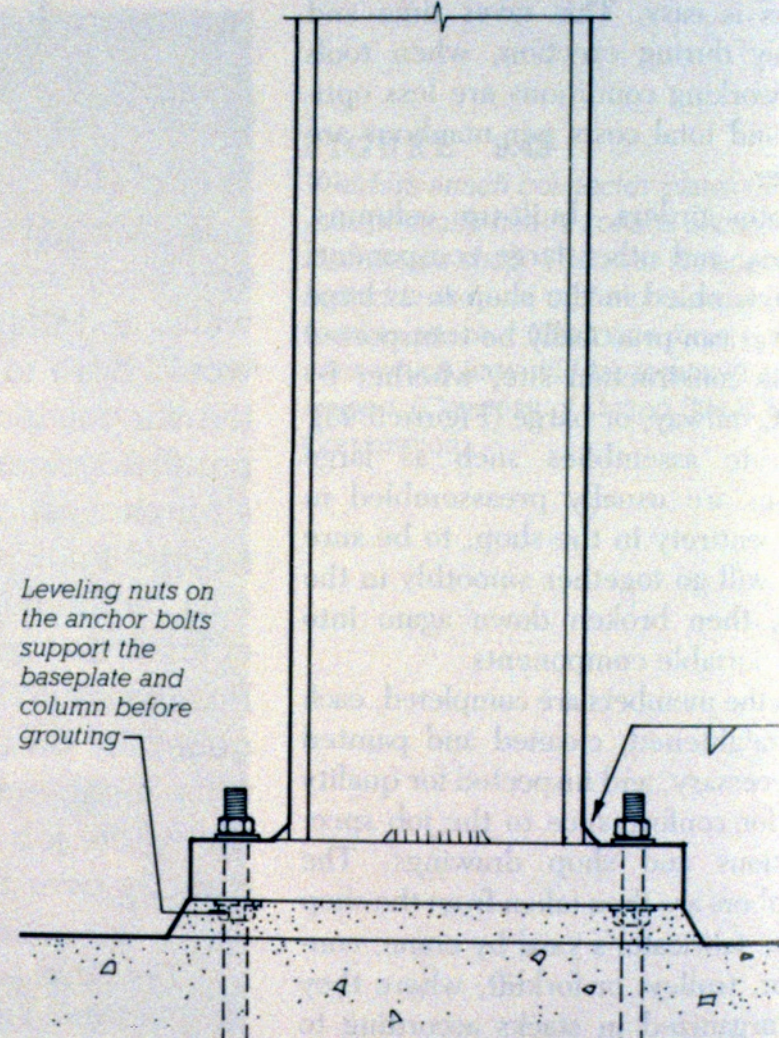




*A thin steel plate is leveled on a bed of grout prior to erection of the column*



*Leveling nuts on the anchor bolts support the baseplate and column before grouting*



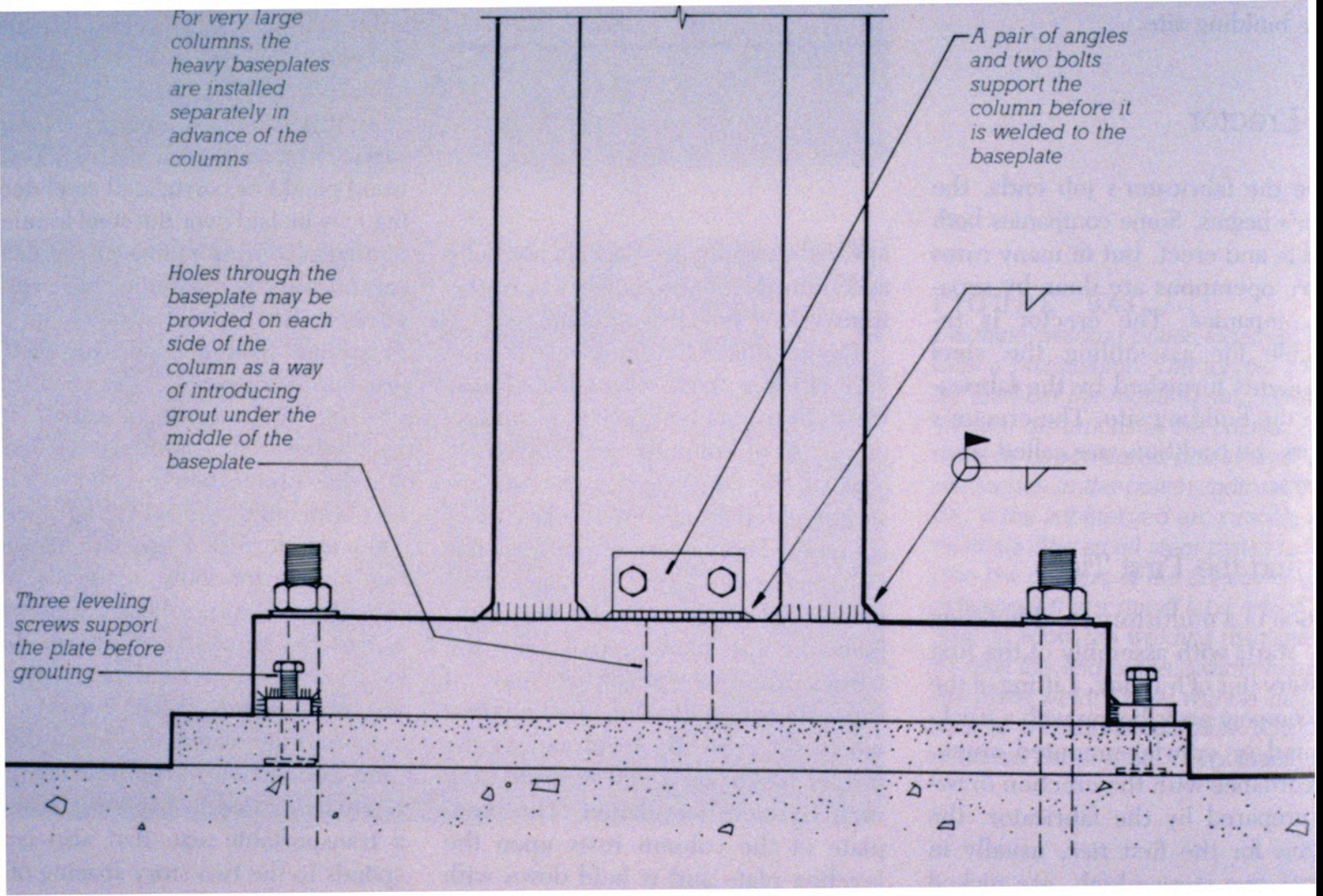


For very large columns, the heavy baseplates are installed separately in advance of the columns

A pair of angles and two bolts support the column before it is welded to the baseplate

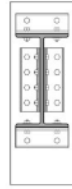
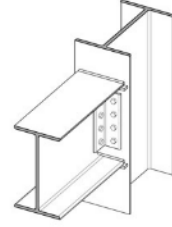
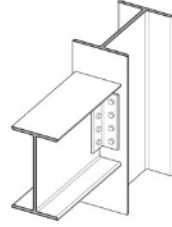
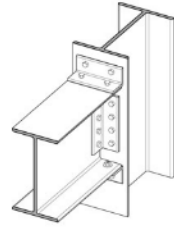
Holes through the baseplate may be provided on each side of the column as a way of introducing grout under the middle of the baseplate

Three leveling screws support the plate before grouting

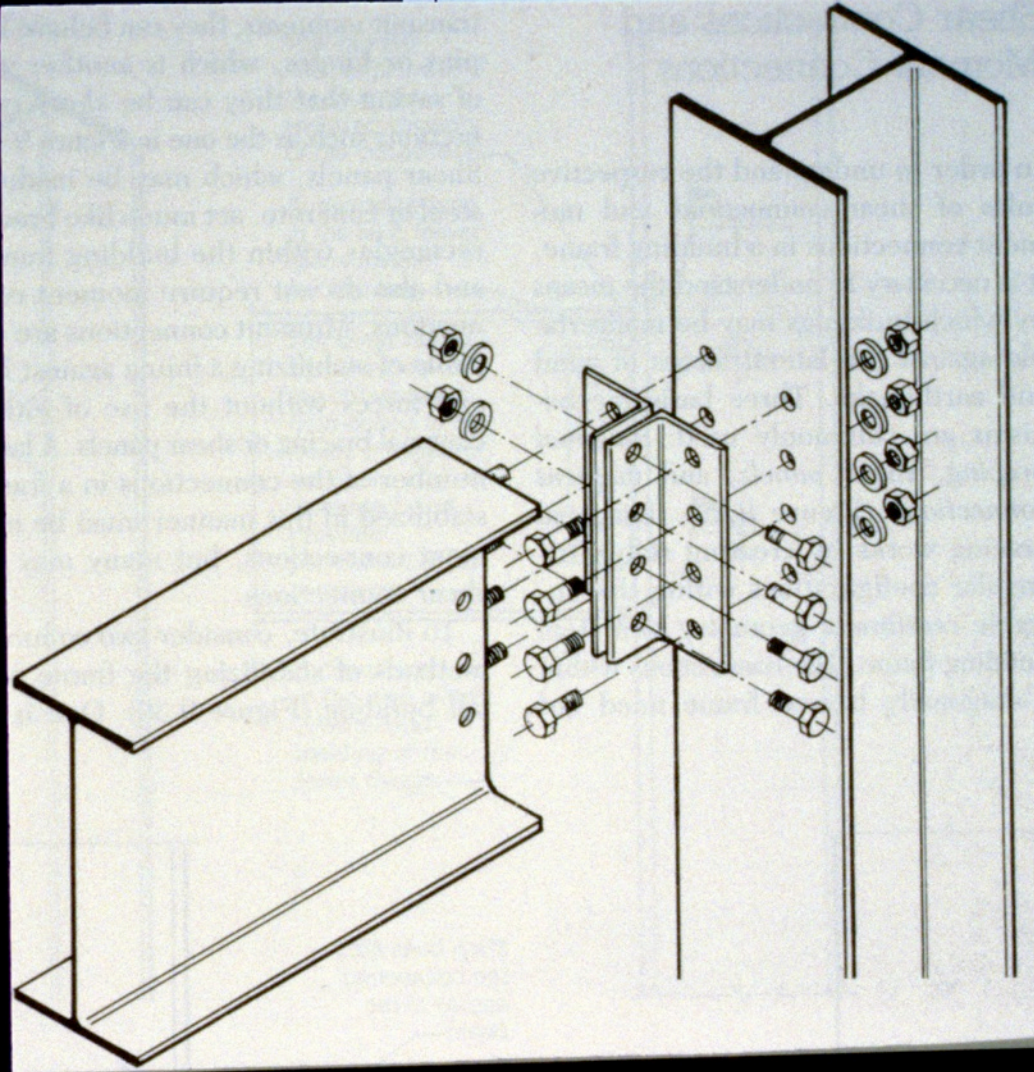
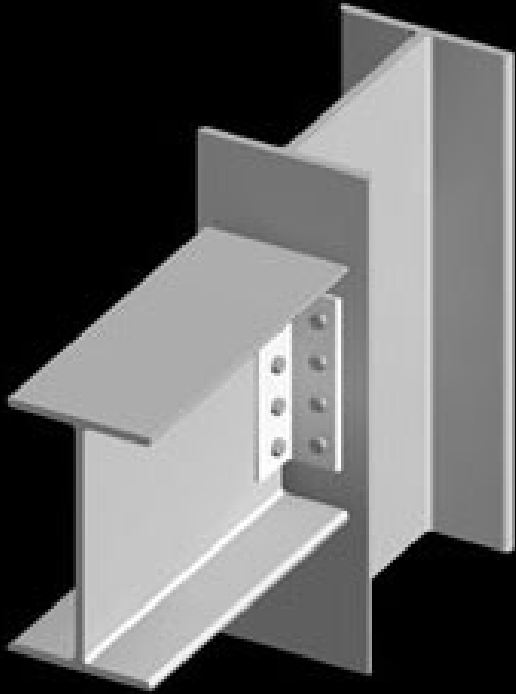




# Beam to Column Connections

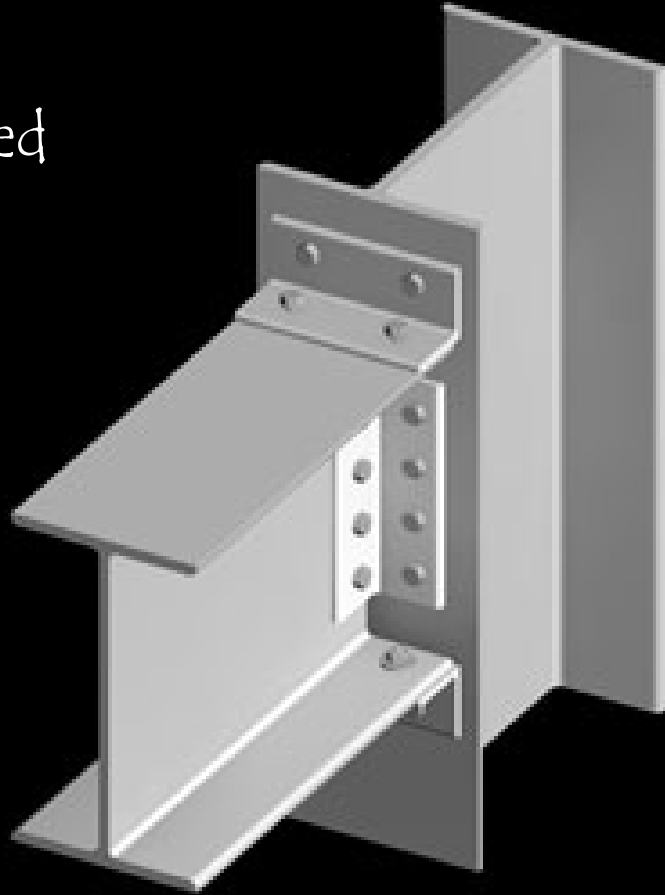


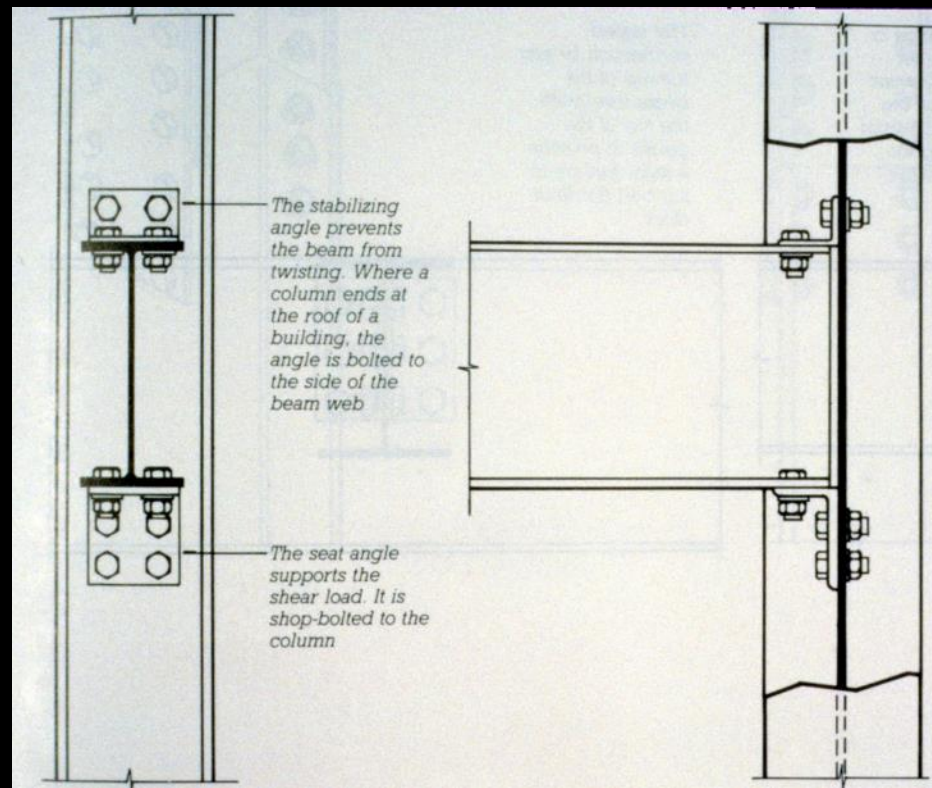
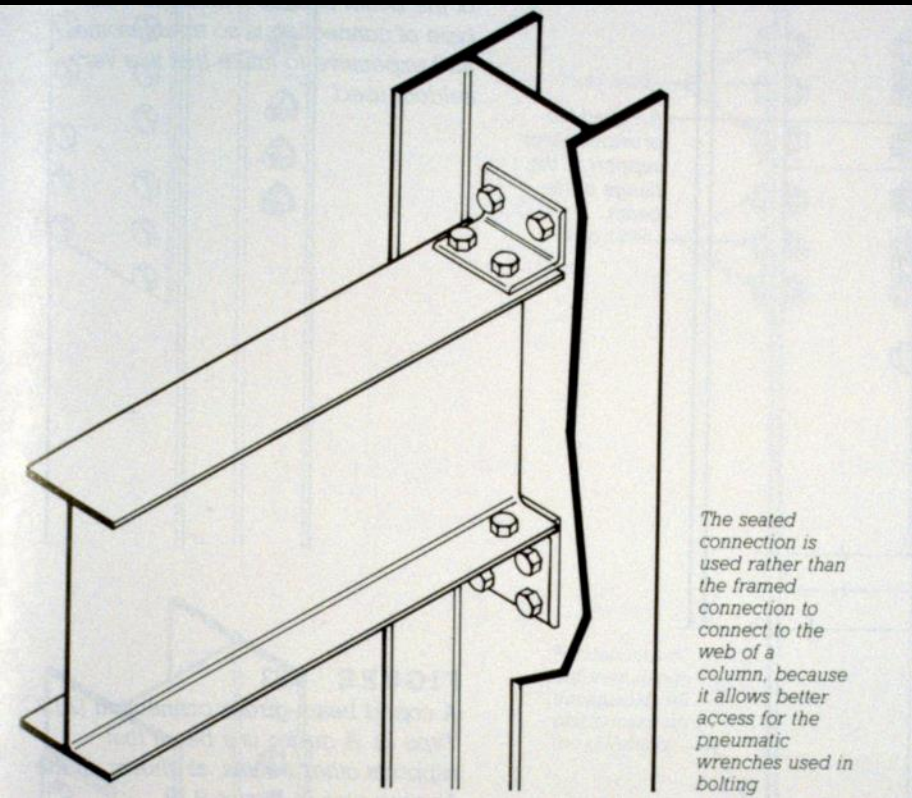
Framed





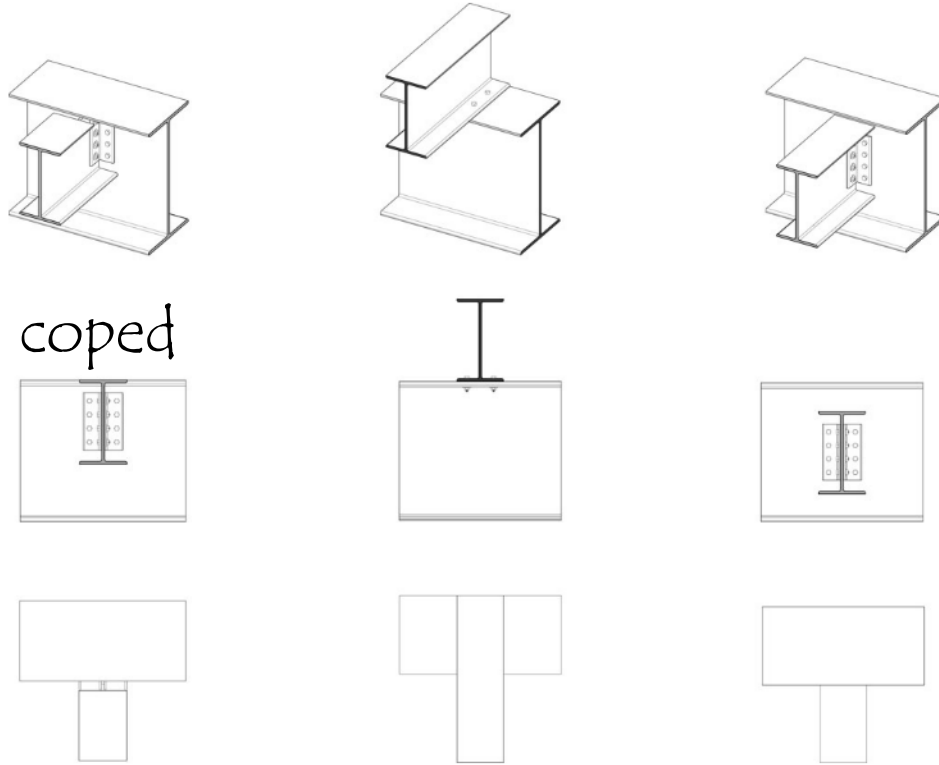
Seated



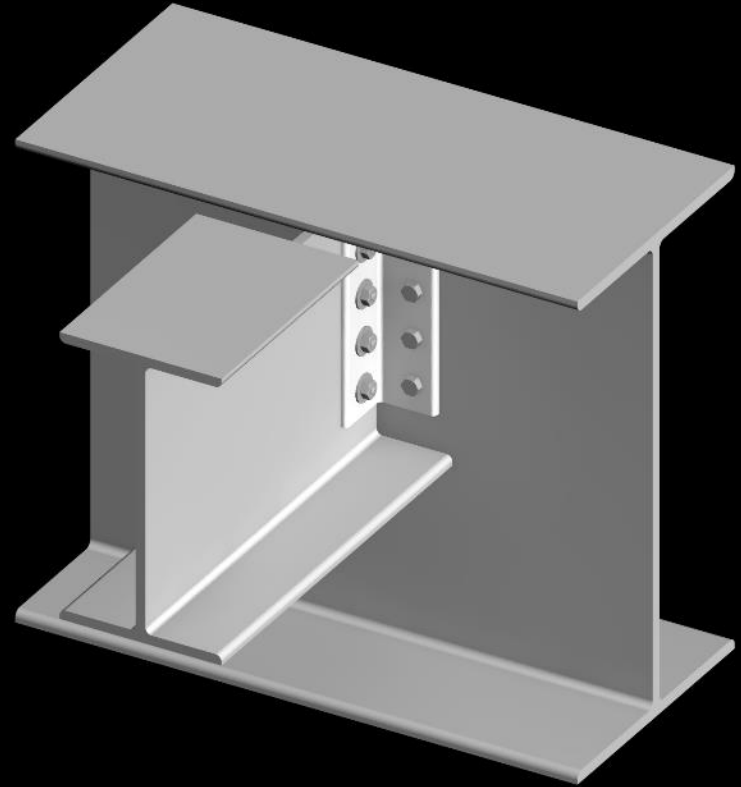




# Beam to Girder Connections

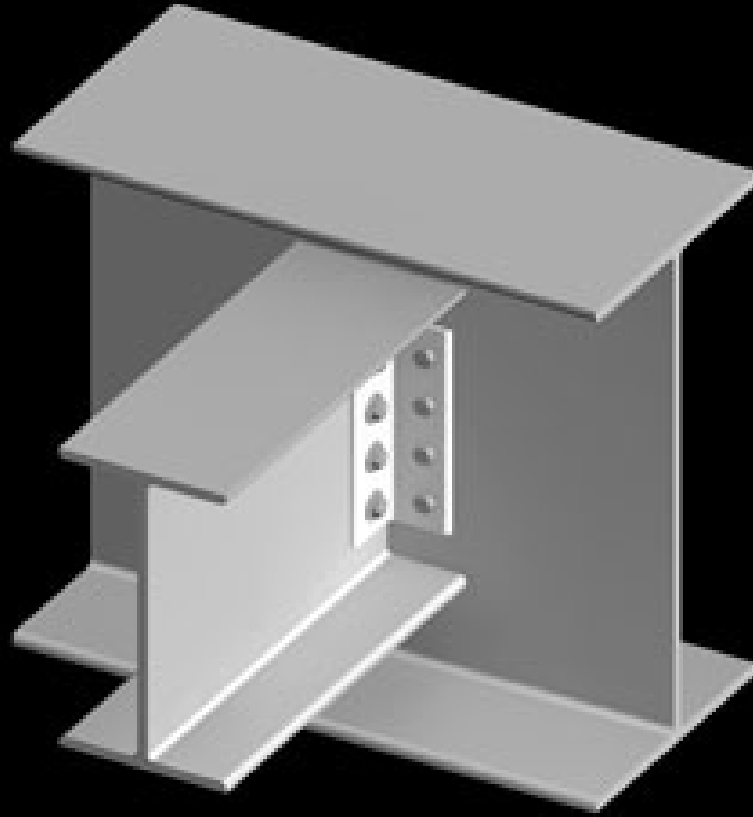


In a coped connection the top flange of the beam is cut away so that the top of the beam and top of the girder will align.





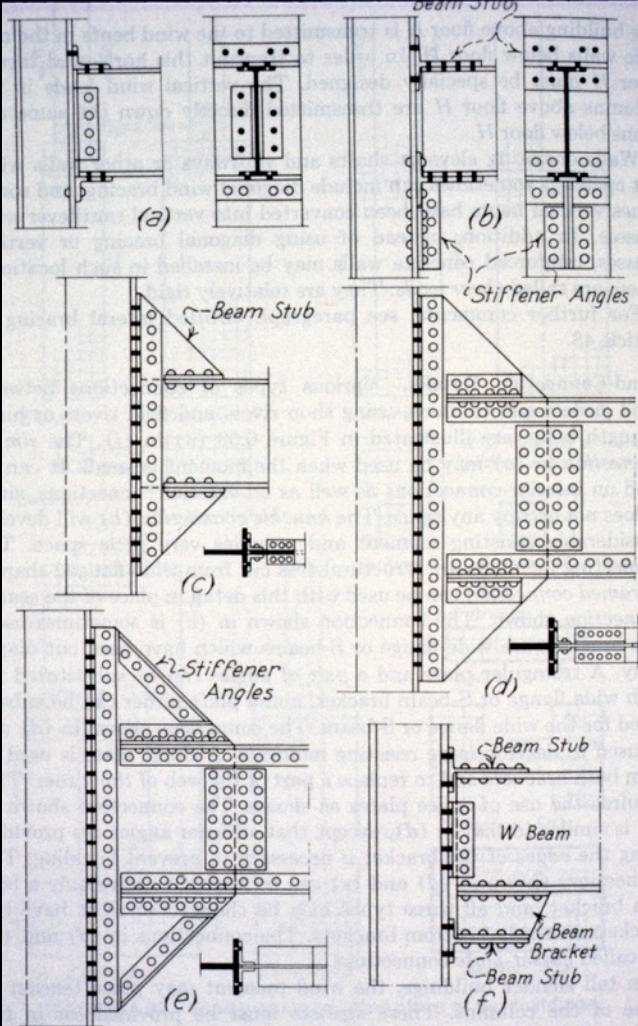
Framed  
connection  
has the beam  
flange below.



Regular  
connection  
has the beam  
sitting on top  
of the girder







For taller buildings greater resistance to horizontal wind loads requires moment resisting connections.

FIGURE 6.30 Types of wind connections.

## Connection types:

### HINGE

- Transfers vertical and horizontal loads
- Not intended to resist some rotation

### PIN

- Transfers vertical and horizontal loads
- Free to rotate

### MOMENT

- Resists bending and rotation





















A low-angle, upward-looking photograph of the interior of the Canadian War Museum. The image captures a complex, industrial-style steel truss ceiling structure. The walls are clad in vertical corrugated metal panels. Several rows of track lighting are installed, with some lights illuminated, casting a warm glow. The perspective creates a sense of height and architectural scale.

Canadian War Museum  
Ottawa, ON

























## SPAN

How do we span to make floor and roof systems?

- beams, girders
- Joists
- Planar trusses
- Box trusses
- Innovative suspension systems

## ESTABLISH HIERARCHY

– LOAD PATH – top down:

Decking sits on

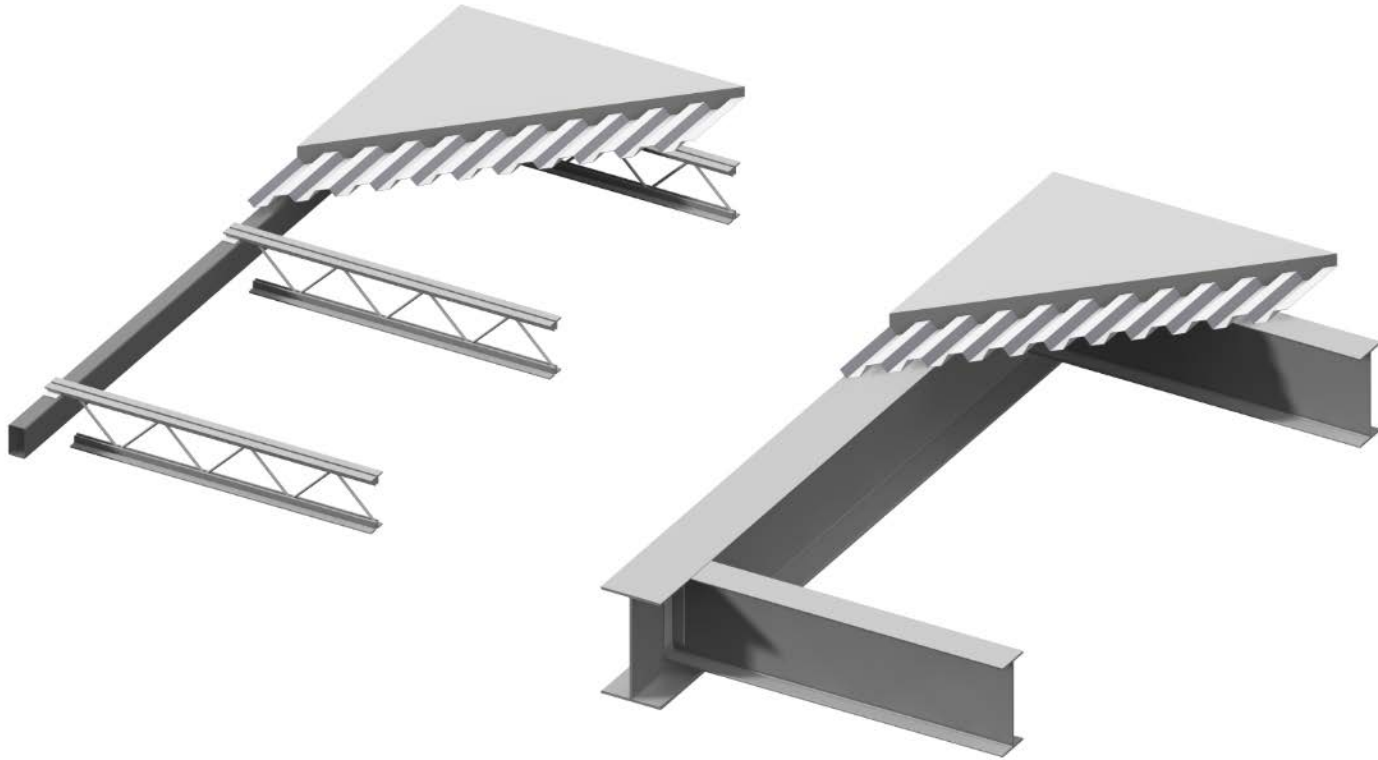
Joists or Beams

Sit on Girders

Girders frame into columns



# Floor Systems







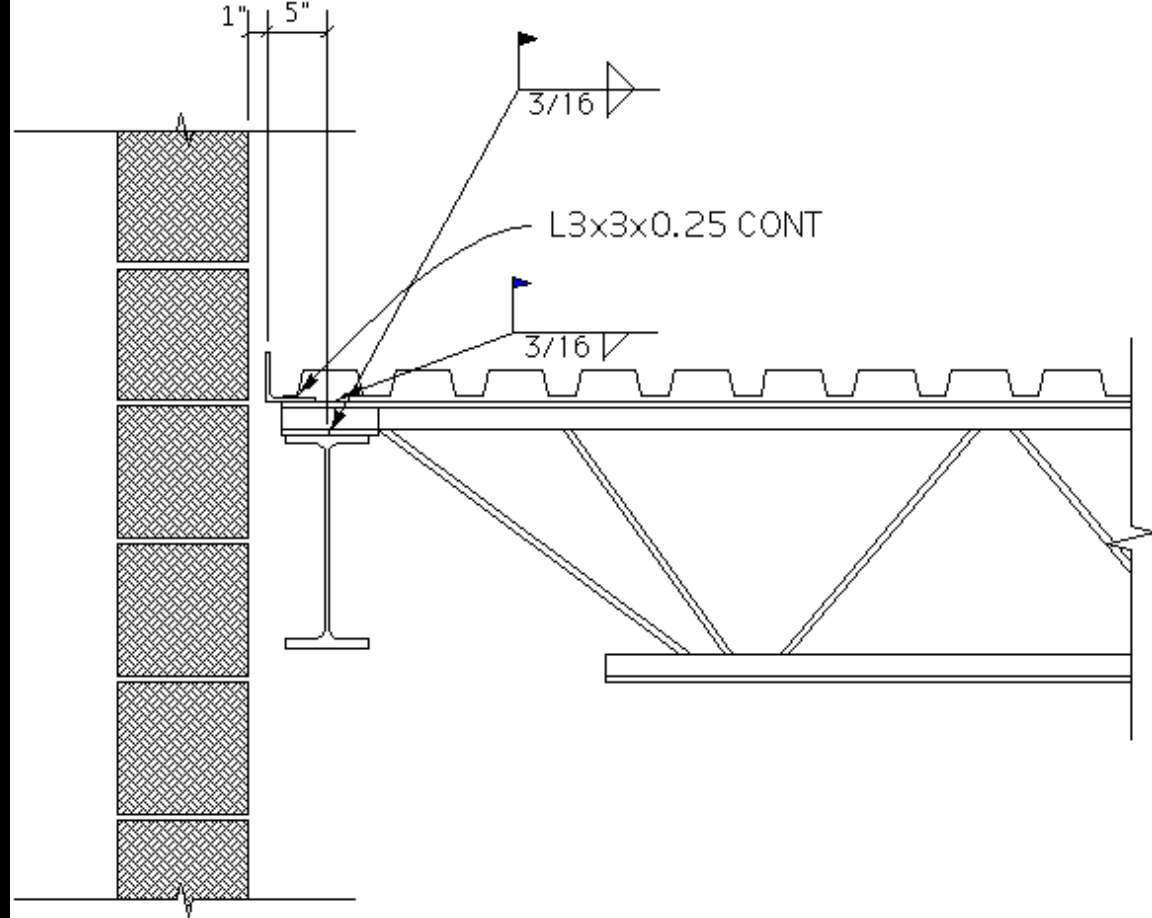


ABSOLUTELY  
UNMATCHED  
IN THIS C  
ENGINEER  
SOLUTIONS AND  
PROFESSIONAL

Open web steel joists



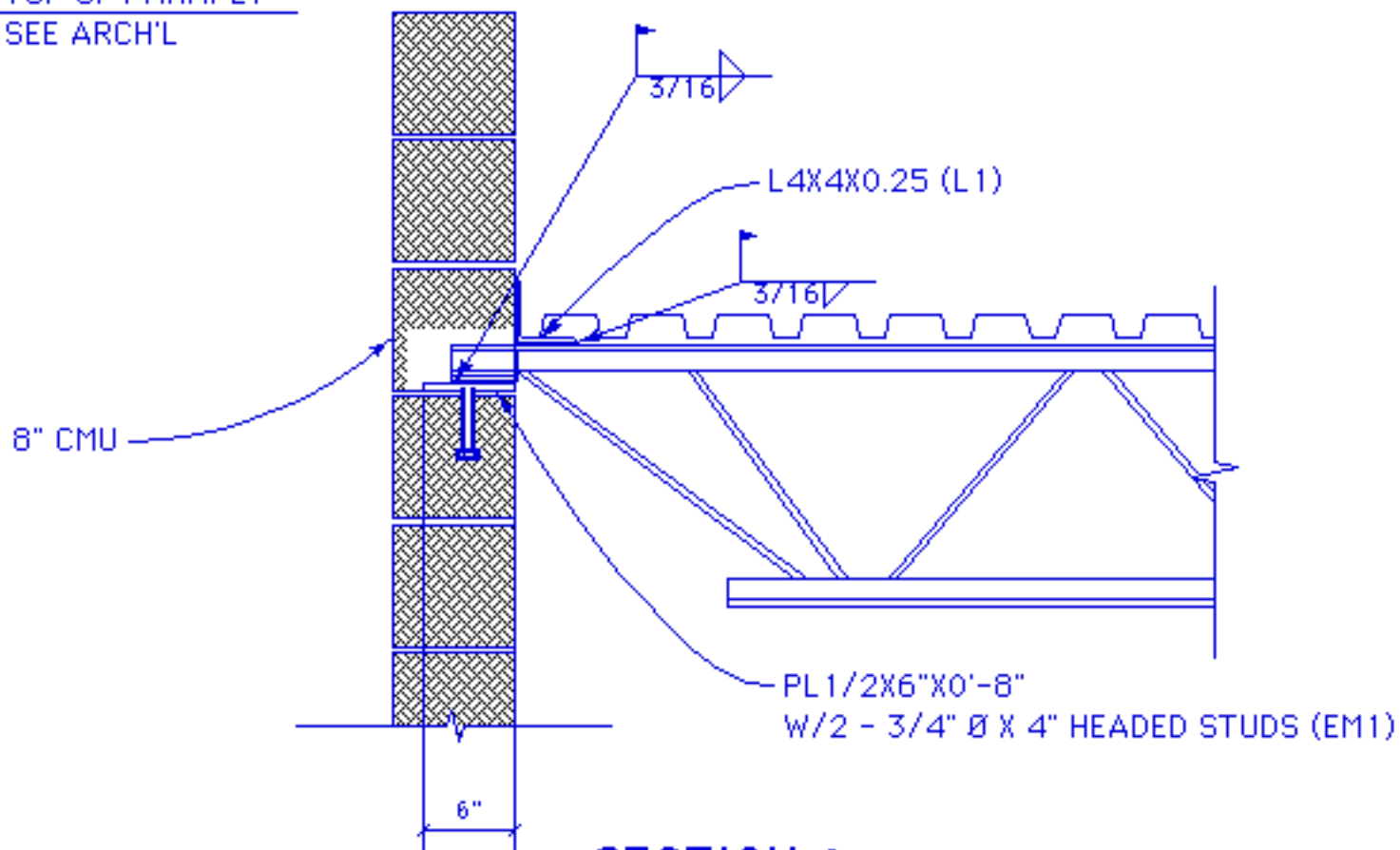




**SECTION 13**



TOP OF PARAPET  
SEE ARCH'L



**SECTION 1**

























karim pinto

erni patti gopar

pradumita jayne morosino

amelia

premiya perkins

kealy

bryanna

peninn bennett

astrid mayer

haavel

allie

tonno

qennis

marjanna

mariss



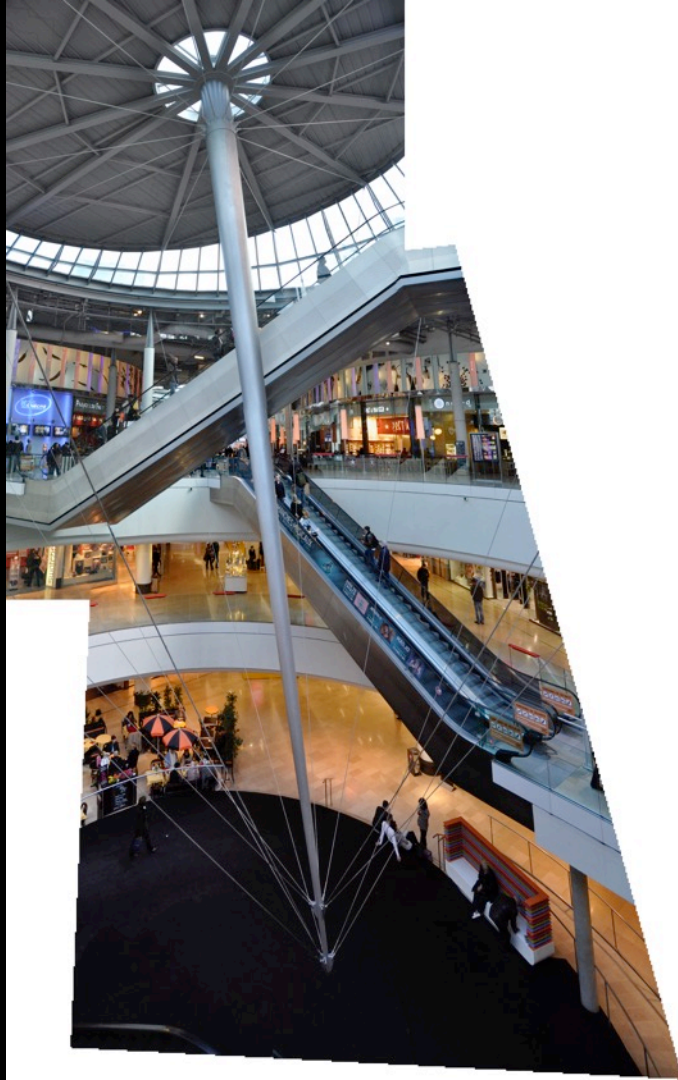
















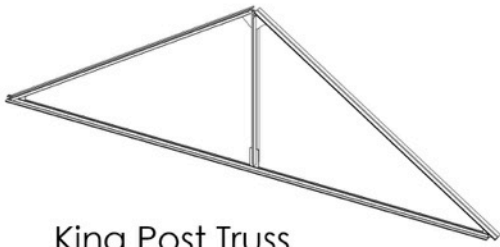




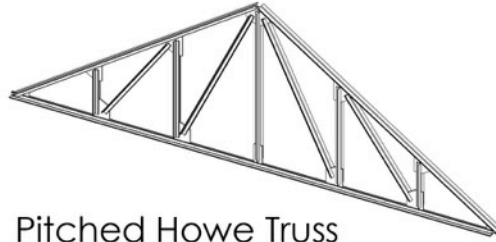




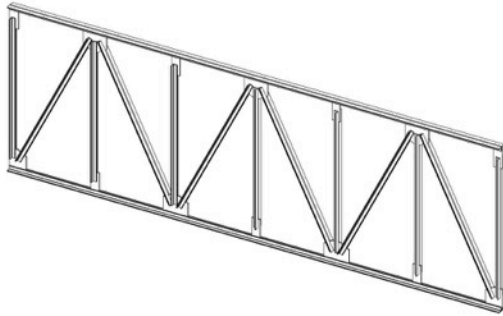
# PLANAR TRUSSES



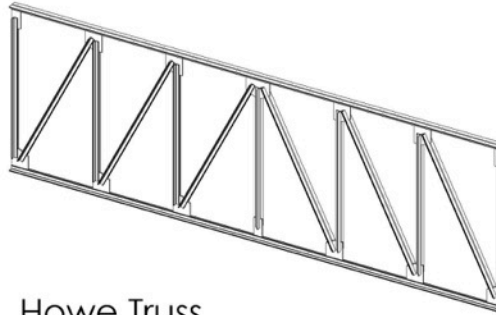
King Post Truss



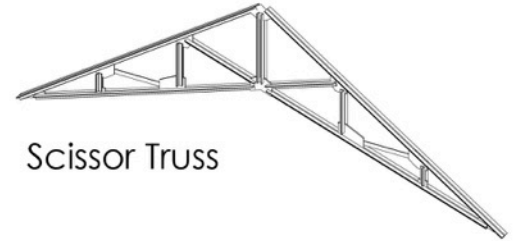
Pitched Howe Truss



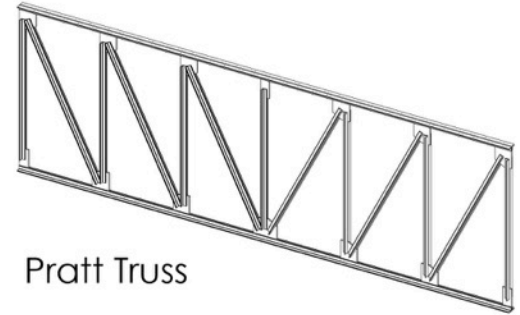
Modified Warren Truss



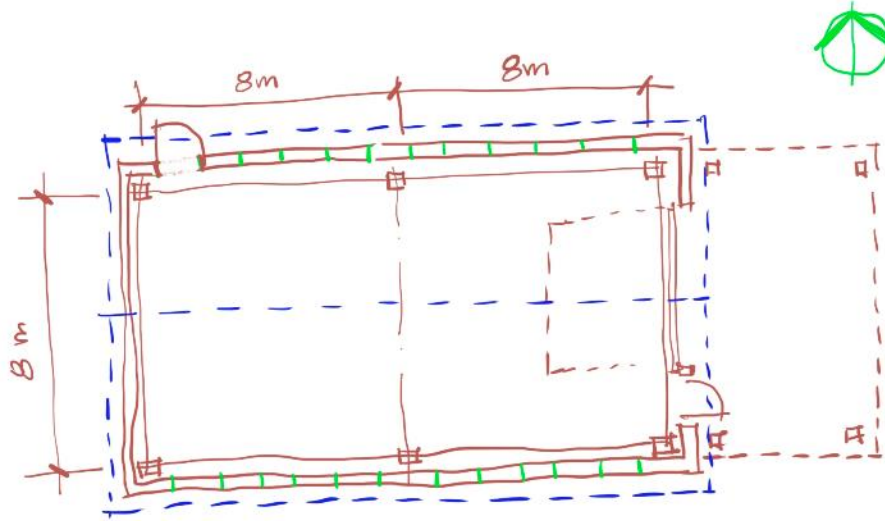
Howe Truss



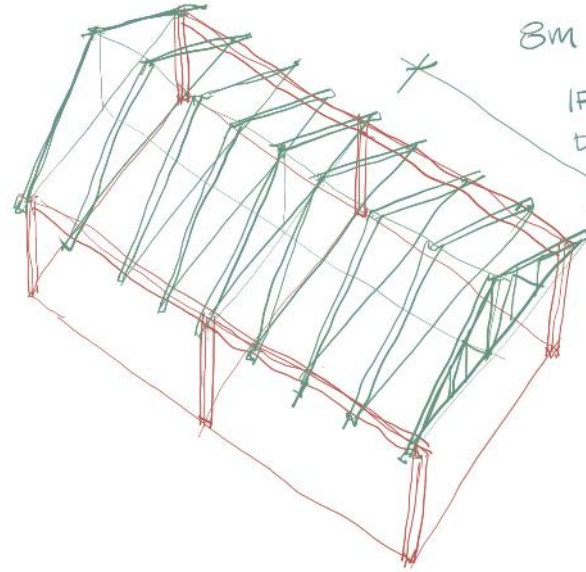
Scissor Truss



Pratt Truss



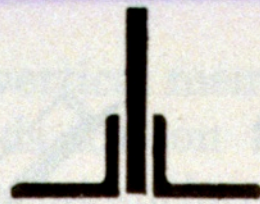
BASIC PLAN



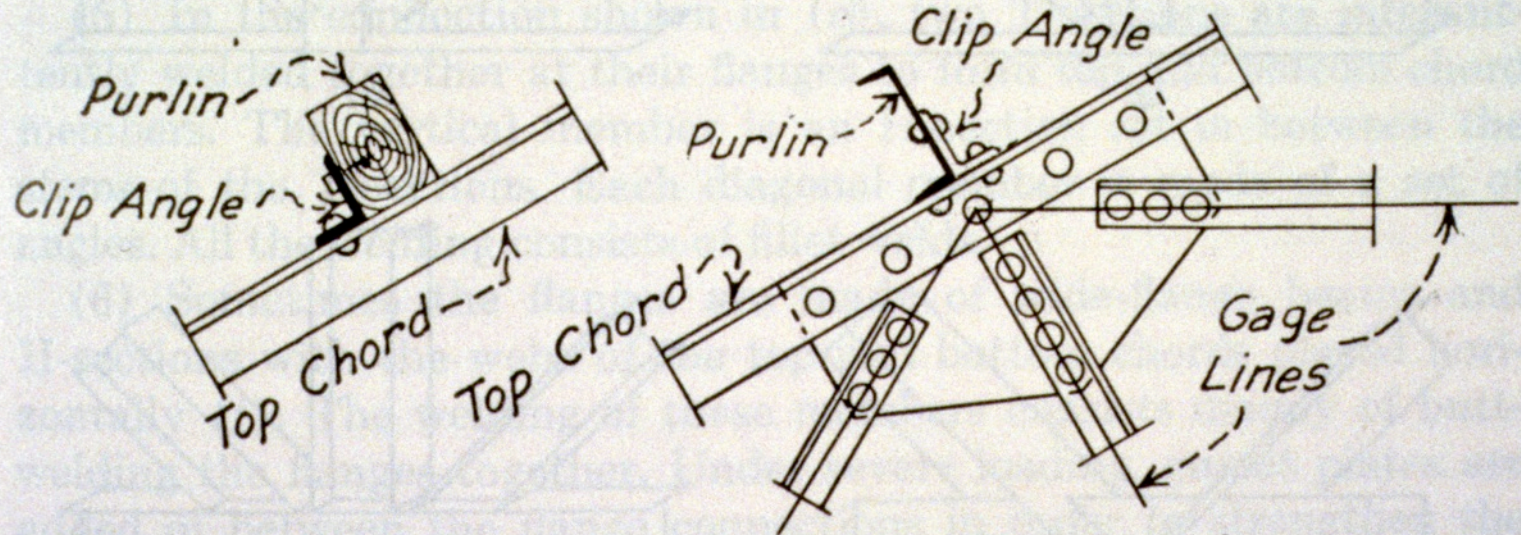
8m ÷ ?

IF 4, THEN ROOF  
DECK SPANS 2m





(a) Top Chord (b) Bottom Chord (c) Bottom Chord  
Sections for Members subjected to Bending Stress



(d) Method of Fastening Purlins to Top Chord

FIGURE 6.17 Simple steel roof truss details.



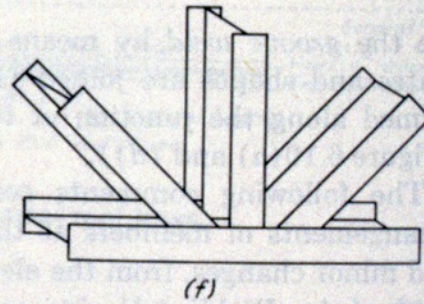
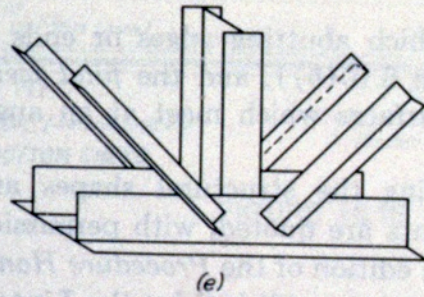
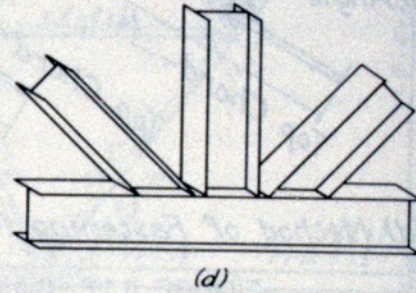
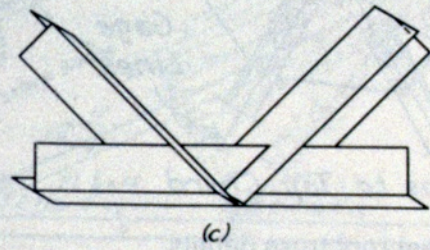
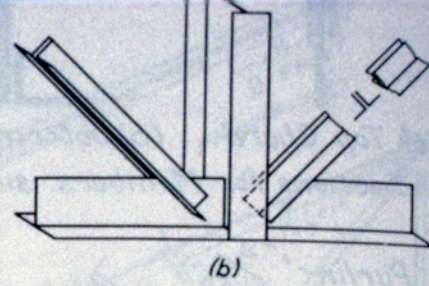
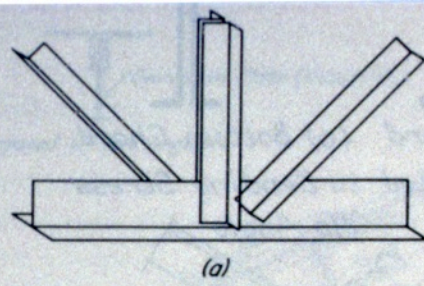
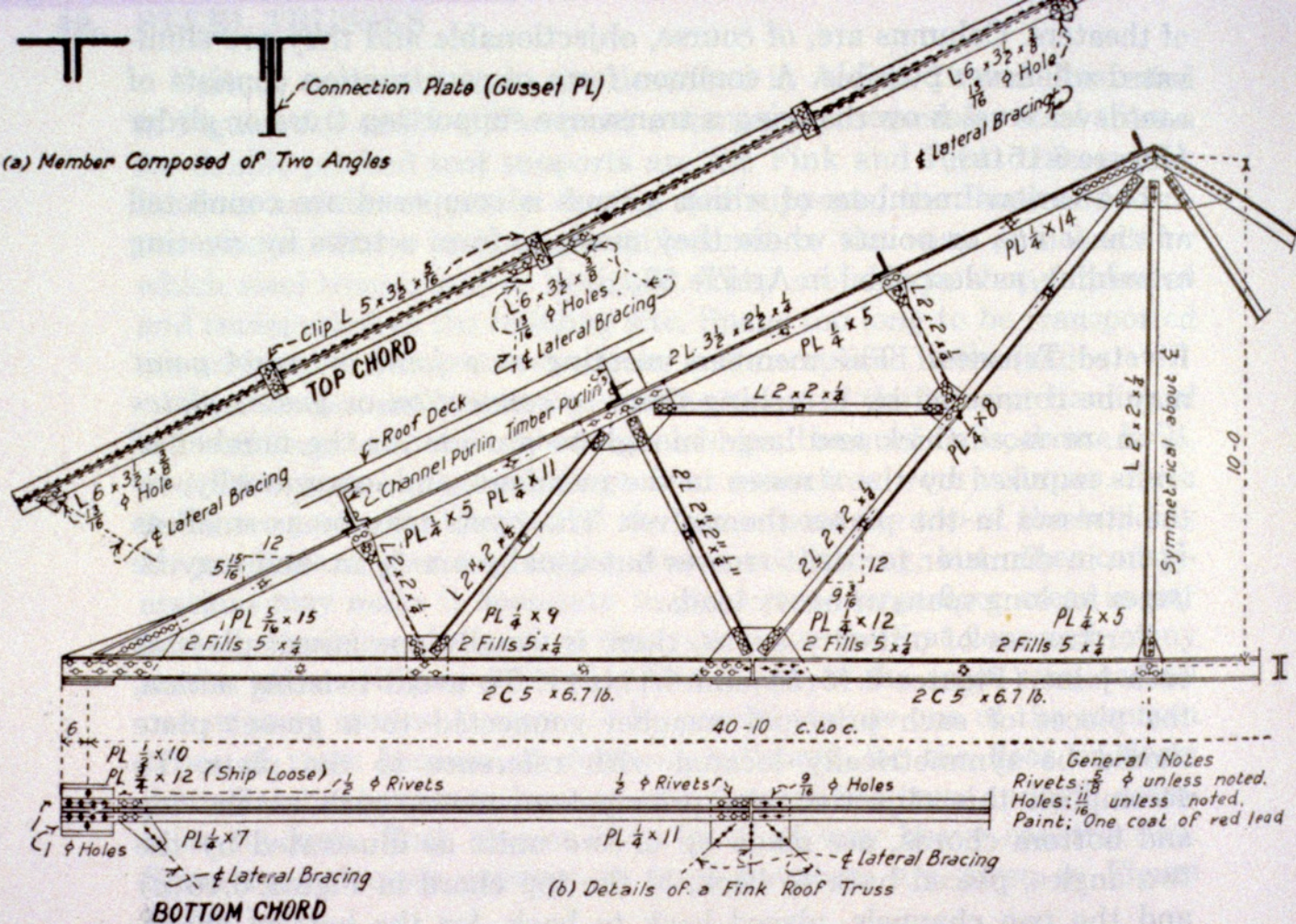


FIGURE 6.18 Connections for simple welded trusses. Lincoln Electric Company.





(a) Member Composed of Two Angles



General Notes  
 Rivets:  $\frac{5}{8}$   $\phi$  unless noted.  
 Holes:  $\frac{11}{16}$  unless noted.  
 Paint; One coat of red lead

(b) Details of a Fink Roof Truss

FIGURE 16.16 Fink steel roof truss.





ELEVATOR

ELEVATOR  
BAGGAGE



























The New School,  
NYC













ONE WAY

114 570 Lbs / 57285 + on  
A Dec 192011

CLOSE



POST NO  
BILLS













































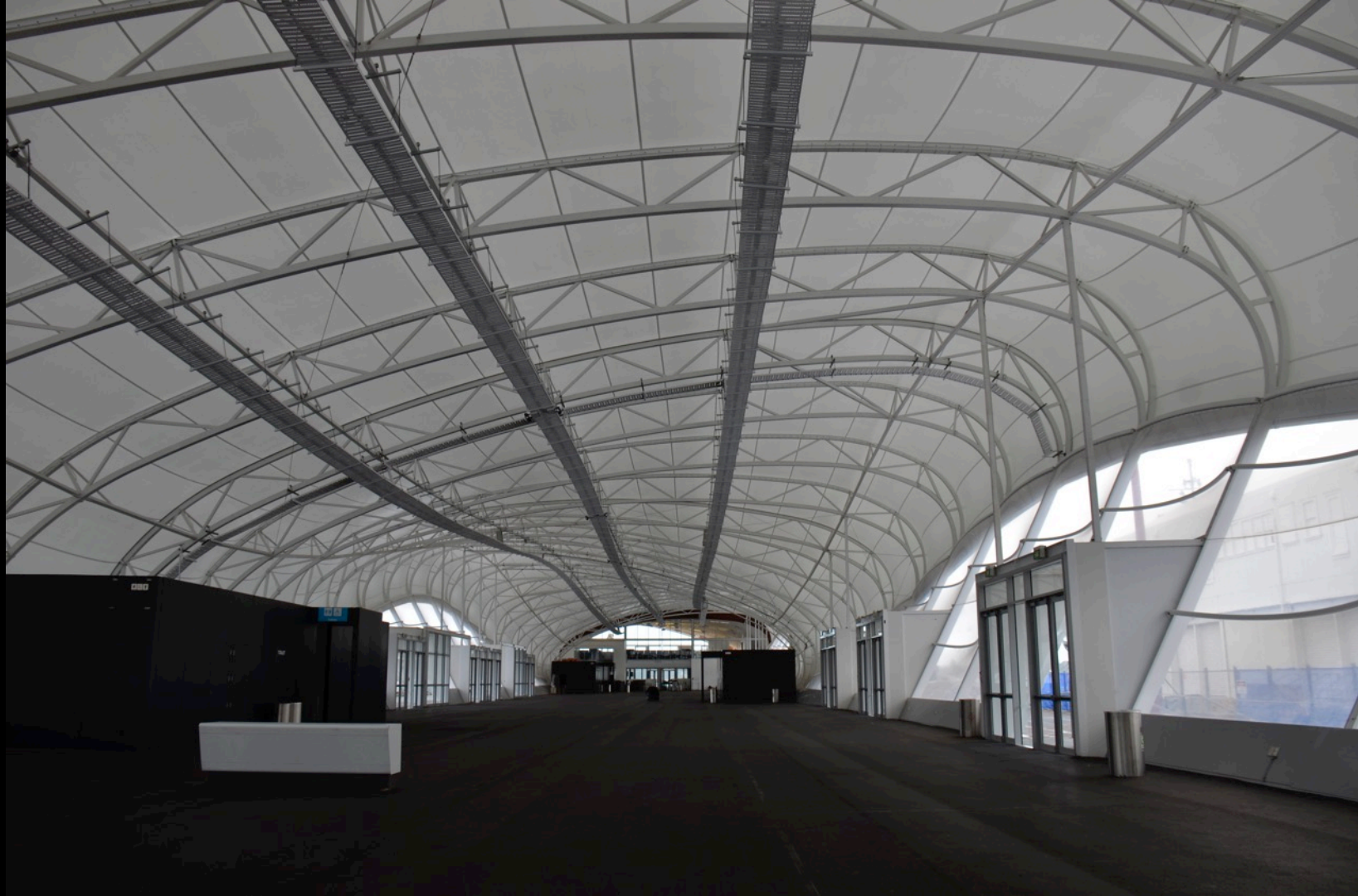




The Cloud  
Auckland, NZ













Les Ailes Shopping Centre  
Montreal, QC





★ War Museum  
Ottawa, ON












The image shows the exterior of the Calgary Water building, a modern architectural structure. The building features a large, curved, arched glass facade that reflects the sky and surrounding environment. A prominent vertical column supports the structure. The building is surrounded by a paved walkway, a parking area with a red motorcycle, and landscaped areas with mulch and young trees. The sky is blue with scattered white clouds.

Calgary Water  
Calgary, AB







# Box Truss







Sainsbury Centre  
England

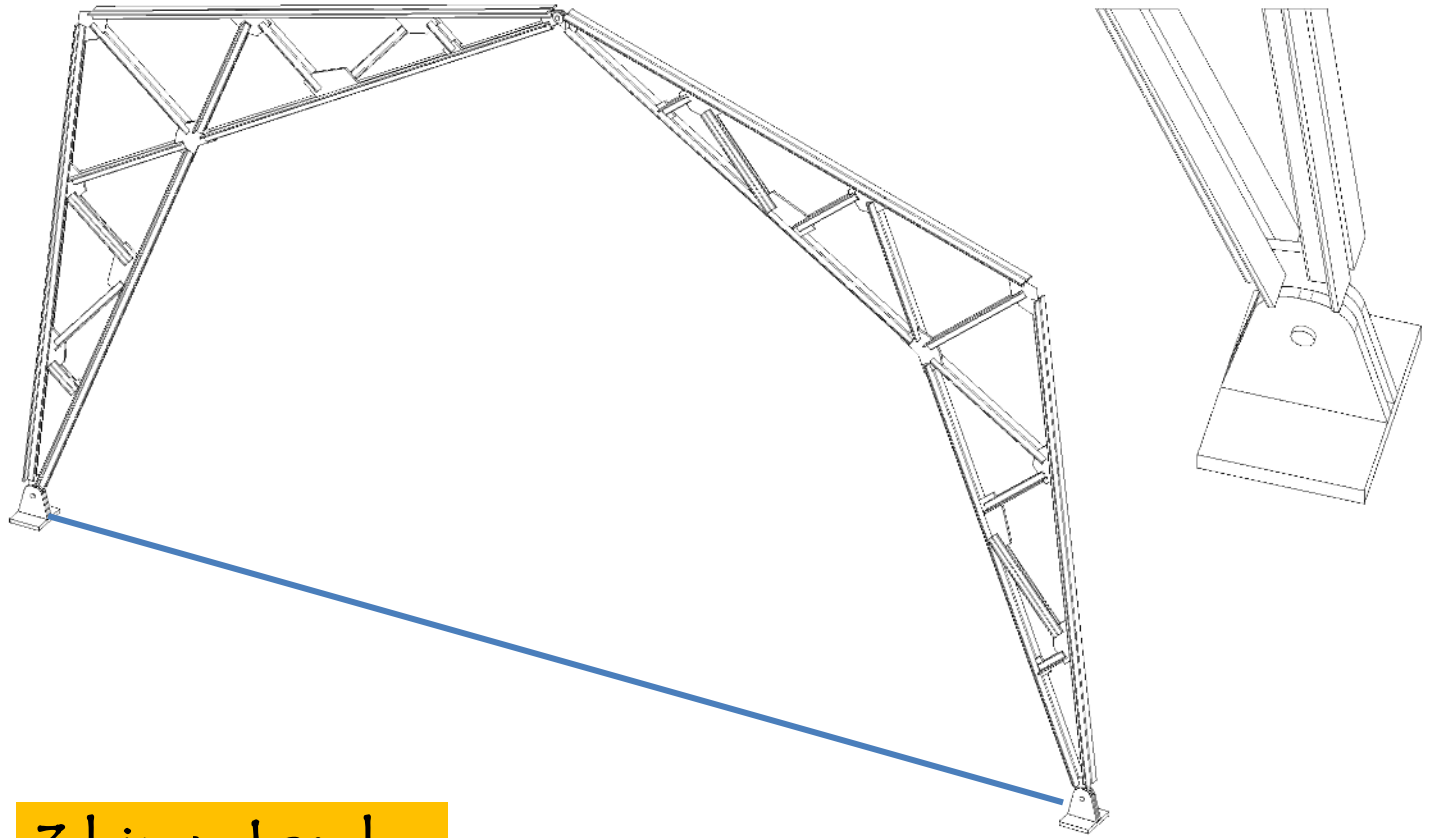


Triangular Truss









3 hinged arch











# Rigid Frames

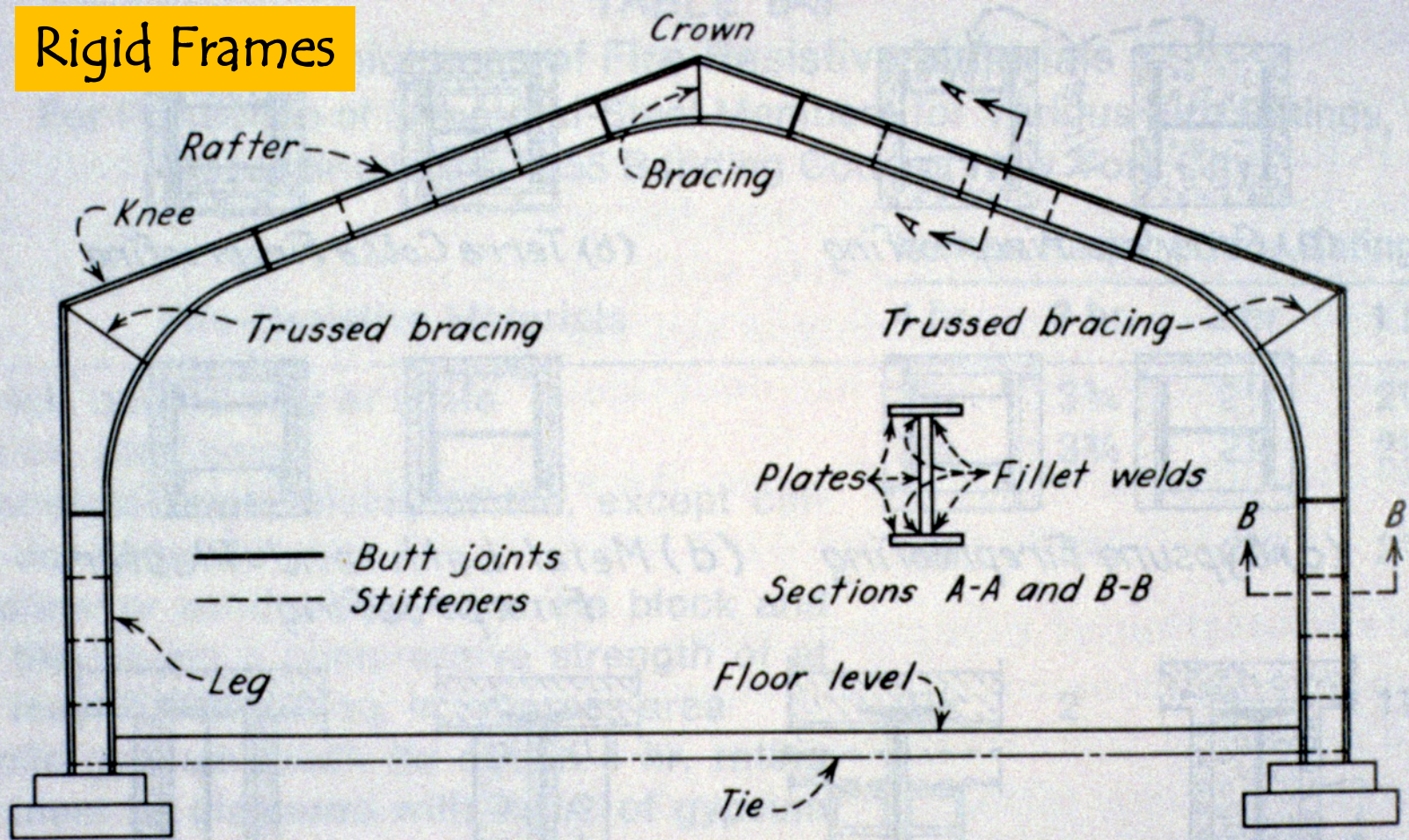


FIGURE 6.32 Steel rigid frame.



Friedrichstrasse Station  
Berlin, Germany



BIOSPHERE  
POTSDAM

30.08.10.08.30.08.10  
VON SAURIERN UND  
SABELZÄHNIGERN



←	Westkreuz Potsdam Hbf Berlin-Spandau Berlin-Spandau	→
	Strausberg Nord Arenshöhe Erfurt Wartenberg	



U

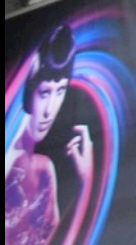


Advertisement for a show featuring a woman in a purple outfit.





FRIEDRICHSTADT PALAS  
Europas größter und modernster Show-Palast



Yma ZU SCHÖN,  
UM WAHR ZU SEIN  
Previews ab 21. August | Weltpremiere 2. September  
friedrichstadtpalast.de | Tickets: 030 - 2326 2326



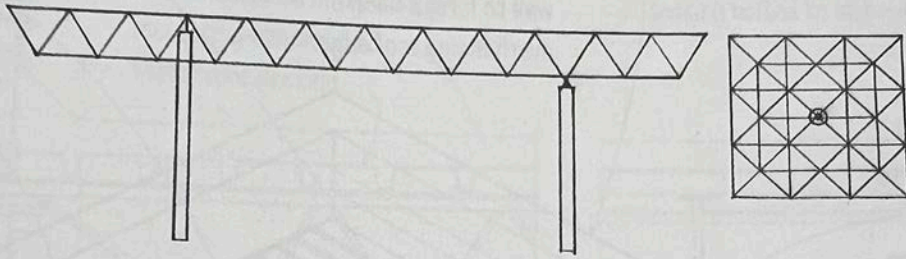


## Space Frames

A space frame is a lightweight, rigid, 3-D structure that's made up of interlocking struts in a geometric pattern. Space frames are used in architecture and structural engineering to create large areas with few interior supports. They are often used in buildings such as stadiums, airports, exhibition halls, and swimming pools.

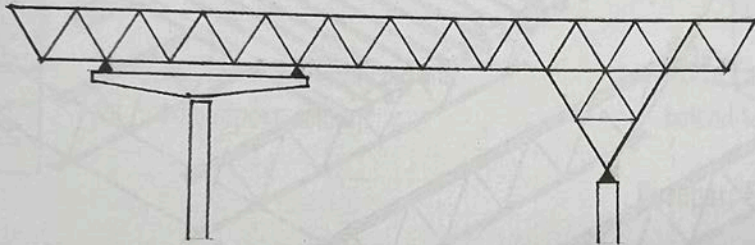
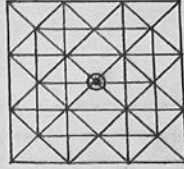


Expo 86 Vancouver



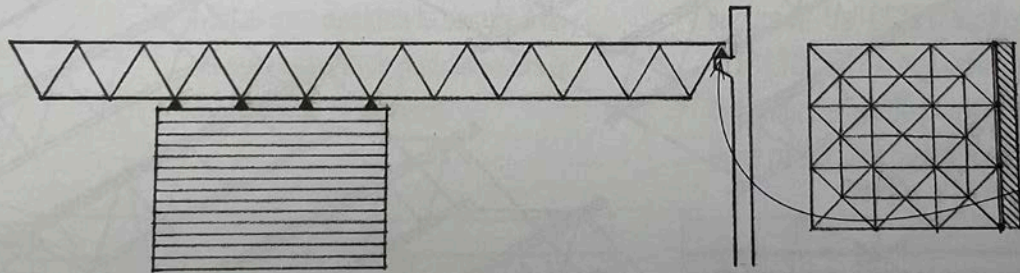
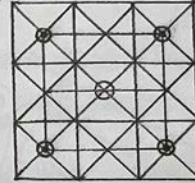
• Top-chord supported

• Bottom-chord supported



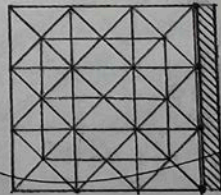
• Four-point cruciform

• Frame capital



• Interior wall

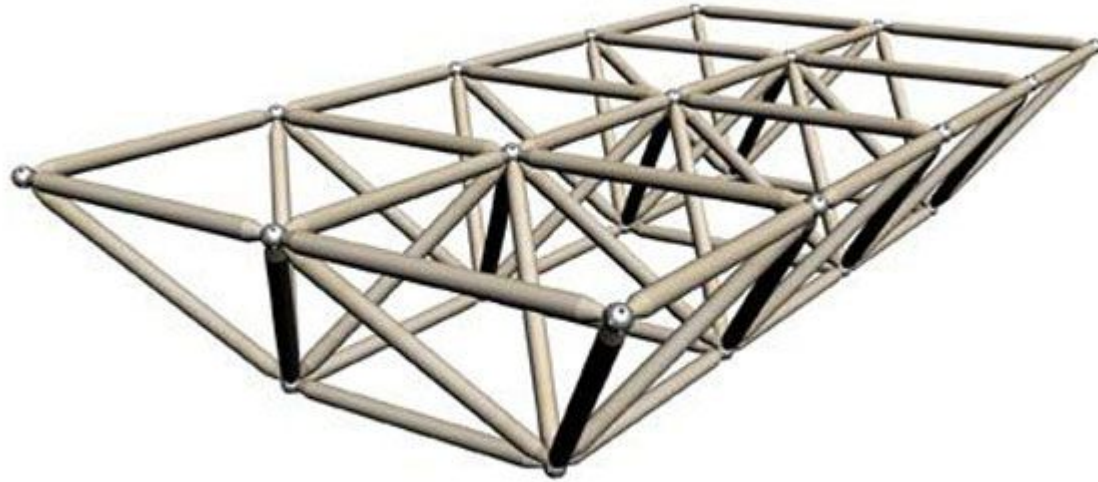
• Exterior wall



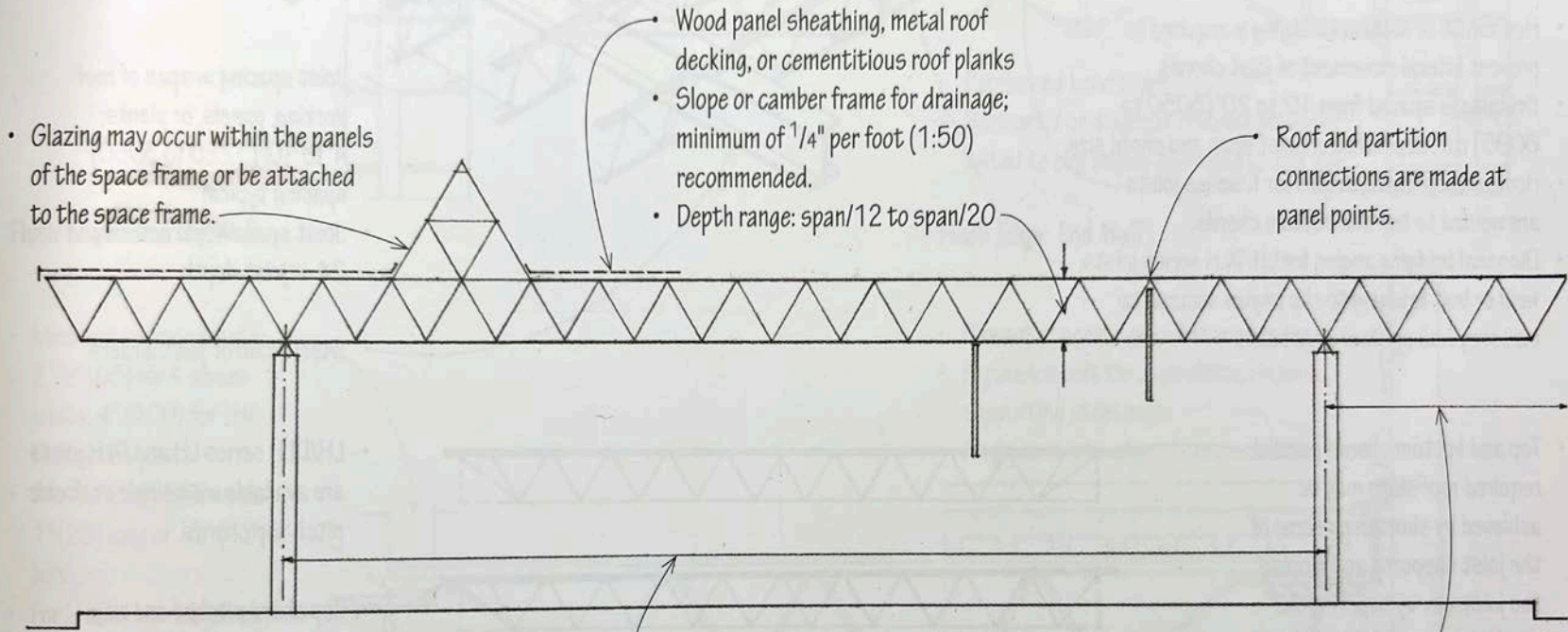
The space frame is ALWAYS supported on its NODES and NEVER supported in the middle of a member.

Trusses and space frames rely on pure axial loading (members in tension or compression) so no bending ever.





Space frames span in all directions equally, unlike other steel systems that span in a single direction – across a space.



- Glazing may occur within the panels of the space frame or be attached to the space frame.

- Wood panel sheathing, metal roof decking, or cementitious roof planks
- Slope or camber frame for drainage; minimum of  $\frac{1}{4}$ " per foot (1:50) recommended.
- Depth range:  $\text{span}/12$  to  $\text{span}/20$

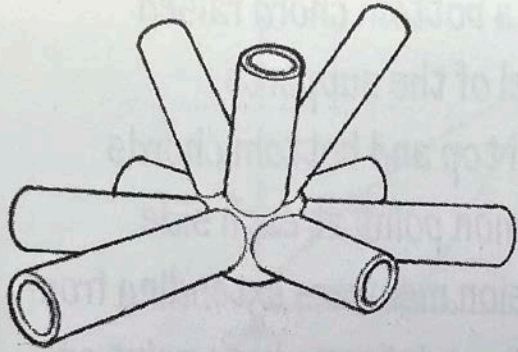
- Roof and partition connections are made at panel points.

- Mechanical services such as piping, conduit, and ductwork may pass through the web spaces.
- Noncombustible steel construction may be left exposed if at least 20' (6095) above the finish floor; consult the building code for requirements.

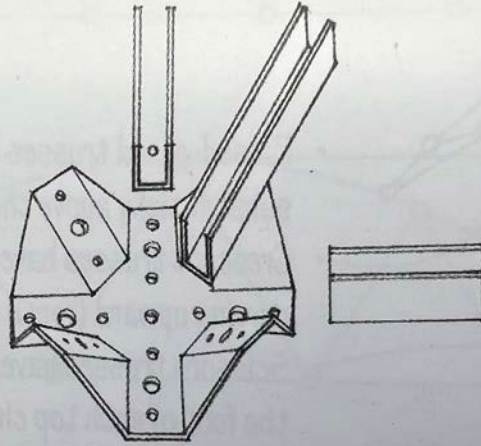
- Span: 6 to 36 modules
- Span range for column-supported space frames: 30' to 80' (9 to 24 m)
- Span range for wall-supported space frames: 30' to 130' (9 to 39 m)

- Overhangs: 15% to 30% of span

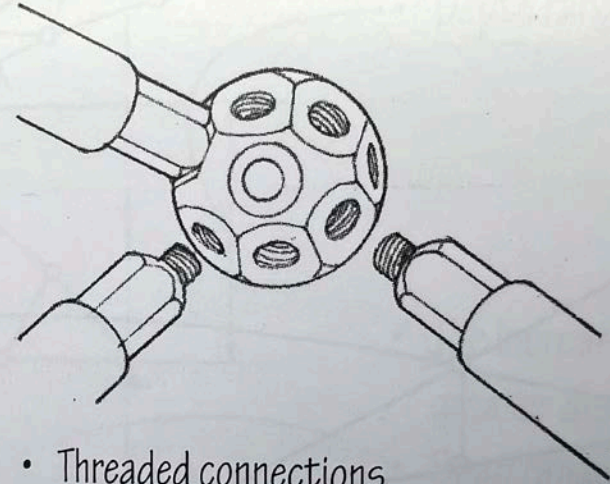




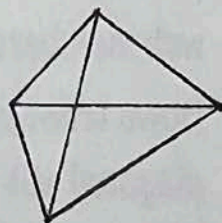
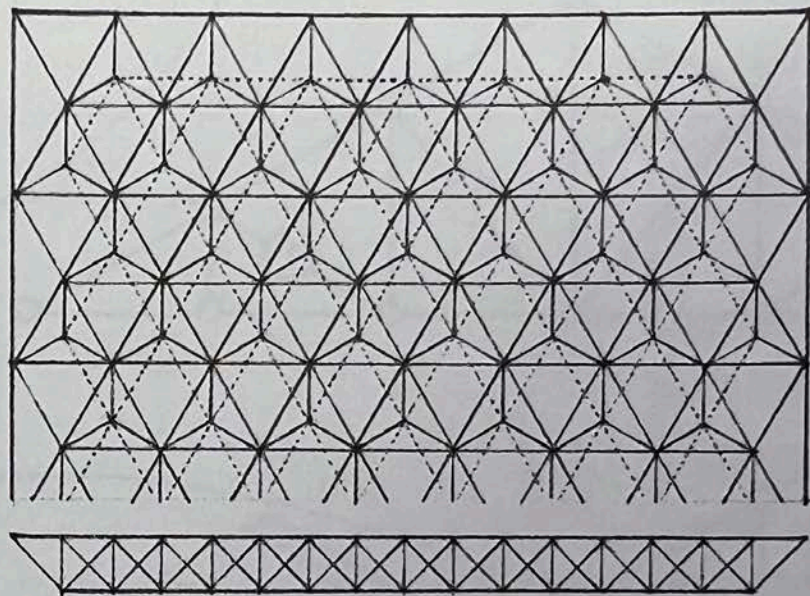
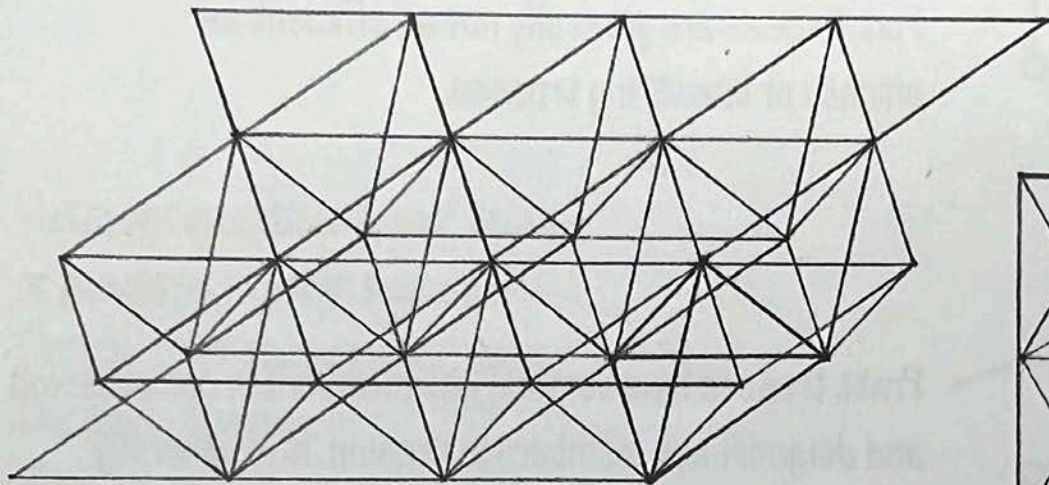
- Welded connection



- Bolted connection

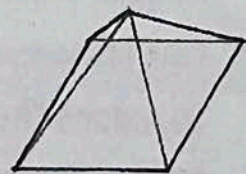
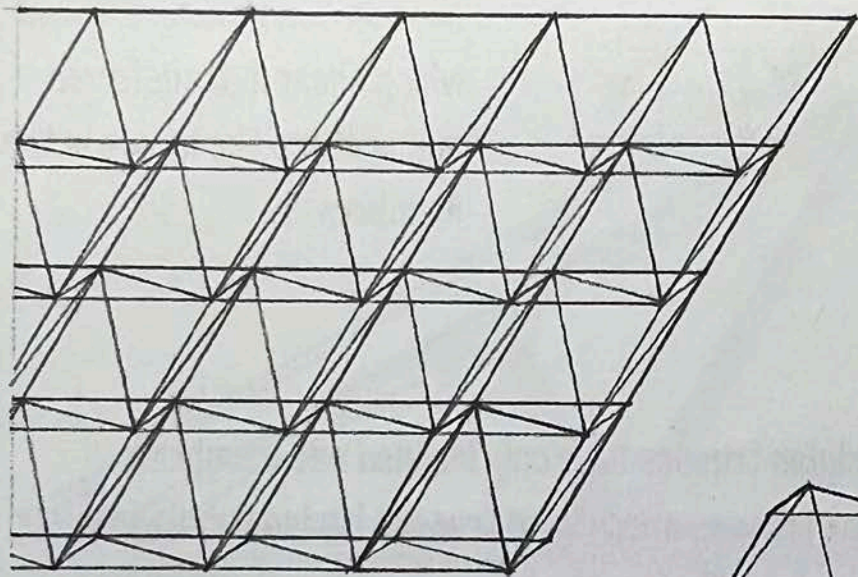


- Threaded connections

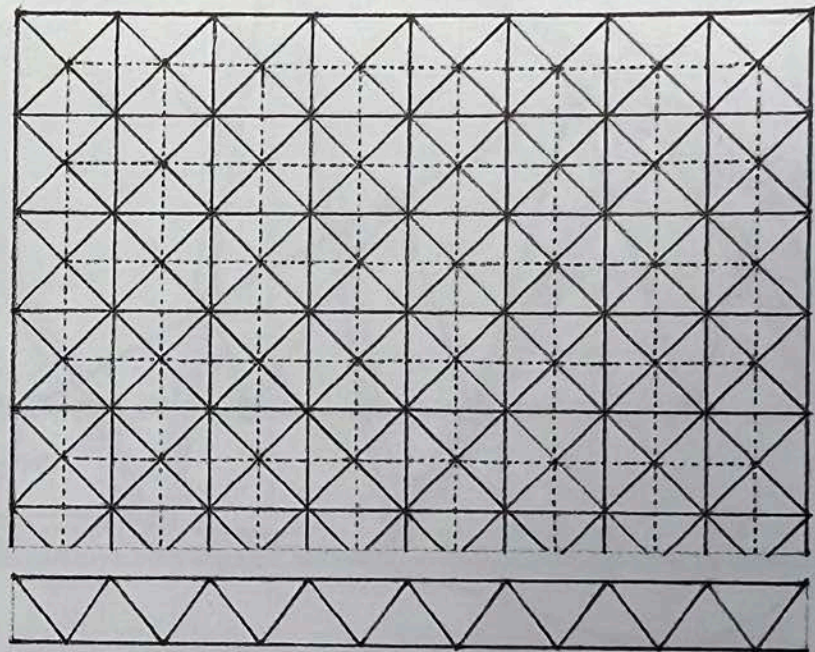


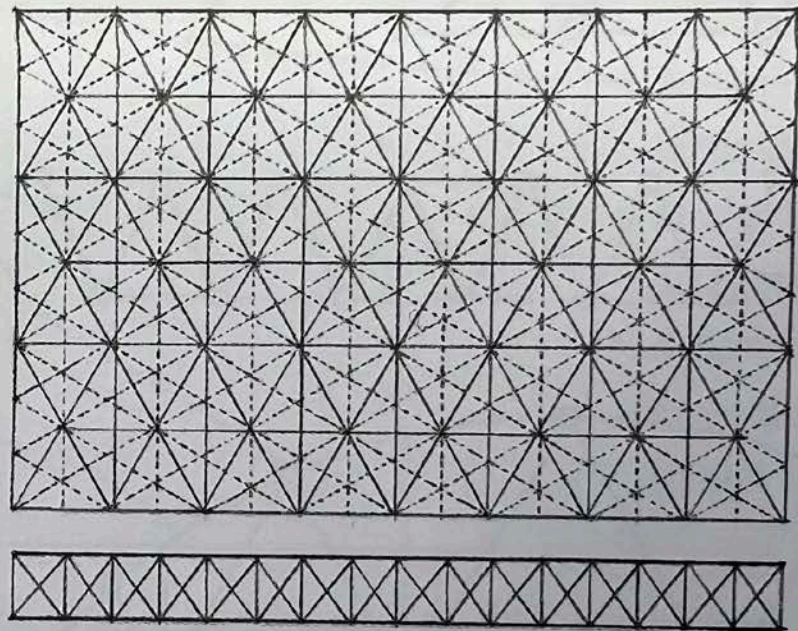
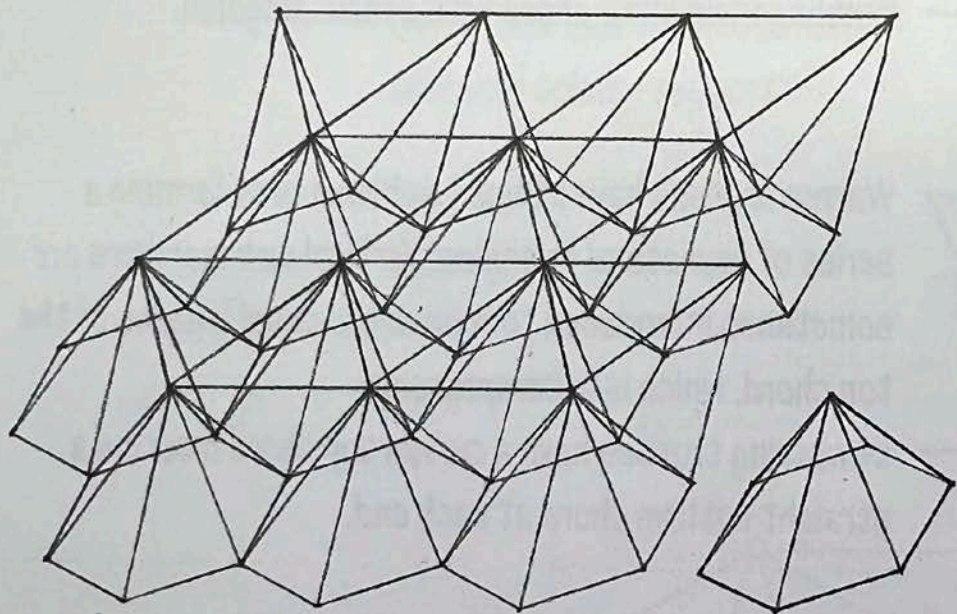
Triangular Grid





Square Grid



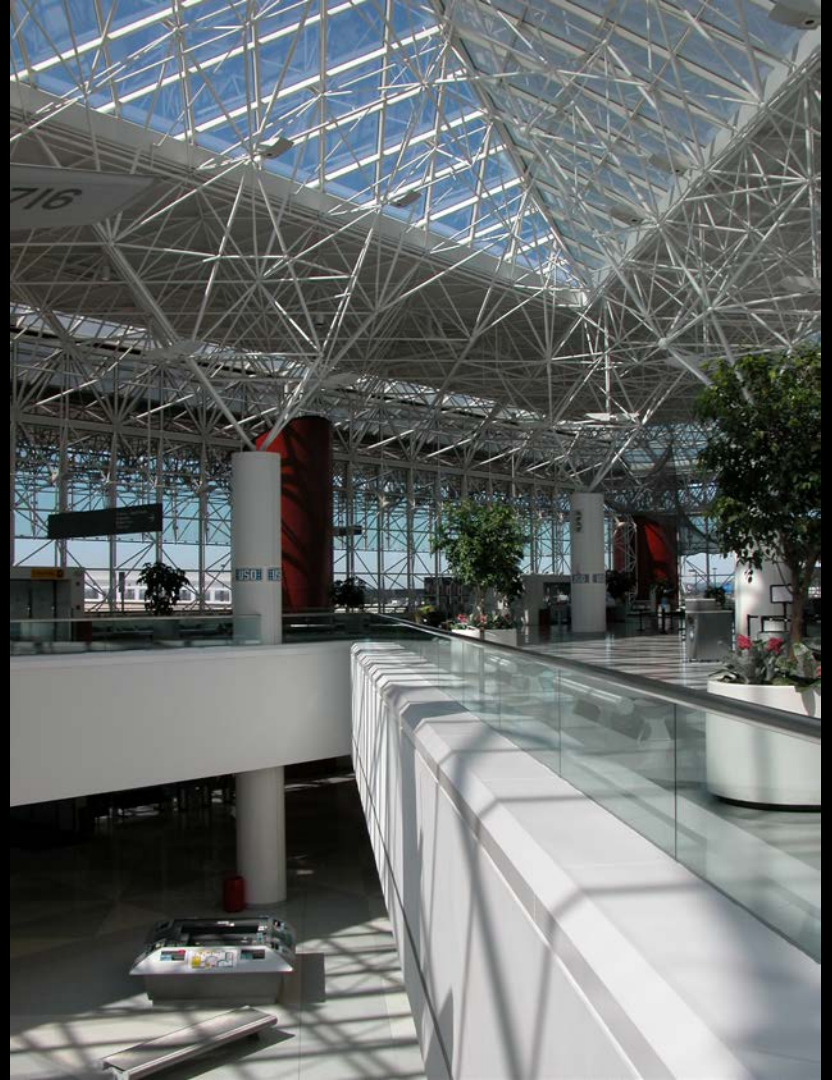


Hexagonal Grid





Baltimore Washington International Airport









Ferrari World, Abu Dhabi













Photo: Iwan Baan

## Zaha Hadid Heydar Aliyev Cultural Center

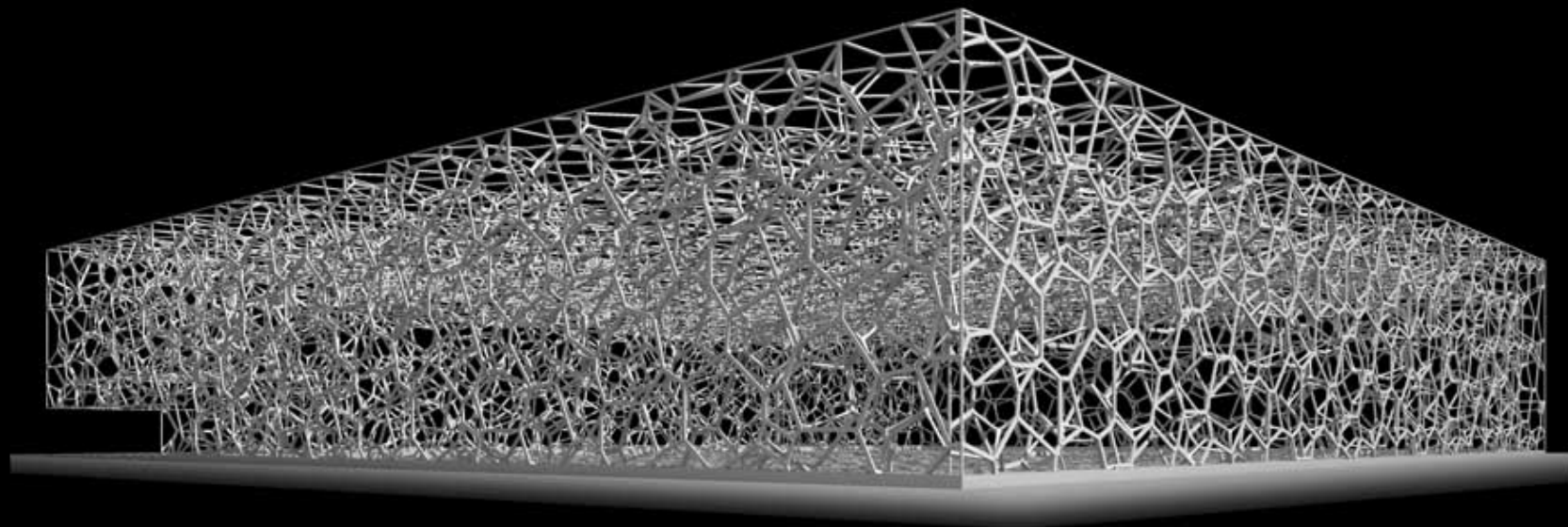


<http://buildipedia.com/aec-pros/from-the-job-site/zaha-hadids-heydar-aliyev-cultural-centre-turning-a-vision-into-reality>

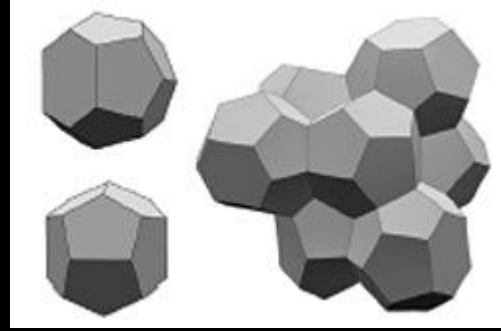
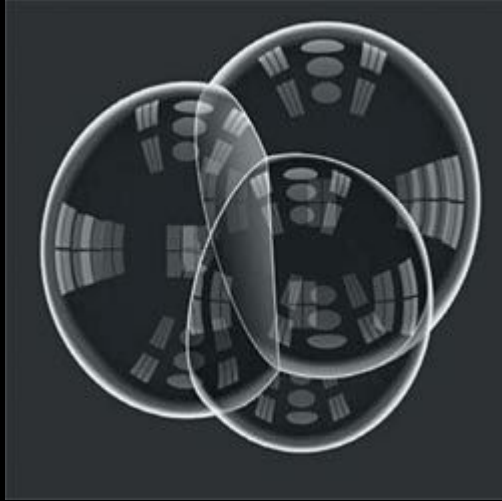




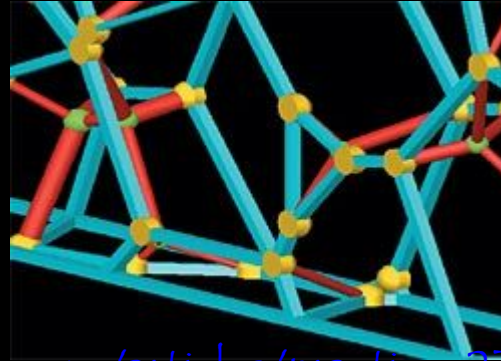
Water Cube, Beijing







Structure of Weaire Phelan foam



<https://architectureau.com/articles/practice-23/>







More Detailed Case Studies





'skydome' AKA Rogers Centre  
Rod Robbie and Michael Allen  
1987



















SCALE









4236 T ≤ 13









Museum of Civilization  
Ottawa/Hull  
Douglas Cardinal Architect  
1987





























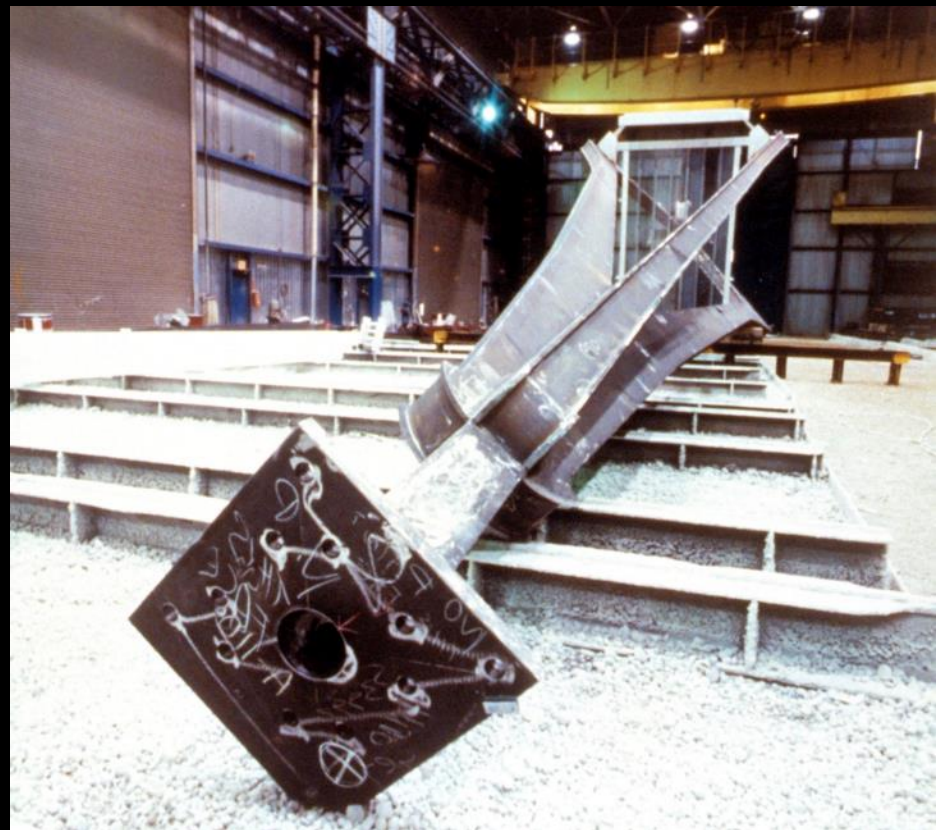
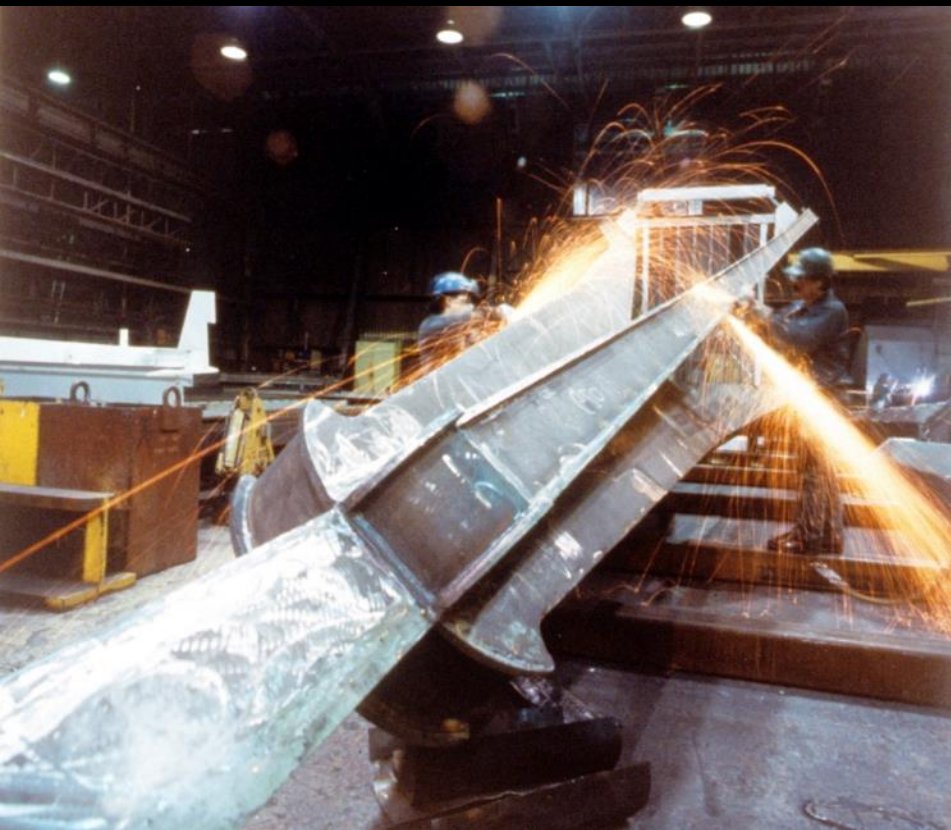
BCE – Brookfield – Place  
Toronto, ON  
Santiago Calatrava  
1992









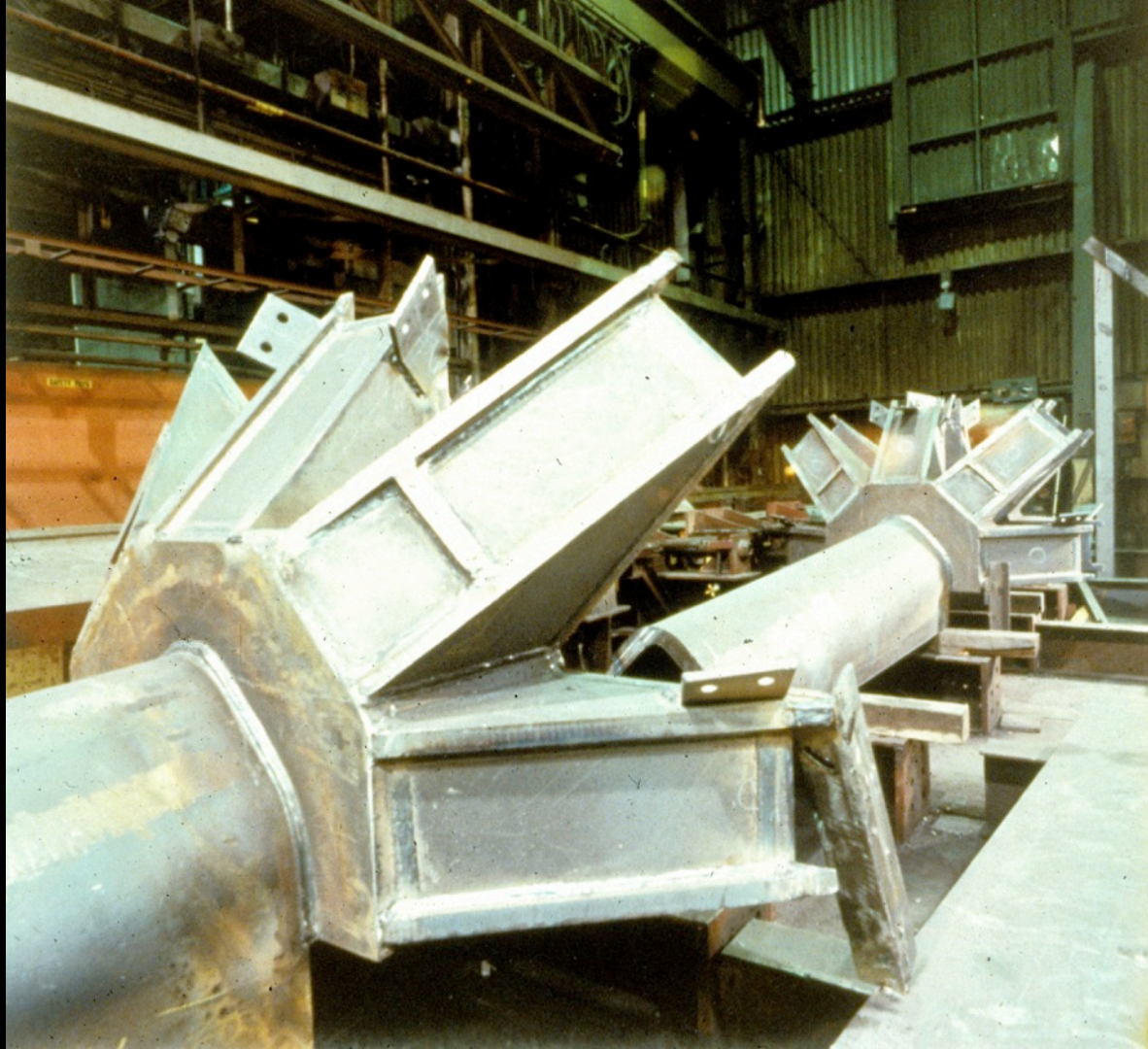






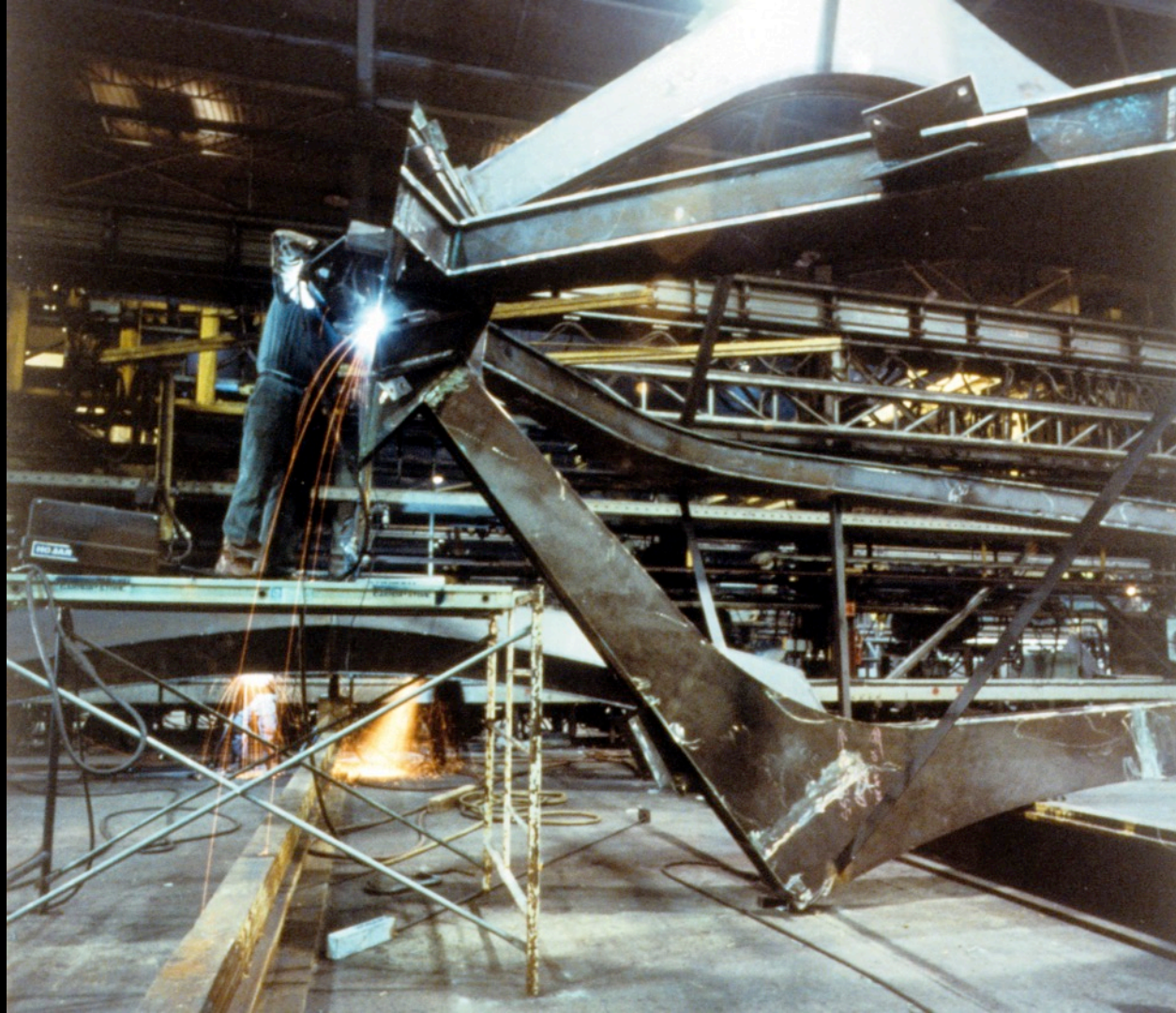


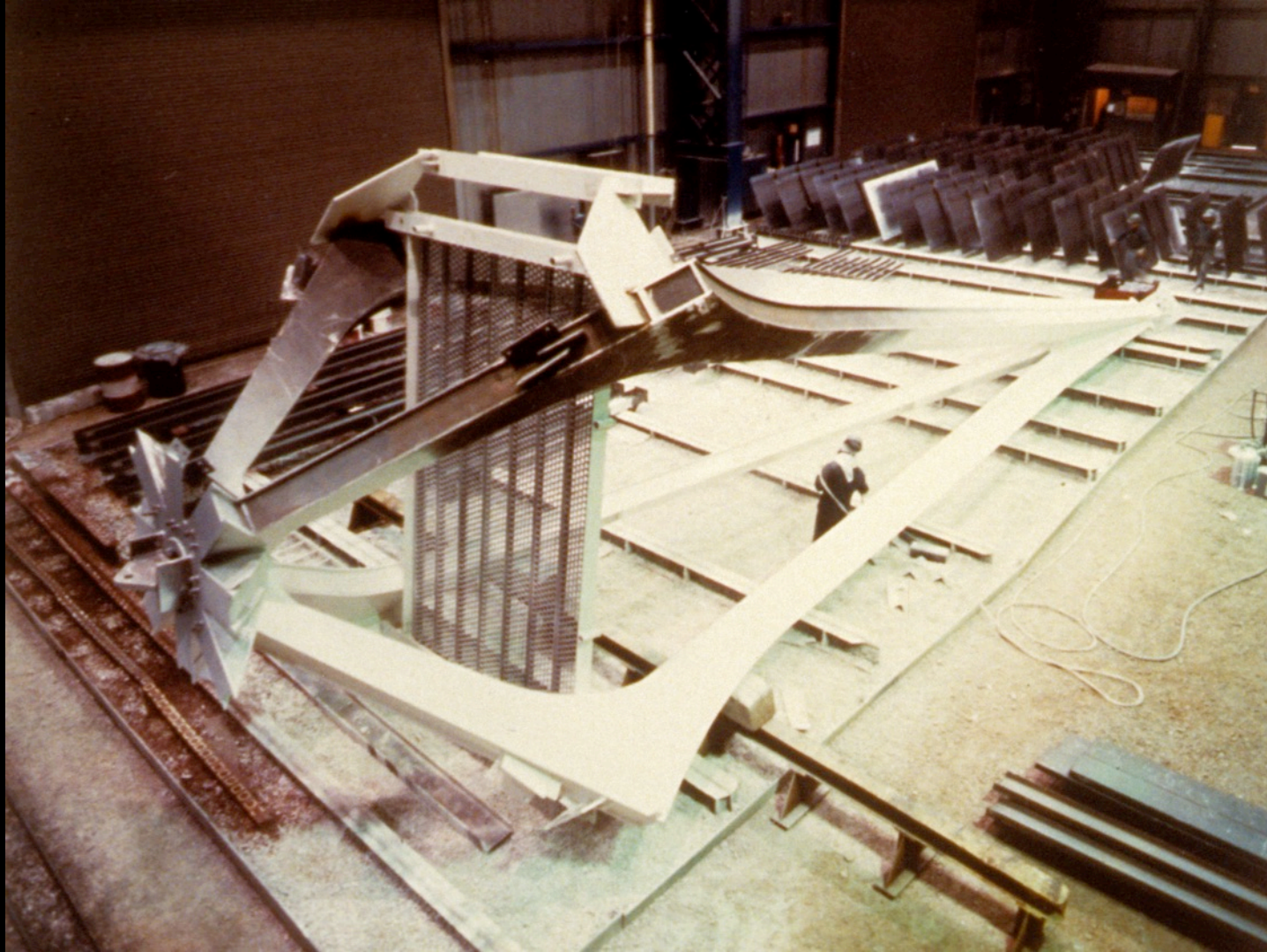




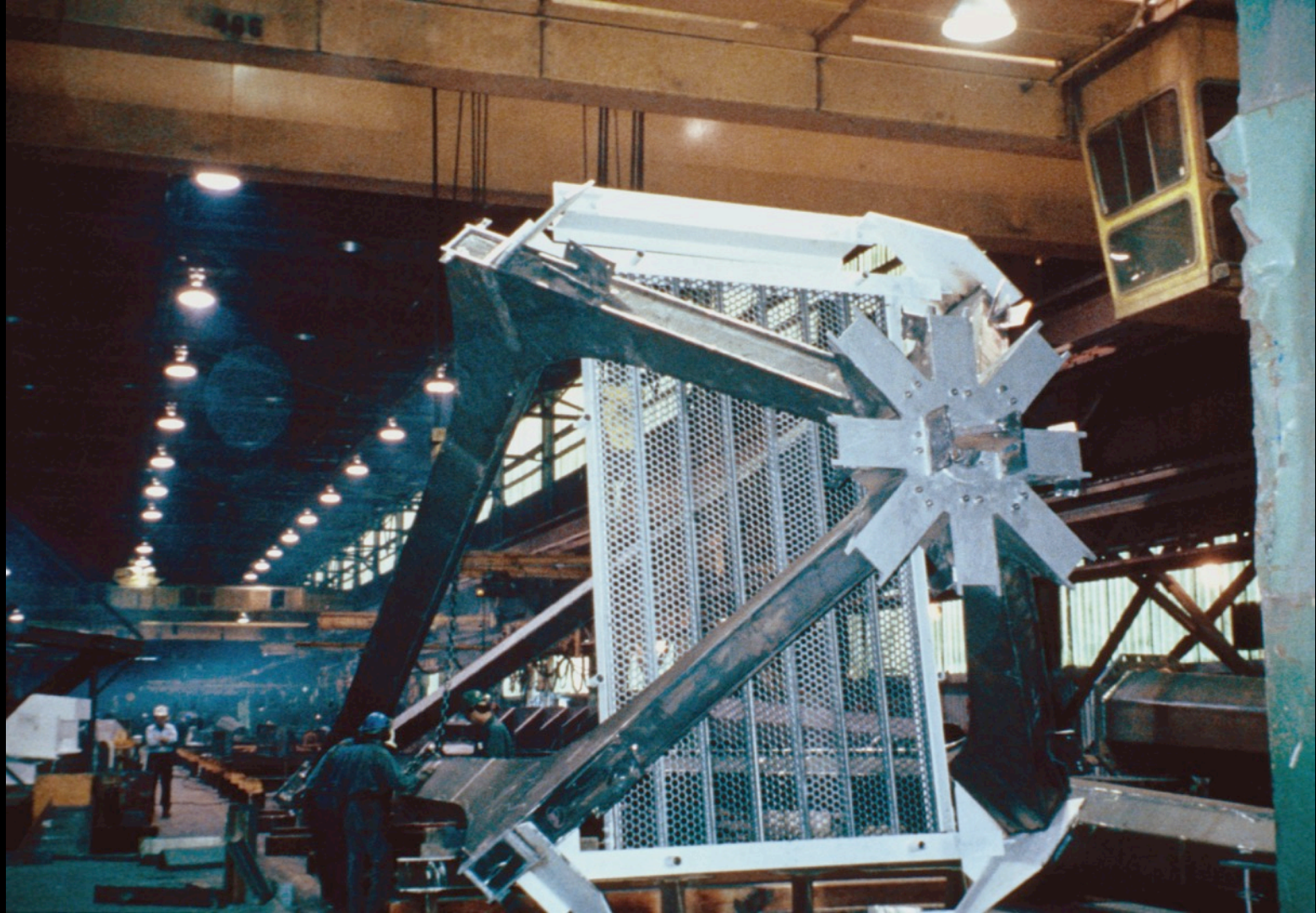






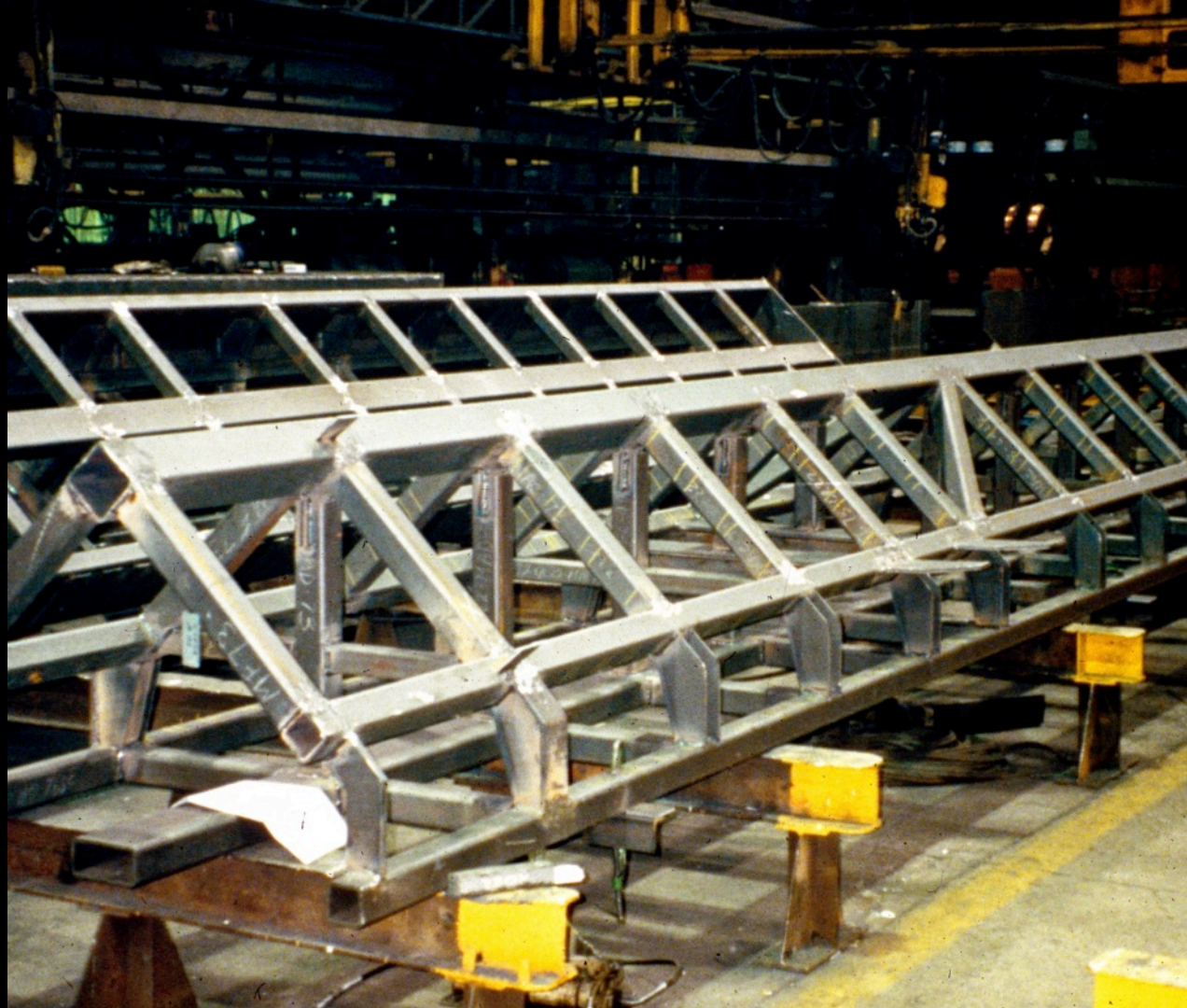


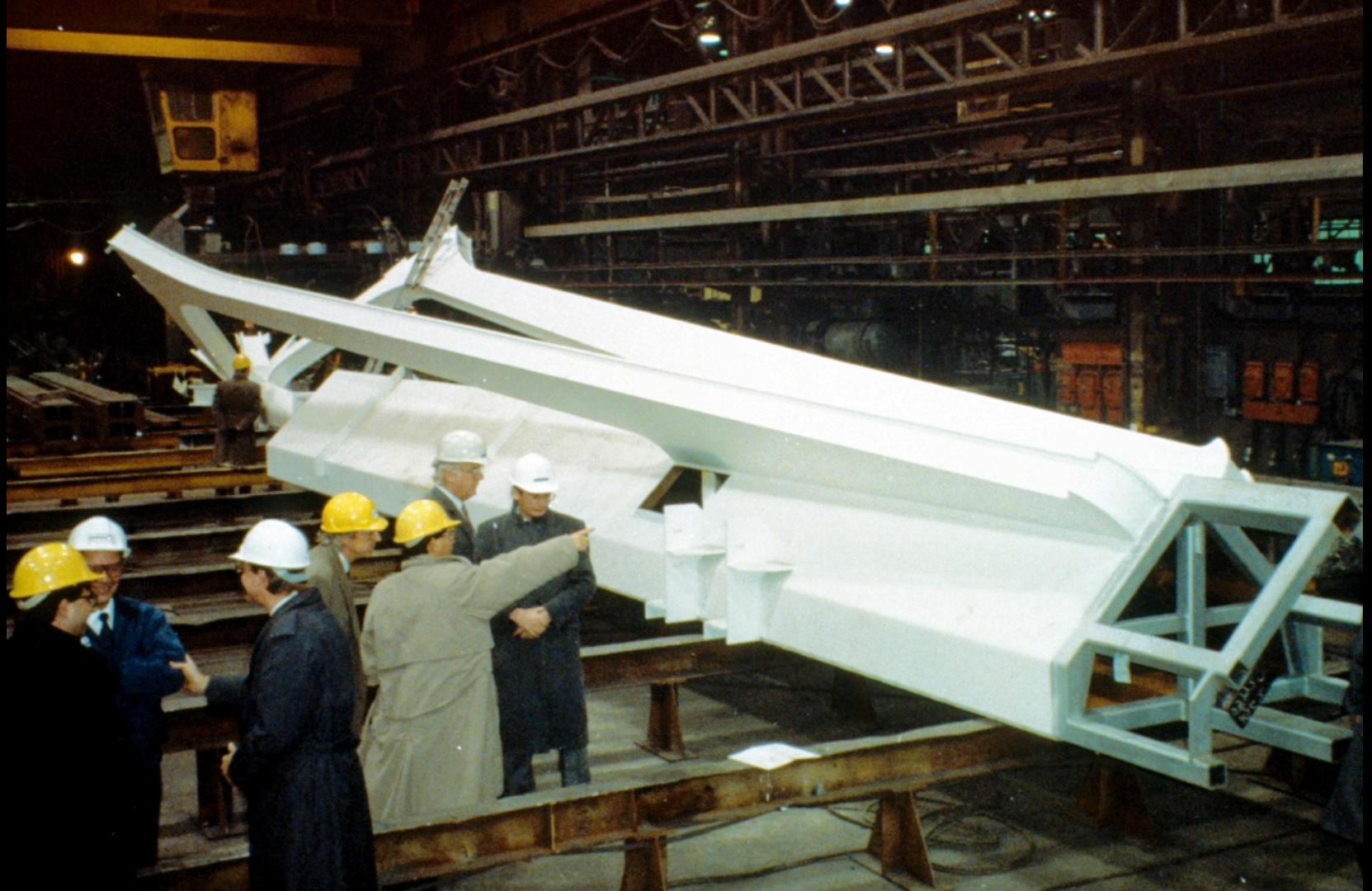










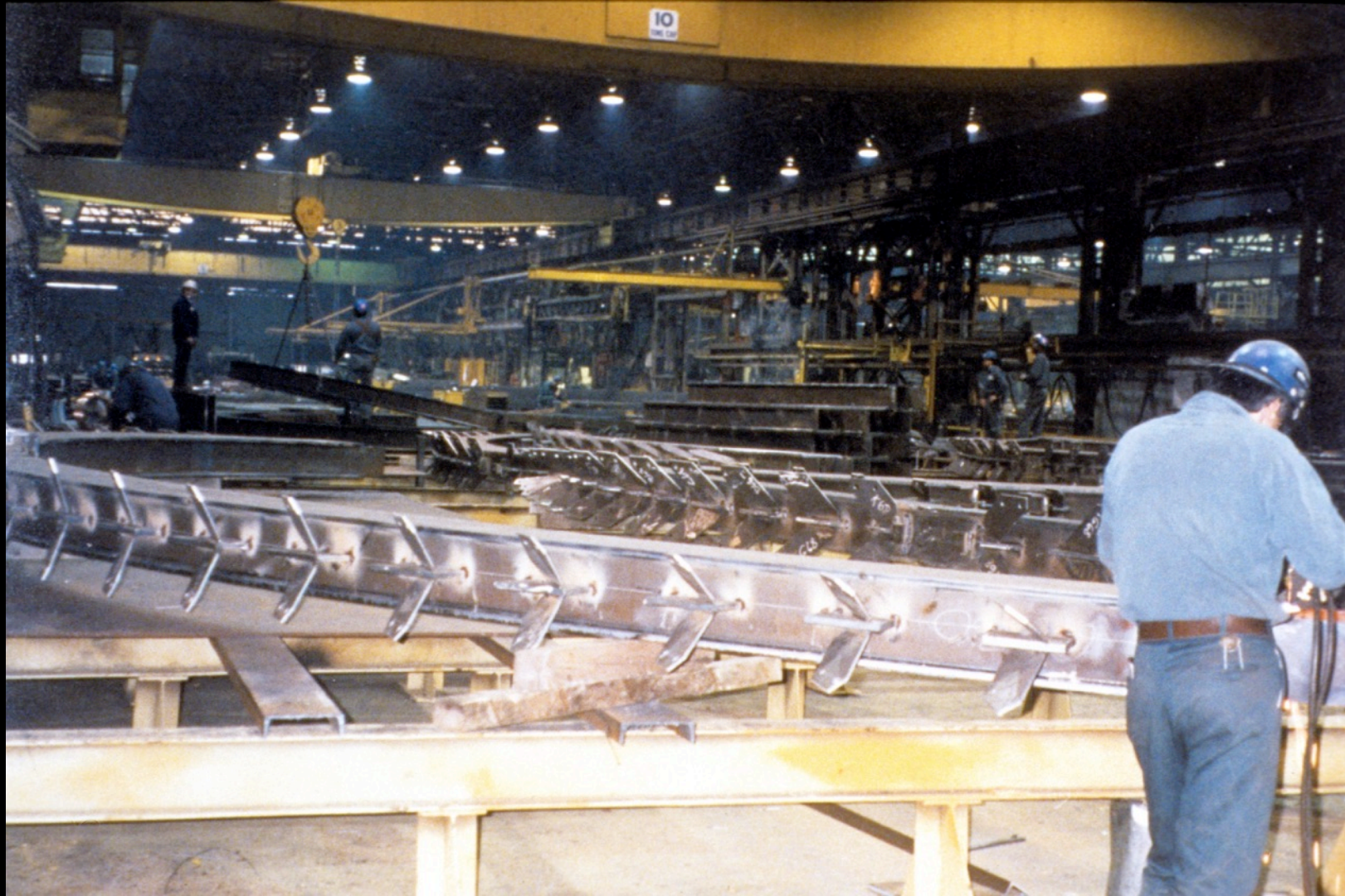
















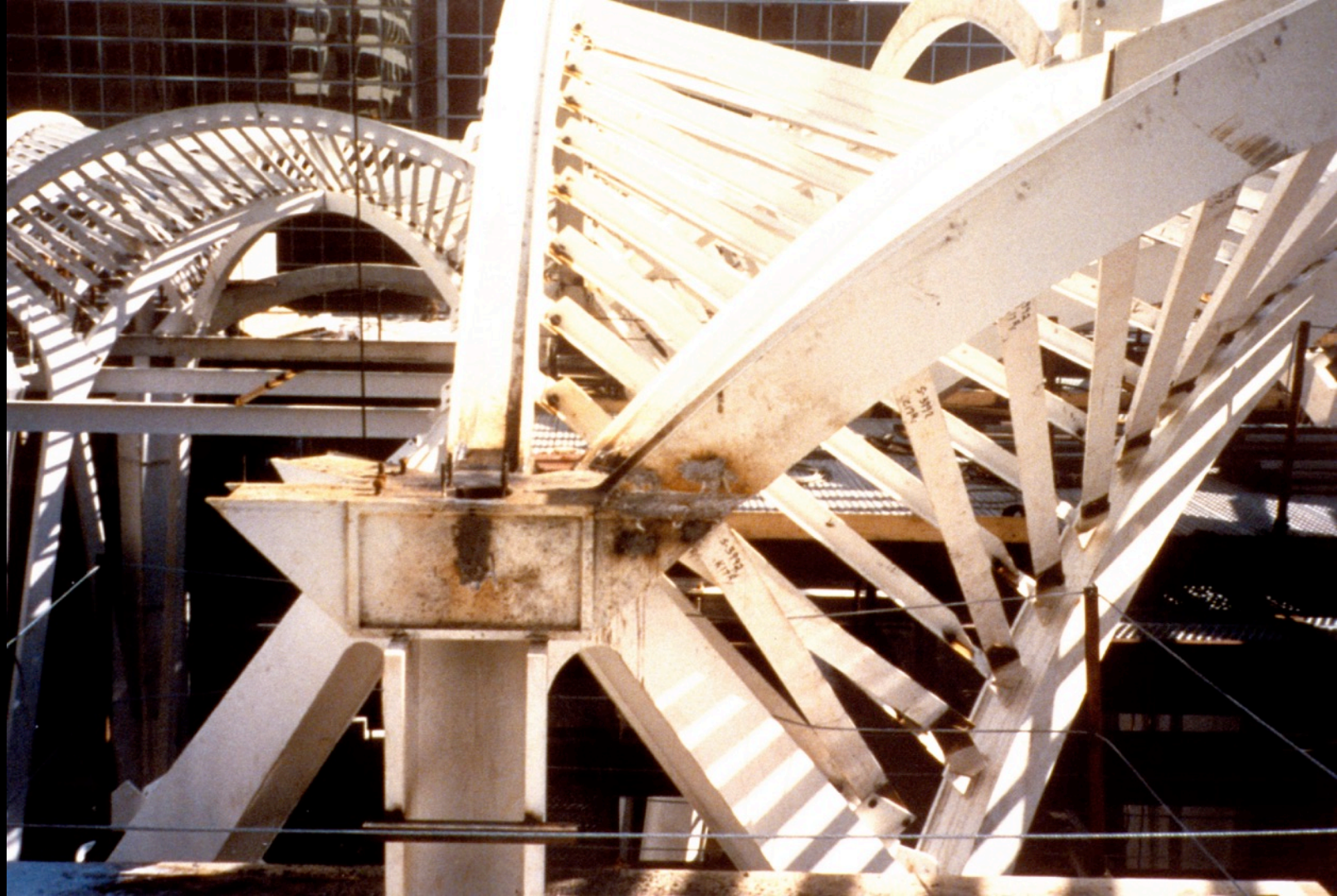








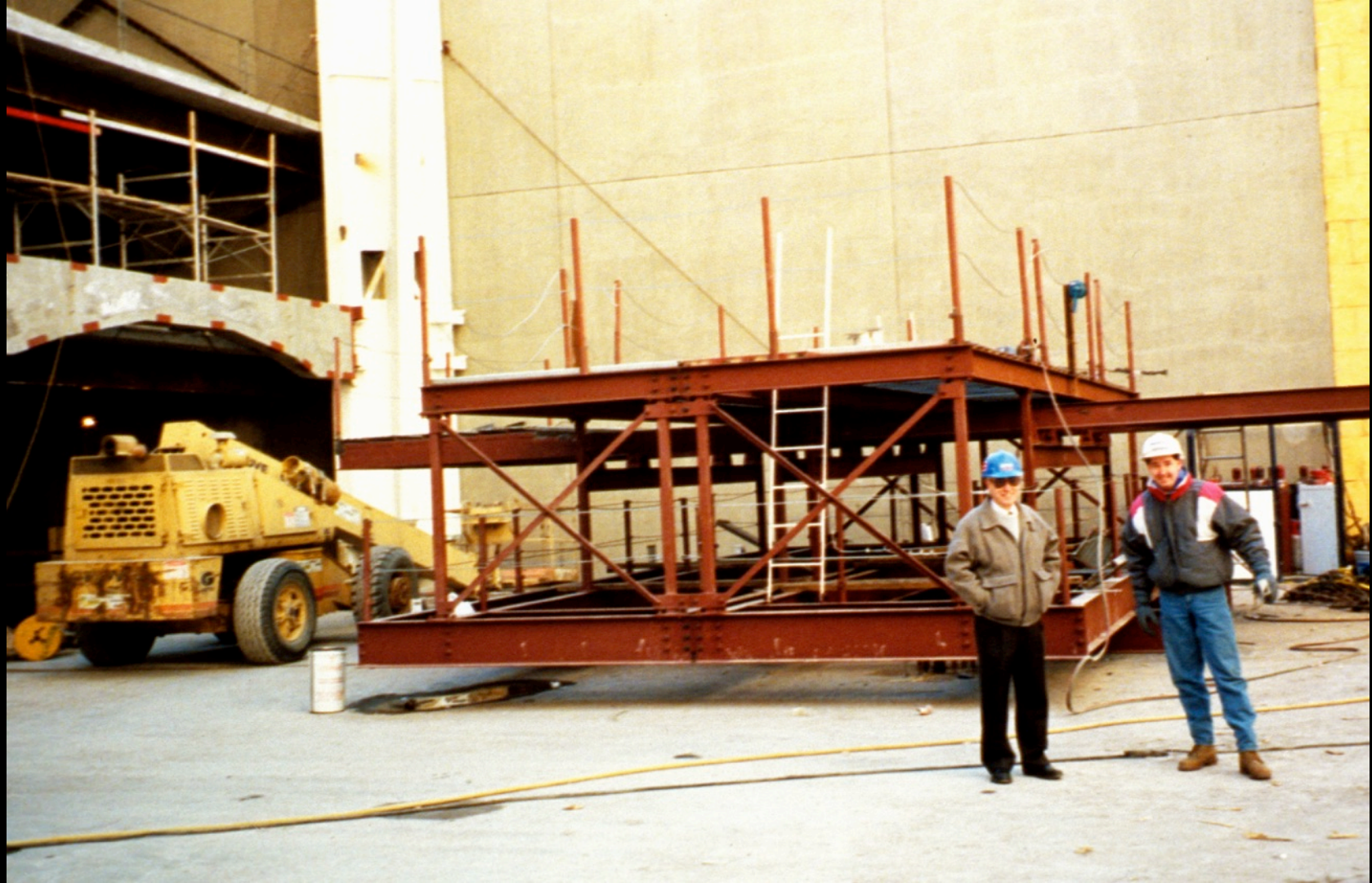








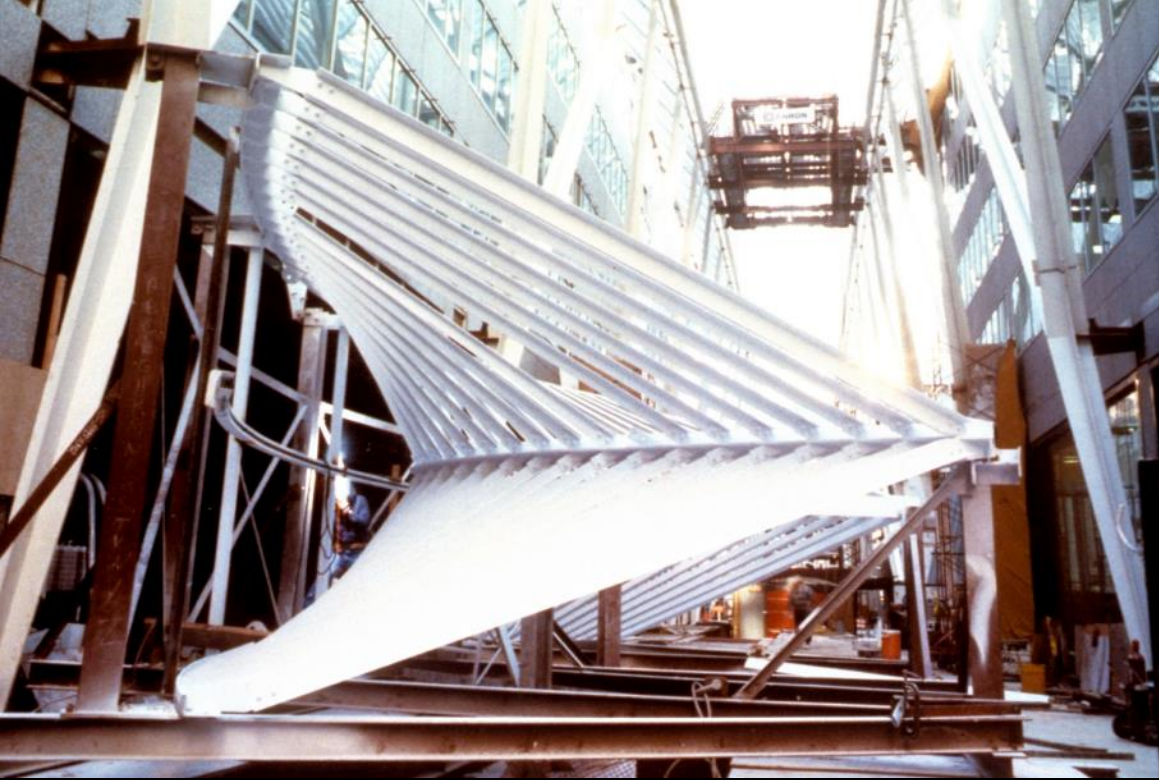














































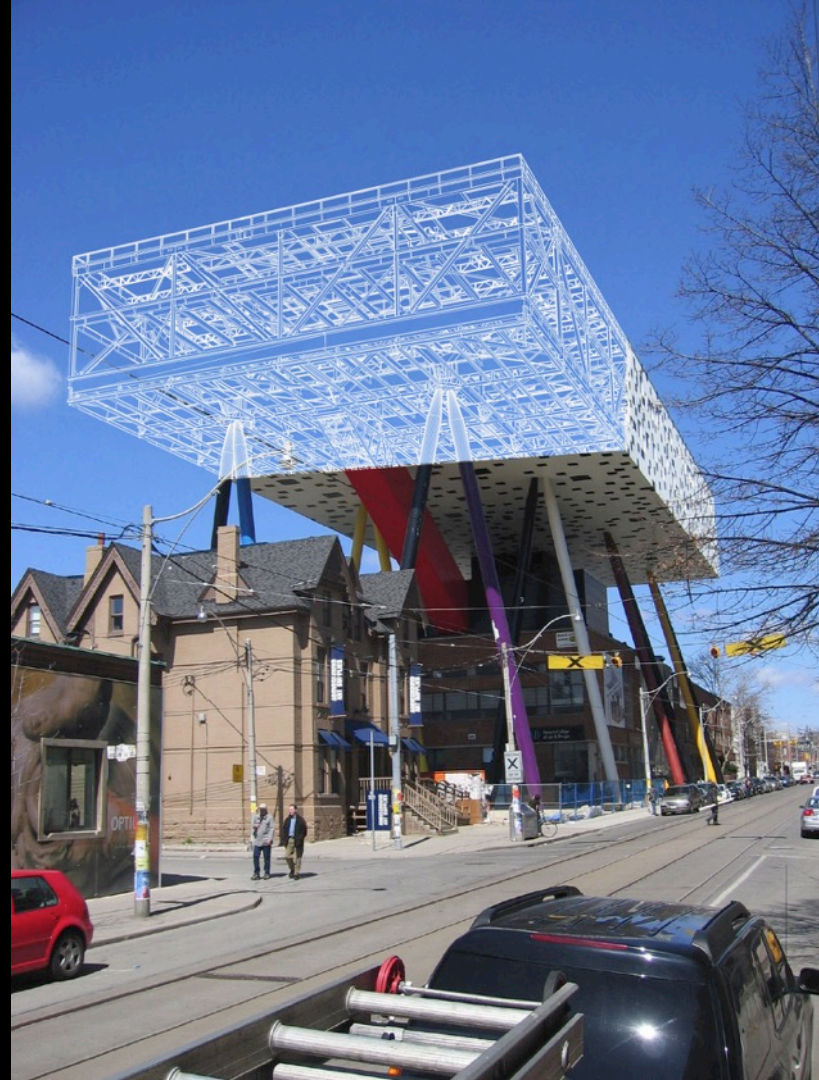


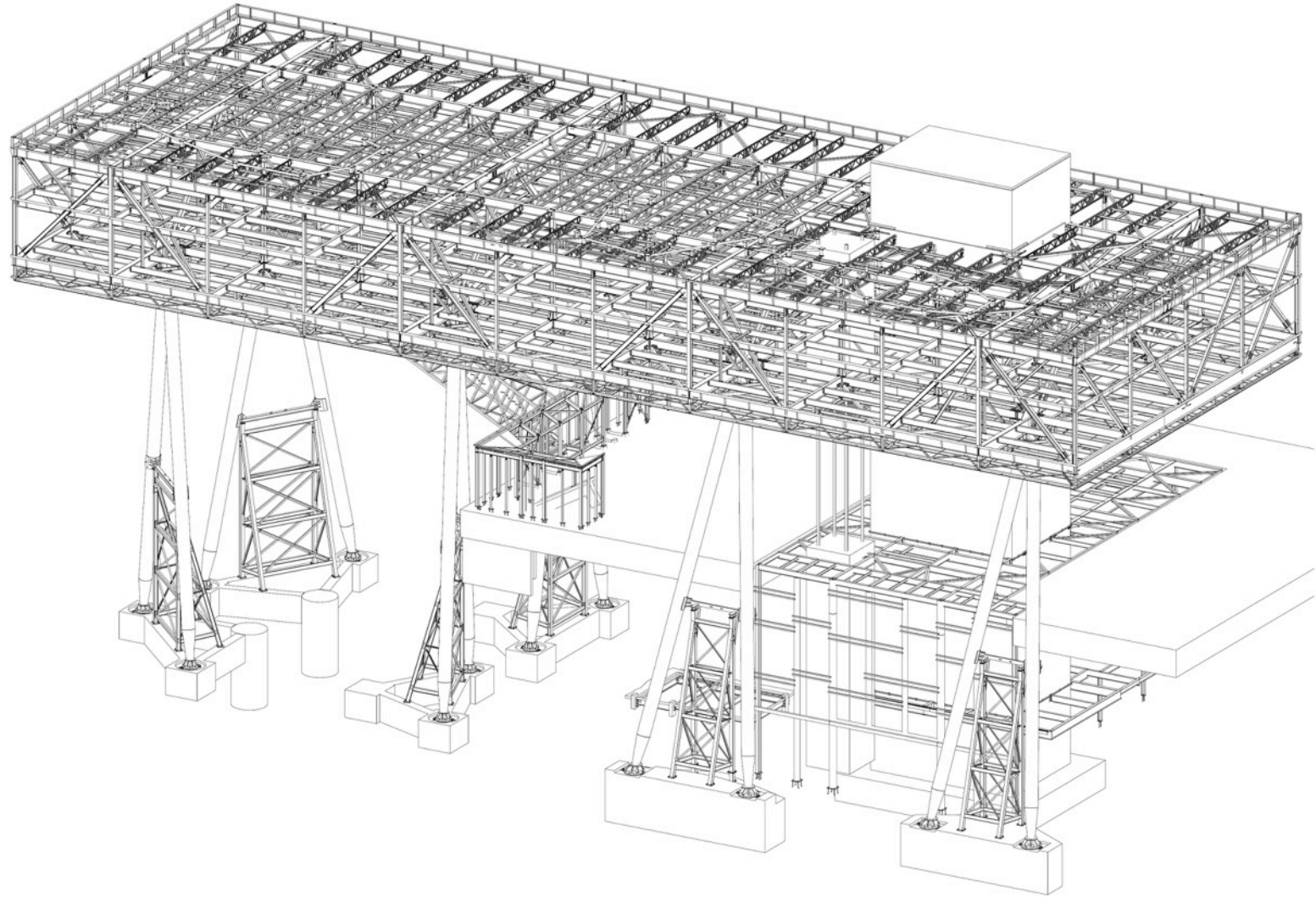




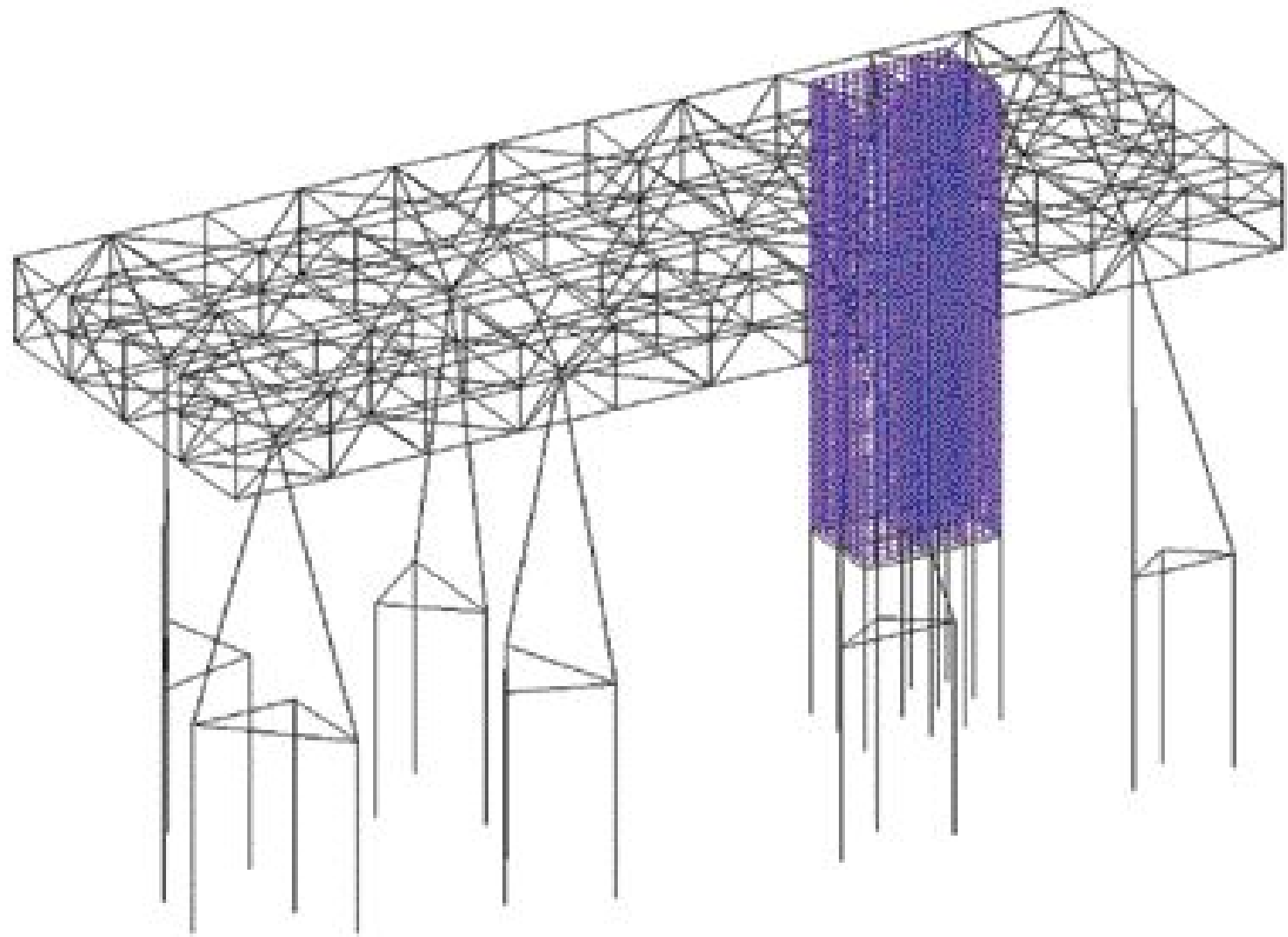


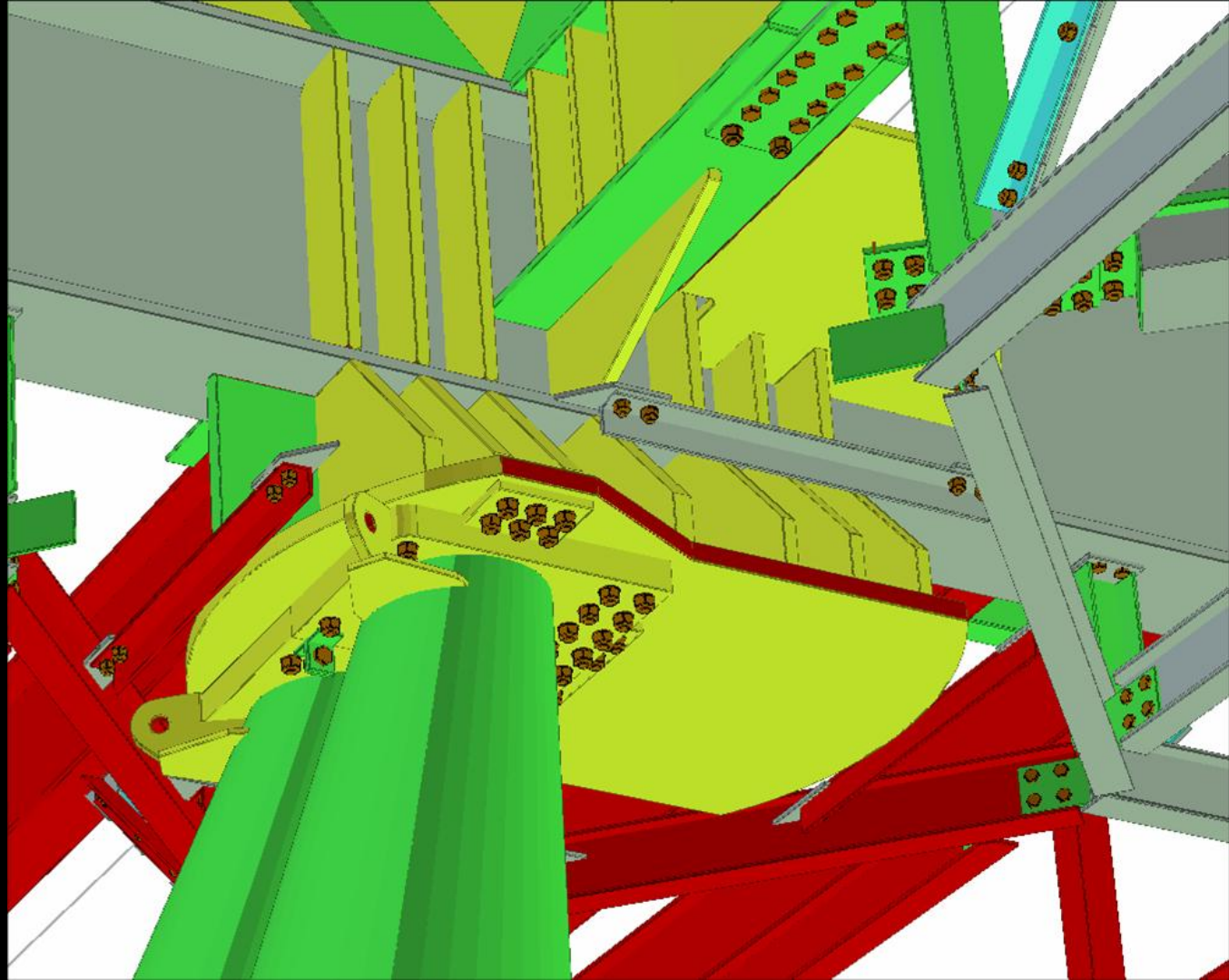
Ontario College of Art and Design  
Toronto, ON  
Will Alsop  
2005















2003 7 9



2003 7 9





2003 7 9



2003 7 9













2003 7 16





2003 7 16



2003 7 28







2003 7 31





2003 8 14

Watch us build a  
stronger future  
with you.

























2009-10-8

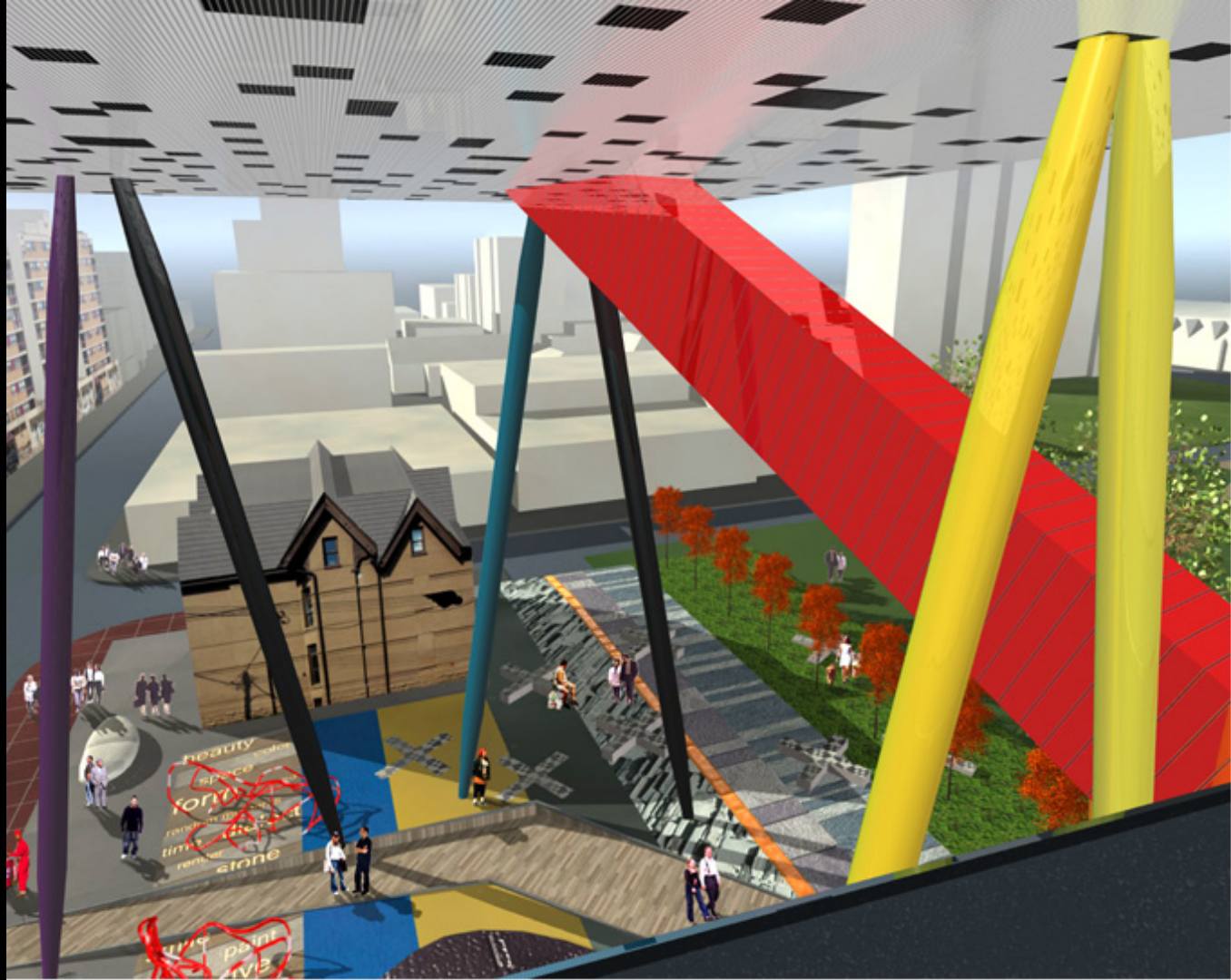














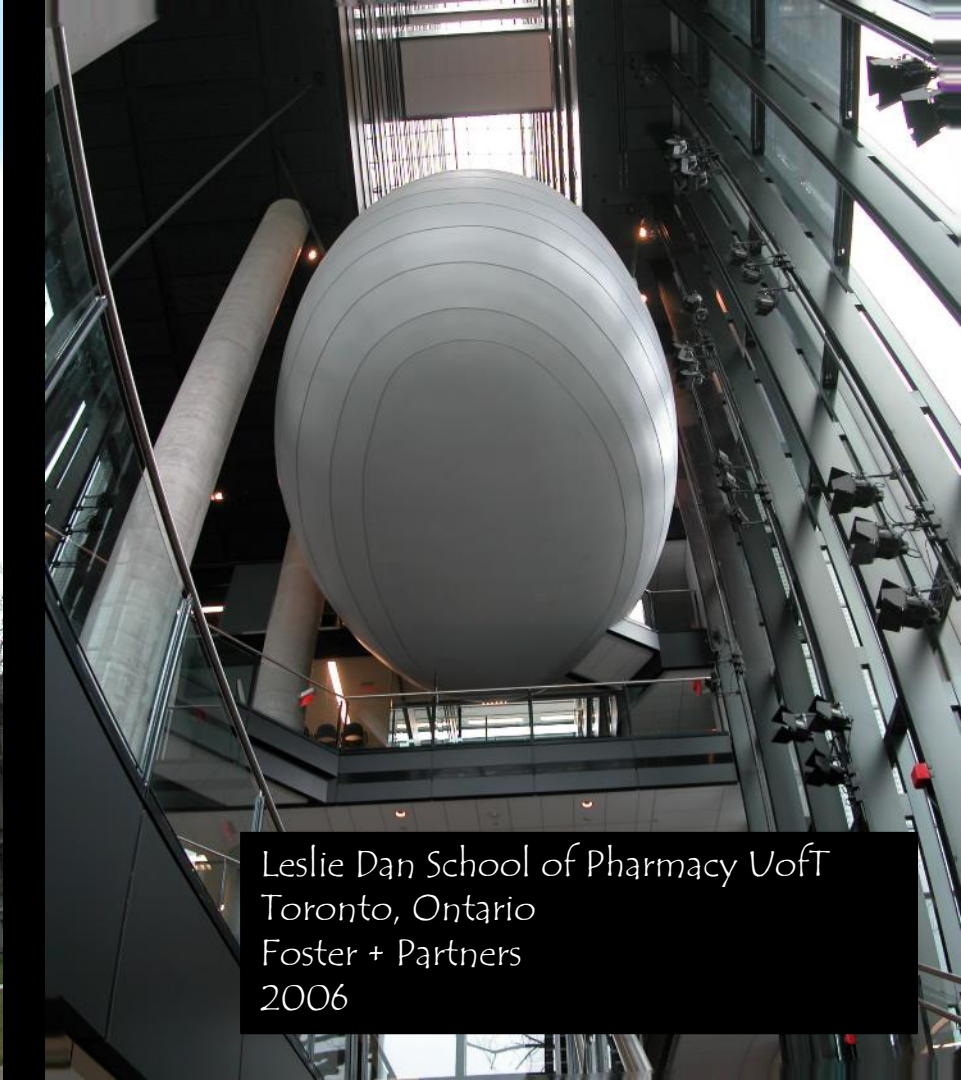






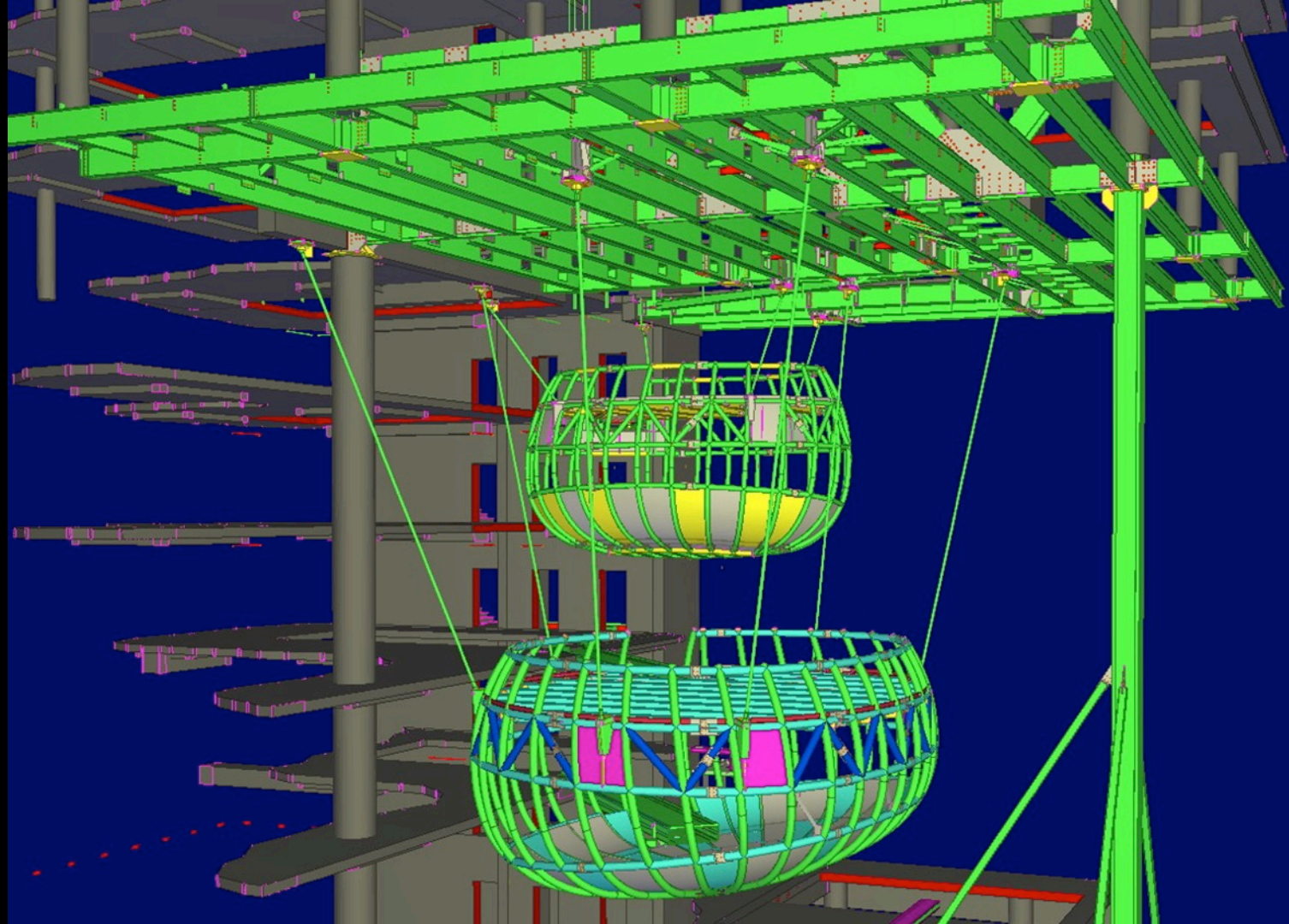


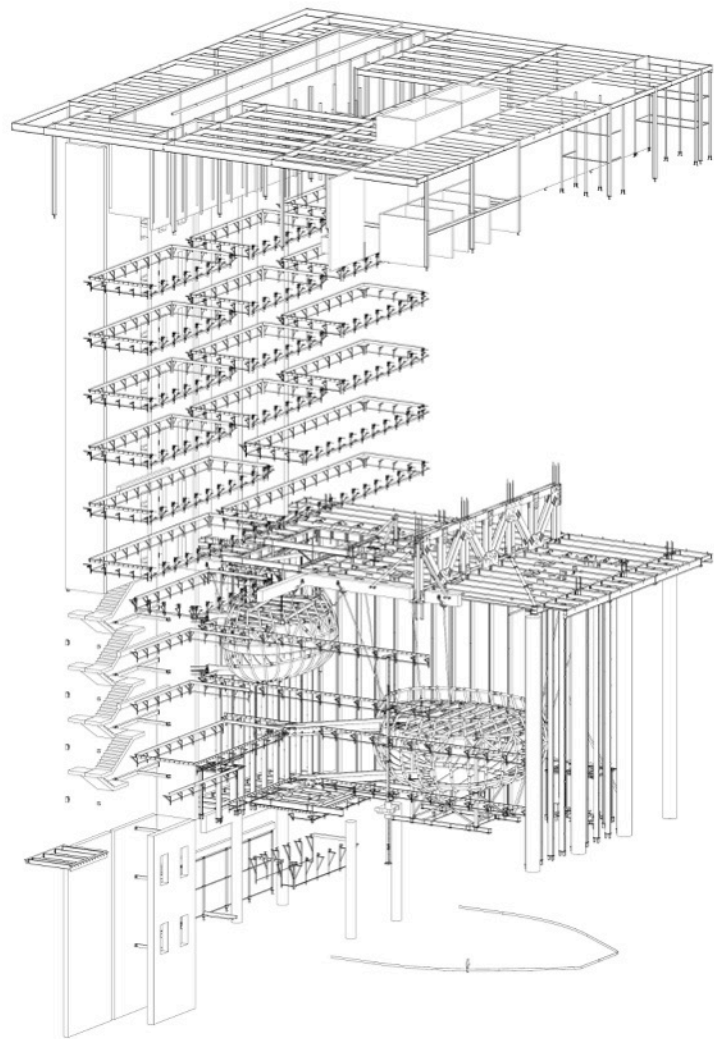




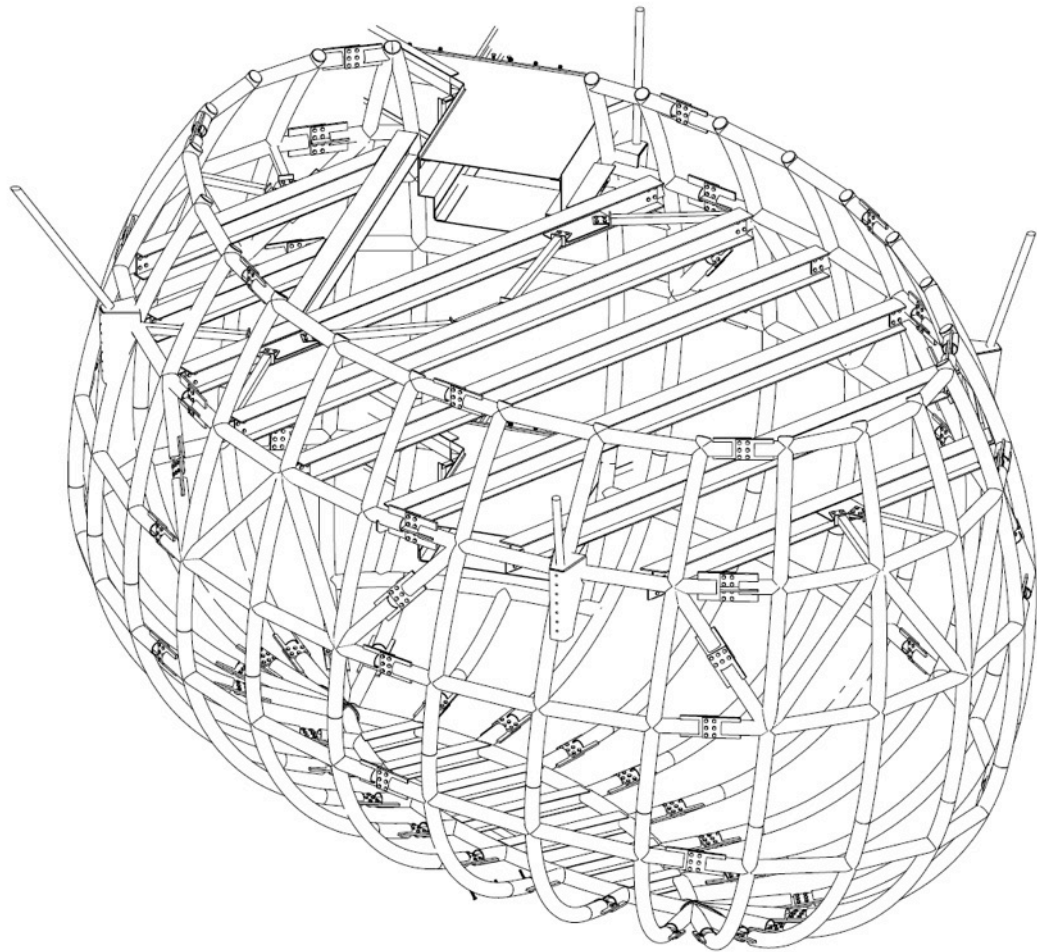
Leslie Dan School of Pharmacy UofT  
Toronto, Ontario  
Foster + Partners  
2006

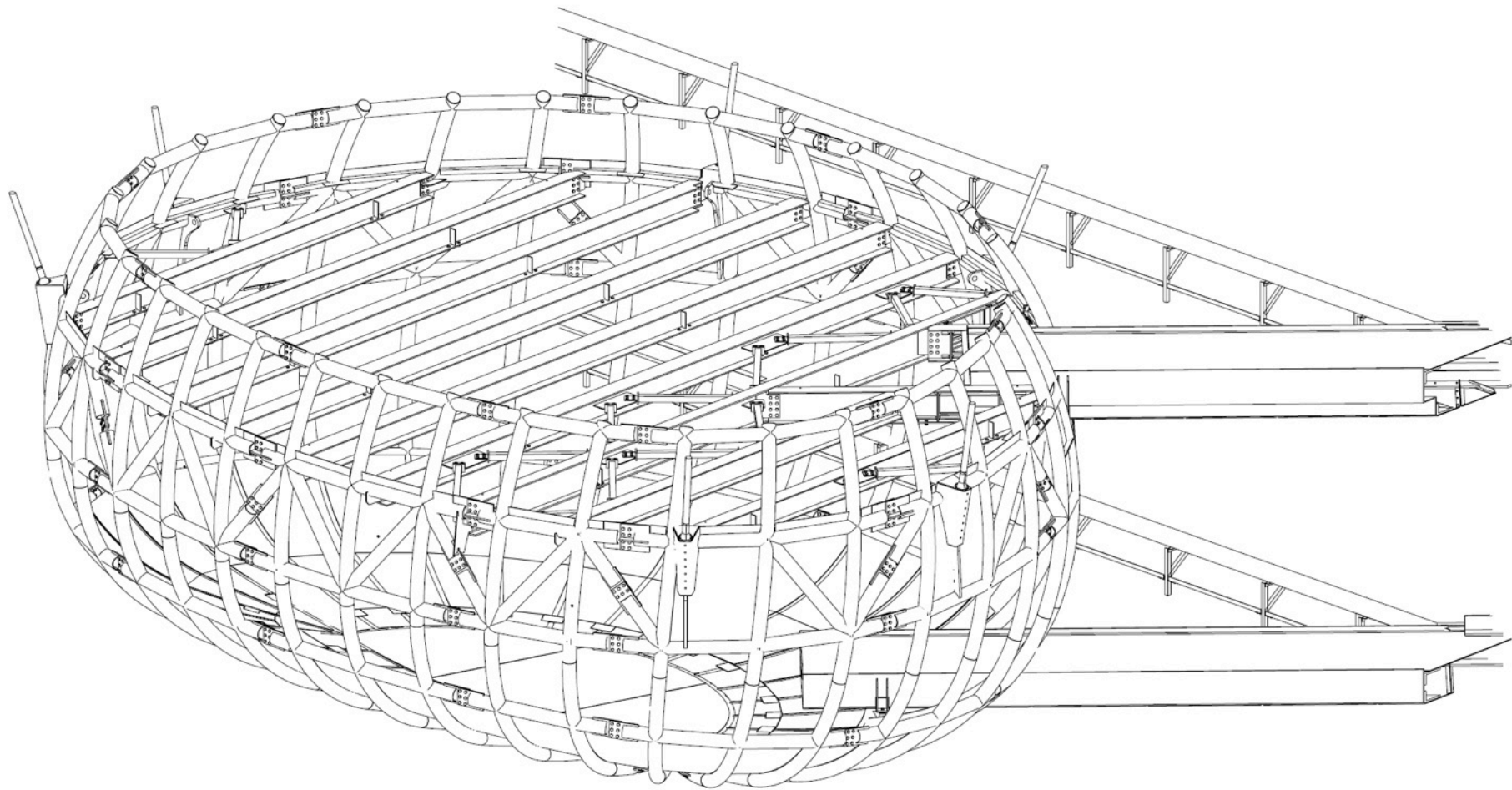
















what it takes to be great

DOUBLING  
ENRICHMENT











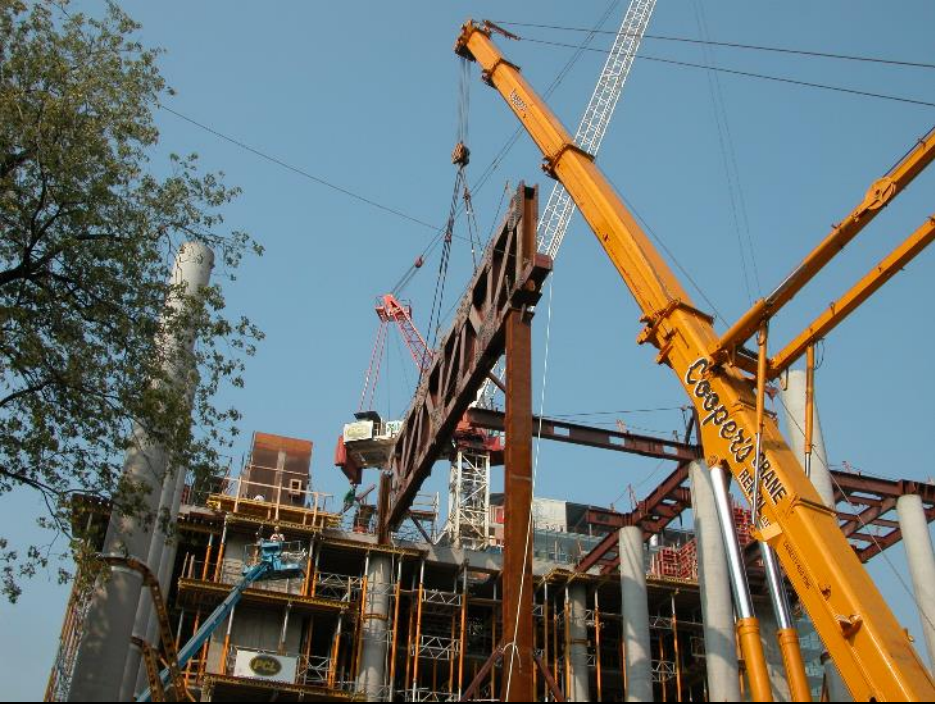








































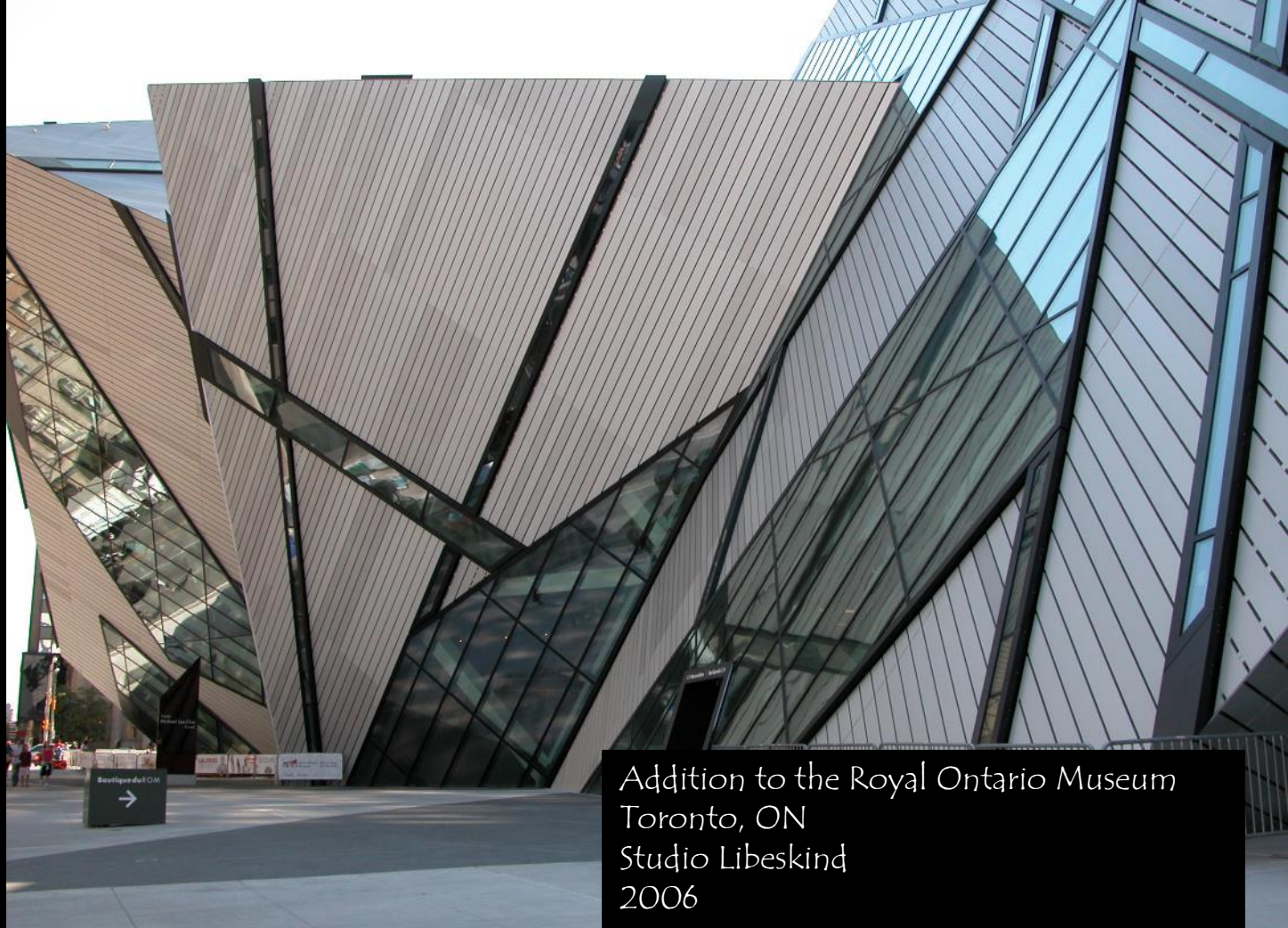


David H. Bloom  
Stoppers Drug Mart  
Lounge

Public Information  
Office  
The Government  
of Ontario  
Linda S. Galt, M.P.  
Minister  
of  
Public  
Information  
and  
Communications  
Office





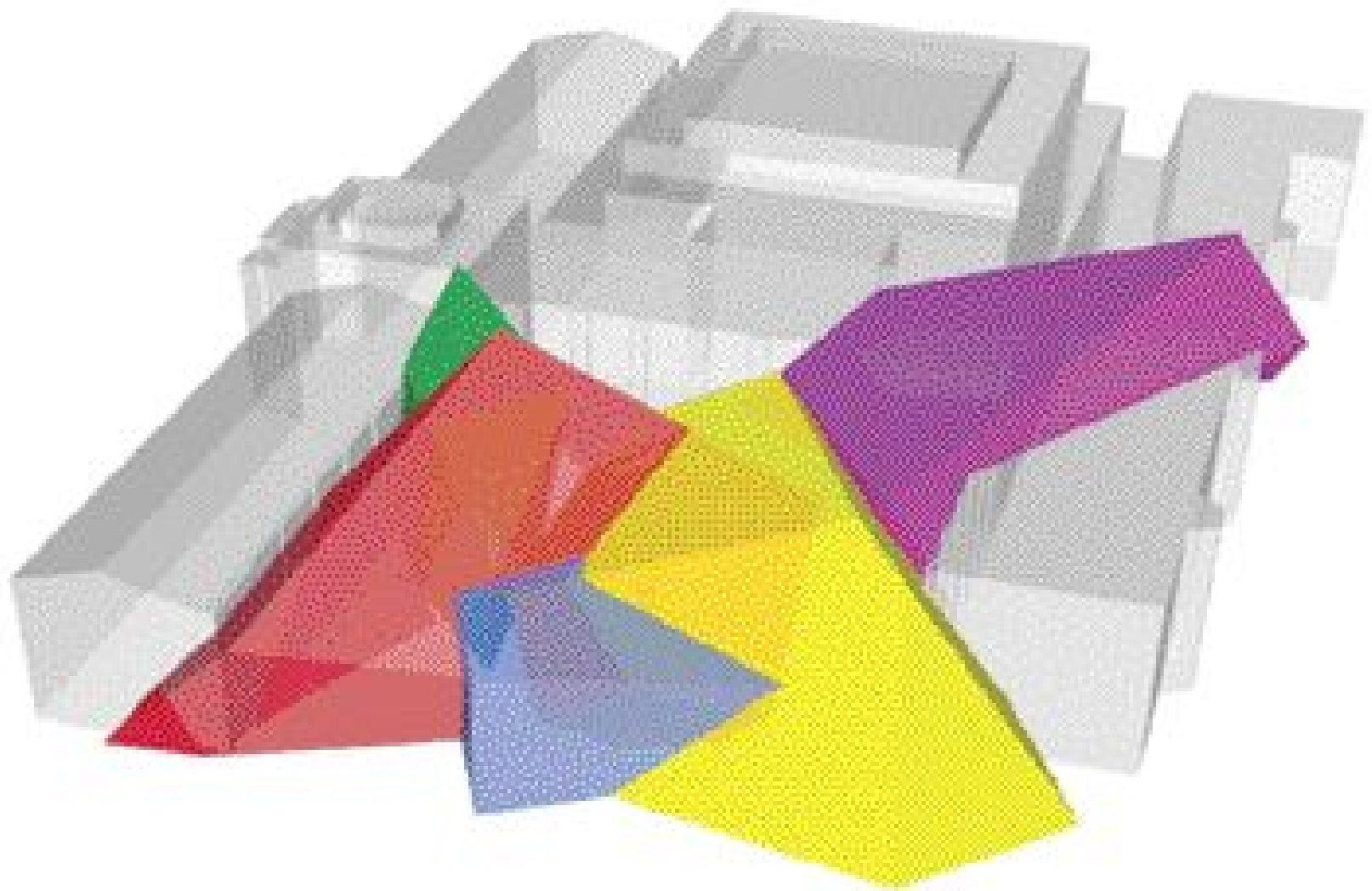


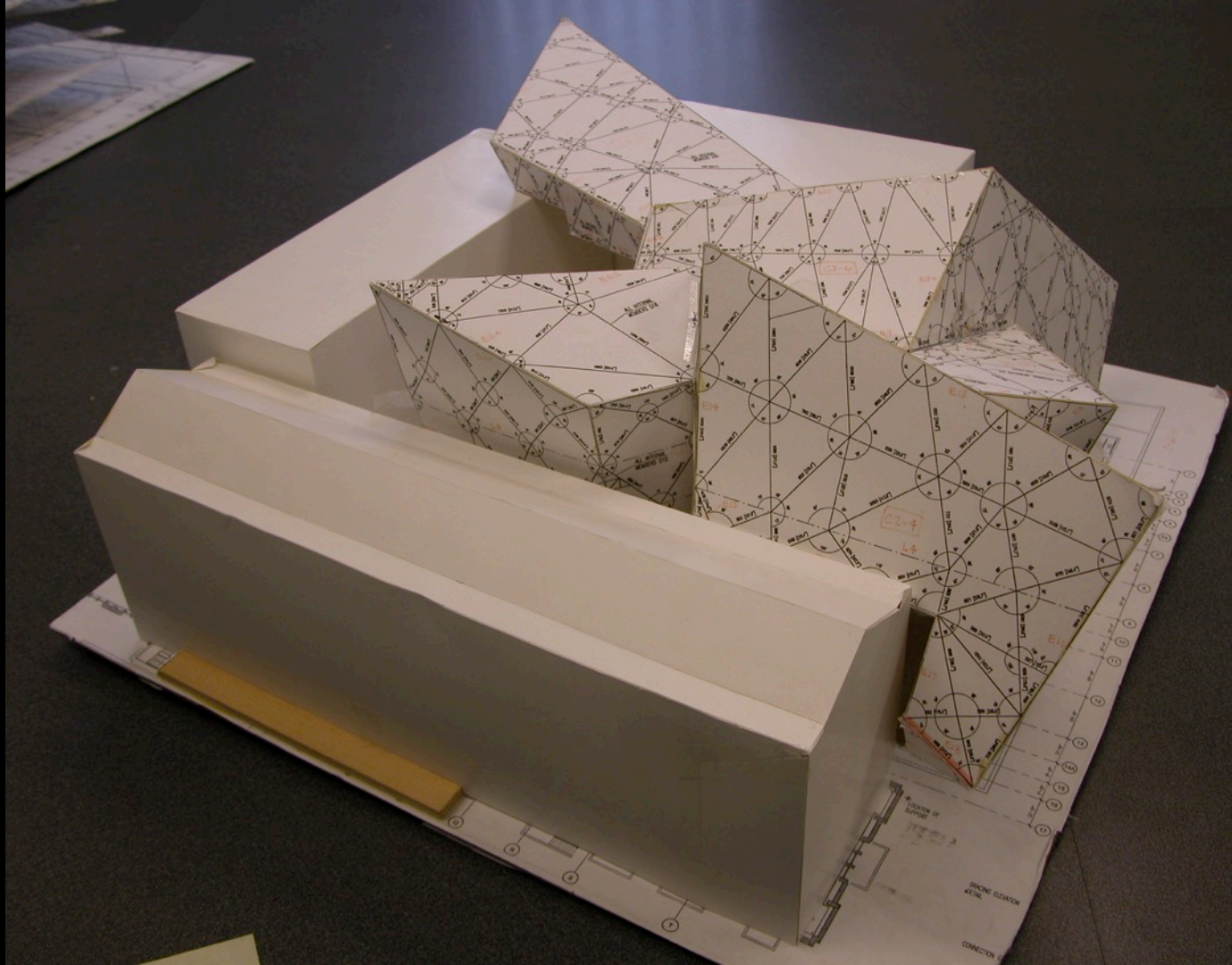
Addition to the Royal Ontario Museum  
Toronto, ON  
Studio Libeskind  
2006



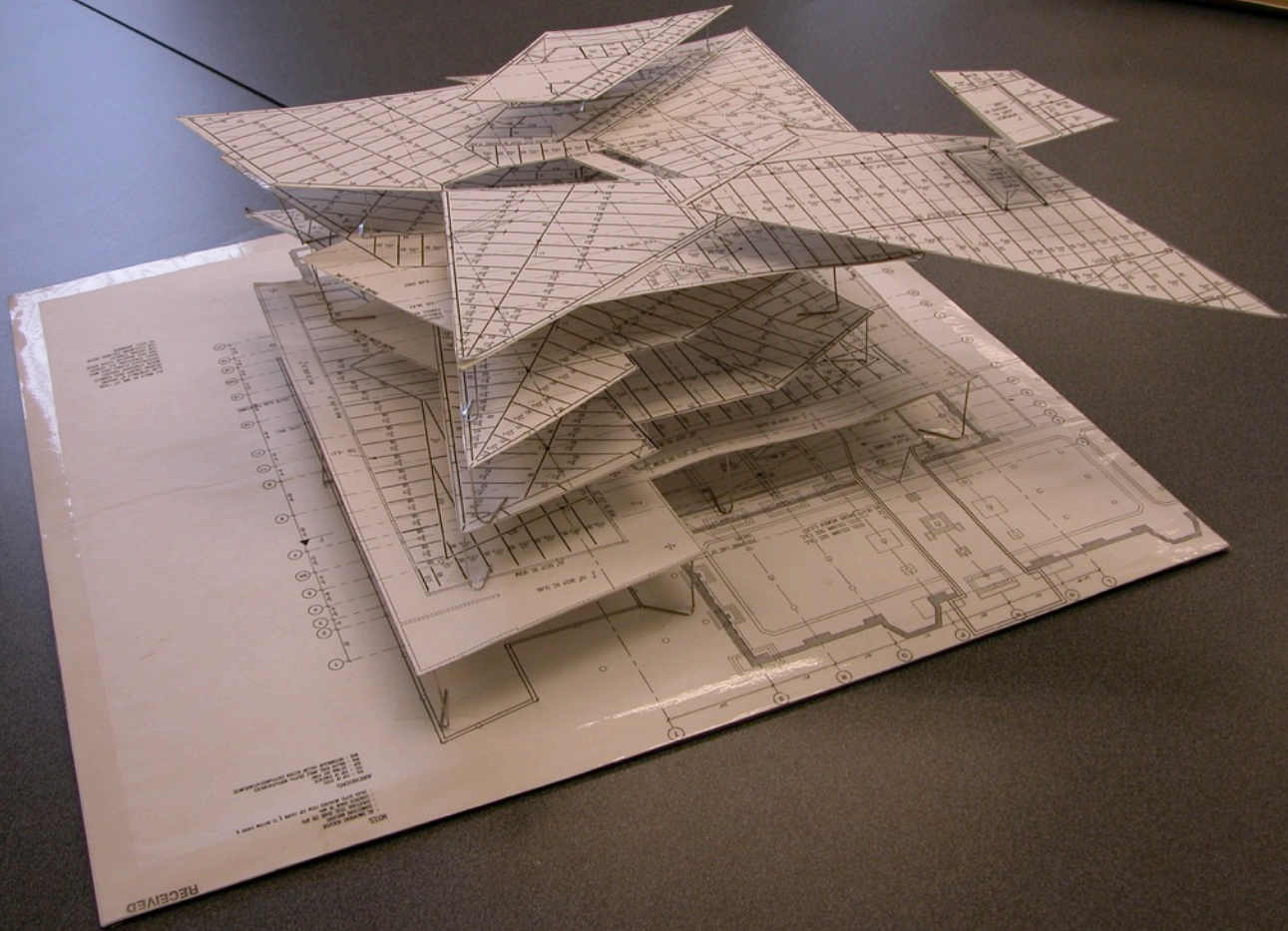
ROM  
TORONTO







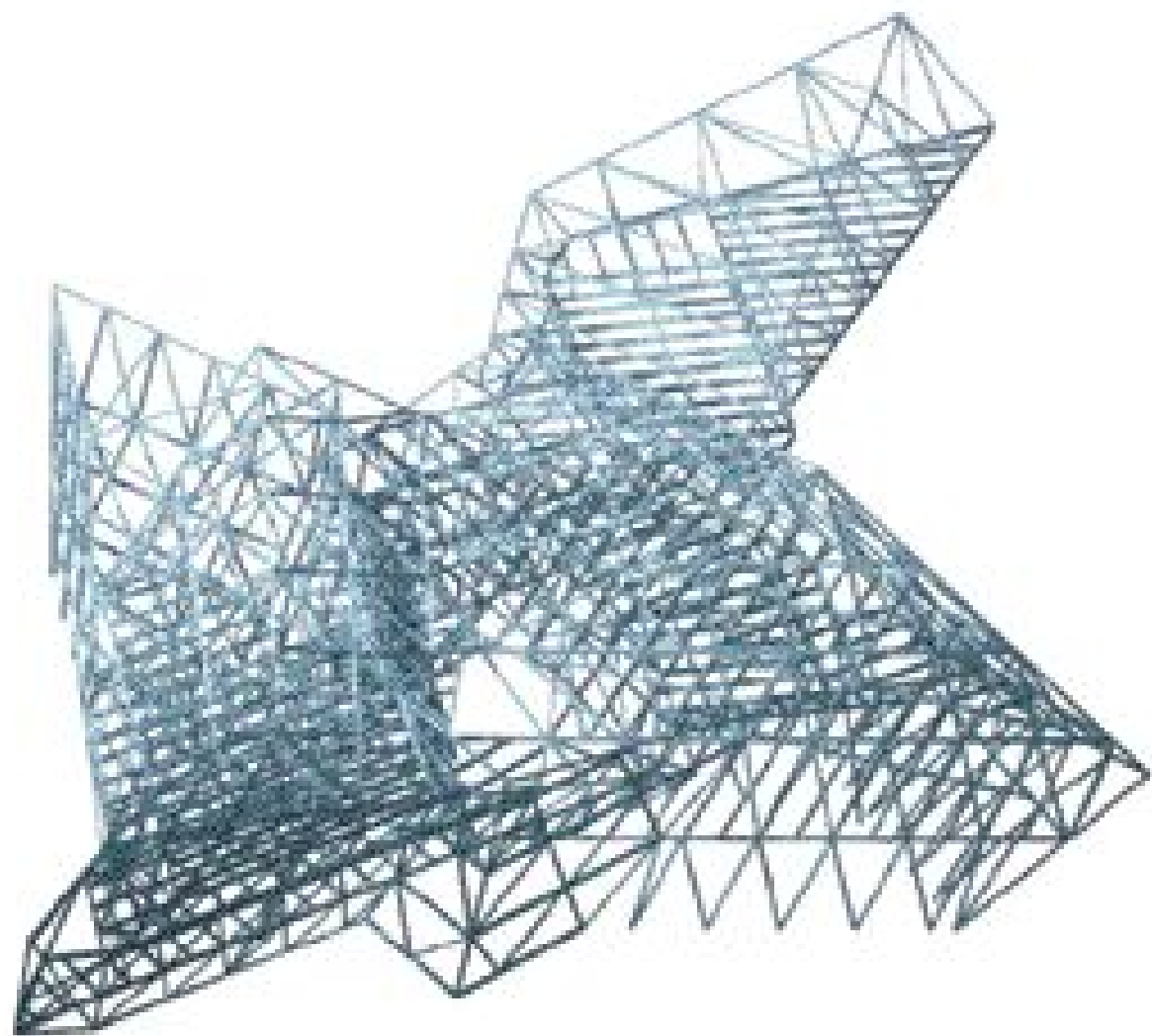




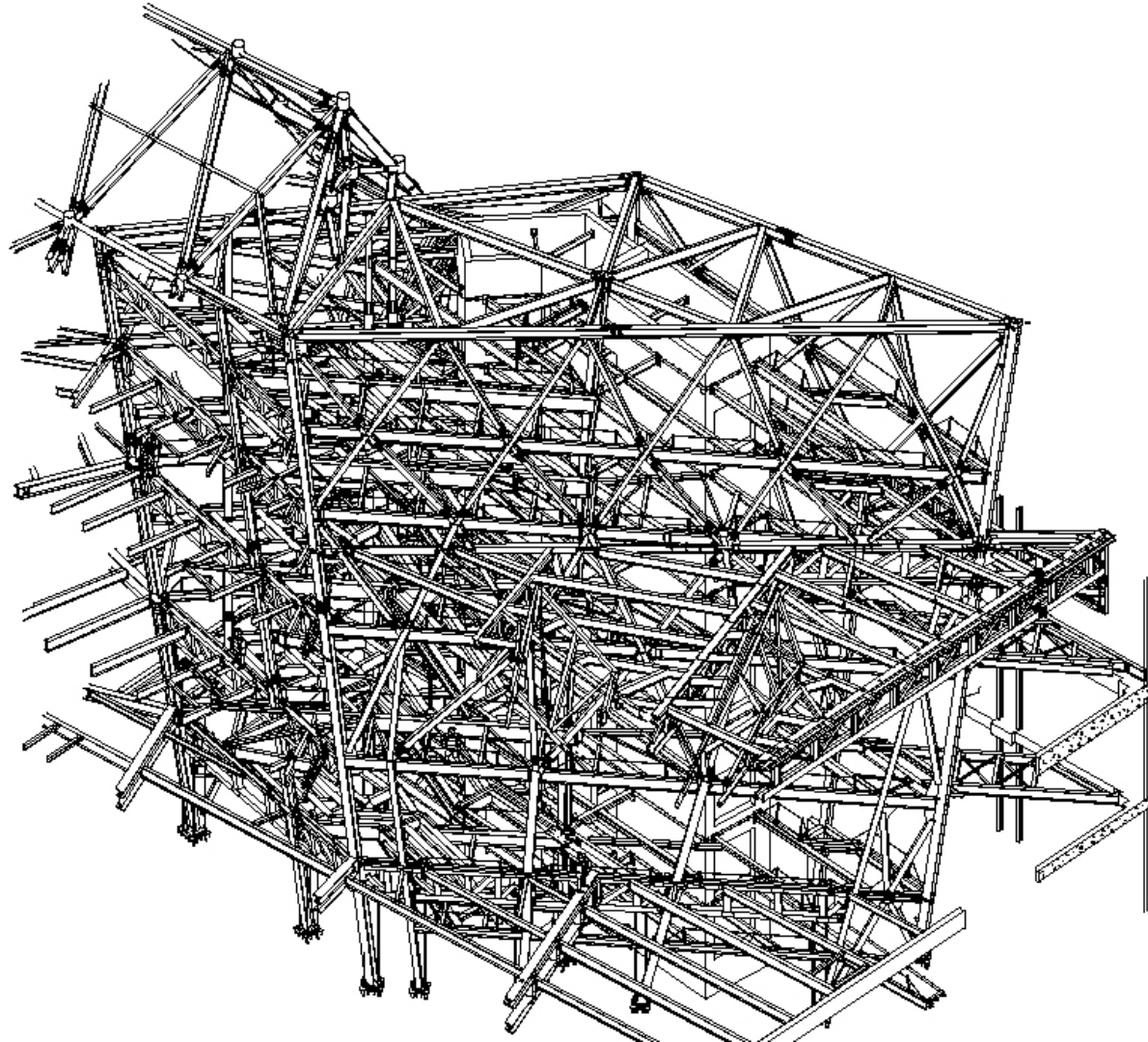
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2. 1/4" = 1'-0"  
3. 1/8" = 1'-0"  
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6. 1/64" = 1'-0"  
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8. 1/256" = 1'-0"  
9. 1/512" = 1'-0"  
10. 1/1024" = 1'-0"

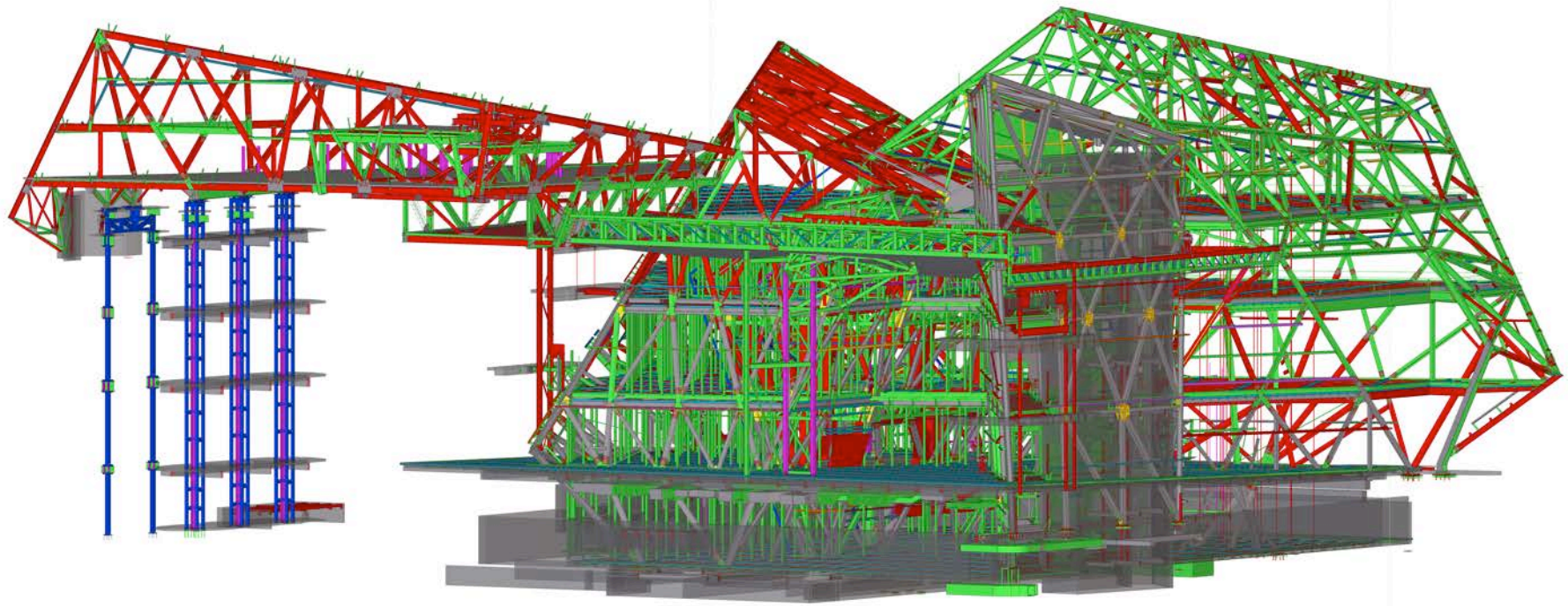
RECEIVED  
1. 1/2" = 1'-0"  
2. 1/4" = 1'-0"  
3. 1/8" = 1'-0"  
4. 1/16" = 1'-0"  
5. 1/32" = 1'-0"  
6. 1/64" = 1'-0"  
7. 1/128" = 1'-0"  
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10. 1/1024" = 1'-0"

RECEIVED

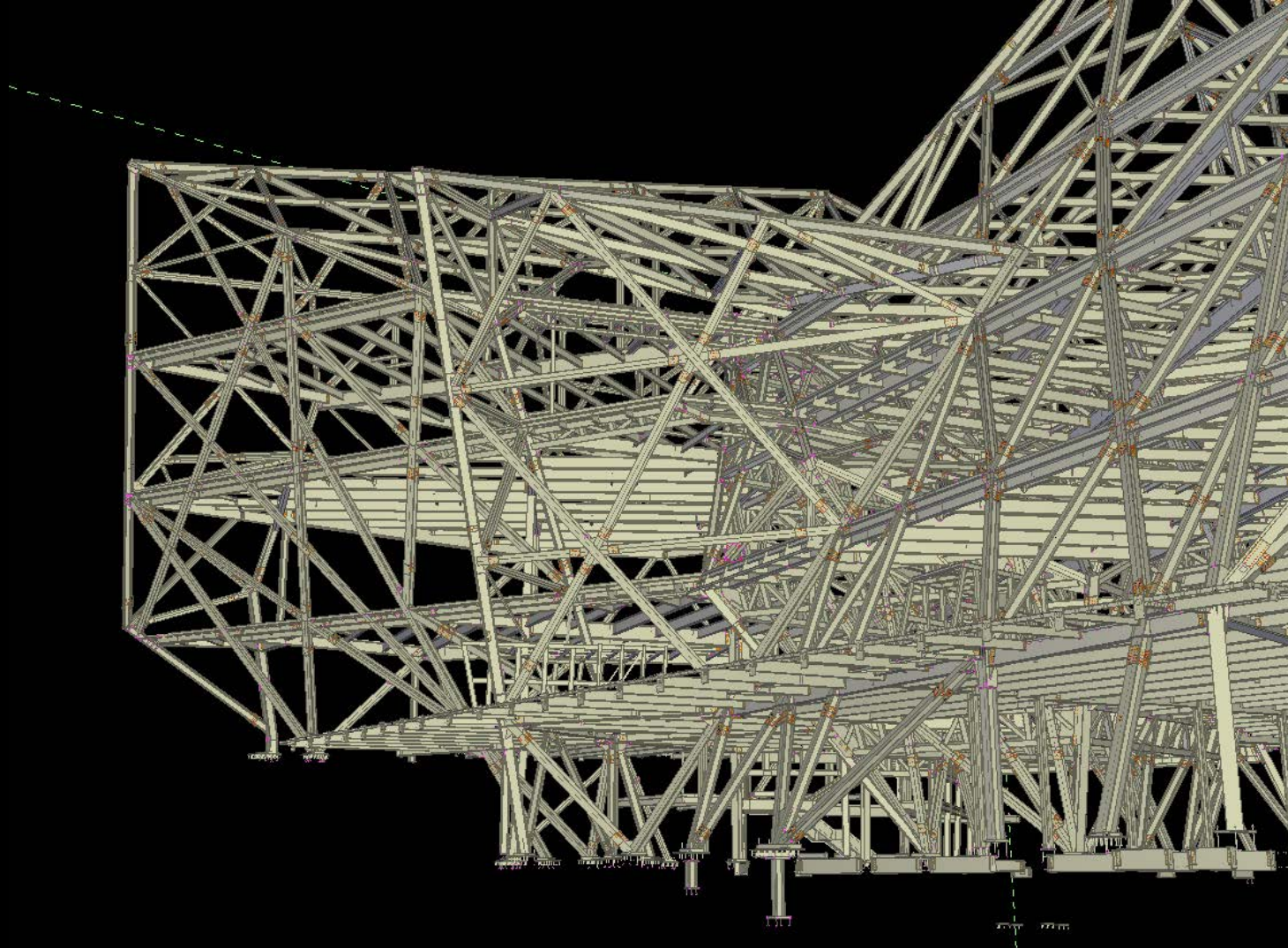


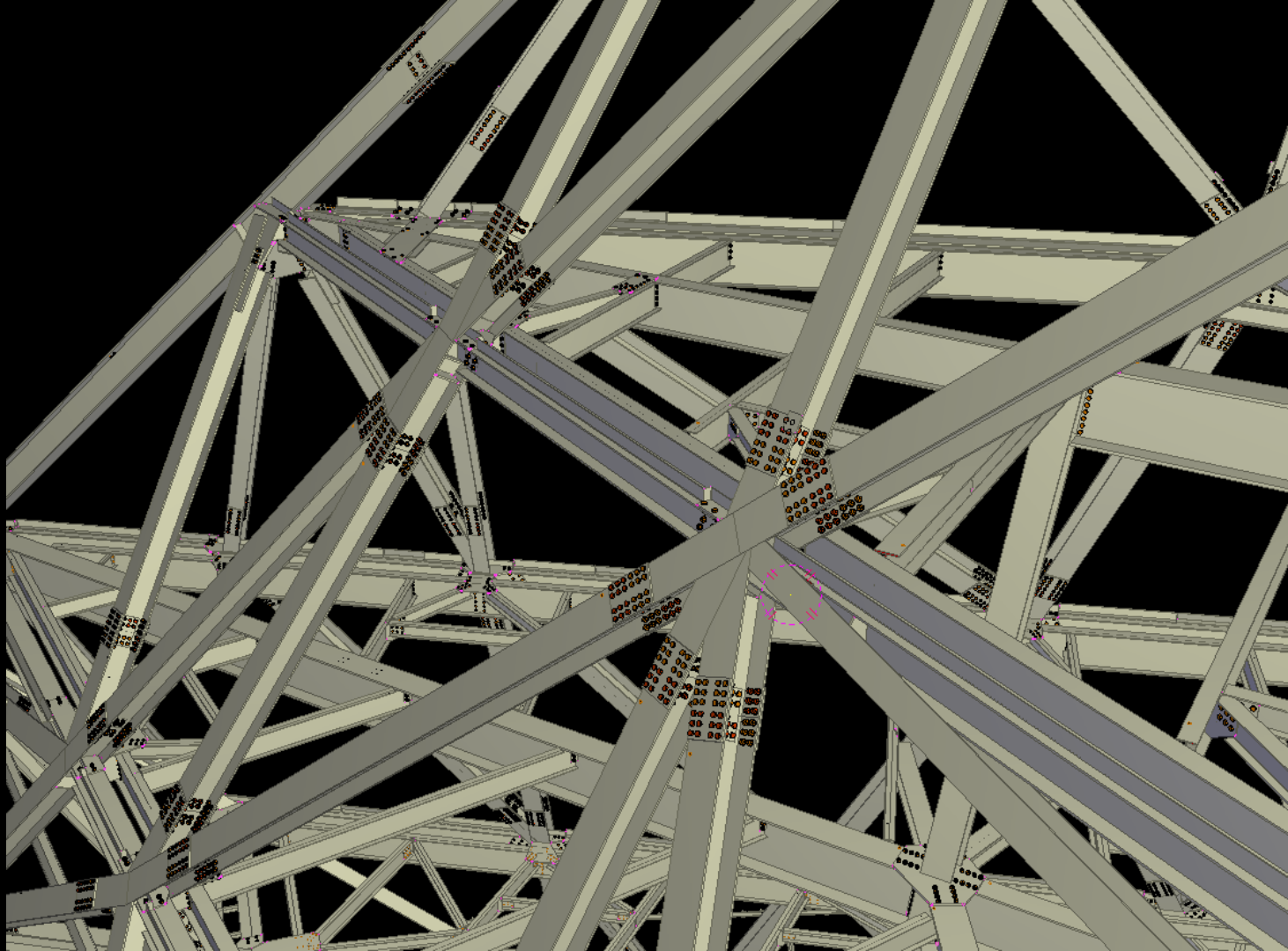




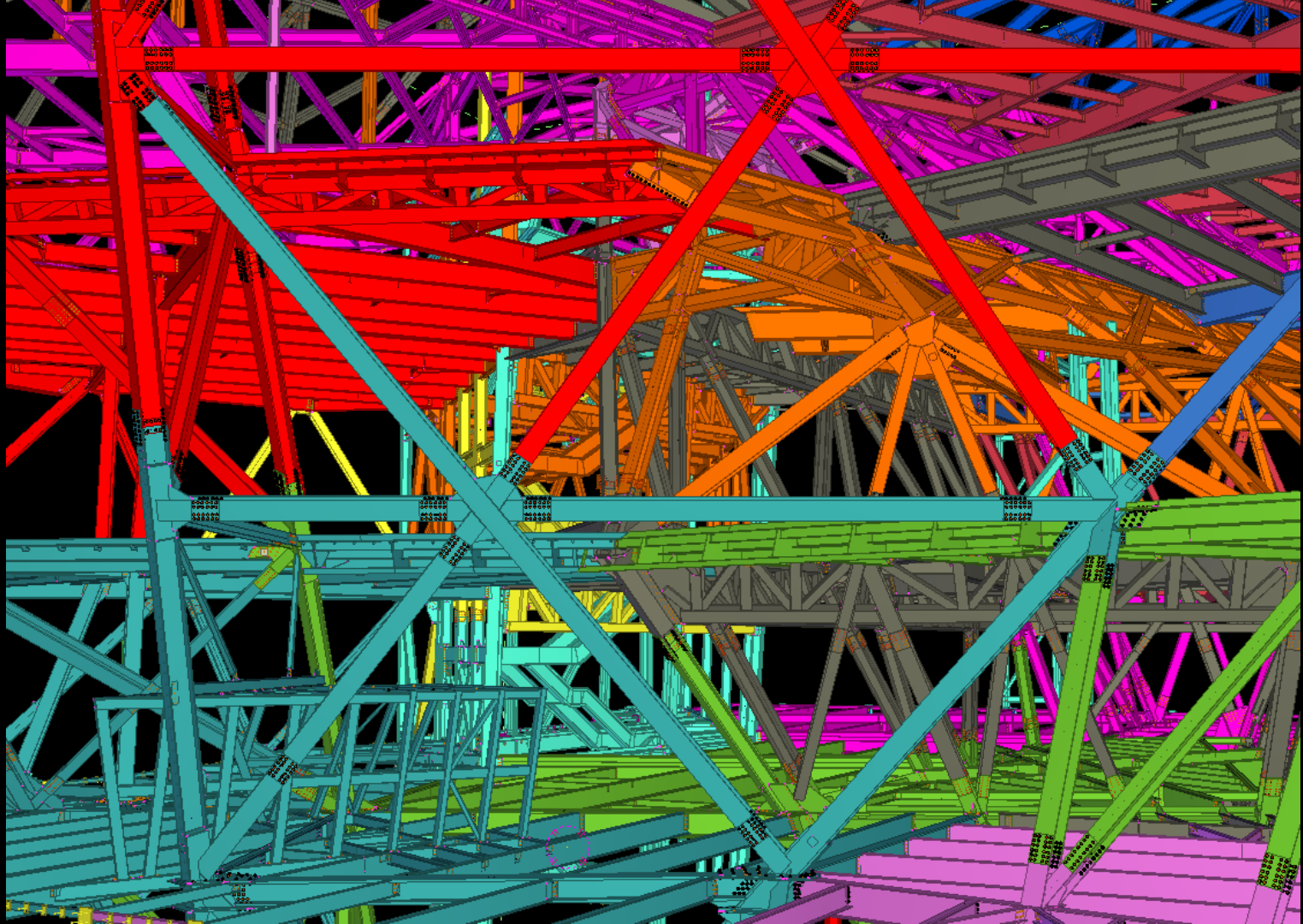


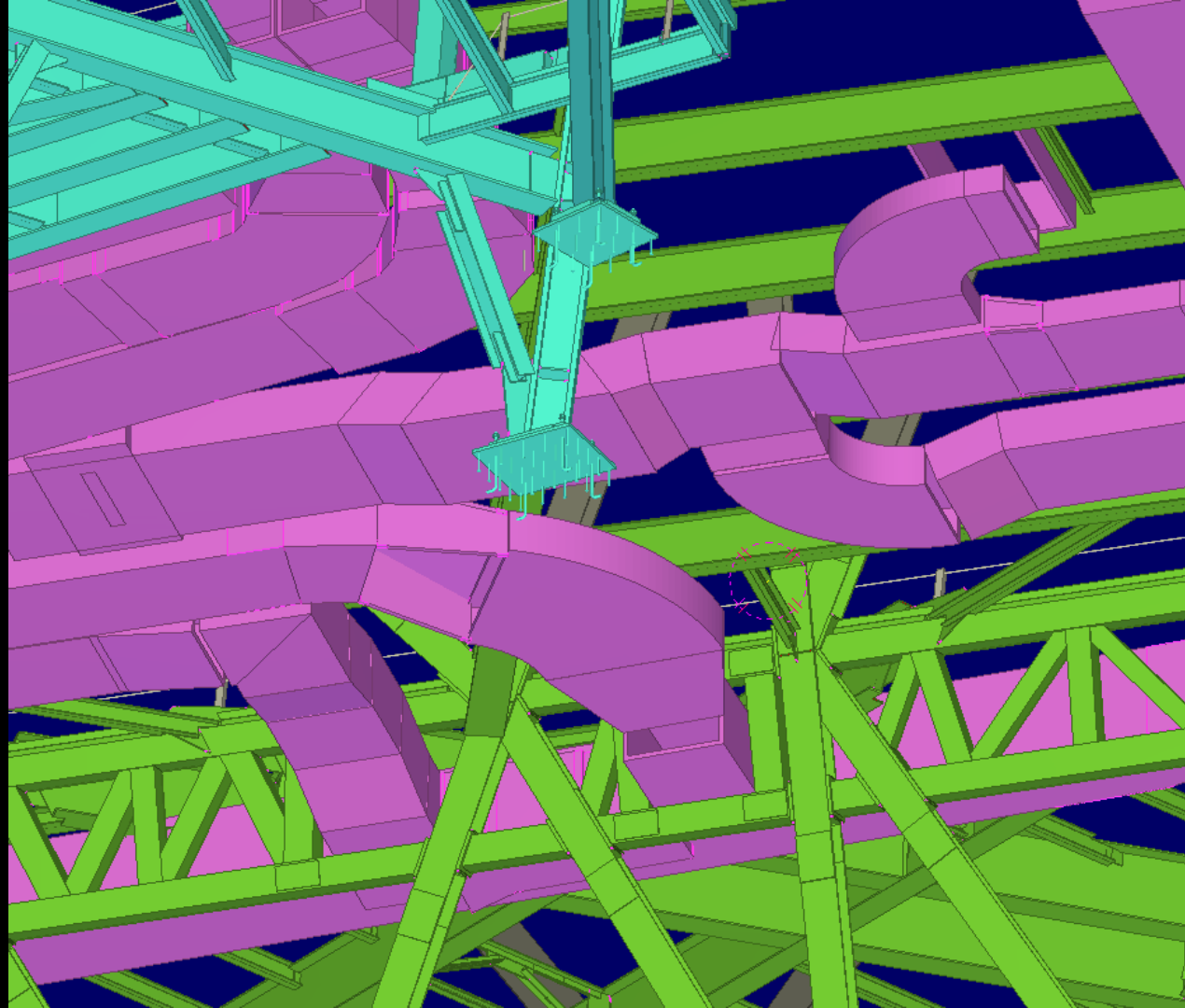




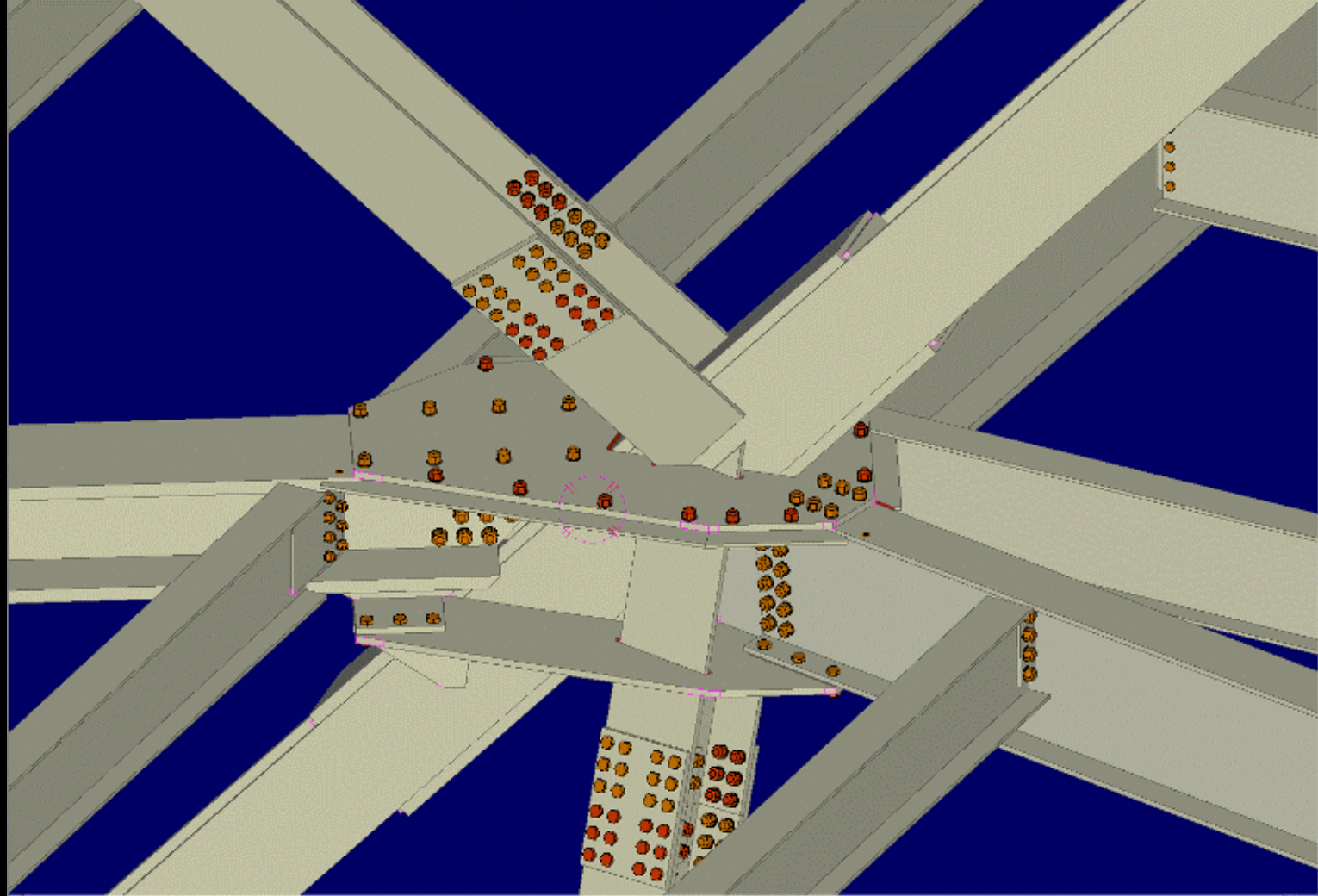






























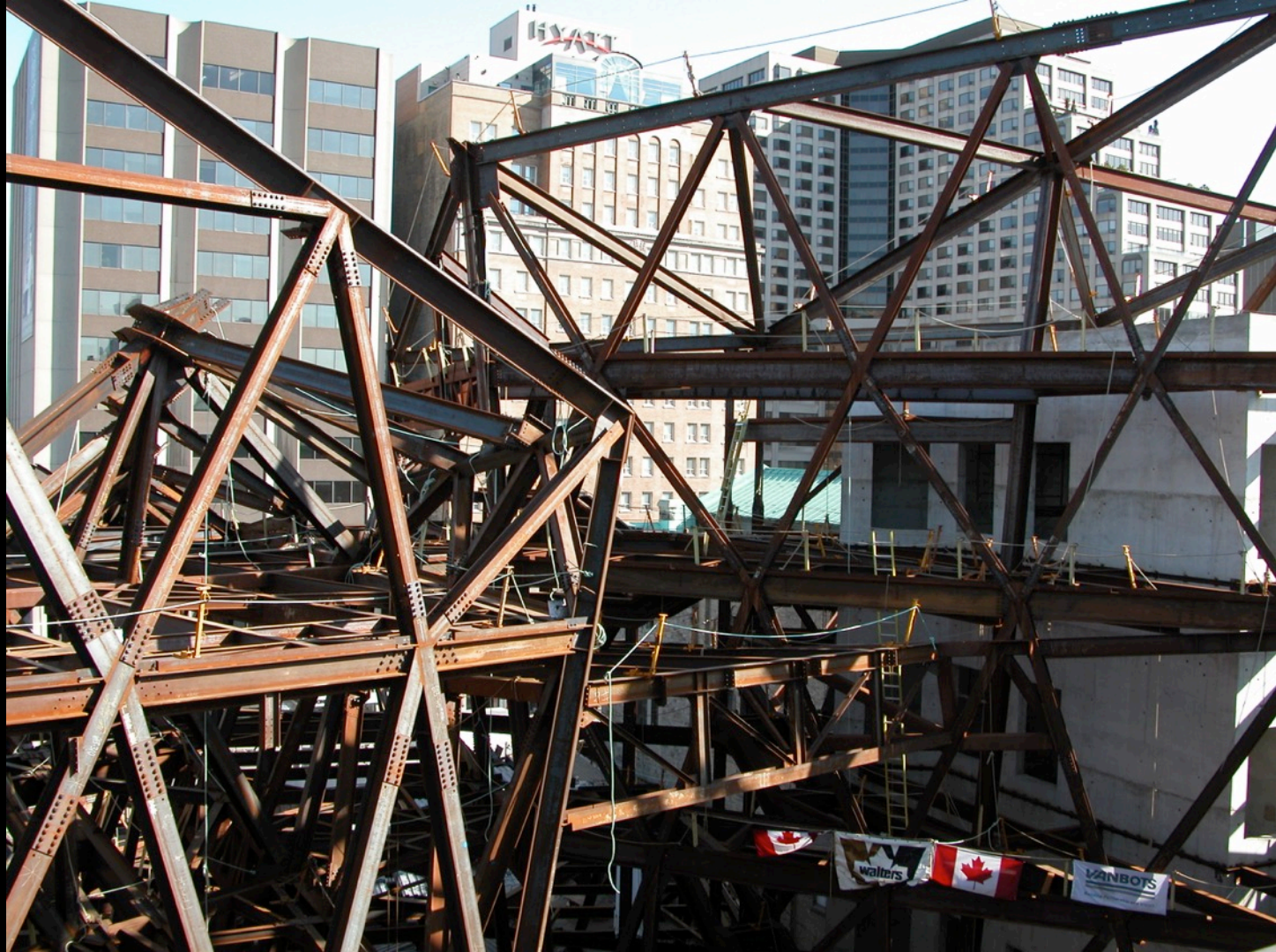
























WALL  
SHELL



3-6











Terri Meyer Boake, BES, BArch, MArch, LEED AP  
Professor School of Architecture University of Waterloo  
email: [tboake@uwaterloo.ca](mailto:tboake@uwaterloo.ca)



Renaissance Hotel, Barcelona, Spain - Ateliers Jean Nouvel

Arch 570:  
Architecturally  
Exposed Structural  
Steel Design

Fall 2021  
Course Home Page

### course outline

last updated November 27, 2021 2:24 PM

#### Territorial Acknowledgement

We acknowledge that the School of Architecture is located on the traditional territory of the Neutral, Anishinaabeg and Haudenosaunee peoples. The University is situated on the Haldimand Tract, the land promised to the Six Nations that includes 10 kilometres on each side of the Grand River. (see references here: <https://uwaterloo.ca/engineering/about/territorial-acknowledgement>)

#### Course Description:

THIS COURSE IS ALL ABOUT DESIGN, NOT CALCULATIONS. LEARNING OUTCOMES INCLUDE AN INCREASE IN YOUR ABILITY TO UNDERSTAND HOW STRUCTURES WORK, AND DETAIL THE SAME. PORTFOLIO WORTHY DESIGN PROJECTS.

Using an international database of case studies this course examines in detail the architectural design, specification, fabrication and construction process for Architecturally Exposed Structural Steel (AESS). It references the standards that were developed by the Canadian Institute of Steel Construction. Lectures will address topics including, the AESS Category Approach, fabrication standards and practices, project communication, tensile structures, diagrid structures, curved steel, castings, pedestrian bridges, steel with glazing, steel with timber. The work of the term will use current steel based competitions to explore detailed design application of the material.



Unless you take my Arch  
570 elective in 3B!

