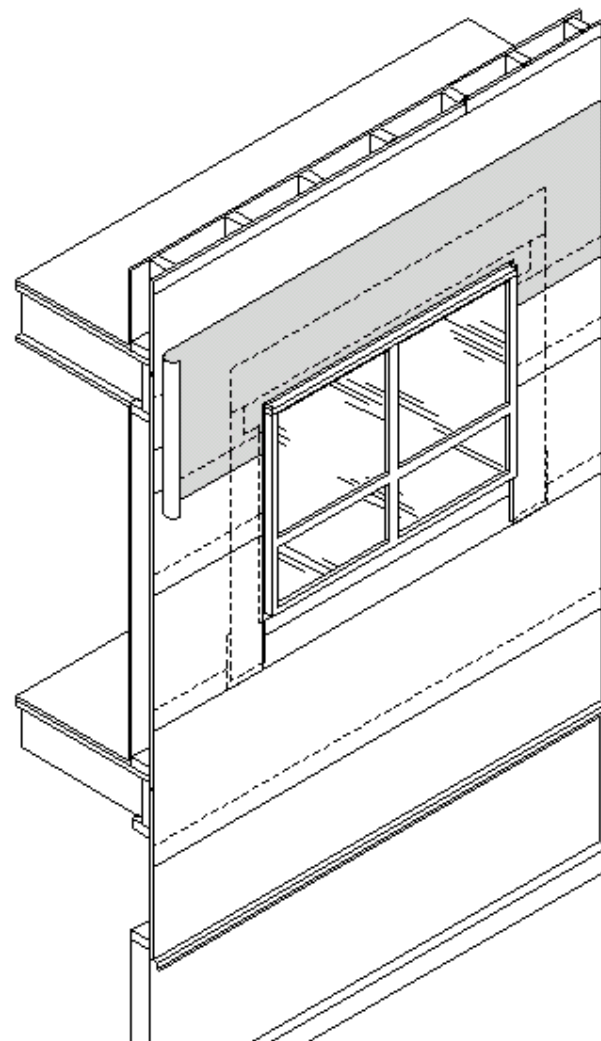


18

Building paper installation second layer fifth row



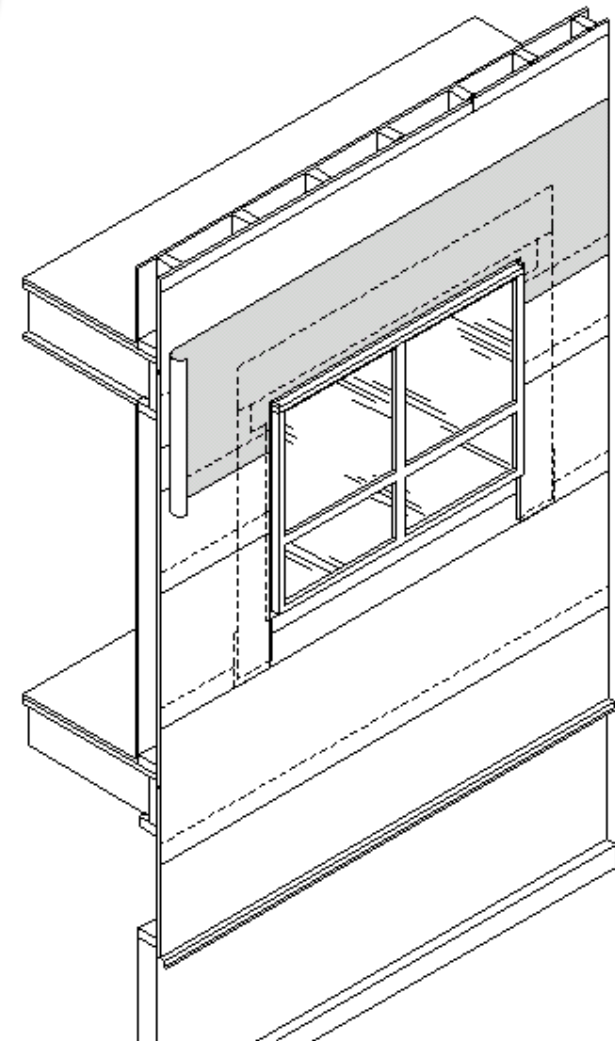
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**



**18** Building paper installation second layer fifth row



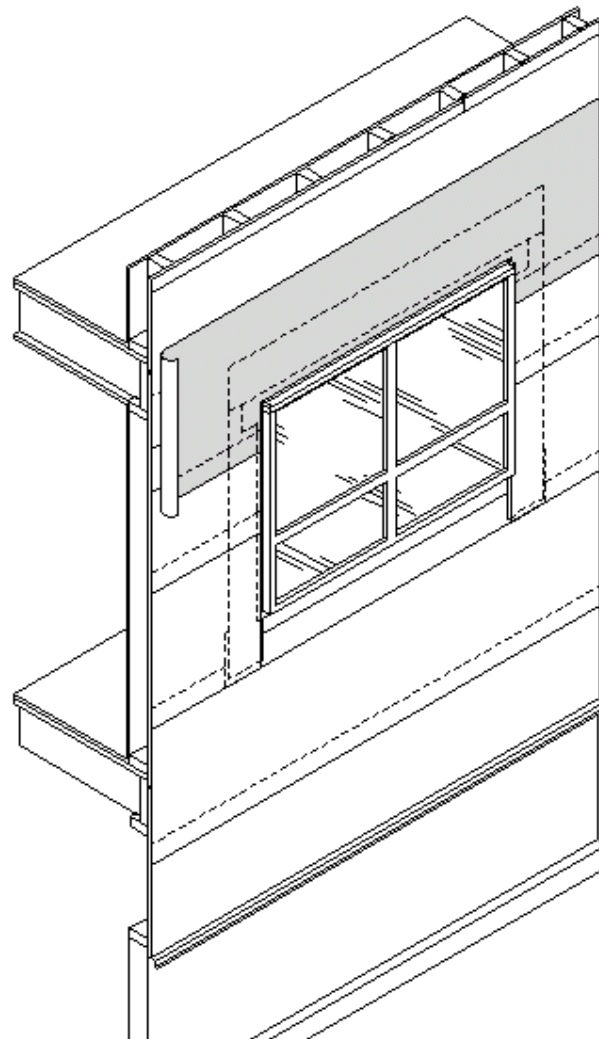
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



18

Building paper installation second layer fifth row



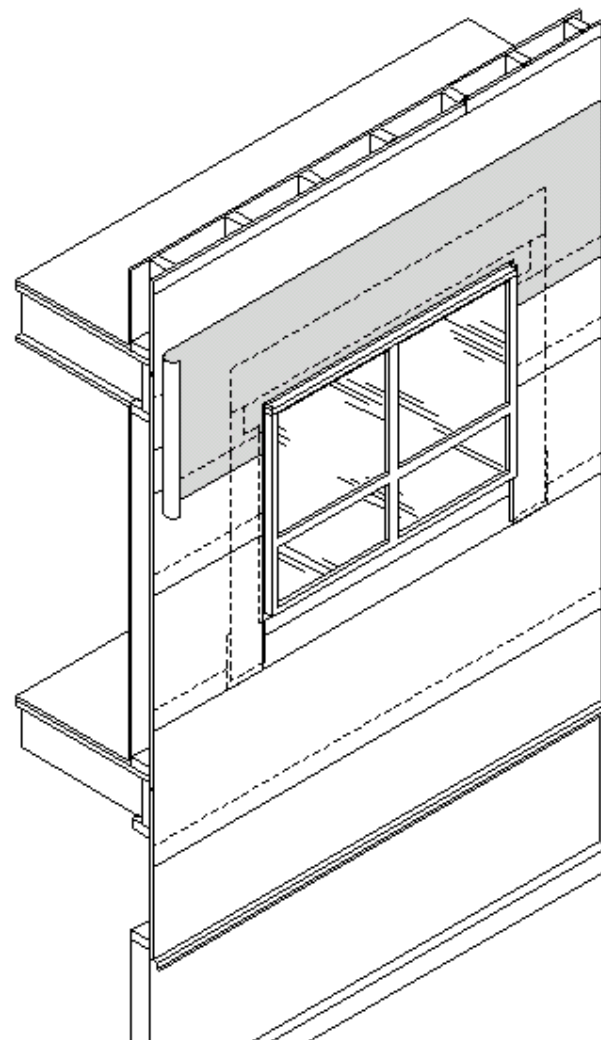
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

18

Building paper installation second layer fifth row



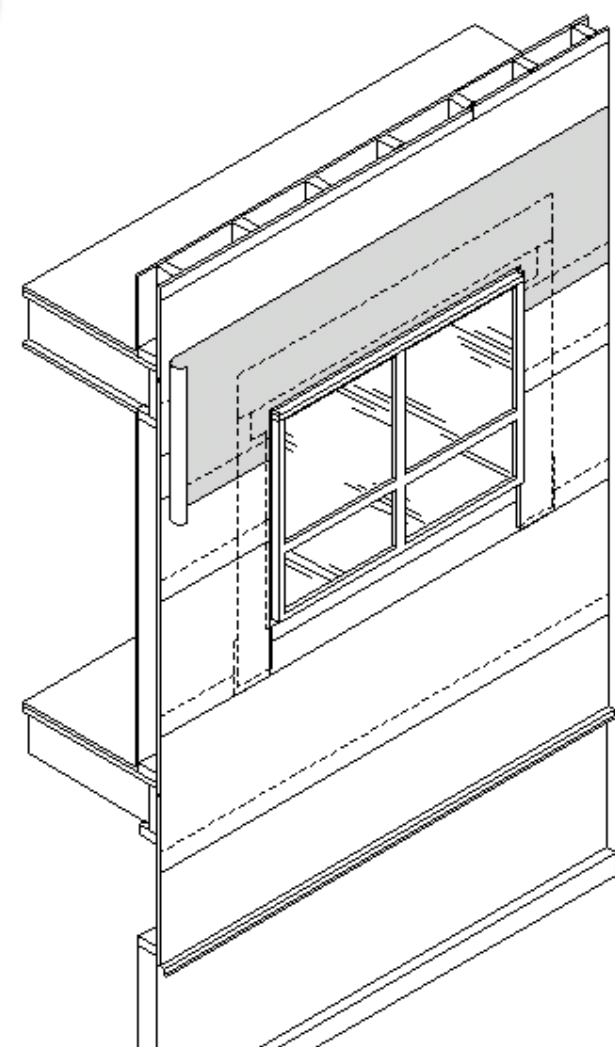
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**



**18** Building paper installation second layer fifth row

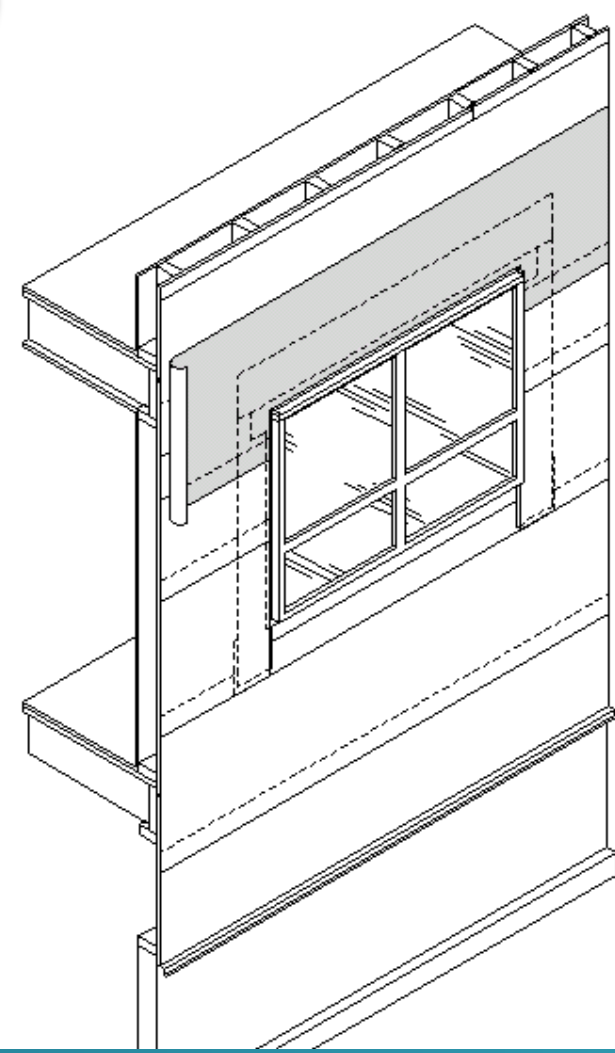


*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



**18** Building paper installation second layer fifth row



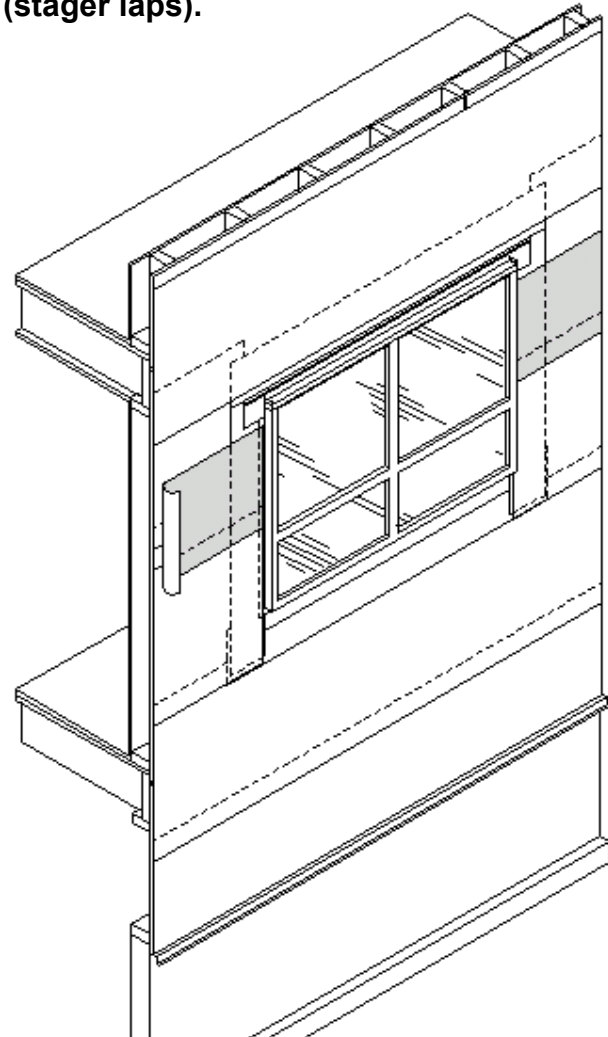
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



17

Building paper installation second layer fourth row (stager laps).



*Raising the Bar*

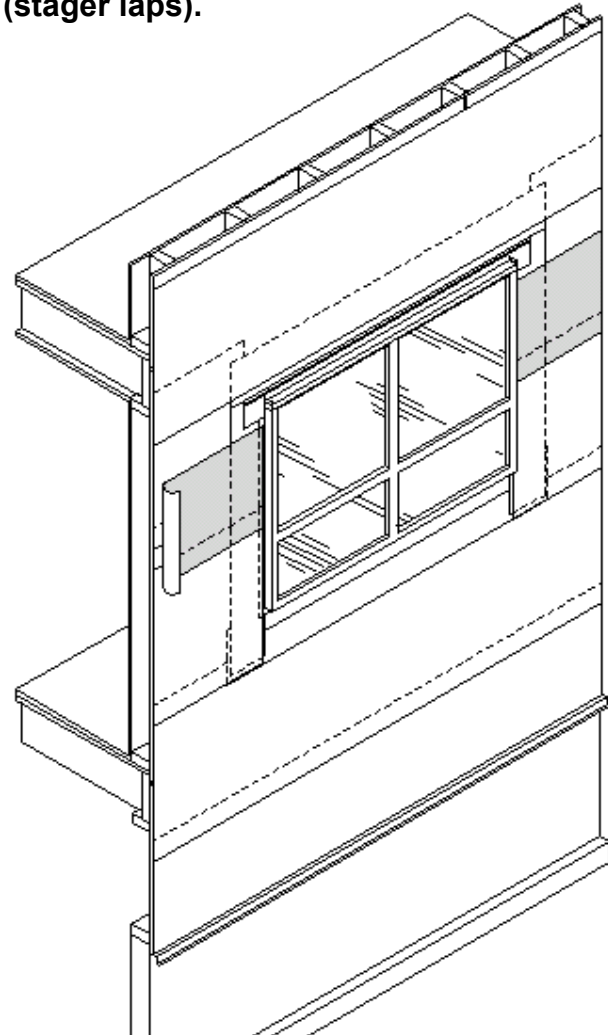
Refining Construction Details through

**Design Verification Testing**



17

Building paper installation second layer fourth row (stager laps).



*Raising the Bar*

Refining Construction Details through

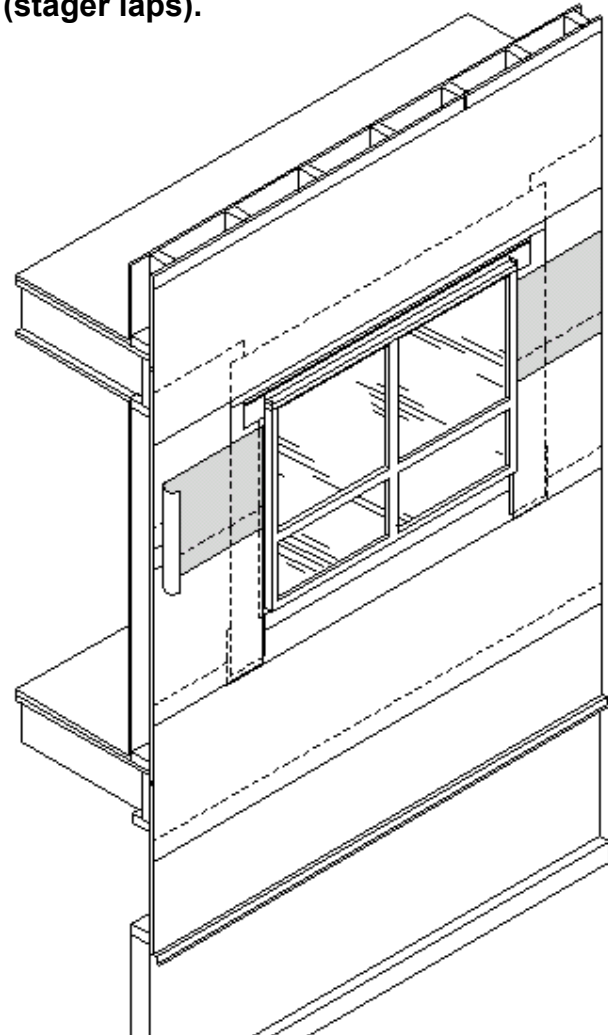
**Design Verification Testing**





17

Building paper installation second layer fourth row (stager laps).



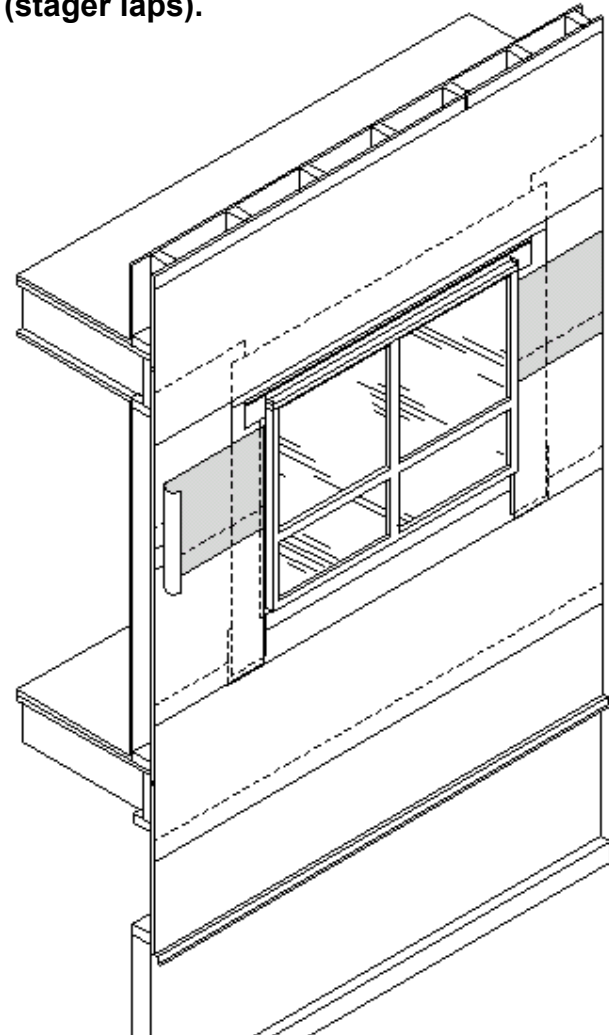
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



17

Building paper installation second layer fourth row (stager laps).



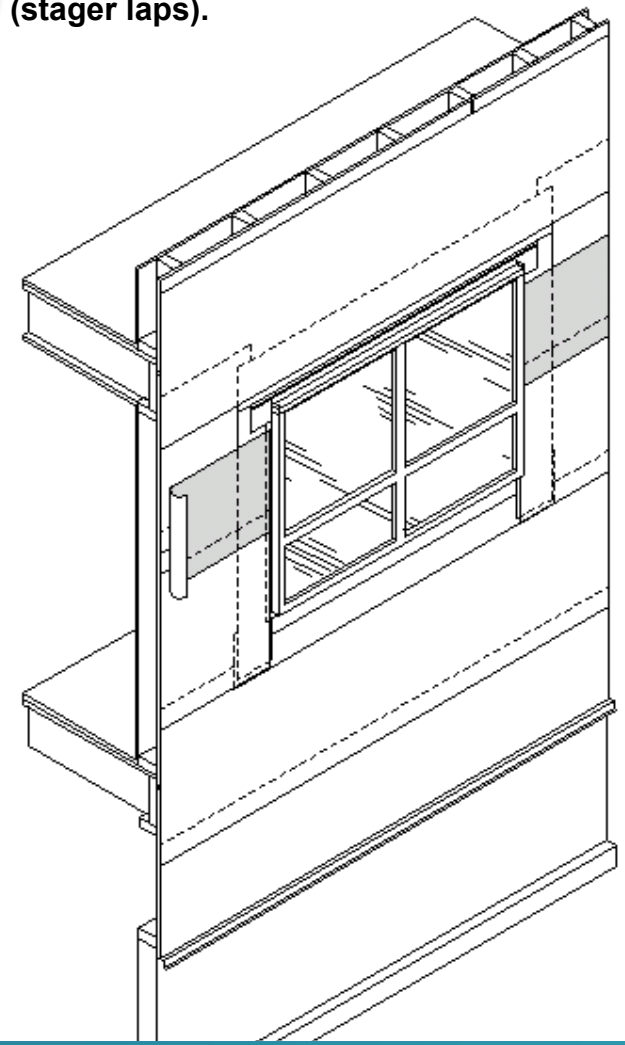
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



17

Building paper installation second layer fourth row (stager laps).



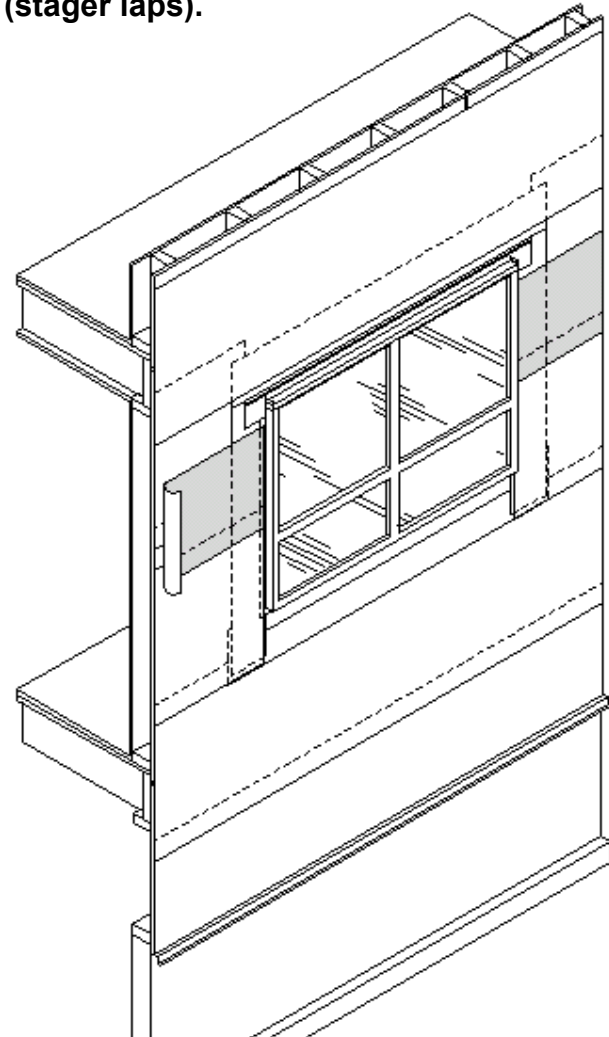
*Raising the Bar*

# Refining Construction Details through Design Verification Testing



17

Building paper installation second layer fourth row (stager laps).



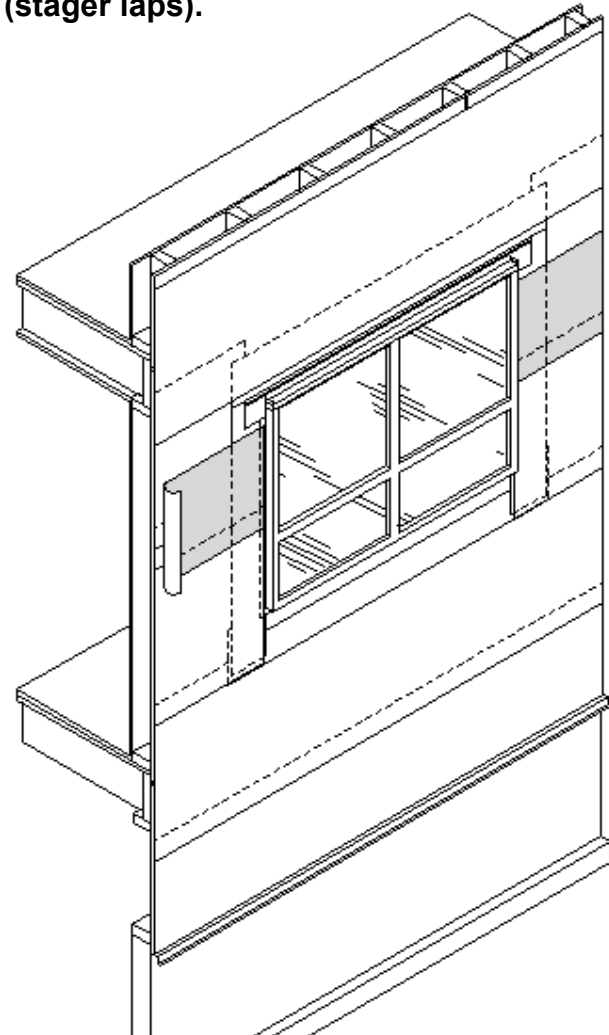
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



17

Building paper installation second layer fourth row (stager laps).

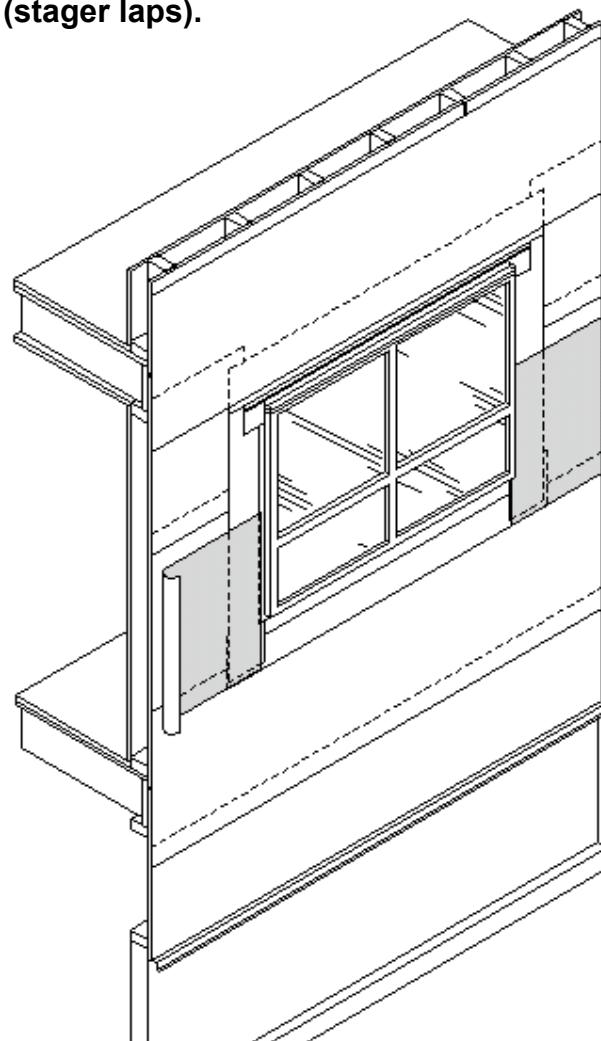


## *Raising the Bar*

# Refining Construction Details through Design Verification Testing

16

Building paper installation second layer third row (stager laps).



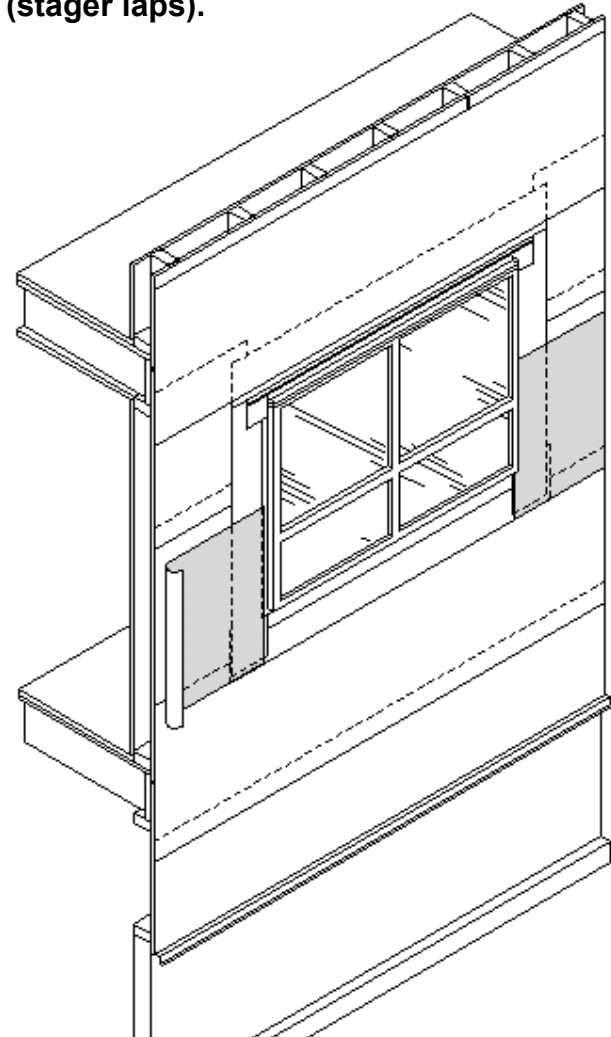
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

16

Building paper installation second layer third row (stager laps).



21



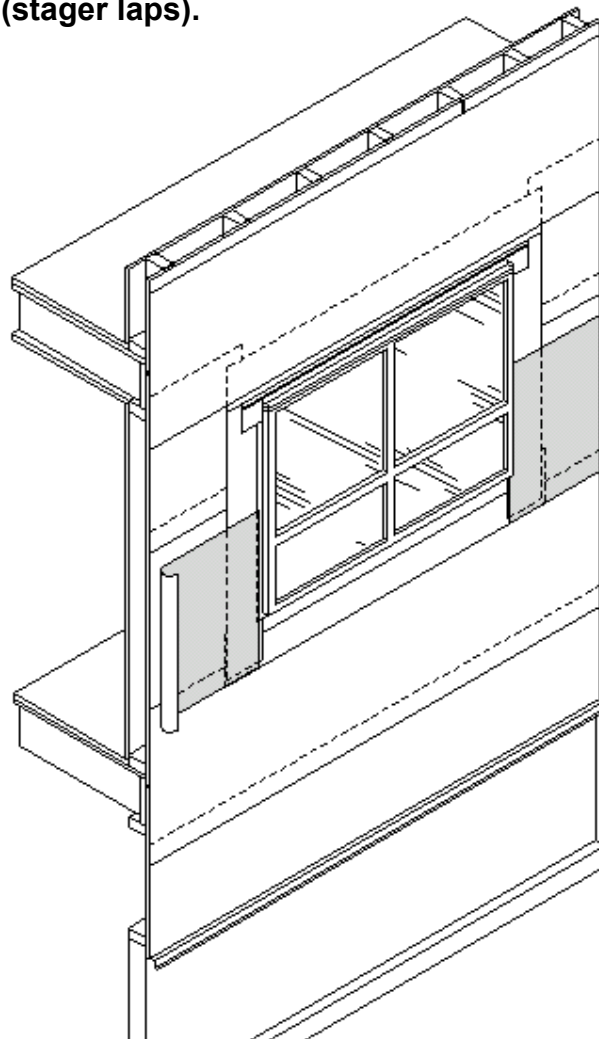
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

16

Building paper installation second layer third row (stager laps).



22

*Raising the Bar*

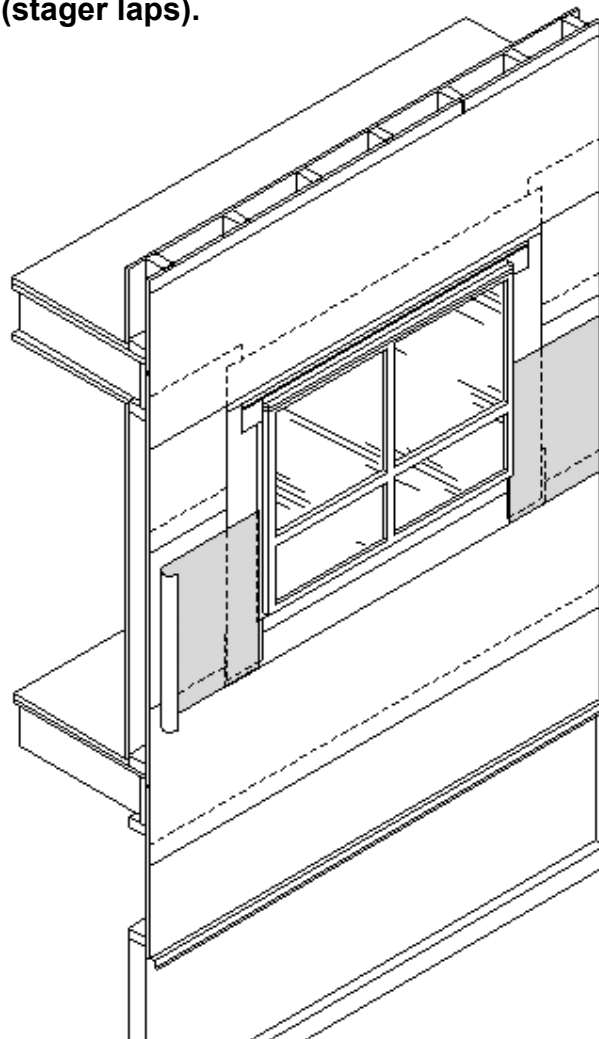
Refining Construction Details through

**Design Verification Testing**



16

Building paper installation second layer third row (stager laps).



23

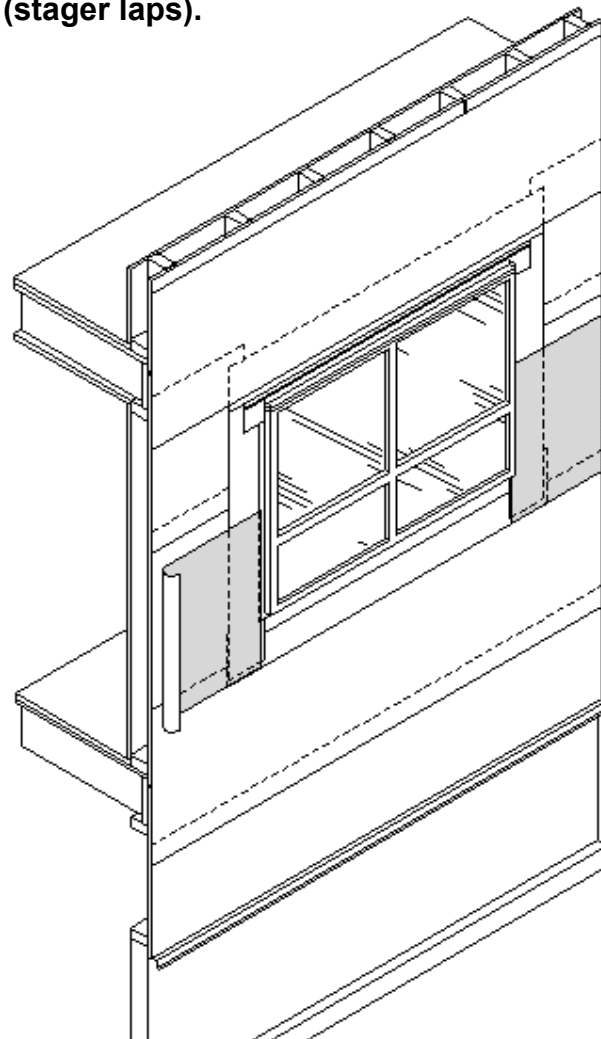
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

16

Building paper installation second layer third row (stager laps).



24

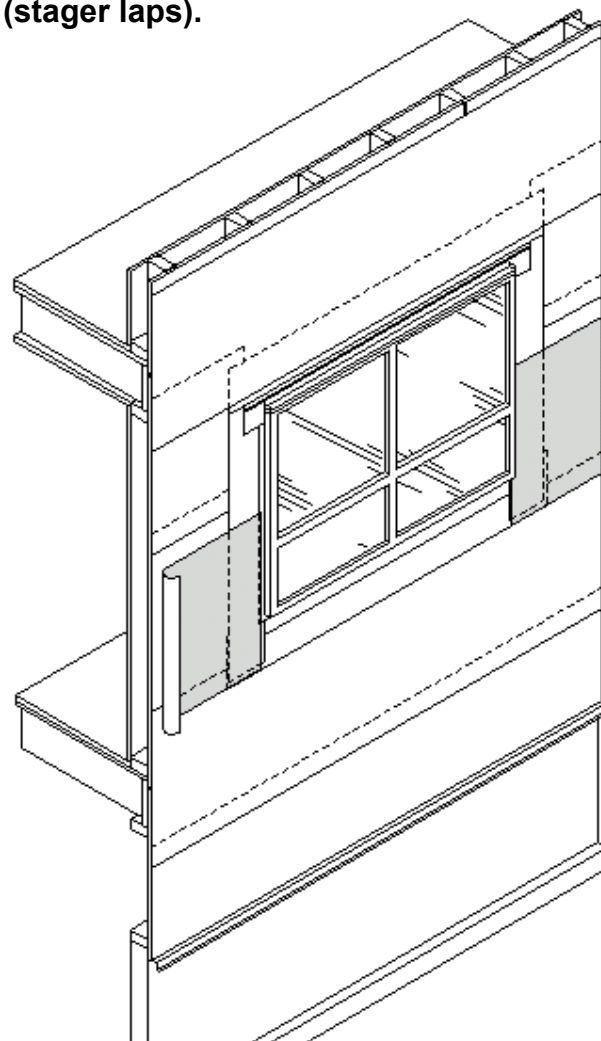
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

16

Building paper installation second layer third row (stager laps).



25

*Raising the Bar*

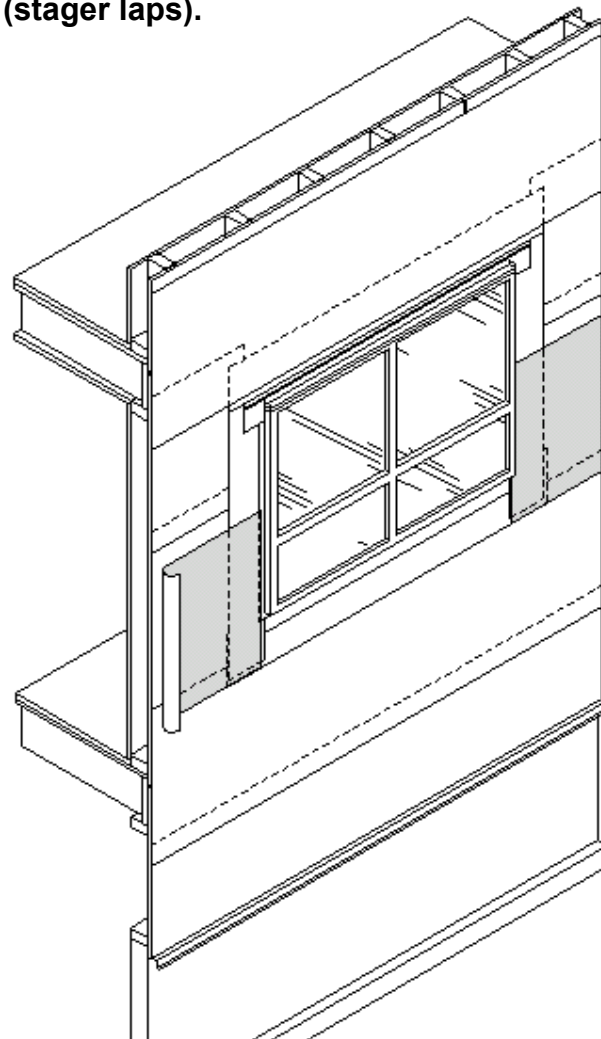
Refining Construction Details through

**Design Verification Testing**



16

Building paper installation second layer third row (stager laps).



*Raising the Bar*

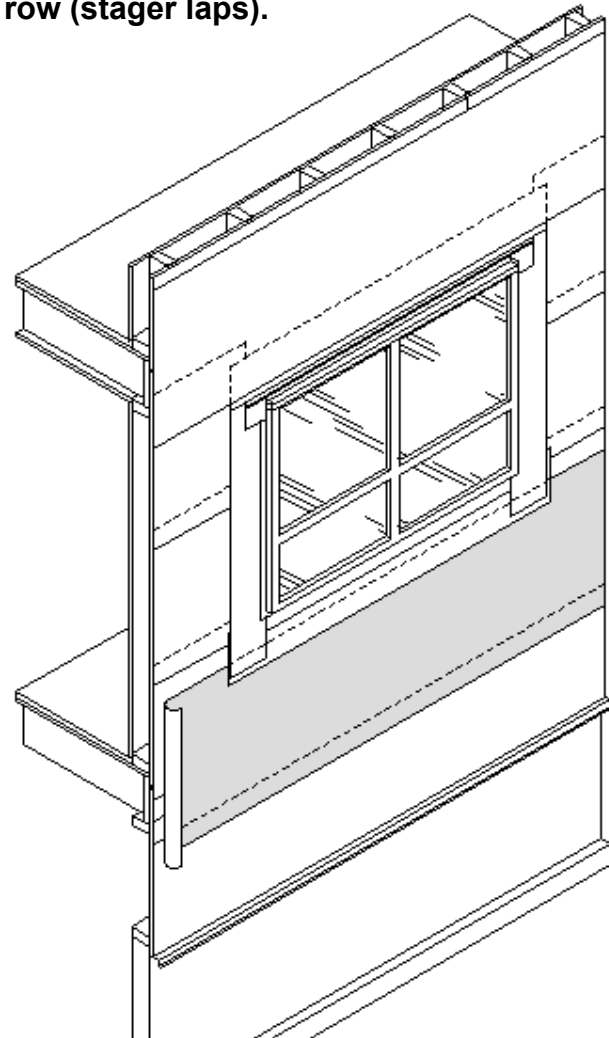
Refining Construction Details through

**Design Verification Testing**



15

Building paper installation second layer second row (stager laps).



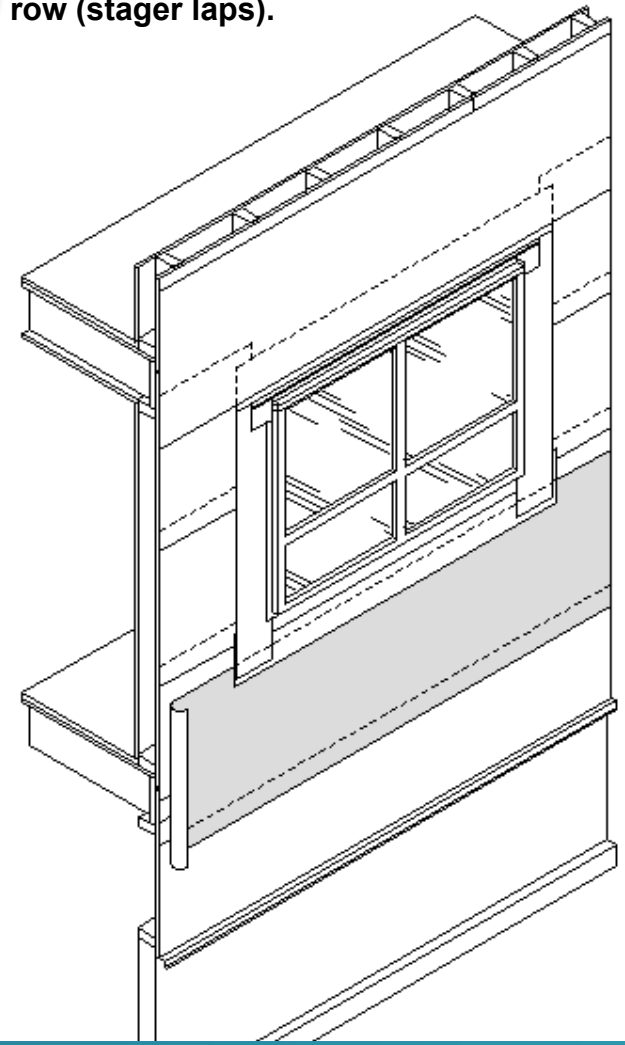
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



15

Building paper installation second layer second row (stager laps).

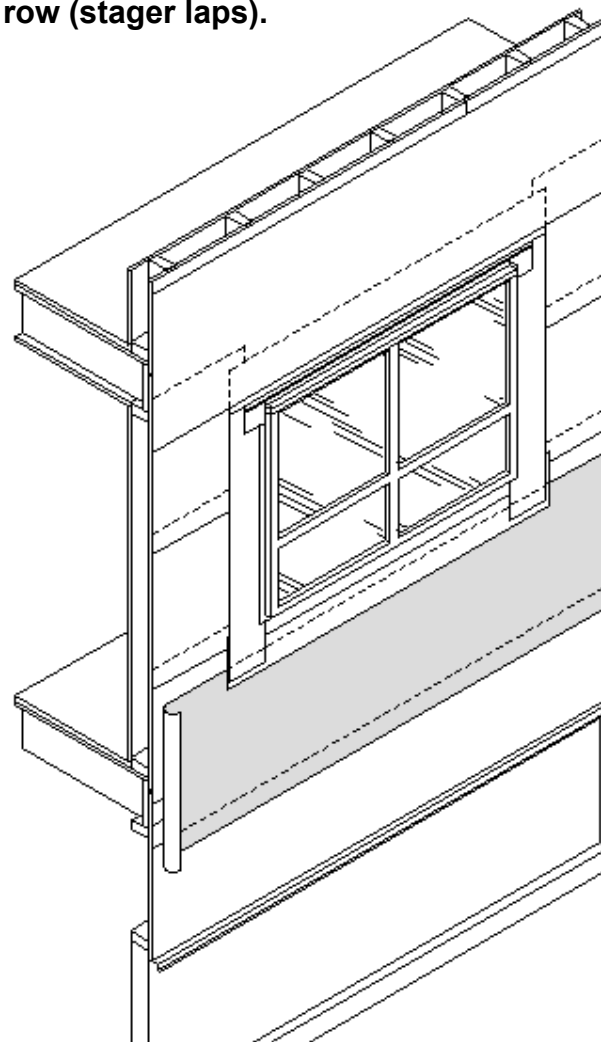


*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**

15

Building paper installation second layer second row (stager laps).



28

*Raising the Bar*

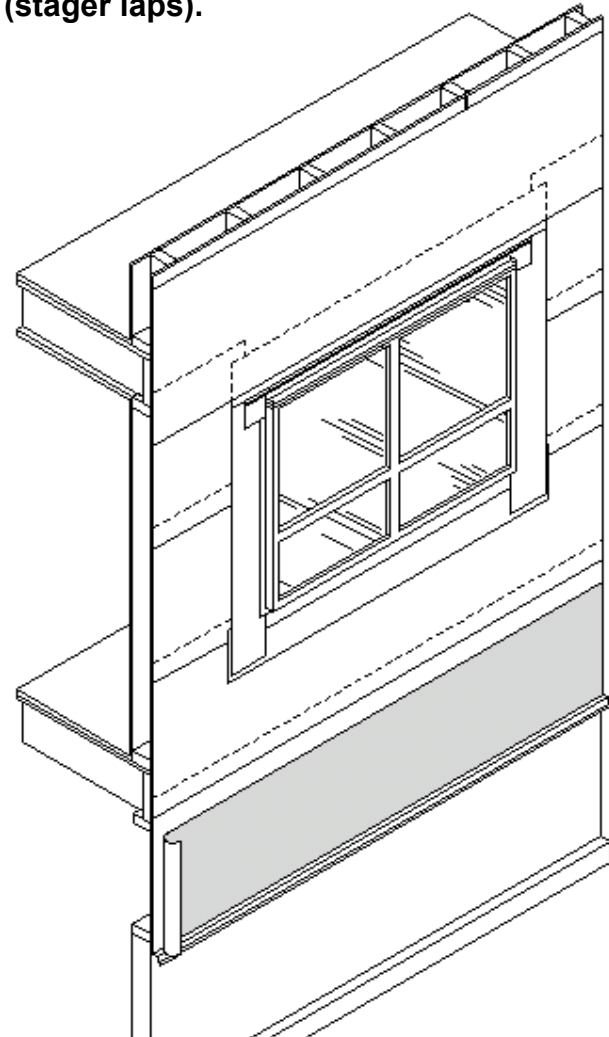
Refining Construction Details through

**Design Verification Testing**



14

Building paper installation second layer first row (stager laps).



*Raising the Bar*

Refining Construction Details through

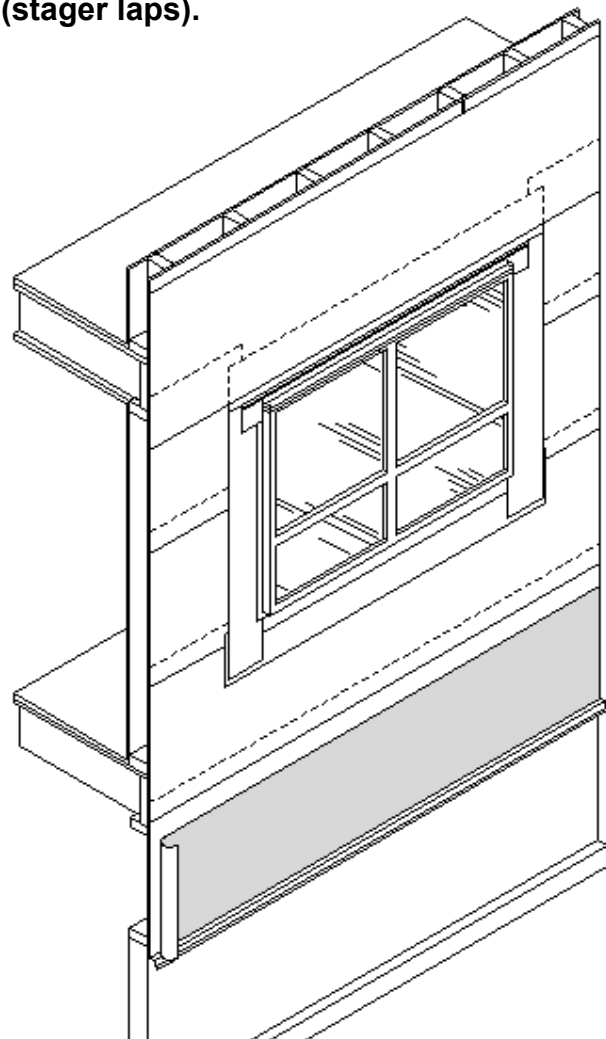
**Design Verification Testing**





14

Building paper installation second layer first row (stager laps).



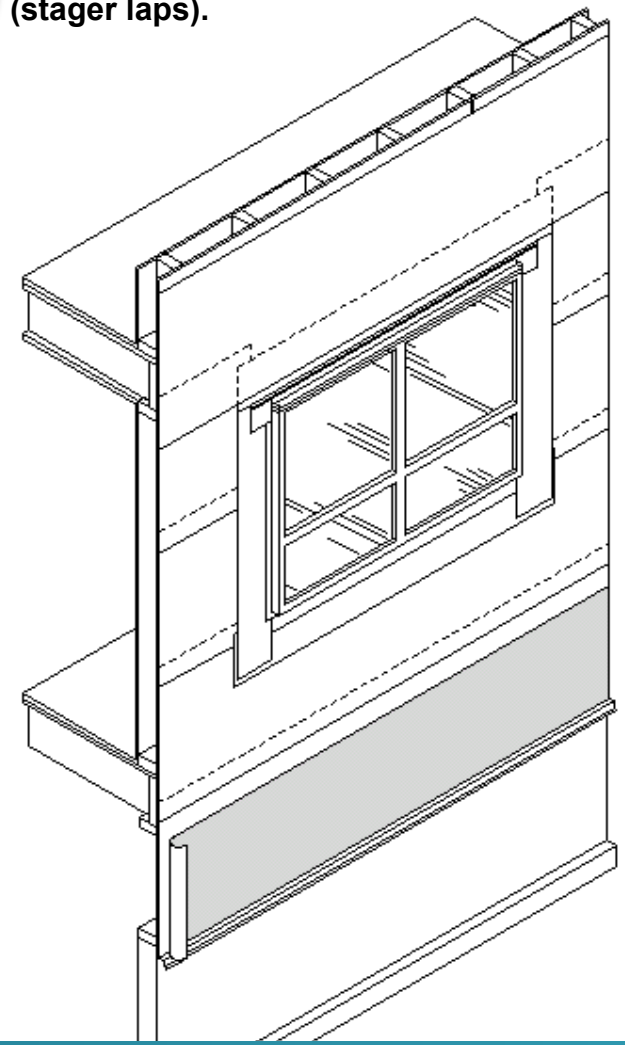
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



14

Building paper installation second layer first row (stager laps).



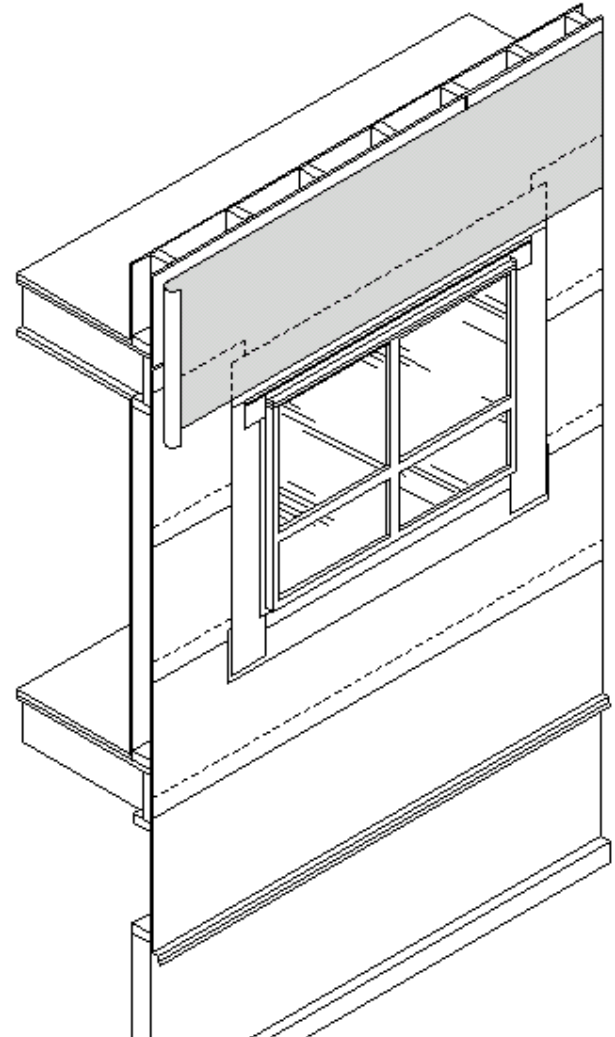
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



13

Building paper installation first layer fifth row.



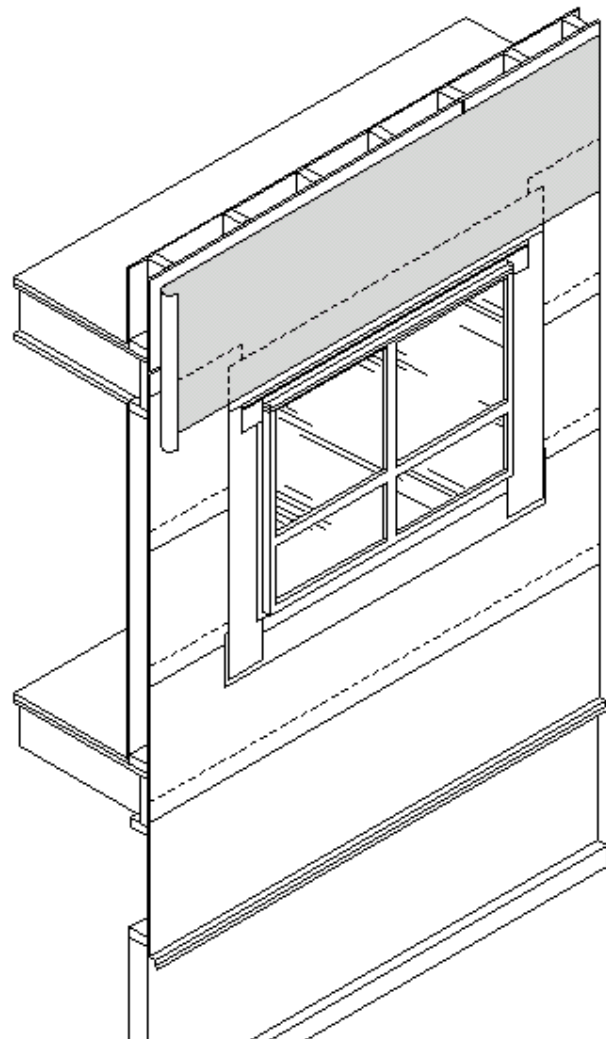
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



13

Building paper installation first layer fifth row.



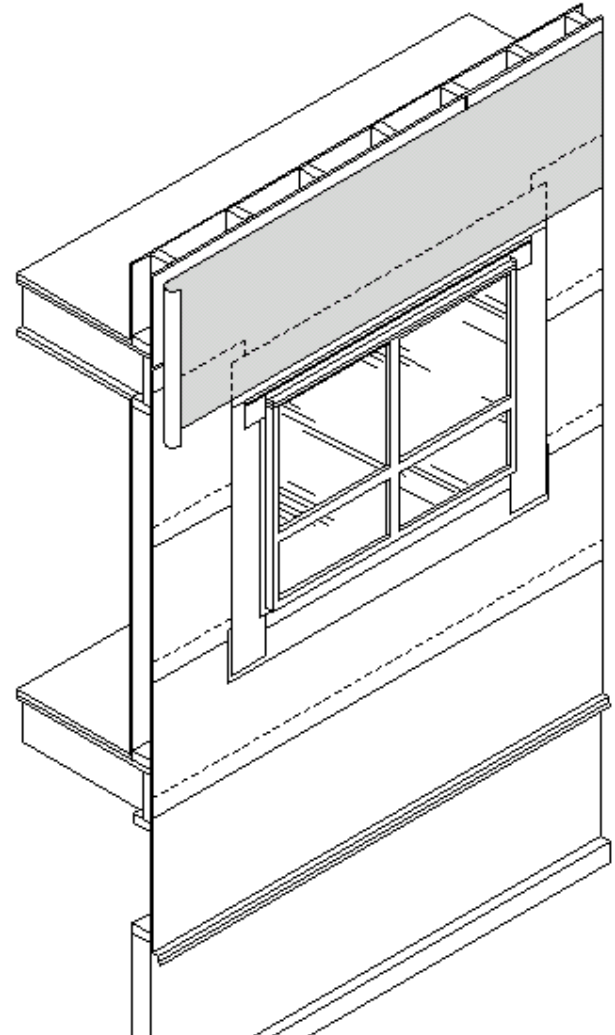
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



13

Building paper installation first layer fifth row.

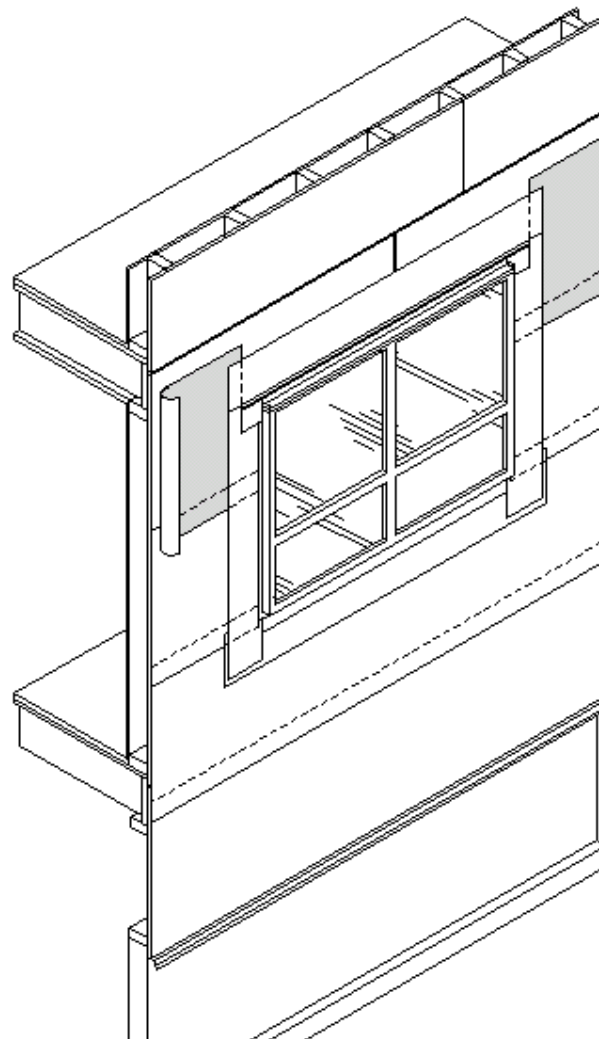


*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**

12

Building paper installation first layer fourth row.



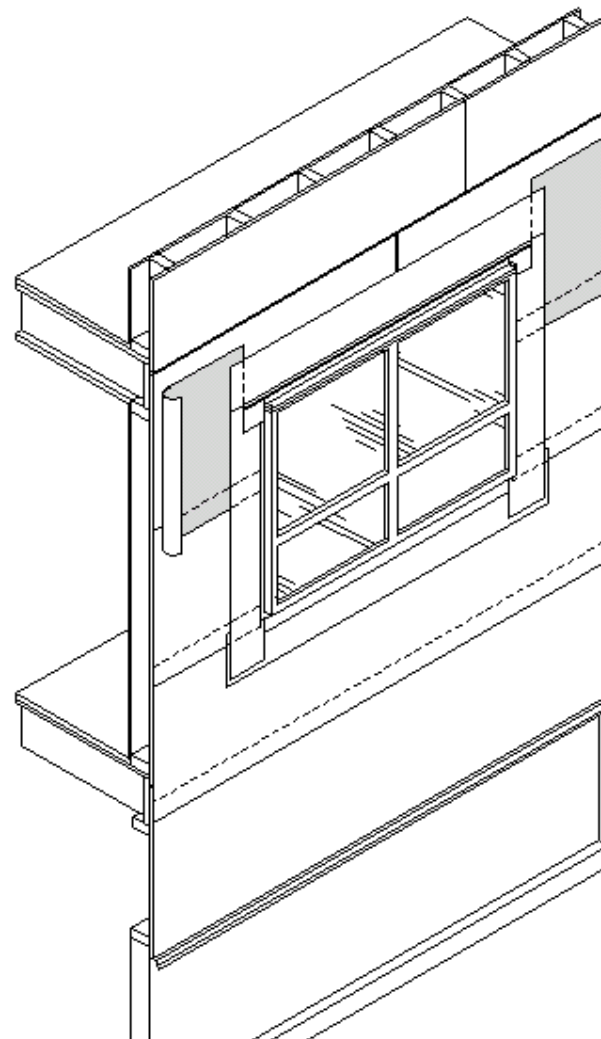
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

12

Building paper installation first layer fourth row.



*Raising the Bar*

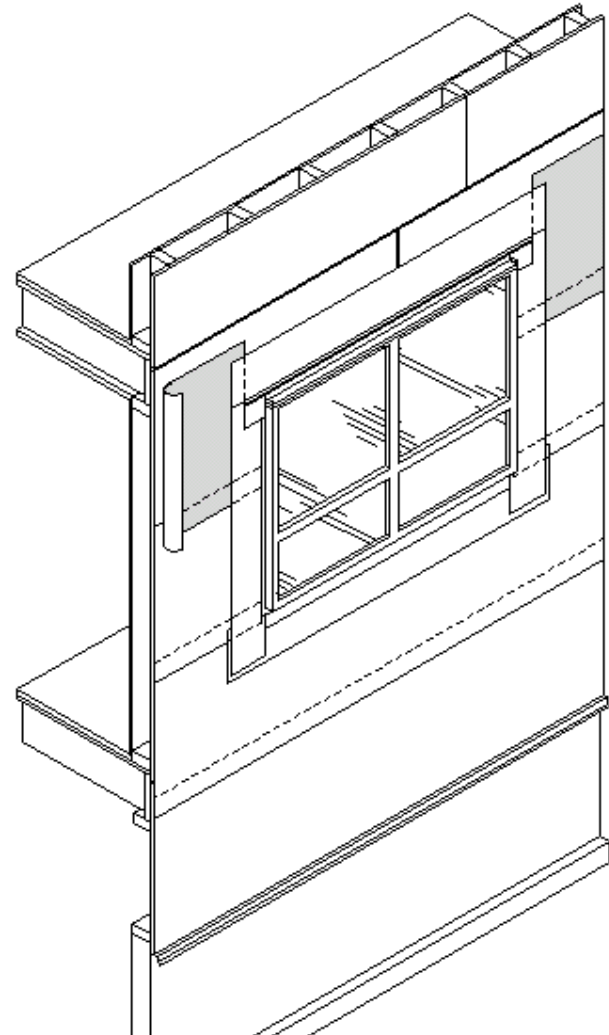
Refining Construction Details through

**Design Verification Testing**



12

Building paper installation first layer fourth row.



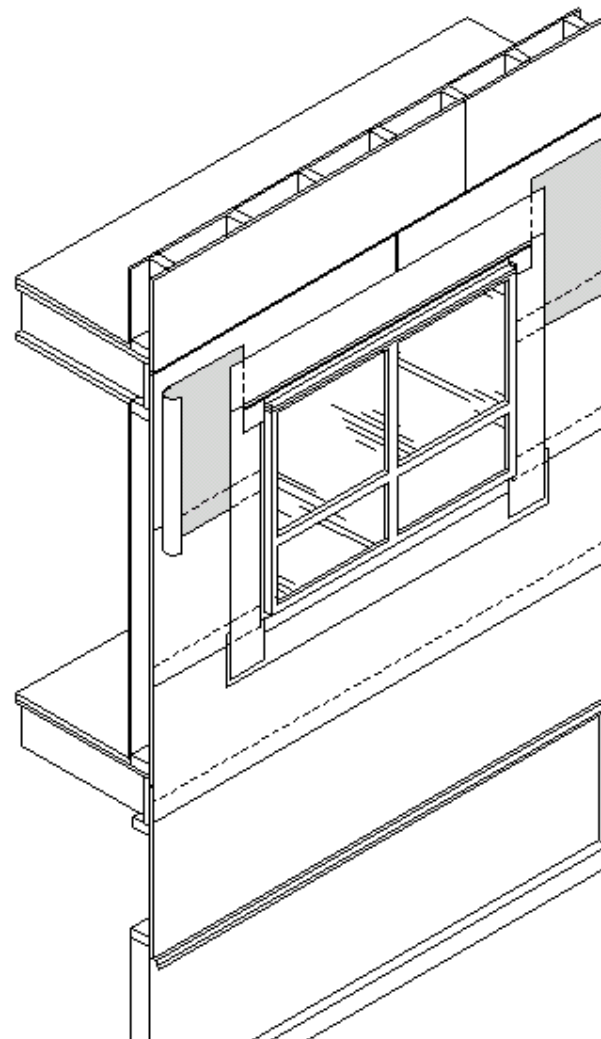
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



12

Building paper installation first layer fourth row.



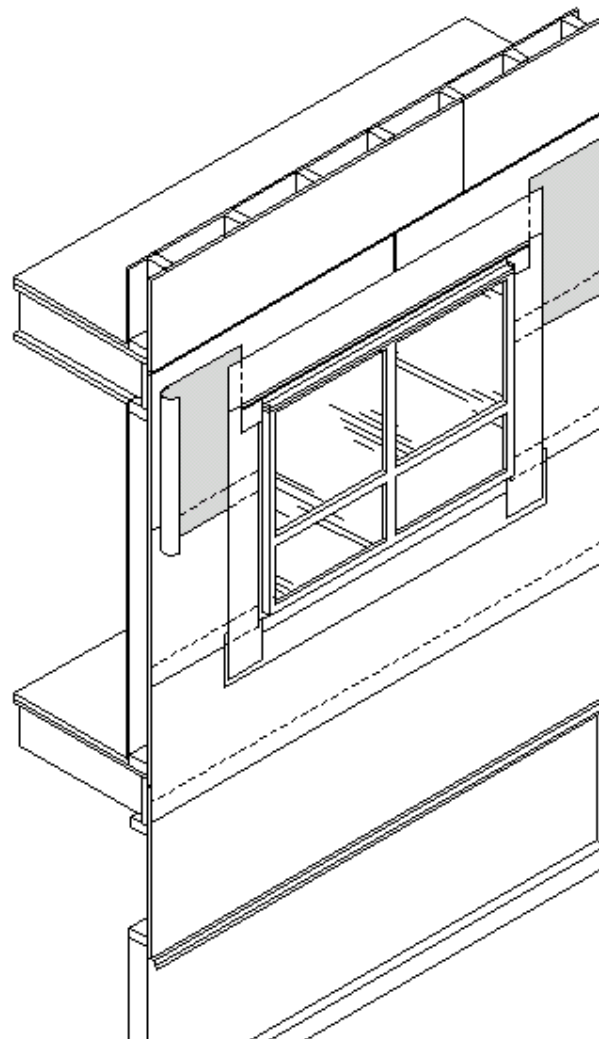
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

12

Building paper installation first layer fourth row.



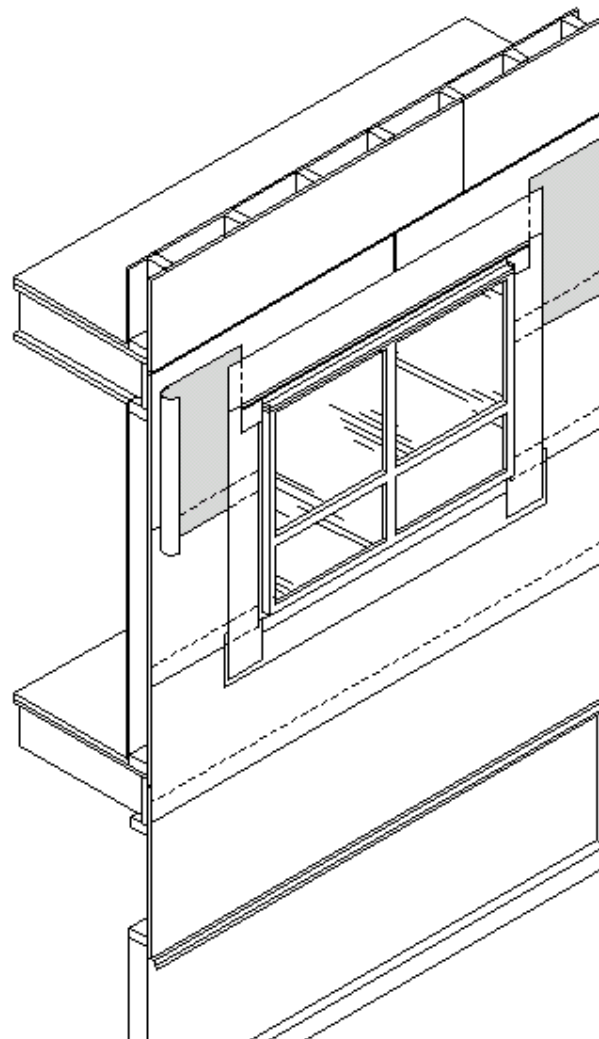
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

12

Building paper installation first layer fourth row.



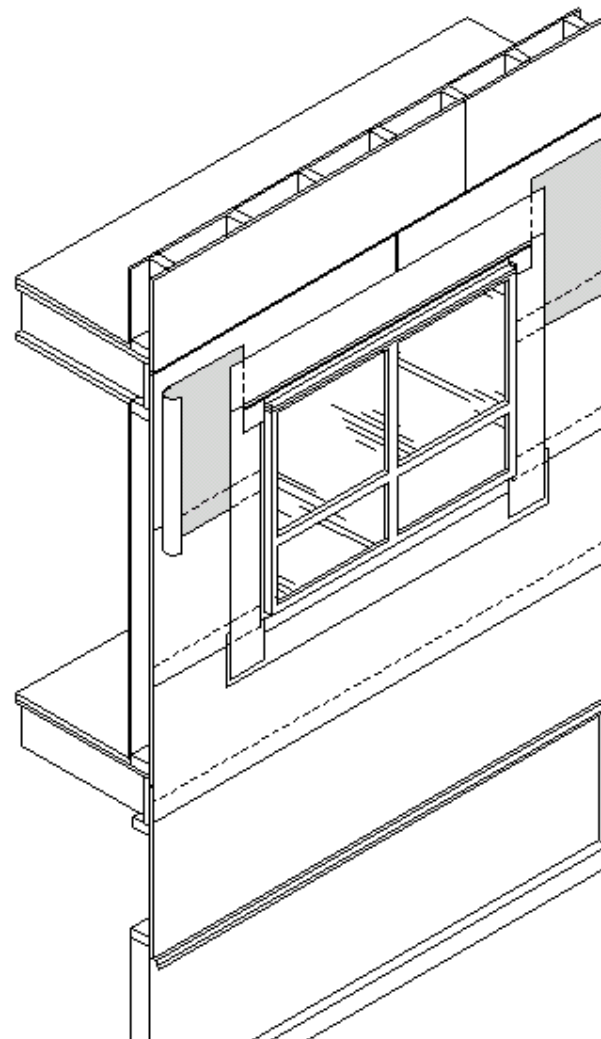
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

12

Building paper installation first layer fourth row.



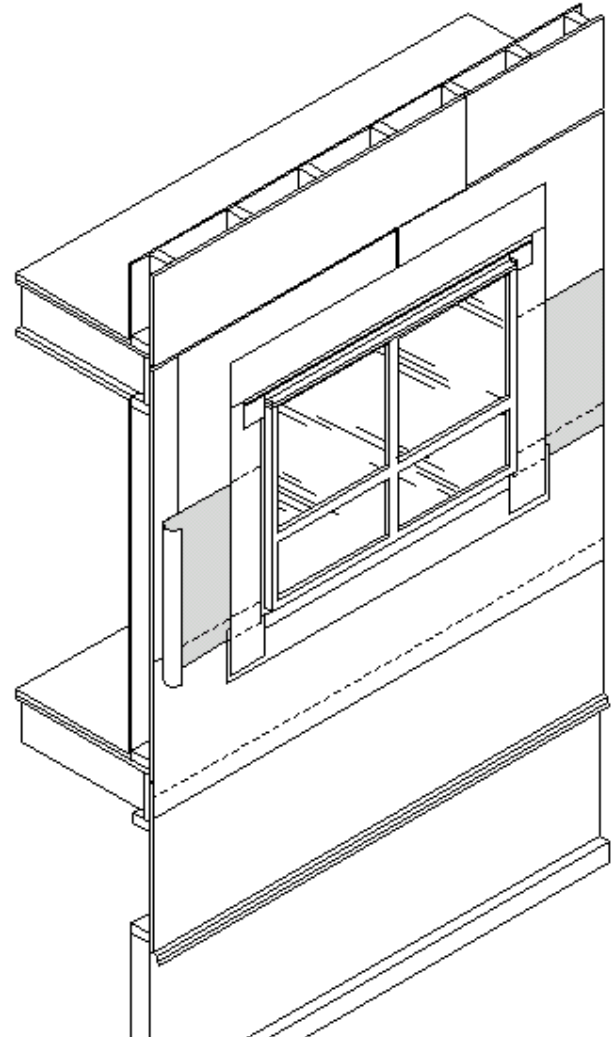
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

11

Building paper installation first layer third row.



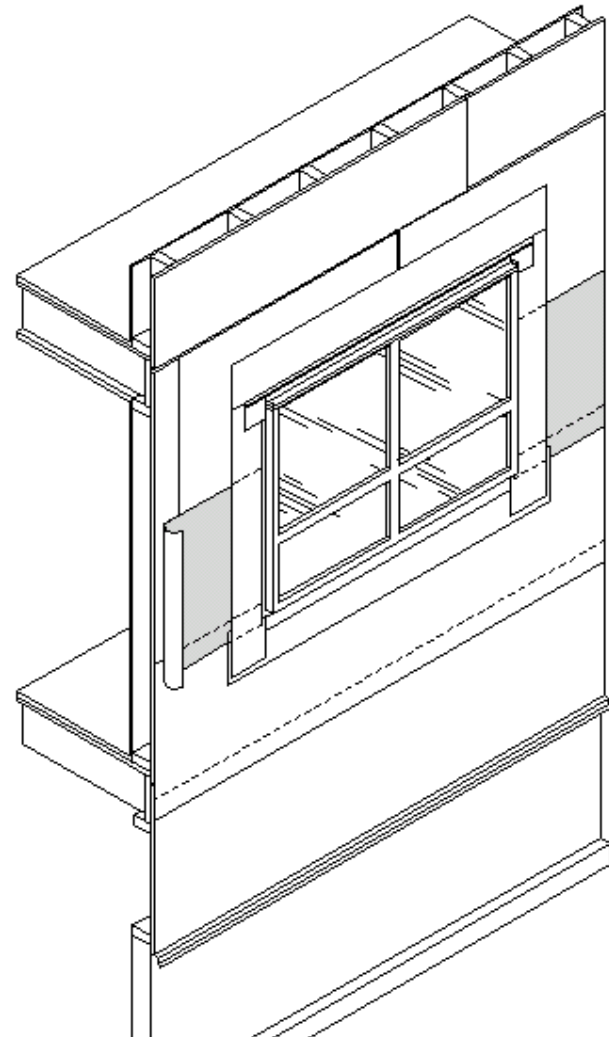
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



11

Building paper installation first layer third row.



*Raising the Bar*

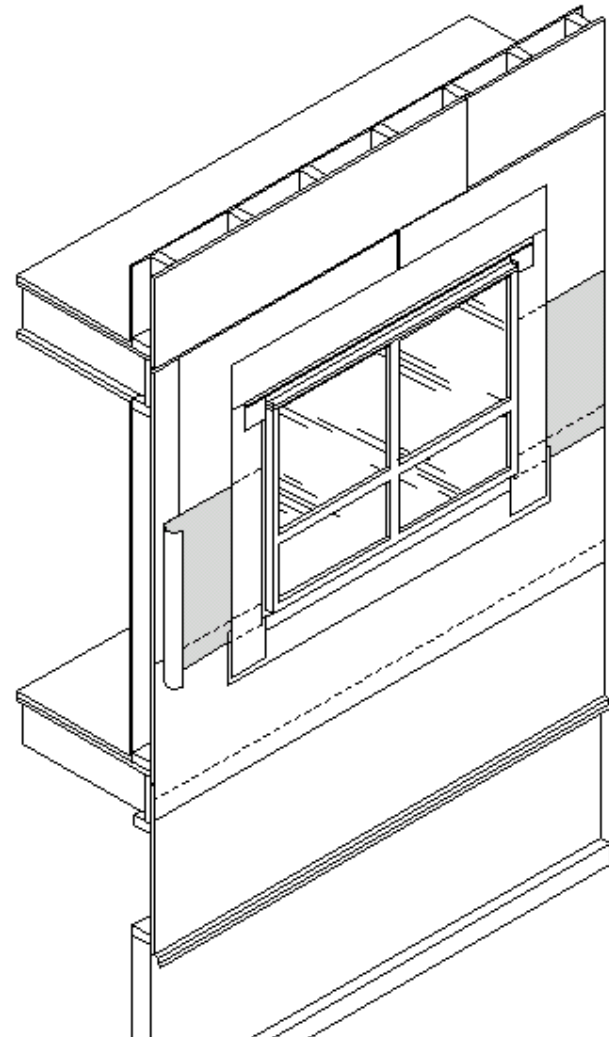
Refining Construction Details through

**Design Verification Testing**



11

Building paper installation first layer third row.

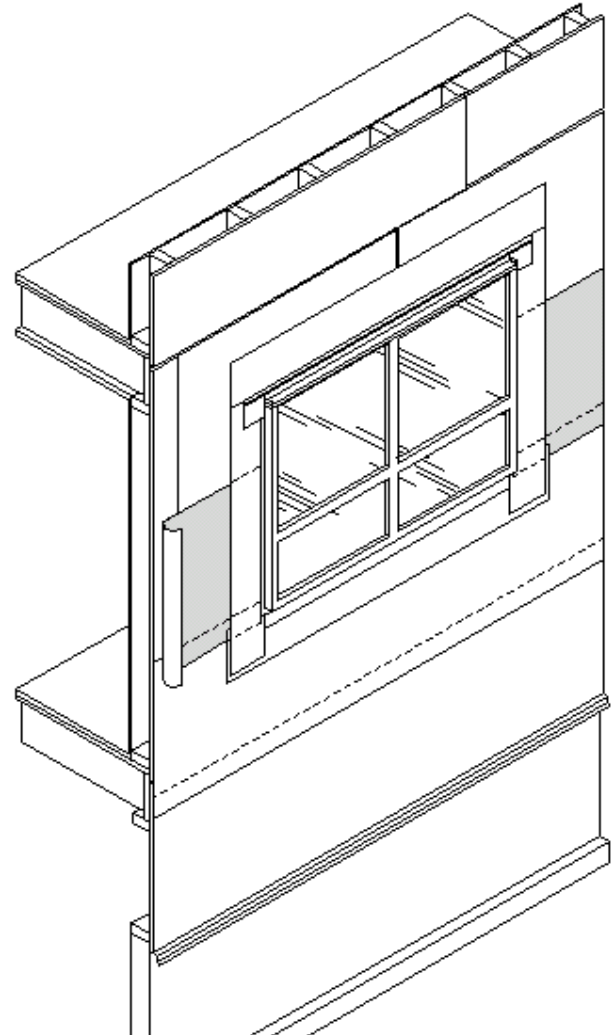


*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**

11

Building paper installation first layer third row.



*Raising the Bar*

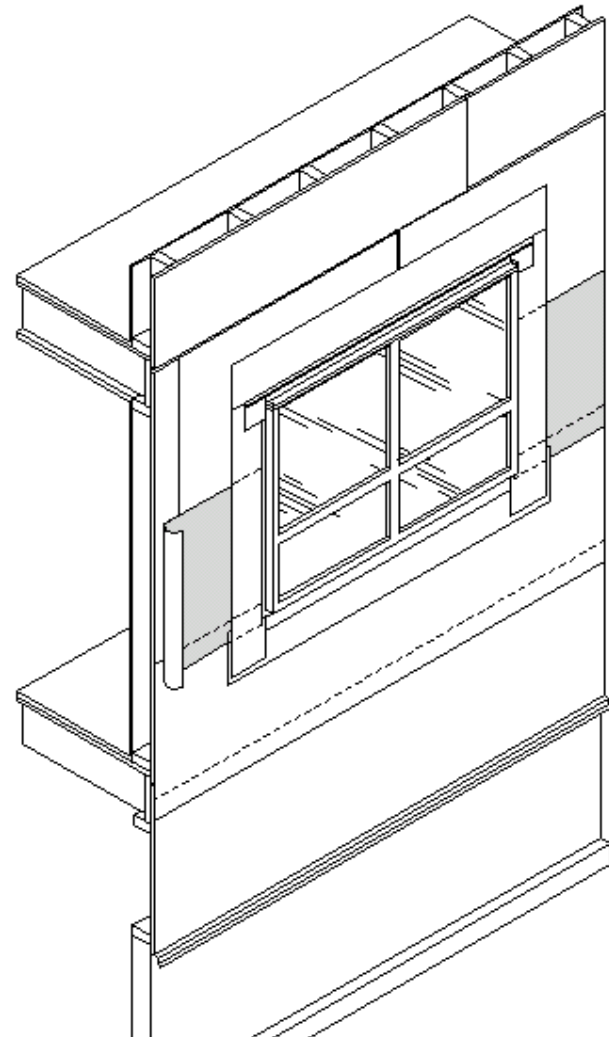
Refining Construction Details through  
**Design Verification Testing**





11

Building paper installation first layer third row.



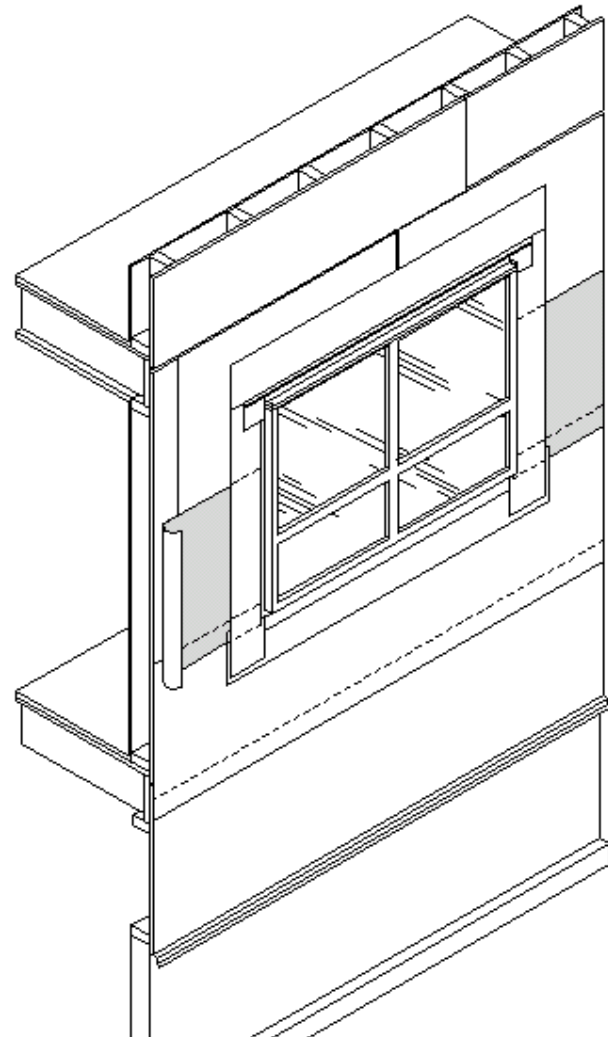
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



11

Building paper installation first layer third row.



*Raising the Bar*

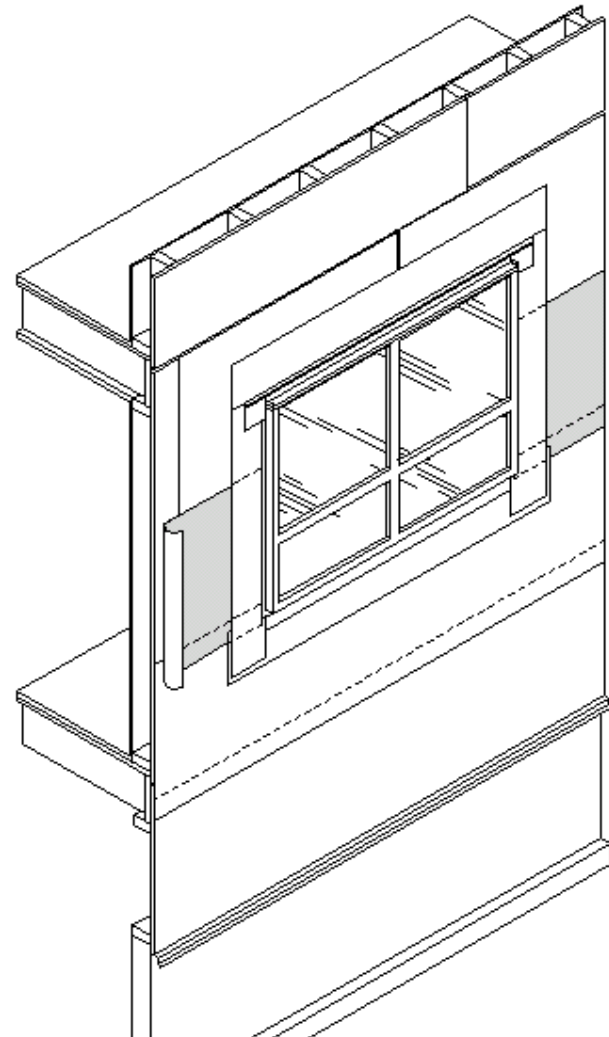
Refining Construction Details through

**Design Verification Testing**



11

Building paper installation first layer third row.

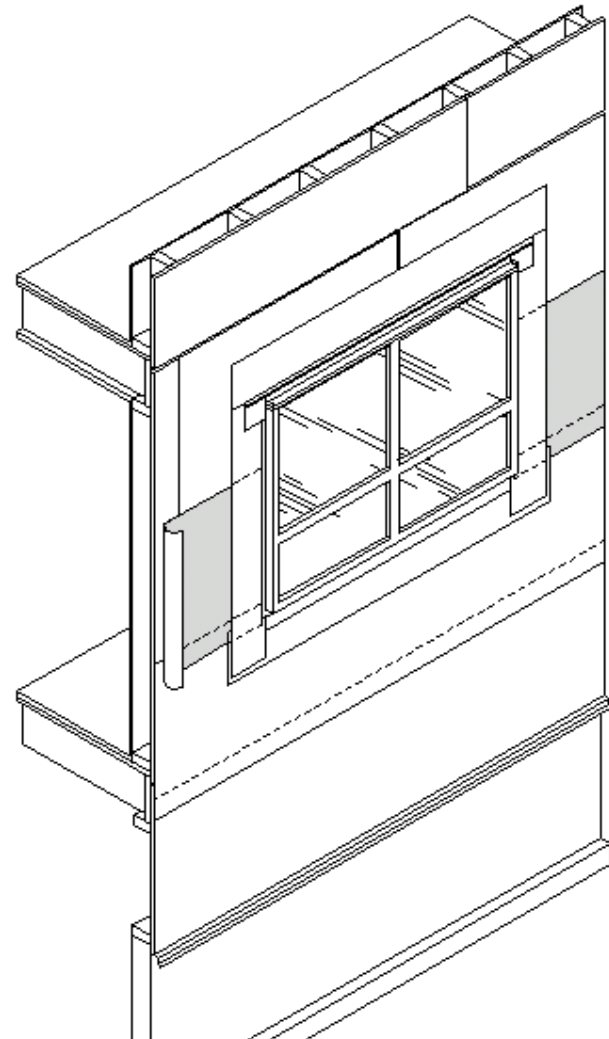


*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**

11

Building paper installation first layer third row.



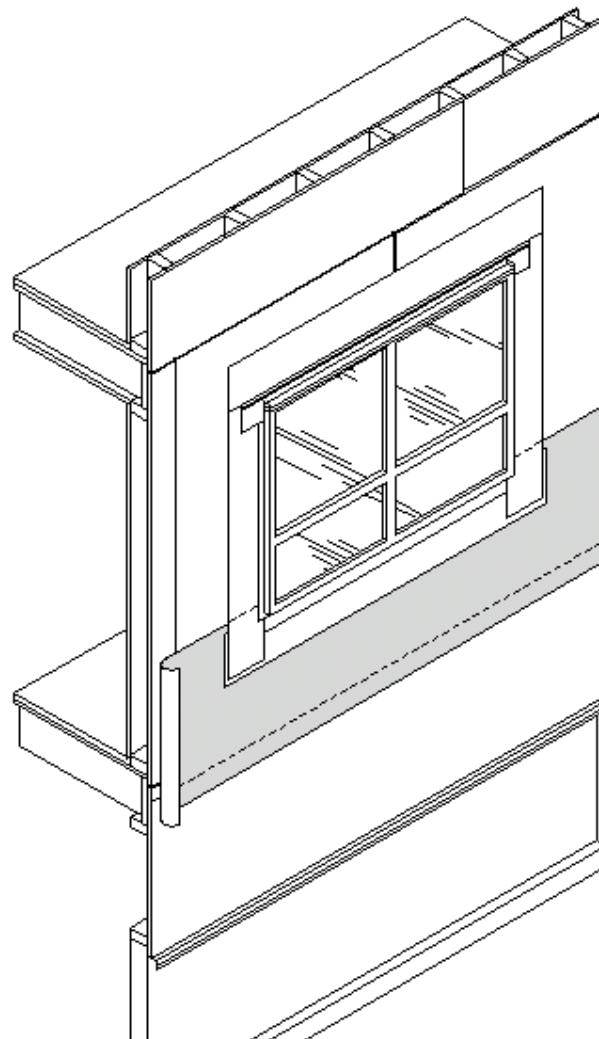
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

10

Building paper installation first layer second row.



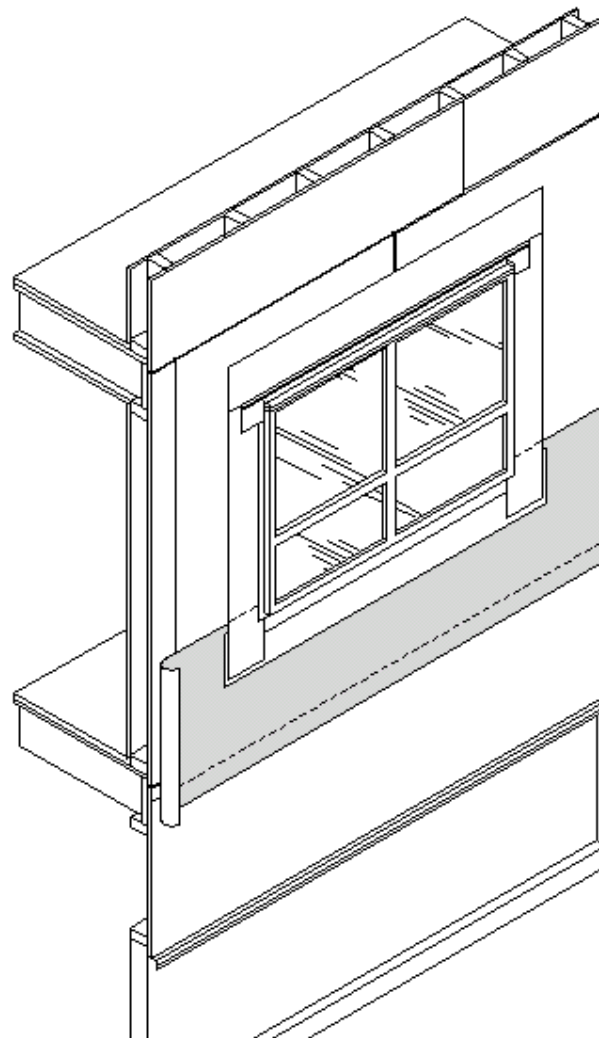
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

10

Building paper installation first layer second row.



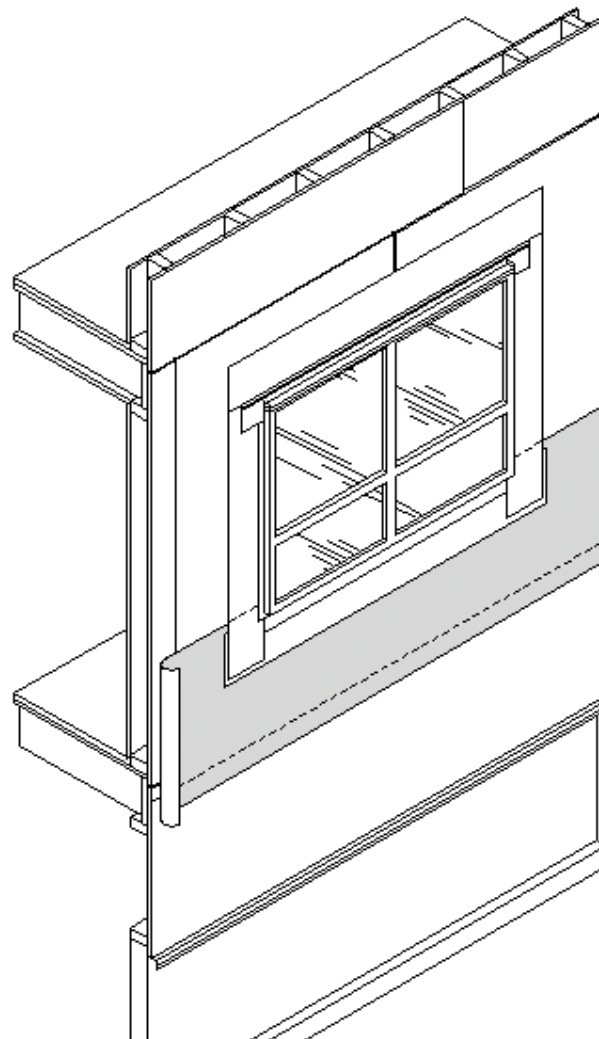
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

10

Building paper installation first layer second row.



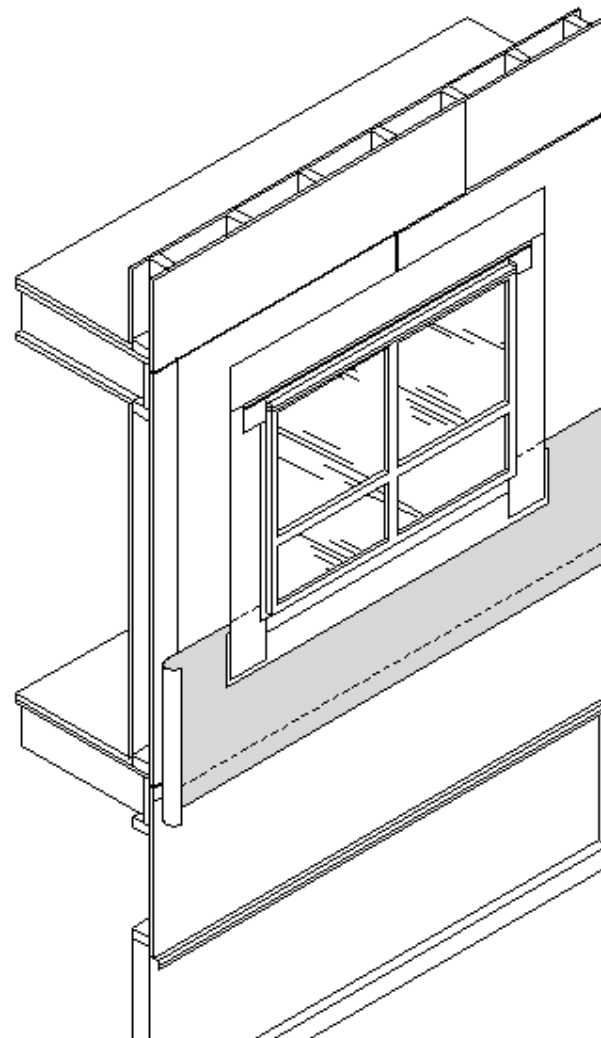
*Raising the Bar*

Refining Construction Details through

**Design Verification Testing**

10

Building paper installation first layer second row.



*Raising the Bar*

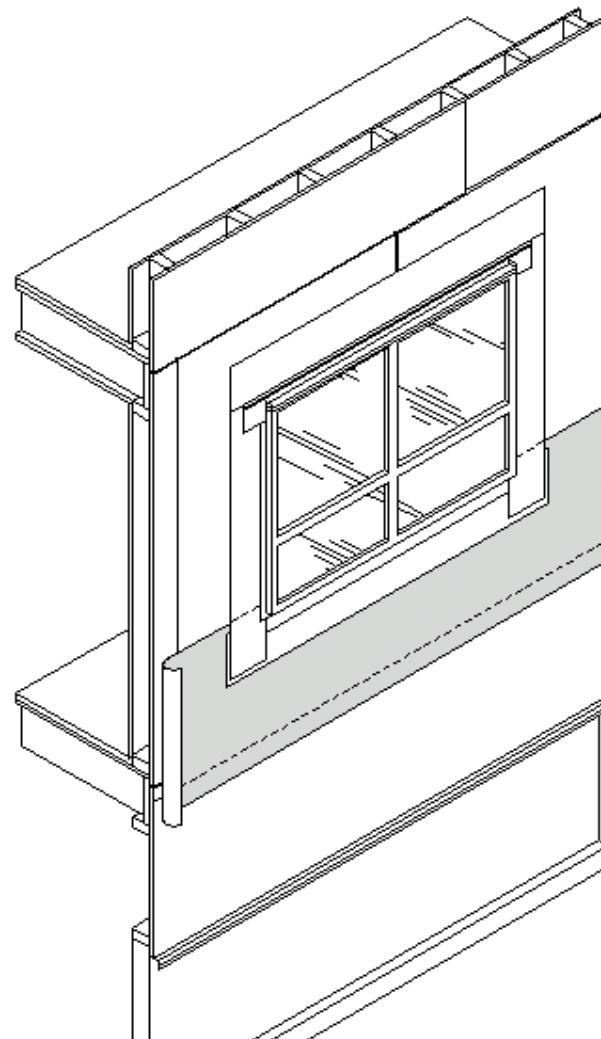
Refining Construction Details through

**Design Verification Testing**



10

Building paper installation first layer second row.



48

*Raising the Bar*

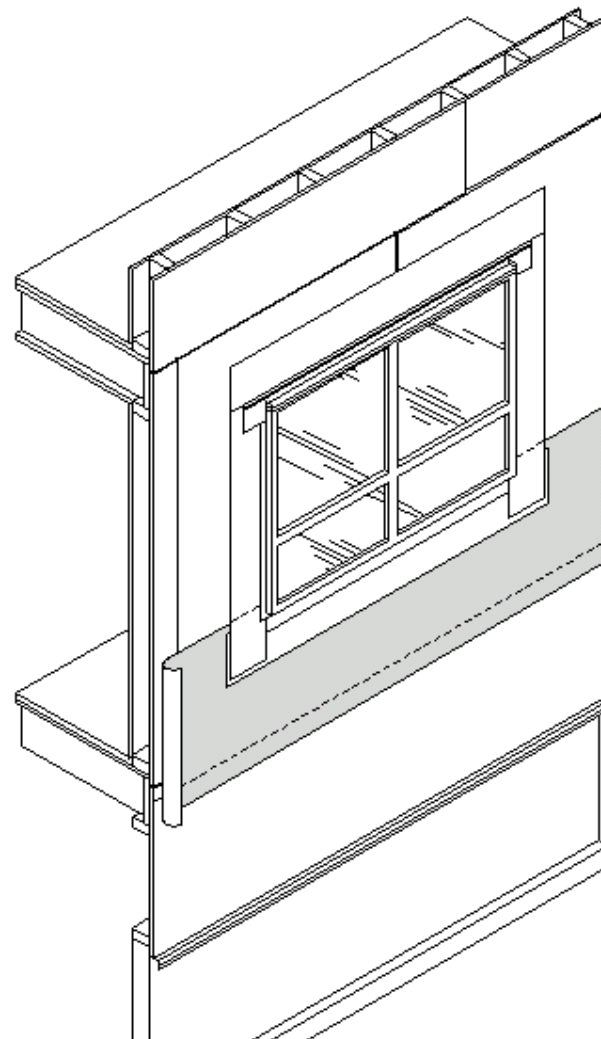
Refining Construction Details through

**Design Verification Testing**



10

Building paper installation first layer second row.



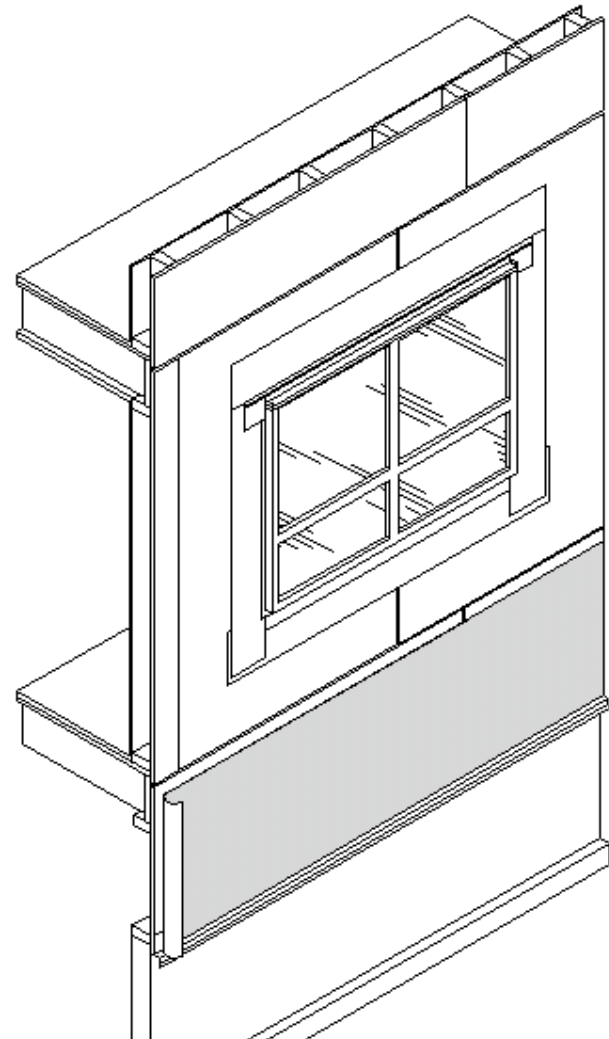
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



9

Building paper installation first layer first row.



*Raising the Bar*

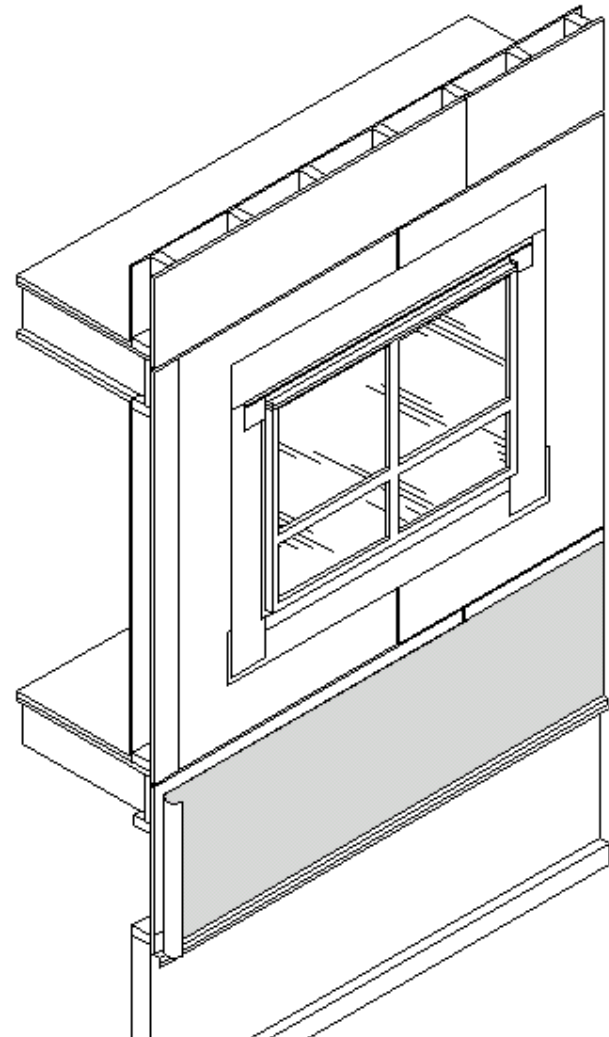
Refining Construction Details through

**Design Verification Testing**



9

Building paper installation first layer first row.



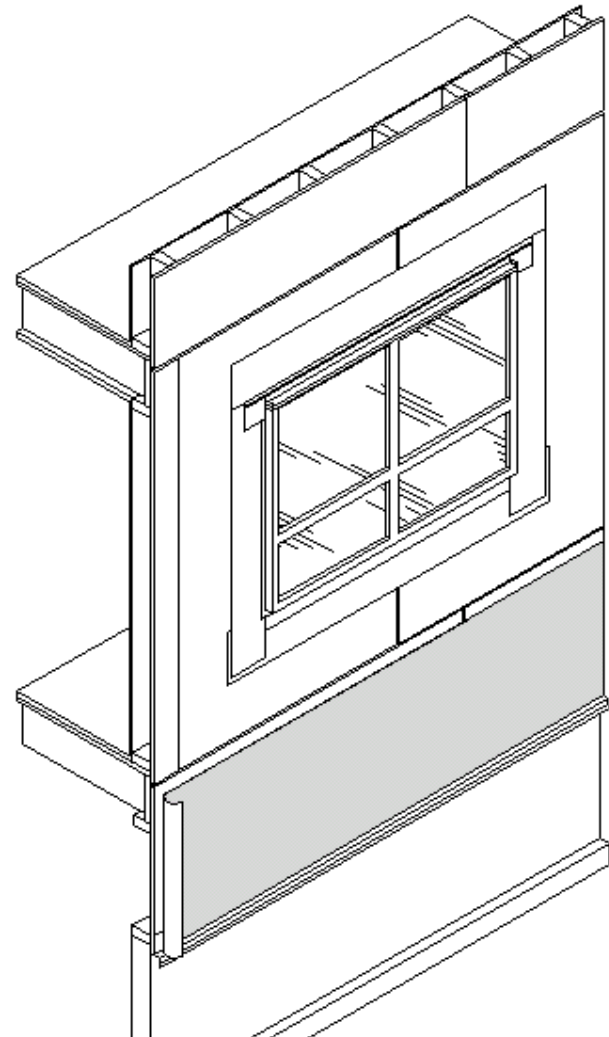
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



9

Building paper installation first layer first row.



*Raising the Bar*

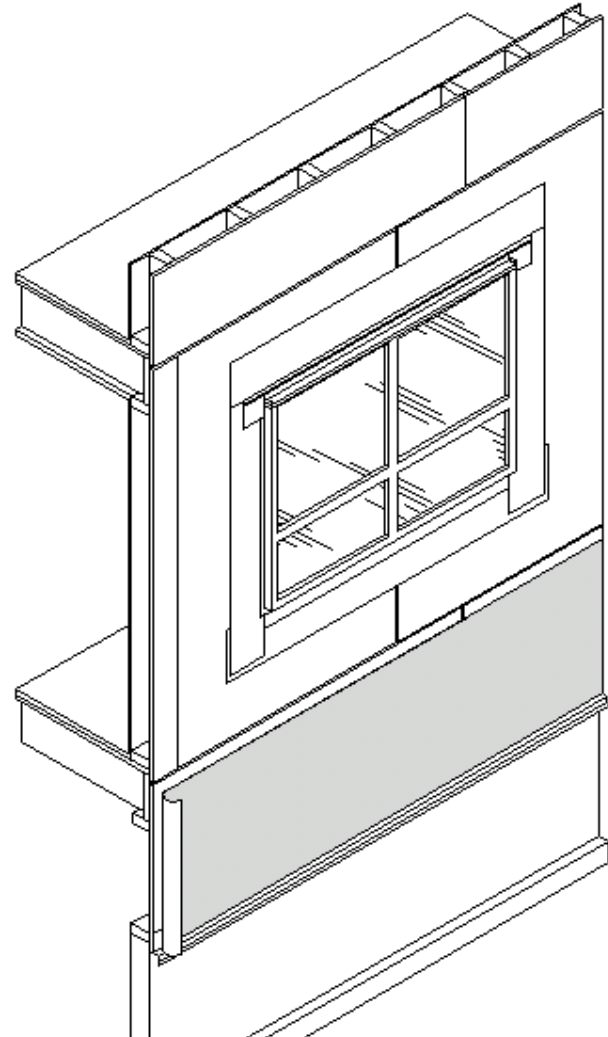
Refining Construction Details through

**Design Verification Testing**



9

Building paper installation first layer first row.



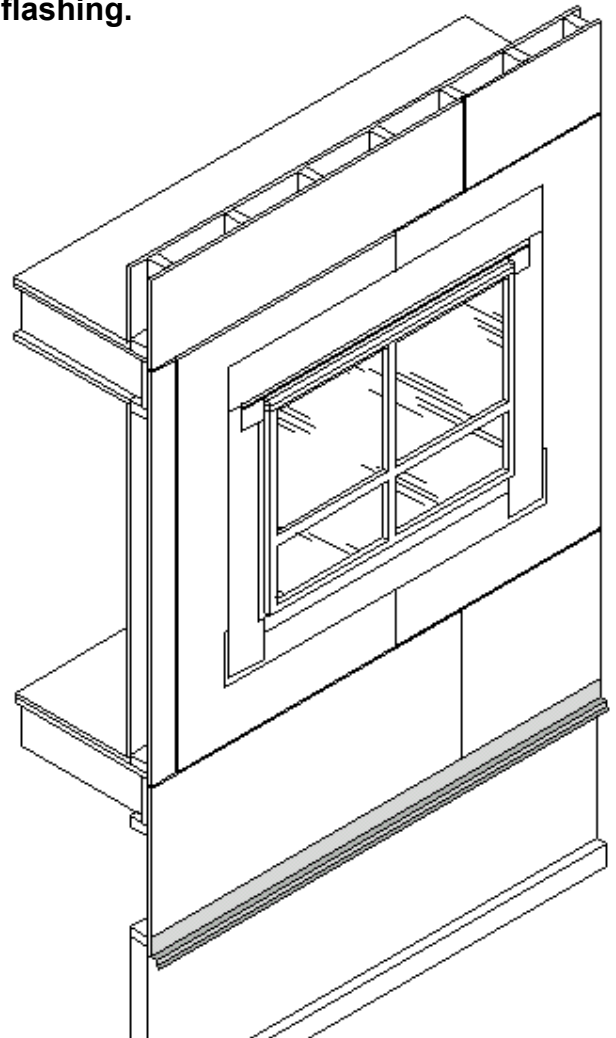
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



8

Begin building installation paper with drip edge flashing.



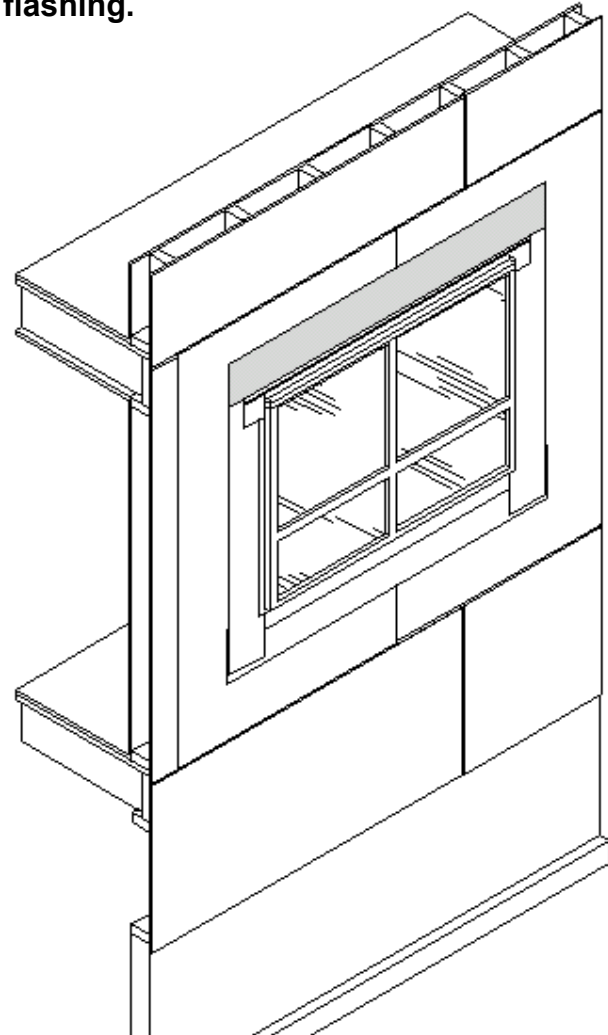
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



7

Install Peel-n-Stick above from substrate to head flashing.



*Raising the Bar*

Refining Construction Details through

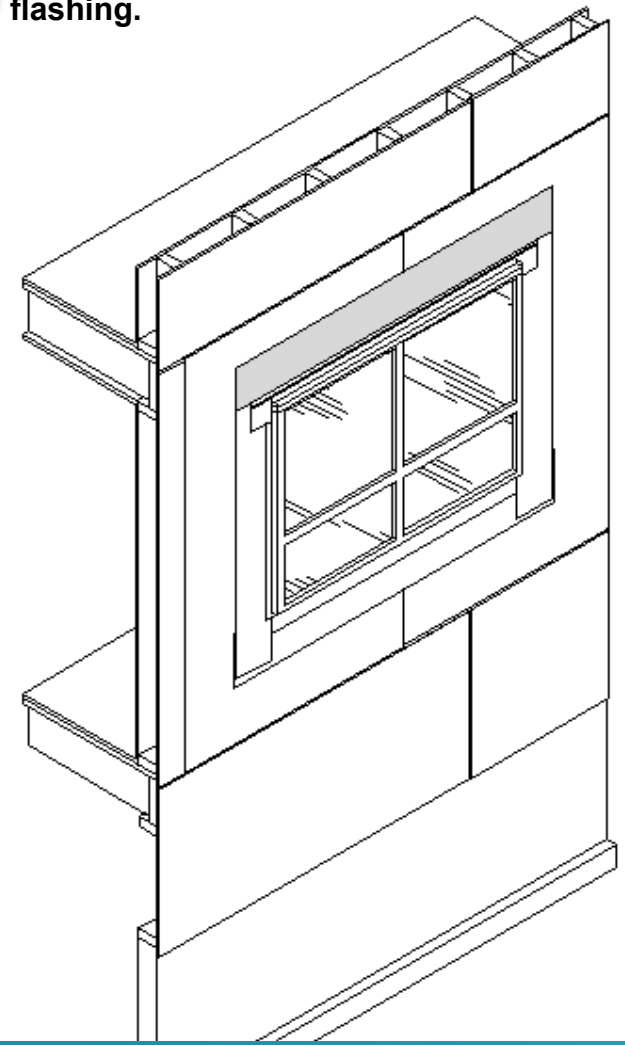
**Design Verification Testing**





7

Install Peel-n-Stick above from substrate to head flashing.



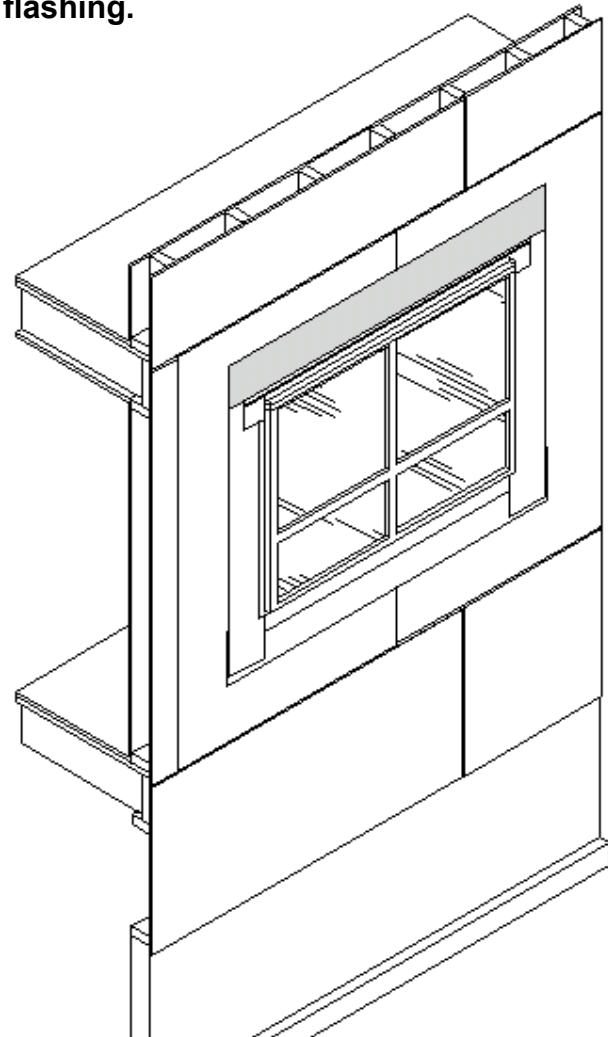
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



7

Install Peel-n-Stick above from substrate to head flashing.



*Raising the Bar*

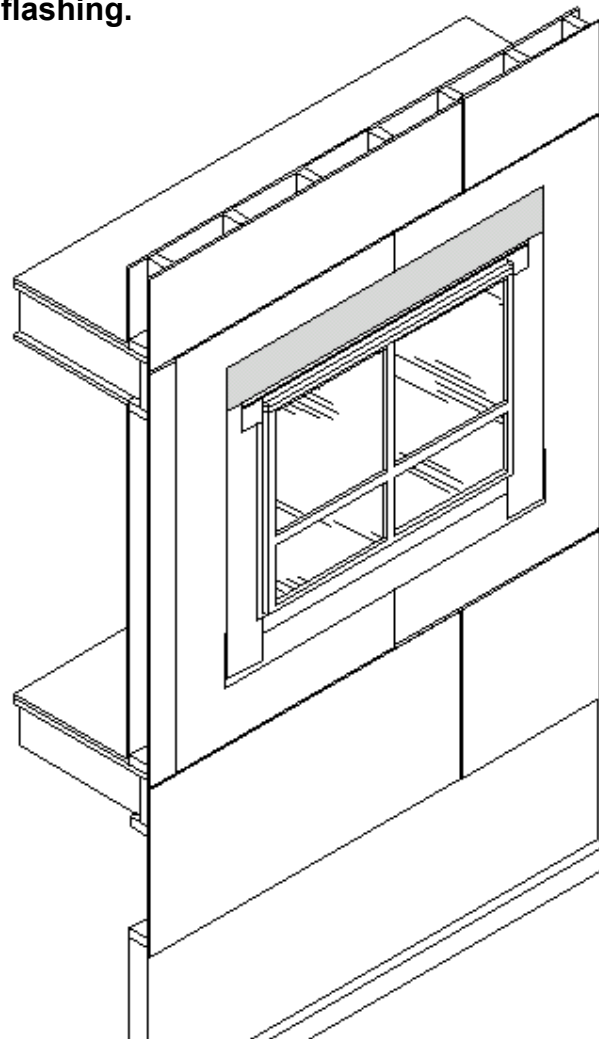
Refining Construction Details through

**Design Verification Testing**



7

Install Peel-n-Stick above from substrate to head flashing.



*Raising the Bar*

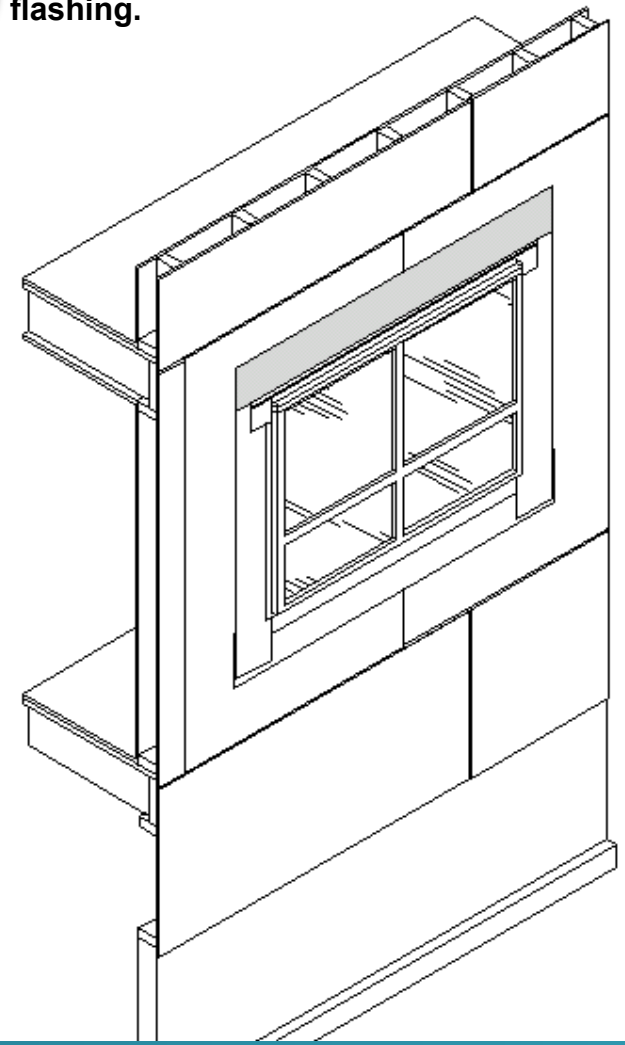
Refining Construction Details through

**Design Verification Testing**



7

Install Peel-n-Stick above from substrate to head flashing.



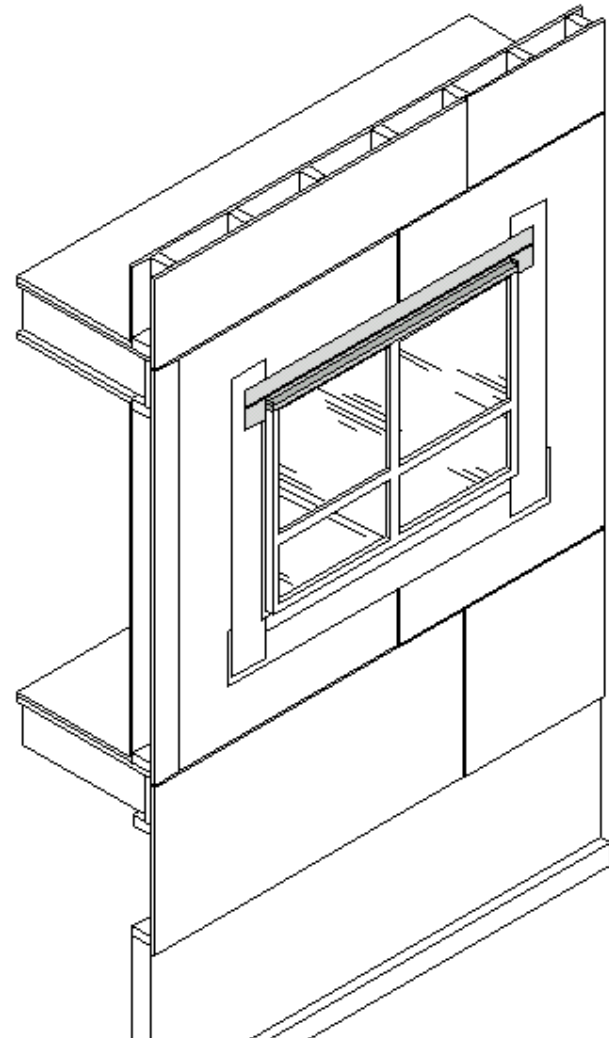
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



6

Install sheet metal head flashing.



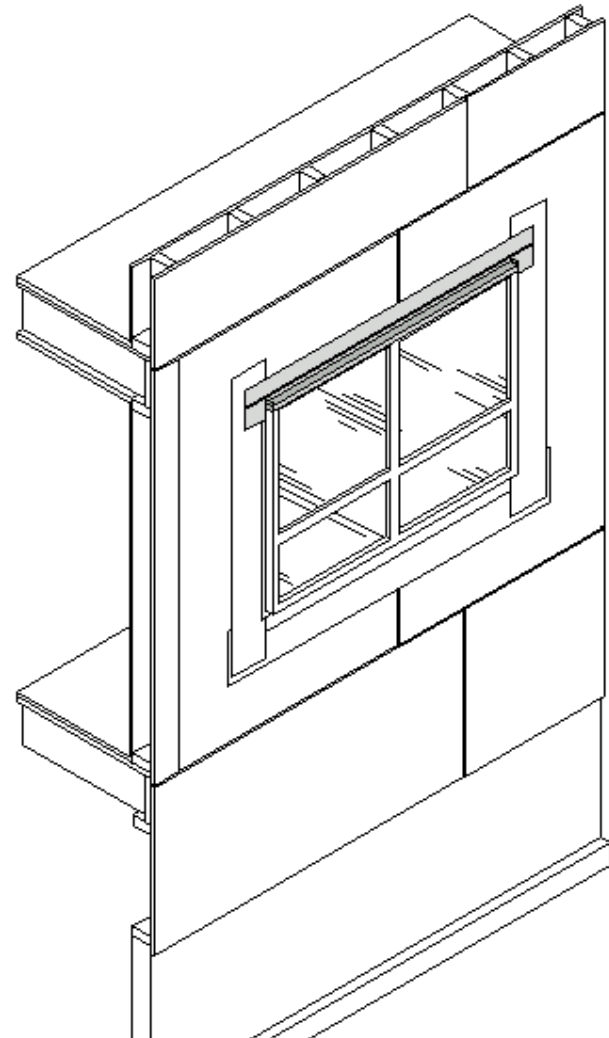
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



6

Install sheet metal head flashing.



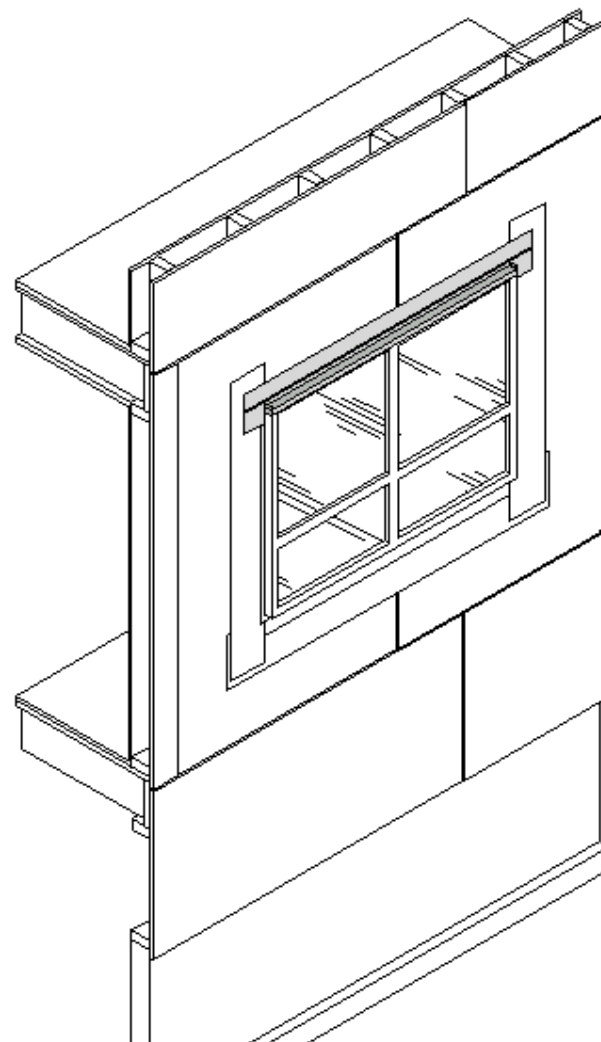
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



6

Install sheet metal head flashing.



*Raising the Bar*

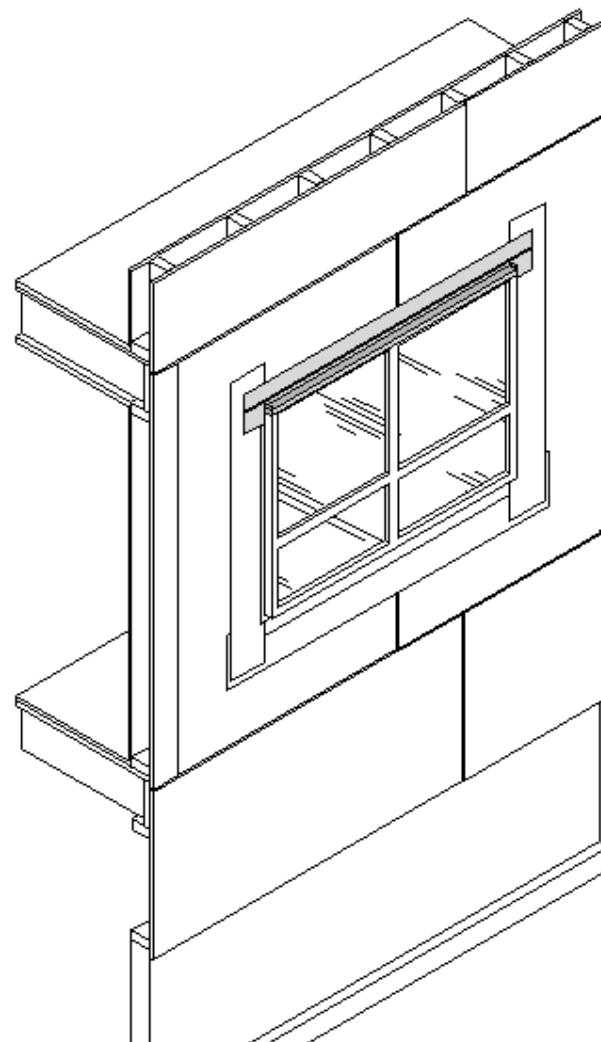
Refining Construction Details through

**Design Verification Testing**



6

Install sheet metal head flashing.



*Raising the Bar*

Refining Construction Details through

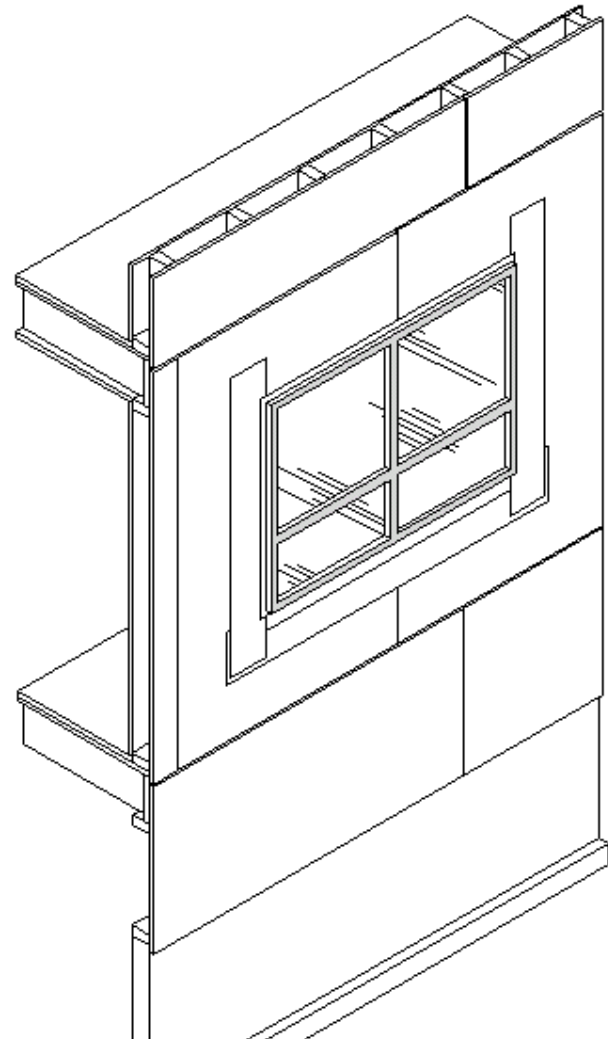
**Design Verification Testing**





5

Install window.



*Raising the Bar*

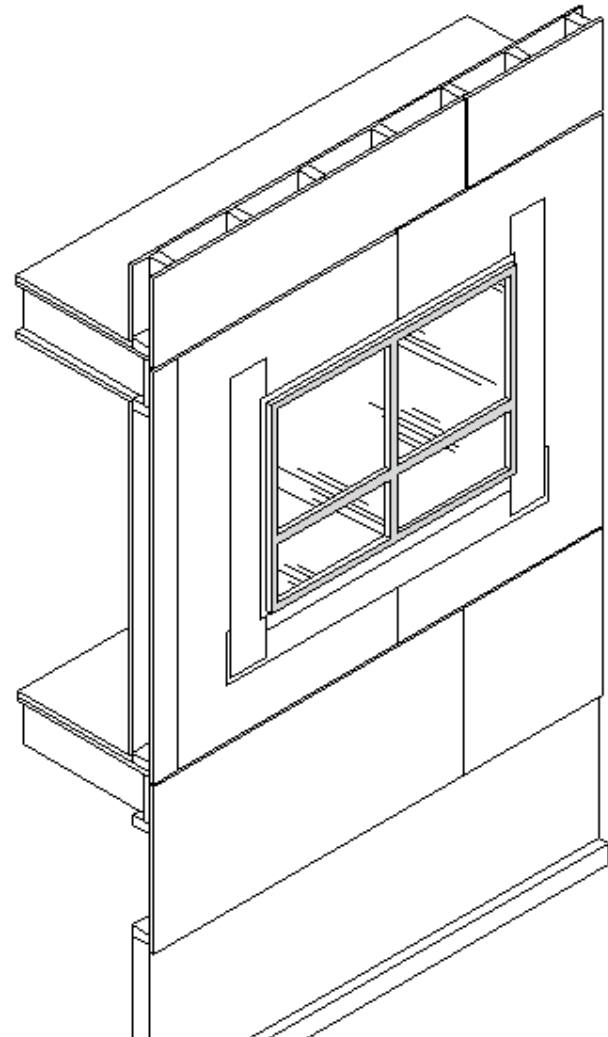
Refining Construction Details through

**Design Verification Testing**



5

Install window.



*Raising the Bar*

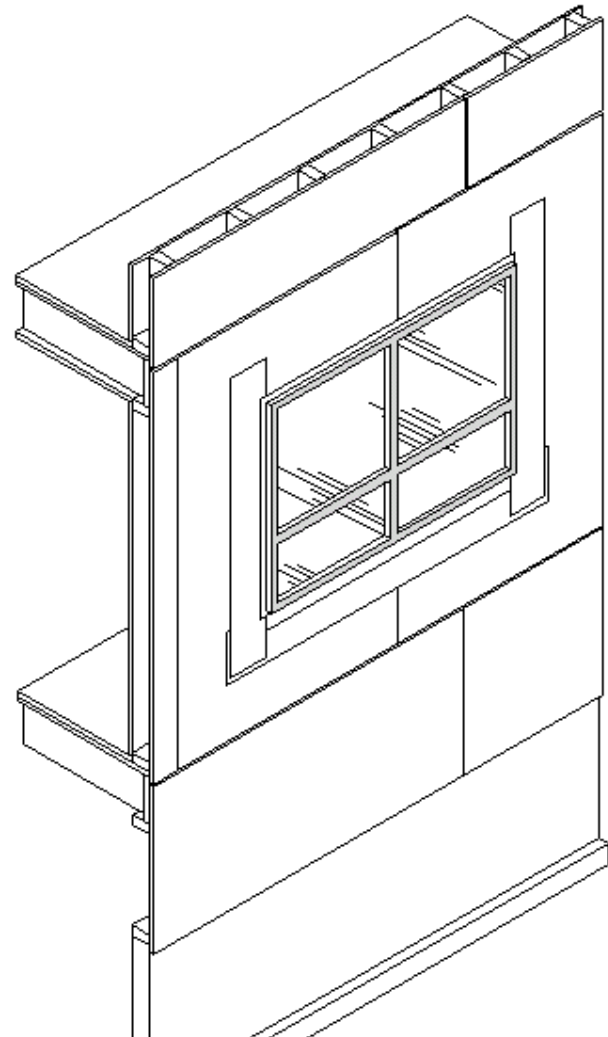
Refining Construction Details through

**Design Verification Testing**



5

Install window.



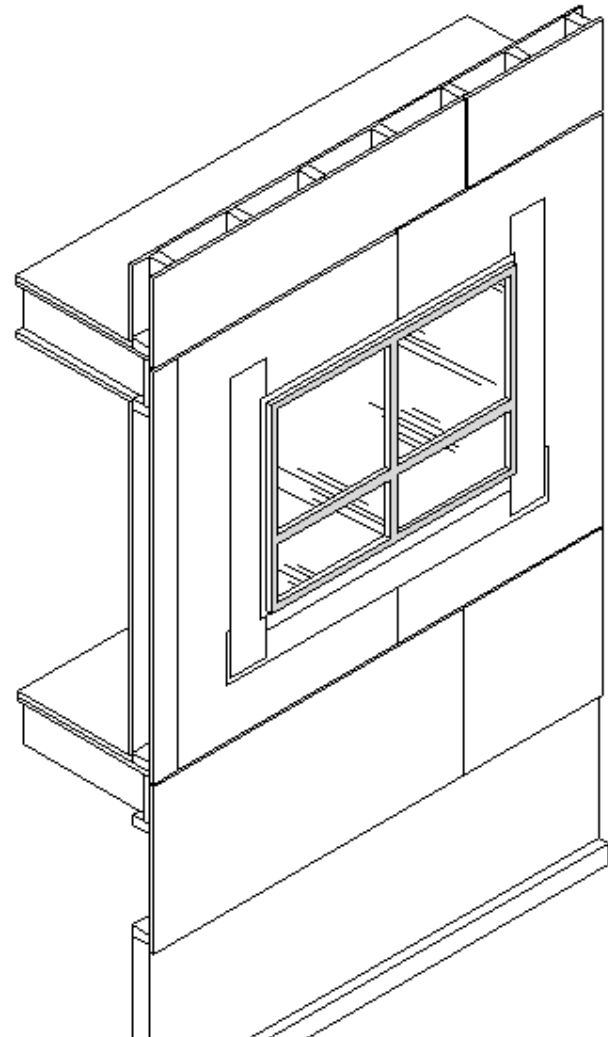
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



5

Install window.



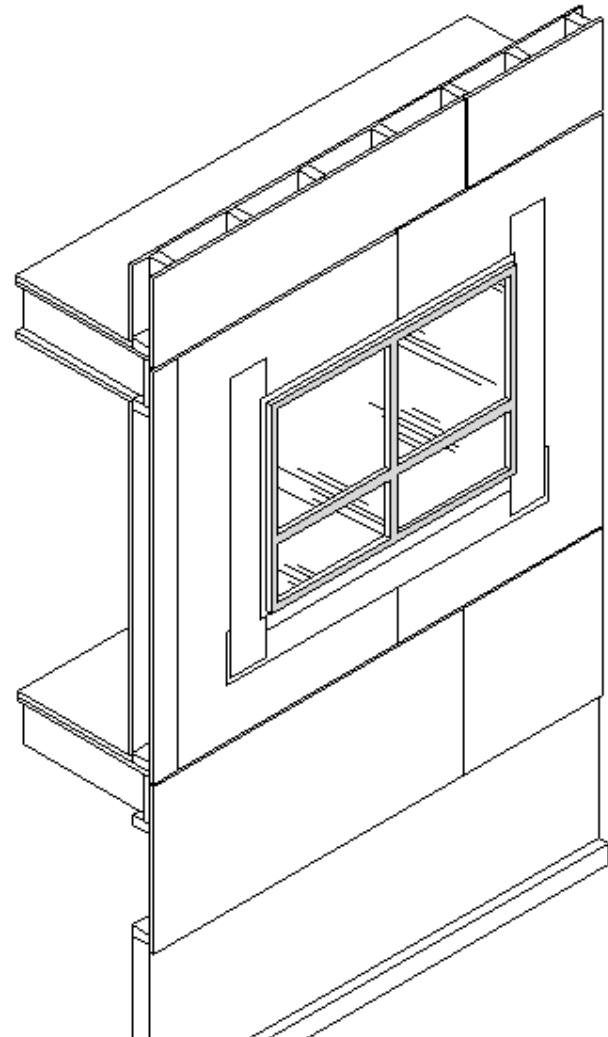
*Raising the Bar*

# Refining Construction Details through Design Verification Testing



5

Install window.

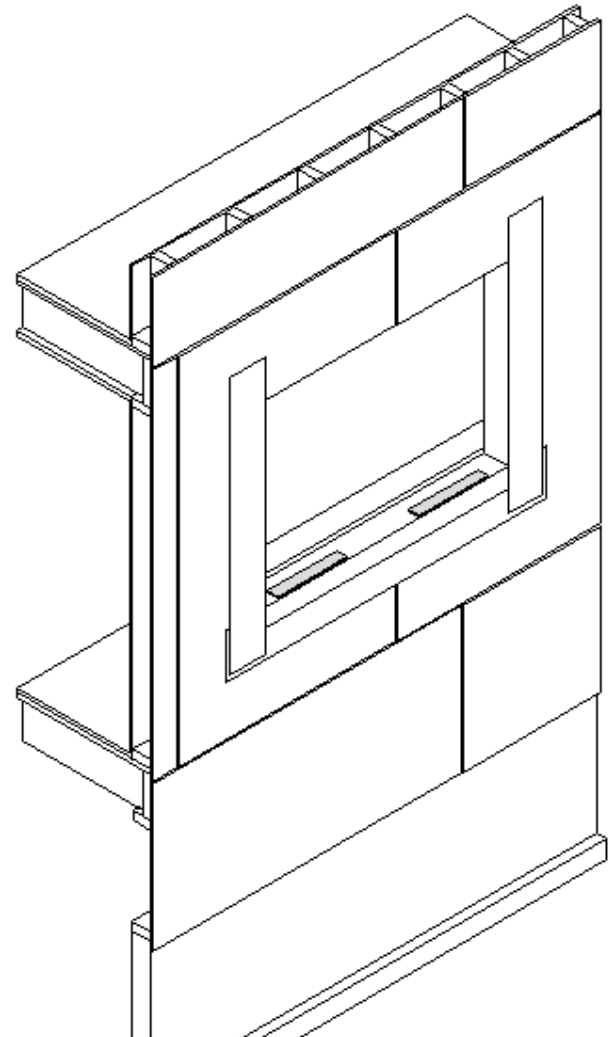


*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



**4** Install shims.



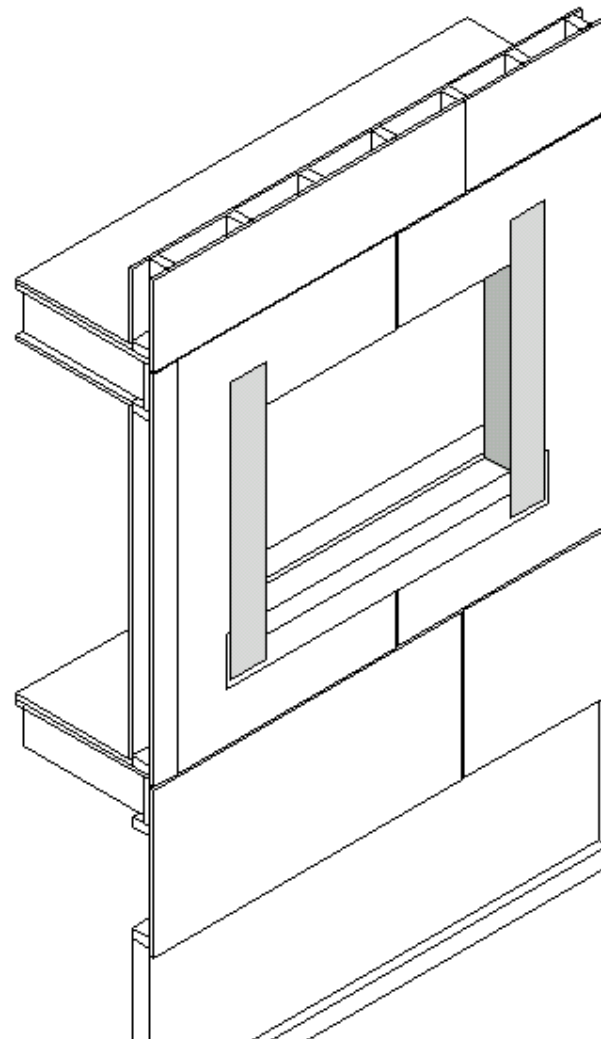
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



3

Install sheet membrane into window opening.



*Raising the Bar*

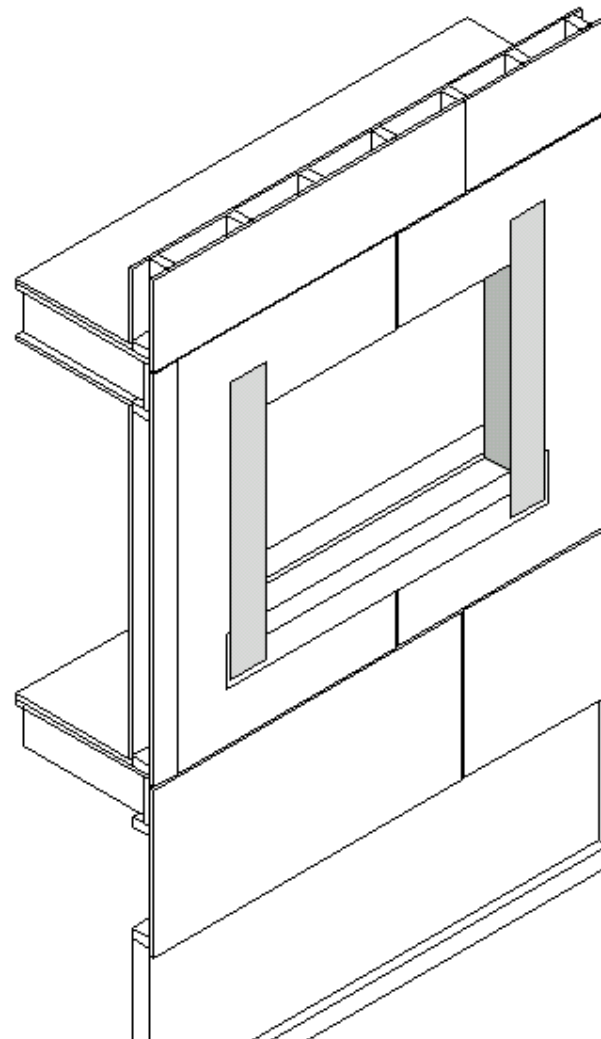
Refining Construction Details through

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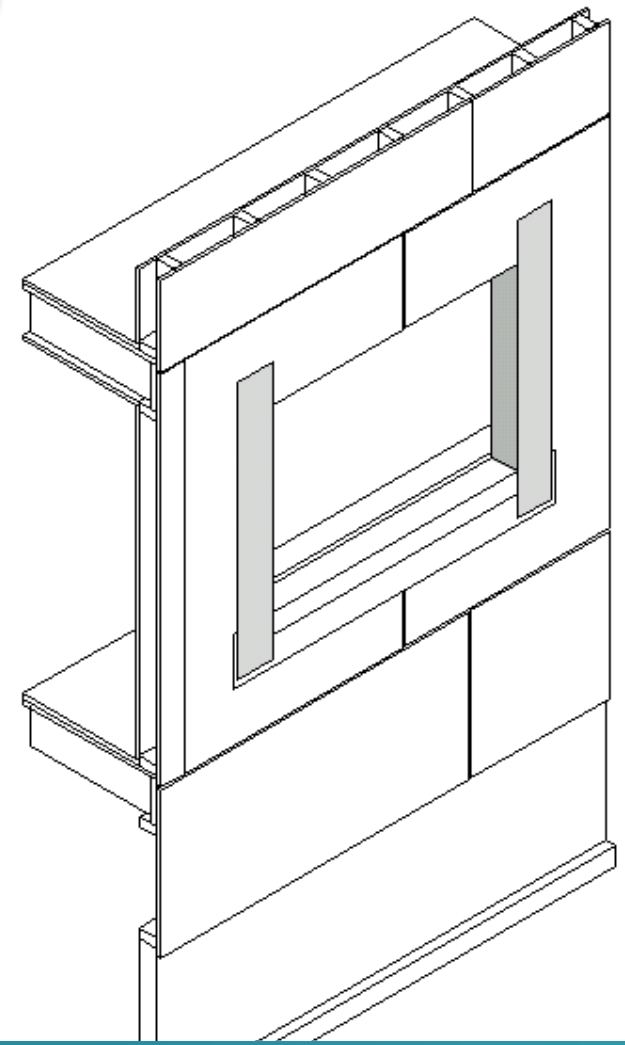
**Design Verification Testing**





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Install sheet membrane into window opening.



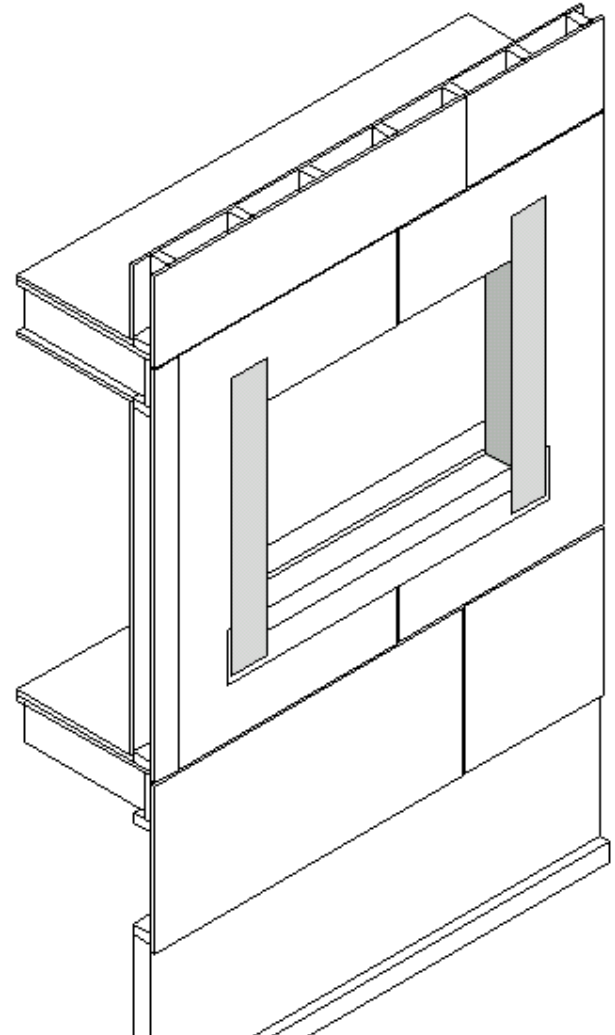
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# Refining Construction Details through Design Verification Testing



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Install sheet membrane into window opening.



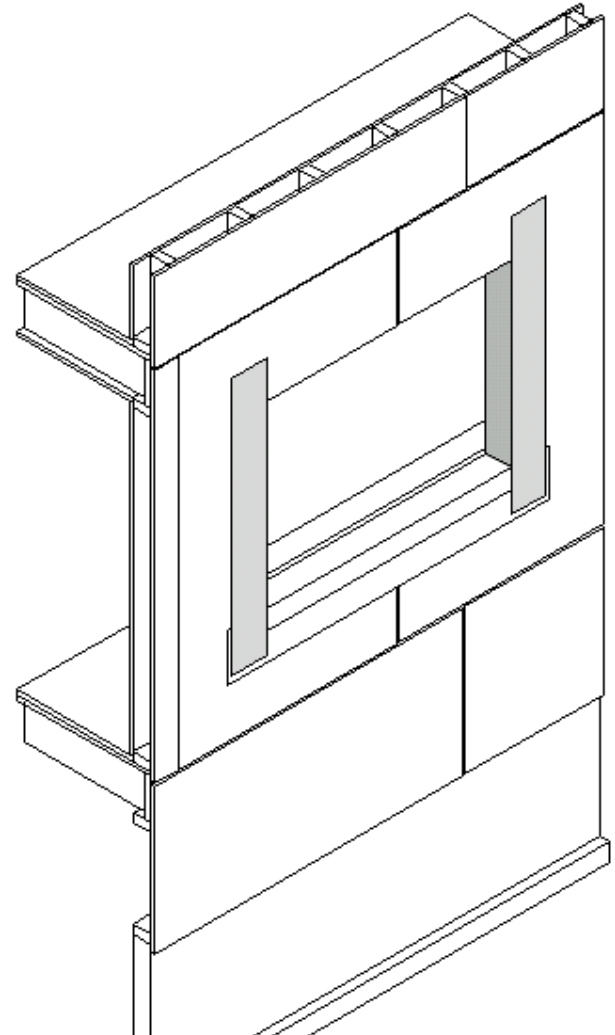
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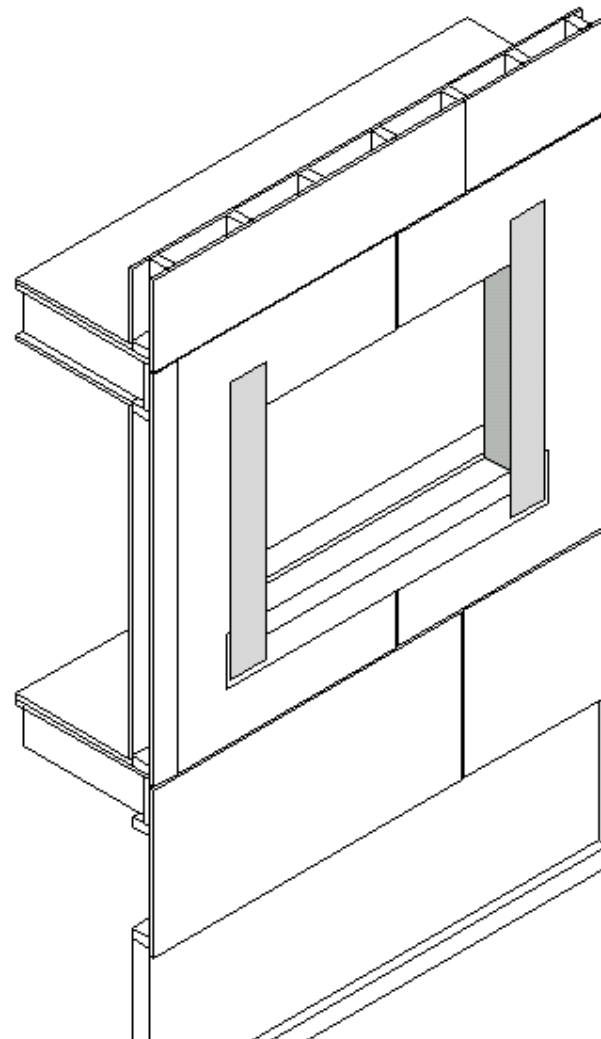
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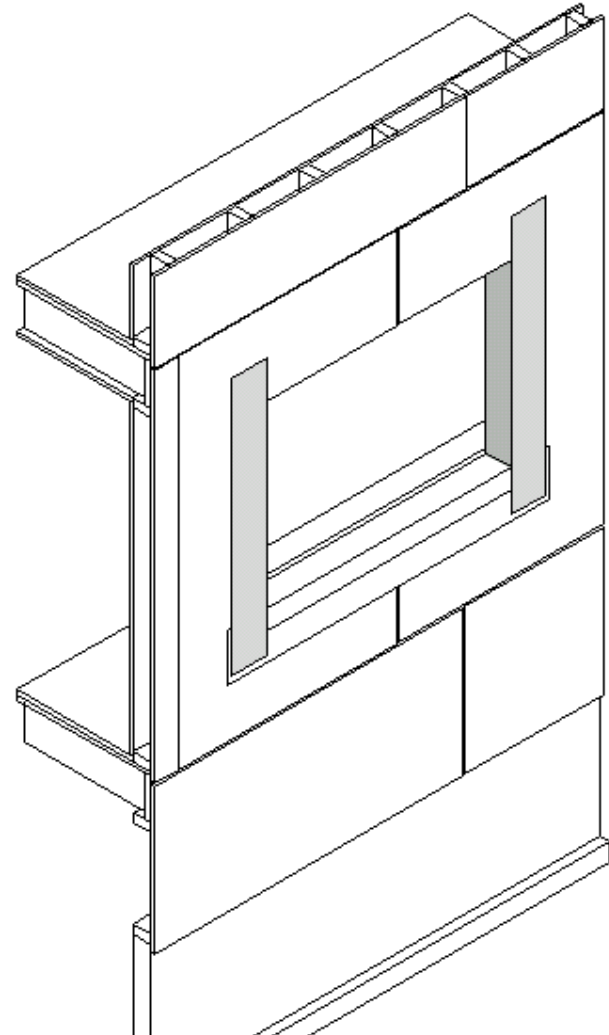
*Raising the Bar*

# Refining Construction Details through Design Verification Testing



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Install sheet membrane into window opening.



*Raising the Bar*

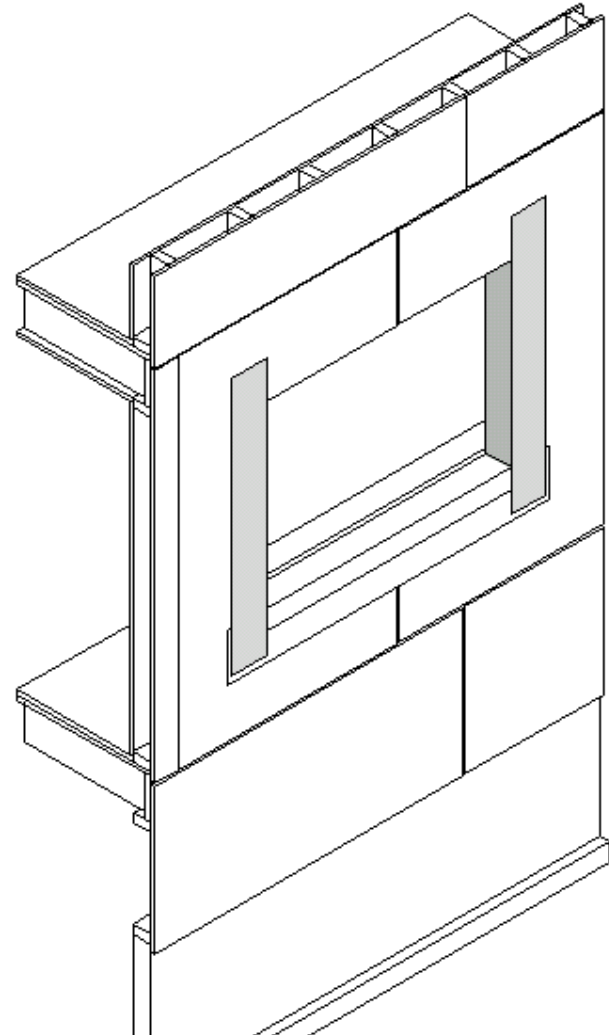
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Install sheet membrane into window opening.



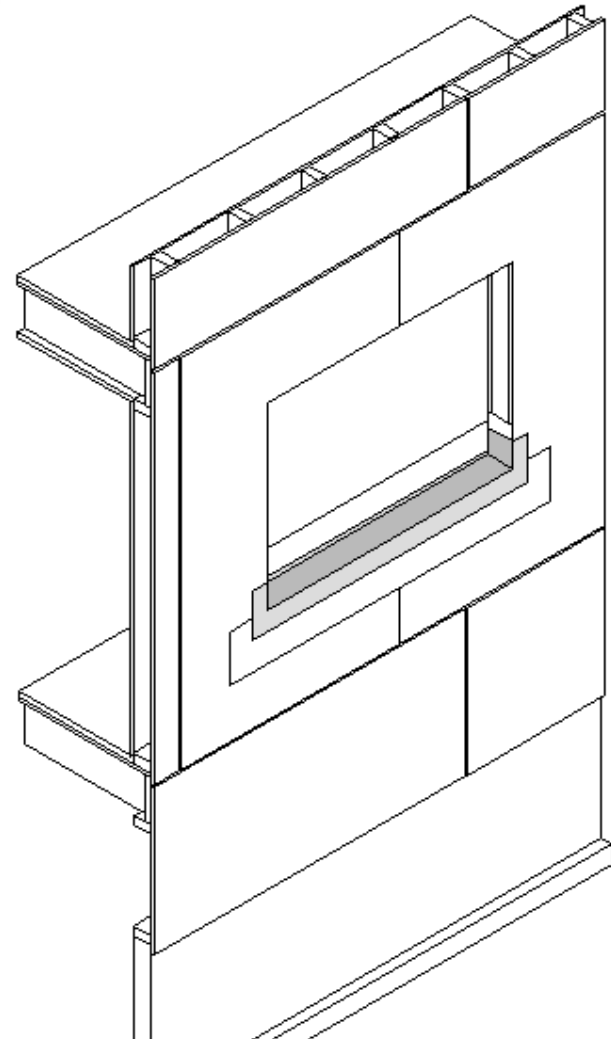
*Raising the Bar*

Refining Construction Details through  
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2

Install sheet metal tray.



*Raising the Bar*

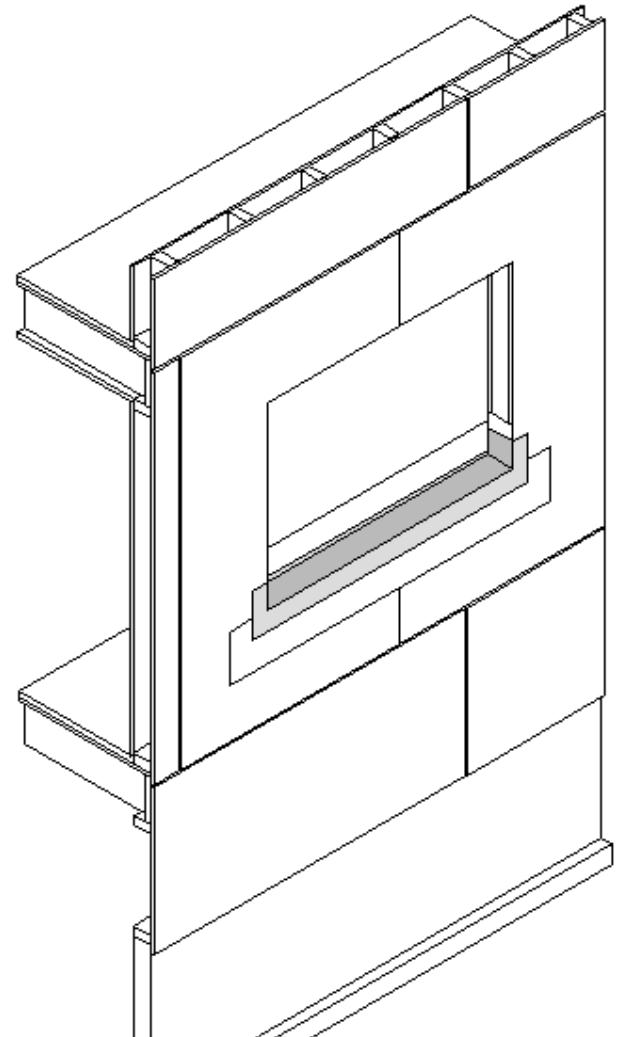
Refining Construction Details through

**Design Verification Testing**



2

Install sheet metal tray.



*Raising the Bar*

Refining Construction Details through

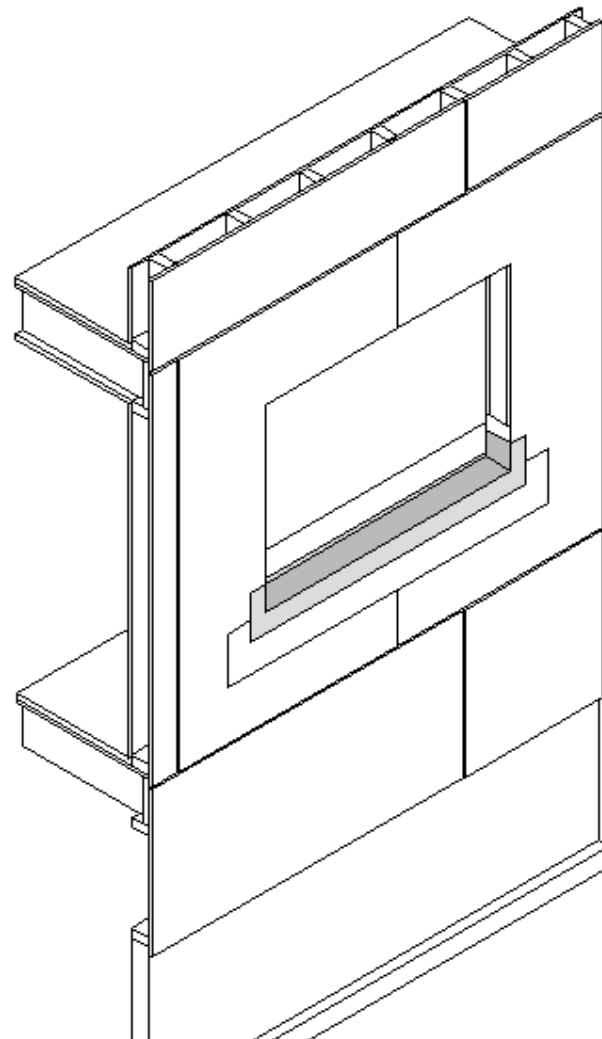
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*Raising the Bar*

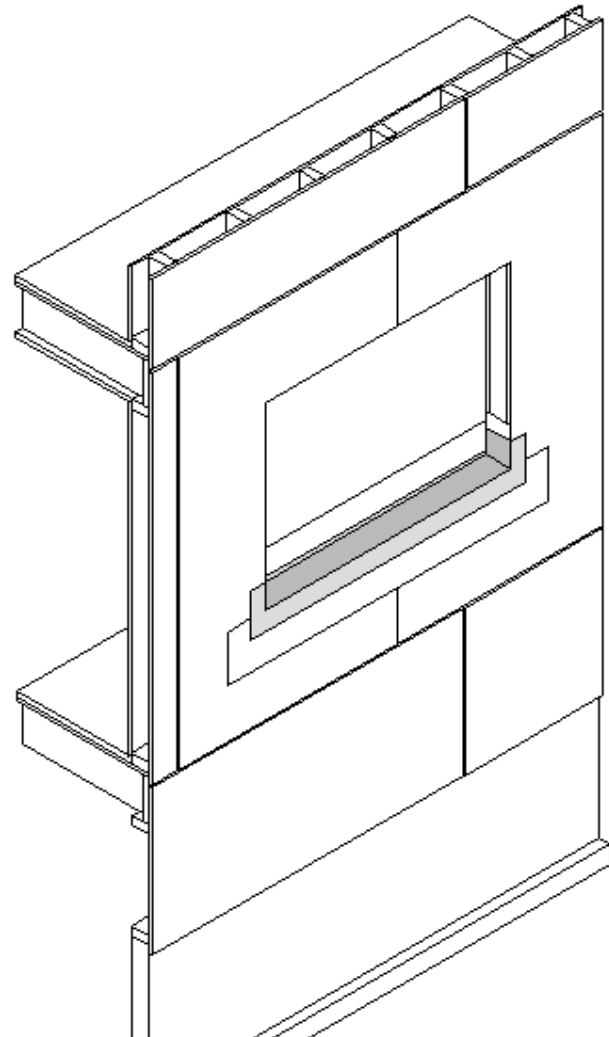
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2

Install sheet metal tray.



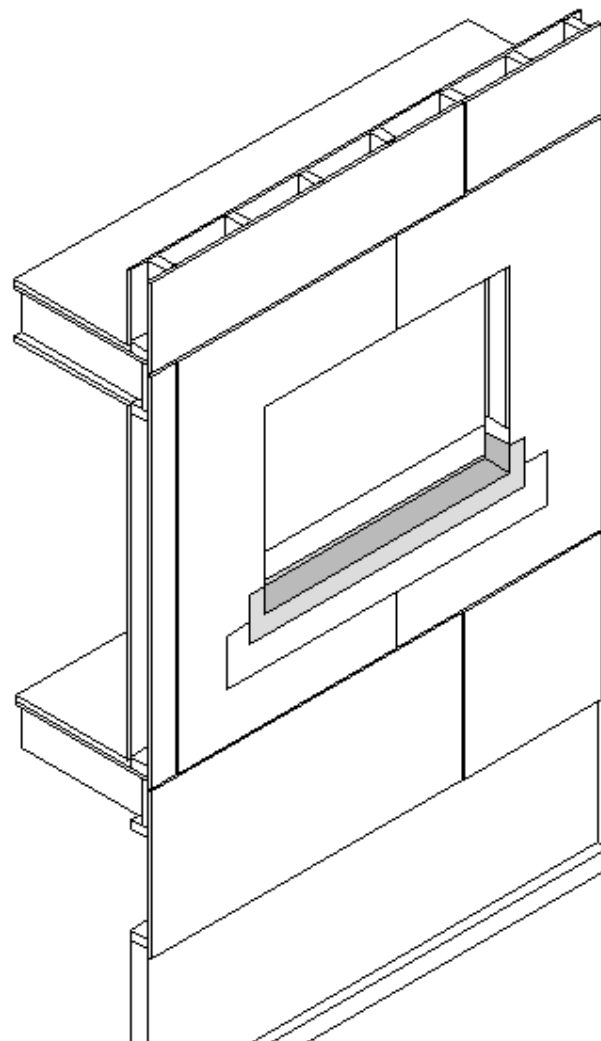
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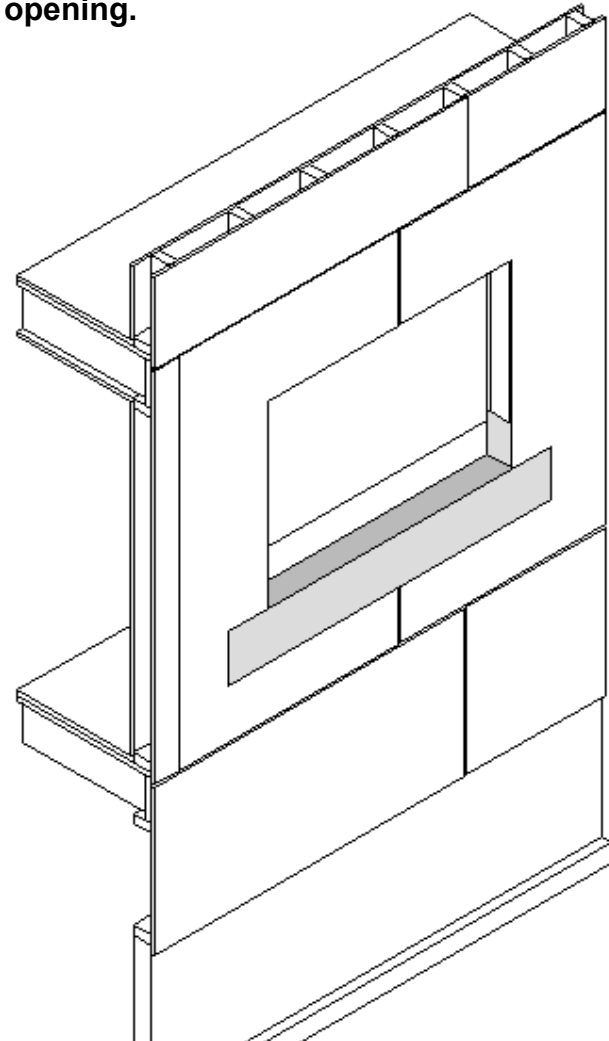
Refining Construction Details through

**Design Verification Testing**



1

Install sheet membrane into and below window opening.



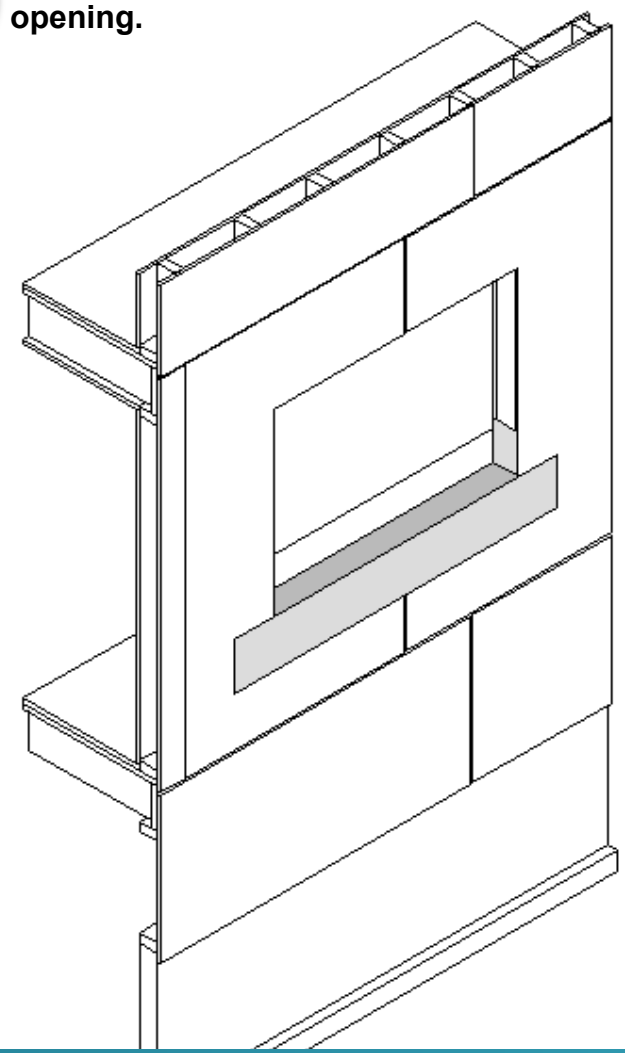
*Raising the Bar*

Refining Construction Details through  
**Design Verification Testing**



1

Install sheet membrane into and below window opening.



*Raising the Bar*

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**Design Verification Testing**



Designation: E 2112 – 07

## Standard Practice for Installation of Exterior Windows, Doors and Skylights<sup>1</sup>

- ✓ ***Difficult to properly install***
- ✓ ***Allows water leakage under typical weather conditions.***
- ✓ ***Leaks air***

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Managing Condensation, Water Intrusion  
& Energy Efficiency in the **Real World**

# Challenges with Using ASTM E 2112 in North American Climate Zones

Kevin C. Day

William C. Brown, P.Eng  
Member ASHRAE

## ABSTRACT

*Designing and constructing window-wall interfaces for long service life must include consideration of potential pathways for water ingress and egress; through both the window system and the interfacing cladding(s). ASTM E 2112 prescribes the installation of windows, patio-type doors and skylights as used primarily in residential and light construction commercial buildings. Adopting ASTM E 2112 allows designers to rely solely on windows to resist water penetration, independent of the adjoining wall assembly. However, experience of the authors has demonstrated that this approach has considerable risk.*

*When mass load-bearing walls, i.e., concrete and masonry, were the norm for buildings, the risk of damage from periodic water penetration at windows (in particular through the framing elements into the sub-sill cavity between the wall and window) was low because the walls had a high tolerance to moisture. In addition, the interior finishes, such as the traditional lime-based wall and ceiling plasters used widely in the 19th and early 20th centuries, were more robust to periodic wetting. Design practices have evolved to include non-load bearing walls with less moisture resistant structural systems, e.g., wood and steel studs, and paper-faced gypsum sheathings, combined with windows that attempt to manage water by intercepting it at the face of the assembly, and draining at the operable interface. Notwithstanding the advances in the performance of sealants and membrane materials, reliance upon face sealed systems has a higher risk of water penetration because of the inherent aging of the materials and loads imposed, thus reducing the overall resistance to water penetration and consequent damage.*

*This paper presents an overview of the design considerations for window installation relative to climate zones across North America. It also presents a series of conceptual details that focus on the control of water ingress from rain, air leakage, and vapor pressure across the window-wall interface.*

## INTRODUCTION

The building construction industry in North America has been challenged since the early 1980's to address the large number of malfunctioning building envelopes. Many consumers have been inconvenienced and financially distressed by the fiasco of water penetration problems associated with windows. Allegations of damage and mold-related problems have been widespread; the assessment of the situation has been pervasive in symposia and academic forums over the last two decades.

The list of technical papers and articles (too long to cite here) which delineate problems between windows and walls typically highlight the interface of the sheathing membrane

with the concealed portion of the window framing. However, there has been a significant difference in the approach to making a water resistant connection. In particular, the degree to which windows are assumed to be water-tight, both by their construction and by their installation, and how water penetration is defined when it enters the wall assembly (or penetrates to the occupied interior space). Although windows are referenced throughout this paper as the generic fenestration element for the purpose of discussion, sliding glass (patio) and conventional doors must adopt the same principles regarding the window-wall interface details.

*Kevin C. Day is a building science specialist for Halsall Associates Ltd., Richmond Hill, ON. William C. Brown is a senior building scientist specialist, Morrison Hershfield Ltd., Ottawa, ON.*

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# “Challenges with Using ASTM E 2112 in North American Climate Zones”

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# “Who are those guys?”

*Butch Cassidy & The Sundance Kid, 1969*

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WHO WE ARE | IF YOU ARE A... | WHAT WE DO | OUR WORK | HOW TO JOIN US | WHERE TO FIND US

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- Competitor
- Student
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## Liquid detailing membrane

# Managing Condensation, Water Intrusion & Energy Efficiency in the Real World

“What Proceedings?”

Eleventh International  
Conference

on

Thermal Performance of Exterior  
Building Envelopes

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& Energy Efficiency in the **Real World**

# “Sponsored by?”

Building Enclosure Integration Committee  
of the  
Building Enclosure Technology & Environmental  
Council (BETEC)  
of the  
National Institute of Building Sciences  
and  
ASHRAE

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# “Organized by?”



**Building Technologies Research  
and Integration Center**



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& Energy Efficiency in the Real World**

“Notwithstanding the advances in the performance of sealants and membrane materials,

reliance upon face sealed systems has a higher risk of water penetration because of the inherent aging of the materials and loads imposed,

thus reducing the overall resistance to water penetration and consequent damage.”

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Managing Condensation, Water Intrusion  
& Energy Efficiency in the **Real World**

## “CONCLUSION

...the combination of wood- or steel-framed construction with **windows that may leak** at some point during their life cycle leads the authors to conclude that only the hot and dry hygrothermal zone may be tolerant of periodic wetting and **secondary protection of the window opening is required** in all other hygrothermal zones.”

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## 2007 Revision of ASTM E 2112

- Pan Flashing Systems
- This practice recommends that pan flashings be used under all windows and doors
- Pan Flashing Seal Discontinuity –
  - to permit drainage from the sill pan to the exterior.

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## 2007 Revision of ASTM E 2112

### Types of pan flashing materials

- metal
- plastic
- composites
- self-adhered

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## Metal pan flashing

- Corners must be welded. Sealant in corners not long-term solution.
- Fasteners penetrate pan. Blind seal problematic.
- Window rough openings must accommodate the thickness of metal pan -- including sealant application.

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## Metal pan flashing (con't)

- \$ COST \$ / custom fabrication
- Requires high skill level
- "5.16.8 Pan Flashings as Thermal Bridges" [Don't use metal if it ever gets cold where you are.]
  - Causes condensation on the interior glass

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## Self-adhered membrane pan flashing

- Folds in corners (“tents”) increases thickness and leads to tearing during window install
- Sometimes removed altogether
- “Bridges” at overlaps creates water path
- Vapor barriers prevent drying

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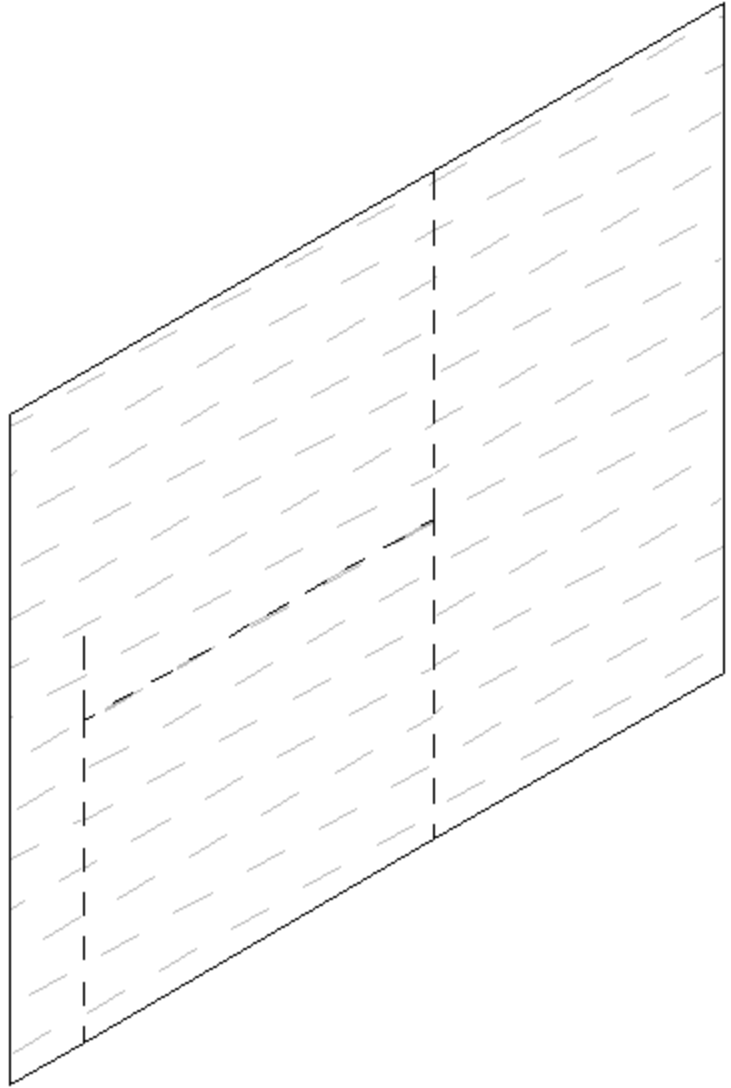
Window Wrap with **Self-Adhered Sill-Pan Flashing**,  
Window and 2 Layers of  
Building Paper Installation

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& Energy Efficiency in the **Real World**

# Peel-n-Stick

Fold Lines



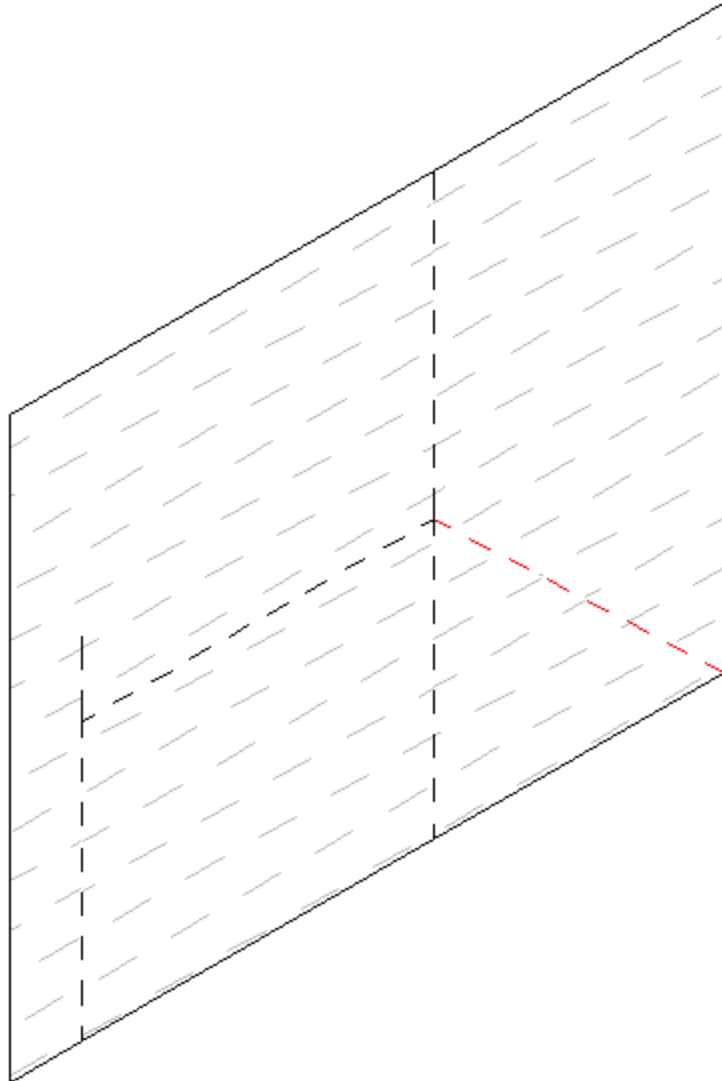
Liquid detailing membrane

Managing Condensation, Water Intrusion & Energy Efficiency in the **Real World**

# Peel-n-Stick

Fold Lines

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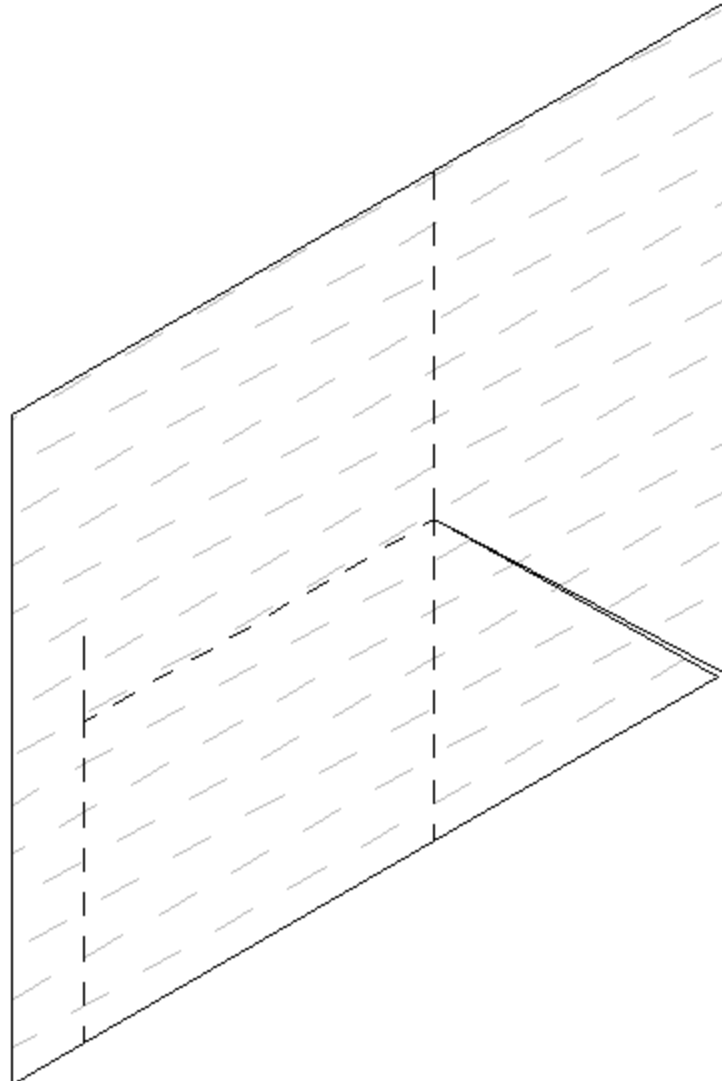
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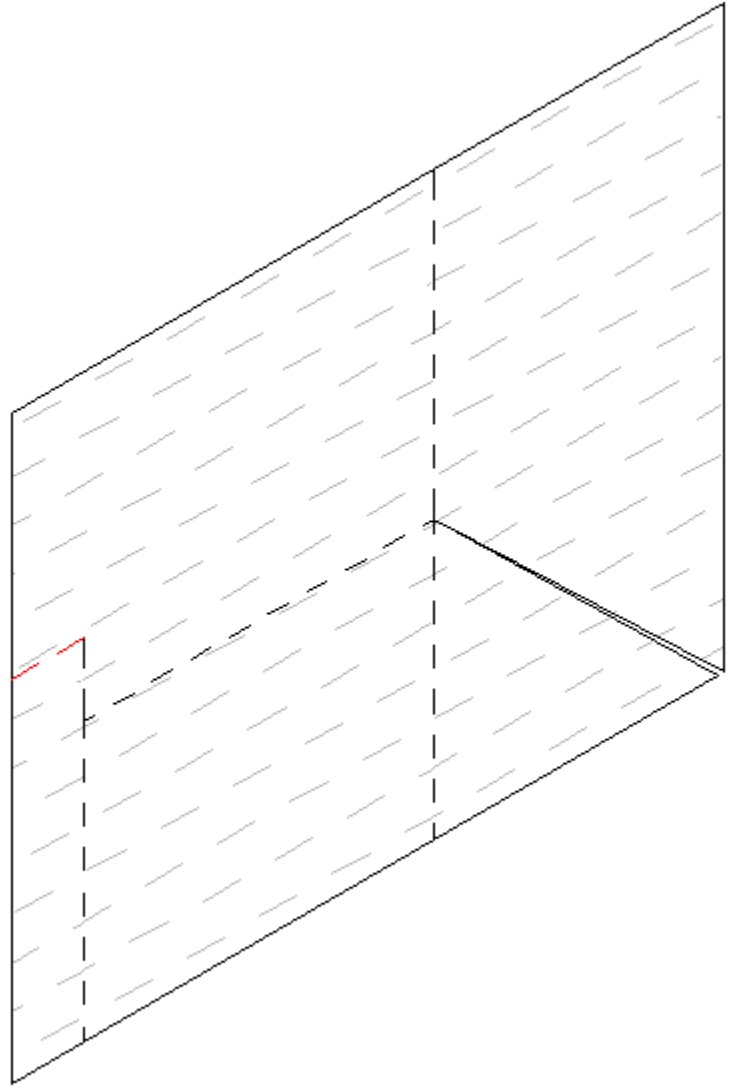
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Liquid detailing membrane

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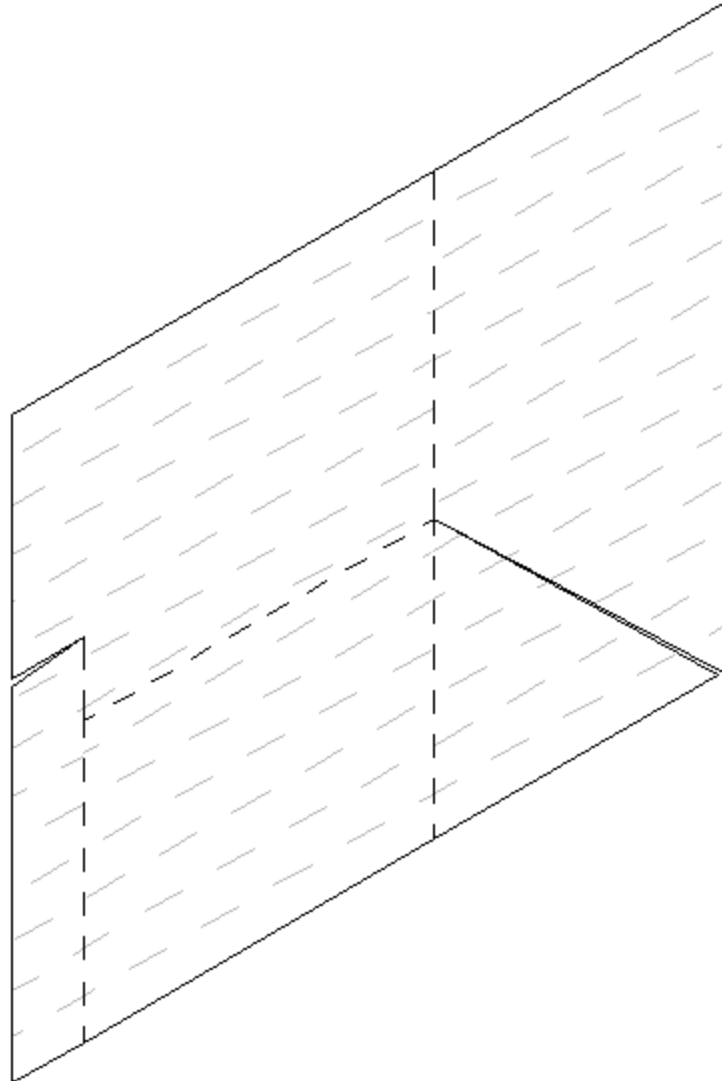


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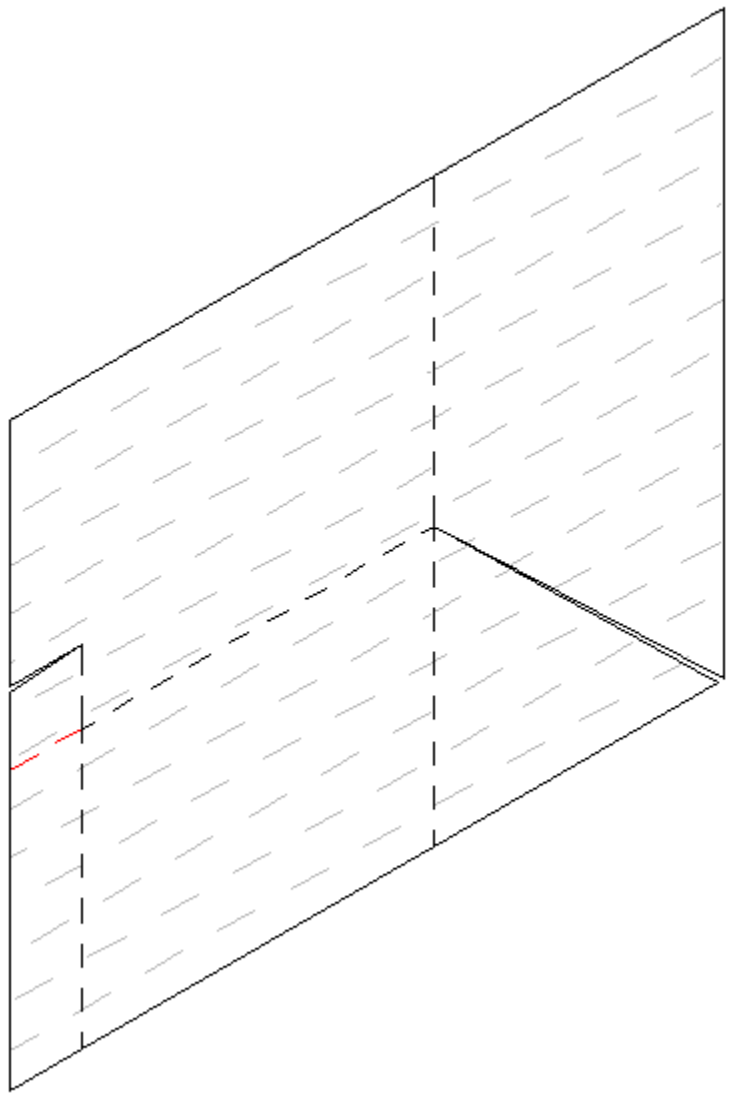
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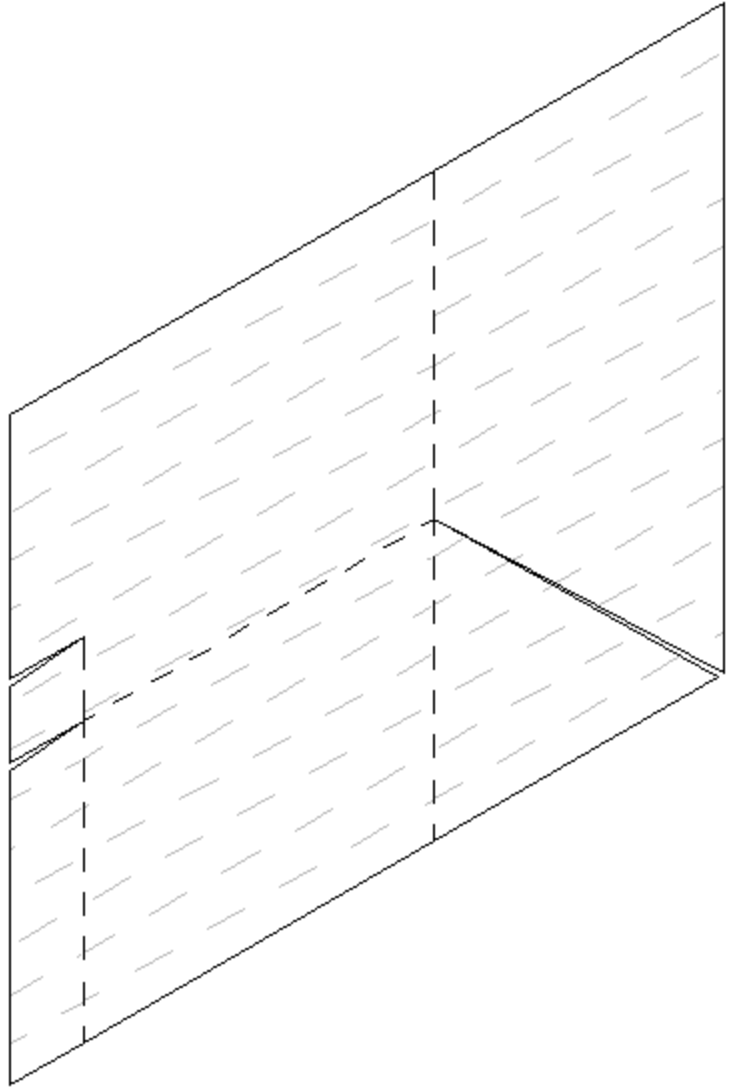
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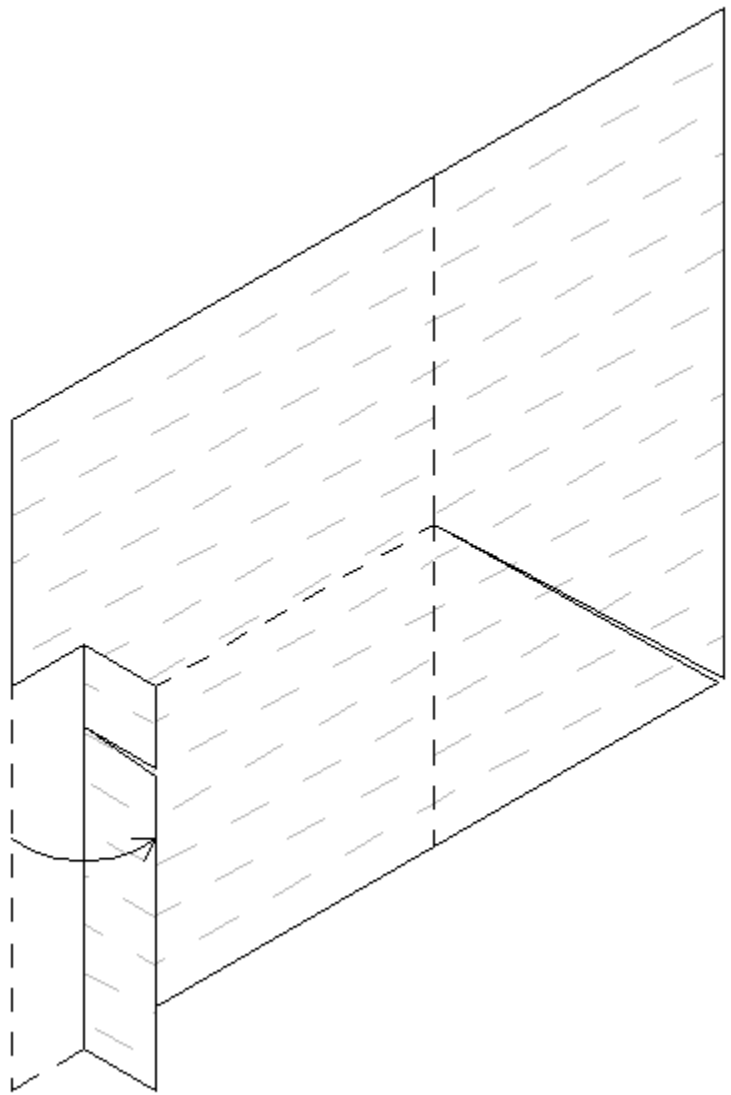


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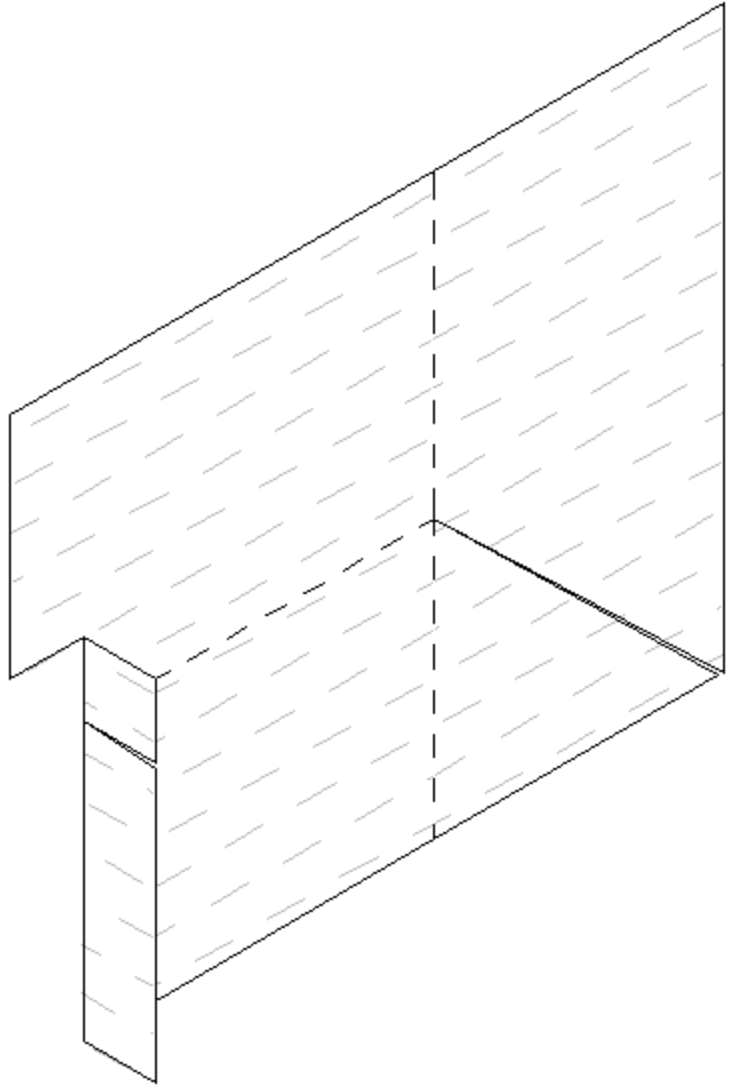


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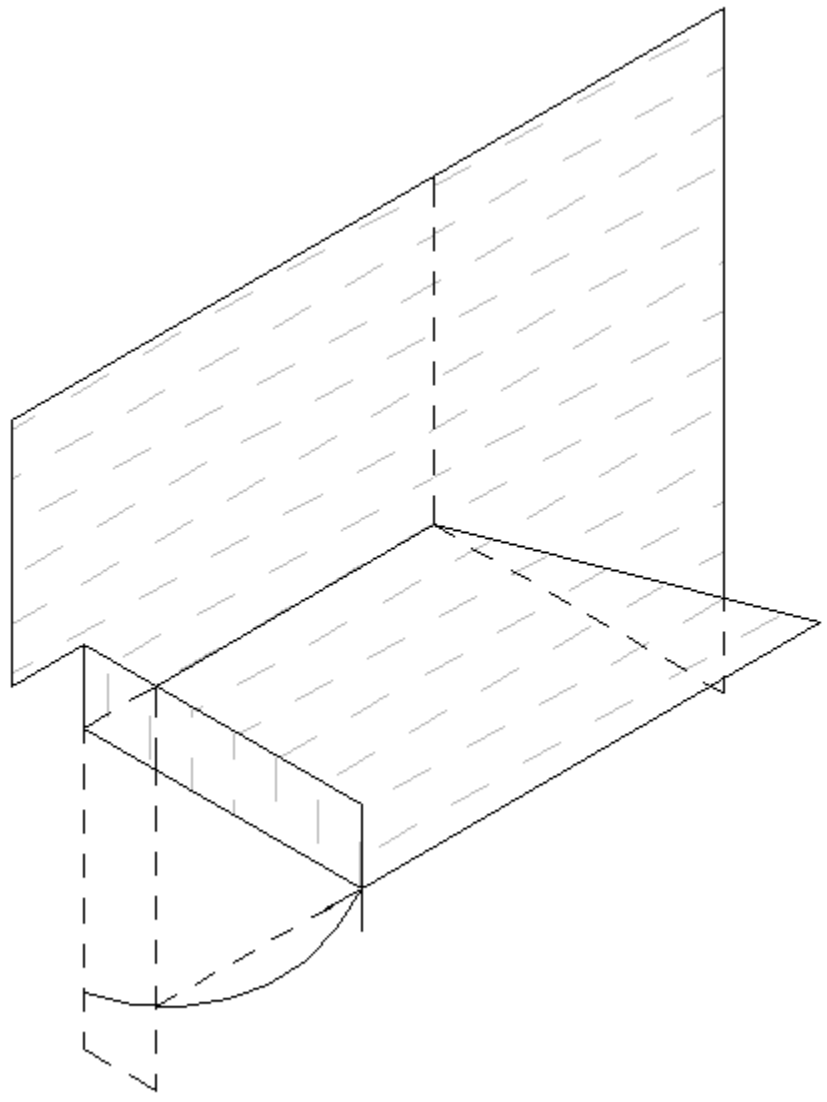


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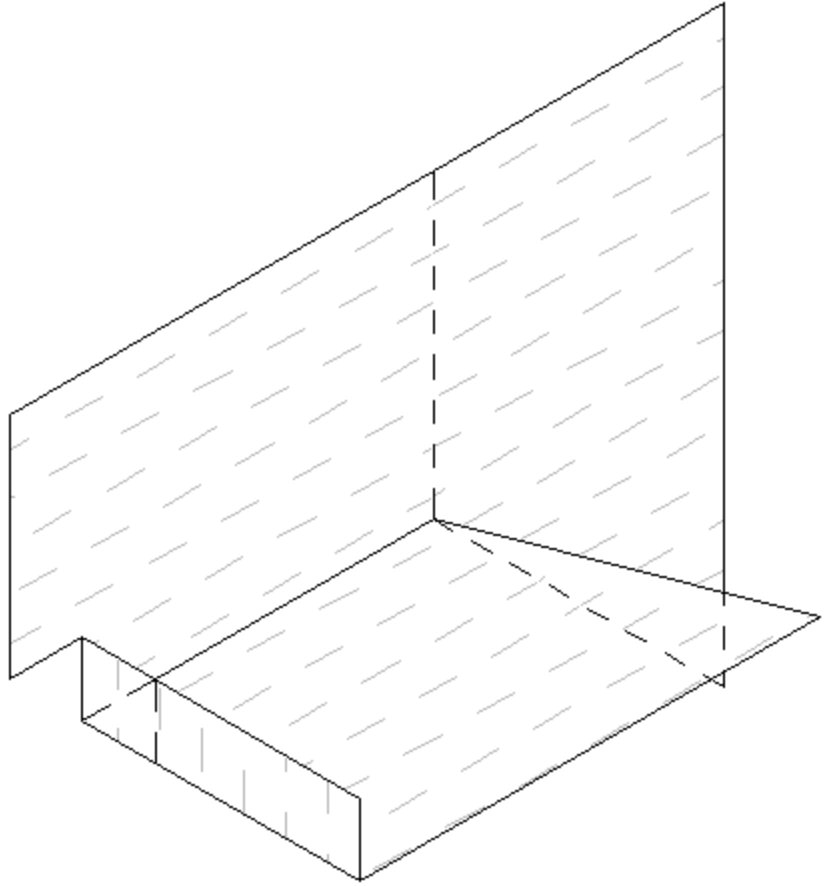


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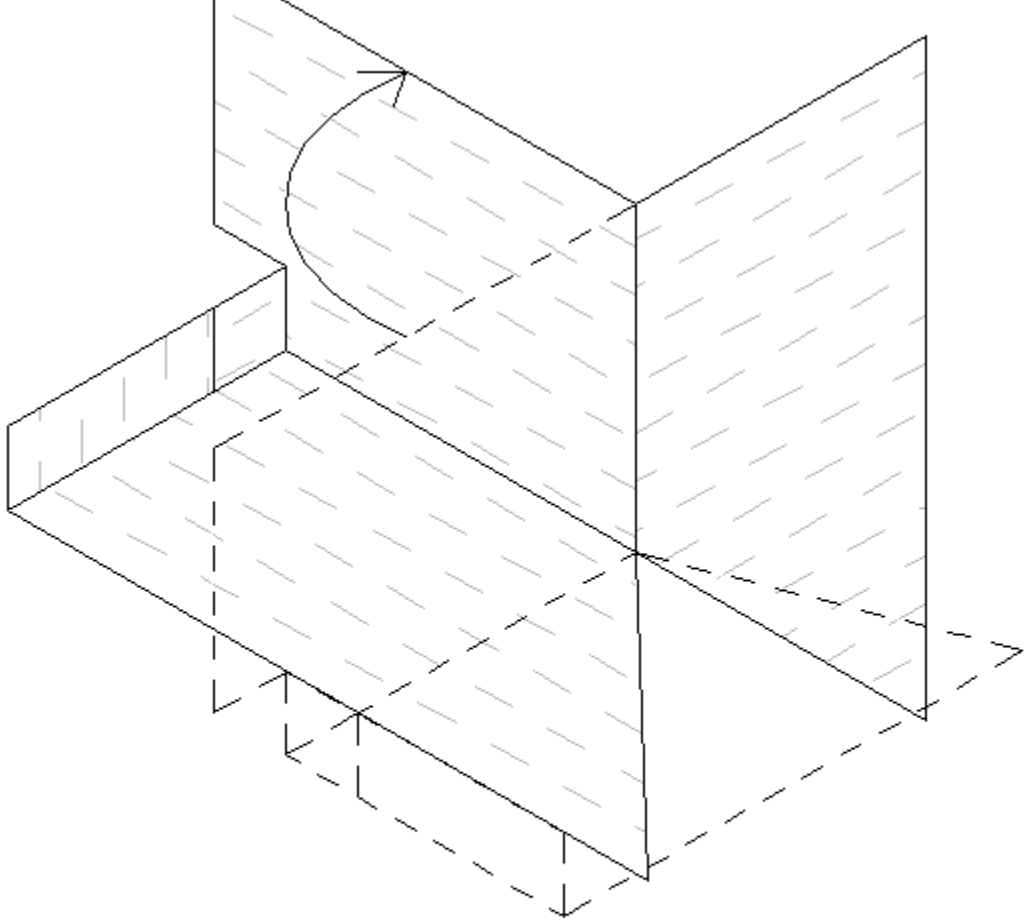


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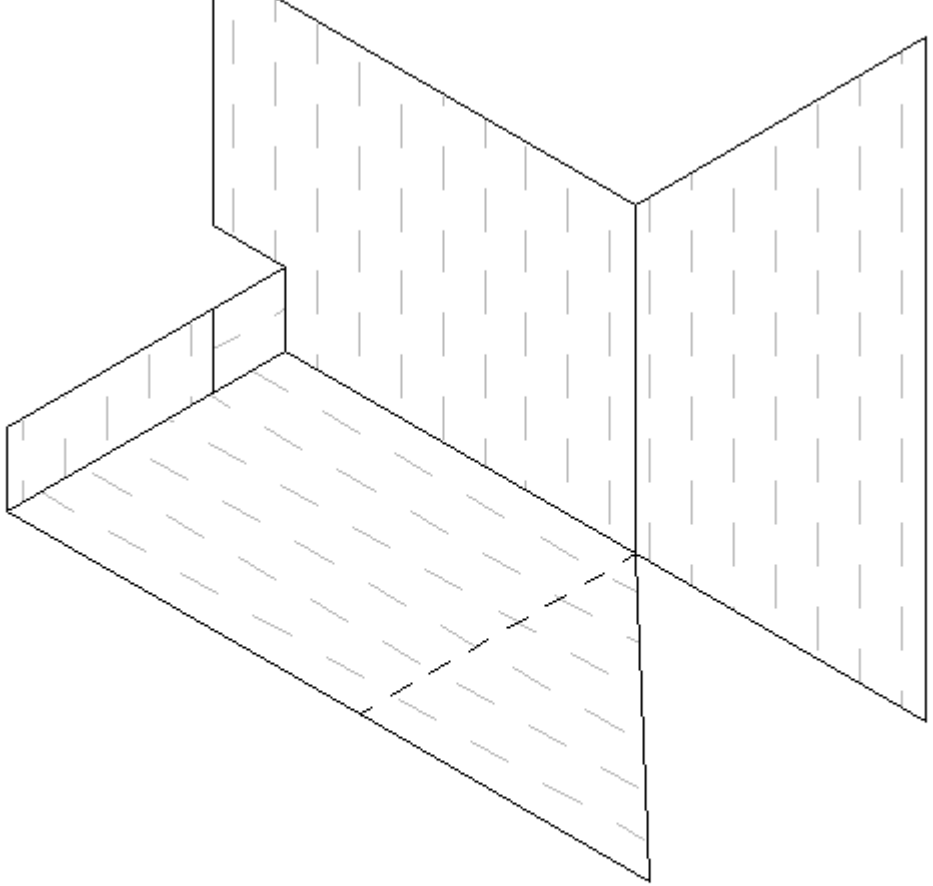
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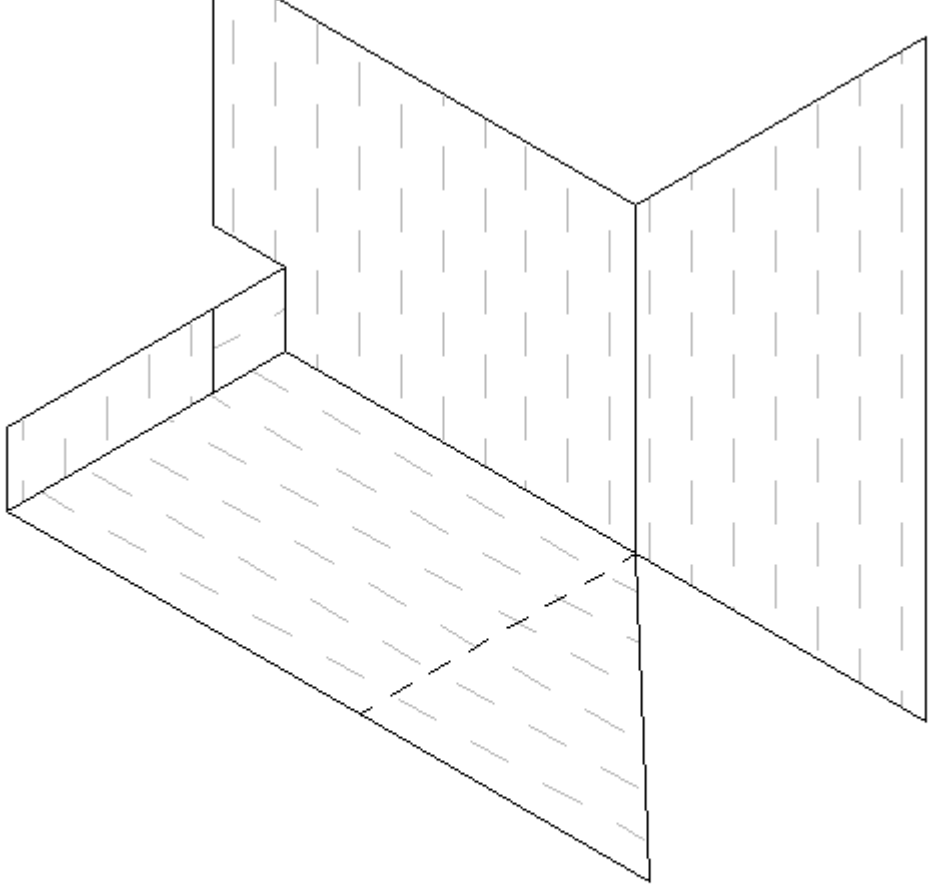


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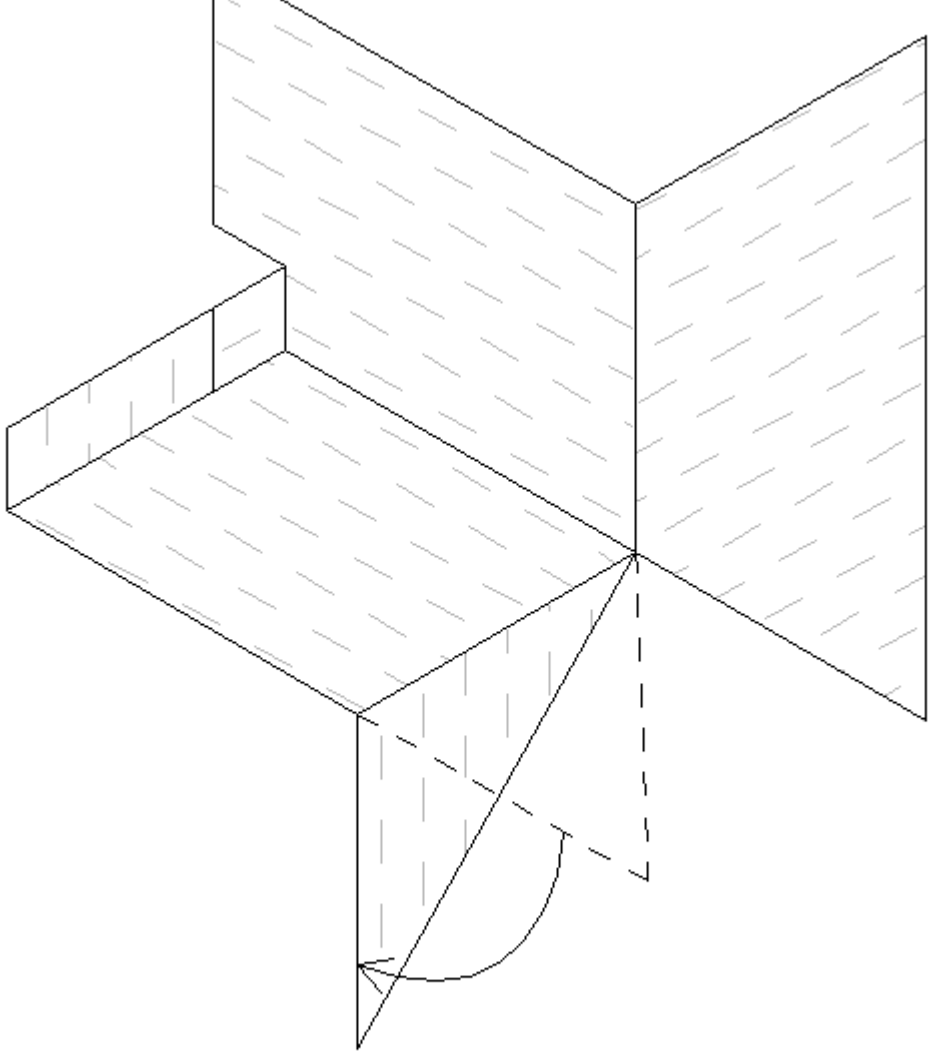
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Liquid detailing membrane

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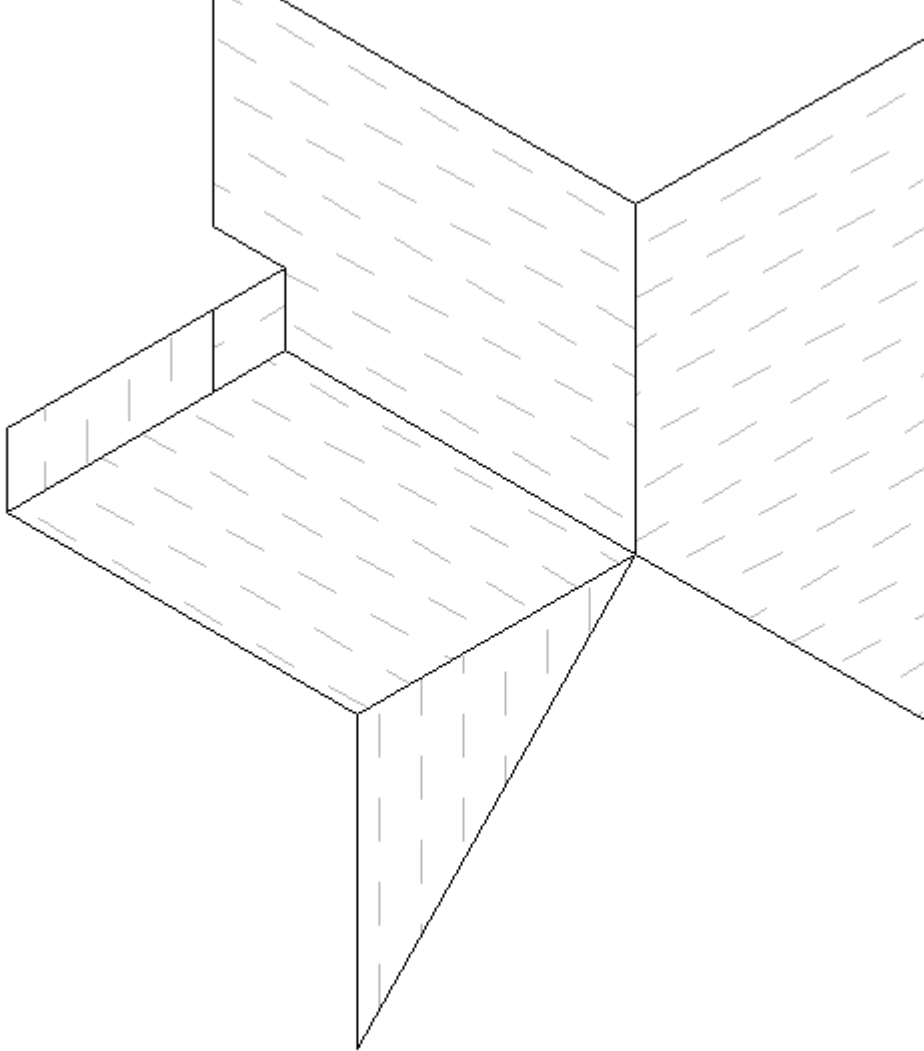
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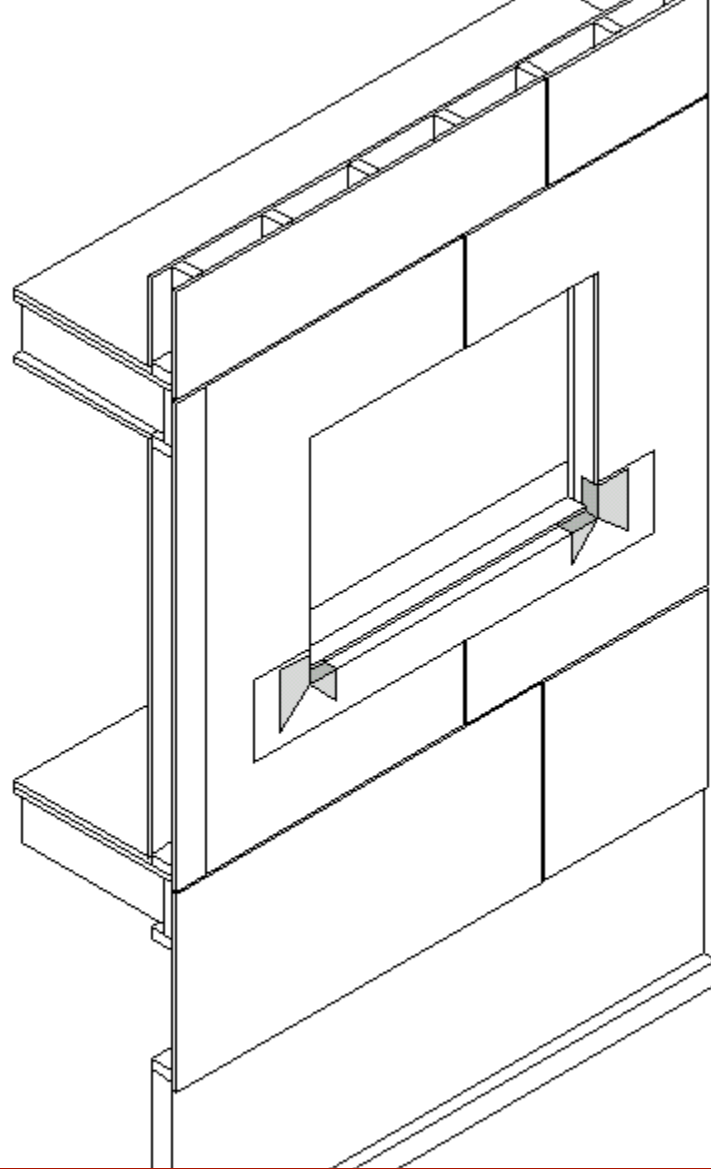
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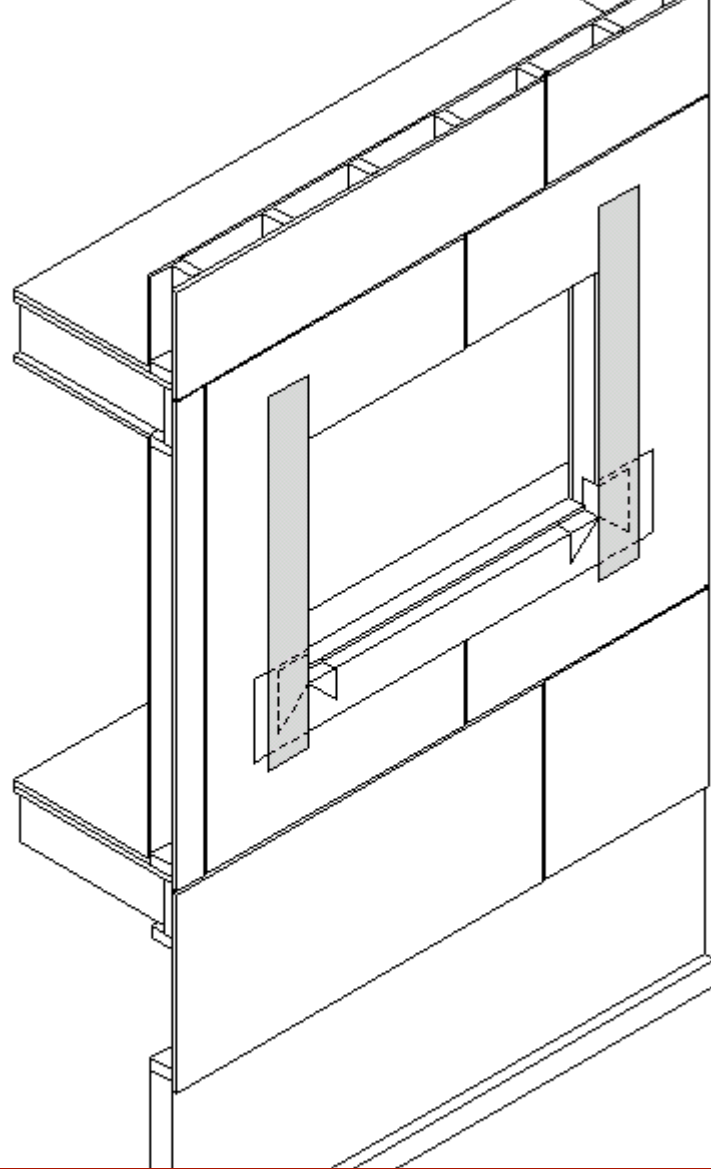
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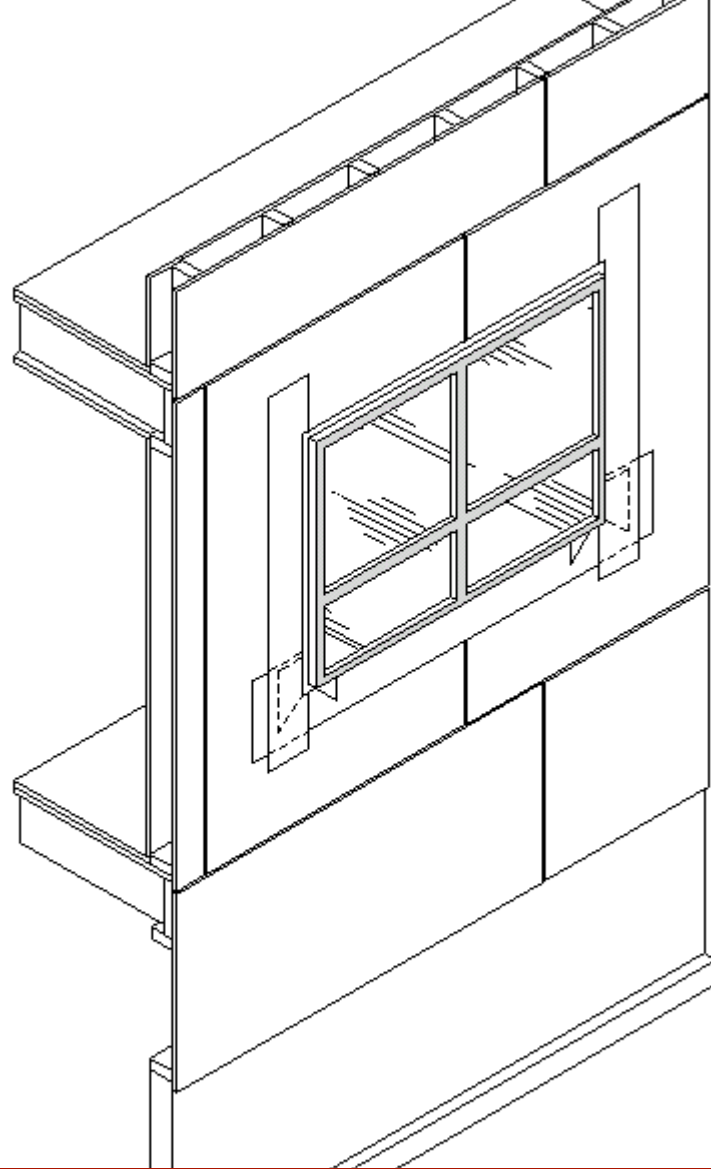
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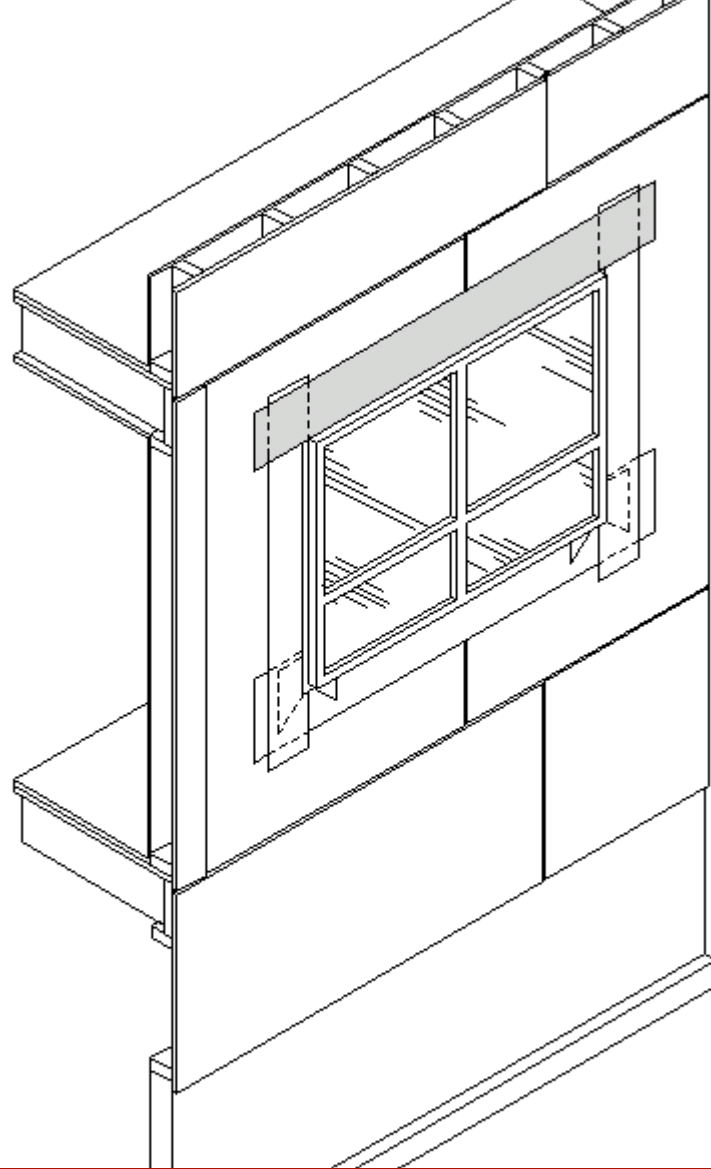
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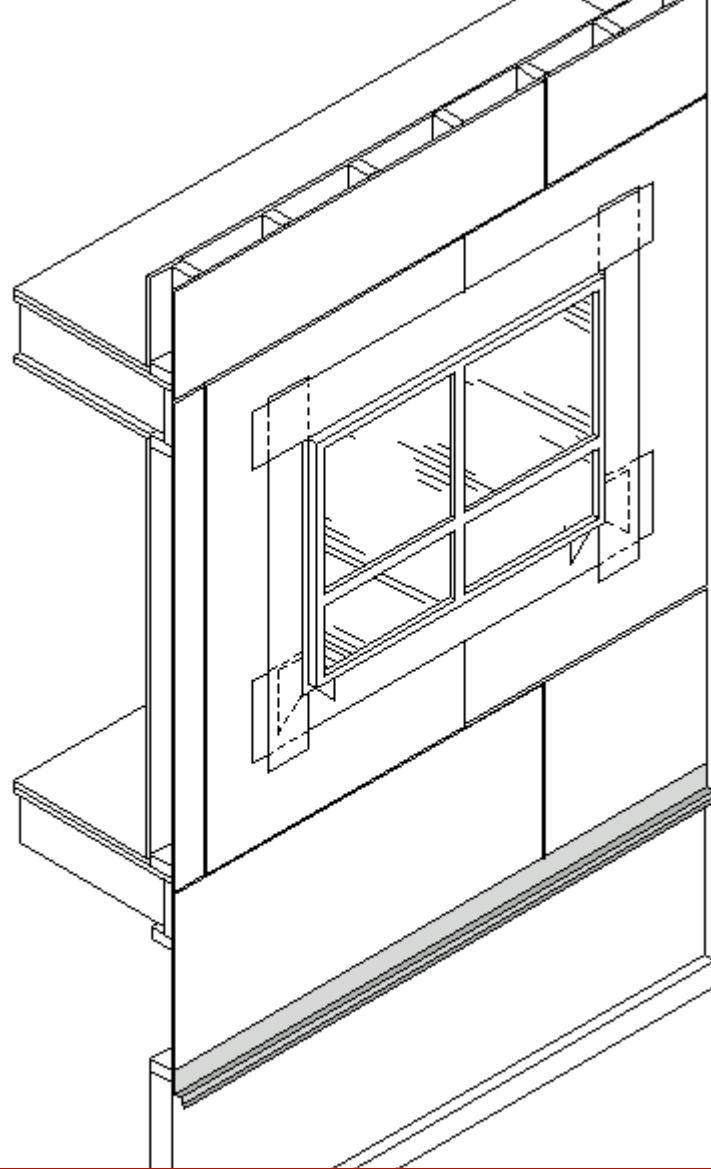
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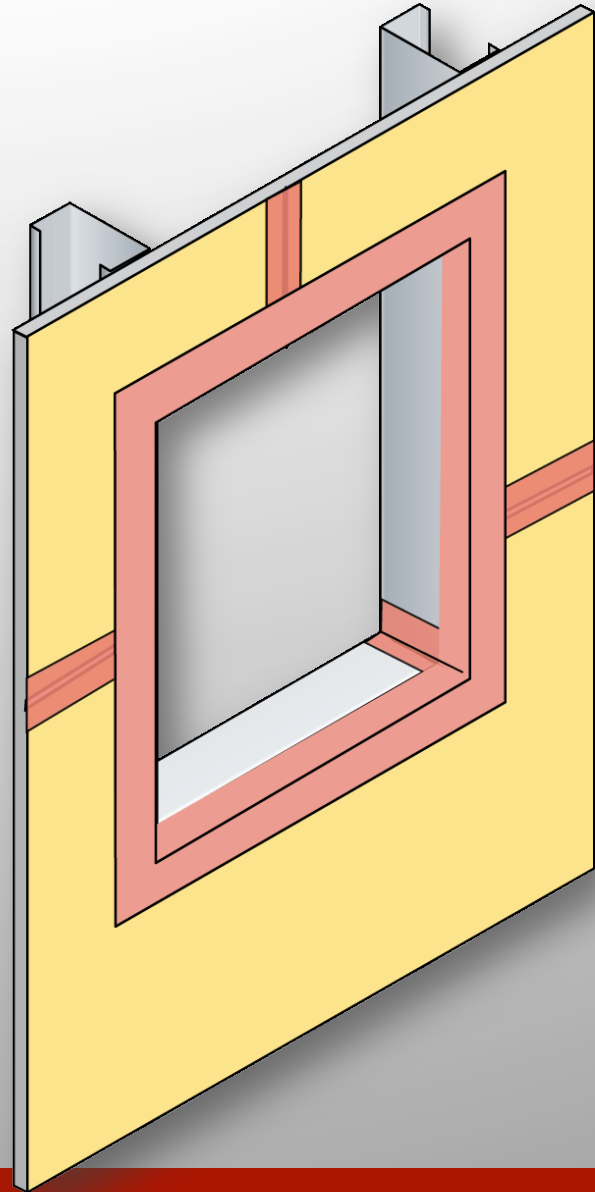
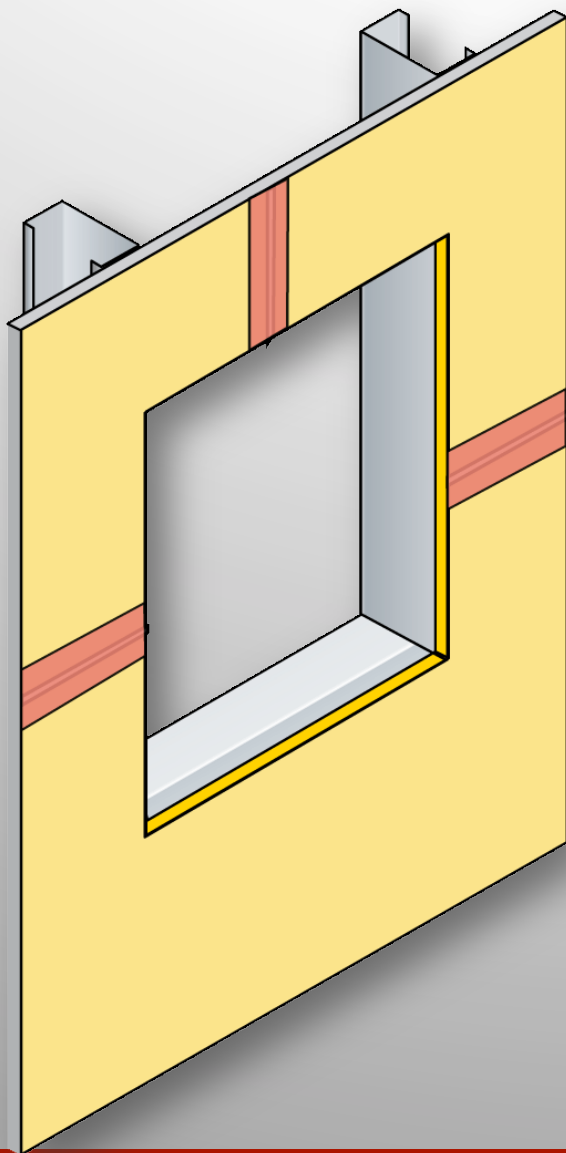
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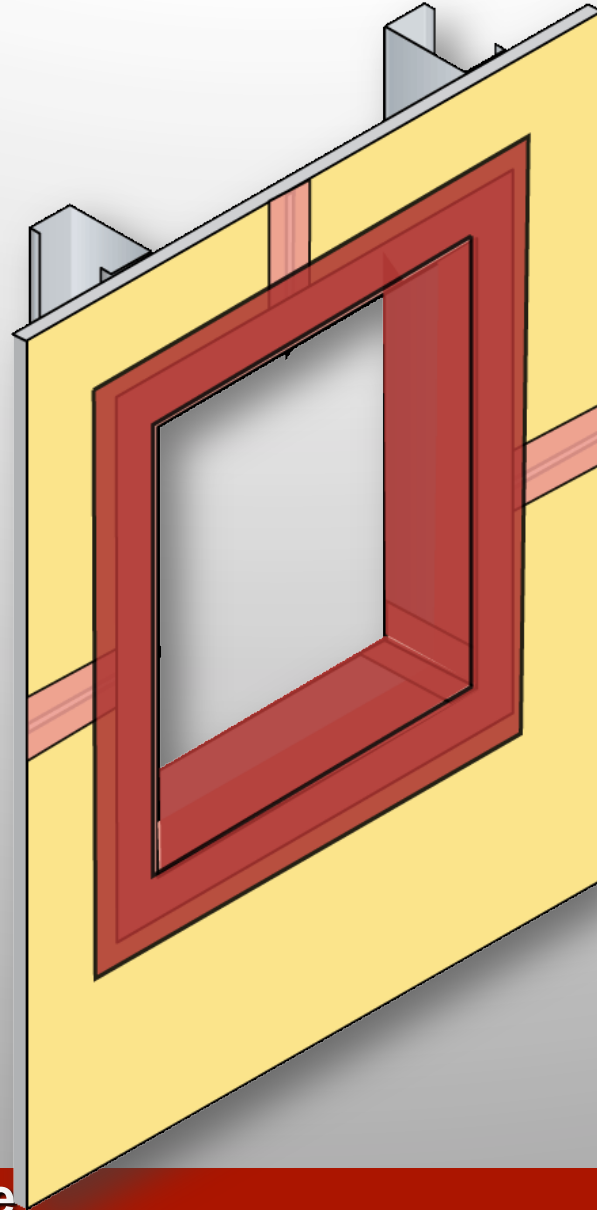
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Liquid detailing membrane

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## STPE liquid pan and rough opening flashing

- Becoming commonly specified
- Recognized in Architectural Record
- Entering ASTM process

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