BUILDING SCIENCE LIVE
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# Considerations for Pre-1940s Steel Windows

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and
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## RDH loves old buildings!

We recognize the beauty of historic buildings and the importance of sensitive rehabilitation for improving performance.

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## Today's Event

1. **Common considerations, resources, and components** for steel windows
2. **Case Study #1 –** Full window rehabilitation at off-site facility
3. **Case Study #2 –** Adding new interior windows behind original steel windows
4. **Case Study #3 –** New replacement steel windows

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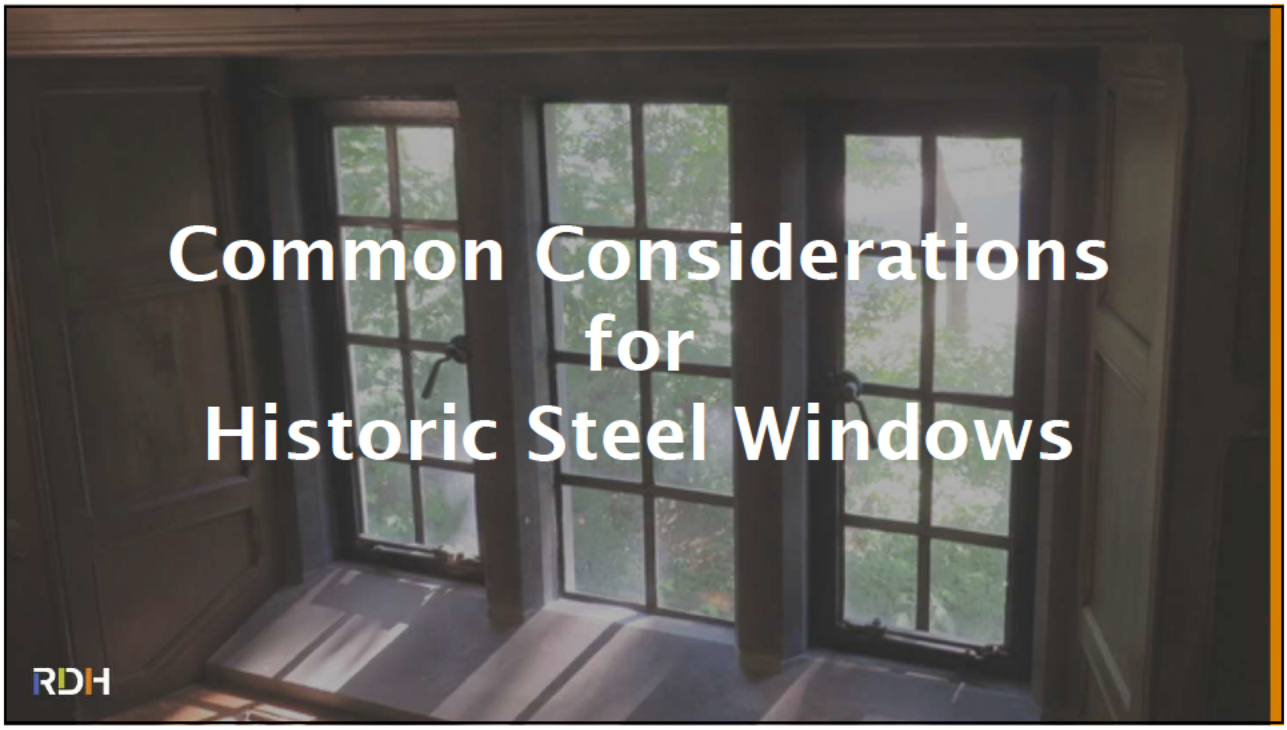


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## My building has old steel windows – now what?!

1. **Understand the building's history and significance:** How do the windows contribute to the heritage character and historic significance? What can change? What cannot change?
2. **Archival research**: Original drawings, specifications, details, old catalogues
3. **Confirm owner objectives**: Heritage character, thermal performance, occupant comfort
4. **On-site condition assessment:**
   - Confirm location and severity of corrosion – loss of section or deformation of steel?
   - Any patterns of deterioration based on exterior exposure or interior conditions/use?
   - Cracked glazing putty?
   - Cracked or missing glass?
5. **Identify hazardous materials**: Lead paint, asbestos in glazing compound
6. **Work with historic preservation authority**: What are the required steps or approvals for investigation, mock-ups, repairs?
7. **Detailed construction documents**: Clarity of details and specifications

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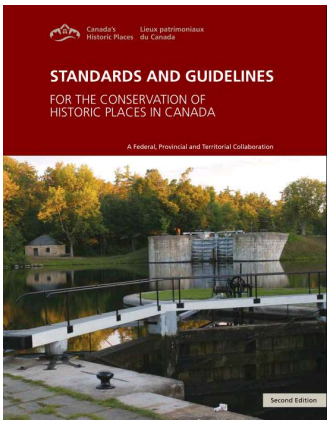
## Reference Documents for Historic Places

**United States**

Secretary of the Interior's
*Standards and Guidelines for the Treatment of Historic Properties*


**Canada**

Parks Canada's
*Standards and Guidelines for the Conservation of Historic Places in Canada*

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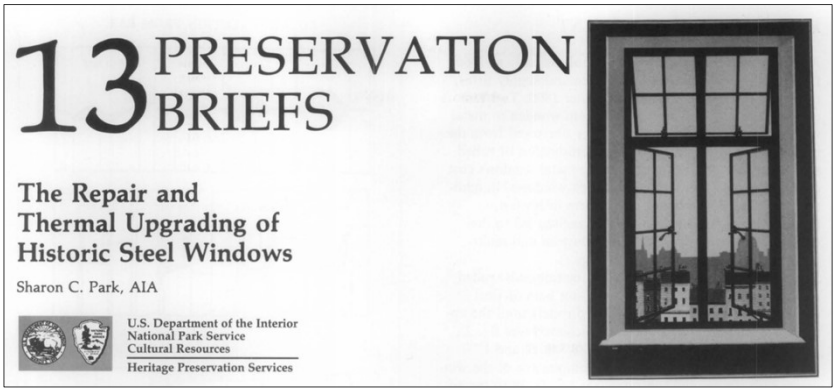
## Reference Documents for Steel Windows

*US National Park Service – Preservation Briefs*
https://www.nps.gov/TPS/how-to-preserve/briefs.htm

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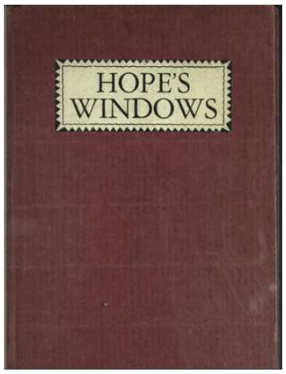
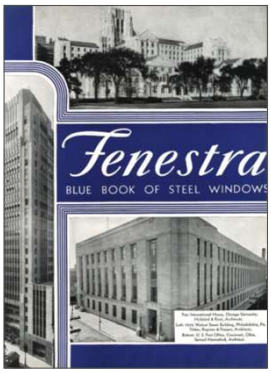
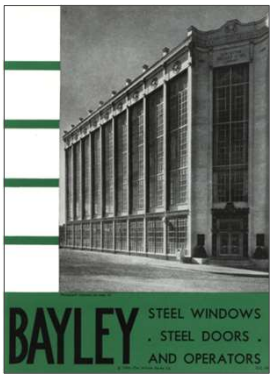
## Reference Documents for Steel Windows

APT Building Technology Heritage Library (BTHL) via apti.org
Internet Archive (archive.org)





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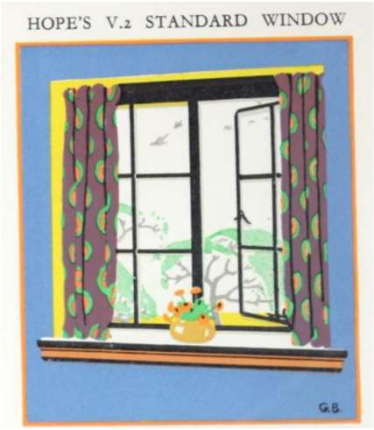
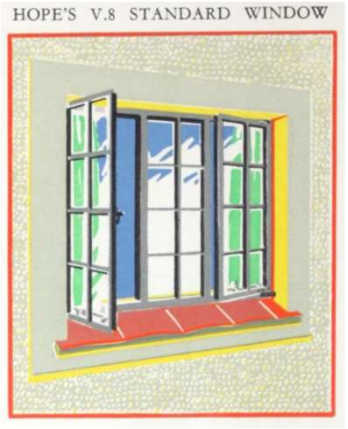
## Hope's Catalogues





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Reference: Hope's Standard Steel Windows
https://archive.org/details/HopesStandardSteelWindows/
various pages

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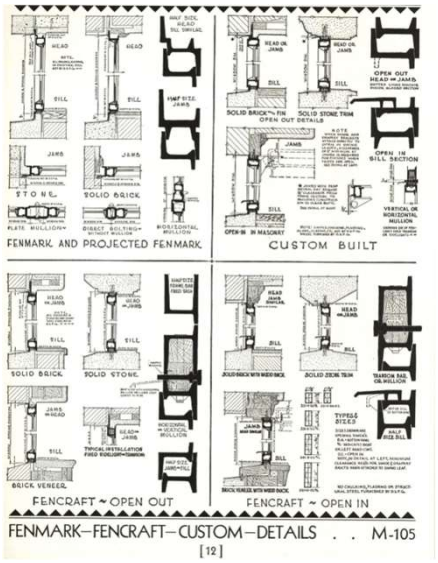
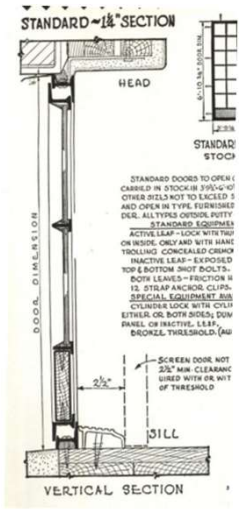
## Fenestra's Catalogue




Reference: Fenestra Catalogue
https://archive.org/details/SweetsCatalog19360010/page/n11/mode/2up

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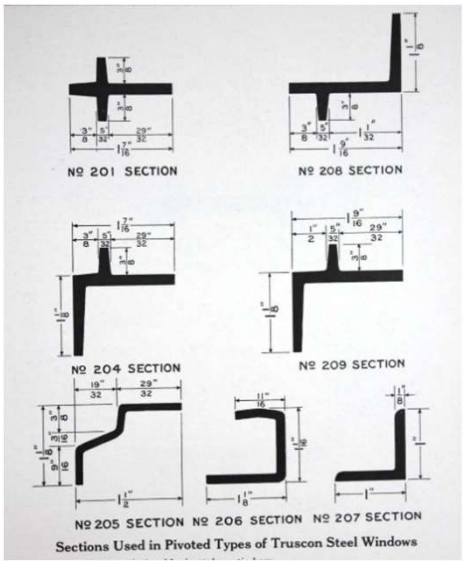
## Common Steel Window Components




**Rolled Steel Sections for Frames and Sash**

Various profiles
Support the glazing
Support operable sash

Reference: Truscon Steel Company
https://archive.org/details/TrusconSteelWindows/page/n7/mode/2up

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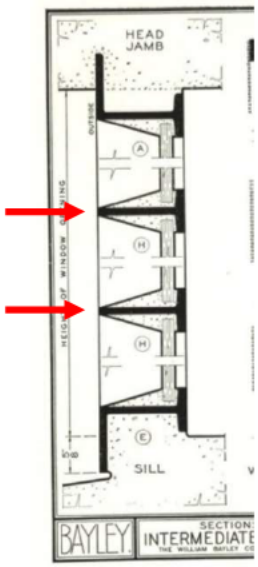
## Common Steel Window Components




**Muntin**

Thin steel section between individual glass lites

Supports the glass

Glazing putty or compound holds and seals the glass against the steel

Glazing "points" or tabs also used to hold the glass into the opening

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Reference: Bayley Steel Windows and Doors
https://archive.org/details/SweetsCatalog19360008/page/n5/mode/2up

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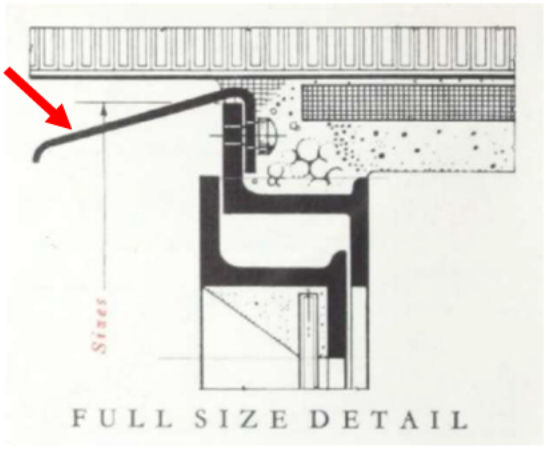
## Common Steel Window Components




**Weatherbar**

Deflects water away from the top or bottom of window

Primarily used at operable windows

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Reference: Hope's Standard Steel Windows
https://archive.org/details/HopesStandardSteelWindows/page/n11/mode/2up

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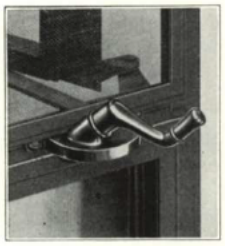
## Common Steel Window Hardware


Reference: Hope's Standard Steel Windows
https://archive.org/details/HopesStandardSteelWindows/page/n29/mode/2up



Geared Underscreen Operator H115

H113 for Projected In Vents Within Reach

H 20 Cam for projected out located within ventilator operates through sill

H112 Pole Catch for Projected In Vents Out of Reach

Reference: Bayley Steel Windows and Doors
https://archive.org/details/SweetsCatalog19360008/page/n13/mode/2up

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## HOPE'S CLEANING HINGES

A Hope V.2.T Standard Window, provided with cleaning hinges.

Reference: Hope's Standard Steel Windows
https://archive.org/details/HopesStandardSteelWindows/

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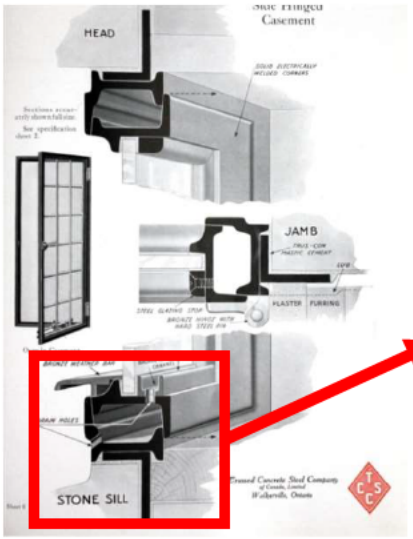
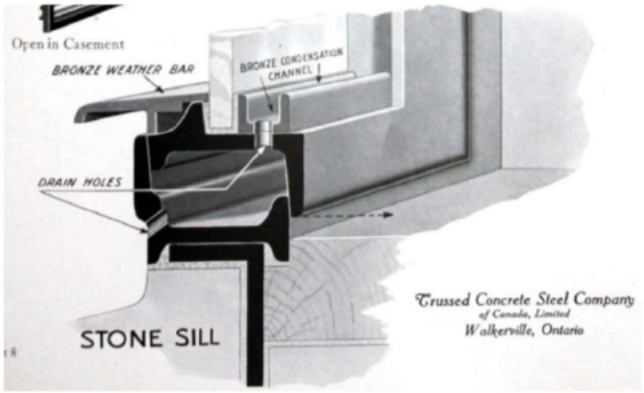
## Common Steel Window Installation

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Reference: Canadian Steel Casements
https://archive.org/details/CanadianSteelCasements/page/n13/mode/2up

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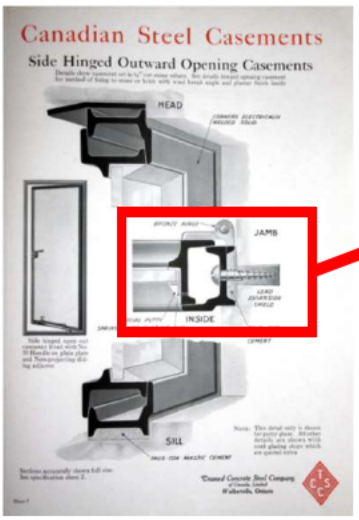
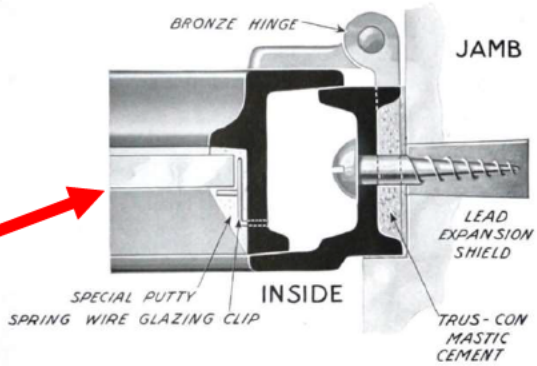
## Common Steel Window Installation

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Reference: Canadian Steel Casements
https://archive.org/details/CanadianSteelCasements/page/n11/mode/2up

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Question Break

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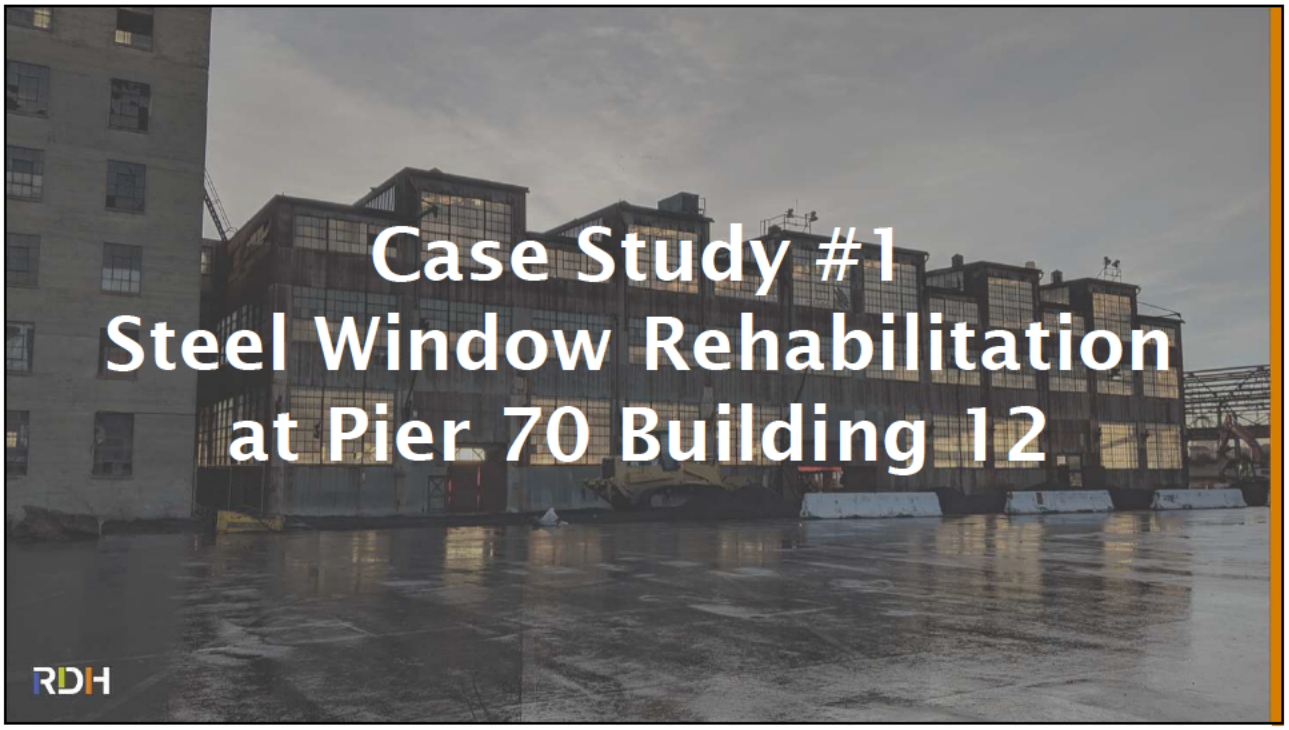
Case Study #1
Steel Window Rehabilitation
at Pier 70 Building 12
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## Pier 70 Building 12, San Francisco, CA

Built circa 1940, historically significant original shipbuilding facility turned into maker's and commercial space

Source: Perkins + Will; Brookfield

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## Building Description

PERSPECTIVE - SOUTH FACADE ALONG 22ND STREET

Source: Perkins + Will; Brookfield

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## Exterior Cladding & Steel Windows - Goals

- Improve existing thermal performance and air- and water-tightness of the building: balancing historic significance, budget, constructability and considering future maintenance
- Comply with the Secretary of Interior's Standards
- Repair rather than replace deteriorated historic features
- If severity requires replacement, new feature should match old design, color, texture and materials (where possible)

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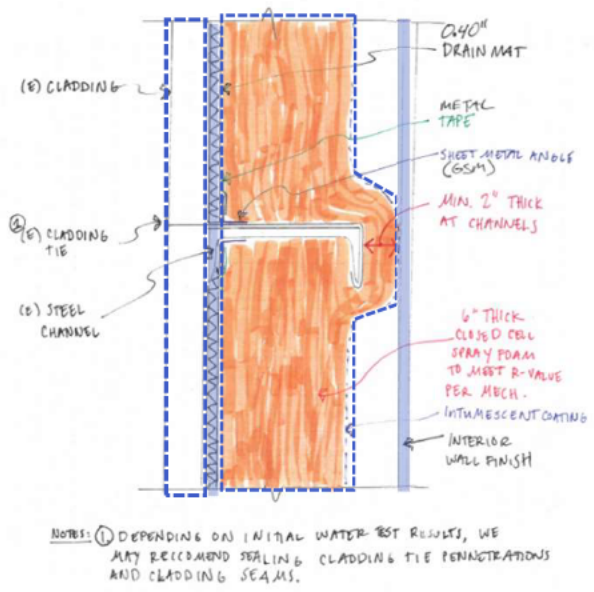
## Exterior Cladding

- Water shedding layer: Repaired corrugated pane
- Water control layer & ventilation: Drainage composite
- Air- and thermal- control layer: Closed-cell spray polyurethane foam (SPF) insulation
- Thermal barrier (fire): Drywall or intumescent coating

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## Steel Windows

- Original windows, steel frames
- Two main configurations
- Vertical mulled joints to create large ribbon-style window

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## Steel Windows

- Operable vents
  - Pivot, hinging at center of light
  - Bent/warped/oxide jacking, many not closing or lacking locking mechanism
  - Maintaining operability desired

Source: Perkins + Will; Brookfield

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## Steel Windows

- Single pane glass
  - 12" x 18"
  - Large percentage of glass broken
- Interior glazed
- Retained with clips and glazing putty
- Abatement required for paint and putty removal for re-glazing

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## Existing Window Assessment and Water Testing

- Determine leak paths through:
  - Frame joinery and operable vents
  - Head, jamb, sill interface
  - Glazing putty original; aged/crazed
  - Vertical mulled joint

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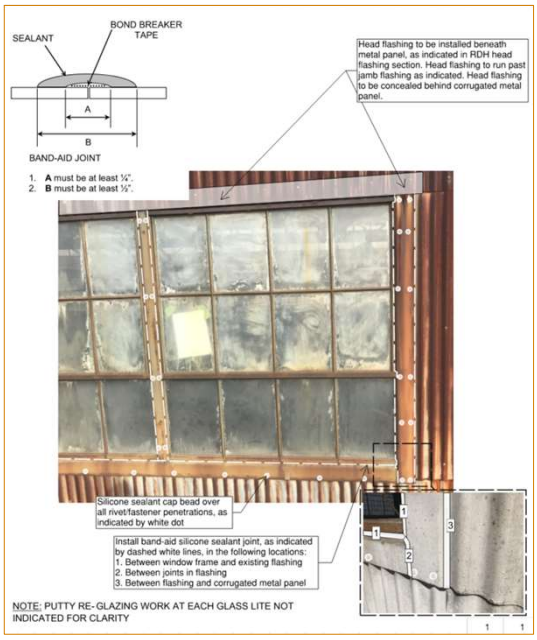
## Addressing Steel Window Deficiencies

- Operable vents:
  - Remove corrosion build-up
  - Replace broken locking mechanism

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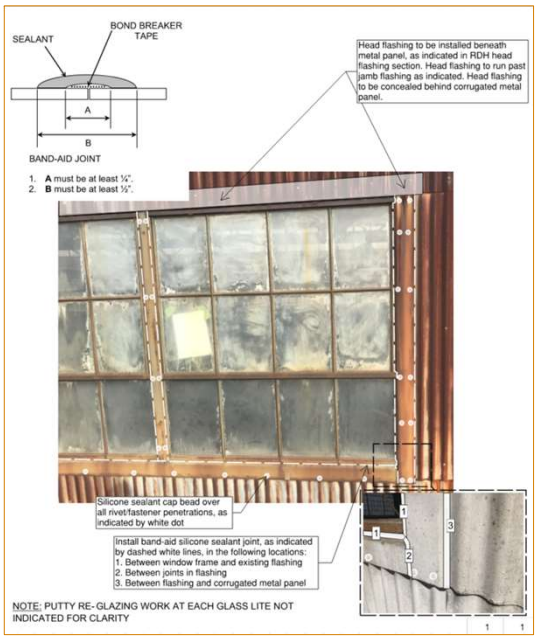
## Addressing Steel Window Deficiencies

- Re-glazing:
  - Decision was made to replace all lites
  - New structural silicone sealant and double-sided adhesive glazing tape
  - Interior heel bead and exterior cap seal

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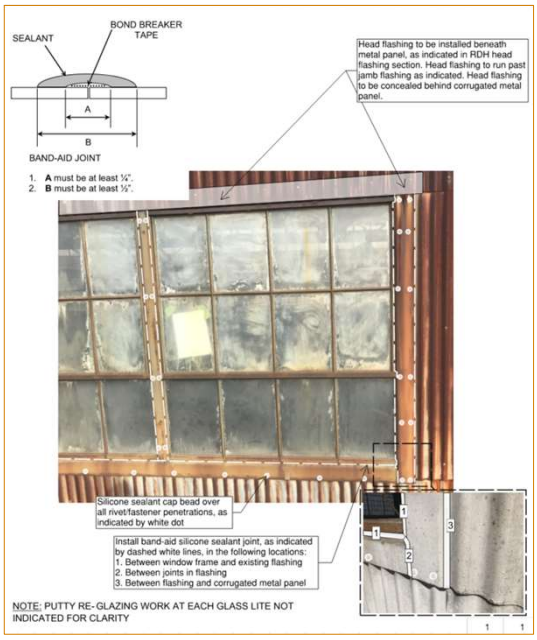
## Addressing Steel Window Deficiencies

- Steel frame:
  - Existing frame not drained; face-seal strategy
  - Ensure proper joint design (bond breaker tape, width dimension, etc.) – seal longevity
  - Re-coat – remove debris/dust and surface prepare to SSPC-SP6 Commercial Blast clean. Zinc-rich primer prior to powder coat base + topcoat

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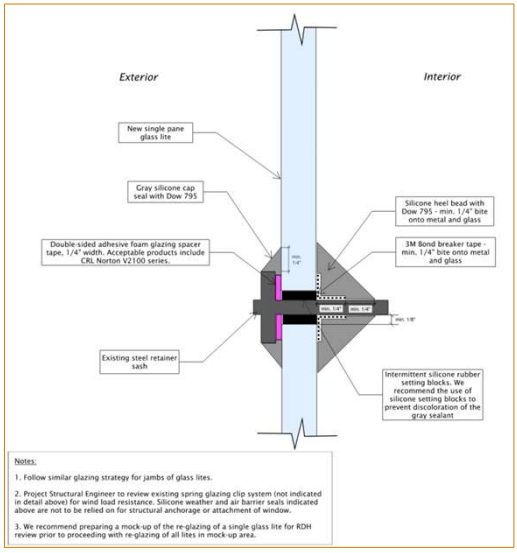
## Structural & seismic considerations

- Structural review of vertical mull
  - Meet wind and deflection loads?
- How is glass retained – captured, reliant on glazing tape or SSG?
- Seismic movement capability of lite in glazing pocket to prevent fall-out in case of seismic event

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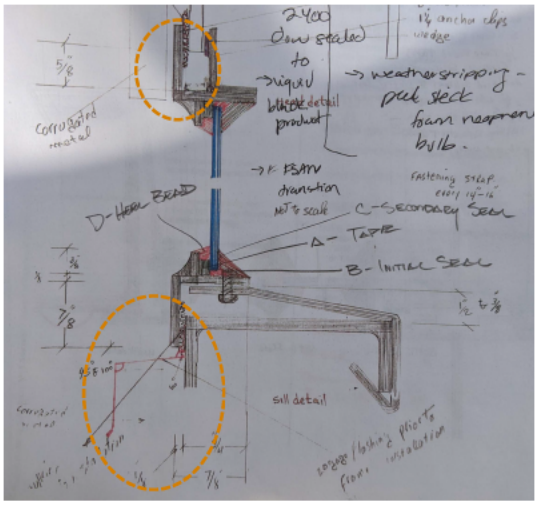
## Steel Window Interface Conditions

- No tolerance in existing rough opening to shim and achieve sub-sill drainage
- Adding sill flashing
- Sealing frame to C-channel
- Strategically shingle-lapping drainage composite
- Water testing of first-in-place window in rough opening planned

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## Off-Site Restoration and Factory Visits

- Surface prep., zinc-rich primer application, powder coating base and topcoat
  - Check narrow joints and hardware
  - Review texture and thickness, number of passes
  - Perform adhesion testing (by means of tape test) per ASTM D3359

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## Off-Site Restoration and Factory Visits

- Review re-glazing strategy and consistency of glazing tape
  - Glazing tape correct cut to fit frame, sealed at intersection
  - Width dimension for sealant bite and tooling (awkward geometry!)
  - Glazing tape and sealant manufacturer to test adhesion to powder coating and glass
  - Field pull test to verify adhesion

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## Off-Site Restoration and Factory Visits

- Review operable vents and gasket strategy
- Continuity of gaskets – pivot vent unique challenge for sealing center hinge
- Mock-up and water test first-in-place

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## Thermal Performance Considerations

- Any window has **thermal loss** through frame, sash, glass and perimeters
- **Air leakage** around operable lites and window perimeters reduces building energy performance
- Air leakage at windows **impacts occupant thermal comfort**
- Large glazed areas can induce **convective loops** creating air "drafts" that impact occupant comfort

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## Thermal Performance Considerations

| Frame Material | Conductivity (U) W/mK | Conductivity R/inch |
|---|---|---|
| Wood | 0.10 to 0.18 | 0.8 to 1.4 |
| PVC | 0.17 | 0.8 |
| Fiberglass | 0.30 | 0.5 |
| Carbon Steel | 45 | 0.02 |
| Bronze | 93 | 0.002 |
| Aluminum | 221 | 0.001 |

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Image source: Manitoba Historical Society

Image source: NumberTen Architectural Group

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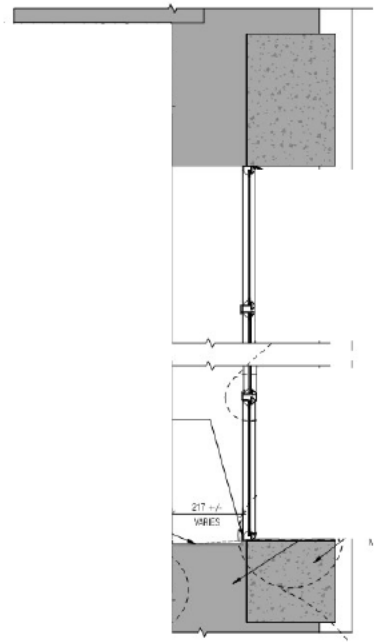

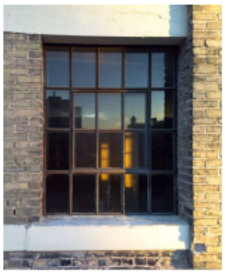

**Original Steel Windows**

- Single pane
- Set within concrete sill and lintel, and brick masonry jambs
- Operable vent at middle lites

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Drawing source: Diamond Schmitt Architects and NumberTen Architectural Group

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## *So how to improve windows for thermal performance?*

### 1. Add exterior storm sash

- Creates air pocket between original window and new outer storm
- Provides an air seal if detailed/installed properly
- Protects but conceals original window

### 2. Replace the window

- "New and better" window
- Double or triple pane IGUs
- Worse frame performance if aluminum frame (?) – thermal break?

### 3. Best of both worlds

- Repair the original window
- Add a new higher-performance interior window to do the "thermal work"

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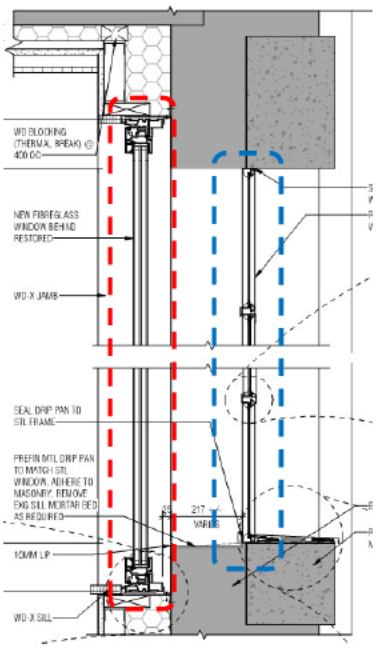
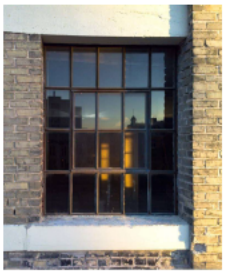
**Interior**

**New triple-pane fiberglass framed windows**

- **Open-in for cleaning**
- **Air-sealed**
- **Set within new interior insulation**
- **Frames not visible from exterior**



**Exterior**

**Original Steel Windows: Clean, repair, paint, replace glass where needed**

Old windows are mostly aesthetic, not providing much thermal or air control benefit

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Drawing source: Diamond Schmitt Architects and NumberTen Architectural Group

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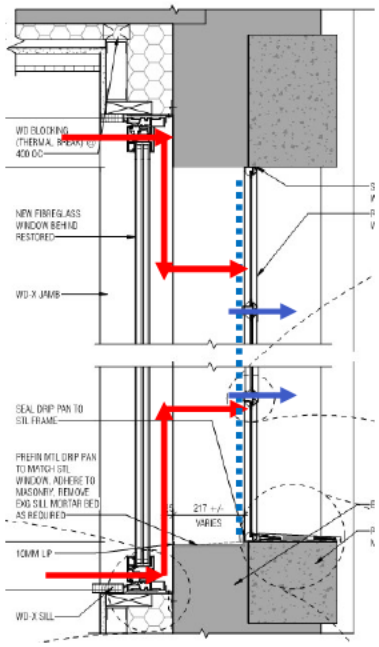


**CAUTION!**

If **warm air leaks** through new interior window into the space between new+old windows – **condensation can occur in winter.**

**Vent the space** between new+old windows to help **clear condensation**

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Drawing source: Diamond Schmitt Architects and NumberTen Architectural Group

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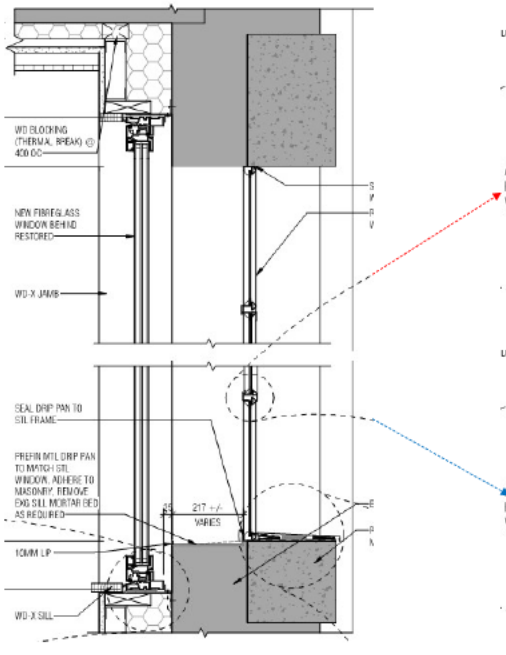


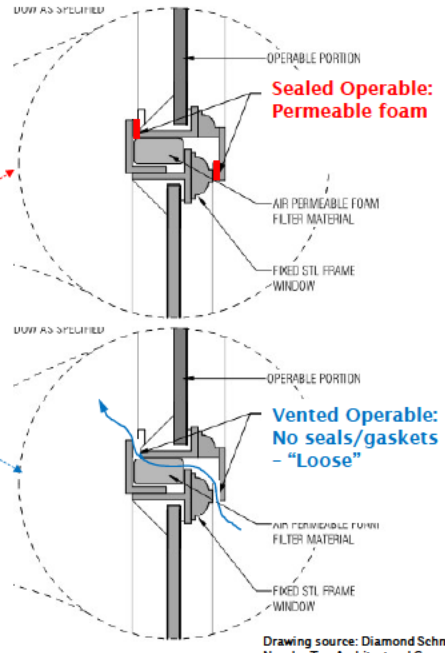


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Drawing source: Diamond Schmitt Architects and NumberTen Architectural Group

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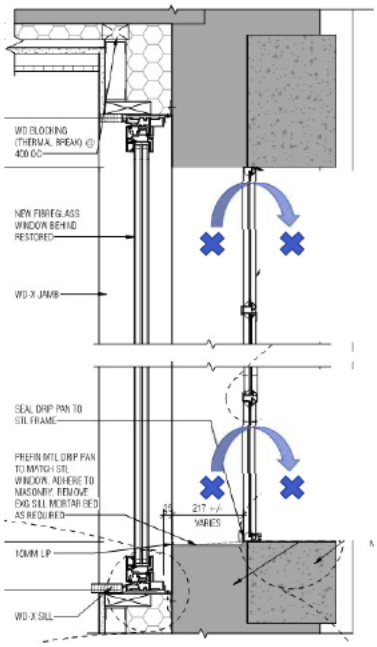


Vent the air space through the window jamb perimeter or through masonry

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Drawing source: Diamond Schmitt Architects and NumberTen Architectural Group

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Question Break

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Case Study #3
Replacement with
New Steel Windows
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## Bowles-Gandier House at Victoria University, Toronto

Built 1931, student residence, Toronto heritage listing

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## Original Windows

- Steel frames and sash
- Single pane glass
- Some operable, some fixed
- Most fixed lites do not have steel frames – glass is set into stone using lead caming

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**Fixed Rectangular Sash**

No steel frame

Lead caming set into stone

Lead caming divides the lites

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**Operable Steel Sash**

Casement operable vent

Steel frame secured to stone

No insulation or thermal break on frame

Lead caming divides the lites within the steel sash

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**Fixed Decorative Lites**

No steel frame

Glass set into stone with lead cames

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**Basement Windows**

Steel framed fixed and operable

Steel muntins (no lead cames)

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## University Objectives

1. Preserve heritage character and aesthetics of the building and the windows
2. Reduce air leakage - improve student resident comfort
3. Reduce future maintenance – particularly concerned with students damaging the interior lead caming

*Note: Improving thermal performance was not a client objective*

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## RDH Condition Assessment

- Steel frame corrosion ranged from minor to significant
- Cracked/bent lead caming
- Bowed glass related to softening of lead caming
- Damage to lead caming by students
- Difficult movement of operable sash
- No opening restriction (current code issue)
- Significant air leakage through operable sash and cracked lead caming – no weatherstripping around operables

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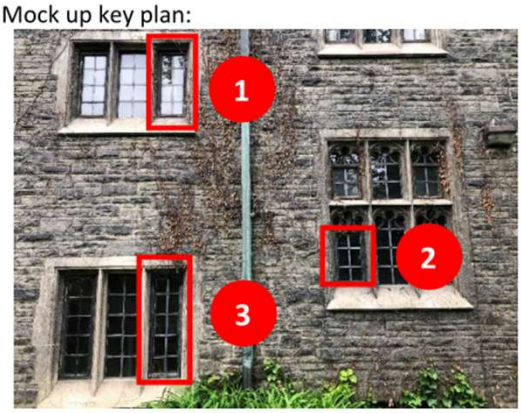
## University's Previous Mock-Ups

Mock up key plan:




**Option 1**: Partial Restoration of Existing Frame, Sash, and Single Pane Glazing

**Option 2**: Partial Restoration of Existing Frame and Sash, and Replace Single Pane Glazing (Operable Section Only) with Insulated Glazing Unit (Style 1)

**Option 3**: Full Unit Replacement including Insulated Glazing Unit (Style 2)

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Info and image courtesy of Victoria University

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**Option 1**: Restoration of Existing Frame, Sash, and Single Pane Glazing.

Pros: Preserves the character-defining elements and restores structural integrity.

Cons: Does not address air infiltration, lead canning remains susceptible to damage, and steel frames and sashes may require repair in the near future.

Before

After

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Info and image courtesy of Victoria University

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**Option 2**: Partial Restoration of Existing Frame and Sash, and Replace Single Pane Glazing (Operable Section Only) with Insulated Glazing Unit (Style 1).

Pros: Improves the structural integrity of the sash and addresses air infiltration.

Cons: Steel frames and sashes may require repair in the near future.

Before

After

New double-pane IGU with lead matrix between glass panes

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Info and image courtesy of Victoria University

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**Option 3**: Full Unit Replacement including Insulated Glazing Unit (Style 2).

Pros: Retains some character-defining elements, addresses air infiltration, and sash and frames will have the longest expected useful life.

Cons: Lead canning remains susceptible to damage.

Before

After

New double-pane IGU with lead tape applied to exterior and interior surfaces

*New lead tape is thinner than the original cames*

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Info and image courtesy of Victoria University

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## RDH Conservation Plan

Table 4.1 - RDH Analysis of Window Rehabilitation Options

| Ref No. | Option | Scope Description | Benefits | Challenges | RDH Comments |
|---|---|---|---|---|---|
| G2 at Operable Sash | Repair and Repaint Existing Steel Sash<br><br>New Sealed IGU with Lead Matrix Between Lites (not TDL) | **Operable Units:**<br>• Repair steel frames as needed<br>• Repaint sashes<br>• Remove existing leaded glass<br>• Install new sealed IGU with lead matrix between lites<br>• Provide weatherstripping around operable windows, where possible | • Reductions in air leakage can be expected due to the new sealed IGU, weatherstripping, and exterior sealants<br>• True divided lite/leaded windows are eliminated at operable units, such that future maintenance efforts with lead caming are reduced | • Heritage aesthetic is not preserved; lead matrix between IGU lites is noticeably different than the TDL existing aesthetic<br>• Air leakage at operable sash is expected if weatherstripping cannot be accommodated<br>• Minor reduction in future maintenance efforts: repainting frames and sash, replacing caulking, and adjusting/replacing weatherstripping will be required every 15-20 years | *RDH does not recommend this option due to the lack of preservation of the exterior heritage aesthetic.* |
| G3 at Operable Sash | Repair and Repaint Existing Steel Sash<br><br>New Sealed IGU with Applied Lead Tape on Interior and Exterior Surface of Exterior Lite (not TDL) | **Operable Units:**<br>• Repair steel frames as needed<br>• Repaint sashes<br>• Remove existing leaded glass<br>• Install new sealed IGU with applied lead tape on exterior side of exterior lite | • Heritage aesthetic is mostly preserved – reference to lead caming is provided with lead tape<br>• Reductions in air leakage can be expected due to the new sealed IGU, weatherstripping, and exterior sealants<br>• True divided lite/leaded windows are eliminated, but aesthetic is somewhat maintained with applied lead tape | • True divided lites and lead caming are not preserved<br>• Air leakage at operable sash is expected if weatherstripping cannot be accommodated<br>• Minor reduction in future maintenance efforts: repainting frames and sash, replacing caulking, adjusting/replacing weatherstripping, and maintaining exterior lead tape will be required every 15-20 years | **RDH recommends this glazing option** as it maintains most of the heritage aesthetic, reduces air leakage through the windows, and has some reductions in future maintenance efforts. |
| R1A at Operable Sash | New Steel Frames and Sash<br><br>New IGU with Single Sheet (non TDL) Interior Lite and TDL with Lead Caming at Exterior Lite | **Operable Units:**<br>• Remove and dispose of existing steel frame and sash<br>• Remove and dispose of existing leaded glass<br>• Install new steel frame and sash<br>• Install new IGU with flat glass interior lite and exterior TDL | • Heritage aesthetic is generally preserved<br>• Reductions in air leakage are expected due to the new steel frames, new IGU, new lead caming, weatherstripping at new operable sash, and new exterior sealants<br>• Minor reduction in future maintenance efforts due to new steel frames | • Replacing IGUs with exterior lead caming will be required every 10-15 years | **This Option is for VU's Consideration** - This option could be considered as it maintains the heritage aesthetic and will reduce air leakage through the windows; however, it is expected to be very expensive based on industry research. |
| R1B at Fixed Sash | New Steel Frames<br><br>New IGU with Single Sheet (non TDL) Interior Lite and TDL with Lead Caming at Exterior Lite | **Fixed Units:**<br>• Remove and dispose of leaded glass set into the stone surrounds<br>• Install new steel frames and new IGU with continuous interior lite and exterior TDL | • Heritage aesthetic is partially preserved; however new wider frames at fixed units will have some impact on the heritage aesthetic (reduced daylight opening)<br>• Reductions in air leakage can be expected due to the new steel frames, new IGU, new lead caming, and exterior sealants<br>• Reduction in future maintenance efforts with new steel frames and factory-applied finish<br>• | • Reduced vision area (daylight opening) through fixed windows due to the new frame<br>• Maintaining the IGUs will be required every 10-15 years | Installing a new frame at the fixed units will impact the heritage aesthetic of the windows, but will be more durable and reduce maintenance costs associated with lead caming.<br><br>**This Option is for VU's Consideration** - This option could be considered as it maintains some of the heritage aesthetic and will reduce air leakage through the windows; however, it is expected to be very expensive based on industry research. |

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## New Window Considerations

- Geometry to match existing
- Weatherstripping to reduce air leakage
- Performance to meet NAFS
- Lead tape on IGUs but apply to exterior surface to provide shadow lines

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**Operable Steel Sash**

New steel framed windows

IGUs with lead tape on #1 and #2 glass surfaces

*Very close match to original*

*No interior lead caming*

*Weatherstripping around vent*

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**Fixed Rectangular Sash**

New steel framed windows

IGUs with lead tape on #1 and #2 glass surfaces

*Daylight opening will be slightly reduced by new steel frame – New fixed frames will match operable windows*

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**Fixed Decorated Lites**

*Preservation*

New glass set in lead cames

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**Basement Windows**

*Preservation*

Repaint frames and sash
New single-pane glass
Repair/replace hardware to match

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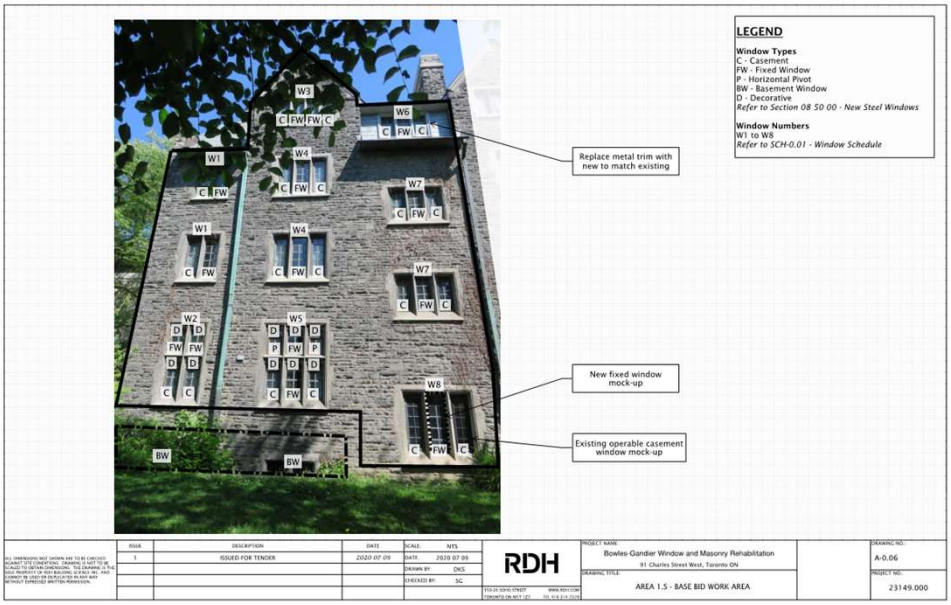


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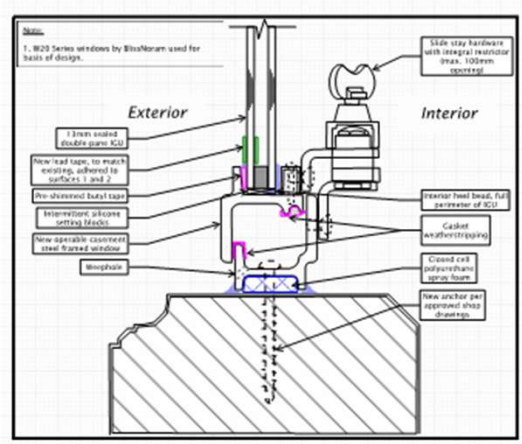
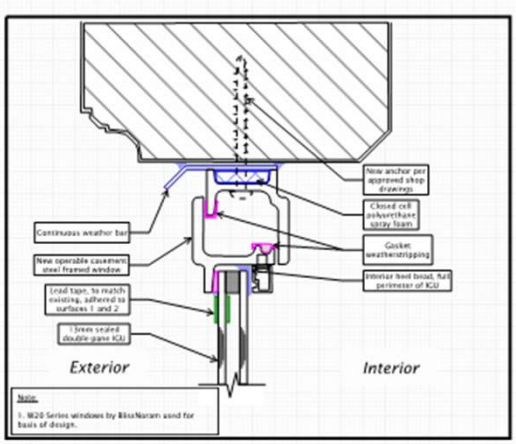



D-1.01 Casement Sill - Rectangular Operable Window




D-1.02 Casement Head - Rectangular Operable Window

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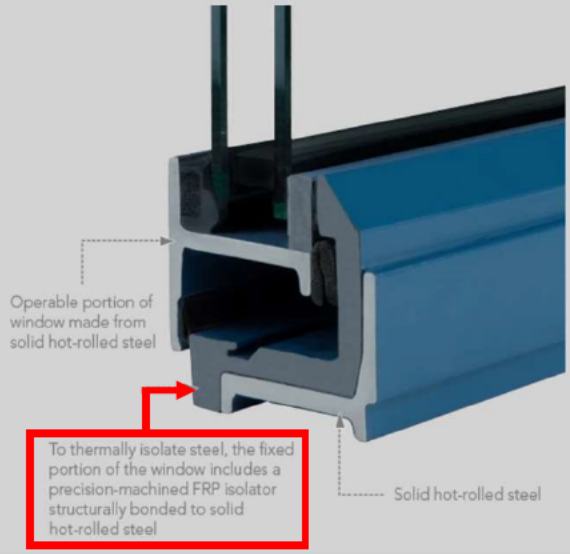
## THERMAL EVOLUTION TECHNOLOGY: SIMPLY A SUPERIOR SOLUTION

Hope's Thermal Evolution technology is a superior approach for creating a thermal break in fixed and operable time-tested solid hot-rolled steel windows and doors.

A Hope's window or door equipped with Thermal Evolution technology features a fiber-reinforced polymer (FRP) isolator that is precision-machined to nest perfectly within Hope's traditional hot-rolled solid steel frame profiles. This highly thermally resistant FRP isolator is structurally bonded to Hope's steel window and door frames to create a powerfully strong and enduring composite construction that delivers impressive thermal efficiency and enhanced resistance to condensation.

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Screenshot from Hope's Windows https://hopeswindows.com/products/thermal-evolution-technology/ 71

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# Question Break

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## Summary

- Conduct research and site assessment to understand existing steel window construction, condition, and significance to the building's character
- Off-site steel window repairs, including mock-ups, enables high-quality consistent work
- Consider retaining existing steel windows and adding new interior sash for thermal and air control improvements
- New steel windows to match existing geometry and daylight openings. Consider thermal improvement, weatherstripping, and glazing options.

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## Thanks!

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