Draft Report - February, 2013

EXTERIOR BUILDING ENCLOSURE EVALUATION

Prepared for
York Condominium Corporation 323 c/o Brookfield Residential Services Ltd.
50 Quebec Avenue
Toronto, ON M6P-4B4

Prepared by:
Halsall Associates
2300 Yonge Street, Suite 2300
Toronto, Ontario
M4P 1E4
(416) 487-5256

Halsall

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Authorization

This report was prepared at the request of the Board of Directors of YCC No. 323 in accordance with our proposal dated June 29, 2012.

1.2 Purpose

The purpose of our evaluation was to:

- Determine the condition of the exterior wall components, including the window and door, metal panel, and concrete wall systems;
- Provide advice regarding management strategies (minimum of 3) for exterior wall repairs and renewals; and
- Present our findings in a report, including discussion of the advantages and disadvantages of the proposed management strategies, and the associated repair and lifecycle budgets.

1.3 Methodology

Work completed for this evaluation included:

- *Interviews*: we met with the Property Manager, Mr. Isan Murat and the Board President Mr. Frank Delling to learn about the historical and current performance problems. We also inquired about specific performance problems related to water leakage and condensation from all residents who were home at the time of our interior review, which we estimate to be about 50% of the suites reviewed.

- *Interior Review*: we reviewed interior surfaces and exterior surfaces where available via balcony access at the following 41 suites: 101, 201, 306, 507, 701, 704, 707, 801, 802, 803, 901, 906, 1001, 1003, 1106, 1108, 1201, 1204, 1205, 1401, 1501, 1507, 1601, 1607, 1901, 1902, 1903, 2001, 2002, 2004, 2006, 2101, 2307, 2407, 2506, 2507, 2508, 2602, 2604, 2607, 2608.

  The interior review locations targeted 19 units with reported leakage issues identified by Property Management, while the balance is a random distribution throughout the building trying to balance units with eastern and western exposures.

- *Exterior Review*: we reviewed exterior surfaces from grade, balconies at accessed units, and from bosun chair at the following selected drops: '01 – South elevation, '01 – East elevation, '07 – West elevation, '07 – North elevation.

  We targeted this review to specific problem areas (such as reported leakage areas) that were identified during the first phase of our interior review and by Property Management or Suite Owners, to attempt to identify conditions that could be contributing to water penetration.

- *Air Leakage Testing*: using a smoke pencil, we assessed air leakage through sample joints in exterior walls, windows, and doors.

Further discussion of the various evaluation techniques has been included under Appendix G.

Information made available for our review as part of our evaluation was as follows:

Date	Description/Title	Author
July 29, 2011	Proposed Window and Door Replacement, Preliminary Report	Belanger Engineering
May 16, 1975	Drawing 15A - Wall Sections	Gothic Developments
May 16, 1975	Drawing 17 – Window Schedule	Gothic Developments
No date	Drawing 17A – Window Schedule	Gothic Developments
No date	List of Leaking Suites	YCC 323

Limitations that apply to this evaluation and report are included in the Appendix.

1.4 General Description

50 Quebec Ave., Toronto is a 26 storey high-rise residential condo building with 195 Suites that was constructed around 1977. The exterior walls are clad with a combination of original aluminum framed punched windows (see Photo No's 1 and 2 in attached photo appendix), window wall assemblies, sliding door assemblies, and aluminum cladding panels (see Photo 3), as well as concrete cladding panels (see Photo 4). Structural concrete floor slabs, balcony slabs, and shear walls are also exposed at typical locations (see Photo 5).

1.5 Component Description

1.5.1 **Punched Windows (see Photo 1 and 2)**: this type of window assembly is located throughout the building at exposed elevations (ie. not at recessed balcony areas). The punched windows generally consist of a combination of metal infill panels, operable window inserts (4 sash slider window assemblies) and fixed windows, in a thermally broken aluminum frame. Fin type weather stripping is present at operable window inserts. Operable windows are drained through concealed drainage tracks which discharge to the exterior through hooded weeper holes.

1.5.2 **Window Wall (see Photo 3)**: this type of window assembly is located throughout the building at recessed balconies and at grade level areas. Window walls are supported at the floor slab level where punched windows are supported inside a wall opening. Similar to the punched windows, the window wall assemblies generally consist of a combination of metal infill panels, operable window inserts, and fixed windows in a thermally broken aluminum frame. Fin type weather stripping is present at operable window inserts. Operable windows are drained through concealed drainage tracks which discharge to the exterior through hooded weeper holes.

1.5.3 **Sliding Balcony Doors (see Photo 3):** Sliding doors are present at all balcony locations. These doors generally consist of 2 sash sliders with a sliding screen sash. Pile type weather stripping is present at balcony doors. The original balcony doors are drained through weeper slots in the door track. New stainless steel tracks have been installed at some door locations and we understand that castors are being replaced on an ongoing basis. In some locations (total number not known by management) a retrofit 2 sash sliding door has been installed outboard of the original door frame.

1.5.4 **Metal Cladding Panels (see Photo 3)**: this type of cladding panel is present at recessed balcony areas as well as on the exposed portion of the West elevation as part of the window wall assembly (see Photo 1). Based on the notes indicated on Gothic Development's Drawing 17 – Window Schedule, we understand that metal cladding panels consist of the following (from exterior to interior):

- 18 gauge aluminum panel with painted Duracron finish;
- Rigid fiberglass core (R10) approximately 2" thick; and
- 22 gauge zinc coated back-up panel.

We did not make any wall openings to confirm this construction. Based on Belanger's report dated July 28, 2011, it seems that the specified wall construction is not present at all locations. Belanger reports that they made a wall opening inside the management office at a metal panel location and observed the following (from exterior to interior):

- aluminum panel;
- fiberglass batt insulation (R9, estimated); and
- 5/8" gypsum board backing.

Based on our visual review of metal panels at several suites and the findings indicated in Belanger's report, we suspect that there may be a mixture of the two metal panel construction types that are discussed above. Further investigation would be required to confirm the most common construction of metal cladding panels.

1.5.5 **Concrete Cladding Panels (see Photo 4)**: this type of panel is present at spandrel areas throughout the building at exposed elevations (ie. not recessed balcony areas). We did not make any wall openings to confirm the wall construction in these areas however; we expect that the wall assembly at concrete cladding panels is as follows (from exterior to interior):

- 4" cast in place concrete panel;
- Fiberglass batt insulation and interior framing (approximately R10);
- Vapour barrier (polyethylene sheeting); and
- 1/2" to 5/8" drywall.

Further investigation would be required to confirm this wall assembly.

1.5.6 **Fixed Glazing (See Photo 2)**: this type of glazing is present throughout the building at punched/strip windows and window wall assemblies. Fixed glazing generally consists of double glazed, clear, insulated glass units (IGUs). Where spot checked, no low e coating was present on original or replacement IGUs.

1.5.7 **Operable Window (4 Sash Sliders) Glazing (see Photo 2)**: this type of glazing is present at all 4-sash sliders throughout the building at punched/strip windows and window wall assemblies. Operable window glazing generally consists of single glazed clear glass. Where spot checked, no low e coating was present on single glazed clear glass.

1.5.8 **Sliding Door Glazing (see Photo 3)**: this type of glazing is present at all original sliding doors. Sliding door glazing generally consists of double glazed, clear IGUs. Where spot checked, no low e coating was present at IGUs.

1.6 Performance and History

We understand that there has been targeted window, door, and cladding repair work completed over the past several years. We are aware of the following:

- Localized sealant repairs including needle glazing at metal-to-metal joinery and localized window perimeter sealant repairs (primarily completed by window washing contractors);
- Localized cladding repairs including routing and sealing wide/visible cracks and localized concrete repairs;
- Localized sliding door retrofits including replacement of sliding door castors and tracks, and weather stripping;
- Localized window retrofits including drainage modifications;
- Localized installation of secondary sliding doors (outboard of the existing doors); and
- Ongoing, targeted replacement of IGU's as required (we understand that this has been on hold for the past few years).

2. KEY FINDINGS

Our summary of key findings identified during our review is described in the following section.

2.1 Exposed Concrete Elements Are In Serviceable Condition but Localized Concrete Cracks and Deterioration May Be Contributing to Water Leakage, and Ongoing Deterioration. Thermal Performance Generally Considered Acceptable, but Could Be Improved

We noted that localized concrete deteriorated at exposed concrete elements including cracks, fractures, delaminations, and spalls. This level of deterioration is generally consistent with the age of the building given that only minor repairs have been completed. Our findings are discussed in detail in Sections 2.1.1, 2.1.2, and 2.1.3 below.

2.1.1 Concrete Cladding Panels

During our exterior review from grade, balcony areas, and suspended access (bosun chair) we noted that about 80% of the concrete cladding panels that we reviewed were cracked or had crack repairs completed. These cracks are likely a result of concrete shrinkage which is an expected and normal behavior for concrete.

The majority of the observed cracks have been previously routed and sealed; only about 5% to 10% of the observed cracks are not sealed. The rout and seal repairs appear to be in generally good condition however, in some locations, cracks are not sealed for their full length (see Photo 6), this could potentially allow water to bypass the sealed portion of the crack.

We did not identify a correlation between unsealed cracks and the location of known leakage areas; no open cracks were observed at leakage locations. It is possible however, that the previous rout and seal repairs have not been effective in preventing water infiltration through cracks. Water testing is required to conclusively rule out previously repaired as well as unrepaired cracks as a source of leakage. Defects in other building components may be contributing to leaks in these areas.

2.1.2 Exposed Floor Slabs and Shear Walls

We identified concrete deterioration including fractures (see Photo 7), delaminations (see Photo 8), and spalls (see Photo 9), at 45% of the exposed concrete floor slabs and shear walls reviewed from suspended access. The level of concrete deterioration noted is consistent with the age of the building and known repair history.

We observed a correlation between the location of slab edge fractures and delaminations and reported leakage locations where leakage staining appeared near at the top of windows, so we expect that this is contributing to water leakage at window head locations.

During our investigation, Brook Restoration was on site completing localized concrete repairs on the '01 (E) and '07 (E) risers (see Photo 10). Based on the work that we observed, we do not expect these repairs to be durable; exposed reinforcing steel was not epoxy coated and saw cuts were not present at the limits of repair areas. However, we understand that these repairs were intended to be temporary in nature.

2.1.3 Construction Joints

During our review from balcony areas and suspended access (bosun chair) we observed that the construction joint (a joint that is formed between adjacent concrete pours at the connection between walls and floor slabs was sealed in some locations while in others, this joint is unsealed (see Photo 11). We suspect that there is a correlation between the open construction joint outside of Suite 2001 and the reported leakage on the ceiling inside Suite 2001. Water testing would be required to confirm this possibility.

2.1.4 Thermal Bridging at Exposed Floor Slabs and Shear Walls; Adverse Impact on Energy Use Expected

Thermal bridging is occurring at exposed floor slabs and shear walls; these elements bypass (bridge) the thermal control layer that is present in the wall assembly and permit energy loss to the exterior through conduction. We did not observe any evidence of interior condensation or occupant comfort issues at floor slabs, soffits, or shear walls which are commonly associated with thermal bridging.

2.2 Aluminum Framed Windows and Doors Require Repairs to Improve Operation, General Water Tightness and Air Tightness (Energy)

2.2.1 Operable Windows

a) Operable Window Drainage Reportedly Inadequate, Contributing to 8 Known Water Leaks

Several suite owners reported that operable window drains backed up during heavy wind driven rain events.

The existing operable window drainage system was found to be in variable condition. At 75% of suites where water leakage was reported at window sills, the Suite owner stated that the operable windows were generally drafty and that the operable window track often filled with water during wind driven rain events.

In several locations checked, only some of the existing drainage holes were functioning (see Photo 12) however, operable window tracks generally drained completely when tested.

While cleaning the drainage channels will help address the problem, we also recommend replacing the weather stripping at operable windows. This will improve the air pressure control across the window system which helps drainage performance.

b) Widespread Air Leakage Found, Adverse Impact of Energy Use and Comfort Expected

We tested operable windows for air leakage using a smoke pencil. Air leakage was noted at all of the locations that we checked; smoke was observed bypassing the operable windows at corners and meeting styles (see Photo 13). The observed leakage is likely related to the condition of the existing weather stripping - we noted that weather stripping at window perimeters is in serviceable condition (see Photo 14) while the weather stripping at meeting styles and window corners were in poor condition (see Photo 15) and no longer effective.

It may be possible to improve the both air and water tightness of operable window assemblies by replacing weather stripping around the sliding window sashes, at corners, and at the meeting style however, mock up repairs with before / after quantitative testing are required to verify the effectiveness of possible retrofit options.

c) Operable Window Operation Generally Poor

Poor ease of operation was reported at about 10% of the Suites we reviewed. Given the age of the operable windows, we expect that the moving parts (rollers, locking hardware and screen restraints) are worn and no longer functioning as intended (see Photo 16).

It may be possible to address these operation issues by replacing moving parts however, mock up repairs are required to assess the effectiveness and cost of this type of repair.

d) Operable Limiters Not Present at Non-Balcony Drops. Retrofits Required to Meet Current Building Code.

During our investigation, we noted that window operation limiters are not present at non-balcony drops. We recommend installing operable window limiters at the sliding windows on non-balcony drops. These would restrict an opening of more than 100mm wide at any windows acting as a guard, or those on non-balcony drops which are located within 1070mm from the interior floor level, which is a requirement of the Ontario Building Code

2.2.2 Sliding Doors

a) Widespread Air Leakage Noted Affecting Energy Use and Comfort, Some Isolated Water Leakage Reported

Similar to the operable windows, air leakage was noted at all of the sliding door locations that were checked using a smoke pencil. Smoke was observed travelling through the sliding door assembly from door corners and meeting styles (see Photo 17).
We noted that the existing door perimeter and meeting style weather stripping is in generally poor condition and no dust plugs were present at door corners (see Photo 18).

Water leakage was reported through the sliding door assembly at 5% of the suites we reviewed. This water penetration at sliding doors is somewhat surprising due to the sheltered nature of the balconies at your building.

It may be possible to improve the both air and water tightness of sliding door assemblies by replacing weather stripping around the doors, at corners, and at the meeting style however, mock up repairs are required to test the effectiveness of possible retrofit options.

b) Sliding Door Operation Generally Poor

We noted that the sliding door track is severely worn in most locations (see Photo 19) and expect that the original door castors are equally worn. We observed the following operational issues:

- Sliding door does not close fully;
- Sliding door locking hardware is difficult or impossible to engage;
- Sliding door opens on its own; and
- Screen door sticks or does not operate on track.

We understand that sliding door track and wheel retrofits have been completed at about 10% of the suites with mixed results. The retrofits included grinding the existing sliding door track level, installing a new stainless steel sleeve over the door track (see Photo 20) and replacing the sliding door castors. We understand that the large size sliding doors (8' wide) bend the stainless steel sleeve, exasperating the issue; however, where checked, the operation of the doors did appear to be significantly improved after retrofits were installed. It may be possible to develop a cost effective retrofit program to improve the operation of the doors however, mock ups of different repair options are required to further assess this possibility.

2.2.3 Insulating Glass Units Performing Beyond Expected Service Life; Ongoing Maintenance and Eventual Replacement Required to Maintain Performance.

We received a copy of your 2013 IGU Survey which was recently completed by your in house staff. We understand the following with respect to IGUs:

- About 75% of the IGUs are original and still in serviceable condition – they are continuing to perform beyond their expected service life of 20 to 30 years ;
- About 20% of all IGUs have been replaced; and
- Only about 5% of all IGUs are currently failed.

Based on your survey results, 5% of IGUs were found to be failed (about 100 units). Unfortunately, we cannot determine the IGU failure rate from this survey alone, because we do not know the period over which this failure occurred. This information can be useful information when contemplating full replacement. We understand that no IGUs have been replaced in the past 2 years. If there were no failed IGUs prior to your decision to stop replacing IGUs, the effective rate of failure would be about 50 units/year or about 2.5% of all IGUs/year. Based on our experience, we would consider this failure rate to be significant enough to warrant a general IGU replacement project. Should the failure rate be below this threshold of about 50 units/year or 2.5%, we recommend continuing to replace IGUs on an ongoing basis.

You may consider monitoring the IGU failure rate over the next year by conducting another survey to compare the total number of failed units year to year. Knowing the failure rate could help to make an informed decision regarding your IGU replacement strategy moving forward and timing for the associated budgets..

2.2.4 Fixed Glazing Generally Water Tight, Some Isolated Leakage at Replaced Units

In general fixed glazing units appear to be water tight. Leakage was reported at about 8% of the reviewed suites. Further, leakage appears to only be an issue where IGU replacement had been completed. We suspect that either the sealant material used during replacement was not installed correctly or the new IGU was not fully compressed against the new sealant; either way this is a workmanship issue. We understand that issues related to leakage at replaced windows are being addressed by Property Management.

We recommend considering alternate glazing contractors for work related to IGU replacement unless the identified workmanship issues can be resolved with your current glazing contractor.

2.2.5 Window and Cladding Panel Perimeter Sealants are Generally Bonded and in Serviceable Condition with Some Localized Deterioration

During our review of the exterior from balcony areas and suspended access we noted that the window perimeter sealants appear to be in fair condition with some localized deterioration at various locations (see Photo No's 21 and 22).

We suspect that there is a correlation between locally failed window perimeter sealant and reported leakage locations particularly where leakage staining appears at window sill areas and floor slab areas. Water testing would be required to confirm this correlation.

2.2.6 Metal-to-Metal Sealants Generally in Poor Condition, Expected to be Contributing to Water Leaks

During our review of the exterior from balcony areas and suspended access we noted that metal-to-metal sealants at punched windows are in very poor condition and in several locations, no longer providing an effective seal (see Photo No's 23 and 24).

We understand that most of the localized metal-to-metal sealant repairs were completed by your window washing contractor. Typically window washers are not experienced in sealant application. Based on the quality/detailing of the metal-to-metal sealant repairs that we observed we do not expect that these repairs will be effective.

We suspect that there is a correlation between failed, poorly installed, and missing metal-to-metal sealants and reported leakage at window head, sill, and floor slab areas. Water testing would be required to confirm this correlation.

2.3 Metal Cladding Panels Are Generally Water Tight, Some Fading of Metal Coatings and Localized Sealant Failures Noted

We received no reports of leakage from the exterior through metal cladding panels. Some performance issues were noted including an isolated report of condensation, fading and chalking of metal panel coatings, and localized sealant failures. These issues are discussed further in Sections 2.3.1, 2.3.2, and 2.3.3 below.

2.3.1 Isolated Report of Condensation Likely Related to Localized Insulation Failure - Further Review Required to Confirm.

At 1 of 40 suites checked (Suite 1205), the resident reported condensation forming on the interior side of a metal cladding panel. We tapped the interior and exterior faces of the panel and noted a rattling sound from inside the panel which is not detected elsewhere.

We expect that the condensation formation observed by the Suite owner is related to an isolated insulation failure. The insulation board inside the panel could be broken or debonded, allowing cold air to contact the warm, interior face of the panel resulting in condensation formation. Further review is required to confirm this condition, including a wall opening and potential repair work.

2.3.2 Profile of Needle Glazing Generally Poor, Localized Failures May Lead to Leakage

The perimeter of metal cladding panels has been generally sealed with a narrow profile needle glazing bead (see Photo 25). This type of sealant profile does not provide a durable seal due to the limited bite onto the aluminum substrate and the thin sealant depth. About 25% of the needle glazing checked during our review was found to be debonded or split.

Although the majority of metal panels are located inside recessed balcony areas, ongoing failure of the needle glazing beads is likely to increase the risk of water leakage at metal panel locations during heavy, wind driven rain events. This risk is greater on the West elevation where metal cladding panels are fully exposed to the elements (ie. not sheltered).

These perimeter seals are also expected to control air leakage so renewing this retrofit will have some additional benefits with respect to energy consumption.

2.3.3 Original Metal Coating at Cladding Panels Generally Fading and Chalked – Condition Generally Consistent with Age

The original bronze coating that is present on metal cladding panels has aged due to weathering and UV exposure and it is now chalked and faded in some areas (see photo 26). Aging of the metal coating on the West elevation is particularly pronounced due to the exposed nature of this elevation.

If the notes indicated on Gothic Development's Drawing 17 – "Window Schedule" are accurate, the coating material is likely Duracron by PPG. This is a standard performance grade coating that we typically expect to last between 5 and 10 years before significant chalking and fading of the coating occurs in fully exposed areas. Given that the coating is about 35 years old; its condition is generally consistent with its age.

Based on the observed condition of the panels, the coating still appears to be providing acceptable protection to the metal. While you could consider recoating the metal surfaces we would consider this to be required only for aesthetic purposes and have not included a recoating budget in the recommended management strategies.

3. DISCUSSION

The prevalence of water leakage through the exterior building enclosure is relatively moderate; only about 19 suites out of 195 suites (roughly 10%) in the building have reported leakage. It is possible though, that many of the defects that have been identified in this report may lead to leakage at additional locations in the future.

The window system is still providing an acceptable level of performance. We do not expect that replacement of the window system is required as long as proactive measures are taken to maintain performance. Thermally, the system is providing a satisfactory level of performance compared to current day aluminum framed window systems. Although better systems are available, we do not believe that replacement of the window system is warranted from an energy perspective.

Some IGU's are still performing however; original IGUs are outside of the generally accepted service life of about 25 years. It is possible that you will see an increased incidence of IGU failure as the existing units continue to age – the exact rate of failure is difficult to predict. If you continue to maintain the existing IGUs it is possible that you will see significantly more service from them. We expect that further information related to the existing failure rate would be valuable information. As discussed, we understand that you are in the process of obtaining this information.

4. MANAGEMENT STRATEGIES

4.1 Minimum Repairs to Address Safety Concerns

As a minimum, we recommend completing targeted concrete repairs to address potential falling hazards and maintain public safety pending implementation of a restoration program. As you have already performed some concrete repairs at many drops, this could involve continuing to perform repairs on an as-needed basis, likely under an annual program. We recommend a budget of $20,000 per year for this work. You could otherwise address concrete deterioration in a one-time repair approach, which we estimate would cost approximately $70,000 excluding engineering or taxes.

Further, installing operable window limiters at the sliding windows on non-balcony drops is needed to meet building code requirements. Limiters will restrict an opening of more than 100mm wide at any windows acting as a guard, or those on non-balcony drops which are located within 1070mm from the interior floor level, which is a mandatory requirement of the Ontario Building Code. You could retain a contractor directly for this work. Our involvement is not required. We recommend a budget of $15,000 to complete these repairs.

4.2 Building Enclosure Restoration Strategies

We present the following strategies with opinions of cost. These include a range of solutions to address the identified problems and promote adequate performance over the identified service life. Opinion of cost breakdowns are presented in Appendix A.

Item 1. below comprises the Base Strategy which we would recommend to maintain acceptable performance of the wall enclosure, i.e. to restore the performance and operation of the existing systems. Items 2. and 3. represent upgrades to the Base Strategy and should be considered in addition to the budget for Item 1. Item 4. for replacement of the IGUs may be considered independent of each strategy, as this relates to an distinct building component.

1. BASE STRATEGY – REPAIRS TO MAINTAIN ACCEPTABLE ENCLOSURE PERFORMANCE	$950,000

This strategy includes renewal of select building components which are at the end of their service life or which are no longer performing, while maintaining those systems which are still providing acceptable performance. In addition to targeted concrete and sealant repairs, this strategy includes window and door retrofits including weather-stripping, castor replacement, and sliding door track replacement at severely worn areas.

In our Opinion of Cost Table, we have included an allowance for sliding door track replacement at 50% of sliding door locations. We expect that we can confirm this pricing following trial repairs. Once pricing has been confirmed for retrofit options, the economy of this type of repair may be re-evaluated.

TIMELINES	
Recommended Project Timing:	2 years
Next Predicted Restoration Intervention:	10 years ($80,000)
Predicted Time Before General Renewal or Replacement:	20 years ($800,000)

Benefits & Advantages	Risks & Disadvantages
▸ Reduce ongoing deterioration at concrete; ▸ Improved water leakage resistance; ▸ Improved energy consumption and thermal comfort by addressing air leakage; ▸ Improved operation at doors and windows; and ▸ Reduced Carbon Footprint.	▸ No aesthetic improvements; ▸ Additional concrete patches may contribute to aesthetic concerns.

SCOPE OF WORK

Item	Description
1.1	Perform concrete repairs at concrete panels, exposed slabs and shear walls.
1.2	Replace weatherstripping at operable windows and doors
1.3	Retrofit operation of balcony doors and operable windows
1.4	Replace targeted sealants
1.5	Clean out window tracks and drainage ports

2. ADDITIONAL REPAIRS (TO BASE STRATEGY) TO UPGRADE AESTHETICS – COATING CONCRETE	$630,000

This budget represents the cost premium over the Base Strategy to coat concrete surfaces.

This strategy includes coating the exposed concrete surfaces at slab edges, shear walls, and concrete panels with an elastomeric coating.
This strategy would bring a uniform look to the concrete surfaces and presents an opportunity to change colour if desired. Depending on the coating selected, variable degrees of water control can be achieved. This budget includes for a high-end, flexible, water resistant coating. If water control is not required, the cost could be reduced by approximately 30%.

TIMELINES

Recommended Project Timing:	Elective, following concrete repairs
Next Predicted Restoration Intervention:	10 years ($500,000)
Predicted Time Before General Renewal or Replacement:	20 years ($500,000)

Benefits & Advantages	Risks & Disadvantages
▸ Brings uniform look to concrete surfaces, improving aesthetics; and ▸ Improved leakage resistance;	▸ High relative cost for limited performance ▸ Once coated, ongoing maintenance (recoating) will be required

SCOPE OF WORK

Item	Description
2.1	Complete required concrete repairs (included separately)
2.2	Coat exposed concrete surfaces

3. ADDITIONAL REPAIRS (TO BASE STRATEGY) TO IMPROVE ENCLOSURE PERFORMANCE - OVERCLADDING	$2,200,000

This budget represents the cost premium over the Base Strategy to overclad concrete walls.

This strategy includes work to improve the performance of the existing systems, specifically at the exposed concrete shear walls, slab edges and concrete panels, and at the metal infill panels. This would be achieved by overcladding with an exterior insulation and finishing system (EIFS) in order to increase thermal performance (R value of approximately 8 to 12 more) at all wall areas, and improve water shedding at non-balcony drops.

This project would bring a uniform look to the concrete surfaces (excluding balcony soffits and balustrades) and presents an opportunity to change colour if desired.

We would recommend completing this work in combination with Item 4. for complete IGU replacement as both strategies will help to improve overall enclosure performance.

TIMELINES

Recommended Project Timing:	Elective
Next Predicted Restoration Intervention (repainting and local repairs):	15 years
Predicted Time Before General Renewal or Replacement:	35 years or more

Benefits & Advantages	Risks & Disadvantages
▸ Improved energy consumption; ▸ Improved thermal comfort; ▸ Improved condensation resistance at walls; ▸ Address ongoing deterioration of exposed concrete; and ▸ Improved water shedding and resistance to water leakage.	▸ High relative cost; ▸ Will change the wall profile and thus, general look of the walls; and ▸ Ongoing maintenance required with this option (repainting).

SCOPE OF WORK

Item	Description
3.1	Install Exterior Insulation and Finishing System at concrete and metal panel surfaces
	Install new extended flashing at exposed windows.

4. REPAIRS (INDEPENDENT OF BASE STRATEGY) TO IMPROVE ENCLOSURE PERFORMANCE - COMPLETE IGU REPLACEMENT	$1,100,000

This strategy should be considered independent of the Base Strategy as it concerns a distinct building component.

This budget includes for replacing the existing insulating glass units (IGUs) with new, low e coated, gas filled units, with warm edge spacers at the perimeters. These units would provide improved performance over the existing with respect to solar heat gain, conductive/convective heat loss, and UV exposure of interior surfaces and finishes.

This program would require interior access to all units to facilitate the replacements. Because of this, we expect the scale/phasing of the work could be adjusted with little impact on overall project cost, as access is a minimal component of the work. Essentially, you could implement this work as a floor by floor phased in approach to help limit disruption or control cash-flow, as required.

As noted in Section 2.2.3, we recommend considering a general IGU replacement program once the rate of IGU failure exceeds 50 units/year. In the meantime, we would recommend that you establish an IGU replacement specification, to ensure that IGUs that are replaced in the interim period are consistent with the ultimate IGUs that will eventually be incorporated in the entire building.

TIMELINES	
Recommended Project Timing:	Elective
Next Predicted Restoration Intervention (select replacements):	20 years
Predicted Time Before General Renewal or Replacement:	30 years or more

Benefits & Advantages	Risks & Disadvantages
▸ Improved energy consumption ▸ Improved thermal comfort ▸ Reduced risk of condensation at windows ▸ Provides new glazing seals at window, improving resistance to water/air leakage.	▸ High relative cost ▸ Replaces units which are still within their services life and providing acceptable performance.

SCOPE OF WORK

Item	Description
4.1	Replace IGUs at fixed windows and doors including renewed glazing seals.

4.3 Trial Repairs and Testing

In order to evaluate if window and door retrofits are an effective and economical solution to the performance issues that have been identified in this evaluation, we recommend competing trail repairs. Trial repairs would include accessing a sample unit or units where performance issues have been identified (poor window/door operation, window/door air leakage) by replacing weather stripping, window and door castors, and modifying the sliding door track. Following repairs, we could complete air leakage and operation testing to confirm the effectiveness of these repairs. Below we have summarized our recommended budget for trial repairs and testing.

	Contractor Costs	Halsall Fees Oversee and Coordinate Repairs	Halsall Fee for Air Leakage Testing (Optional)
Window Retrofits	$650	$1,500	$1,800
Door Retrofits	$2350	$1,500	$2,000
Total	$3000	$3,000	$3,800

5. CONSIDERATIONS

5.1 Energy Savings

This evaluation has not quantitatively considered cost savings for reduced energy consumption which is expected to result from implementing the proposed strategies. Window repairs will improve air leakage performance, while replacements will do this as well as provide improved thermal performance. However, based on our experience, energy payback on window replacements projects is not typically within 20 years. For this reason, and as is the case for your building, we typically recommend against replacing the windows until they have reached their useful service life and are no longer providing acceptable performance. However, other factors such as aesthetics and functionality (and the repair costs to address these) will also play a part in the timing for window replacement. The cost payback of replacing the weatherstripping at the windows and doors is expected to have a payback within 15 years, however in-situ quantitative air leakage testing before and after repair work, and further review of our energy bills would be required to estimate this.

The overcladding option will provide improved thermal performance at the walls, which will provide energy savings and also improved wall durability which will have an effect on maintenance costs. There are many factors which can significantly affect the energy savings associated with adding insulation to the walls. If you require, we can perform an energy analysis to help refine this measure.

Finally, IGU replacement payback is not expected to be within 20 years when considering the full cost of new IGU units. In new construction applications, features such as low e coatings and gas fill can be justified against the cost premium to provide these upgrades, as providing the base materials/units is "sunk" in construction. In our experience, the cost to of these features makes up approximately 15% to the cost of the installed unit, while the labour and other materials make up the remaining 85%. For this reason, we recommend you check the prevalence of failed/fogged units at your building prior to planning for full IGU replacement, as this will help you to weight other factors that justify replacement.

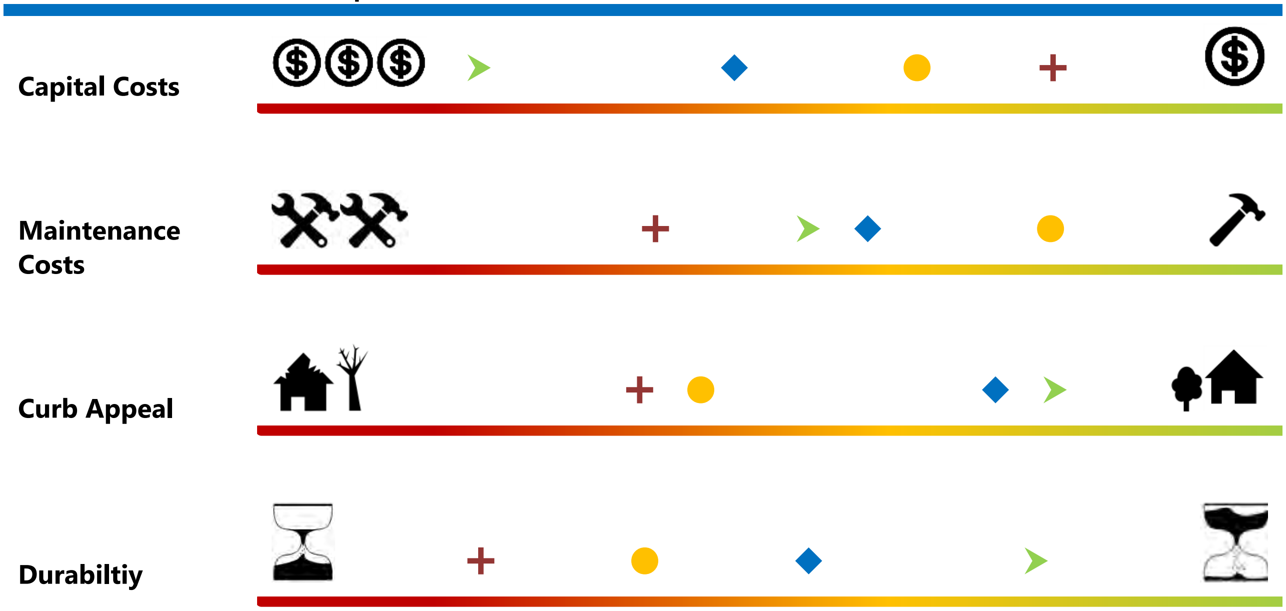
5.2 Decision Matrix Criteria

Each Management strategy has qualitative economic, environmental and social impacts that should be considered when planning future investments for your facility. To help you gauge which strategy best meets your short and long-term objectives, we are providing a qualitative comparison of the impacts that matter to your facility.

Less desirable outcomes are located on the left hand side of each scale and more desirable outcomes on the right.

- + Immediate Repairs to Address Safety Concerns: $85,000
- ● Strategy 1 : Repairs to Maintain Performance - $830,000
- ◆ Strategy 2: Aesthetic Improvements - $615,000
- ➤ Strategy 3: Repairs to Improve Performance - $3,300,000 (Combined)

Economic Impacts



Environmental Impacts

Global Warming Potential

Resource Conservation

Raw Material Consumption

Social Impacts

Safety

Aesthetics

Respectfully submitted,
HALSALL ASSOCIATES
A Parsons Brinckerhoff Company

David Ruhl, B.A.Sc
Project Associate

Jake Smith, P.Eng.
Project Manager

John Kosednar, P.Eng.
Project Principal

Appendix A
Opinion of Cost

APPENDIX A
OPINION OF COST

The following costs are our opinion of value of the remedial work described in this report. They are calculated using quantities obtained during our evaluation and information we have obtained from similar projects. Actual costs will vary depending upon the time of tender, schedule of work and conditions under which the work must be carried out. Halsall has not investigated the presence of pollutants, contaminants and hazardous materials that may be encountered during the work. Depending on the materials present, additional funds may be required for remediation measures.

As every project has its own peculiarities, actual costs can only be established by obtaining bids, preferably on the basis of competitive tenders, from specialized contractors. The costs provided herein should only be used for comparison of options and general budgeting purposes.

1 BASE STRATEGY – REPAIRS TO MAINTAIN ACCEPTABLE ENCLOSURE PERFORMANCE

No.	Description	Opinion of Cost
1.1	**Access and Site Protection**	
a)	Mobilization and Demobilization	$ 13,000
b)	Suspended Access	$ 17,000
c)	Grade Level Protection	$ 15,000
1.2	**Concrete Repairs**	
a)	Slab Edge	$ 17,000
b)	Cladding Panels	$ 4,000
c)	Shear Walls	$ 19,000
1.3	**Targeted Sealant Repairs**	
a)	Window Perimeter Sealants	$ 8,000
b)	Metal-to-Metal Sealants	$ 40,000
1.4	**Window and Door Retrofits/Renewal**	
a)	Balcony Doors	$ 300,000
b)	Operable Windows	$ 100,000
c)	Allowance for Sliding Door Track Replacement (50% of doors)	$ 150,000
1.5	**Miscellaneous Allowances**	
a)	Building Permit	$ 1,000
b)	Bonding	$ 5,500
c)	Construction Contingency	$ 69,000
	Sub-Total - Estimated Construction Cost	**$ 758,500**
1.6	Design, Specifications and Tendering	$ 6,000
1.7	Project Management, Construction Review and Contract Administration	$ 55,000
1.8	Allowance for Mock Ups and Testing	$ 15,000
	Pre-Tax Subtotal	$ 834,500
1.9	HST - 13%	$ 108,500
	Total Estimated Project Budget (Current Dollar Value)	$ 945,000

APPENDIX A

OPINION OF COST

2 ADDITIONAL REPAIRS (TO BASE STRATEGY) TO UPGRADE AESTHETICS – COATING CONCRETE

No.		Description	Opinion of Cost	
2.1		**Access and Site Protection**		
	a)	Mobilization and Demobilization	$	8,000
	b)	Suspended Access	$	52,000
	c)	Grade Level Protection	$	15,000
2.3		**Concrete Coating**		
	a)	Concrete Cladding Panels and Exposed Slab Edges	$	111,000
	b)	Shear Walls (Outside and Inside Balony Surfaces)	$	99,000
	c)	Baloncy Ballustrades (Outside Surfaces)	$	31,000
	d)	Balcony Soffits	$	252,000
2.4		**Miscellaneous Allowances**		
	a)	Building Permit	$	1,000
	b)	Bonding	$	3,500
	c)	Construction Contingency	$	16,000
		Sub-Total - Estimated Construction Cost	**$**	**513,500**
2.5		Design, Specifications and Tendering	$	5,000
2.6		Project Management, Construction Review and Contract Administration	$	35,000
		Pre-Tax Subtotal	$	553,500
2.7		HST - 13%	$	72,000
		Total Estimated Project Budget (Current Dollar Value)	$	630,000

APPENDIX A

OPINION OF COST

3 ADDITIONAL REPAIRS (TO BASE STRATEGY) TO IMPROVE ENCLOSURE PERFORMANCE - OVERCLADDING

No.		Description	Opinion of Cost
3.1		**Access and Site Protection**	
	a)	Mobilization and Demobilization	$ 43,000
	b)	Suspended Access	$ 56,000
	c)	Grade Level Protection	$ 15,000
3.2		**EIFS Overcladding**	
	a)	Concrete Surfaces	$ 1,458,000
	b)	Exposed Metal Panels	$ 182,000
3.3		**Miscellaneous Allowances**	
	a)	Building Permit	$ 6,000
	b)	Bonding	$ 18,000
	c)	Construction Contingency	$ 176,000
		Sub-Total - Estimated Construction Cost	**$ 1,840,000**
3.4		Design, Specifications and Tendering	$ 7,000
3.5		Project Management, Construction Review and Contract Administration	$ 132,000
		Pre-Tax Subtotal	$ 1,979,000
3.6		HST - 13%	$ 257,300
		Total Estimated Project Budget (Current Dollar Value)	$ 2,236,300

APPENDIX A

OPINION OF COST

4 REPAIRS (INDEPENDENT OF BASE STRATEGY) TO IMPROVE ENCLOSURE PERFORMANCE - COMPLETE IGU REPLACEMENT

No.	Description	Opinion of Cost
4.1	**Mobilization and Demobilization**	$ 30,000
4.2	**IGU Replacement**	
a)	Balcony Doors	$ 597,000
b)	Punched Windows and Window Wall	$ 203,000
4.3	**Miscellaneous Allowances**	
b)	Bonding	$ 8,500
c)	Construction Contingency	$ 83,000
	Sub-Total - Estimated Construction Cost	**$ 891,500**
4.4	Design, Specifications and Tendering	$ 4,000
4.5	Project Management, Construction Review and Contract Administration	$ 64,000
	Pre-Tax Subtotal	$ 959,500
4.6	HST - 13%	$ 124,800
	Total Estimated Project Budget (Current Dollar Value)	$ 1,084,300

Appendix B
Photographs

Photo 1: Punched windows and exposed metal wall panels on the West elevation.

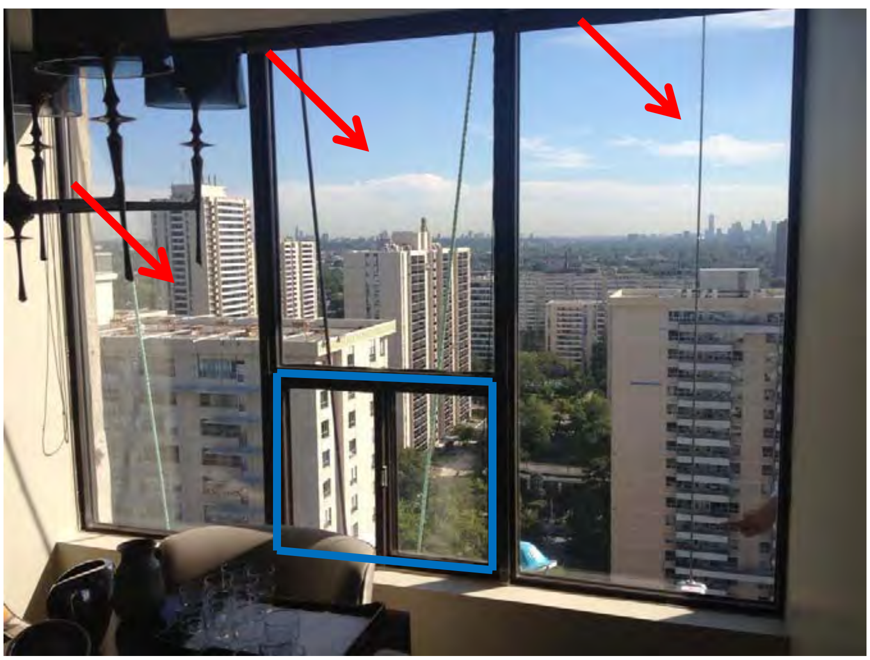


Photo 2: A typical punched window assembly; fixed glazing is indicated with red arrows, the operable window insert is identified with a blue box.

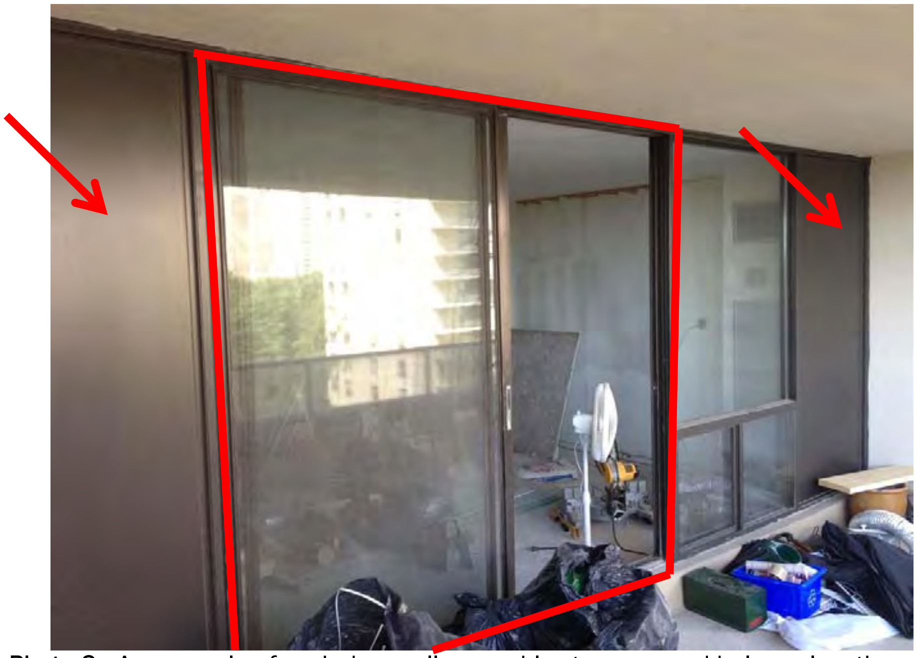


Photo 3: An example of a window wall assembly at a recessed balcony location. The sliding balcony door that is inset into the window wall frame is identified with a red box. Metal cladding panels are identified with red arrows.

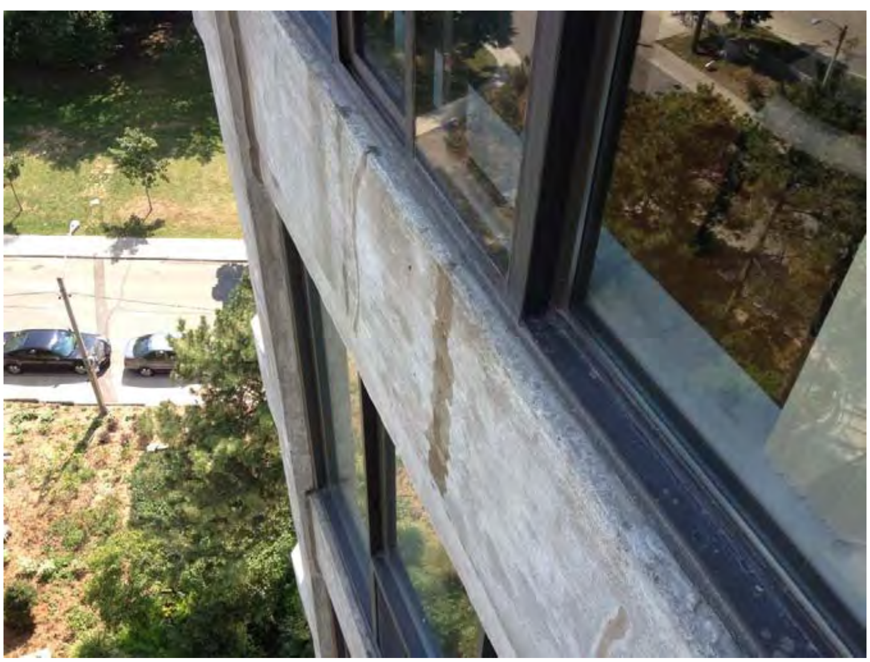


Photo 4: Concrete cladding panels are located below punched windows.

Photo 5: Structural concrete floor slabs (red arrows), balcony slabs (blue arrows), and shear walls (yellow arrows) are exposed at typical locations.

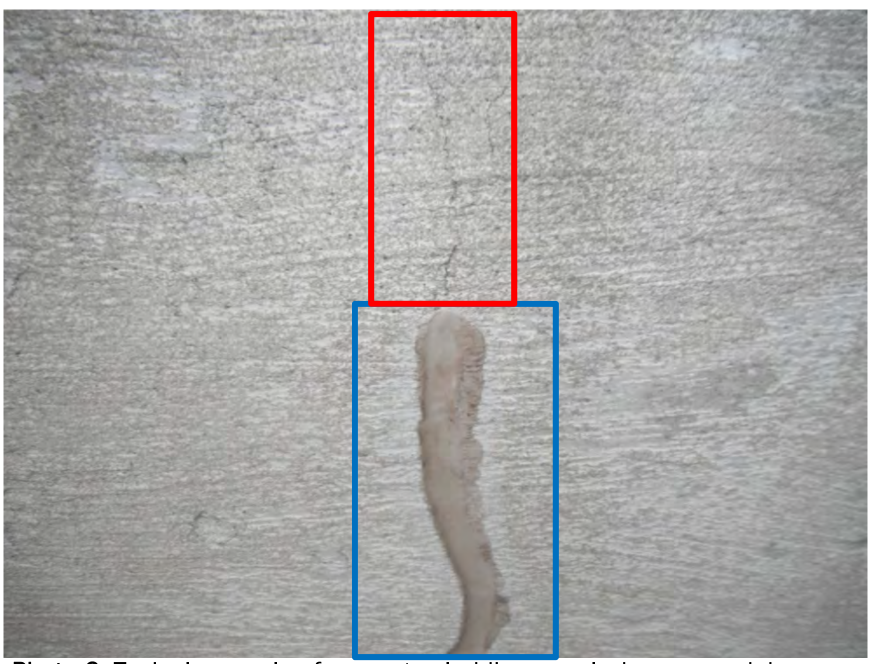


Photo 6: Typical example of concrete cladding panel where a crack has previously been partially sealed. The sealed portion of this crack is highlighted with a blue box, while the unsealed portion is highlighted with a red box.

Photo 7: An example of a fractured concrete floor slab above a window location (red arrow).

Photo 8: An example of a fractured and delaminated concrete (red box) at a concrete cladding panel below a window.

Photo 9: An example of a concrete spall due to corrosion of reinforcing steel in exposed concrete floor slabs.

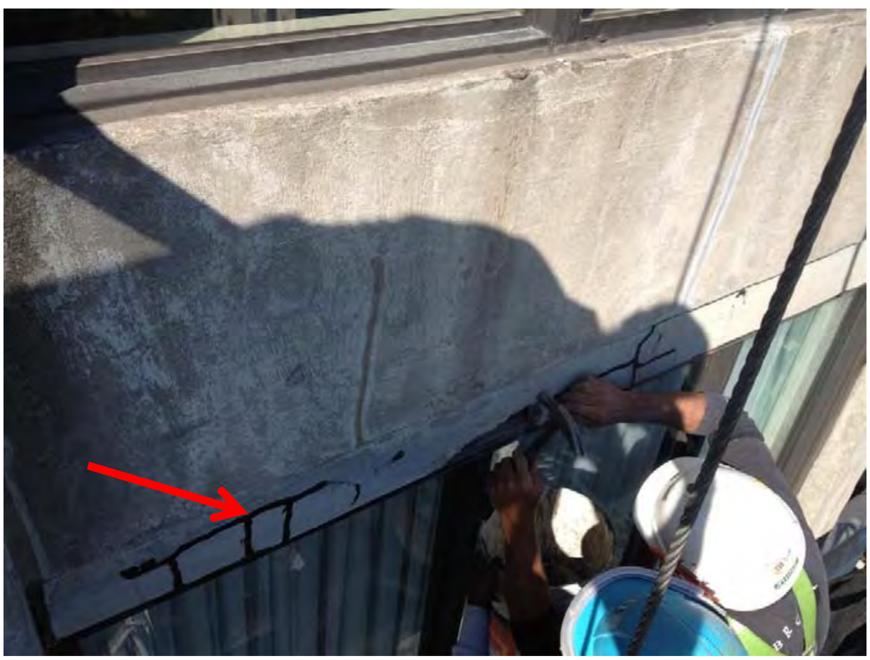


Photo 10: Photo of concrete repair work under way. Concrete fractures have been previously sealed over using brown sealant (red arrow). Brook is completing a repair at a previously sealed location.

Photo 11: An example of a wall to floor slab construction joint is identified with a red arrow.

Photo 12: Operable window drainage performance was variable throughout the building. In this location, only 1 of 4 drains was functioning, as confirmed by pouring water into the window track.

Photo 13: Using a smoke pencil, we noted widespread air leakage at operable windows – note the smoke travelling through the closed operable window at the bottom of the meeting style (red arrow).

Photo 14: Fin type weather stripping at operable windows appeared to be in generally serviceable condition.

Photo 15: Dust plugs (weather stripping at window corners) are in poor condition.

Photo 16: An example of a worn window track; likely a result of worn out rollers.

Photo 17: Air leakage was also noted at the top and bottom corners of sliding doors. Note the smoke travelling through the top corner of a closed sliding door (red arrow).

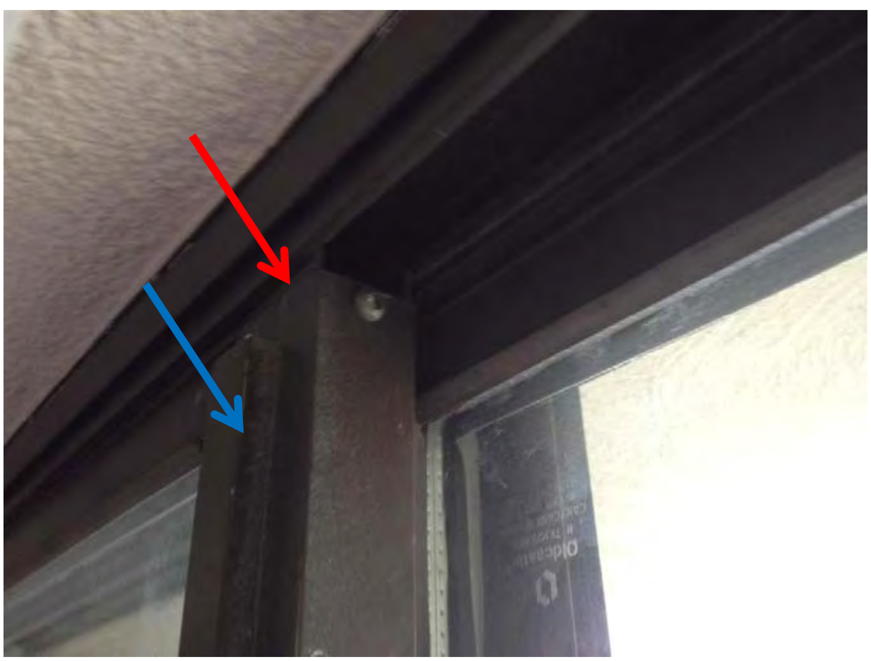


Photo 18: The existing door perimeter and meeting style weather stripping (blue arrow) is in generally poor condition and no dust plugs were present at door corners (red arrow indicates where dust plug should be).

Photo 19: An example of a sliding door track that is severely worn.

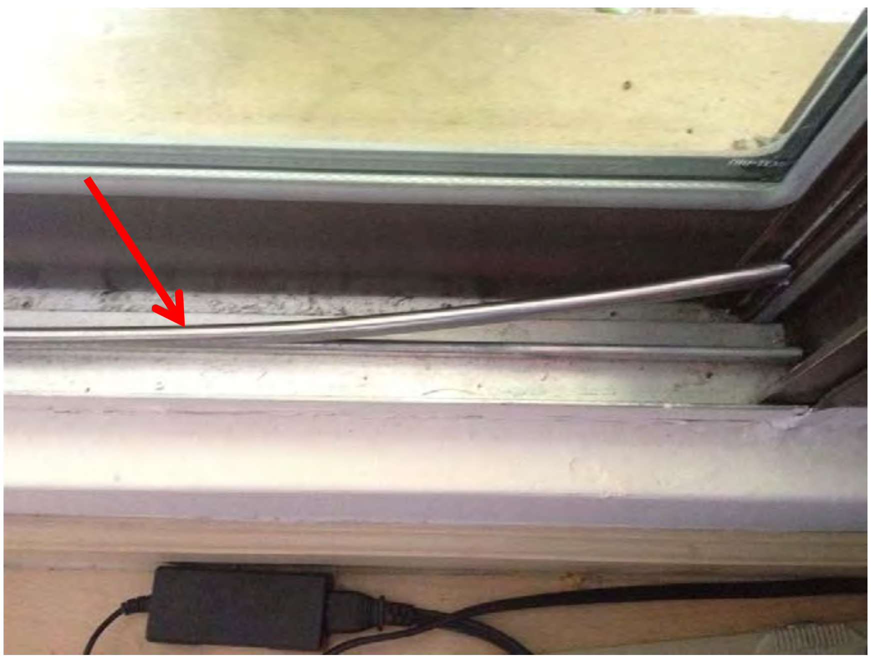


Photo 20: New stainless steel sleeves (red arrow) have been installed at some sliding door locations. In some places, the sleeve has become bent and is no longer functioning as intended, as shown in the photo above.

Photo 21: An example of a localized section of debonded window perimeter sealant.

Photo 22: An example of a debonded sealant joint at a precast panel perimeter.

Photo 23: An example of failed metal-to-metal sealant at a window jamb.

Photo 24: Another example of failed metal-to-metal sealant at a window head.

Photo 25: The profile of the needle glazing at metal cladding panels (indicated with red arrow) is generally thin and narrow.

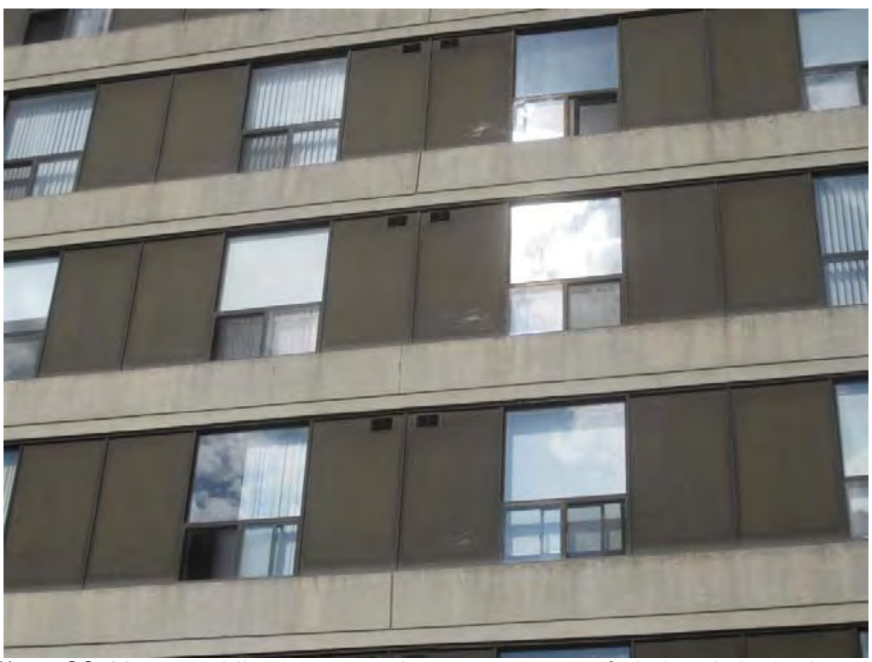


Photo 26: Metal cladding panel coatings are generally faded and chalked.

Appendix E
Glossary

APPENDIX E
GLOSSARY OF TERMS

Term	Definition
Adhesion	That property of a coating or sealant which measures its ability to stick or bond to the surface to which it is applied.
Adhesion Failure	Failure of a compound by pulling away from the surface with which it is in contact. (See "cohesive failure")
Air Infiltration	The amount of air leaking in and out of a building through cracks in walls, windows and doors.
Backer Rod	A polyethylene or polyurethane foam material installed under compression and used to control sealant joint depth, provide a surface for sealant tooling, serve as a bond breaker to prevent three-sided adhesion, and provide an hour-glass contour of the finished bead.
Balcony	A horizontal surface exposed to the outdoors that is not located over interior living space.
Barrier Sealed Window System	A window system that is sealed at the exterior with generally no internal drainage provisions. This system generally relies on one line-of-defense against water and air leakage.
Base Coat (EIFS)	A compound used to embed and to cover the reinforcing fabric in an EIFS lamina. The base coat acts as the primary weatherproofing layer and typically also provides fire protection to the insulation.
Base Coat (Stucco)	The term typically used to describe the first (scratch coat) and second (brown coat) plaster layers.
Bead	A sealant or compound after application in a joint irrespective of the method of application, such as caulking bead, glazing bead, etc. Also a molding or stop used to hold glass or panels in position.
Bite	The dimension by which the inner edge of the stop overlaps the edge of the glass.
Bond Breaker	A material, usually foam or plastic tape, used to prevent three-sided adhesion in a sealant joint.

APPENDIX E
GLOSSARY OF TERMS

Term	Definition
Adhesion	That property of a coating or sealant which measures its ability to stick or bond to the surface to which it is applied.
Building Envelope	The building elements that separate the inside conditioned space from the outside weather (or an unconditioned space within the building). This typically includes the exterior walls, windows, doors, roofs and terraces/decks and foundations.
Butt Joint	Joint between 2 adjacent/abutting surfaces
Chalked	Oxidized
Cladding	The exposed (outer) portion of the exterior wall assembly.
Cohesive Failure	Splitting and opening of a compound resulting from over-extension of the compound caused by excessive movement. (See adhesion failure)
Delamination (2)	As steel corrodes, it expands, pushing on the concrete with sufficient force to cause it to crack and fracture. The fractured concrete is termed a "delamination". When sounded by dragging a chain over the surface or by tapping with a hammer, the concrete sounds hollow.
Double Glazing	In general, any use of two lites of glass, separated by an air space, within an opening, to improve insulation against heat transfer and/or sound transmission. In insulating glass units the air between the glass sheets is thoroughly dried and the space is sealed, eliminating possible condensation and providing superior insulating properties.
Drainage System	A system intended to direct water that penetrates exterior seals back out to the exterior through discrete weep holes.
Drip Edge/Slot	Drips edges and slots are incorporated into construction to provide proper water shedding away from the building. Slots are typically cast into the underside of the concrete slab edge to prevent water from running along the underside of the slab, whereas drop edges are typically formed out of sheet metal.
Duracron	Medium performance protective finish applied to window frames. Not recommended for use as an exterior finish due to chaulking and colour retention problems when exposed to high levels of UV.

APPENDIX E
GLOSSARY OF TERMS

Term	Definition
Adhesion	That property of a coating or sealant which measures its ability to stick or bond to the surface to which it is applied.
Duranar	High performance protective finish applied to metal components. The fluoropolyner based coating provides a chemically inert finish, UV resistant, and reduced fading over service life.
EIFS	The abbreviation for "Exterior Insulation and Finish System", also referred to as synthetic or insulated stucco. EIFS consists of rigid insulation covered with a thin skin (lamina).
Emissivity	The measure of a surface's ability to emit long-wave infrared radiation.
Face Sealed	A building envelope strategy where all water is intended to be entirely shed at the exterior surface (i.e. there is no means of draining out water that penetrates past the exterior face).
Frame	An assembly of members to support glazing or spandrel infill.
Gas-Filled Units	Insulating glass units with a gas other than air in the air space to decrease the unit's thermal conductivity (U-value) or to increase the unit's sound insulating value.
Glazing	(n) A generic term used to describe an infill material such as glass, panels, etc.
Glazing	(v) The process of installing an infill material into a prepared opening in windows, door panels, partitions, etc.
Head	The top of a window or door.
IGU	Two or more panes of glass spaced apart and hermetically sealed.

APPENDIX E
GLOSSARY OF TERMS

Term	Definition
Adhesion	That property of a coating or sealant which measures its ability to stick or bond to the surface to which it is applied.
Insulating Value (U-factor)	Heat transfer occurs as a result of conduction, convection, and radiation through the window frame and glazing. This is indicated in terms of the U-factor of a window assembly, expressed in W/sq m-°C (Btu/hr-sq ft °F). The lower the U-factor, the greater the window's resistance to heat flow. Centre of Glass (C. O. G.) U-factor refers to the heat transfer of the glass neglecting any perimeter boundary conditions. Total effective U-factor refers to the complete window system (i.e. includes losses through frames and glass edges).
Jamb	The sides of a window or door assembly.
Low-Emittance Coatings (Low-E)	Consists of an invisible metallic coating that improves the thermal performance of an IGU by blocking infrared radiant heat transfer through the glass. Some coatings have been designed to also reduce solar heat gain.
Mullion	A vertical framing member in a fenestration assembly.
Needle Glazing	Caulking compound installed at glass-metal joint in fenestration assemblies.
Punched Window	Single rather than continuous (strip) windows.
R-Value	The thermal resistance of a glazing system expressed ft^2/hr/°F/Btu (m^2/W/°C). The R-value is the reciprocal of the U-value. The higher the R-value, the less heat is transmitted throughout the glazing material.
Sash	The operable portion of a window assembly.
Sealant	A caulking compound used to fill and seal a joint in or between building components.
Sheathing	Refers to the material applied on the outside of (wood or steel stud) framed wall and roof assemblies.
Sill	The bottom of a window or door assembly.
Soffit	Underside (typically of a slab).

APPENDIX E
GLOSSARY OF TERMS

Term	Definition
Adhesion	That property of a coating or sealant which measures its ability to stick or bond to the surface to which it is applied.
Spall	A broken off fragment of a building material, such as concrete or masonry, which has been detached from a physical blow, freeze/thaw action, movement binding or internal pressures (such as efflorescence or corroding steel elements).
System	Describes a combination of materials and components that work together to perform a particular function (such as an air barrier system, moisture barrier system).
Weatherstripping	A material used around operable windows used to control air leakage and water leakage.
Window	The component of an exterior wall that is installed in a vertical orientation and provides vision, day lighting, and/or ventilation.
Window Wall	A lightweight form of curtain wall consisting of pre-manufactured metal framing (combination and composite window framing), transparent vision panels, and opaque glass or metal spandrel panels. **Note:** Window walls span from the underside of a floor slab to the top of the next lower floor slab and are available in two basic forms: (a) separate slab edge cover (SSEC) window wall; and (b) integral slab edge cover (ISEC) window wall. For the SSEC system, the window-wall framing bears entirely on the slab with a separate metal cover for the exposed edge of the slab. The ISEC system only partially bears on the slab with the exterior sections of the window wall extending over the slab edge to the head of the adjacent window wall below.

Appendix F
Performance & Deterioration

APPENDIX F
CLADDING
PERFORMANCE & DETERIORATION

This appendix presents the mechanisms by which cladding performance degrades, and how components become vulnerable to deterioration.

1. GENERAL BUILDING ENCLOSURE PERFORMANCE & DETERIORATION

1.1 Finishes

Finishes are the outermost layers of the enclosure assemblies (both interior and exterior). They should be designed to be suitable for the intended exposure and use. While their function is usually aesthetic, finishes can also serve as protective layers for underlying building components. Finishes typically degrade with age and exposure but premature failures can be an indication of other issues within the building enclosure.

2. SEALANTS

Sealants are one of the most common and integral parts of almost every building enclosure. Sealants usually function as structural support (structural glazing), air flow control seals, as seals to resist leakage and to provide an aesthetic finish.

2.1 Urethane Sealant Deterioration

Urethane sealants ("organic") typically provide moderate to good adhesion and performance at a moderate cost. The surface of this material progressively deteriorates by cracking and crazing with exposure to ultraviolet sunlight (UV). Black and white colours resist this problem better because of the colour additives. With age and/or lower temperatures, flexibility tends to decrease and splitting or separation occurs. If exposed to sustained wetting and heat, some urethane sealants may soften and fail.

2.1.1 UV Degradation

Polyurethane sealants are not recommended for glass application because of ultra violet (UV) bounce back through glass. The UV rays will attack the sealant at the bond line resulting in premature failure of the sealant.

2.2 Silicone Sealant Deterioration

Silicone sealants ("inorganic") typically provide good adhesion and upgraded service life at a relatively higher cost. Silicone sealants are less susceptible to deterioration from UV and their flexibility is better in cold weather. As a result, they can provide a longer service life than other sealants. However, silicones tend to require more care in cleaning and preparing the substrate to achieve proper adhesion. Most silicones also bleed oil residues that can stain adjacent surfaces, but some more modern products are available that control staining.

3. GLAZING SYSTEM PERFORMANCE

3.1 Rain Water Leakage Resistance

The ability for rain water to penetrate window and door systems varies according to both the volume of rainfall and the severity of the inwards driving wind pressure. This tends to make managing leakage problems on an as-needed basis an ineffective strategy. Leakage can be unnoticed for months or years and then suddenly appear when a storm event impacts a specific building elevation.

3.1.1 Windows

Codes and standards require that these systems be designed to resist limited storm events. The intensity of storm that they must resist varies according to weather data for the geographic region and the building height. The general intent has been for the design to accommodate storms that occur 90% of the time. That is to say, there is a 10% chance for more severe storms to occur and overwhelm the design capacity.

However, the design standards have become more demanding since 1990. There is also no requirement for the manufactured windows to be able to perform as per the design. Sample windows that are manufactured and tested to demonstrate design adequacy do not always represent the product supplied to construction sites months or years later. Deviations from the tested design standard can lead to leakage occurring more easily than intended.

Added to this are the effects of degrading weather stripping, seals and drainage systems that can become obstructed with dirt or debris. Depending on how robust the original design was to these changes, aged window and door systems can be found to allow leakage during storms that occur on a frequent basis.

In addition, there are widespread problems with how joints between window and door sections are sealed. The industry often relies on tight fitting joints with sealant squeezed between parts to resist water ingress. This can initially act to resist leakage, allowing the manufacturer and installer to pass initial performance testing (if specified) and/or warranty periods. However, the sealant application within the tight fitting joint does not comply with sealant specifications or accepted industry practice. Movements cause the seals to fail. The volume of water that penetrates these joints varies according to wind pressures, and does not become evident at the interior if absorbed by insulation and other wall materials.

As a result, problems with leakage through window and door systems are common. These are frequently the source of water leaking into wall systems. The extent to which these cause concealed damage that might lead to the need for cladding restoration or replacement needs to be carefully considered and managed.

3.2 Air Leakage

Air leakage that occurs adds to energy consumption and can interfere with the ability for the mechanical system to maintain acceptable interior comfort and air quality.

Where the original construction did not incorporate an adequate air barrier, missing caulking at the frame perimeter and around associated sills and trim can also allow excessive air leakage. Exfiltration around these elements can also lead to concealed condensation and associated deterioration.

3.3 Operable Window Weather Stripping Deterioration

Weather stripping seals for operable windows and doors are critical elements that act to resist both air and rain water leakage. Deterioration with age and wear and tear reduces the ability to maintain an adequate seal.

With age, various plastics and rubbers can shrink, become less flexible and/or permanently deform. Shrinkage can lead to gaps forming at joints. Reduced or inadequate compression can allow increased air and/or water leakage. The material types and formulations influence the rate at which this occurs.

3.4 Interior Condensation

Window and door systems have limited ability to resist developing cool interior surfaces during cold weather. Interior air deposits condensation (water) when it comes into contact with a surface that is at a temperature below the “dew point”. As temperatures drop, there is a corresponding reduction in the interior humidity limit that can be sustained without allowing condensation to form.

To control condensation, interior humidity can be controlled by actions that include reducing humidifying devices and increased operation of exhaust fans. Avoiding elements that obstruct warm air flow, or adjusting mechanical ventilation to direct air onto the problem areas can also provide some relief.

Photo 1.: Example of severe condensation from thermal bridging, excessive humidity and poor heat distribution.

3.5 Insulating Glass Unit (IGU) Seal Failure

Insulating glass units are formed by sealing 2 or more lights of glass together with desiccant exposed to the interior air cavity to maintain low enough humidities that avoid condensation or fogging during cold weather.

These have a limited service life. Even with properly applied and intact seals, water vapour slowly penetrates the unit and is absorbed by the desiccant. Once the desiccant is consumed, the cavity humidity rises. Condensation or fogging begins to form in cool weather. The inner glass surfaces eventually become “scummed”, and water can become visible at all times.

Replacement of failed or fogged IGU becomes desired for aesthetic reasons. In general, thermal isolation and other performance attributes are not materially altered.

IGU failure is accelerated if bulk water is allowed to collect against the seals. This can collect as a result of excessive rain water leakage, poor system drainage, and/or from problems with condensation being allowed to drain into the glazing pocket.

The perimeter seals can also fail prematurely if not originally applied correctly, or if installation does not incorporate proper support.

3.6 Coating/ Paint Deterioration

Acrylic factory applied paint finish (such as “Duracron” by PPG) is commonly applied to aluminum and steel used to fabricate window and door systems. This is vulnerable to deterioration with UV exposure. The surface “chalks”, leaving a light-coloured residue that can be easily scuffed or marred. The chalk can be removed by cleaning, but this action then exposes more paint to deterioration. This action can lead to the paint being completely eliminated in areas of high exposure in 20 years.

Photo 2.: High performance fluropolymer coatings (“Duranar” by PPG) better resist deterioration with UV exposure. These are expected to provide acceptable performance for more than 30 years.

Appendix G
Evaluation Techniques

APPENDIX G
CLADDING
EVALUATION TECHNIQUES

This appendix presents the techniques used to evaluate cladding.

1. GENERAL BUILDING ENCLOSURE EVALUATION TECHNIQUES

1.1 Visual Review from Grade or Roofs

A visual review from grade and roof levels is an evaluation technique used to capture general observations about the cladding condition. The purpose of this review is to check for conditions that may compromise performance or durability or to identify areas that may require further "up close" review. Binoculars can be used as part of this review. Non-destructive devices may also be employed to check select conditions. Devices utilized include probes, flashlights, mirrors, and a variety of thickness/distance measuring devices. Sample joint seals or coatings may also be non-destructively probed to check bond and flexibility.

1.2 Visual Review from Suspended Access

A visual review from suspended access equipment is used to perform an "up close" sampling of varying conditions over the building height and on sample elevations. The review can be performed via a suspended stage or Bosun's chair if suitable tie-back points are available. A Contractor needs to be retained to set up and operate the suspended stage. Bosun's chair review can be completed by trained and certified professionals. The maximum allowable suspension height for Bosun's chair is 92 m, as per CSA-Z91.

Photo 1.: Suspended Access Equipment – Swing Stage (left) and Bosun's Chair (right)

1.3 Water Leakage Testing

Water leakage testing is used to help isolate specific building enclosure discontinuities that may be allowing rain water ingress. Depending on the suspected leakage path(s), the testing may involve depressurizing the building to simulate the effects of wind-driven rain. A blower door fan can be used to depressurize a suite or a small house. Where possible, depressurizing an entire building is typically done by adjusting the mechanical ventilation/exhaust systems to simulate some inward wind pressure.

Photo 2.: Example of Water Testing on a Curtain Wall Assembly

1.4 Wall Cladding Thermographic Scans

A thermographic camera views variations in surface temperature. Rather than the visible light spectrum, the camera senses infra-red radiation. This non-destructive test identifies areas that are warmer (brighter) or colder (darker) in comparison with adjacent areas. The variations can arise from problems that may include: missing or poor insulation, thermal bridges, air leakage, or entrapped moisture.

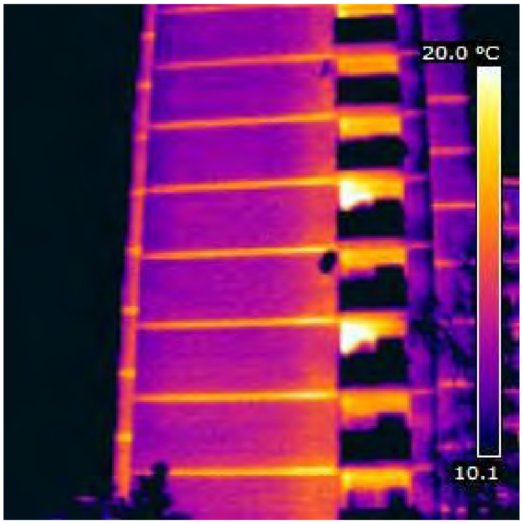


Photo 3.: Example Thermal Image - Insulated Masonry Wall with Un-Insulated/Exposed Concrete Floor Slab Edges.

A thermographic wall cladding scan is typically undertaken in winter months when there is a temperature differential between the interior and exterior of at least 20°C. This promotes more pronounced variation in the thermal images, facilitating interpretation. When feasible, pressurizing the building interior may also promote air leakage that may be detected by the scan.

Thermographic scans are completed at night to avoid thermal images being improperly influenced by variations in solar gain. Low wind speed is also desired to reduce risk for cooling that might act to conceal problems.

Interpreting thermographic scan images requires experience and judgment. The extent to which the as-built construction is understood also influences the analysis. While some thermal images can be readily diagnosed as a problem condition, some problems only result in faint thermal variations. Some stark thermal variations can simply be a normal result of building characteristics. These can include differences between window and wall thermal insulation/isolation, variations from interior heat distribution, or differences in reflective properties of surface finishes. The distance and angle of camera view can also influence the thermal image.

The thermographic scan analysis can lead to thermal bridges, thermal anomalies, and air leakage being identified.

1.4.1 *Thermal Bridges*: Enclosure designs can include elements that bridge through the insulation layers and readily conduct heat. Examples can be portions of the structure exposed to the exterior, or elements that are connected to the interior structure. These thermal images are typically a natural result of the design. If significant enough or believed to be contributing to problems, retrofit measures can be considered to improve performance.

1.4.2 *Thermal Anomalies*: Thermal anomalies are locations where variations cannot be readily explained as thermal performance that is expected from the enclosure elements and details. These are often locations where the intensity and pattern of heat loss is greater in comparison to other similar areas. Only variations that appear significant enough to warrant concern are identified. Follow-up investigation is typically required to confirm the cause and significance of the anomaly, and to determine the scope of remedial work that may be appropriate.

1.4.3 *Air Leakage*: Some thermal anomalies result from air leakage. These are typically where the breach in air seal is large enough and sufficient pressure is achieved to cause significant air flow. The thermal image from air leakage can appear to "flare" from the source. However, thermography is generally not an adequate test for evaluating air sealing. Widespread problems with air leakage or air leakage that follows diffuse paths through an enclosure may not be detected if it does not cause noticeable variations in exterior surface temperatures.

1.5 Cladding and Energy Performance Analysis

Cladding and energy performance analyses are completed to evaluate the cladding from an energy performance perspective. There are a variety of methods used to complete the analyses, including performance modeling, simplified energy analysis, energy modeling, and utility benchmarking.

1.5.1 *Performance Modeling:* The performance of typical wall assemblies can be analyzed for thermal, air and moisture resistance using numerical modelling techniques. Proposed upgrade/retrofit options may also be analyzed to check performance improvements and potential long-term impacts on existing wall components that will remain.

1.5.2 *Simplified Energy Analysis:* A simplified energy consumption analysis provides a comparison of the energy consumption for the current conditions, and allows estimating savings that may be achieved once retrofit measures are completed. RETSCREEN or CBIP Screening Tool (computer software) are usually employed for this analysis.

The accuracy of this analysis is subject to a range of assumptions including occupant heating/cooling loads, building usage patterns (frequency and duration of open doors and windows), thermostat settings, and fluctuations in energy costs. While this analysis can be reasonable to estimate potential savings for options comparison, more involved energy modeling would be required if there is need for improved confidence in the savings estimates.

1.5.3 *Energy Modeling:* An energy model of the existing building can be created using whole-building energy simulation tools such as eQuest, which are calibrated to represent actual, metered utility consumption. With a base building energy model we are able to provide better estimates of the energy saving opportunities of individual and combined energy conservation measures (ECMs). Whole building energy modeling goes beyond more simple, standalone estimates of ECM savings by being able to better capture the complex interactions of building systems. For example, although it is fairly straightforward to determine energy savings from a lighting retrofit, without a whole-building model, it is difficult to accurately estimate the corresponding increase in heating that would result from the reduced internal heat load.

Using the existing energy model, we can model the approximate impact of various ECMs, and develop an optimal aggregate strategy to reduce energy consumption. For each measure an outline of the estimated energy savings is generated.

1.5.4 *Utility Benchmarking:* Utility benchmarking improves the ability to predict energy savings opportunities that may be available. This would involve analyzing 12 months of sequential utility bills (heating fuel and electricity) data that is made available. The analysis is then compared to our database of similar buildings and industry knowledge pertaining to the energy utilization index (EUI) (total annual kWh/ft² gross floor area).

1.6 Air Leakage Evaluation

Air leakage evaluation aims to identify opportunities for air sealing to improve comfort and energy performance, and to reduce risk for moisture deposition within the building enclosure assembly causing deterioration.

1.6.1 *Basic Qualitative Air Leakage Assessment:* This is typically completed through sample joints in the exterior walls, windows and doors using smoke pencils. The aim is to identify locations allowing air leakage, and qualitatively judge the extent to which they may be a concern.

2. SEALANTS

2.1 Non-destructive Bond Testing – “Push-in” Adhesion Test

The *Push-In* test is commonly used to establish whether there have been joint seal failures that are not always easily identified from a visual inspection. The test determines the adhesion of the sealant to the substrate without cutting the sealant. The tester pushes an instrument into the centre of the sealant. If the sealant does not tear away from the substrate, the bond is acceptable.

The *Push-In* test is only able to indicate an adhesive failure at the bond line and will not give the mechanism of failure.

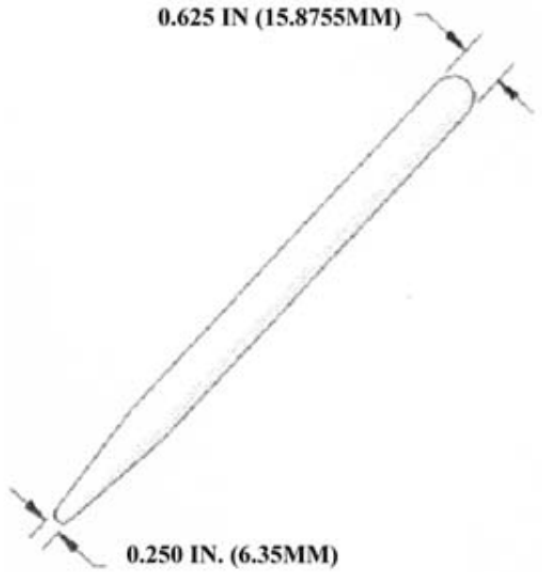


Photo 1.: Probing Tool (Figure from ASTM C1521).

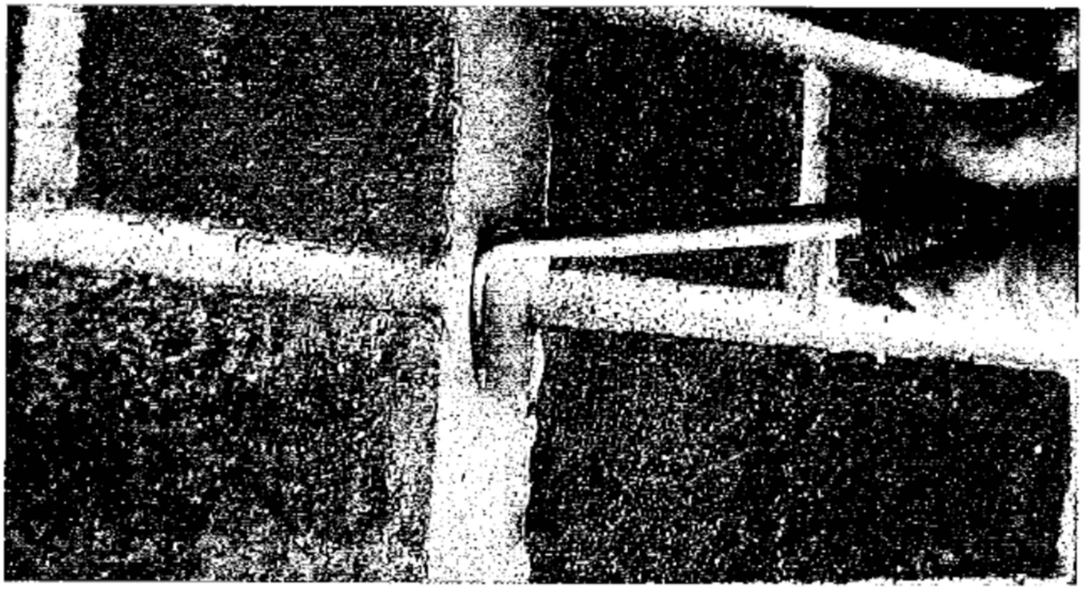


Photo 2.: Example of the Push in test (From Tremco Sealant Restoration Guide).

Appendix H
Repair and Renewal Techniques

APPENDIX H
CLADDING
REPAIR & RENEWAL TECHNIQUES

This appendix presents the techniques available to repair or renew deteriorated cladding for the deterioration mechanism outlined in Appendix F.

1. GENERAL BUILDING ENCLOSURE REPAIR AND RENEWAL TECHNIQUES

1.1 Local (or Targeted) Repairs

Local (or targeted) cladding repairs generally refer to lower cost solutions that address structural deterioration, discontinuities in the air, water or vapour control layers, or other performance issues at specific locations. The purpose of these repairs is to maintain acceptable performance and extend the useful service life of the existing component(s).

1.2 Over-Cladding

Over-cladding involves the installation of a new wall cladding assembly outboard of the existing cladding. Over-cladding is generally considered when the repair and/or energy costs required to maintain the existing building enclosure become excessive.

The existing cladding must be restored or be in sound condition prior to over-cladding. Over-cladding can offer thermal, air flow and/or rainwater control upgrades as well as improved cladding durability. The aesthetic appearance of the cladding is also renewed. This renewal technique is typically more cost effective than general cladding replacement.

1.3 Cladding Replacement/Re-cladding

Cladding replacement (or re-cladding) involves removing the existing cladding and installing a new assembly. Renewal of some or all of the building enclosure control layers is typically included in these projects. Re-cladding is generally considered when costs to manage life-safety risks associated with the existing components become excessive or when the existing cladding system no longer provides the desired performance.

2. SEALANTS

2.1 Replace Currently Deteriorated Sealants

Localized defects that present a breach through the seal need to be repaired on an ongoing basis as part of maintenance. When specialty access is necessary and/or when there are widespread problems, a general program of repair becomes necessary.

However, repeated localized repair generally does not achieve full renewal. This leads to varying vintages and types of materials. Joints between these can increase difficulty maintaining an acceptable seal. The rate of failure can also lead to ongoing local repairs being a more costly management strategy than applying a general program of renewal. Full renewal is recommended prior to conditions degrading to this unacceptable state.

In general, sealant removal and replacement is most effective. This allows removing deteriorating materials and applying new materials to sound substrates. The new sealant selection must consider performance requirements and compatibility with existing surfaces.

In some instances, cap sealing or over-beading is an acceptable solution. With proper joint design and surface preparation, this solution can achieve similar performance to a replacement program. However, the joint seals are required to be larger; these cannot always be accommodated and/or the aesthetic appearance may not be desirable.

2.2 Full Sealant Replacement

Widespread defects or localized non-uniform defects where the existing seals have degraded to an unacceptable state causing breaches through the seal indicate that a general program of repair may be necessary.

Unlike targeted replacement, seals installed as part of a full renewal program are of the same vintage and type of material for a particular joint. The rate of failure of these seals tends to be more uniform thereby making ongoing maintenance more easily predicted.

While full sealant renewal typically incurs higher initial costs than a targeted replacement program, cost savings for items such as access can be realized due to economies of scale when compared to ongoing targeted repair programs that require multiple mobilizations

Full sealant removal and replacement allows removing deteriorated materials and applying new materials to sound substrates. The new sealant selection must consider performance requirements and compatibility with existing substrates.

3. GLAZING SYSTEMS

3.1 Glazing Treatments

3.1.1 Low Emissivity Coatings

Low emissivity (“low-e”) glass coatings are now standard practice in modern window and door systems. These are films that act to resist ling wave radiation, a mechanism by which heat flows through the glass. By providing improved thermal isolation, these improve energy consumption. Condensation resistance can be improved.

The low-e film is generally not noticeable, but can be detected depending on the viewing angle and light condition. These act to screen ultraviolet light, reducing fading of furnishings, finishes and window coverings. However, interior plant growth can be adversely affected.

3.1.2 Warm Edge IGU Spacers

This feature employs a spacer between the IGU lights that is not as conductive as traditional metal spacers. While available products are relatively recently developed, we recommend incorporating this feature in the IGU fabrication. These will improve energy performance and reduce risk for condensation forming on glass perimeters.

3.1.3 Dual Sealed IGU

We generally recommend dual seals be incorporated in manufacturing the IGUs. As the perimeter seal is most critical in preventing vapour ingress that causes failure, this promotes durability and reduces risk for premature failures.

3.1.4 Inert Gas Fill

Inert gas (typically Argon) can be applied within IGUs. The heavier gas molecules are better insulators than standard air, improving thermal isolation.

IGUs need to be almost entirely purged of air and filled with gas to achieve the targeted improvement. However, it is difficult to ascertain that this is achieved as part of quality control. There is also risk for the gas escaping over time, eliminating the benefit.

Some manufacturers automatically include gas fill as part of their process, so there can be little or no additional cost for this feature. Some manufacturers are not readily equipped to offer this feature, so requiring it reduces their ability to offer competitive pricing. We recommend that this be included and priced as an optional item.

Laminated glass is available, incorporating clear polymer films. These strengthen and retain glass together even when broken.

This can be desirable as a safety feature for overhead glass, for improving resistance to forced entry, and/or in conjunction with other design features intended to provide blast resistance.

Laminated glass also provides better acoustic isolation.

3.1.5 Local or General Replacement of Glass or IGUs

Failed/fogged IGUs tend to be replaced on an ongoing basis in response to concerns regarding aesthetics. The periodic and ongoing nature of this cost can lead to a failure to recognize that this represents a significant investment that should be carefully managed.

With interior retainers, installation occurs from the interior. Systems that require replacement from the exterior can incur greater cost related to access.

Improved surety and quality can be achieved by considering and specifying requirements and desired options to be integrated. These can be more effectively procured and inspected with larger programs of IGU replacement. Specific features that should be considered include:

- *Glass thicknesses*: Assuring adequate thicknesses are provided to resist wind loads

- *Glass Types*: Assuring tempered or laminate safety glass is provided where required by Building Code.
- *Glass Coatings*: Requiring low-e or other treatments to improve performance energy conservation.
- *Spacer Type*: Improving to include a modern warm edge spacer rather than a standard metallic spacer to reduce condensation problems that can be a contributing problem to repeated failure.
- *Seal Type*: Requiring a more reliable double seal and production from a certified manufacturer to promote durability.
- *Glazing Seals*: Requiring appropriate weather seals and considering adding interior vapour/condensation seals to promote durability.

3.2 Windows and Doors

3.2.1 Exterior Metal Joint Cap Seal Retrofit

Metal-to-metal joints that require sealing can be sealed with a cap or “band-aid” profile. Halsall designs this retrofit seal with proper joint size and profile so as to maintain a reliable seal and accommodate movement that can occur.

Silicone is preferable despite oil residues that follow. If these silicone seals join with non-silicone perimeter seals, special measures become necessary to promote compatibility/continuity.

The addition of hand-tooled sealant over the metal joints can be seen to adversely impact appearance, particularly at locations that may be viewed from close proximity. This is influenced by the contractor skill. Necessary cleaning of the metal surfaces can also accentuate this addition. To avoid this latter problem, general cleaning or re-finishing can be desired to leave a more uniform appearance.

Accepting reasonable maintenance, our experience has been that this retrofit can reliably seal these joints in excess of 20 years.

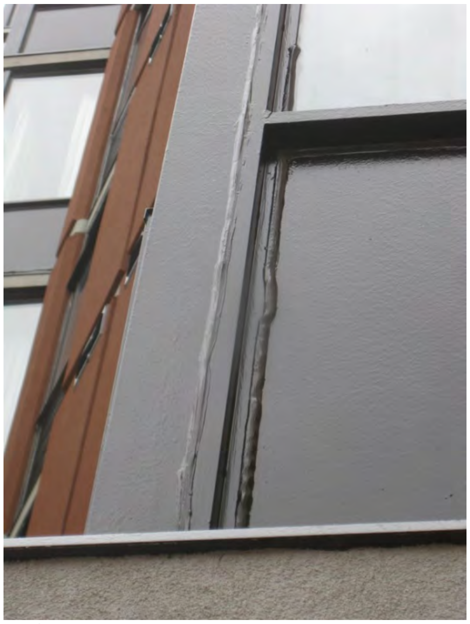


Photo 1: Example of workmanship variations in cap-sealed metal joints.

3.2.2 Exterior Glazing Cap Seals

Joints at glass perimeters can be retrofit sealed with a silicone cap seal. Common industry practice applies a small fillet seal, but this tends to quickly fail as it does not comply with proper joint design. Halsall typically specifies a larger seal, but this has the drawback of being visible within the glass sight line.

Halsall is typically judicious in applying this measure. Even where exposed glazing tape edges appear poor, the remainder of the seal can continue to be adequate. In addition to avoiding unnecessary cost, these seals are automatically renewed when IGUs are replaced. A properly applied retrofit seal can make glass replacement more difficult.

Photo 2: Example of cap seal at glass/metal joint limited to bottom of IGU.

3.2.3 Exterior Re-Finishing (Re-Painting)

The proliferation of acrylic coatings is leading to increased demand for field refinishing of window and door systems. There are a variety of retrofit finishes and application techniques that can be employed.

In general, we do not recommend employing standard acrylic or alkyd paint finishes. The paint material cost is typically small in comparison to the application cost, so a more durable finish is preferable. Urethane type coatings are available that are expected to provide a 15 to 20 year service life. Other finishes could also be selected to try and achieve a longer service life.

Spray application could be considered but can be prohibitively costly in instances requiring significant access and protection. Application by brush or roller can be more practical, but does not achieve as uniform a finish.

Compatibility must be achieved with the existing substrate. This can be a particular problem with oil residue from silicone sealants. These sealants typically need to be removed and re-applied in conjunction with re-finishing.

3.2.4 Operable Window Retrofitting

Operable window air and water leakage resistance can be restored by conducting trial repairs and field testing to tailor a scope of work to try and achieve acceptable performance. The types of measures included in typical retrofits can include:

- Replacing weather stripping with similar or improved seals
- Sealing penetrations or joints found to allow leakage
- Augmenting rainwater drainage openings
- Improving ventilation of the drained cavity(s)
- Repairing and lubricating hardware

With tighter weather stripping, operation can become more difficult.
The extent to which performance is reliably achieved will vary according to the challenges associated with the identified scope of work, and contractor workmanship implementing the solution.

Photo 3: Example of challenging retrofit seal at operable sill corner

3.2.5 Interior Air/Vapour Seals

Air leakage around or through frames can contribute to drafts, energy loss, and contribute to problems with concealed condensation. Retrofit sealing perimeter and other joints that are visibly open and allowing air leakage can provide a practical means to reduce these problems.

3.2.6 Retrofit Frame Insulation

Where existing frames are poorly insulated, there can be opportunities to improve performance. Open cavities or gaps that are found to be conducting cold inwards can often be filled with urethane foam. This can often be injected through holes drilled through frames that are concealed within retainers or with plugs. Where feasible, this work needs to be carefully conceived and implemented to achieve improvement without causing damage or accidental adverse impact.

Appendix J
Limitations

LIMITATIONS

- The scope of our work and related responsibilities related to our work are defined in our project authorization ("Conditions of Assignment").

- Any user accepts that decisions made or actions taken based upon interpretation of our work are the responsibility of only the parties directly involved in the decisions or actions.

- No party other than the Client shall rely on the Consultant's work without the express written consent of the Consultant, and then only to the extent of the specific terms in that consent. Any use which a third party makes of this work, or any reliance on or decisions made based on it, are the responsibility of such third parties. Any third party user of this report specifically denies any right to any claims, whether in contract, tort and/or any other cause of action in law, against the Consultant (including Sub-Consultants, their officers, agents and employees).The work reflects the Consultant's best judgement in light of the information reviewed by them at the time of preparation. It is not a certification of compliance with past or present regulations. Unless otherwise agreed in writing by Halsall, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity; it is written to be read in its entirety.

- Only the specific information identified has been reviewed. No physical or destructive testing and no design calculations have been performed unless specifically recorded. Conditions existing but not recorded were not apparent given the level of study undertaken. Only conditions actually seen during examination of representative samples can be said to have been appraised and comments on the balance of the conditions are assumptions based upon extrapolation. Therefore, this work does not eliminate uncertainty regarding the potential for existing or future costs, hazards or losses in connection with a property. We can perform further investigation on items of concern if so required.

- The Consultant is not responsible for, or obligated to identify, mistakes or insufficiencies in the information obtained from the various sources, or to verify the accuracy of the information.

- No statements by Halsall are given as or shall be interpreted as opinions for legal, environmental or health findings. Halsall is not investigating or providing advice about pollutants, contaminants or hazardous materials.

- The Client and other users of this report expressly deny any right to any claim against Halsall, including claims arising from personal injury related to pollutants, contaminants or hazardous materials, including but not limited to asbestos, mould, mildew or other fungus.

- Budget figures are our opinion of a probable current dollar value of the work and are provided for approximate budget purposes only. Accurate figures can only be obtained by establishing a scope of work and receiving quotes from suitable contractors.