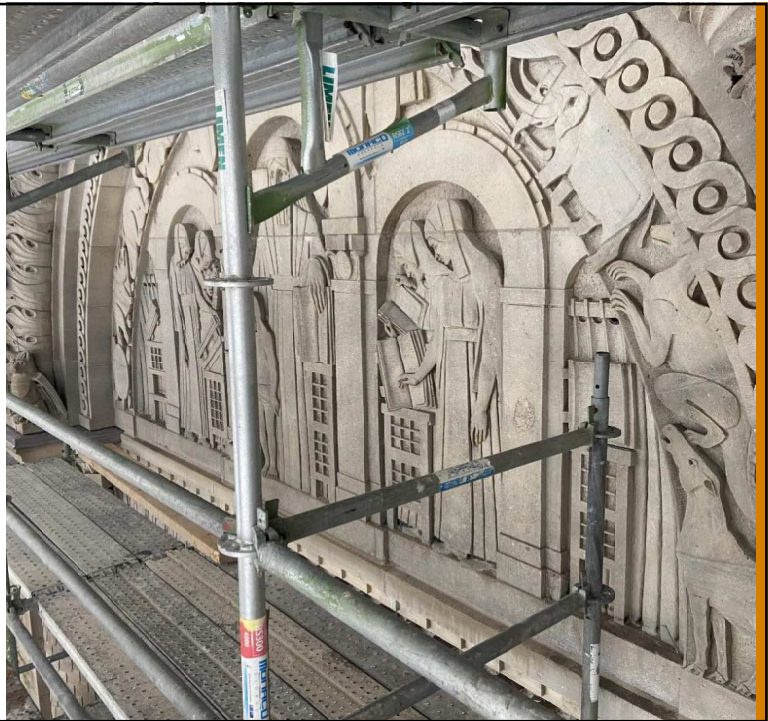


RDH BUILDING SCIENCE LIVE
NOVEMBER 10, 2021

Historic Limestone Masonry Repairs: Intervention for Prevention

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Associate, Building Science Engineer

Erica Barnes, MASc, P.Eng.
Building Science Engineer



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 - You will get a follow-up email re. how to access the recording and a pdf of slides
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 - We will break partway and at the end for questions
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**We love old
buildings.**

5

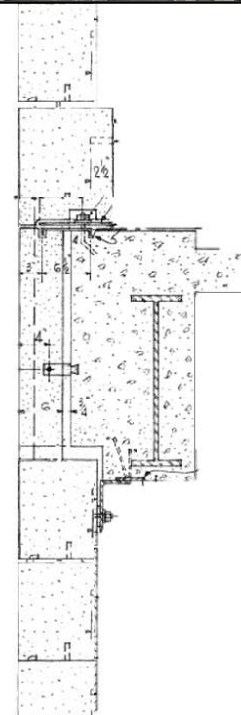
What we're looking at:

- Main focus is early/mid 1900s buildings with limestone cladding located in Climate Zone 6
- Common field observations
- Common repair strategies
- Specific example scenarios

What we're not:

- Seismic
- Major structural issues

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“Normal” Wear & Tear



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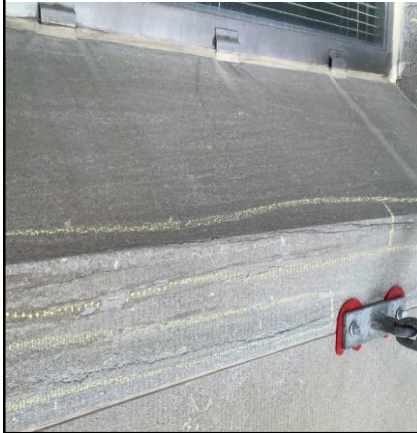
>> **Hot Tip!** Visible weathering can help distinguish limestone from sandstone (hint: there are fossils)



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>> **Hot Tip!** Visible weathering can help you identify the orientation of the stone bedding planes

Naturally Bed



Face Bed



Edge Bed



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“Enhanced” Wear & Tear

- Higher exposure (e.g., parapet)
- Skyward-facing surfaces
- Receiving runoff from adjacent surfaces



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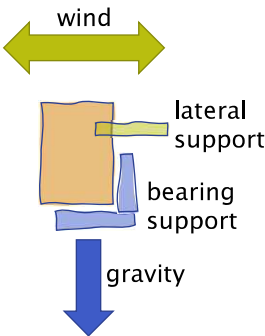
More than Just Wear & Tear?



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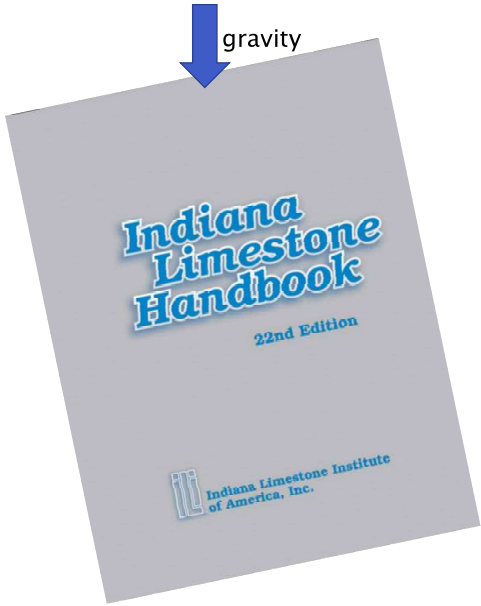
Deterioration at Stone Supports

Assuming limestone as masonry cladding, supported by building structure



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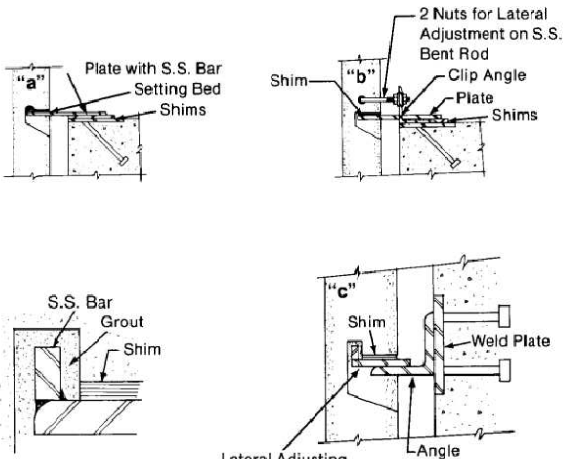
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Indiana Limestone Handbook
22nd Edition
Indiana Limestone Institute of America, Inc.

support systems

“a” & “b” Supports Above Floor
“c” & “d” Supports in Front of Floor
“b” Supports Above Floor




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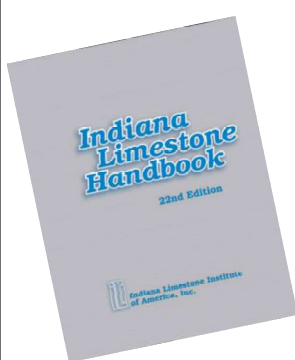
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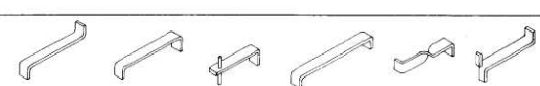
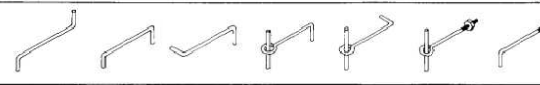
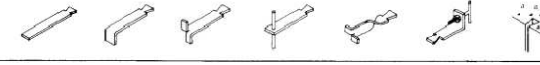



wind



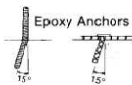


<https://ilii.com/pages/handbook/>

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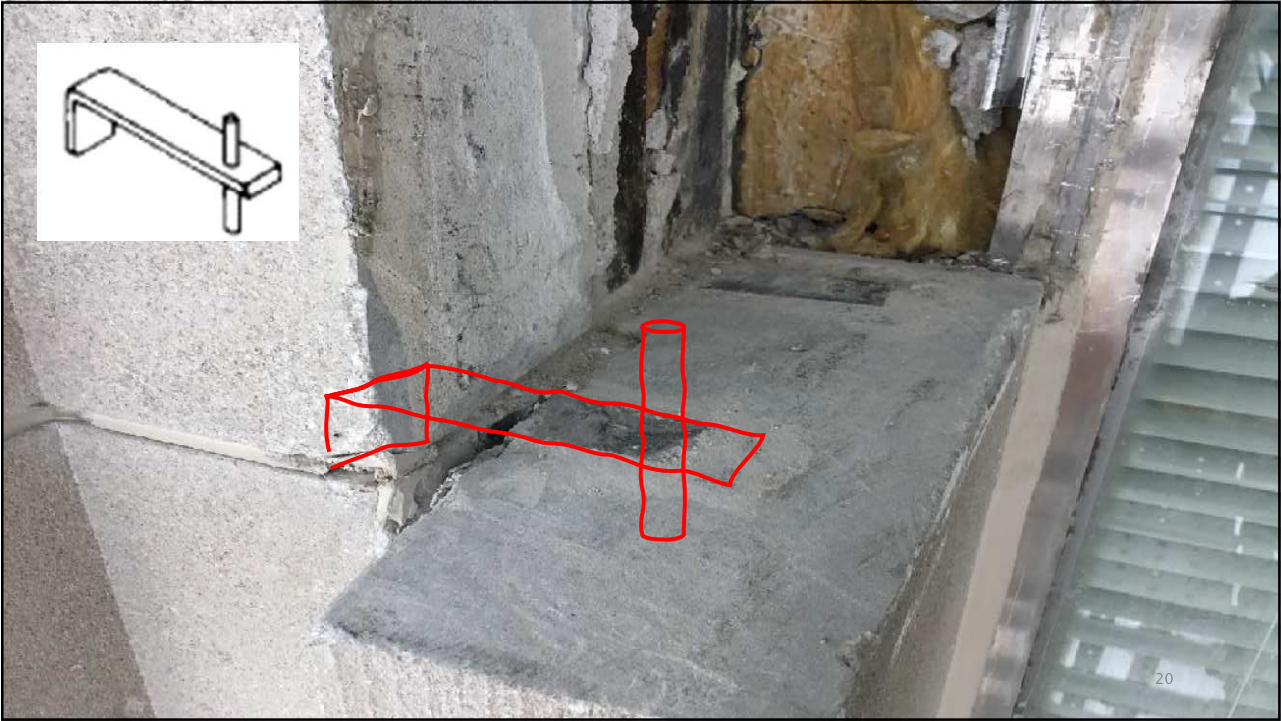
strap anchors	
rod anchors	
dovetail anchors	
miscellaneous anchors	
expansion anchors follow manufacturer's recommendations on use.	
special anchors Bracket mounted to masonry or steel	

Epoxy Anchors

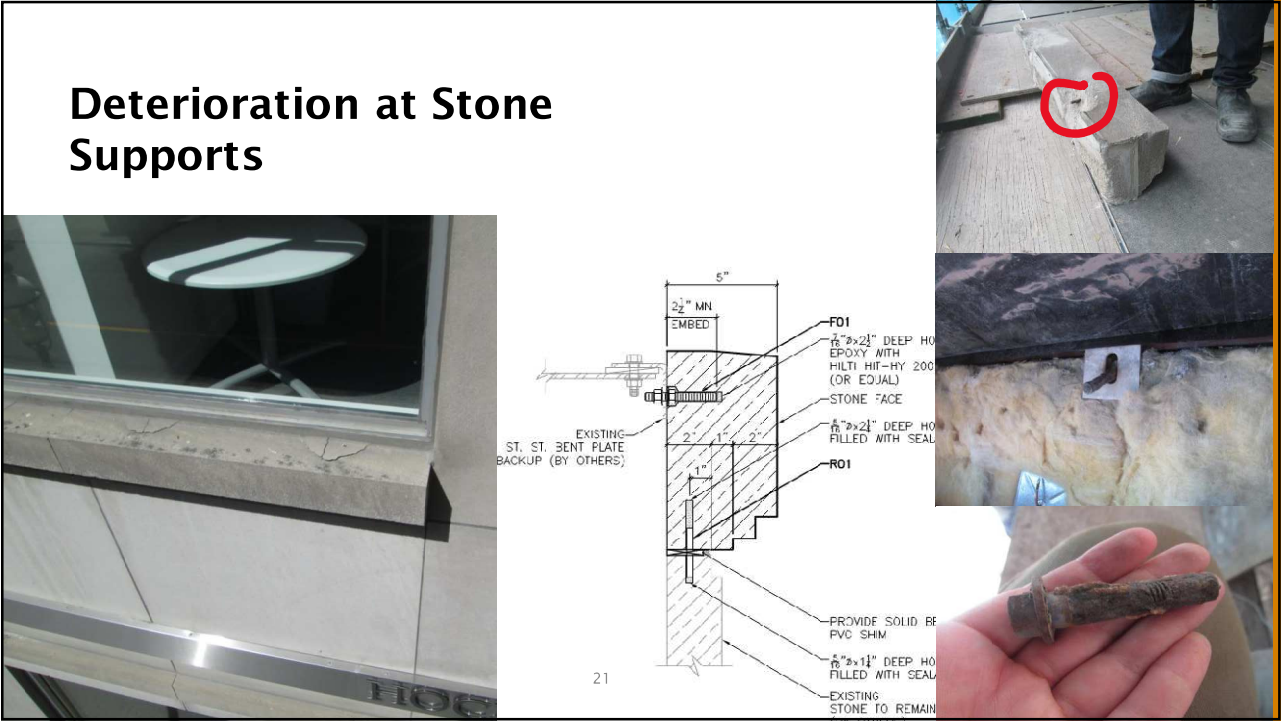


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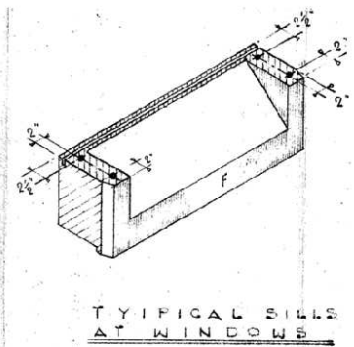
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Deterioration at Attached Components

→ Typical culprits: window anchors,
parapet flashing anchors



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**Deterioration at Attached
Components**



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**Deterioration at Attached
Components**



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More than Just Wear & Tear?



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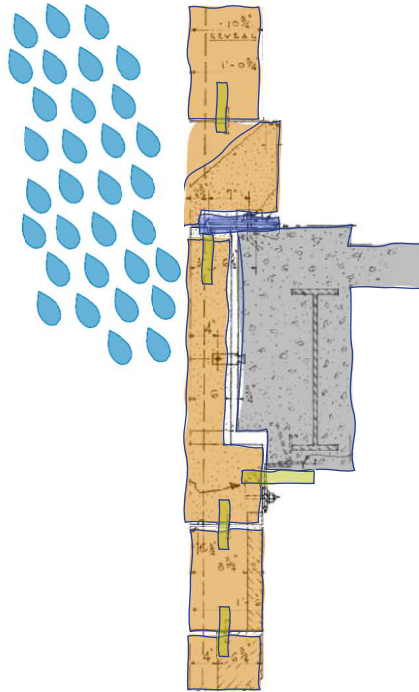
Common Repair Types



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From Inside → Outside

- Stone structural gravity support repairs
- Stone structural lateral anchorage repairs
- Limestone body repairs
- Preventative strategies

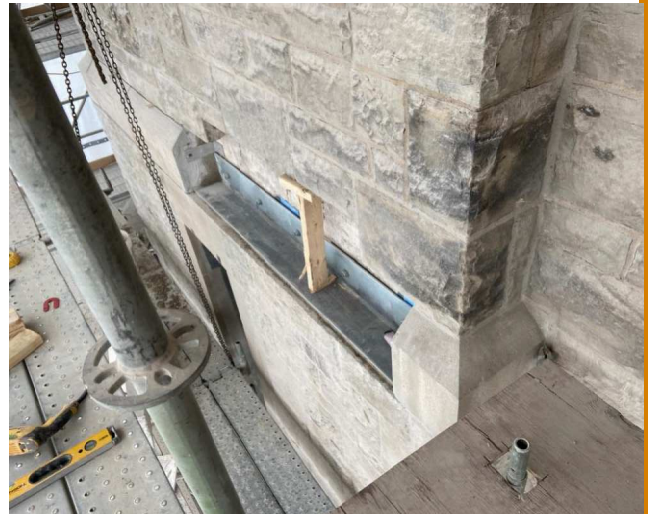


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Gravity Support Replacement



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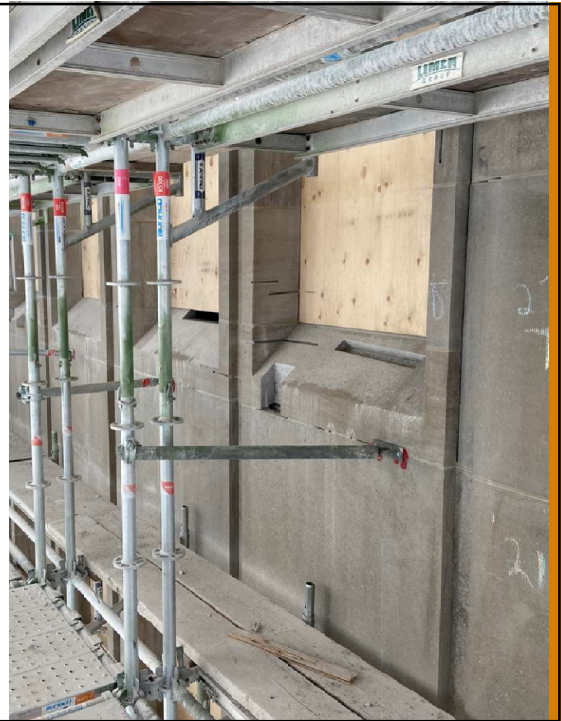
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Limestone Body Repairs

- Repair mortar patch
- Stone dutchman
- Pinning and Stitching
- Replace



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Repair Mortar Patch

- Cementitious, mineral-based, vapour permeable mortar – product is specific to stone type
- Often referred to by the commonly used product name 'Jahn'



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Repair Mortar Patch

Appropriate for:	Not appropriate for:
<ul style="list-style-type: none">• Patching deteriorated or damaged stone that is at risk of holding water• Rebuilding damaged carved stone to recreate the carved detail• Repairs 12-50mm (0.5-2 inch) deep	<ul style="list-style-type: none">• Repairs where continued movement is anticipated• High exposure surfaces such as parapets and sills (skyward facing surfaces)



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Repair Mortar Patch



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Repair Mortar Patch



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Stone Dutchman

- Limestone shop or site cut to fit the volume of deteriorated stone removed
- Appropriate for larger repair areas and skyward facing surfaces



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Stone Dutchman



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Stone Dutchman

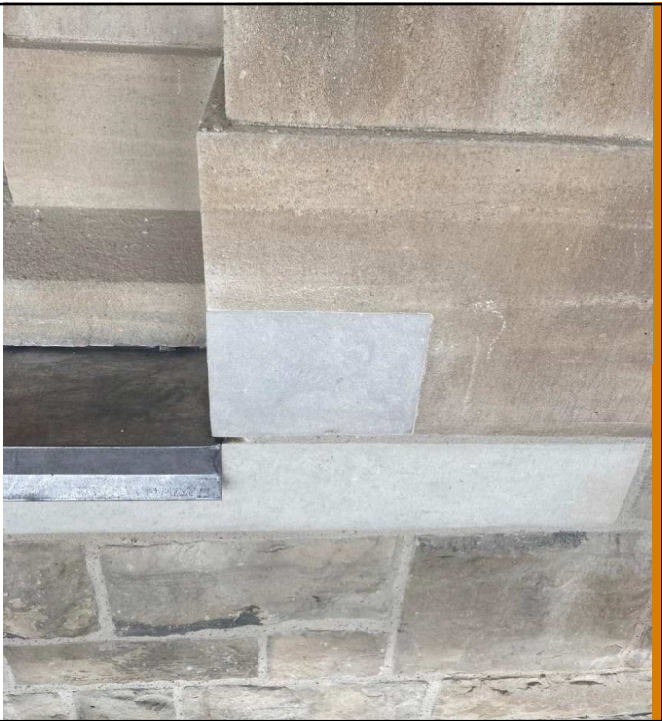


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Stone Dutchman



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In-Situ Cracked Stone Stitching



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Fractured Stone Stitching



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Full Stone Replacement

→ Appropriate where there is extensive and/or significant deterioration, and deteriorated stone is in a high-risk or difficult to access area



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Full Stone Replacement



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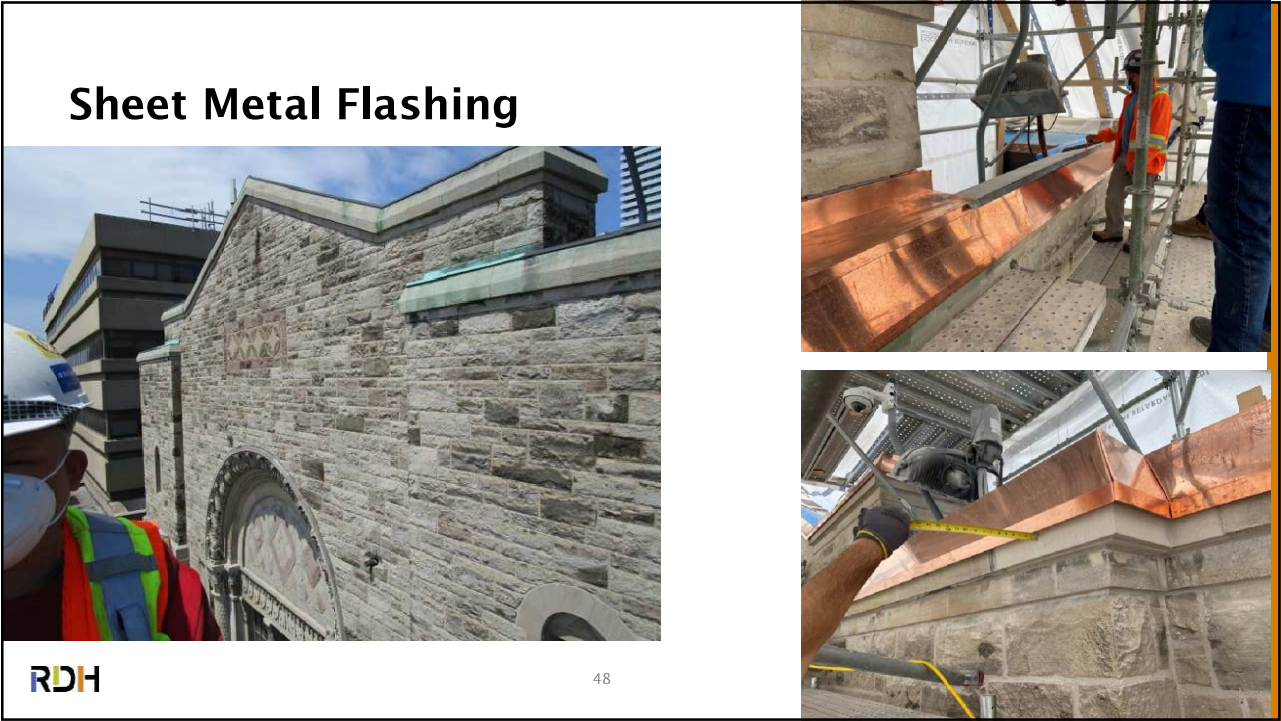
Preventative Repairs

- Mortar Repointing
- Sheet metal flashing

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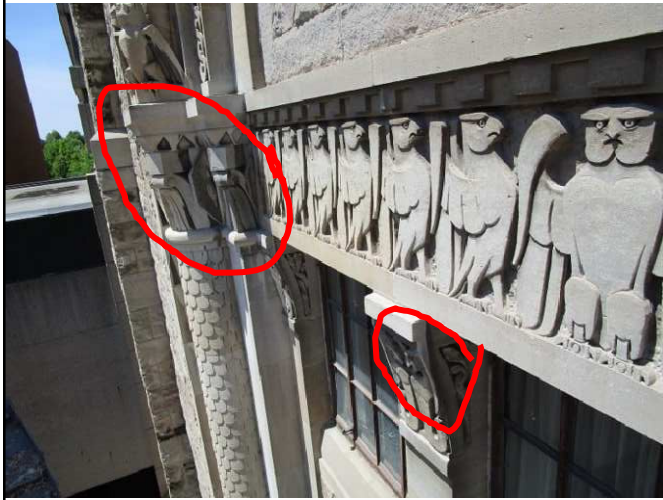


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Sheet Metal Flashing



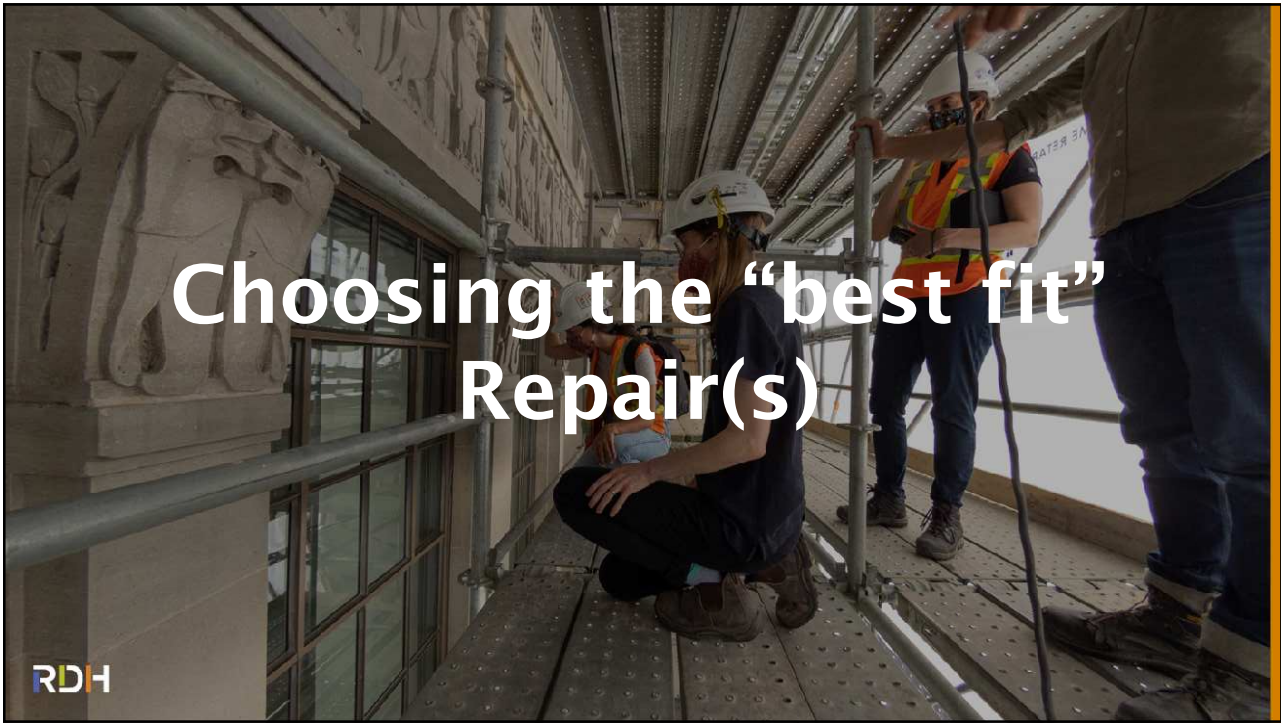
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Choosing the “best fit” Repair(s)



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Choosing the “best fit” repair(s)

→ Question we ask ourselves

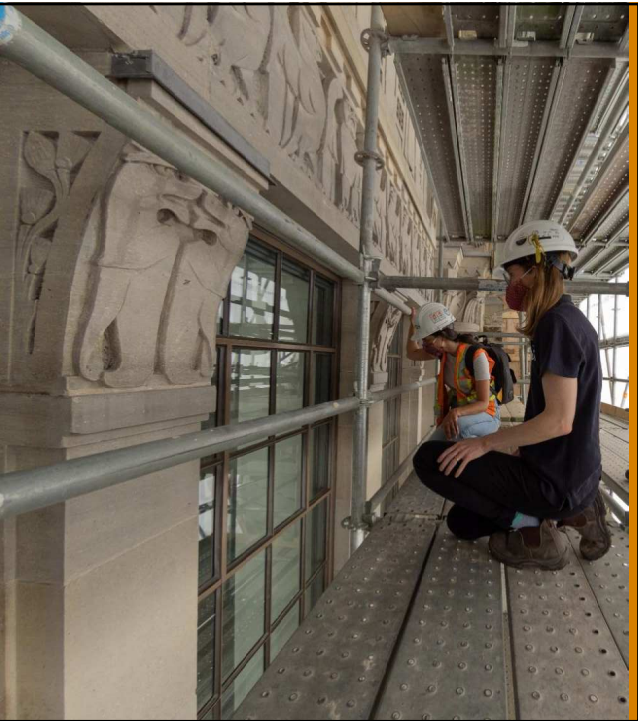
- Is it holding water?
- Is there a fall risk?
- Could there be concealed deterioration?
- How stable is this condition?

→ Intervention strategies:

- Do Nothing
- Remove Fall Risk
- Do Something
- Replace Stone



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Scenario 1



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Scenario 1

OBSERVATIONS + CONTEXT

- Erosion is occurring along the stone bedding plane of an edge-bed stones at window jambs
- 1960s office tower, 24-storeys
- Climate Zone 6
- Owner's project requirements are for 40-year service life


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Scenario 1

INTERVENTION STRATEGY

- Rout along lines of erosion and fill void with repair mortar
- Rationale is to prevent water entry along lines of existing erosion






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Scenario 1... Bonus!



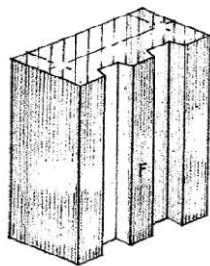
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Scenario 1

OBSERVATIONS + CONTEXT

→ Erosion is also occurring along the bedding plane on both sides of a narrow 50mm (2-inch) projection of a *face-bed stone*



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Scenario 1

INTERVENTION STRATEGY

→ Rout along lines of erosion and fill void with repair mortar (same)
→ Pin face of the projection to main body of stone

→ Rationale is to prevent water entry along lines of existing erosion, and to secure narrow projections at possible points of weakness

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Scenario 2

INTERVENTION STRATEGY

- Or stone Dutchman where erosion pattern is too close to edge of stone to enable pinning
- Rationale is to replace areas of deterioration that are minor/moderate now but could pose a future risk



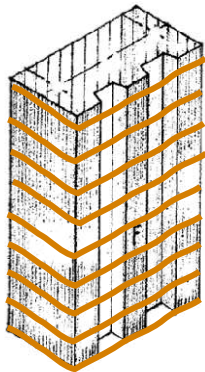
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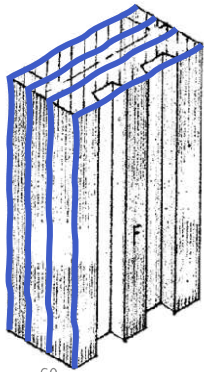
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>> **Hot Tip!** Visible weathering can help you identify the orientation of the stone bedding planes

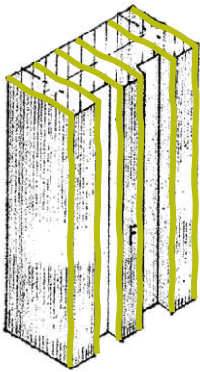
Naturally Bed



Face Bed



Edge Bed



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Scenario 2



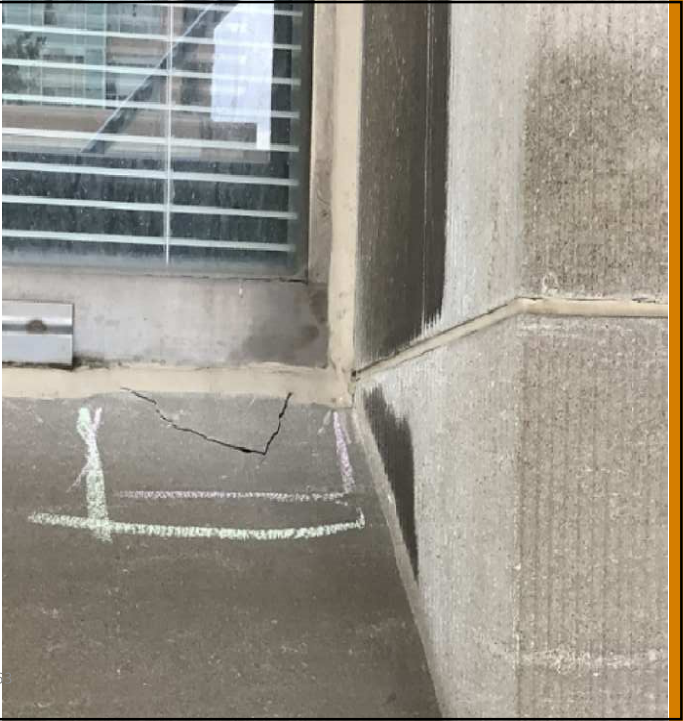
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Scenario 2

OBSERVATIONS + CONTEXT

- Cracking and spalling at location of existing window anchor
- 25% of window sills affected, concentrated at upper storeys
- Window removal and replacement is included in the project scope; all existing anchors will be removed







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Scenario 2

INTERVENTION STRATEGY

- Remove existing anchors
- Localized stone Dutchman repairs
- Anchor new windows with alternate strategy
- Rationale is to have highly durable repair material at openings and skyward-facing surfaces





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Scenario 3



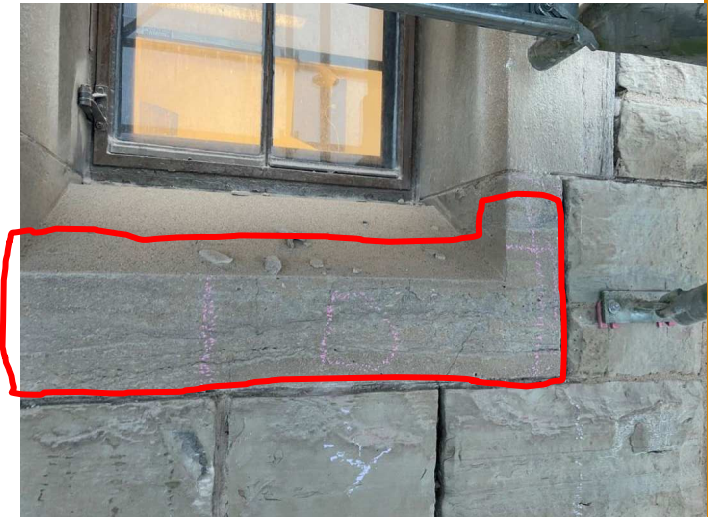
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Scenario 3

OBSERVATIONS + CONTEXT

- Cut back stone 6-inches
- Deterioration extends further than expected
- Window frame removal not included in the scope
- Adjacent office occupied



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Scenario 3

INTERVENTION STRATEGY

- Cut back stone for the full depth of deterioration
- Keep window frame in place
- Install large stone dutchman
- Rationale is to repair the deteriorated stone on this high exposure sill but not disrupt the building operations and the stone surrounding the window frame



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Scenario 4



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Scenario 4

OBSERVATIONS + CONTEXT

- Existing bird spikes were fastened into the stone sills
- The stone sills were exhibiting signs of increased deterioration, including cracking and scaling
- Removal of the bird spikes and fasteners and replacement with an electric bird wire is included in the scope



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Scenario 4

INTERVENTION STRATEGY

- Fill the fastener holes with repair mortar
- Repair the significantly deteriorated stone with a stone dutchman
- Protect the sill surfaces with sheet metal flashing
- Rationale is the stone body is repaired, high exposure surfaces are protected, and the original heritage fabric is retained.



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Scenario 5

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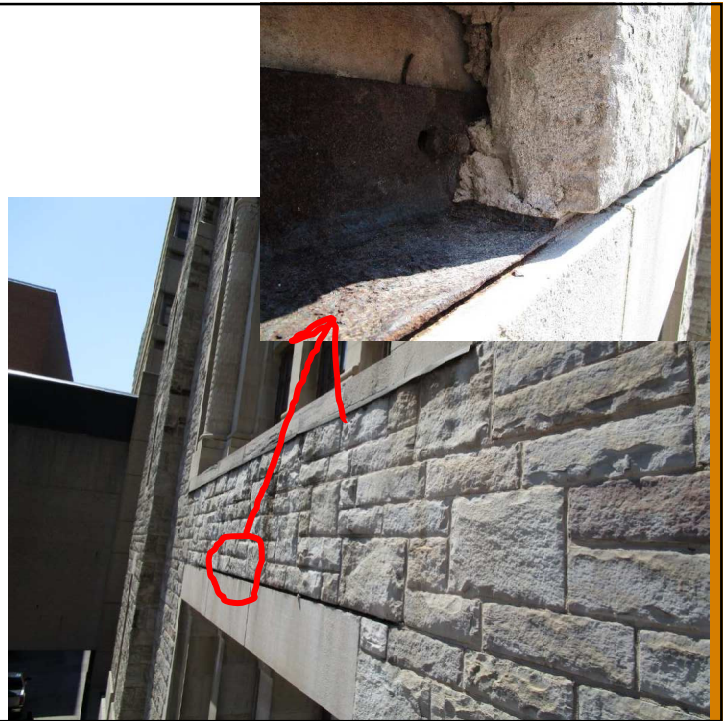
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Scenario 5

OBSERVATIONS + CONTEXT

- The stone masonry panel is out of plane (bowing)
- From an exploratory opening, the shelf angle below the panel is significantly corroded
- The sheet metal flashing at the window sill above is bent and directing runoff water onto the panel.

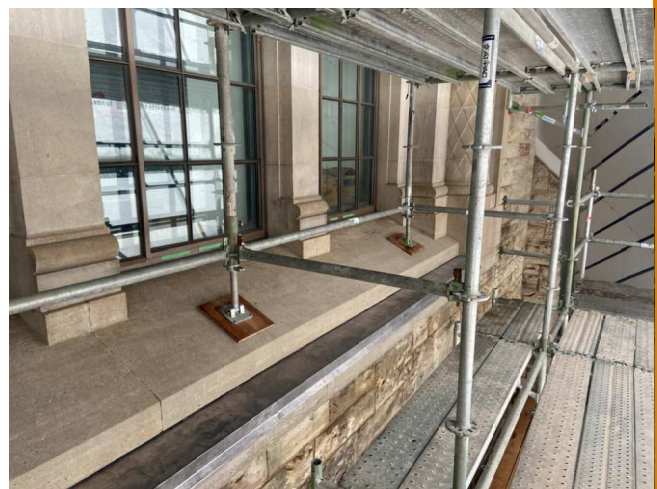


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Scenario 5

INTERVENTION STRATEGY

- Remove the stone panel
 - Replace the shelf angle
 - Reinstall the stone panel with new lateral anchorage
 - Install new sheet metal flashing with drip edge at top of panel
- Rationale is to reset the stone panel and protect the stone and shelf angle from excess water run off



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Scenario 6

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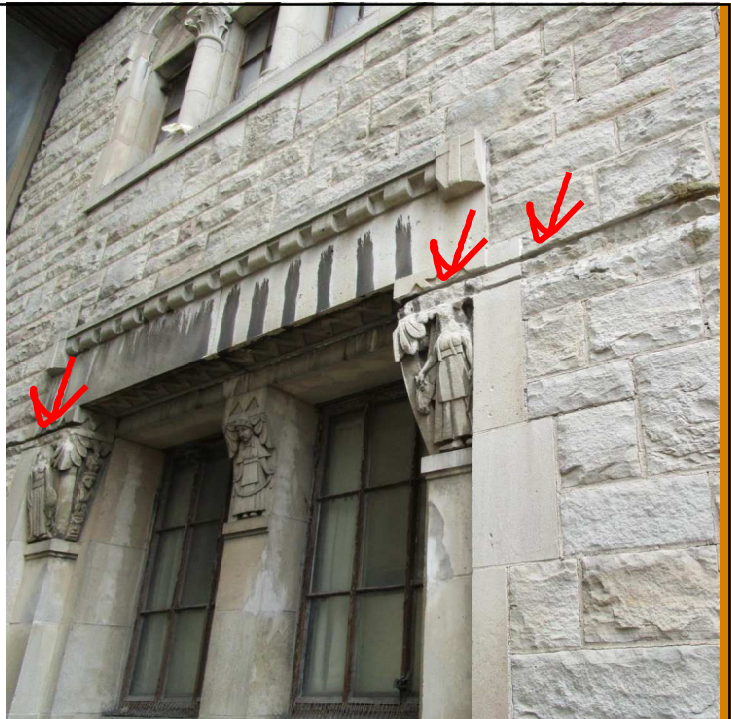
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Scenario 6

- Stone previously cut to form reglet for canopy
- There is no evidence of increased stone deterioration within the cut area
- The elevation is protected from wind driven rain and is not easily visible from grade

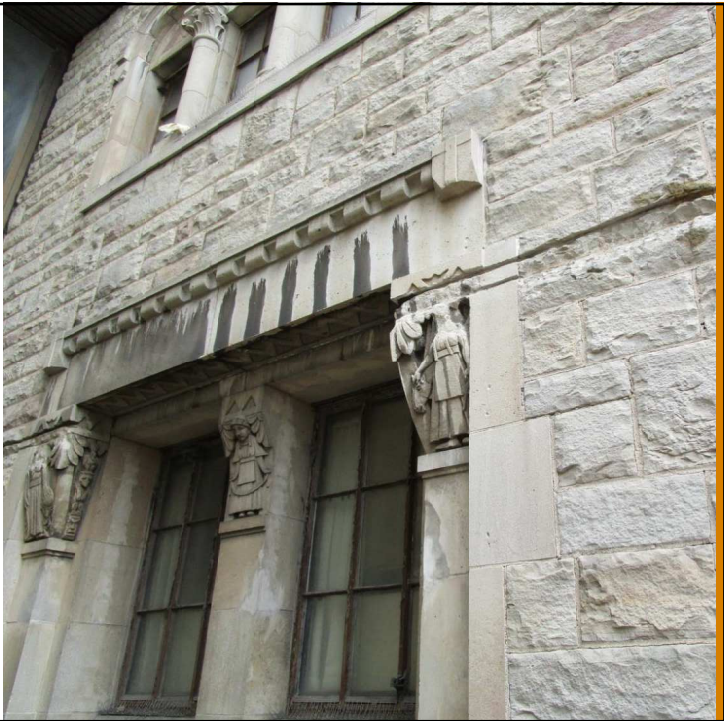
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Scenario 6

- Do nothing to stone body
- Rationale is that the cut stone surface is not at high risk of holding water and the area has low visibility





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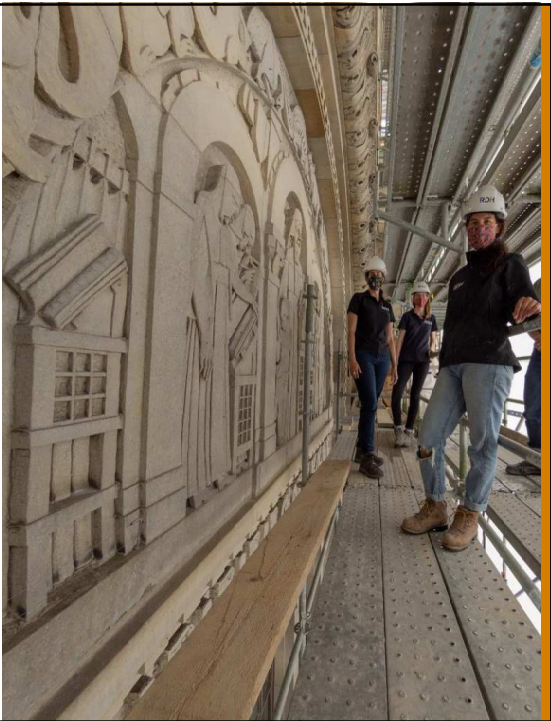
HISTORIC LIMESTONE MASONRY REPAIRS:
INTERVENTION FOR PREVENTION

Discussion + Questions

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Learning Objectives

1. Identify common types of limestone masonry deterioration.

2. Identify when limestone masonry deterioration requires further evaluation to understand the root cause of the deterioration.

3. Compare repair strategies that are typically applied to limestone masonry.

4. Select an appropriate repair approach to address limestone deterioration and to meet project-specific objectives.

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“Normal” Wear & Tear



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Stone Gravity and Lateral Support

- Gravity support replacement
- Lateral anchorage replacement
- Gravity and lateral support repairs



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Repair Mortar Patch



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Lime Injection Mortar



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Scenario 4

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Scenario 4

OBSERVATIONS + CONTEXT

- Crack propagating from the existing window frame anchor
- Stone removal completed for a depth of ~3-inch and crack continues
- Remainder of stone is in good condition
- Window frame removal is not included in the scope but corroded window anchor is accessible following window sash removal

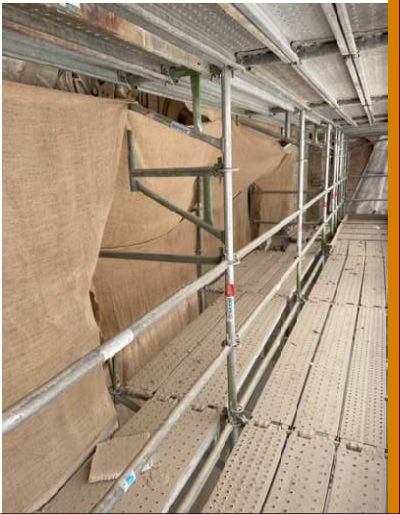
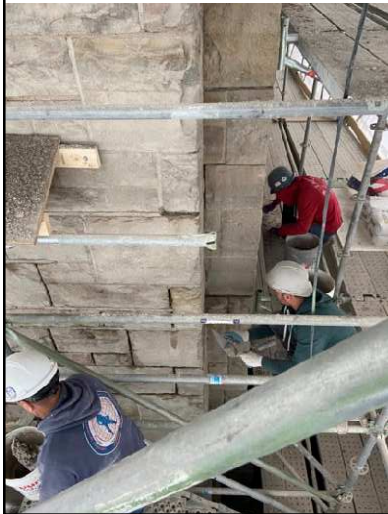


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Mortar Repairs



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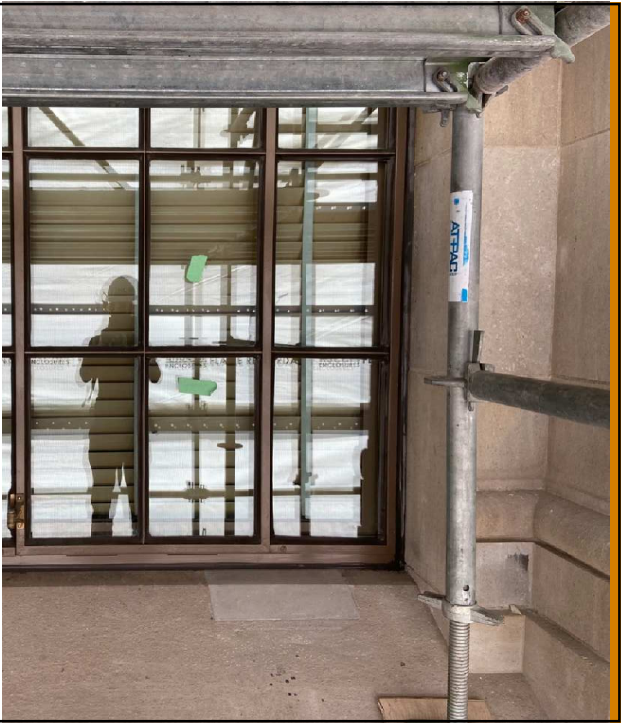
Scenario 4

INTERVENTION STRATEGY

- Remove corroded window anchor
 - Pin across crack
 - Install stone dutchman
- Rationale is to remove the source of deterioration, stabilize the stone, and protect the exposed stone surface



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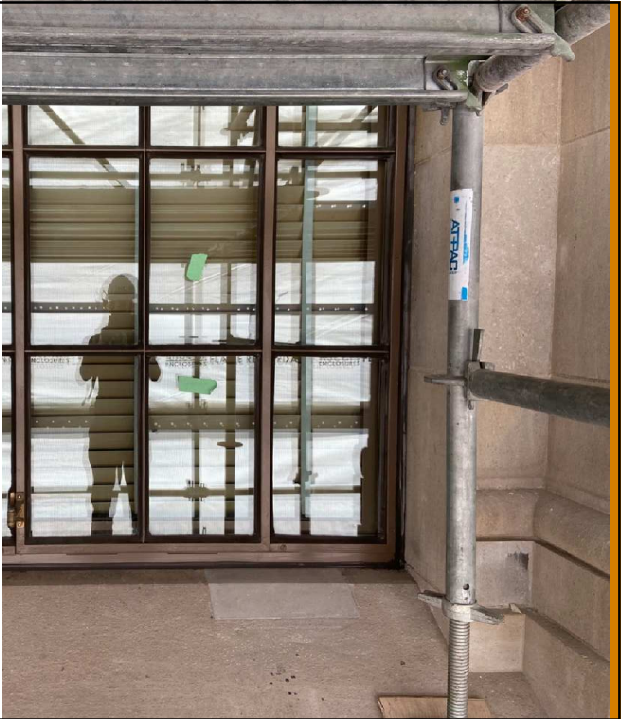


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In-Situ Cracked Stone Stitching



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