



**BUILDING
INNOVATION** 2019

National Institute of
BUILDING SCIENCES
CONFERENCE & EXPO

The Whitney Museum

A Building Envelope Case Study

Georgia Ewen-Campen / Heintges Consulting Architect & Engineers



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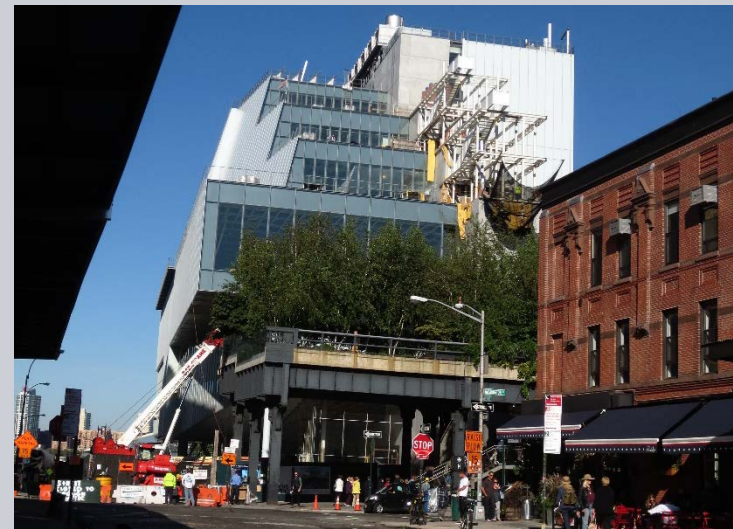
Whitney Museum of American Art

Architect:	Renzo Piano Building Workshop in collaboration with Cooper Robertson
Structural Engineer:	Robert Silman Associates
MEP Engineer:	Jaros Baum & Bolles
Facade Consultant:	Heintges
Roofing Consultant:	Henshell & Buccellato
Energy Consultant:	Viridian
Construction Manager:	Turner Construction
Curtain Wall:	Gartner
Precast Fabricator:	BPDL

Facade Design

Massing / Materiality

Light / Transparency



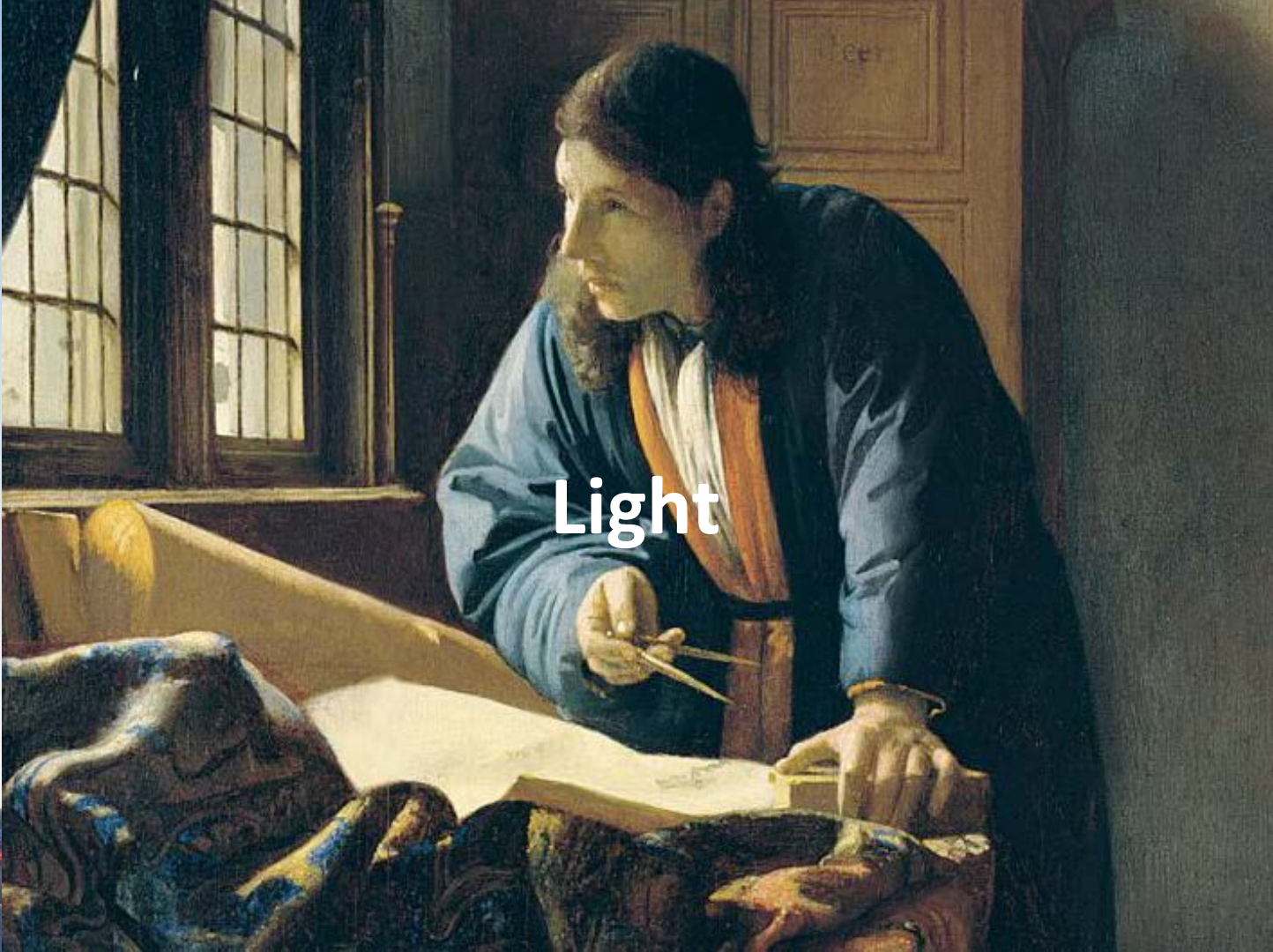
Facade Design

Massing / Materiality

Light / Transparency



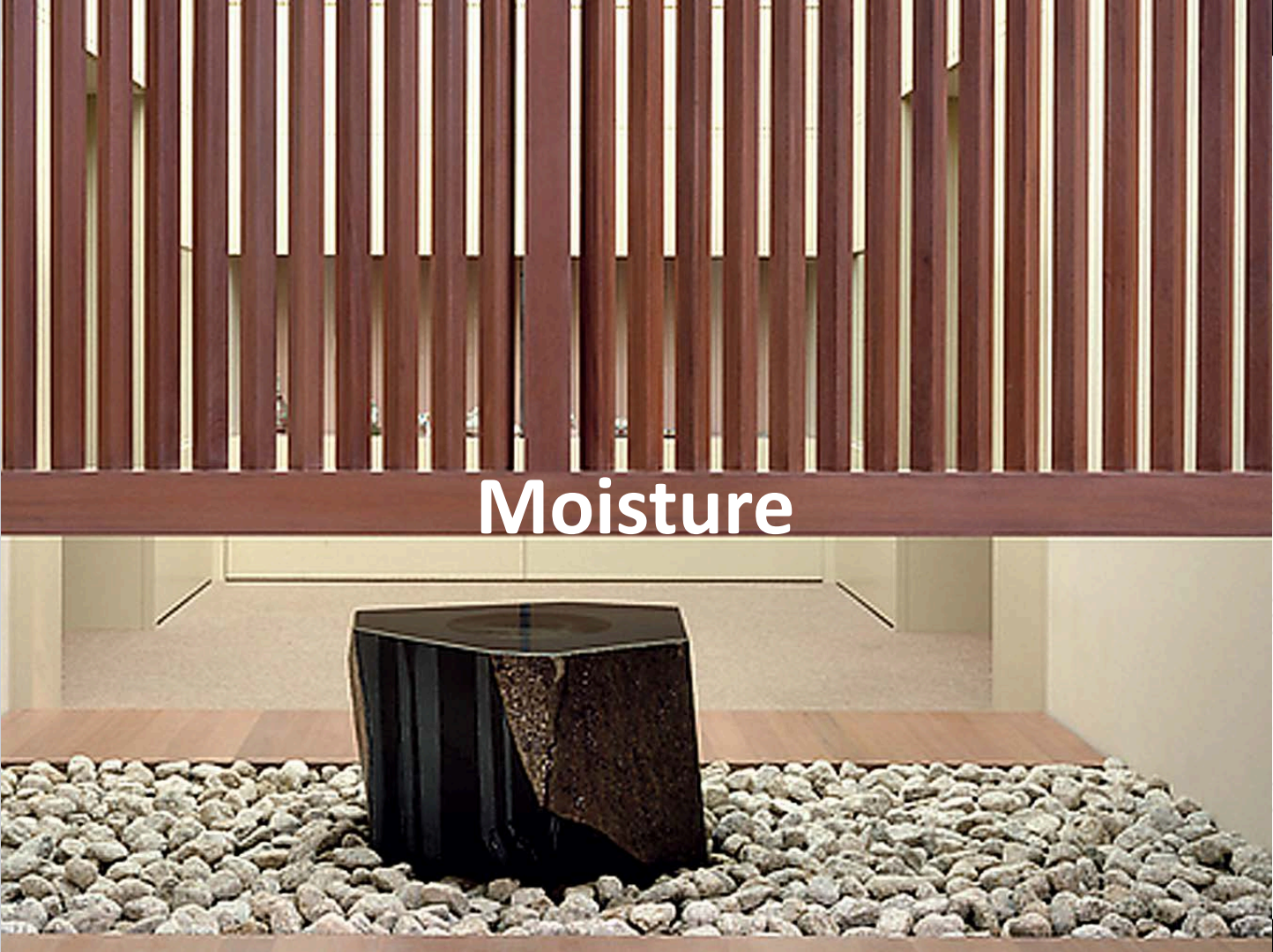
Performance Criteria



Performance Criteria



Performance Criteria



Moisture

Performance Criteria

Natural Light Control

Interior Environment

Condensation Mitigation

Light



Performance Criteria

Natural Light Control

Interior Environment

Condensation Mitigation



Performance Criteria

Natural Light Control

Interior Environment

Condensation Mitigation



Moisture

Facade Overview

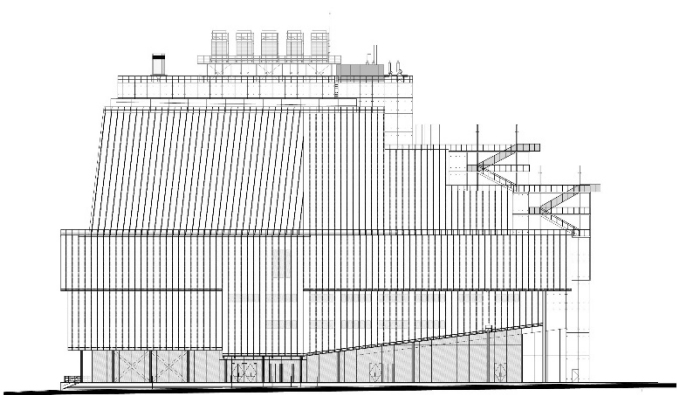
Wall Type 1:
Precast concrete panels

Wall Type 2:
Unitized curtain wall with
steel plate rain screen

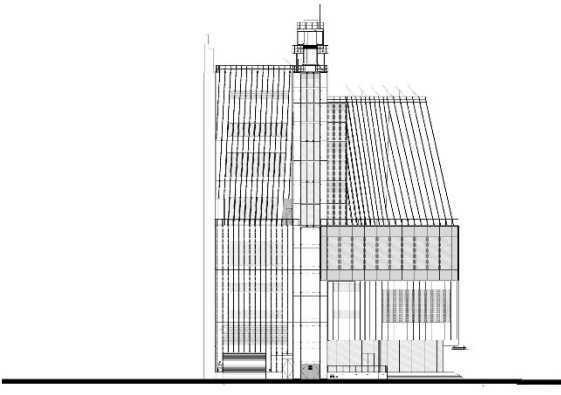
Wall Types 3, 4, 5, 8 + 10:
Large insulating glass units
capture-glazed onto custom
steel framing

Wall Type 6:
Tension cable wall with
monolithic glazing

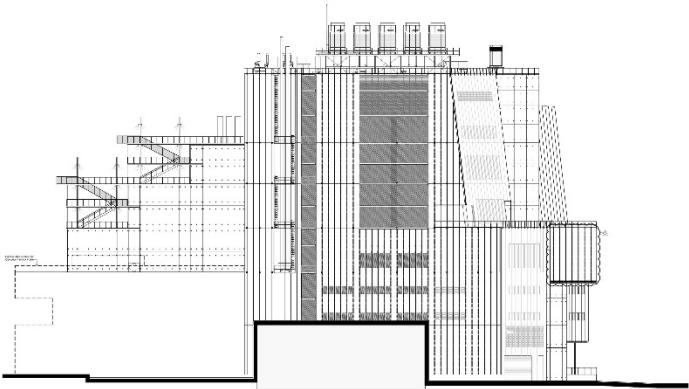
Wall Type 7:
Steel sawtooth monitors
with north-facing clerestory
windows.



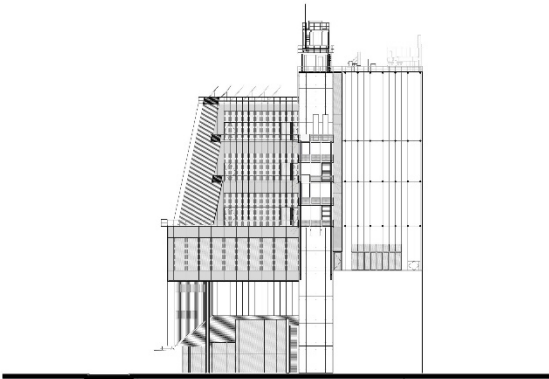
SOUTH ELEVATION



WEST ELEVATION



NORTH ELEVATION



EAST ELEVATION

Facade Overview

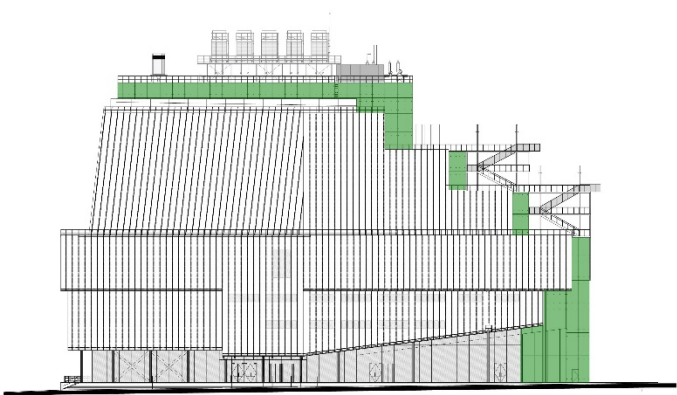
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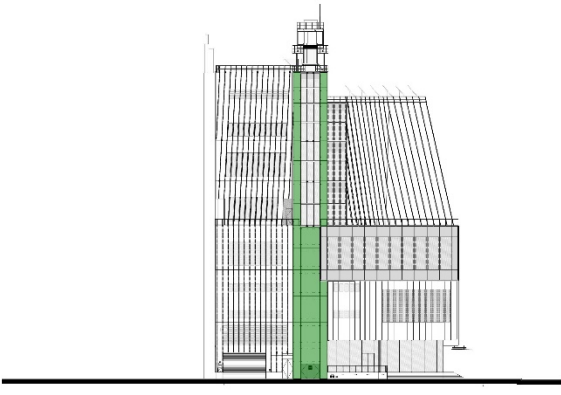
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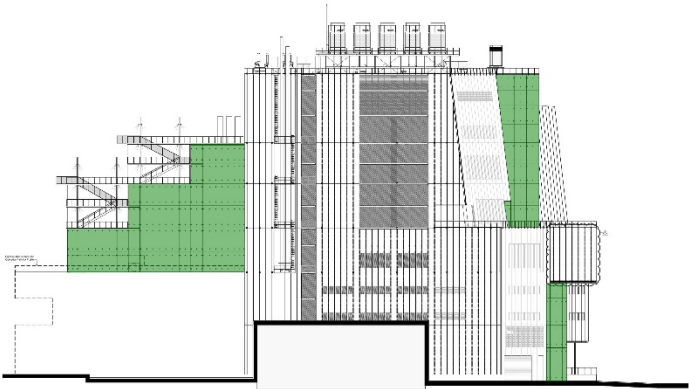
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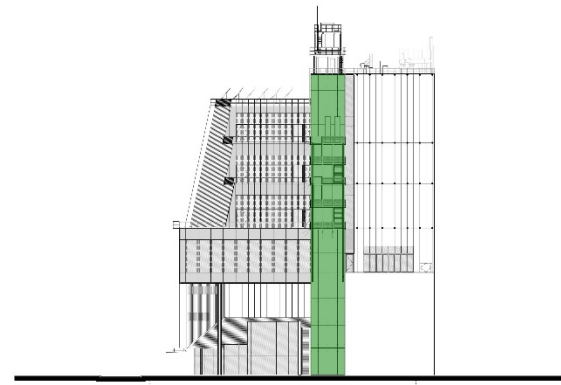
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Facade Overview

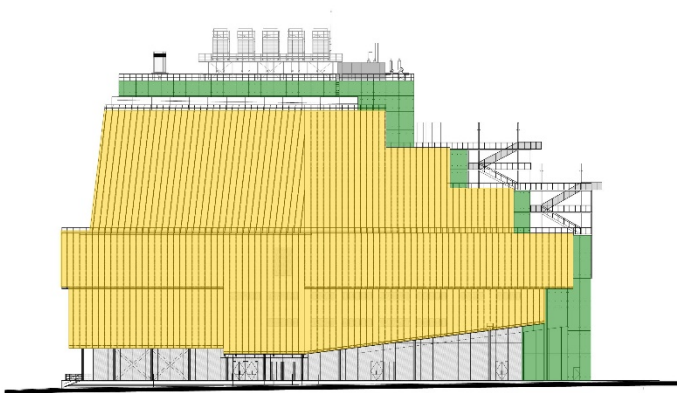
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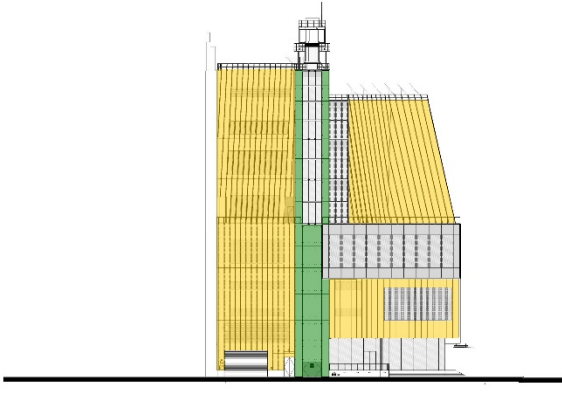
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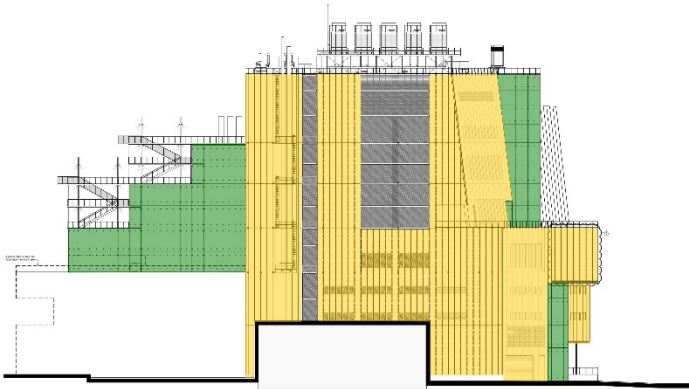
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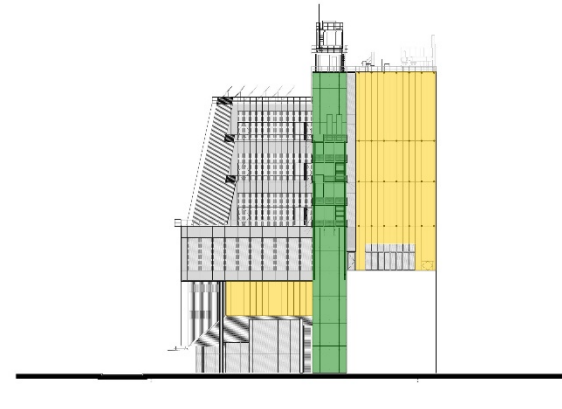
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EAST ELEVATION

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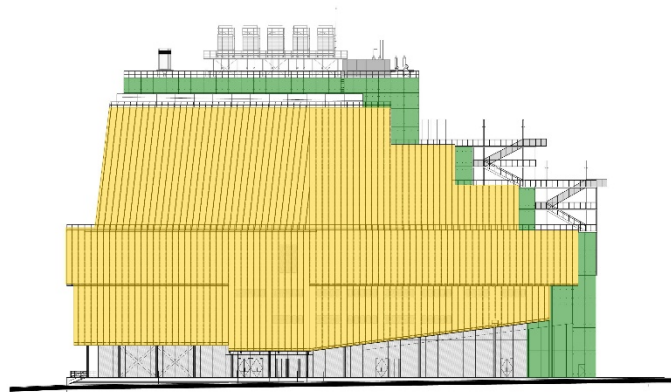
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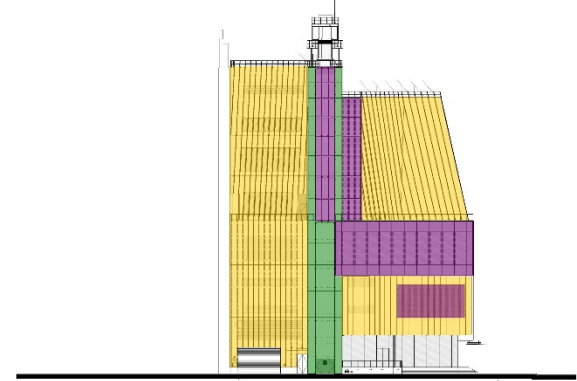
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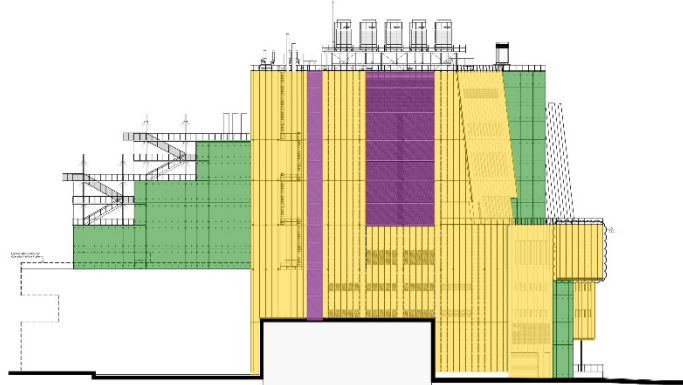
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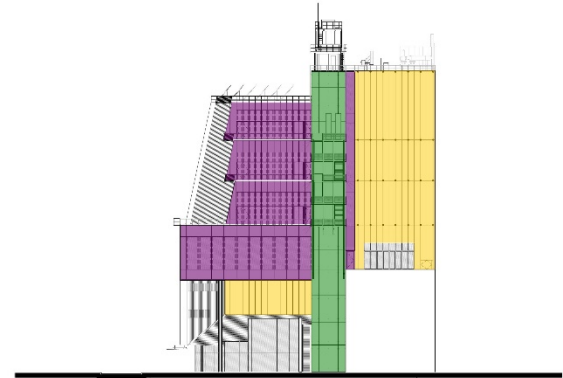
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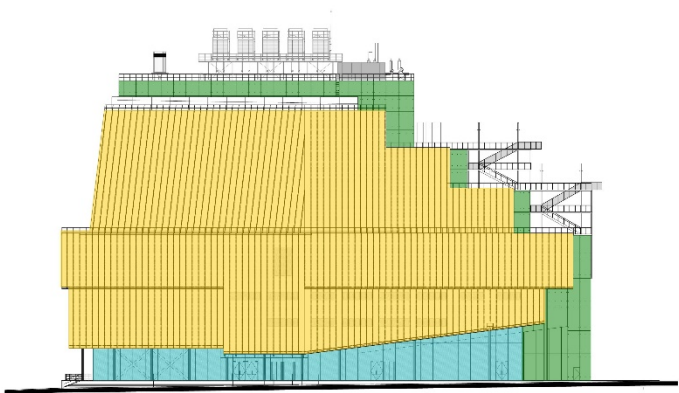
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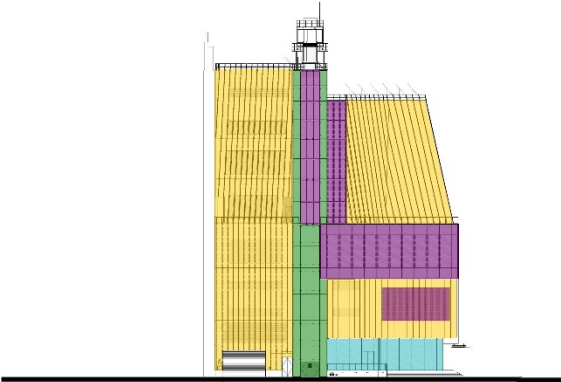
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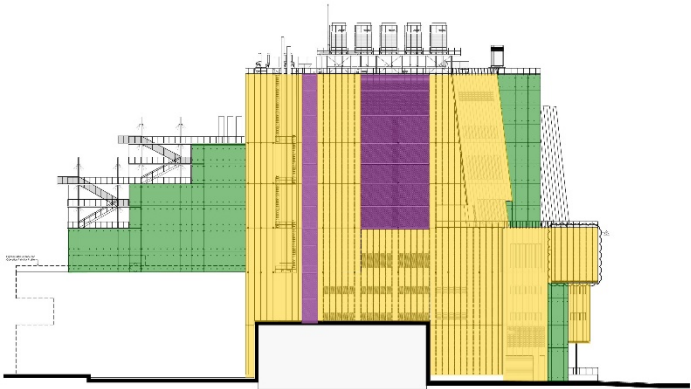
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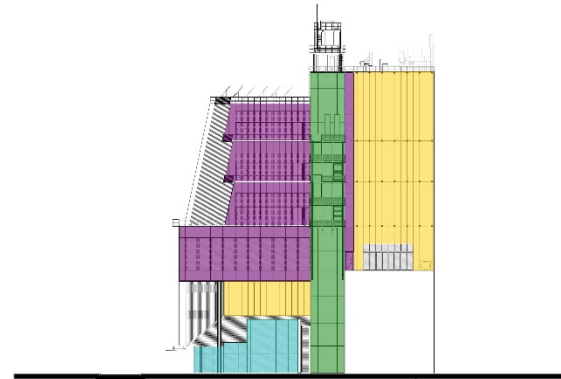
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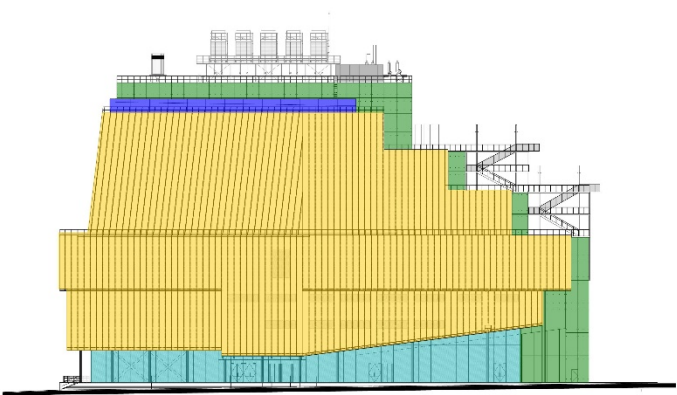
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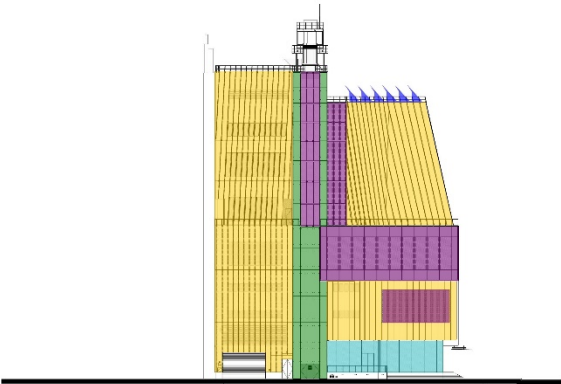
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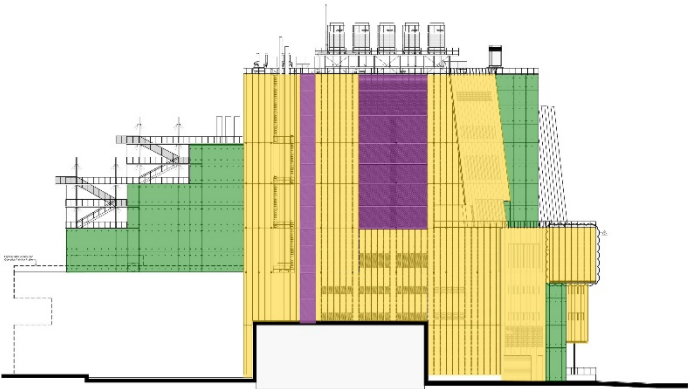
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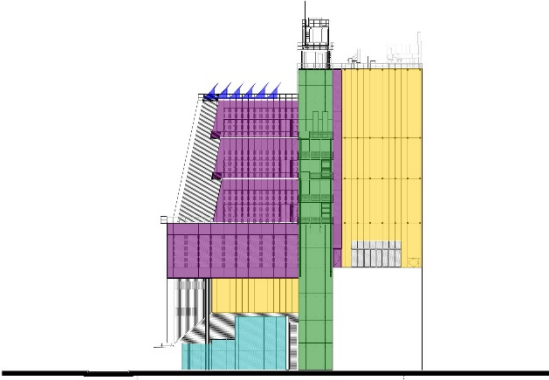
SOUTH ELEVATION



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EAST ELEVATION

Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control



*Unitized curtain wall with
steel plate rain screen*

Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control

*Unitized curtain wall with
steel plate rain screen*

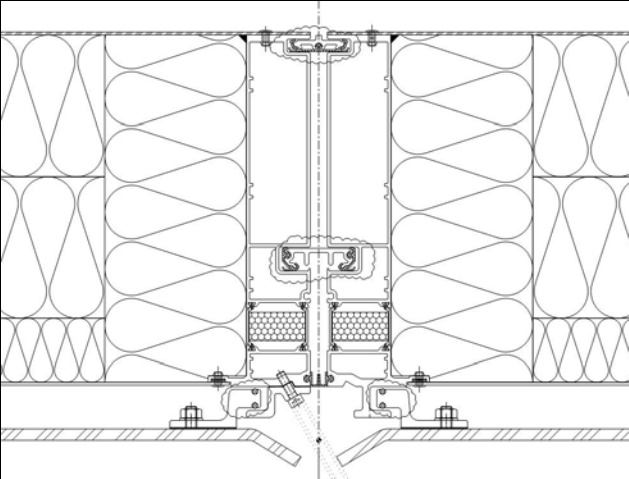
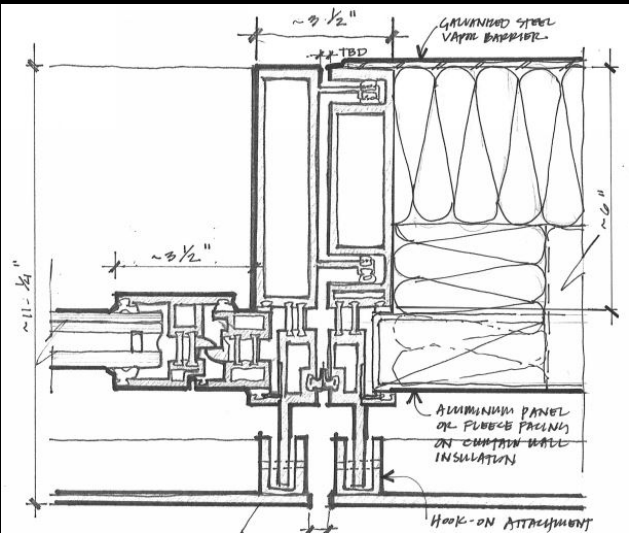


Steel-clad curtain wall

- Thermal Performance
- Condensation Mitigation
- Quality Control



*Unitized curtain wall with
steel plate rain screen*

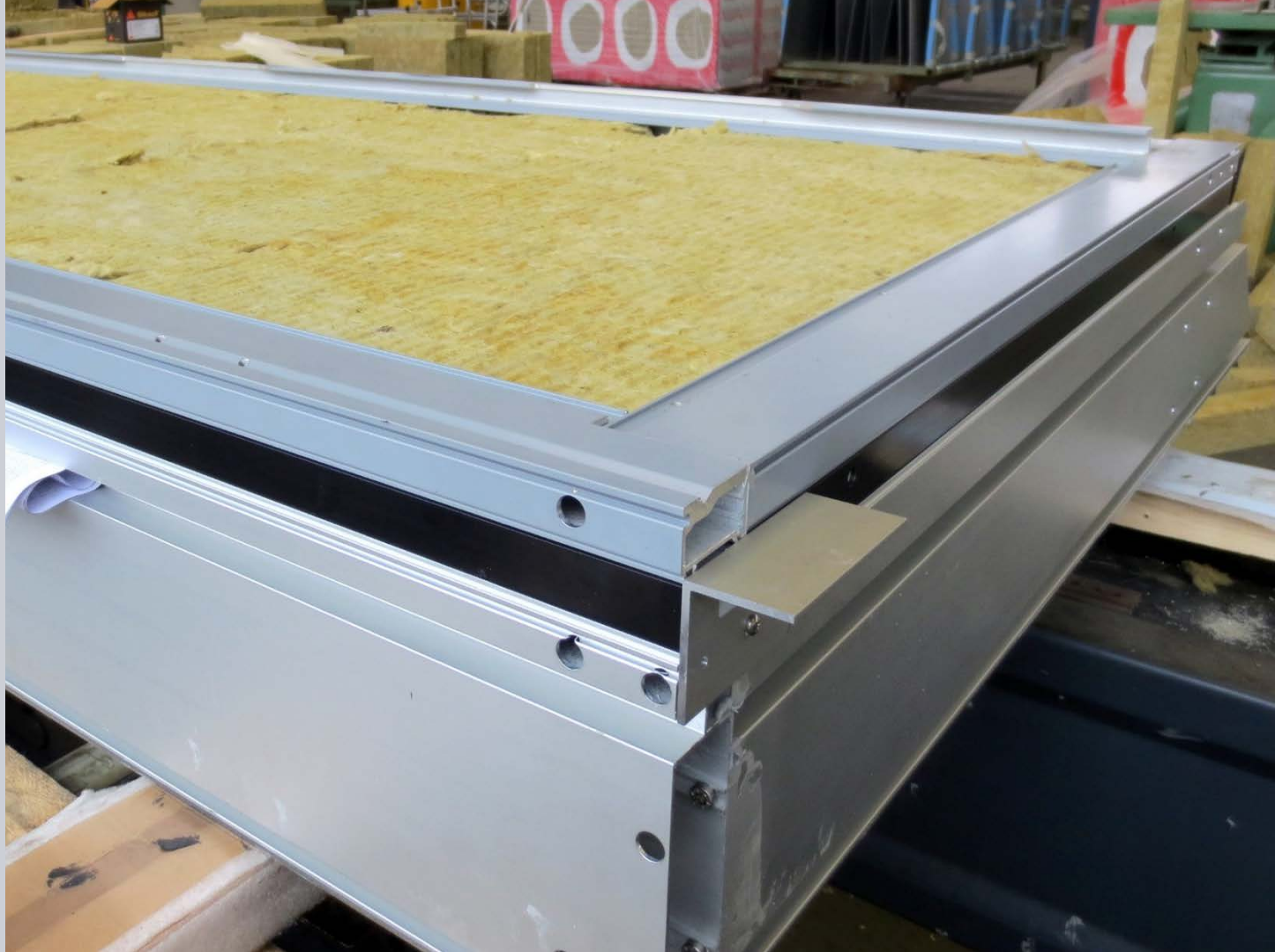


Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control



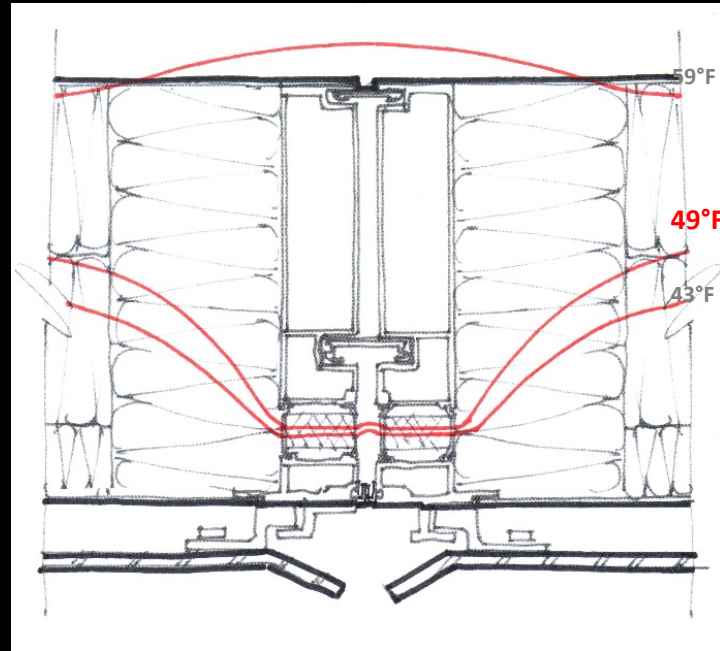
Thermal Insulation

Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control



Wintertime Design Conditions:

Exterior Temperature:	13 °F
Interior Temperature:	72 °F
Interior Relative Humidity:	45%
Dewpoint:	49 °F

Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control



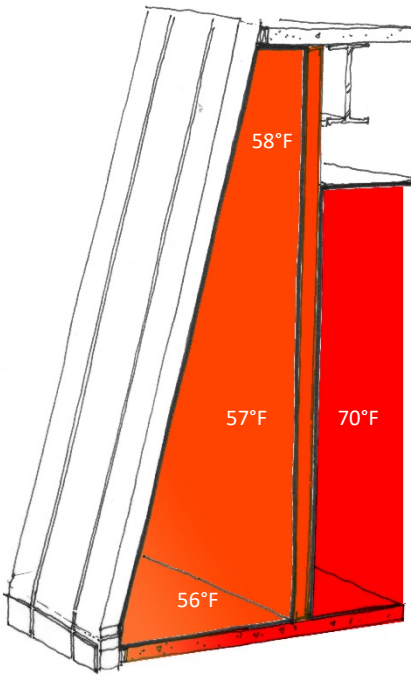
Galvanized steel air seal sheet

Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control



Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control



Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control



Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control



Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control



Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control

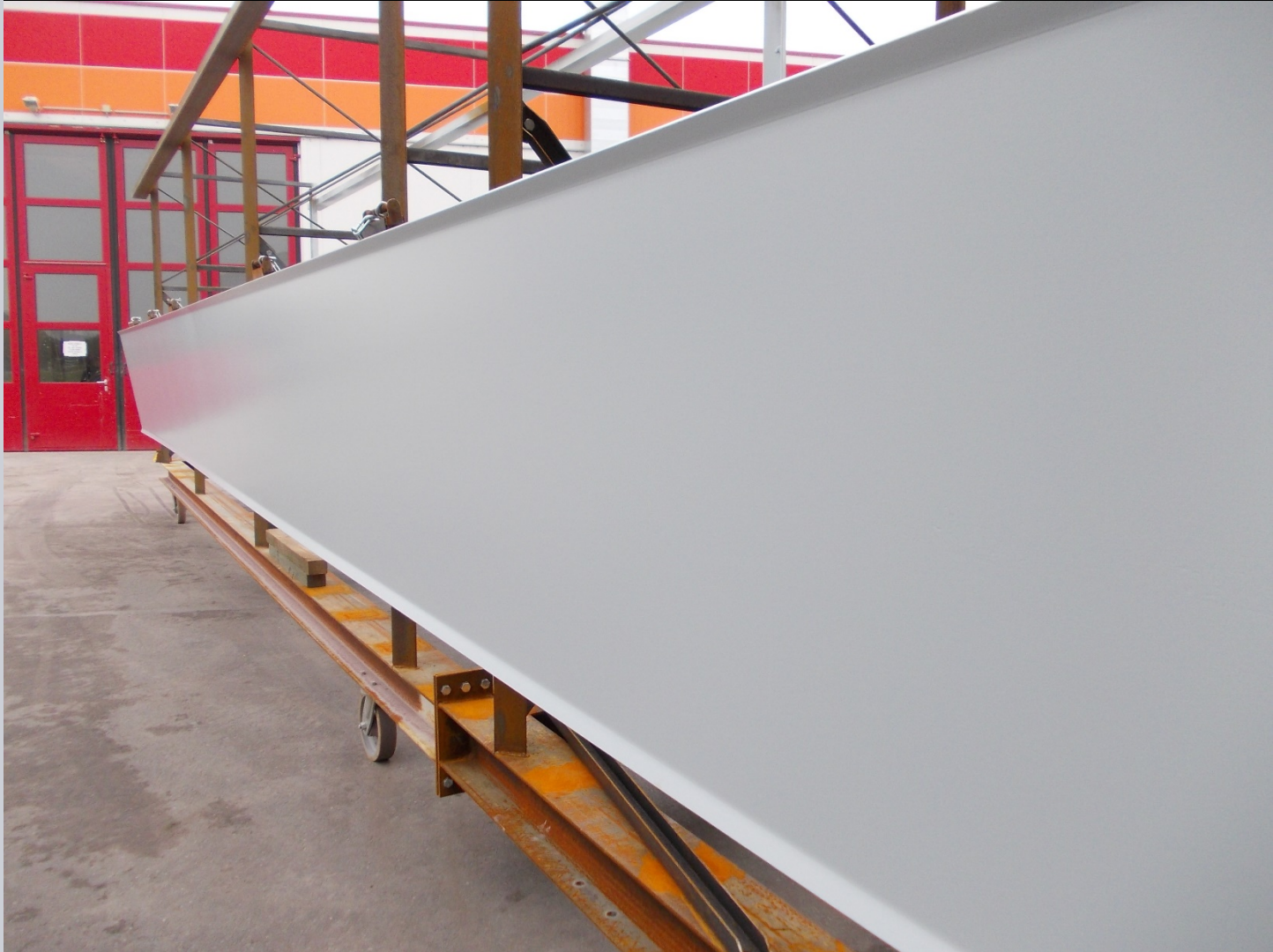


Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control



Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

Quality Control



Steel-clad curtain wall

Thermal Performance

Condensation Mitigation

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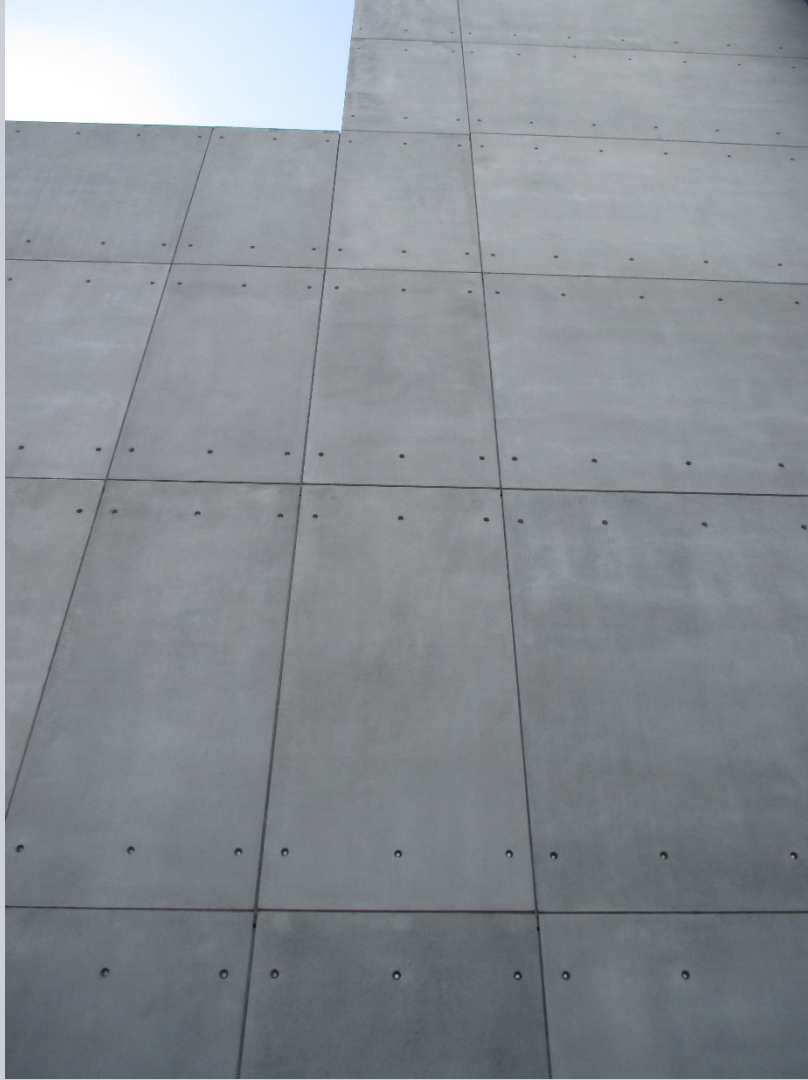


Precast panels

Thermal Performance

Condensation Mitigation

Quality Control



Precast panels

Thermal Performance

Condensation Mitigation

Quality Control



L-shaped precast panels

Precast panels

Thermal Performance

Condensation Mitigation

Quality Control



L-shaped precast panels

Precast panels

Thermal Performance

Condensation Mitigation

Quality Control



Precast panels

Precast panels

Thermal Performance

Condensation Mitigation

Quality Control



L-shaped precast panels

Precast panels

Thermal Performance

Condensation Mitigation

Quality Control



Closed cell spray foam insulation

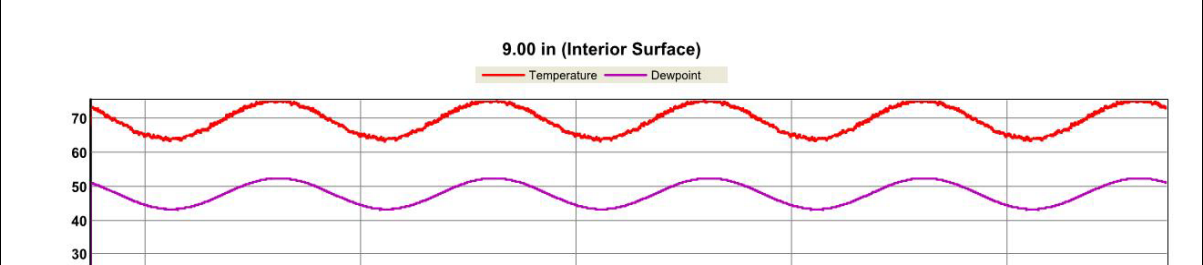
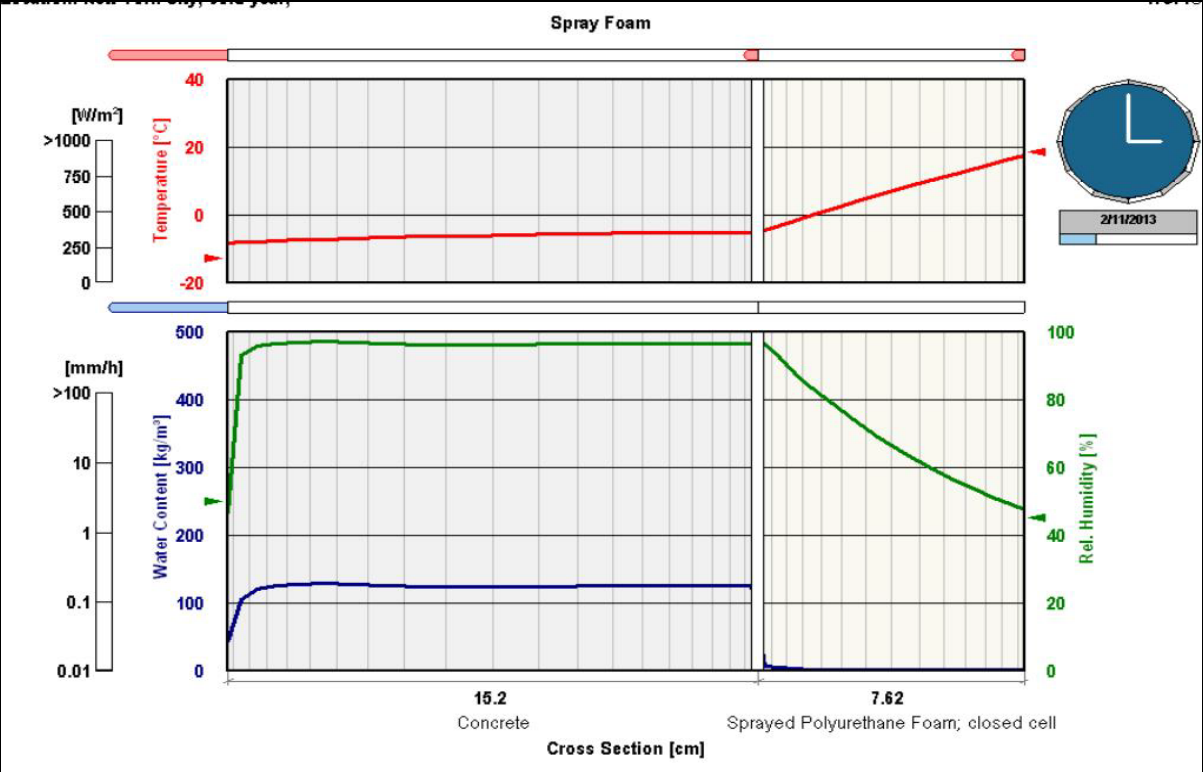
Precast panels

Thermal Performance

Condensation Mitigation

Quality Control

Closed cell spray foam insulation

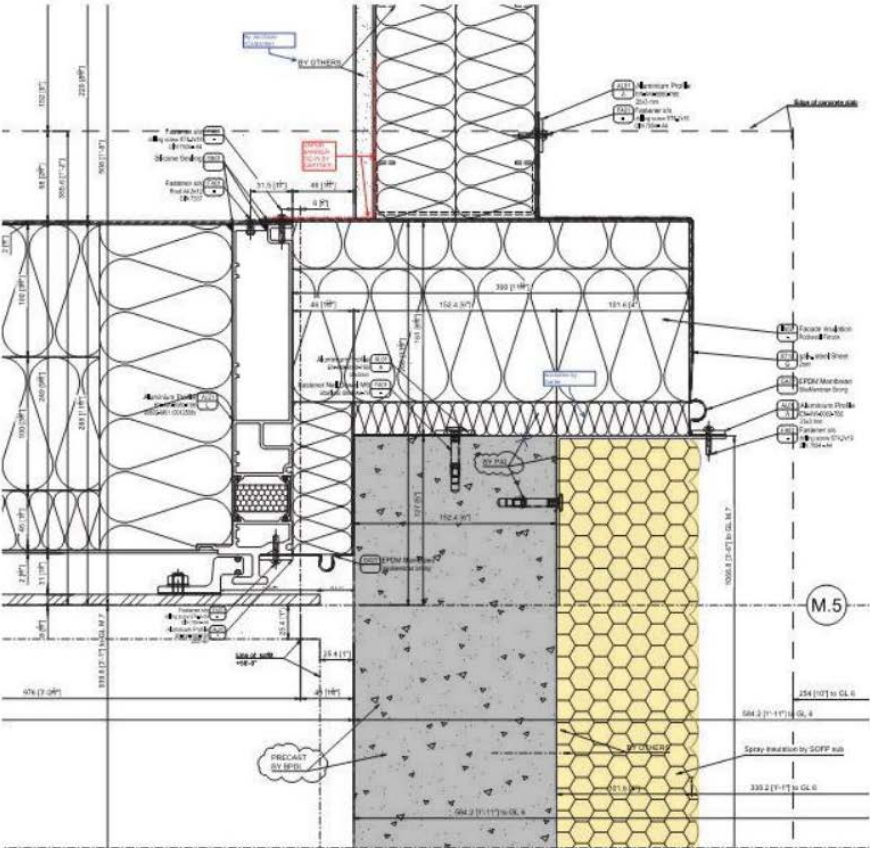


Precast Panels

Thermal Performance

Condensation Mitigation

Quality Control



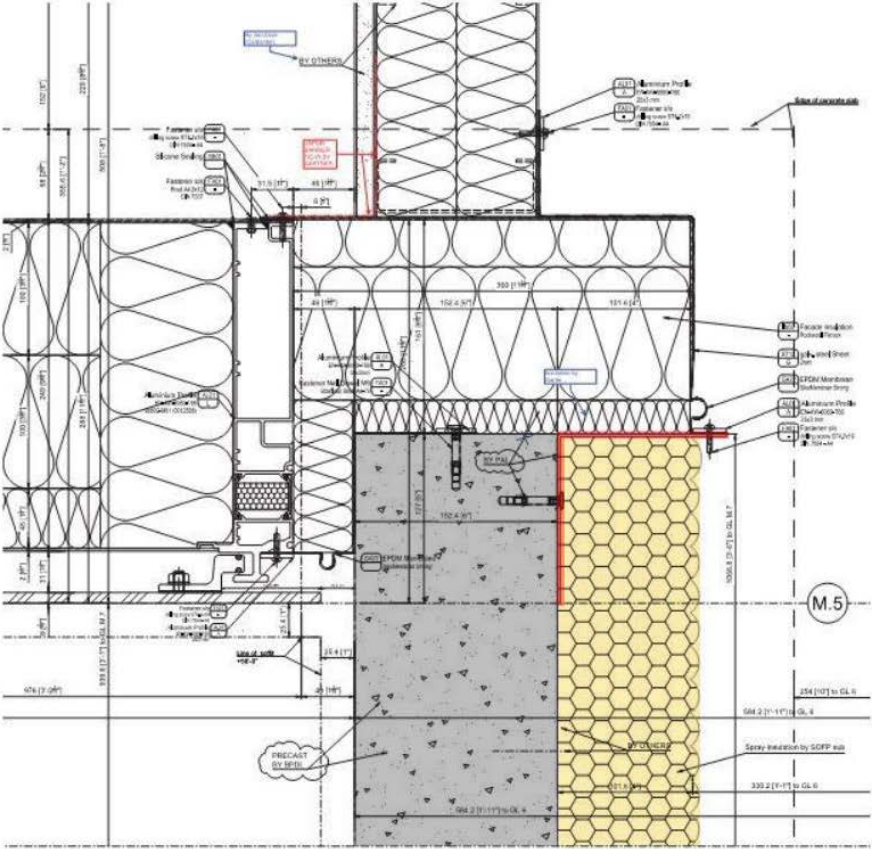
Interface conditions

Precast Panels

Thermal Performance

Condensation Mitigation

Quality Control



Interface conditions

GARTNER: 02-086

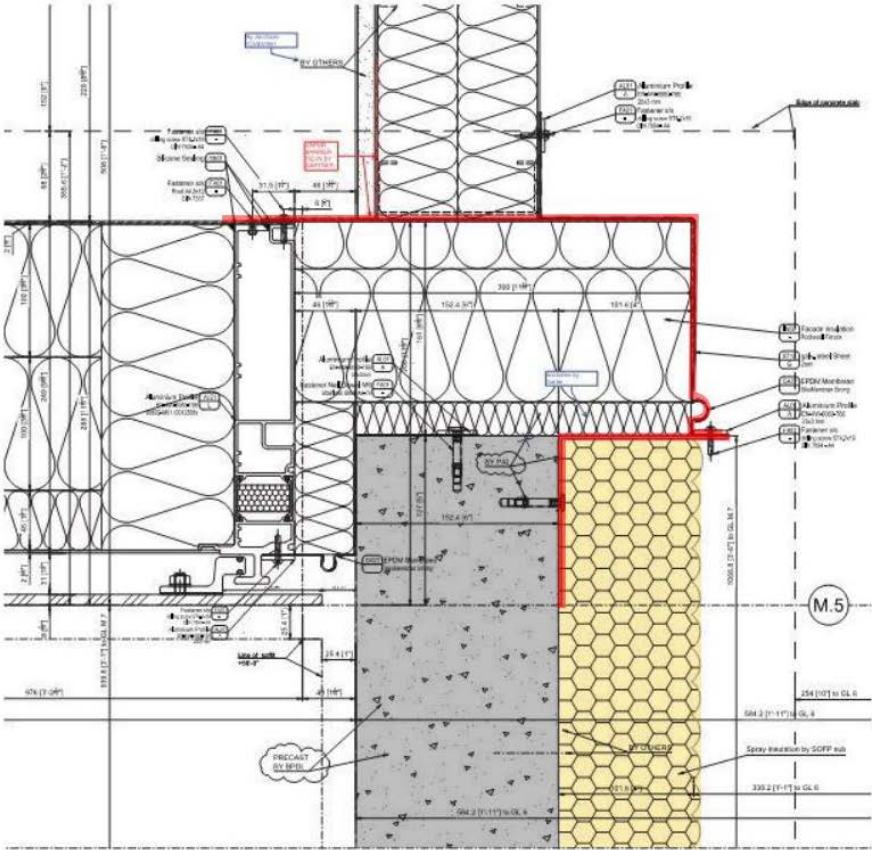
KEY INTERFACE CONDITION #12
heintges

Precast Panels

Thermal Performance

Condensation Mitigation

Quality Control



Interface conditions

GARTNER: 02-086

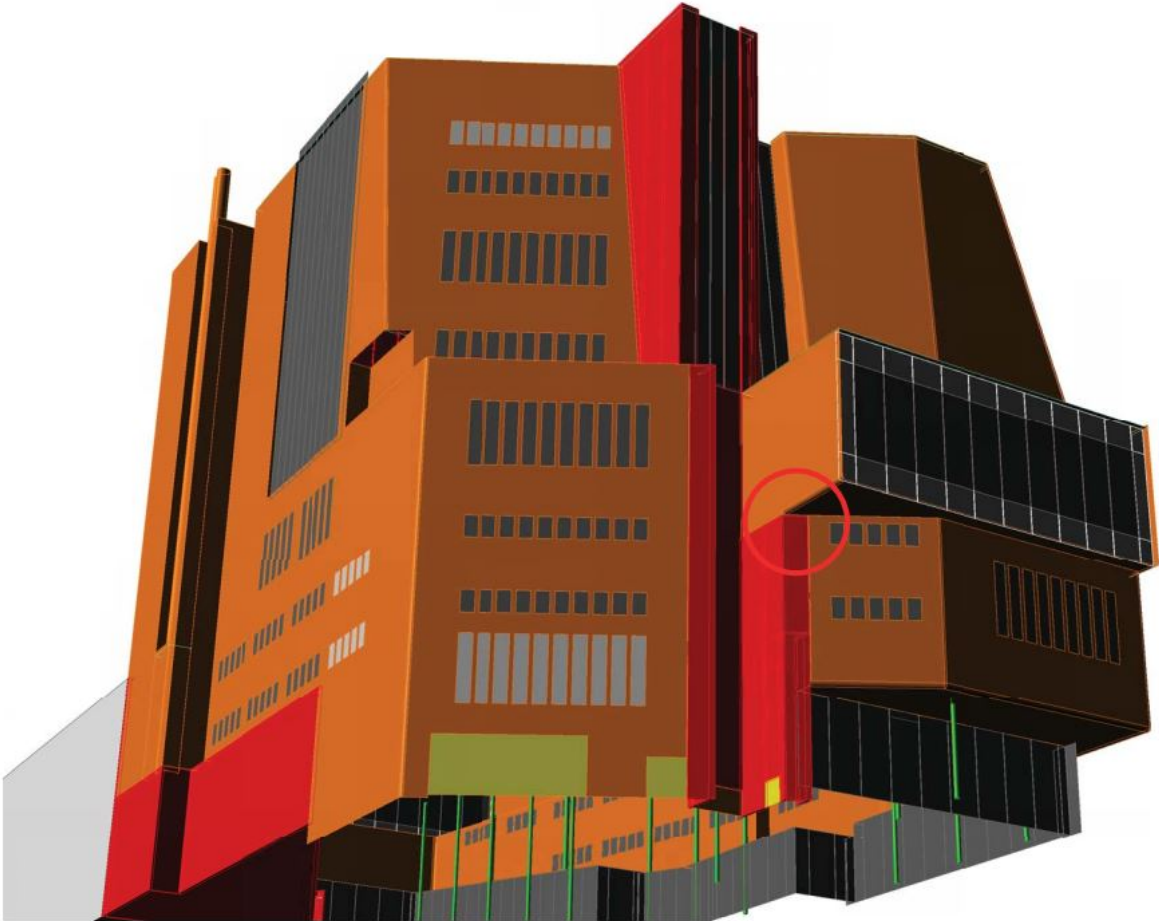
KEY INTERFACE CONDITION #12
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Precast panels

Thermal Performance

Condensation Mitigation

Quality Control



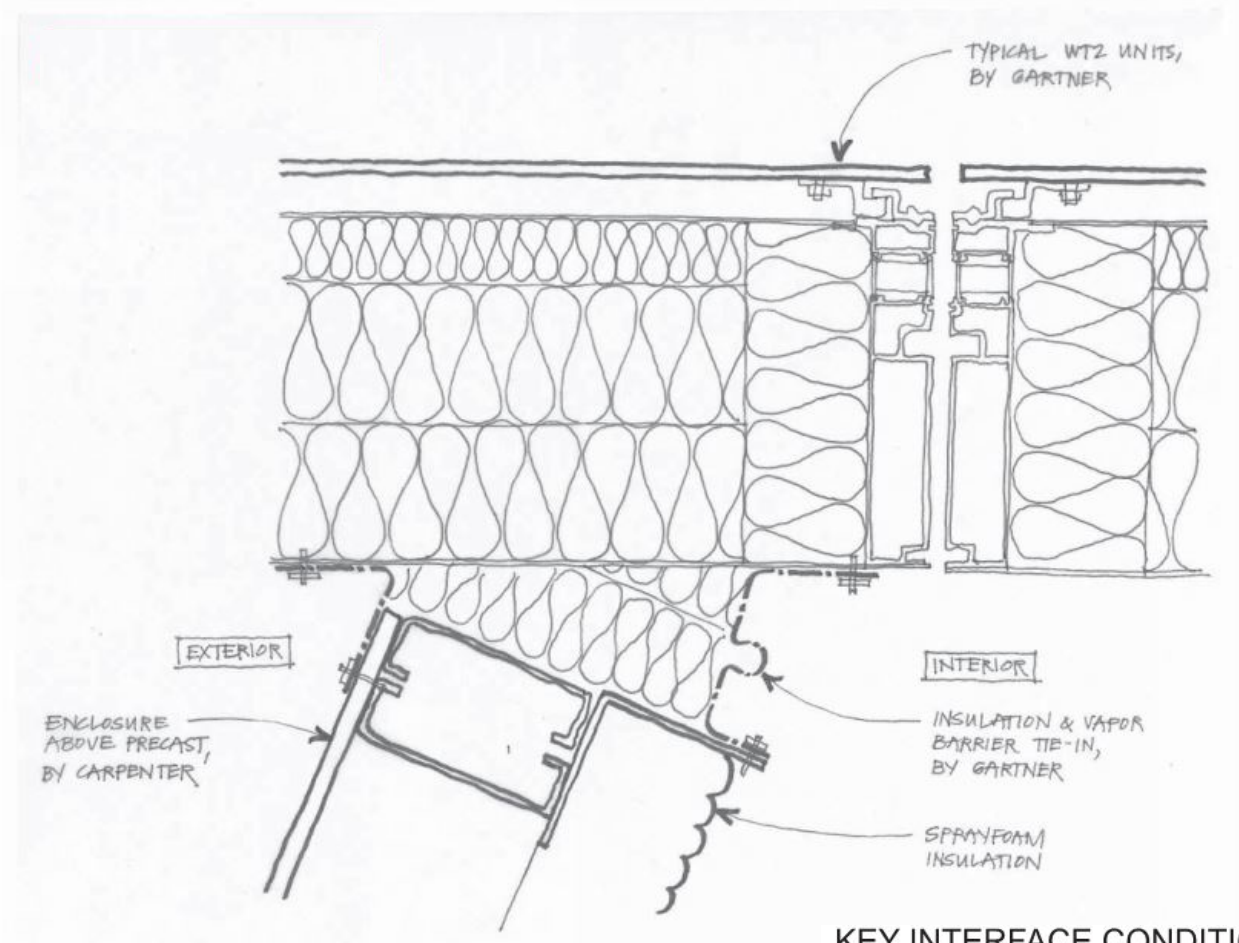
Interface conditions

Precast panels

Thermal Performance

Condensation Mitigation

Quality Control



KEY INTERFACE CONDITION #8

Precast panels

Thermal Performance

Condensation Mitigation

Quality Control

Interface conditions

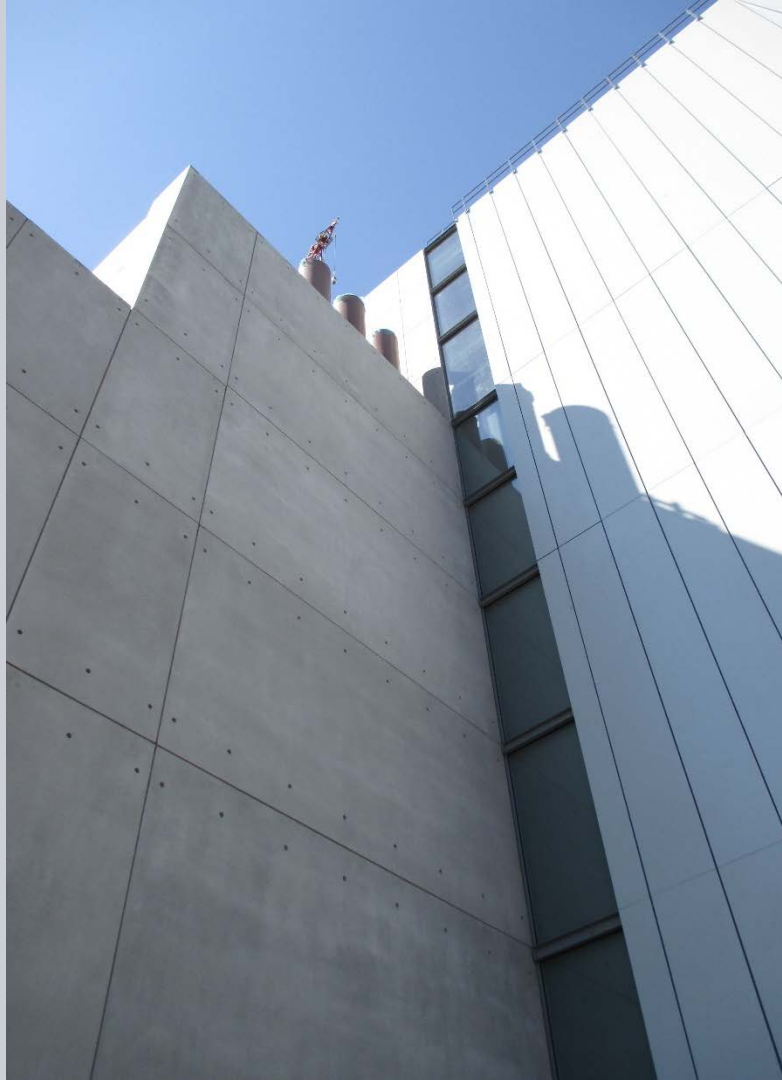


Precast panels

Thermal Performance

Condensation Mitigation

Quality Control



Interface conditions

Glazed curtain wall

Natural Light Control

Condensation Mitigation

Quality Control



Glazed curtain wall

- Natural Light Control
- Condensation Mitigation
- Quality Control



Glazed curtain wall

Natural Light Control

Condensation Mitigation

Quality Control



Glazed curtain wall

Natural Light Control

Condensation Mitigation

Quality Control



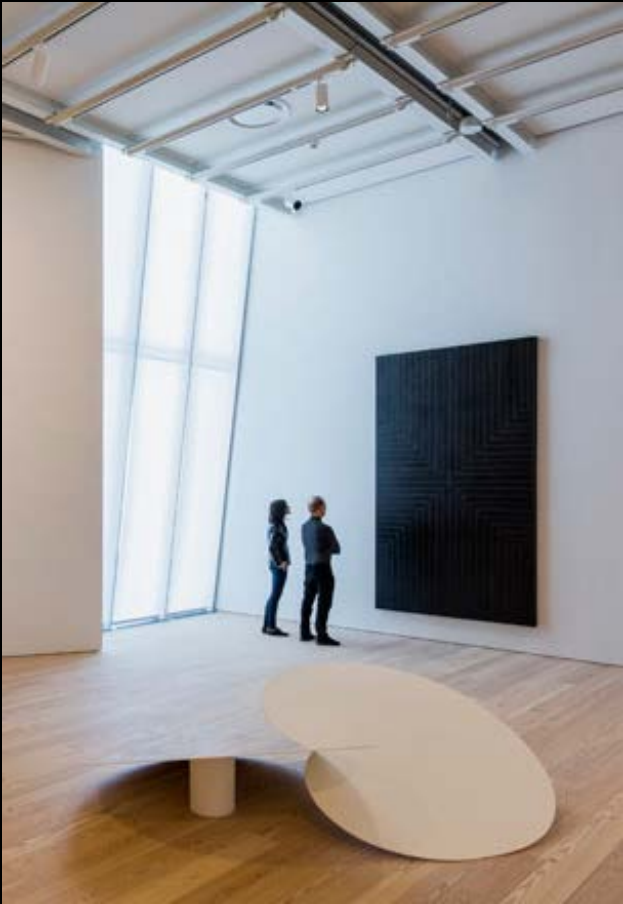
Controlling light levels

Glazed curtain wall

Natural Light Control

Condensation Mitigation

Quality Control



UV control

Glazing from outside to inside

Low Iron Pilkington Optiwhite 10 mm with combi neutral 70/40
12 mm argon
Laminated glass:
Low iron Pilkington Optiwhite 5 mm
1,52 mm PVB- interlayer (Trosifol BG R20)
Low-iron Pilkington Optiwhite 5 mm

light transmittance : approx. 73%
light reflectance (outside) : approx. 13%
light reflectance (inside) : approx. 13%

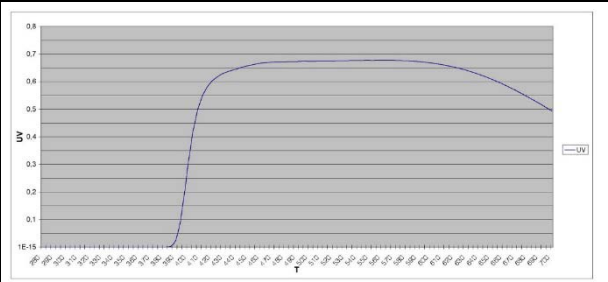
solar direct transmittance : approx. 36%
solar direct reflectance (outside) : approx. 38%
solar direct reflectance (inside) : approx. 37%

solar factor (g-value) : approx. 39%
shading coefficient : approx. 45%

UV-transmittance : approx. 0%
UV-reflectance : approx. 8%
UV-absorption : approx. 92%

color rendering index : approx. 97

thermal transmittance (NFRC) Ug: approx. 1,36 W/m²K



UV transmittance by wave length

Glazed curtain wall

Natural Light Control

Condensation Mitigation

Quality Control



Mechanical Shades

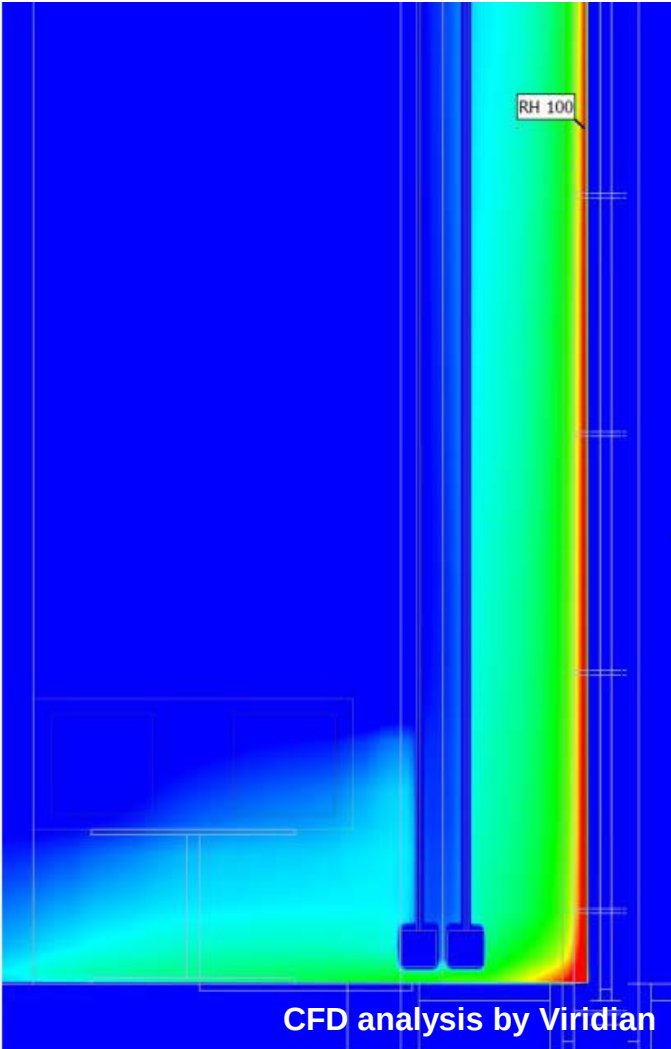
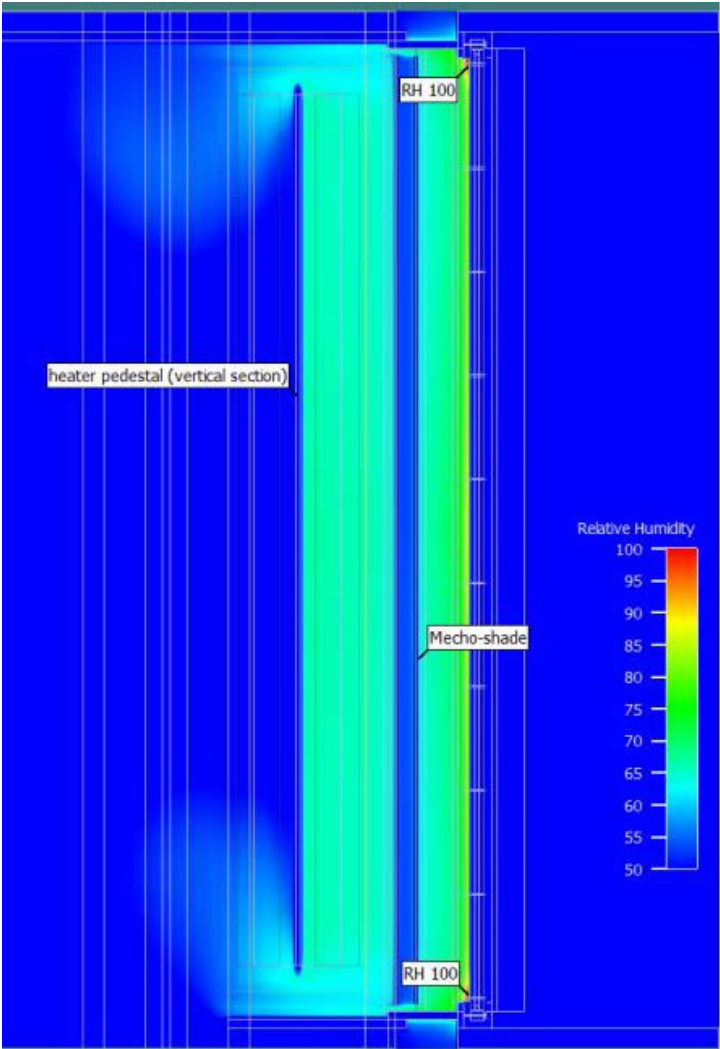
Glazed curtain wall

Natural Light Control

Condensation Mitigation

Quality Control

Mechanical Shades



CFD analysis by Viridian

Glazed curtain wall

Natural Light Control

Condensation Mitigation

Quality Control



Blocking direct solar penetration

Glazed curtain wall

Natural Light Control

Condensation Mitigation

Quality Control



Ceramic frit

Rooftop Monitors

Natural Light Control

Condensation Mitigation

Quality Control



Rooftop Monitors

- Natural Light Control
- Condensation Mitigation
- Quality Control

Pre-fabricated framing



Rooftop Monitors

Natural Light Control

Condensation Mitigation

Quality Control



Rooftop Monitors

Natural Light Control

Condensation Mitigation

Quality Control



Daylighting

Rooftop Monitors

Natural Light Control

Condensation Mitigation

Quality Control



Daylighting

Rooftop Monitors

Natural Light Control

Condensation Mitigation

Quality Control



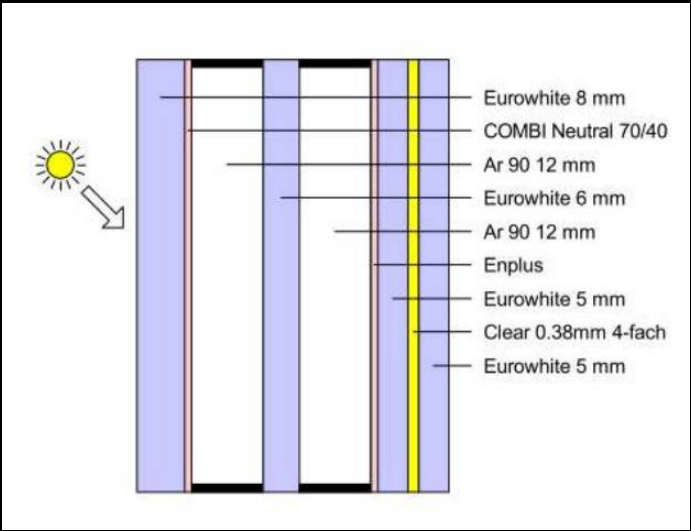
Rooftop monitors

Rooftop Monitors

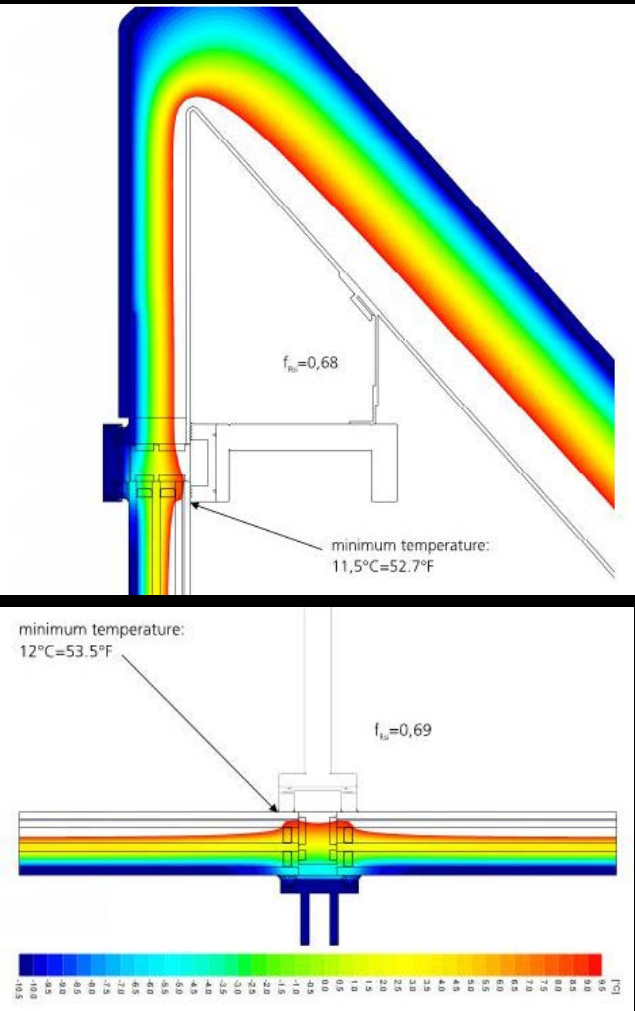
Natural Light Control

Condensation Mitigation

Quality Control



Glazing U-value: 0.12 Btu/hr ft² °F
System U-Value: 0.11 Btu/hr ft² °F



Triple glazing

Rooftop Monitors

Natural Light Control

Condensation Mitigation

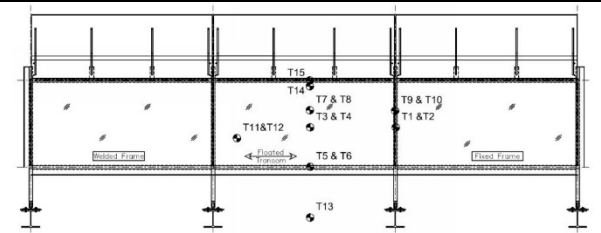
Quality Control



Thermal cycling: AAMA 501.5

Rooftop Monitors

Natural Light Control
Condensation Mitigation
Quality Control



thermocouples locations (inside and outside)

vertical glass side

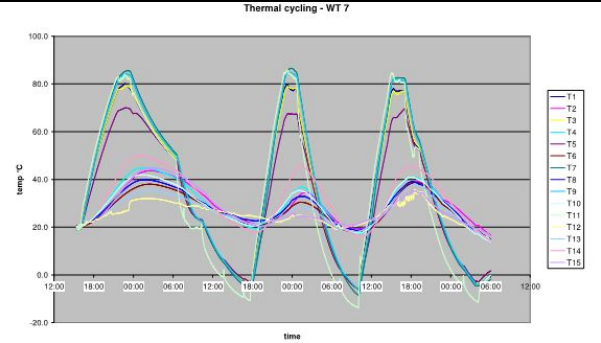
- | | | | |
|-----|----------------------------|-----|------------------------|
| T1 | mullion outside | T2 | mullion inside |
| T3 | center of glass outside | T4 | center of glass inside |
| T5 | transom outside | T6 | transom inside |
| T14 | upper edge of glass inside | T15 | upper transom inside |

inclined panel side

- | | | | |
|----|-------------------------------|-----|-------------------------------|
| T7 | center of metal panel outside | T8 | center of metal panel outside |
| T9 | edge of metal panel outside | T10 | edge of metal panel inside |

gutter

- | | |
|-----|---------------|
| T13 | gutter inside |
|-----|---------------|



Thermal cycling: AAMA 501.5

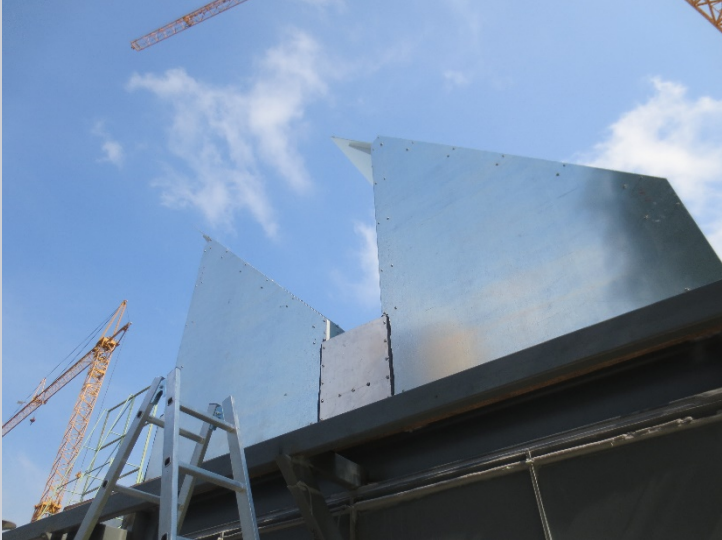
Min Interior Surface Temp: 60.9 F

Rooftop Monitors

Natural Light Control

Condensation Mitigation

Quality Control



Flood testing and vector mapping



Tension Cable Wall

Natural Light Control

Condensation Mitigation

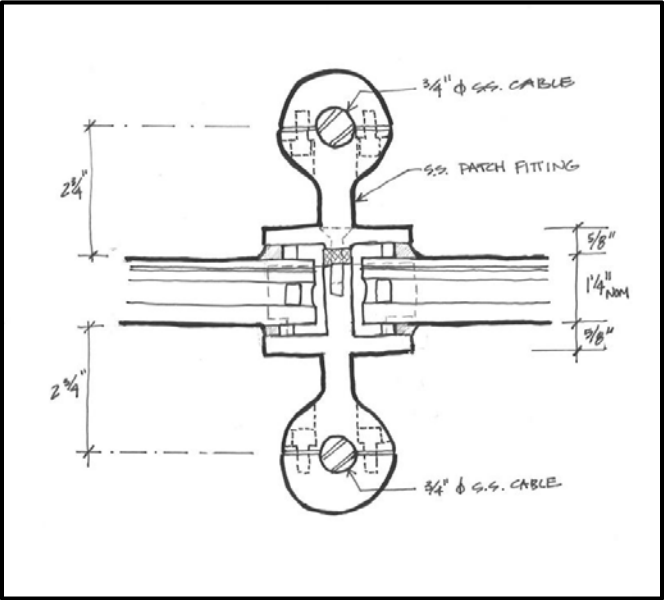
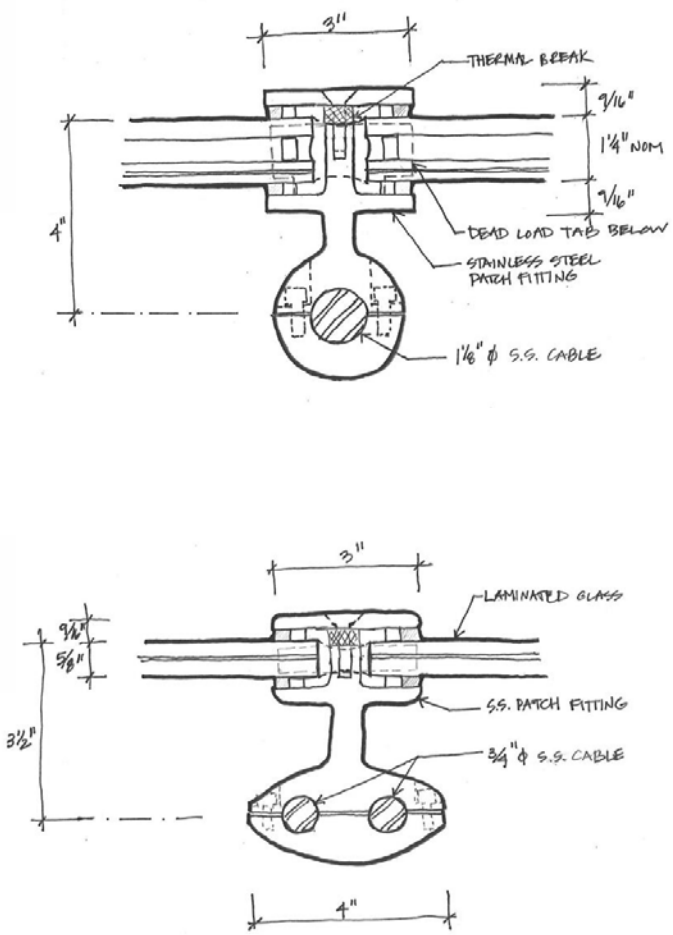
Quality Control



Lobby

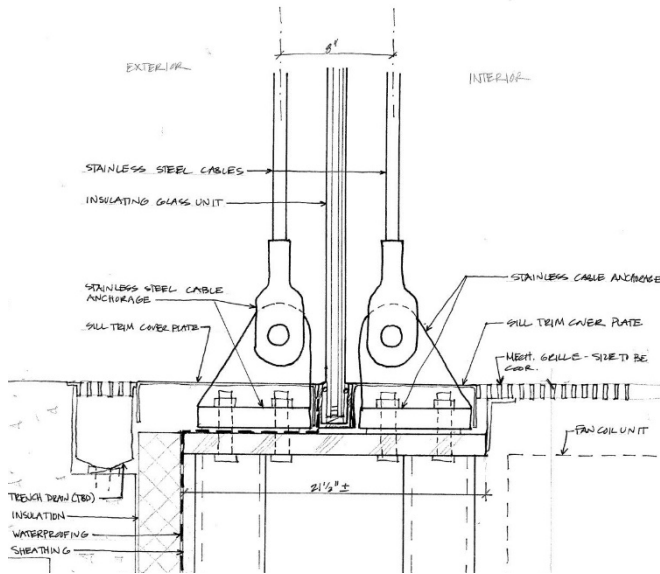
Tension Cable Wall

- Natural Light Control
- Condensation Mitigation
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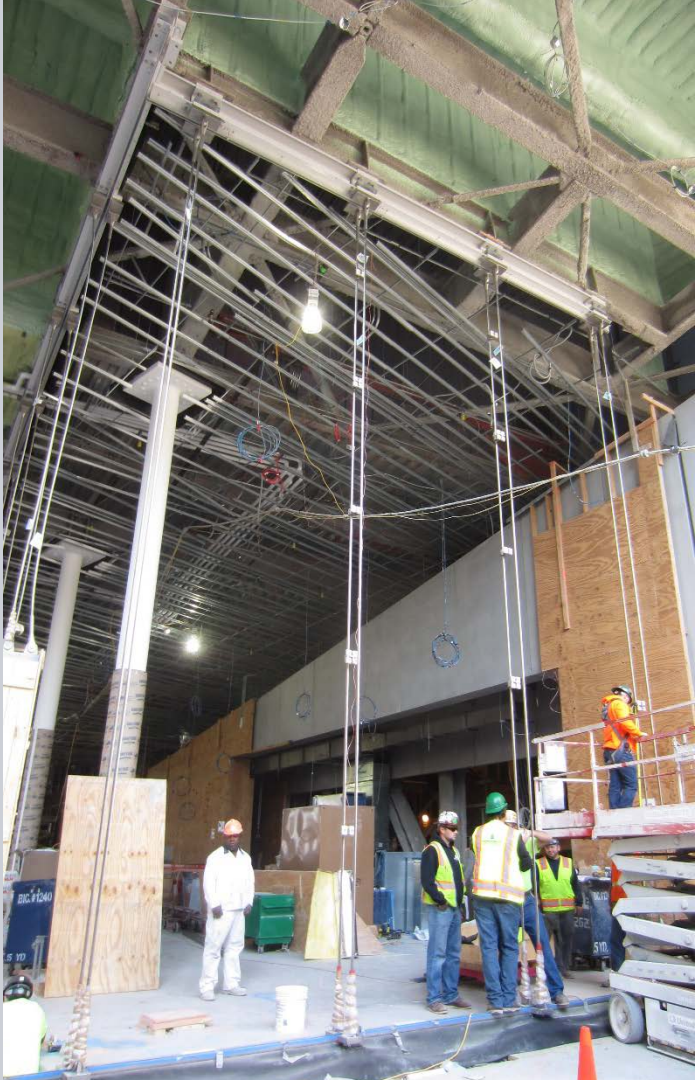
Tension Cable Wall

- Natural Light Control
- Condensation Mitigation
- Quality Control



Tension Cable Wall

- Natural Light Control
- Condensation Mitigation
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Tension measurement



Tension Cable Wall

Natural Light Control

Condensation Mitigation

Quality Control



Tension Cable Wall

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Thank you

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