REPORT FOR:

Carlton Street Skywalks
Structural and Cladding Investigation

City of Winnipeg Project No. 2013-139

Submitted to:	City of Winnipeg Planning Property and Development Department
Attention:	Mr. Brent Novak, P.Eng.
Date:	April 5, 2016
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CKP File No.	2015-1231

Crosier Kilgour & Partners Ltd.™

CONSULTING STRUCTURAL ENGINEERS

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1. Introduction

At the request of the City of Winnipeg Planning Property & Development Department, a structural investigation of the south bridge bearings and cladding on the north and south skywalks was completed by Crosier Kilgour & Partners personnel. The purpose of the investigation was to provide an opinion as to the current condition of the structure and cladding, identify areas of duress, and provide recommendations aimed at extending the service life of the structure and cladding.

The following report details the problem background and provides a summary of our observations and findings, as well as provides opinions regarding the condition of the structure. Recommended repairs and estimates of budget construction costs are also provided based on our review of the existing material, the site conditions, and our experience with the investigation and restoration of structures.

2. Structure and Cladding Description

The following sections provide a description of the existing structures and cladding. The information provided is based on a review of the existing architectural and structural drawings, and visual observations made during the site reviews. The following drawings were reviewed as part of this investigation:

<u>North Skywalk</u>

- Architectural drawings A-1 through A-3 by Number Ten Architectural Group and The LM Architectural Group, undated.
- Structural drawings S-1 through S-3 by Crosier, Greenberg & Partners dated July 3, 1974.
- Steel shop drawings 1 through 9 by Empire Iron Works dated June, 1974.

<u>South Skywalk</u>

- Architectural drawings A-1 through A-3 by Number Ten Architectural Group and The LM Architectural Group dated July 23, 1974.
- Structural drawings S-1 and S-2 by Crosier, Greenberg & Partners dated July 23, 1974.
- Steel shop drawings 1 through 6 by Empire Iron Works dated June, 1974.
- Precast shop drawings 520-1 through 520-4 by Con Force Structures dated September, 1974.

2.1 Structural Description – North Skywalk

The skywalk connecting the RBC Winnipeg Convention Centre (WCC) with the Delta Hotel has two spans (Photographs #1 and #2). The steel framing for the west span consists of a Pratt-style truss constructed of hollow structural steel (HSS) members. The steel truss spans in the east-west direction between a 10” x 60/78” cast-in-place concrete beam at the WCC side, to cast-in-place post-tensioned cantilevered concrete beam at the opposite end.

The east span consists of single Pratt-style truss on the north elevation of the skywalk that is connected to the concrete wall on the south side of the skywalk via steel W-Section and HSS members.

The typical roof structure consists of 14 gauge steel roof deck spanning in the east-west direction (longitudinal) to steel cross members. The typical floor slab consists of a 2½" concrete slab on 3" metal deck. The slab spans in the east-west direction (longitudinal) and is supported on steel cross-members.

2.2 Structural Description – South Skywalk

The skywalk connecting the RBC Winnipeg Convention Centre (WCC) with 155 Carlton Street is a single span bridge (Photographs #3 and #4). The west end of the north skywalk at the WCC is supported on a 10" x 60/78" cast-in-place concrete beam. The east connection to 155 Carlton consists of a steel bracket bolted to the concrete frame of the building. The original structural drawings indicate that the west support was designed to accommodate thermal movement by way of a "Spencer" 100 kip short span bearing.

The typical floor slab consists of a 2½" concrete slab on 3" metal deck. The slab spans in the east-west direction (longitudinal) and is supported on HSS 8 x 8 cross-members.

2.3 Cladding and Windows

The existing cladding consists of 4" thick conventionally reinforced precast concrete panels. The panels are connected to the steel frame using a rigid connection at top and an adjustable connection at the bottom. Based on the configuration of the connections, the majority of the vertical cladding load is transferred to the structure in bearing through the bottom connection. The top connection provides lateral stability and transfers horizontal wind loads to the frame. A typical cross-section through the precast panels is shown in Figure 1 below.

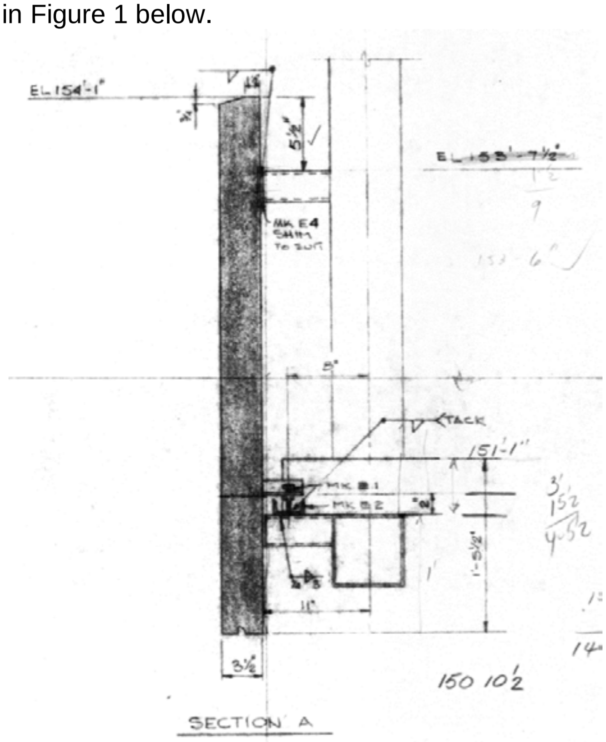

Figure 1: Typical Cladding Cross-Section

The continuous strip windows are double-glazed aluminum frame units. The windows are original to the structures and therefore are unlikely to have state-of-the-practice performance enhancements such as low emissivity coatings, superior thermal resistant spacers, and/or gas filled cavities.

3. Summary of Previous Investigation and Repairs

A limited investigation of the north skywalk connecting the RBC Winnipeg Convention Centre (WCC) with the Delta Hotel was prompted by concerns of displacement and crushing of the existing metal door frame, and cracking and displacement of the tile flooring at the joint between the WCC and the skywalk.

The initial visual inspection revealed localized crushing of the metal door frame separating the WCC from the north skywalk. The crushing was most apparent on east elevation in the upper north corner. Cracking and displacement of the wall finishes were also noted from the skywalk where the truss members are framing through the wall finishes.

The bearings at the west end were exposed from underside and revealed fractured concrete, spalling, and exposed reinforcing steel that undermined the truss column bearing plates. Localized crushing of the concrete beam was also observed suggesting that the bearings were overstressed.

The findings of our investigation and analysis concluded that the sliding bearing connection at the east end of the west truss span had seized. As a result, thermal contraction of the bridge created a significant horizontal force on the west bearings. The horizontal forces were transferred through the truss columns and into the anchor bolts securing the column base plates to the concrete beam. Eventually the forces created by the thermal contraction of the bridge caused the concrete beam face to crack, spall, and undermine the base plates. The increase stress on the concrete below the installation shims combined with the reduced cross-section of the beam resulted in localized crushing of the concrete and downward movement of the truss. The lack of adequate grout below the base plates likely contributed to the degree of crushing observed on the northwest bearing.

Repairs to the west bearings commenced in late August, 2015. The repairs consisted of widening and reinforcing the existing concrete beam below the bridge bearings and modifying the existing steel bearing plates to accommodate movement due to thermal expansion and contraction. The repairs were completed in fall 2015.

A visual review of the bearing connections at the east end of the west bridge span did not reveal any evidence of distress.

4. Summary of Findings

To assess the existing structure and cladding a visual review was completed of the exterior using a mobile aerial lift. Non-destructive testing techniques such as sounding surveys of the concrete cladding panels were supplemented with destructive inspection recesses to access the south bridge bearing at the east end of the south skywalk. A thermographic scan of the building envelope of both skywalks was completed using a high resolution thermographic camera with a telephoto lens to identify areas of heat loss which can be sources of deterioration. The following sections summarizes our significant findings. Refer to Drawings S1.1 through S1.3 in Appendix A for locations and extents of deterioration. Photographs are provided in Appendix B.

4.1 South Skywalk Connections

An inspection recess was created through the existing cementitious stucco soffits to allow visual assessment of the bridge connections at 155 Carlton. Photograph #5 shows the connection of the steel bridge beam to the concrete beam of 155 Carlton. The connection appears to be in good condition with no evidence of deterioration or structural duress.

Photograph #6 shows the steel angle supporting the edge of the steel floor deck. The steel angle is in good condition with no evidence of deterioration or structural duress.

Access to the west connection to the WCC were not able to be accessed due to the configuration of the architectural finishes.

4.2 Cladding Assessment

The existing concrete cladding panels are in poor condition and exhibit varying degrees of cracking, delamination, and spalling.

- Concrete delamination and spalling was typically observed along the cladding joints near the top of the panels. The delamination is a result of corrosion of the existing reinforcing steel (Photographs #9, 10, 14, 16, 17, 22, 24) and/or cladding anchorages (Photographs #7-11, 14, 16, 17, 20-22).
- Loose concrete was observed at several locations that was able to be easily removed with a hand hammer. Photograph #15 shows the progression of one location where loose concrete was removed.
- Cracking was observed at several locations (Photographs #11-15, 18, 19, 23). In most instances the cracking was related to corrosion of the anchorages and/or reinforcing steel.
- Freeze-thaw deterioration of the joint edges was observed (Photographs #6, 19). The conditions are consistent with water becoming trapped behind the existing joint sealant.
- The existing panel joint sealants are in poor conditions and exhibit varying degrees of ultra violet (UV) degradation including, cracking (Photographs #7, 24), and reversion (Photographs #7, 15, 19, 24). In some instances the joint sealants have either pulled away from the joint edge (Photograph #8), or are missing entirely leaving the joint open and prone to moisture infiltration (Photographs #7, 9-11, 16, 17, 20, 22). The existing joint sealants have exceeded their useful service-life. Replacement is required.
- Evidence of a previous repair was observed at one location on the south elevation of the south skywalk (Photograph #21). The patch was debonded and in poor condition. Several existing spalls had been coated with an epoxy resin.

4.3 Windows and Glazing

The existing aluminum framed windows are original to the structure and have exceeded their intended service-life.

- Approximately 75% of the existing insulated glazing units (IGUs) in the north skywalk are original 1974 units. All of the IGUs in the south skywalk are original 1974 units. The expected service-life of an IGU is 20 to 25 years.

- Three (3) IGUs in the north skywalk have failed glazing seals resulting in fogging of the unit (Photograph #25). No evidence of failed IGUs in the south skywalk was noted. Replacement of the failed IGUs is required.
- Large gaps were observed at several joints between the vertical mullions and sill/head (Photograph #26). The large gaps are contributing to air leakage.
- The exterior glazing seals show evidence of shrinkage related to long term aging. Shrinkage of the exterior glazing seals (Photograph #27) will allow a direct path for moisture infiltration.
- Several IGUs on the north elevation of the south skywalk had evidence of movement. In one location a gap between the glazing edge and aluminum framing was visible on the upper west corner (Photograph #28). The cause of the movement could not be confirmed but may be related to the slope of the framing which caused the IGUs to creep to the west over time. Further investigation beyond the scope of this work would be required to confirm the cause(s).
- The existing sealants around the aluminum framed glazing are in poor condition and have exceeded their useful service-life (Photographs #7, 8, 14, 16, 17, 19, 20). Replacement is required.
- Two (2) units were observed with evidence of a being struck with a projectile such as a BB gun.

4.4 Other Observations

- Moisture staining, deterioration, and suspected biological growth was observed on the interior surfaces of the drywall on the north skywalk (Photograph #29)
- Photographs #31 and #32 shows the connection between the existing sign at the east end of the north skywalk to the concrete beam. The connection plate has pulled away from the beam. Three of the four bolts have been removed from the holes and the fourth bolt has pulled out. A review of the top connection indicates that the sign has been hit multiple times. The top connection to the skywalk appears to be welded to the skywalk frame and has been repaired previously. Repair of the sign connection is required to address a potential safety hazard.
- A cursory visual review of the existing roofing was completed at the same time as the cladding review. The roofing is an SBS-modified torch-applied waterproofing membrane. The roof membrane appears to be relatively new and good condition. Further investigation would be required to provide a formal opinion on its condition.
- Cracking of the stucco soffit was observed near the east end of the north skywalk (Photograph #32). Localized hammer soundings did not reveal any evidence that the stucco was loose or in danger of falling.

4.5 Thermographic Survey

A thermographic scan of the Carlton Street Skywalks in Winnipeg was completed as part of cladding assessment. A copy of the thermographic survey report is provided in Appendix C. The following provides a summary of the significant findings.

Thermal bridging occurs at locations where members of the wall assembly span between the warm interior and cold exterior surfaces. These thermal bridges create a more direct path for heat flow and cause elevated temperatures on the exterior surface of the cladding during cold weather. The thermal anomalies created by these members are usually linear and relatively uniform in appearance. Typical examples of thermal bridging can be seen in Figures 2 and 3 below.

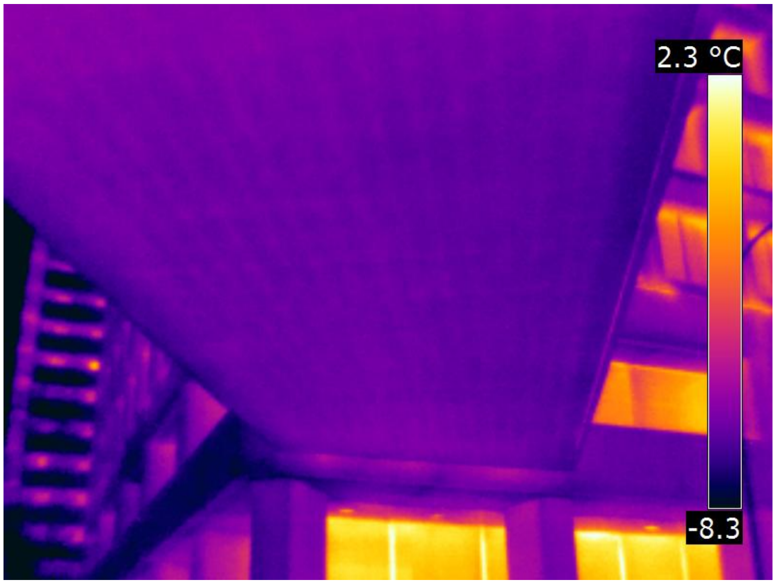

Figure 2: Image showing a typical example of thermal bridging at soffit supports below the skywalk.

Figure 3: Image showing a typical example of thermal bridging at precast panel weld plate connections.

Thermal anomalies caused by air leakage are typically more random in appearance. These anomalies can appear as intense bright spots where a concentrated air leak occurs. Alternately, they can appear as plumes or fingers where the leakage is more disbursed. A good example of both types of air leakage anomalies is shown in Figure 4 below. A concentrated air leak appears as an intense light source at the side of the heating unit. Additionally, a wide-spread plume caused by air leakage above the unit can be seen on the surface of the window.

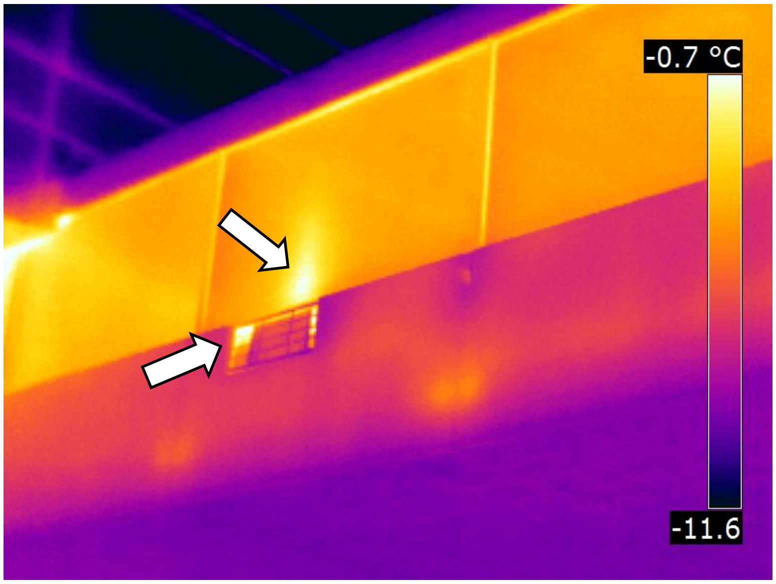

Figure 4: Image showing air leakage at the mechanical heating unit. Examples of both direct and indirect (disbursed) air leakage patterns can be seen.

Overall, the anomalies particularly those caused by thermal bridges, are typical and are generally expected in this type of construction. While modern construction details have been refined to minimize the extent of thermal bridging, it can never be completely eliminated.

5. Analysis and Recommendations

The existing concrete cladding panels are in poor condition. The majority of the deterioration observed is due to corrosion of the embedded steel panel anchorages and/or reinforcing steel. In the absence of a protective barrier on the exposed surfaces of the concrete, moisture will permeate through the concrete and eventually induce corrosion of steel in the presence of oxygen. The process of converting iron to rust is expansive with the rust occupying a much larger volume than the original reinforcing steel bar. Eventually the volume increase will create excessive internal stresses in the concrete that exceed the tensile capacity of the concrete causing cracking and delamination of the adjacent concrete surface.

Moisture arises from many sources, for exterior cladding the main sources are rain and melting snow. In this instance however, the results of the thermographic survey suggest that air leakage through the building envelope is a likely contributing factor. Air leakage can have a detrimental impact of the performance and longevity of the building envelope. When air leakage occurs during cold weather, it can deposit large amounts of moisture within the wall assembly in the form of ice and frost. When temperatures moderate in early spring, these accumulations melt typically causing damage to interior finishes. If left unchecked, additional deterioration will occur and can include damage to structural components. Biological or mould growth may also occur. When air leakage occurs during cold weather, it can deposit large amounts of moisture within the wall assembly in the form of ice and frost on the interior face of the precast cladding panels.

Thermal anomalies consistent with air leakage were observed at various locations around both skywalks. Transitions between the skywalks and the adjacent buildings were also noted. Additionally, we also observed air leakage at the mechanical units and windows which is contributing to deterioration of the precast cladding panels and building enclosure components. In addition, moisture leakage either from wind driven rain penetration or condensation from air leakage is damaging interior finishes or resulting in suspected biological growth. Further investigation of the suspected biological growth by an environmental consultant is recommended.

Based on our experience in the repair and restoration of concrete structures it is our professional opinion that repair of the concrete cladding panels is not practical or cost effective. This opinion is based on the extent and location of deterioration, the logistics of repairing the panels in place, and the appearance of the completed repair.

With respect to the windows, the absence of an effective air seal between the window and rough openings is contributing to significant air leakage. The rough opening sealant and frame joints are also in poor condition and a significant contributor to air leakage. Displacement in the windows frames was observed which is undermining the integrity of the IGU retention on the south skywalk. The vast majority of the IGUs have a date stamp of 1974 and are therefore original to the skywalk. In summary, the windows have outlived their useful service-life.

Overall, the existing cladding and windows are in poor condition and have outlived their expected service-life. The following sub-sections provide recommendations for addressing the deterioration observed.

5.1 Required Repairs (within 3 months)

The existing sign at the east end of the north sidewalk is in poor condition and the lower connection to the concrete beam has been severely compromised. The conditions represent a potential safety concern. Removal, repair, or replacement of the sign is therefore required as soon as reasonably possible.

The condition of the sign has been reported to the City of Winnipeg prior to submission of this report and we understand that the owner of the sign has been made aware of the conditions.

5.2 Short Term Maintenance

A significant amount of loose concrete was removed from the cladding panels during the visual assessment and to the best of our knowledge, there were no remaining areas of loose concrete following our site investigation. Notwithstanding, corrosion of the embedded anchorages and reinforcing steel will continue in the presence of atmospheric moisture causing further cracking and delamination. As a result, there is a very high probability that additional areas of loose concrete will have to be removed in the near future; and periodically until permanent repairs are completed. For the purposes of budgeting and planning we recommend that a visual inspection via a mobile lift be completed every 3 to 4 months so any new areas of loose concrete can be removed. More frequent inspections from grade level is also recommended in order to identify any areas of loose concrete which are in immediate danger of falling.

The recommendations provided in this section will be required on an ongoing basis until permanent repairs can be made.

5.3 Medium Term Considerations

At present, the likelihood of a catastrophic collapse or dislodgment of the precast cladding panels from the building appears to be fairly low. This is primarily due to the design of the anchors which consists of four connections point per panel. The bottom connections appear to provide the vertical support for the panels while the top anchors provide horizontal stabilization and transfer wind loads to the structure. At the time of the site inspection, the majority of the concrete deterioration was typically concentrated along the panel joints and/or the concrete cover over the top panel anchorages. Despite the concrete deterioration, our observations indicate that the majority of the top anchors are still well embedded in the concrete panel.

Notwithstanding, there is a significant risk to public safety if repairs are deferred beyond 2016. It is for this reason that we strongly recommend that the deteriorated panels be temporarily stabilized to minimize risk until repairs are completed. The conceptual scope of work consists of installing steel members across the face of the cladding panels that are bolted to the panels and connected back to the structure. Where necessary, localized repairs to the precast panels would be completed.

It must be emphasized that this recommendation is not considered or intended to be a permanent solution. It is for this reason that we recommend that a stabilization scenario not exceed 3 years in service.

5.4 Long Term Recommendations

The long term recommendations consist of a complete re-cladding of the two skywalks. The conceptual scope of work would include removal of the existing windows, cladding, roofing, and soffits, and installation of a new glazed aluminum curtain wall system. For the purposes of budgeting we have assumed that the appearance of the skywalks would mimic the current skywalks connecting Cityplace to the Delta Hotel.

The new curtain wall would incorporate performance enhancements such as low emissivity coatings, superior thermal resistant spacers, and/or gas filled cavities to improve thermal resistance.

Note that salvaging the existing roofing membrane may be feasible however further investigation would be required. For the purposes of planning and budgeting we included replacement of the roofing in the estimates of probable construction costs.

6. Estimates of Probable Construction Costs

Accurate estimation of construction costs for remediation projects is difficult to provide because of the inherent number of variables associated with working on an existing structure. Hidden conditions inevitably exist which can result in increases in the overall cost of repairs. Based on the level of investigation and available information, the budget is considered a Class 5 (-50% to +100%) estimate. The Class 5 estimate is a rough estimate prepared based on very limited information with no engineering work completed, which is used to make an assessment of initial viability and for long range capital planning. Please note that the costs presented are for construction only, and excludes taxes, contingencies, and professional fees for design and specification preparation, tendering, field reviews, and contract administration services. All costs presented in 2016 dollars and do not include taxes, consulting fees or contingencies.

Please note that only work requiring a capital investment outlined in Sections 5.3 and 5.4 have been included in the following tables.

6.1 Medium Term Considerations

Work under this section includes only that work required to stabilize the precast cladding panels until a permanent repair can be made.

Table 1: Medium Term Considerations

Description of Work	Unit Cost	Estimate
1. Temporary stabilization of precast cladding panels.	Allow	$75,000.00
2. Miscellaneous concrete repairs to the existing precast concrete panels required to complete stabilization work.	Allow	$10,000.00
3. General Requirements: Mobilization, insurance, permits, site protection, etc.	Allow 30%	$25,000.00
Estimate of Probable Construction Costs		**$110,000.00**

6.2 Long Term Recommendations

Table 2: Long Term Recommendations

Description of Work	Unit Cost	Estimate
1. Demolition and removal of existing cladding, windows, roofing, and soffits.		
1.1 North Skywalk	Allowance	$100,000.00
1.2 South Skywalk	Allowance	$150,000.00
2. Installation of a new glazed aluminum curtain wall.		
2.1 North Skywalk	2,000 ft^2 x $140 /$ft^2$	$280,000.00
2.2 South Skywalk	2,500 ft^2 x $140 /$ft^2$	$350,000.00
3. Replacement of existing roofing membrane.		
3.1 North Skywalk	1,500 ft^2 x $25 /$ft^2$	$37,500.00
3.2 South Skywalk	2,500 ft^2 x $25 /$ft^2$	$62,500.00
4. Replacement of existing soffits.		
4.1 North Skywalk	1,500 ft^2 x $50 /$ft^2$	$75,000.00
4.2 South Skywalk	2,500 ft^2 x $50 /$ft^2$	$125,000.00
5. General Requirements: Mobilization, insurance, permits, site protection, etc.	Allow 25%	$295,000.00
Estimate of Probable Construction Costs		**$1,475,000.00**

For the purposes of budgeting and planning we recommend a preliminary construction budget $1,475,000.00 be carried for recladding of the two skywalks over Carlton Street. We strongly recommend that updated budget construction costing be obtained once the scope of work has been confirmed, particularly regarding the cost of mobilization and access due to the unique conditions of working over a street.

7. Closure

At the request of the City of Winnipeg Planning Property & Development Department, an investigation of the existing precast concrete cladding panels and structure was completed by Crosier Kilgour & Partners Ltd. The purpose of the investigation was to provide an opinion as to the current condition of the structure and cladding, identify areas of duress and provide recommendations aimed at extending the service life of the structure.

The results of the investigation confirmed that the south bridge connection at 155 Carlton is in good condition with no evidence of structural duress. Access to the west connection was not accessible and would require a significant amount of demolition of existing building finishes beyond the scope of this investigation. No evidence of duress has been observed. Notwithstanding, further investigation is warranted and should be completed as part of future repairs.

The existing concrete cladding panels are in poor condition and exhibit varying degrees of cracking, delamination, and spalling. In addition, the existing aluminum framed windows are original to the structure and have exceeded their intended service-life. Based on the findings presented in this report, recladding of the two skywalks crossing Carlton Street is recommended at an estimated cost of $1,475,000.00.

Lastly, investigation of the suspected biological growth observed on the inside face of the drywall on the north skywalk is recommended. The investigation should be completed by a qualified environmental consultant.

We trust that this provides the information you require. Upon your review, if you have any questions, or require further information, please contact the undersigned.

Derek J. Mizak, P.Eng.
Principal

PROVINCE OF MANITOBA
D. J.
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Member
20801
APRIL 5/16
REGISTERED PROFESSIONAL ENGINEER

APEGM
Certificate of Authorization
Crosier Kilgour & Partners Ltd.
No. 235 Date: APRIL 5/16

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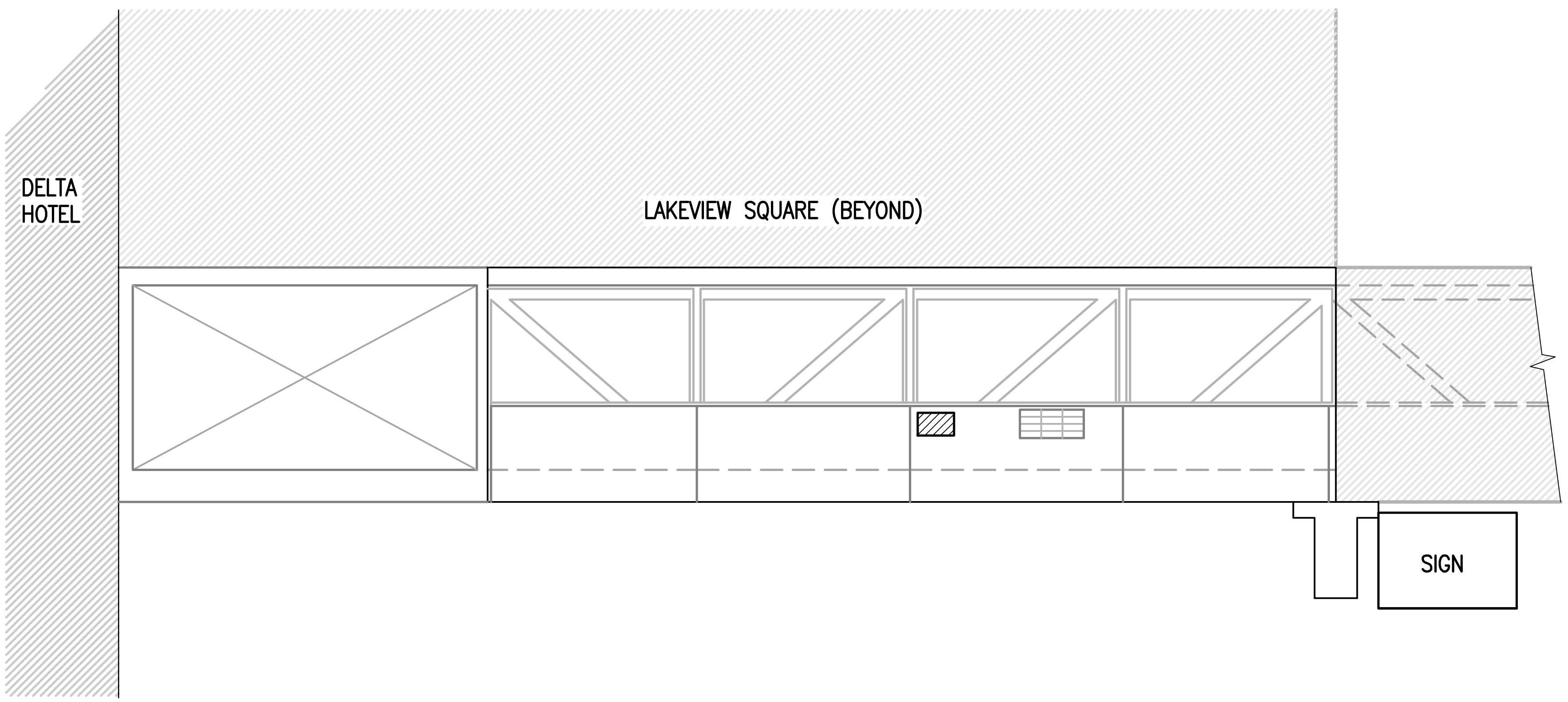
Appendix A

Drawings

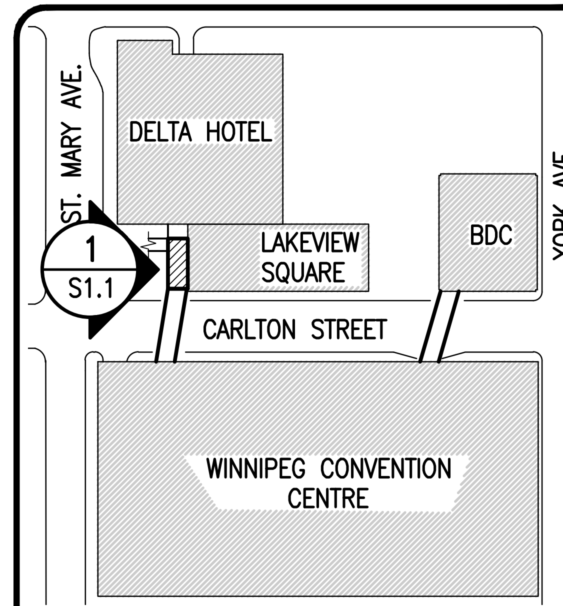


1
S1.1
NORTH ELEVATION
1/8" = 1'–0"

LEGEND:
SPALL
CRACK

DRAWING NOTES:
1. FAILED JOINT SEALANT
2. MISSING SEALANT
3. CRACK
4. EXPOSED CLADDING ANCHORS

NOTES:
1. CONCRETE DETERIORATION AROUND ANCHOR
2. EXIST PATCH POOR CONDITION
3. FREEZE THAW DETERIORATION OF PANEL EXPOSED REINFORCEMENT



SITE PLAN
NOT TO SCALE

No.	Date	Issue/Revision	By

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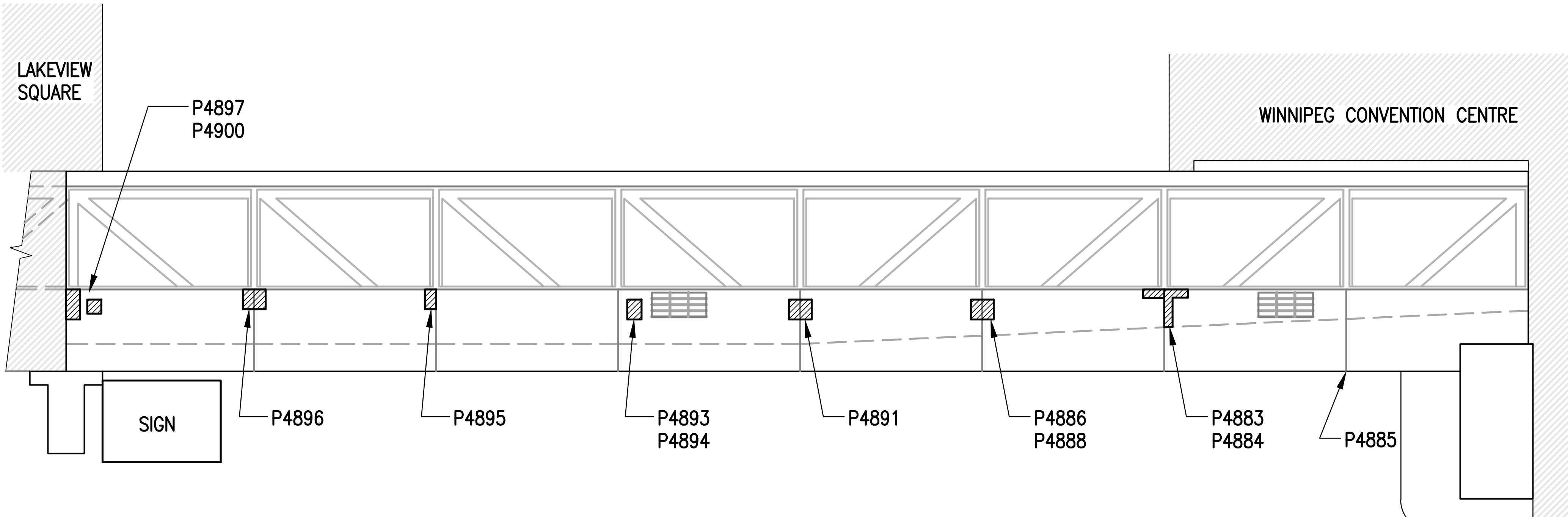
CONSULTING STRUCTURAL ENGINEERS

Project
CARLTON STREET SKYWALKS

CARLTON STREET
WINNIPEG, MANITOBA

Sheet Title
WALKWAY #1
NORTH ELEVATION

File	Date
2015-1231	2016-04-05
Design	Drawn
DJM	ZBG / JHC
Revision	Sheet No.
A	S1.1



1 NORTH ELEVATION
S1.2
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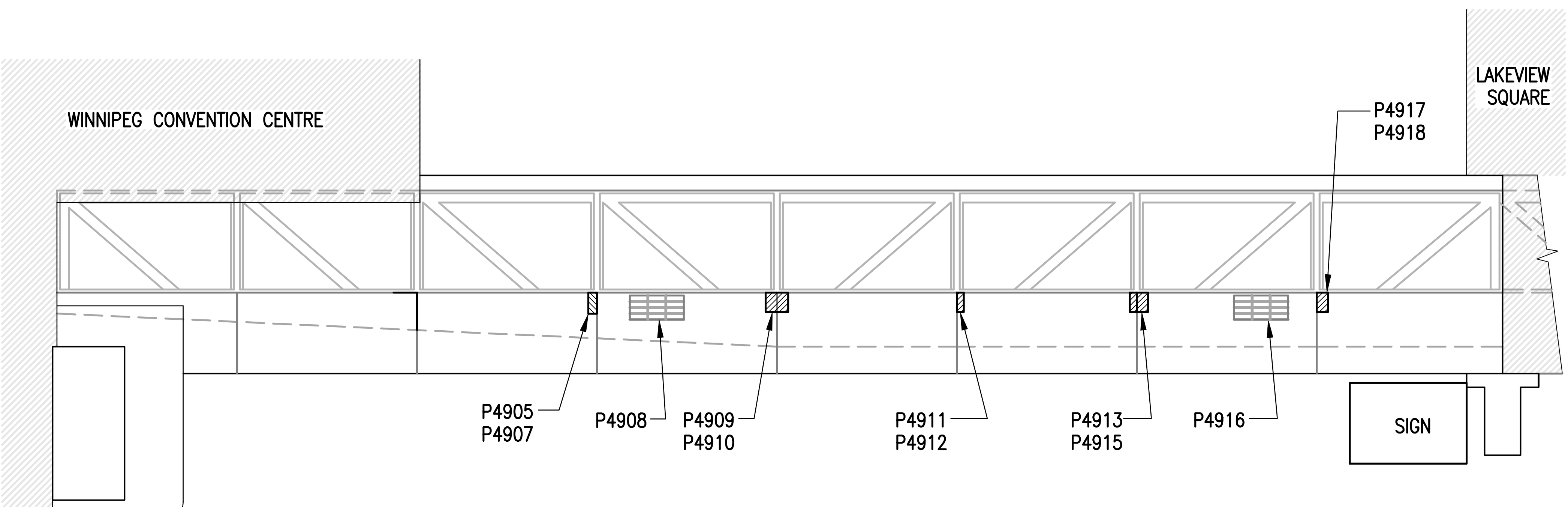


2 SOUTH ELEVATION
S1.2
1/8" = 1'–0"

LEGEND:

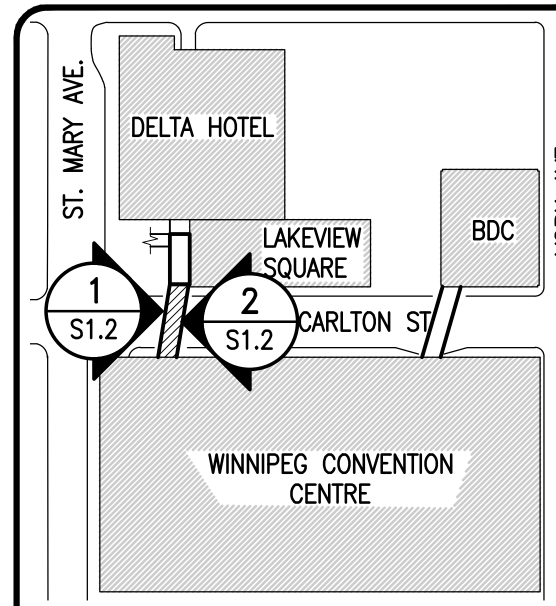
- SPALL
- CRACK

DRAWING NOTES:

1. FAILED JOINT SEALANT
2. MISSING SEALANT
3. CRACK
4. EXPOSED CLADDING ANCHORS

NOTES:

1. CONCRETE DETERIORATION AROUND ANCHOR
2. EXIST PATCH POOR CONDITION
3. FREEZE THAW DETERIORATION OF PANEL EXPOSED REINFORCEMENT



SITE PLAN
NOT TO SCALE

No.	Date	Issue/Revision	By

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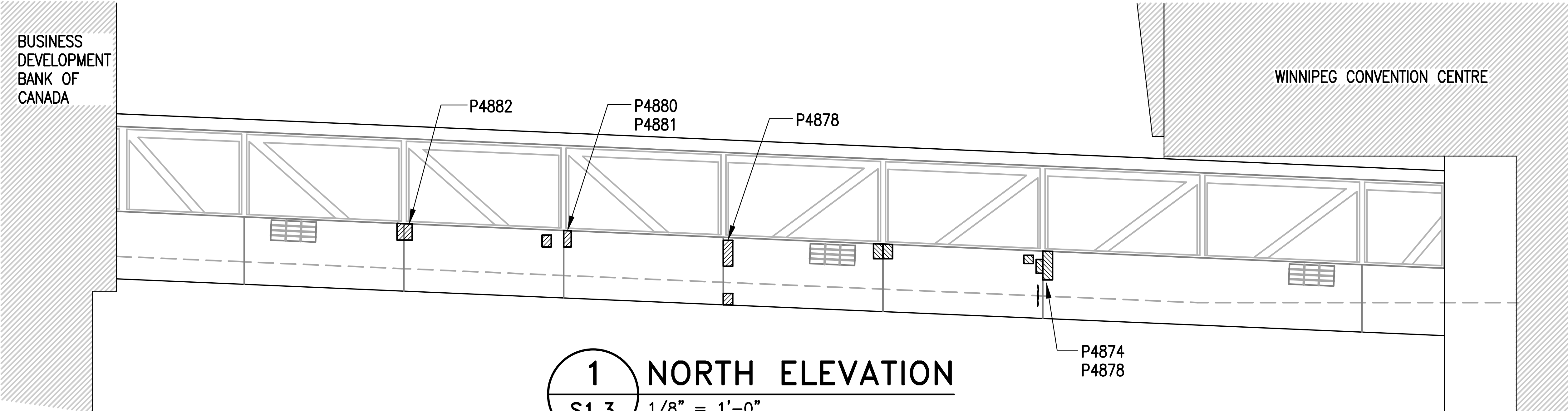
CONSULTING STRUCTURAL ENGINEERS

Project
CARLTON STREET SKYWALKS

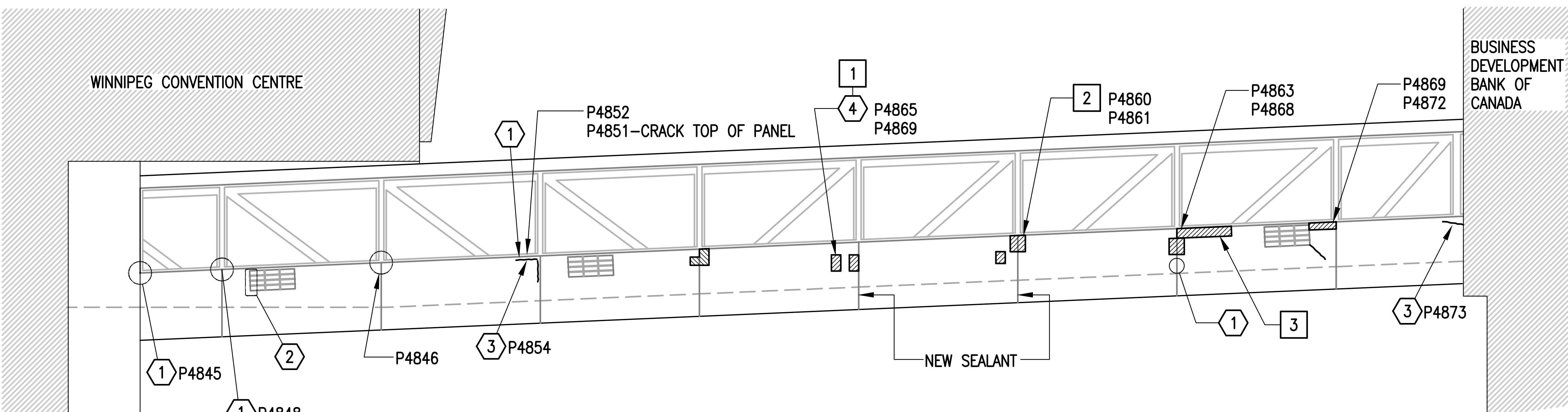
CARLTON STREET
WINNIPEG, MANITOBA

Sheet Title
WALKWAY #1
NORTH AND SOUTH ELEVATIONS

File	Date
2015-1231	2016-04-05
Design	**Drawn**
DJM	ZBG / JHC
Revision	**Sheet No.**
A	S1.2



1
S1.3
NORTH ELEVATION
1/8" = 1'-0"



2
S1.3
SOUTH ELEVATION
1/8" = 1'-0"

LEGEND:

SPALL

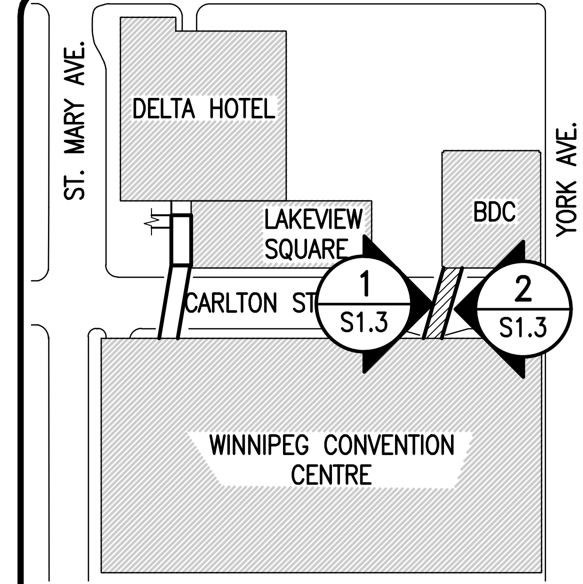
CRACK

DRAWING NOTES:

1. FAILED JOINT SEALANT
2. MISSING SEALANT
3. CRACK
4. EXPOSED CLADDING ANCHORS

NOTES:

1. CONCRETE DETERIORATION AROUND ANCHOR
2. EXIST PATCH POOR CONDITION
3. FREEZE THAW DETERIORATION OF PANEL EXPOSED REINFORCEMENT



SITE PLAN
NOT TO SCALE

No.	Date	Issue/Revision	By

300-275 Carlton Street
Winnipeg, Manitoba R3C 5R6
T 204. 943. 7501
F 204. 943. 7507

Crosier Kilgour & Partners Ltd.
CONSULTING STRUCTURAL ENGINEERS

Project
CARLTON STREET SKYWALKS
CARLTON STREET
WINNIPEG, MANITOBA

Sheet Title
WALKWAY #2
NORTH AND SOUTH ELEVATIONS

File	Date
2015-1231	2016-04-05
Design	**Drawn**
DJM	ZBG / JHC
Revision	**Sheet No.**
A	S1.3

Appendix B

Photographs

Photograph #1:

North elevation of north skywalk.

Photograph #2:

South elevation of north skywalk.

<u>Photograph #3:</u>

North elevation of south skywalk.

<u>Photograph #4:</u>

South elevation of south skywalk.

Photograph #5:

South skywalk, southeast bearing connection at 155 Carlton Street.

Photograph #6:

South skywalk, shelf angle supporting the steel floor decking at 155 Carlton Street.

Photograph #7:

North Skywalk – North Elevation

Delamination and spalling at the cladding anchorages.

Deterioration of the precast joint sealants and window rough opening sealants.

Photograph #8:

North Skywalk – North Elevation

Delamination and spalling at the cladding anchorages.

Freeze-thaw deterioration at panel joints.

Deterioration of the precast joint sealants and window rough opening sealants.

Photograph #9:

North Skywalk – North Elevation

Delamination and spalling at the cladding anchorages with exposed reinforcing steel.

Photograph #10:

North Skywalk – North Elevation

Delamination and spalling at the cladding anchorages with exposed reinforcing steel.

Photograph #11:

North Skywalk – South Elevation

Delamination and spalling at the cladding anchorages.

Cracking along face of panel.

Photograph #12:

North Skywalk – South Elevation

Close-up of precast panel shown in Photograph #11.

Cracking visible along the side of the precast panel consistent with delamination.

Photograph #13:

North Skywalk – South Elevation

Cracking visible along edge of precast opening.

Photograph #14:

North Skywalk – South Elevation

Delamination and spalling at the cladding anchorages.

Photograph #15:

North Skywalk – South Elevation

Top: Conditions prior to concrete removal.

Middle: Cracking and spalling on right side of joint.

Bottom: After removal of loose concrete. Corroded reinforcing visible.

Photograph #16:

South Skywalk – North Elevation

Delamination and spalling at the cladding anchorages.

Deterioration of the precast joint sealants and window rough opening sealants.

Photograph #17:

South Skywalk – North Elevation

Delamination and spalling at the cladding anchorages.

Deterioration of the window rough opening sealants.

Photograph #18:

South Skywalk – South Elevation

Cracking on top surface of the precast panel.

Photograph #19:

South Skywalk – South Elevation

Freeze-thaw deterioration at panel joints.

Cracking along face of panel.

Photograph #20:

South Skywalk – South Elevation

Delamination and spalling at the cladding anchorages.

Deterioration of the window rough opening sealants.

Photograph #21:

South Skywalk – South Elevation

Delamination and spalling at the cladding anchorages.

Existing debonded patch.

<u>Photograph #22:</u>

South Skywalk – South Elevation

Delamination and spalling at the cladding anchorages and reinforcing steel.

<u>Photograph #23:</u>

South Skywalk – South Elevation

Large concrete spall adjacent to mechanical opening.

<u>Photograph #24:</u>

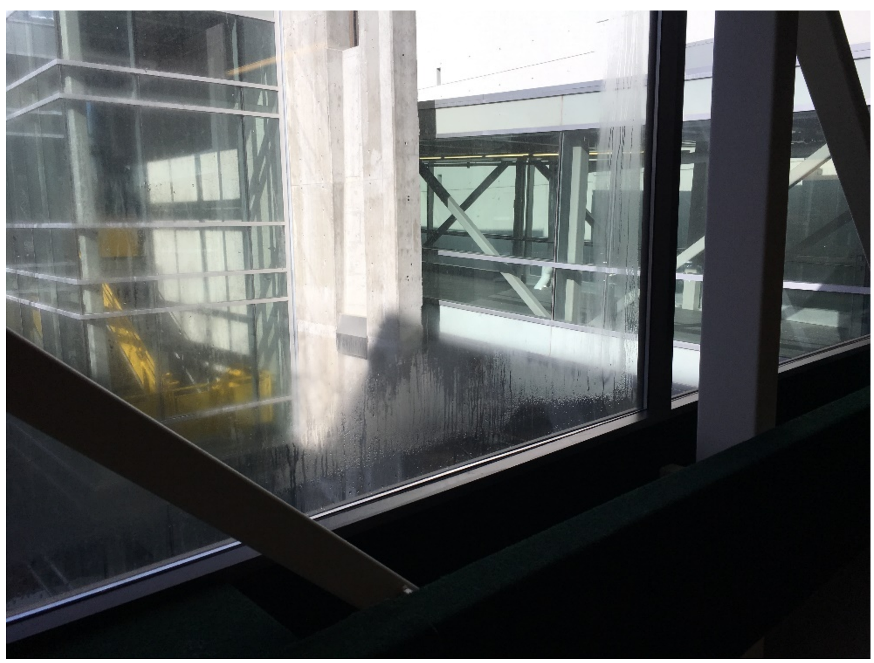
South Skywalk – South Elevation

Close-up view of concrete spall shown in Photograph #23.

<u>Photograph #25:</u>

North Skywalk – North Elevation

Failed insulated glass unit.



Photograph #26:

South Skywalk – South Elevation

Open joint in window framing.

Photograph #27:

South Skywalk – South Elevation

Deteriorated exterior glazing seal.

Photograph #28:

South Skywalk – North Elevation

Gap visible between glazing and window frame.

Photograph #29:

North Skywalk – South Elevation

Water damage with suspected biological growth on interior face of drywall.

Photograph #30:

North Skywalk – East End

Sign connection to beam.

Photograph #31:

North Skywalk – East End

Close-up of sign connection to beam showing missing and displacement bolts.

Photograph #32:

North Skywalk

Soffit stucco.

Appendix C

Thermographic Survey

THERMOGRAPHIC SURVEY FOR:

Carlton Street Skywalks
Structural & Cladding Condition Assessment

Submitted to: City of Winnipeg

Attention: Mr. Brent Novak, P. Eng.

Date: April 5, 2016

Submitted by: Crosier Kilgour & Partners Ltd.
300-275 Carlton Street
Winnipeg, Manitoba R3C 5R6
Phone: 204.943.7501 Fax: 204.943.7507
Website: www.ckpeng.com

Contact: Chris Richter, C.E.T.

CKP File No. 2015-1231

Crosier Kilgour & Partners Ltd.™

CONSULTING STRUCTURAL ENGINEERS

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6. Weather Data 79

1. Disclaimer and Limitations

This report has been prepared for the sole benefit of the City of Winnipeg. This report may not be reviewed, referred to or relied upon by any other person or entity without the prior written permission of Crosier Kilgour & Partners Ltd. and the City of Winnipeg.

While Infrared cameras can detect minute temperature variations on materials surfaces, there are numerous factors that can affect the readings. These factors musts be understood and accounted for when interpreting the images. Factors include but are not limited to:

- Wind
- Solar loading
- Positive/negative indoor air pressure
- Adjacent buildings or structures
- Surface moisture
- Reflections
- Low emissivity materials

2. Equipment

Infrared Scanner:	Calibrated radiometric FLIR B360 thermal imaging camera. The camera is equipped with a standard 25° wide (viewing angle) lens. For select images, the thermal camera was fitted with either a 45° wide angle or 6° telephoto lens. All thermal images were recorded to an internal Compact Flash memory card.
Visible Light Camera:	Integrated visible light camera in FLIR B360 thermal imaging camera. Additional visible light images may have been taken using a Nikon Model Coolpix AW110 digital camera.
Temperature / Relative Humidity:	Kestrel 3000 handheld weather station.
Pressure Meter:	TSI DP-CALC Micromanometer Model 8705.

3. Background Information

At your request, a thermographic scan of the Carlton Street Skywalks in Winnipeg was completed as part of a structural and cladding assessment. The scan was completed by Chris Richter, C.E.T., a Certified Level III Thermographer. Images were captured starting at approximately 7:00 a.m. on December 15, 2015 to minimize the effects of solar radiation on the cladding assembly. At the time of the scan the temperature was -11°C and the relative humidity was approximately 87%. The wind was from the east southeast at around 10 km/h and the sky was cloudy. A copy of the weather data from Environment Canada has been included in Section 6 of this report for reference.

For the testing, a blower door was installed in the north skywalk in an attempt to pressurize the skywalk to aid in the identification of air leakage locations. Unfortunately, significant leakage from the mechanical units installed in the walls of the skywalk resulted in a maximum pressure differential of approximately 7 Pascal when compared to the Convention Centre. It is important to note that the Convention Centre is positively pressurized when compared to the north skywalk therefore air exfiltration from the skywalk can generally be anticipated. Additionally due to time constraints and the positive pressurization of the Convention Centre, the blower door was not installed in the south skywalk prior to collecting the images contained in this report.

The thermographic scan uses infrared sensing photographic equipment to “observe” and record variations in the temperature of the exterior of the building. Thermal patterns created by such things as air leakage, thermal bridging, missing insulation or moisture within the wall assembly can be identified.

Thermal bridging occurs at locations where members of the wall assembly span between the warm interior and cold exterior surfaces. These thermal bridges create a more direct path for heat flow and cause elevated temperatures on the exterior surface of the cladding during cold weather. The thermal anomalies created by these members are usually linear and relatively uniform in appearance. Typical examples of thermal bridging can be seen in Figures 1 and 2 below.

Figure 1: Image showing a typical example of thermal bridging at soffit supports below the skywalk.

Figure 2: Image showing a typical example of thermal bridging at precast panel weld plate connections.

Thermal anomalies caused by air leakage are typically more random in appearance. These anomalies can appear as intense bright spots where a concentrated air leak occurs. Alternately, they can appear as plumes or fingers where the leakage is more disbursed. A good example of both types of air leakage anomalies is shown in Figure 3 below. A concentrated air leak appears as an intense light source at the side of the heating unit. Additionally, a wide-spread plume caused by air leakage above the unit can be seen on the surface of the window.

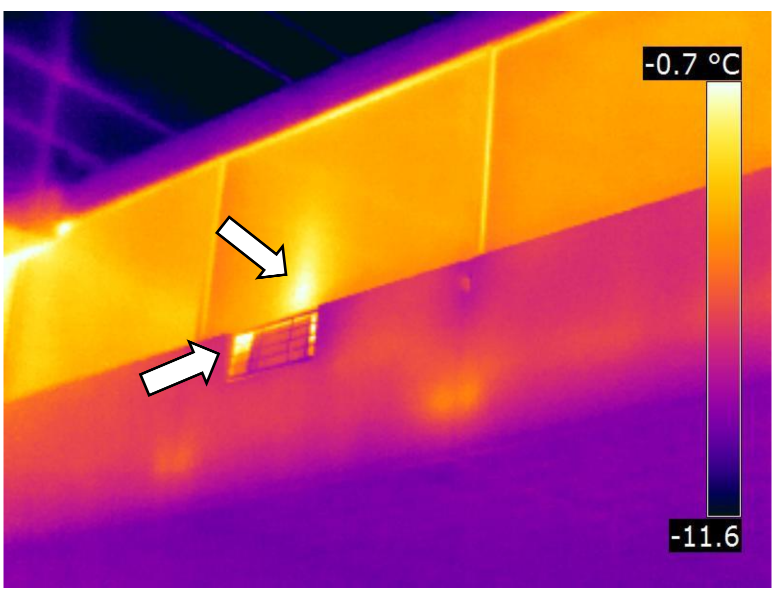


Figure 3: Image showing air leakage at the mechanical heating unit. Examples of both direct and indirect (disbursed) air leakage patterns can be seen.

Overall, the anomalies particularly those caused by thermal bridges, are typical and are generally expected in this type of construction. While modern construction details have been refined to minimize the extent of thermal bridging, it can never be completely eliminated.

Air leakage on the other hand can have a detrimental impact of the performance and longevity of the envelope. When air leakage occurs during cold weather, it can deposit large amounts of moisture within the wall assembly in the form of ice and frost. When temperatures moderate in early spring, these accumulations melt typically causing damage to interior finishes. If left unchecked, additional deterioration will occur and can include damage to structural components. Biological or mould growth may also occur.

Thermal anomalies consistent with air leakage were observed at various locations around both skywalks. Transitions between the skywalks and the adjacent buildings were also noted. Additionally, we also observed air leakage at the mechanical units and windows. Photograph Nos. 21, 27, 33 and 87 show typical examples of the conditions observed. As discussed above, this type of air leakage can cause deterioration of the building enclosure components. Additional detailed review of these locations is recommended to better assess any damage or deterioration that may exist.

We trust this provides the information you require at this time. Should you have any questions or if you require any clarification, please call.

Yours truly,

Chris Richter, C.E.T.

F:\2015\1200-1299\2015-1231\corres\2015-1231 Thermographic Scan Report.docx

4. Satellite Image

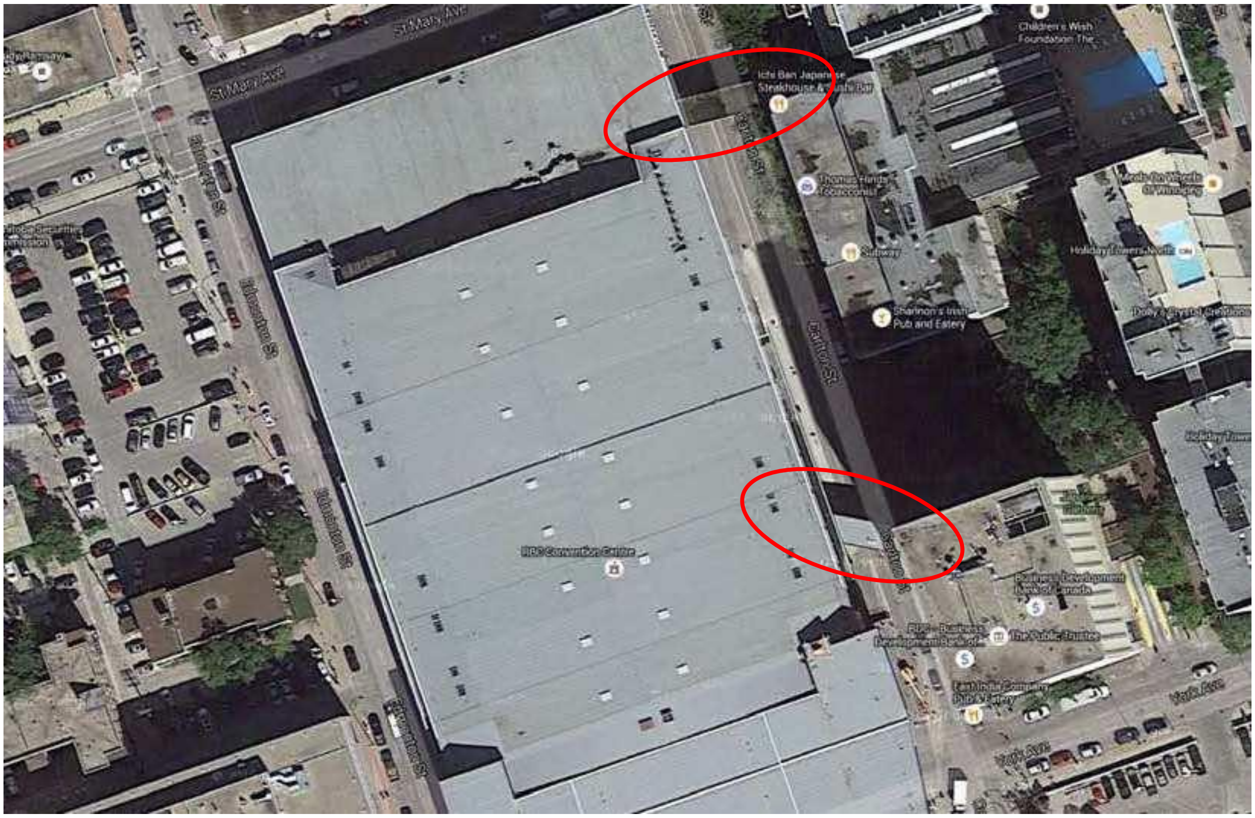


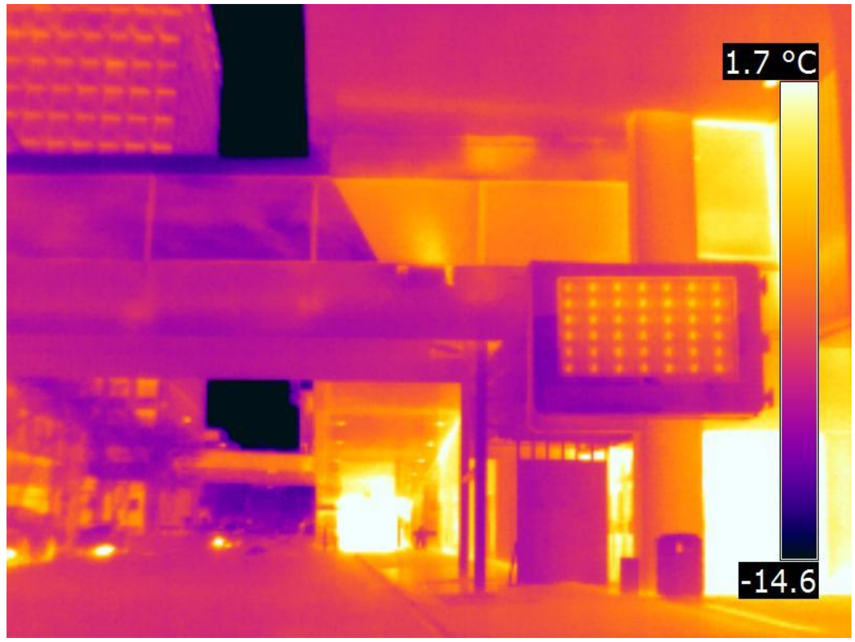
Figure 1: Satellite image of RBC Convention Centre with skywalk bridge locations highlighted.

5. Thermographic Scan

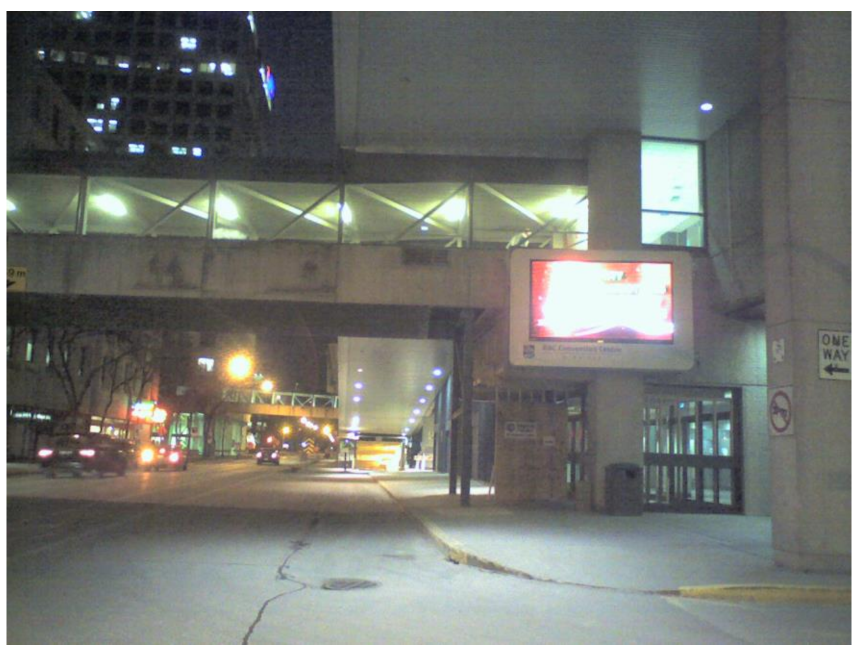
5.1 North Skywalk to Delta Hotel

Photograph #1:

Partial north elevation. Note air leakage at mechanical unit.

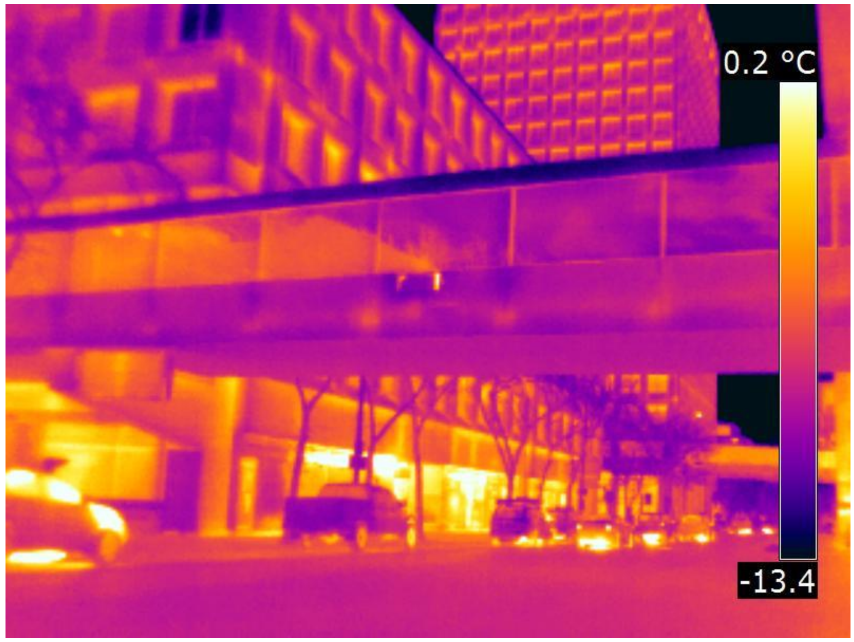


Photograph #2:

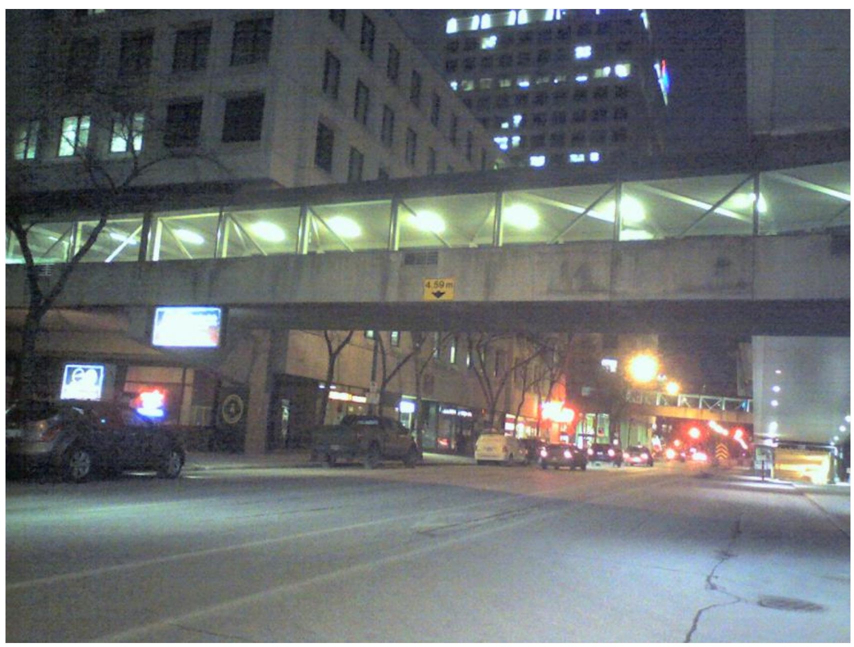


Photograph #3:

Partial north elevation.

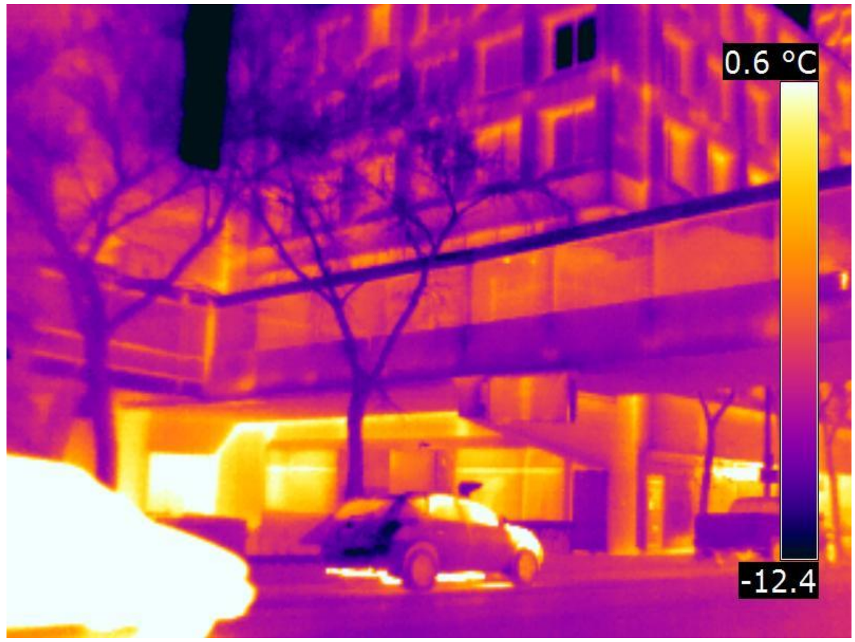


Photograph #4:

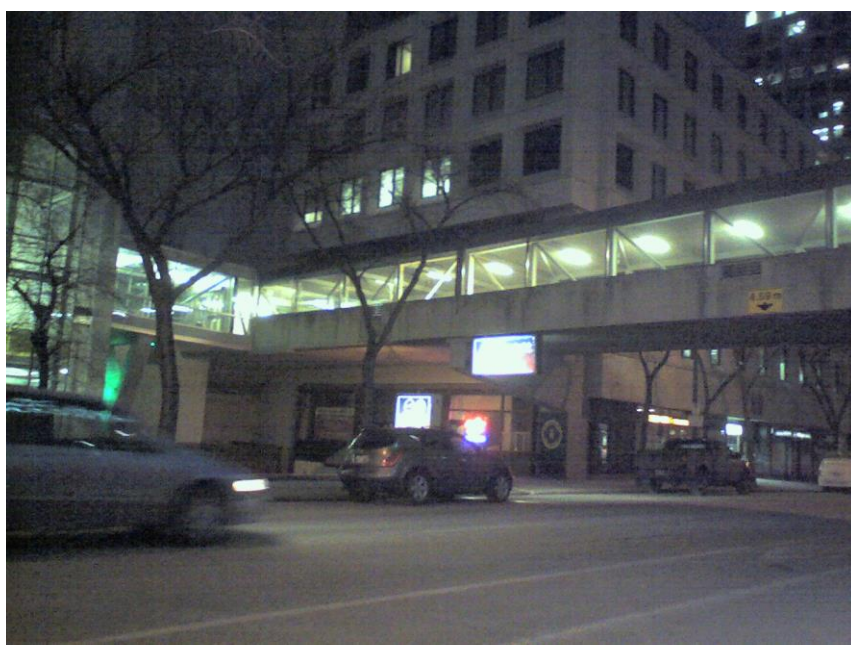


Photograph #5:

Partial north elevation.

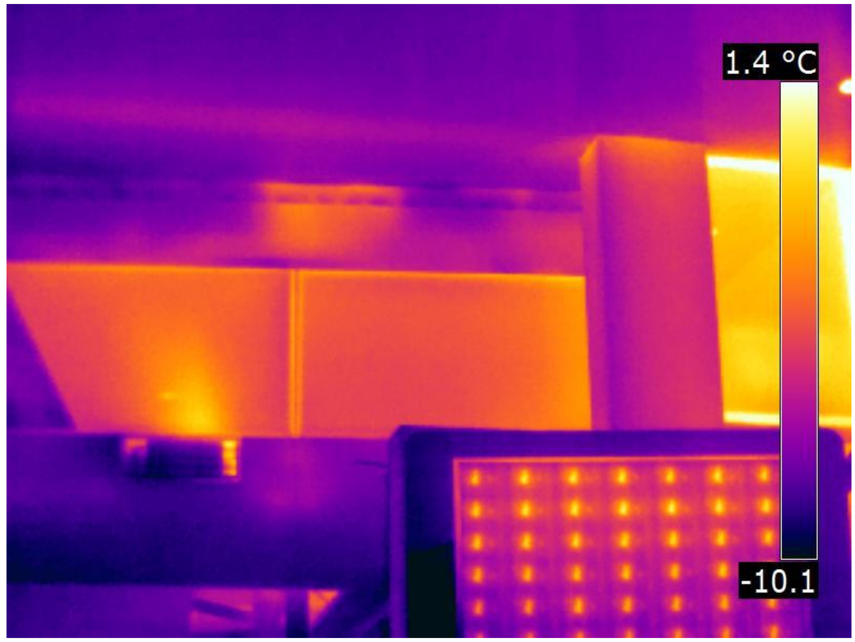


Photograph #6:

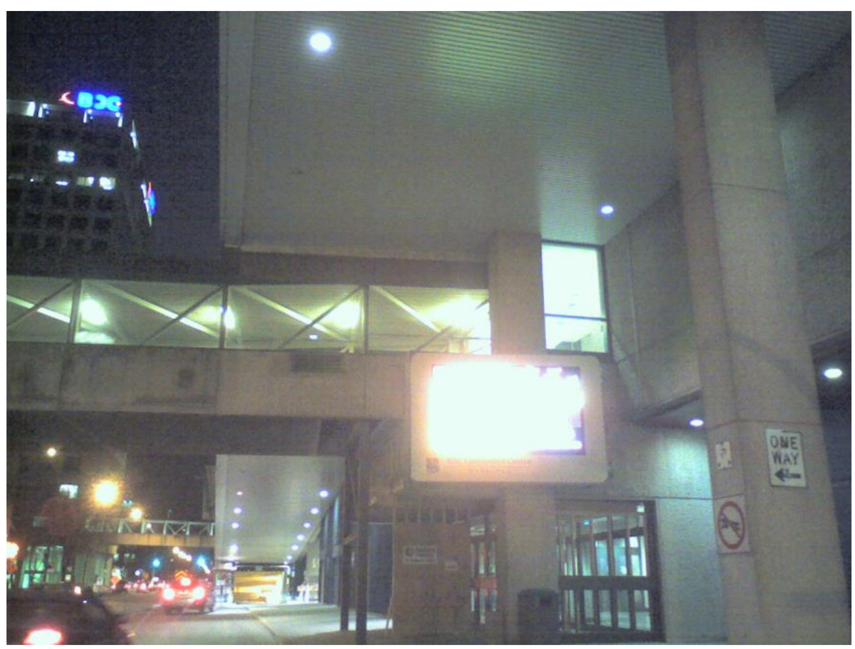


Photograph #7:

Detail view of north elevation showing air leakage at mechanical unit. Also note probable air leakage above and below vertical window mullion.

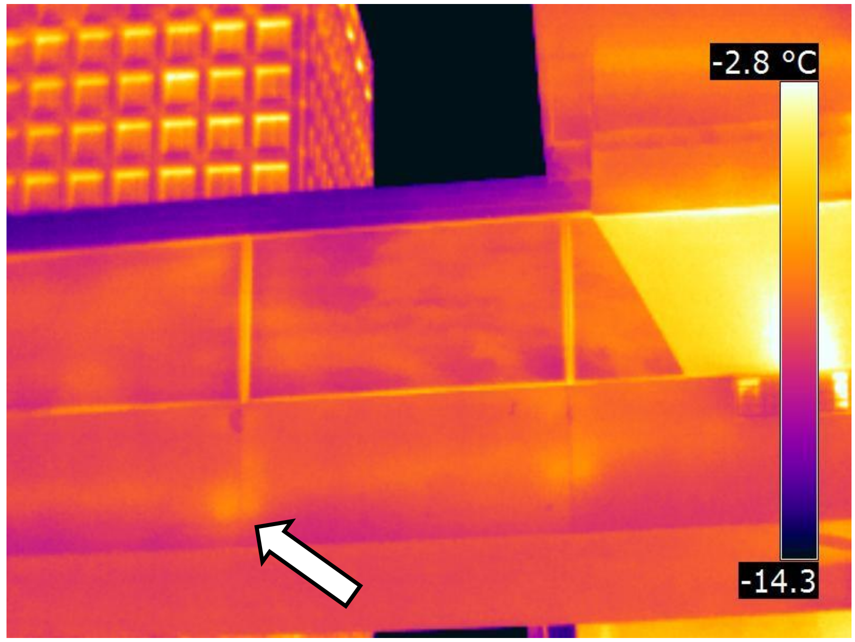


Photograph #8:

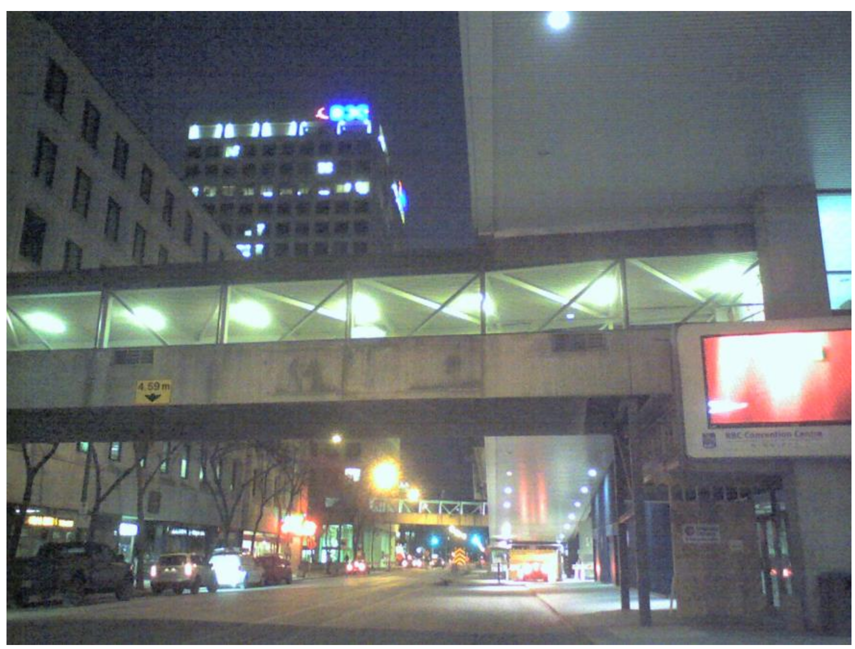


Photograph #9:

Detail view of north elevation. Note thermal bridging at precast panel connection plates.

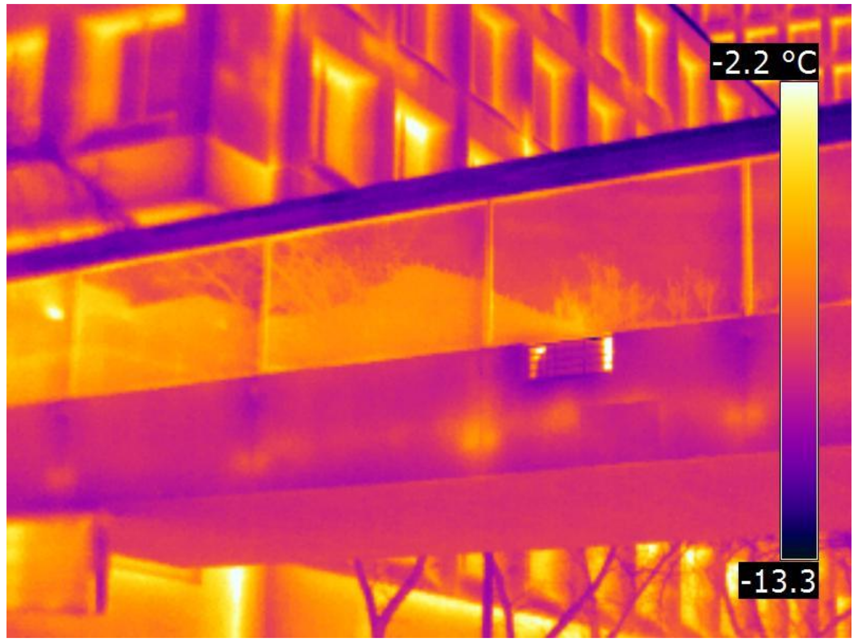


Photograph #10:

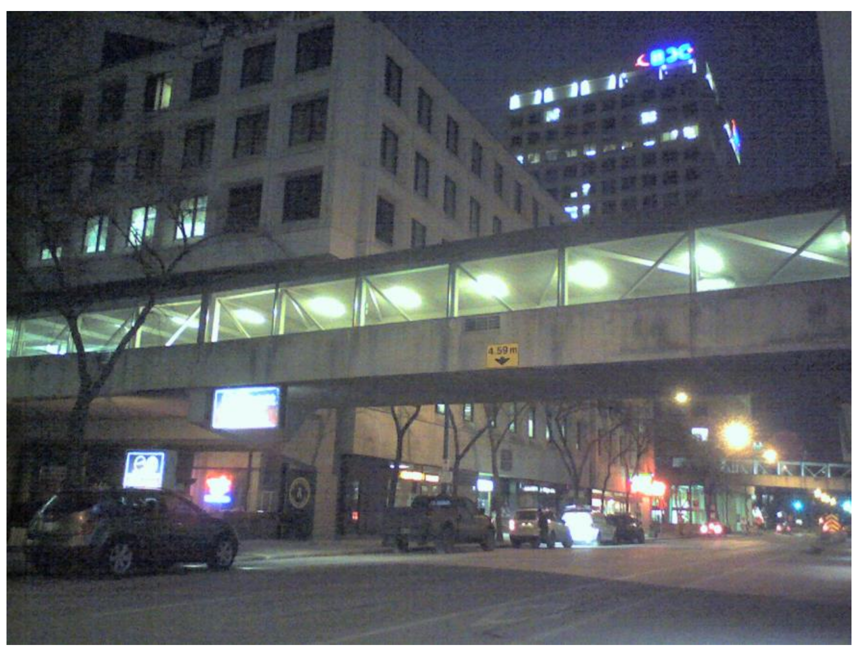


Photograph #11:

Partial north elevation.

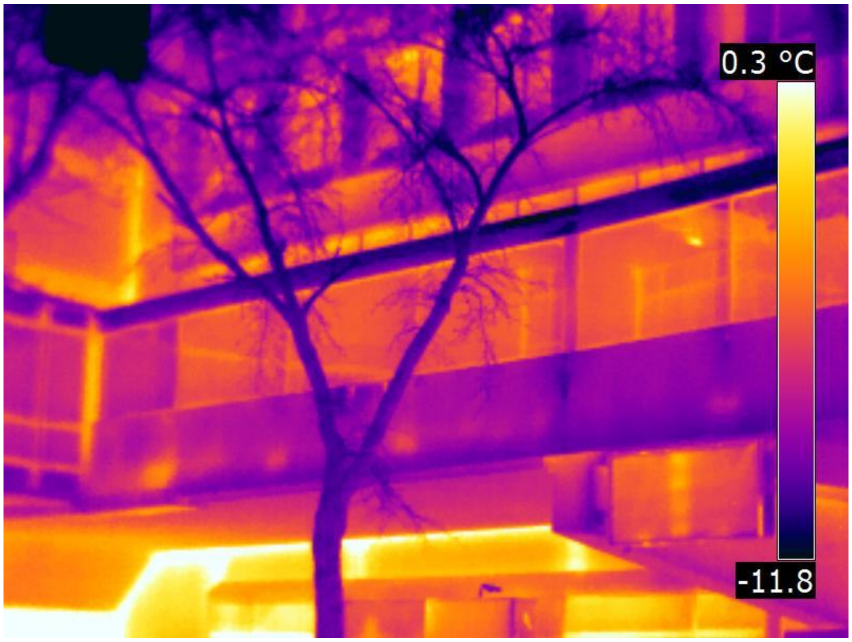


Photograph #12:



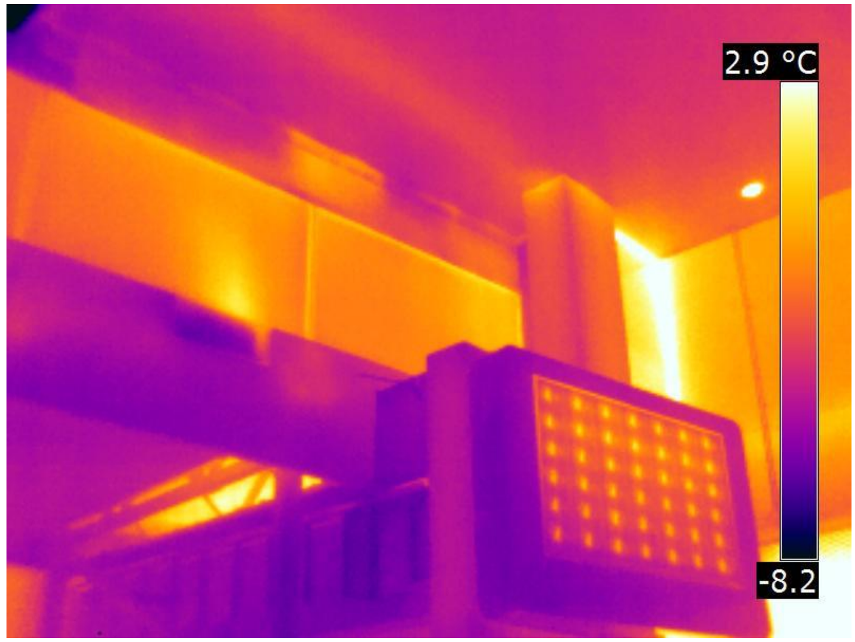
Photograph #13:

Partial north elevation.



Photograph #14:

Photograph #15:
Partial north elevation.



Photograph #16:

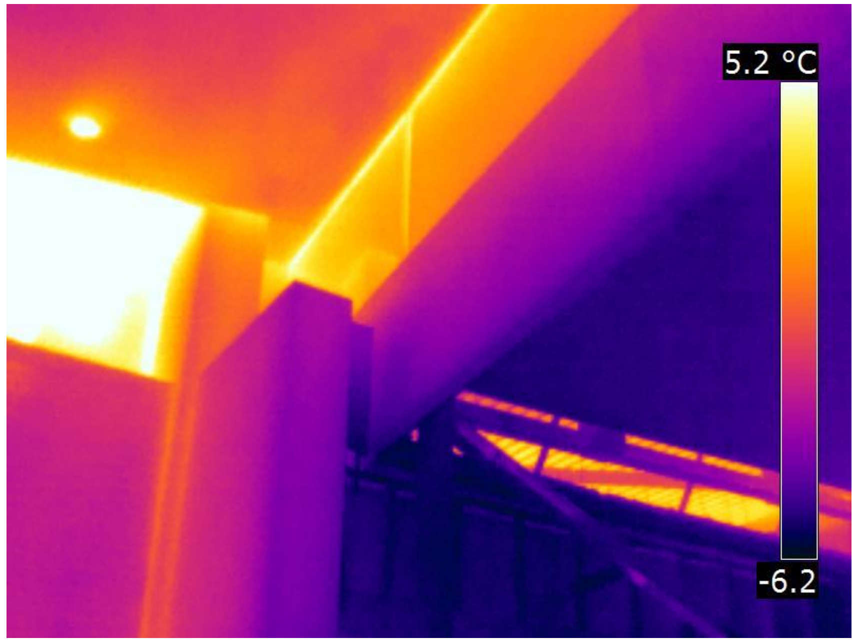
Photograph #17:

Detail view of open soffit at west end of skywalk. Note elevated temperature within soffit area likely caused by a combination of thermal bridging and air leakage.

Photograph #18:

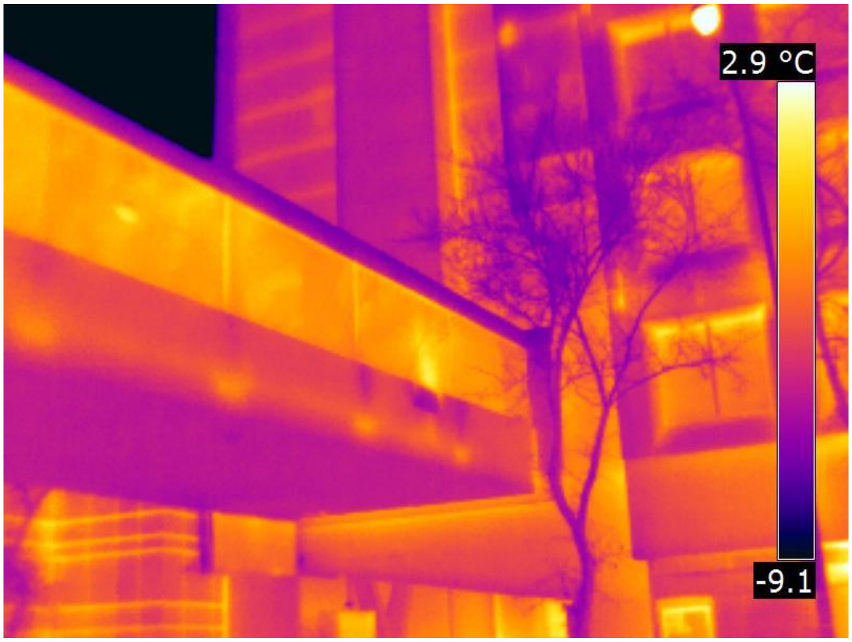
Photograph #19:

Detail view of soffit at west end of skywalk.



Photograph #20:

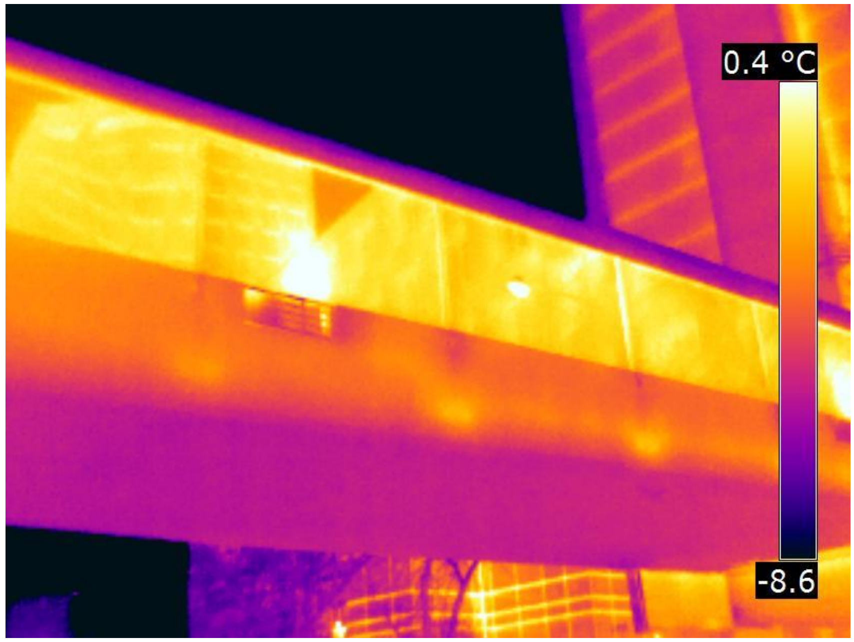
Photograph #21:
Partial south elevation.



Photograph #22:

Photograph #23:

Partial south elevation. Note air leakage and thermal bridging.



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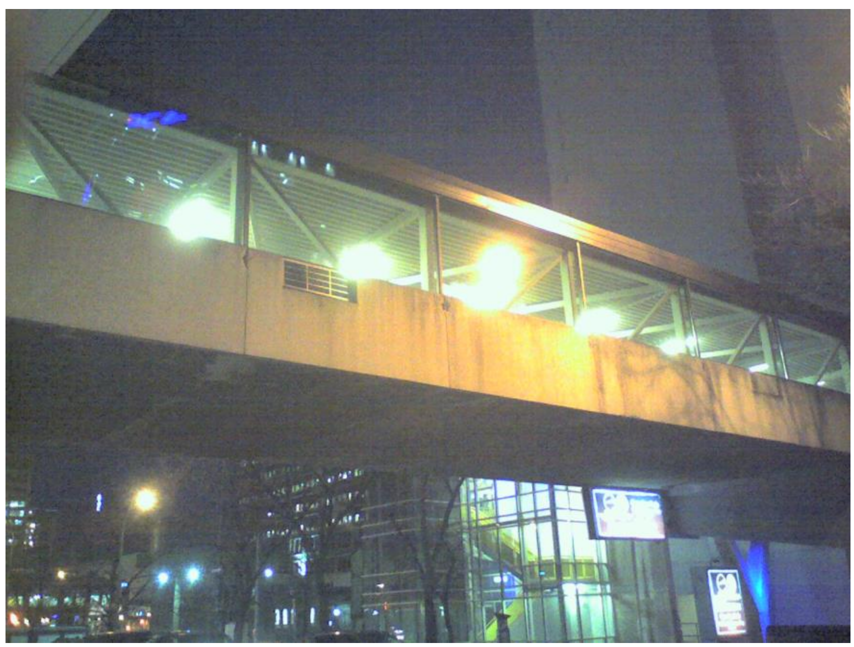
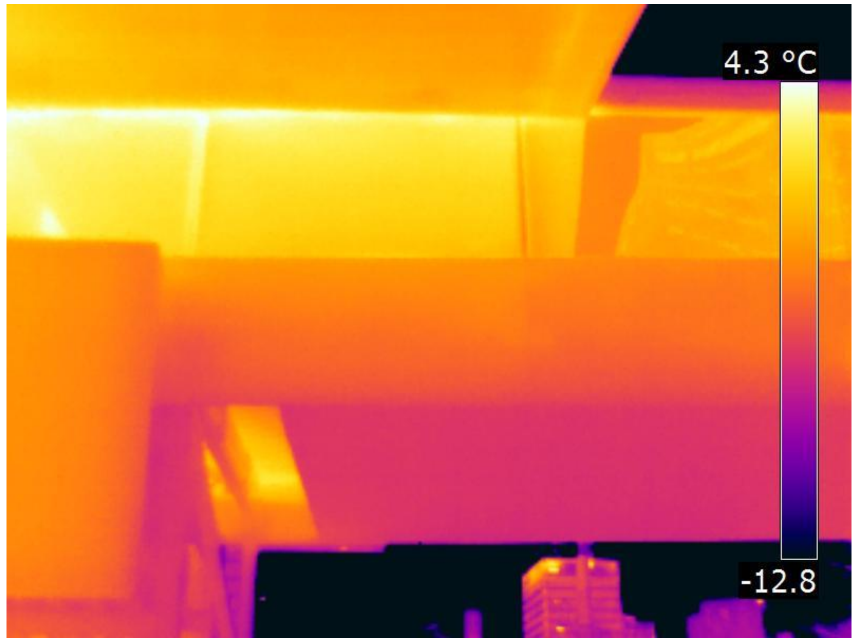
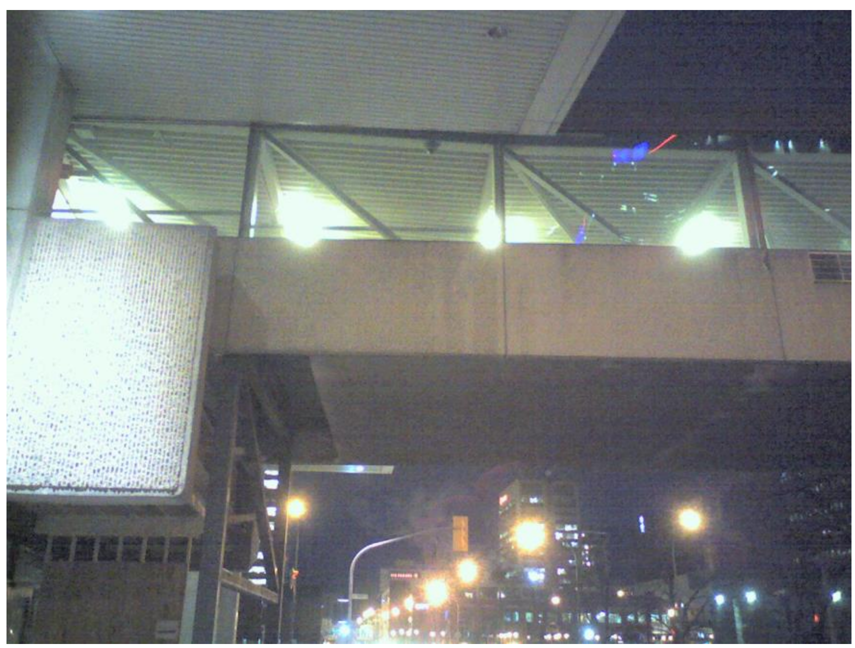


Photograph #25:

Detail view at west end of skywalk.

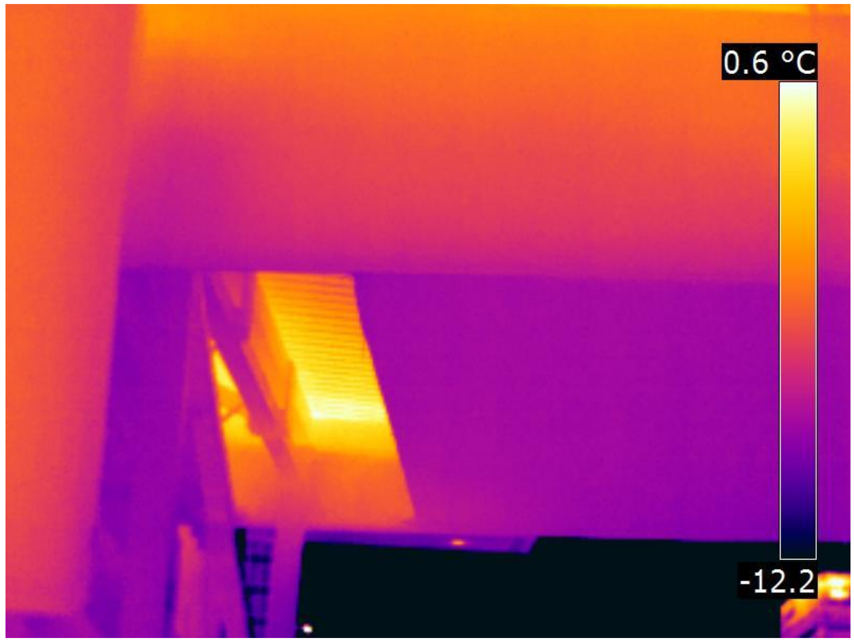


Photograph #26:

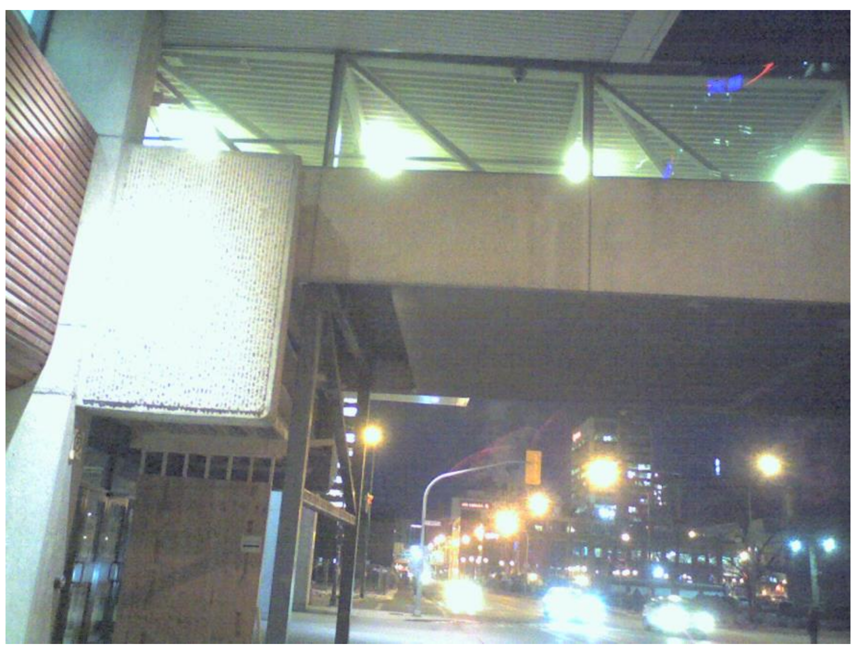


Photograph #27:

Detail view at west end of skywalk.

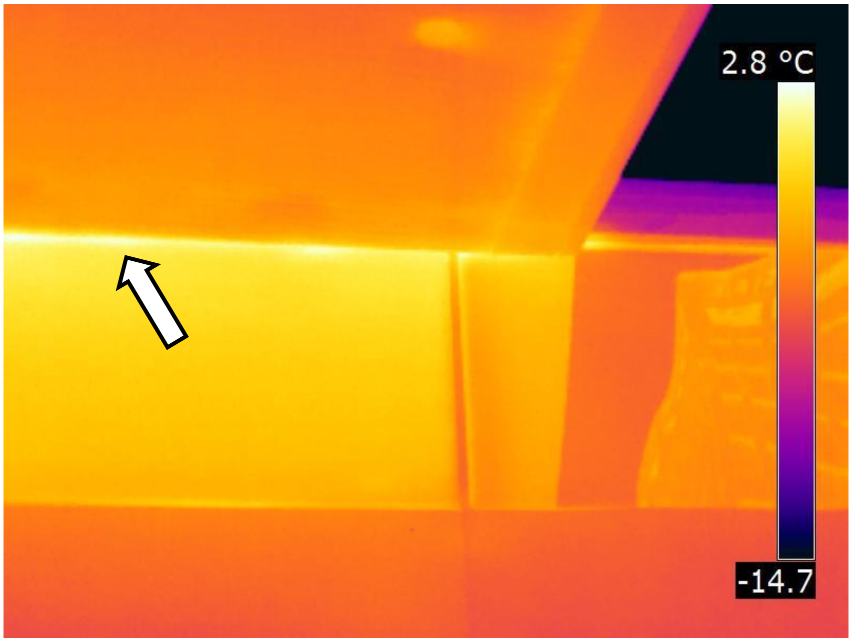


Photograph #28:

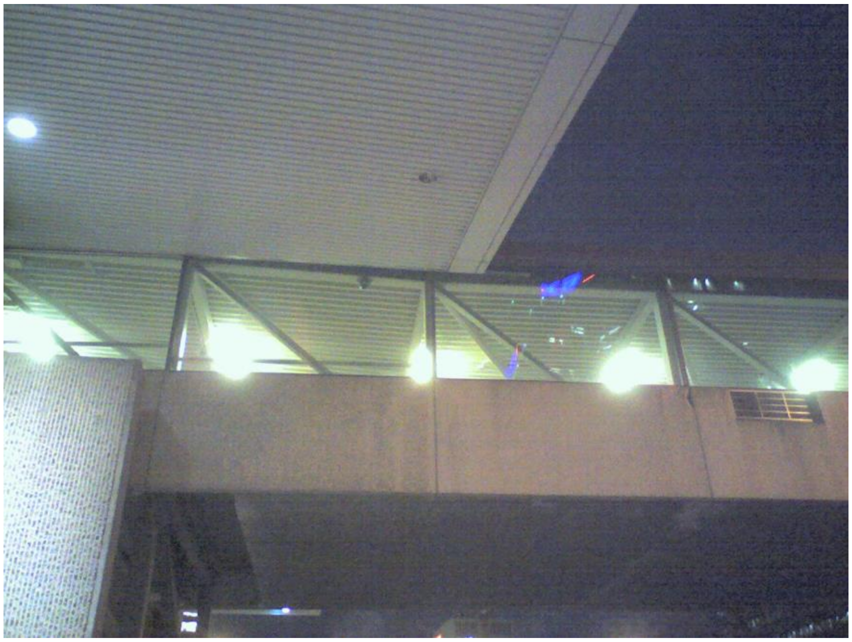


<u>Photograph #29:</u>

Detail view at west end of skylight. Note apparent air leakage at connection to soffit above.

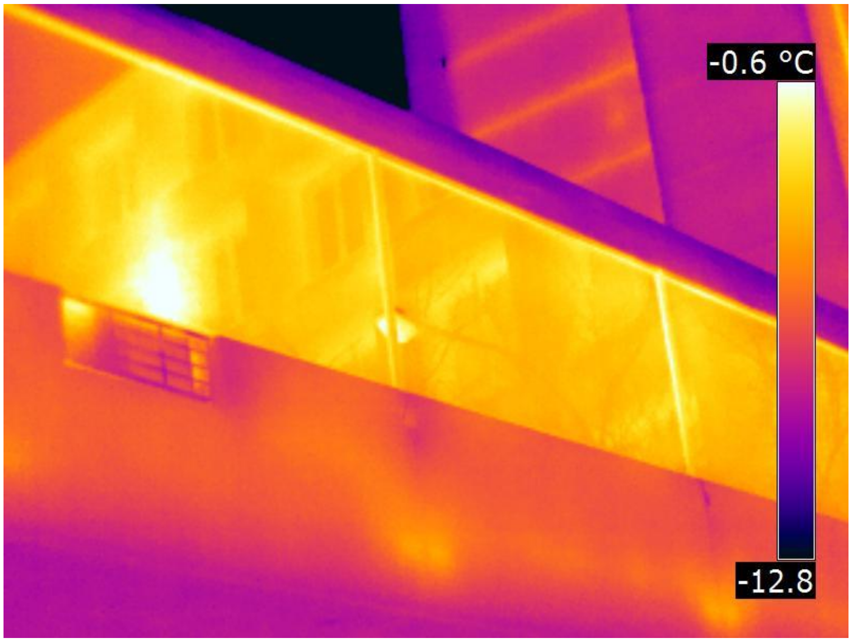


<u>Photograph #30:</u>

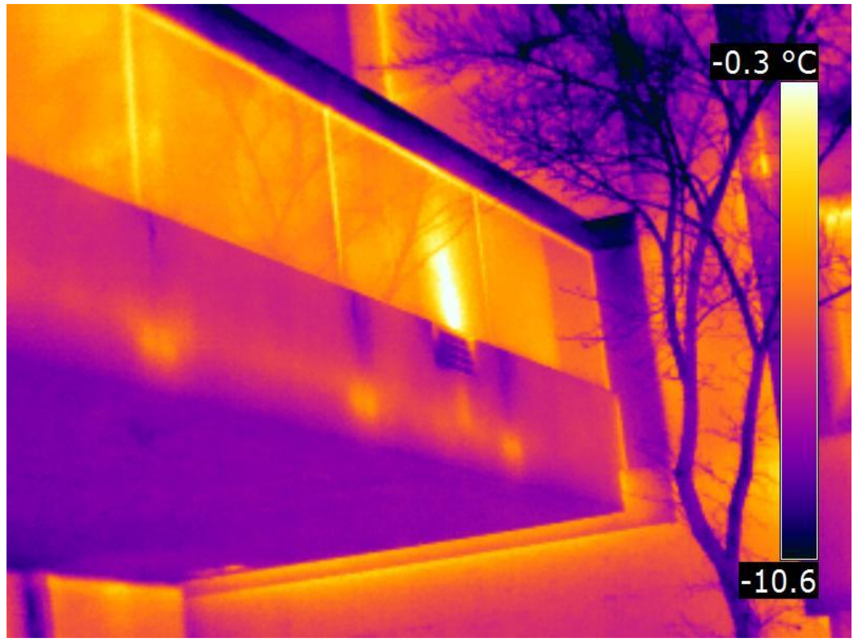


<u>Photograph #31:</u>

Partial south elevation.

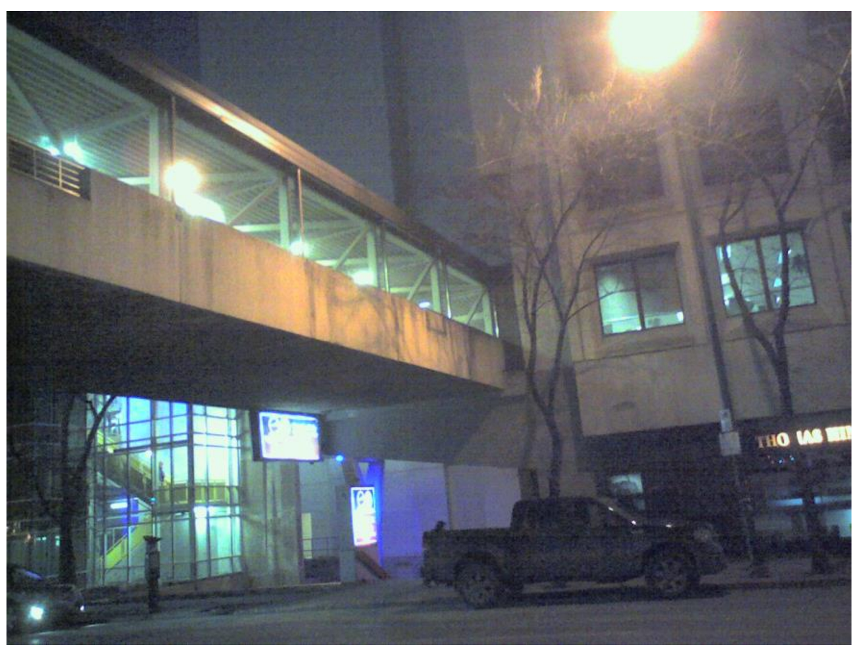


<u>Photograph #32:</u>



Photograph #33:

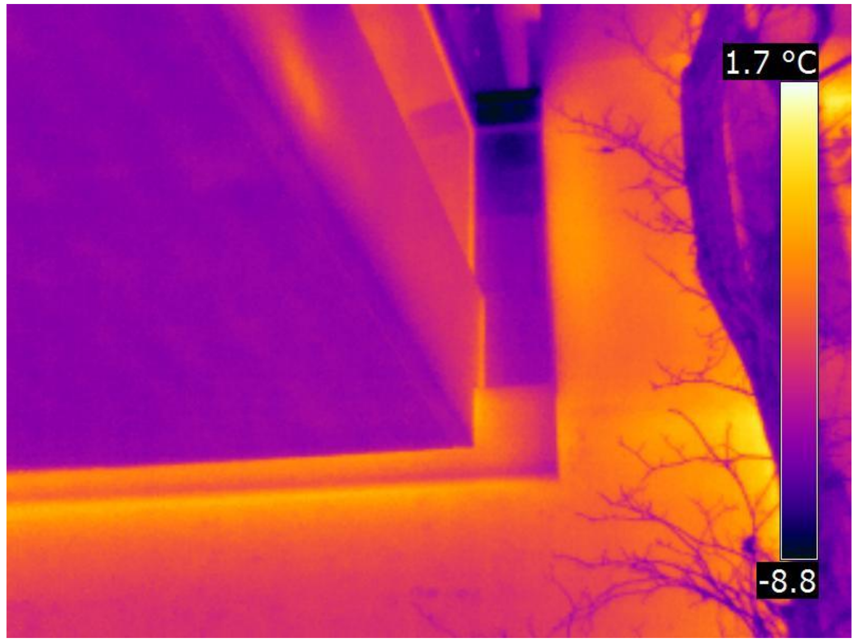
Partial south elevation. Note significant air leakage from mechanical unit.



Photograph #34:

Photograph #35:

Detail view at east end of skywalk.



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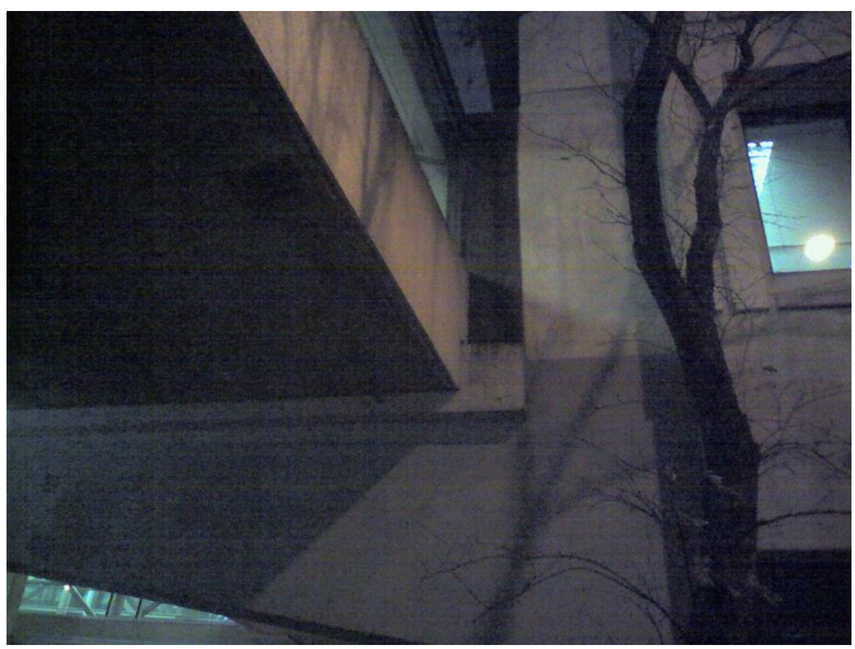
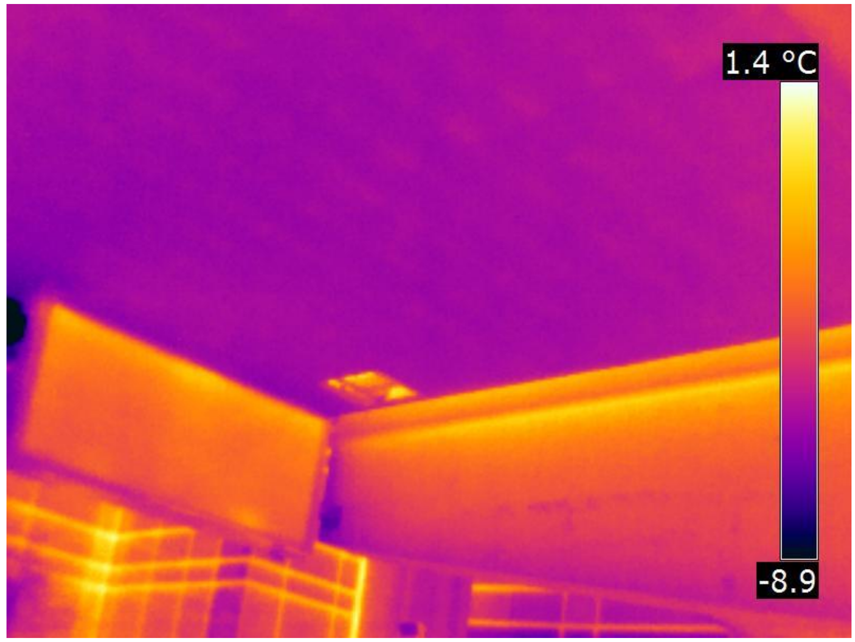
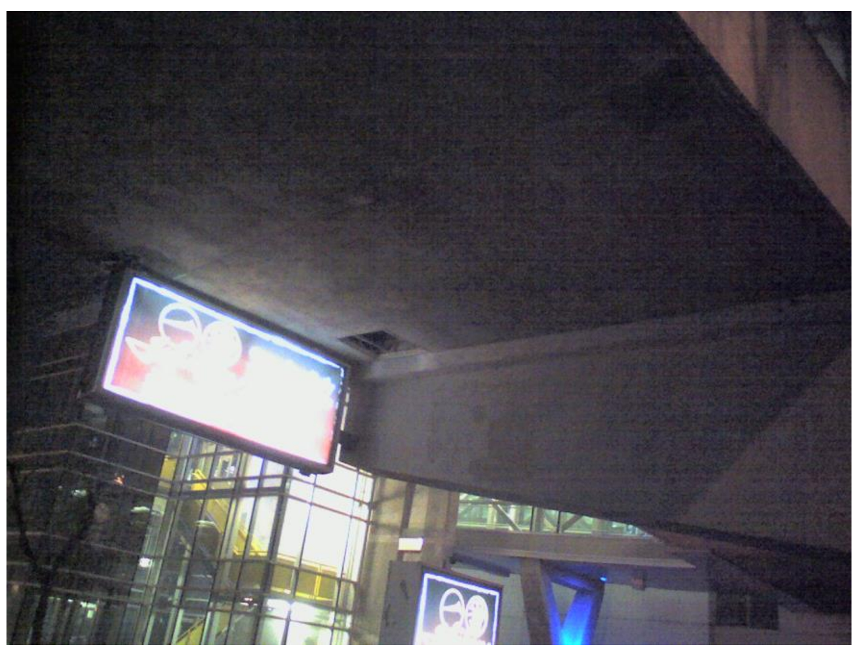


Photograph #37:

Detail view at east end of skywalk.

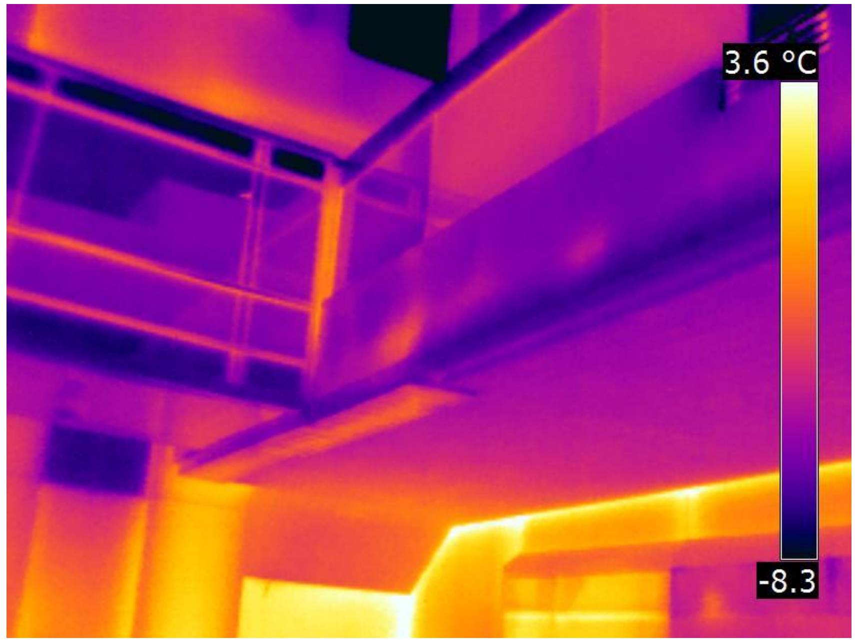


Photograph #38:

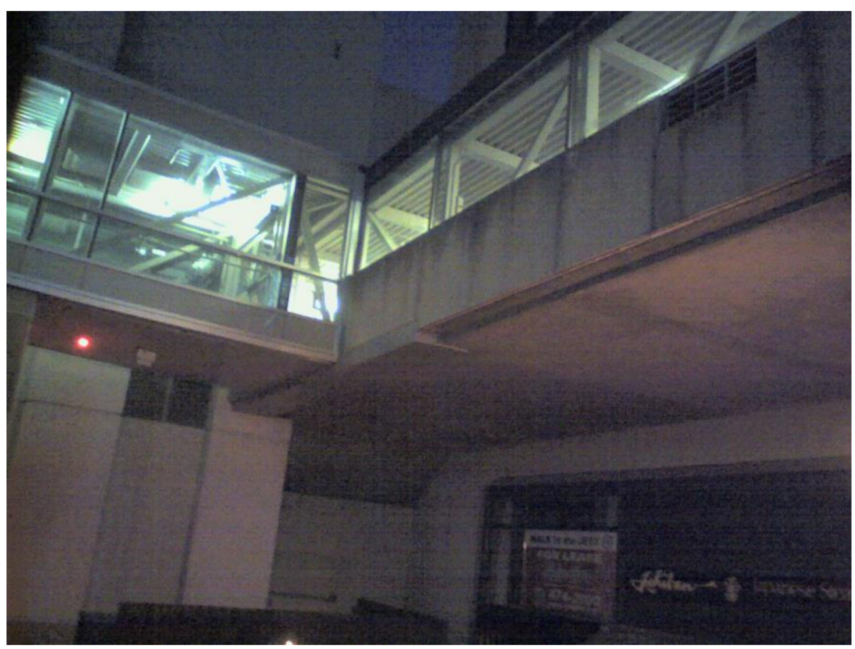


Photograph #39:

Detail view at east end of skywalk.

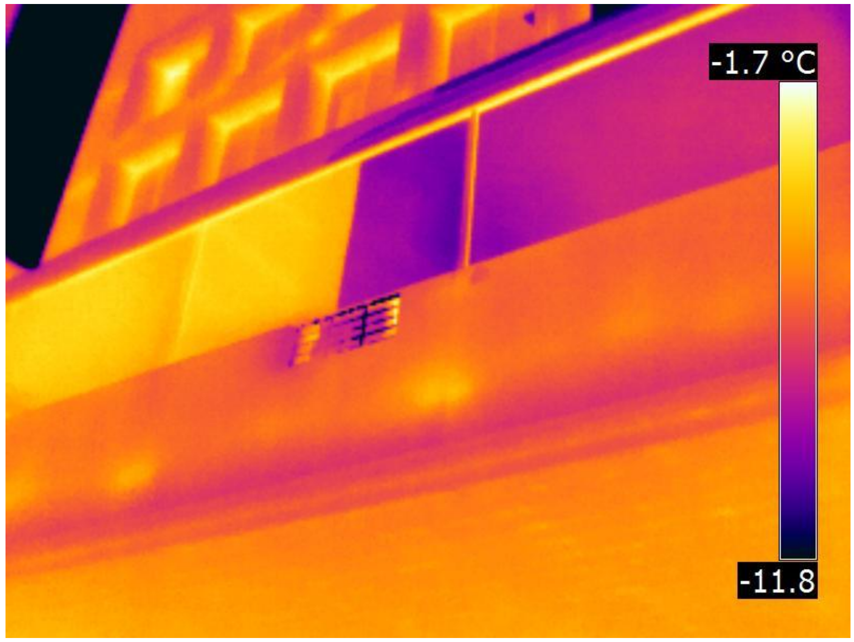


Photograph #40:

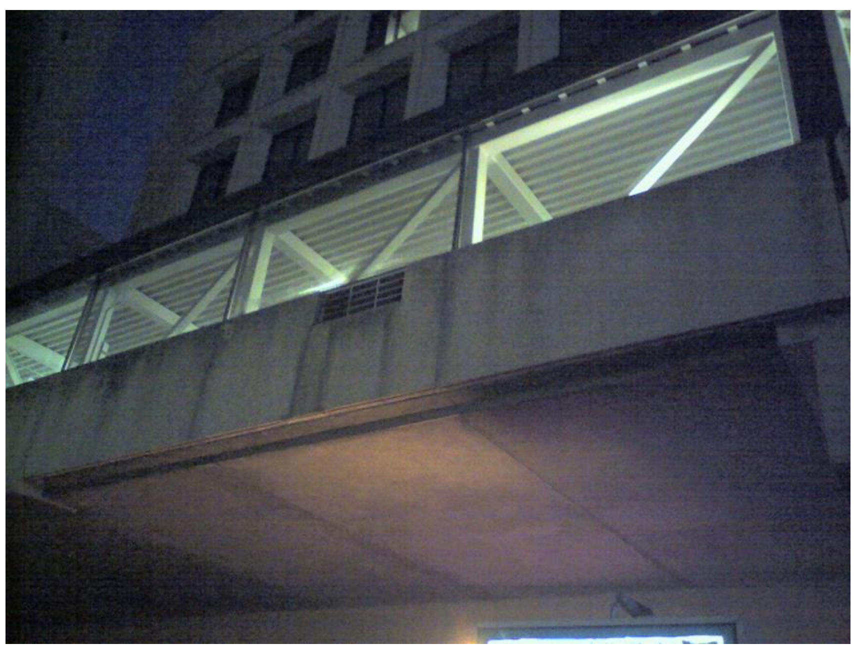


Photograph #41:

Detail view of north elevation.

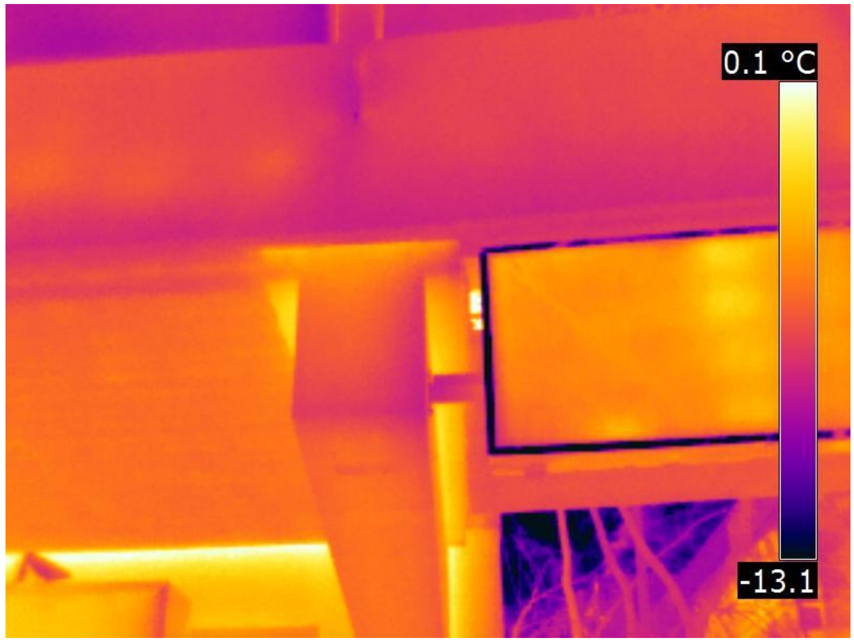


Photograph #42:



Photograph #43:

Detail view at east support.



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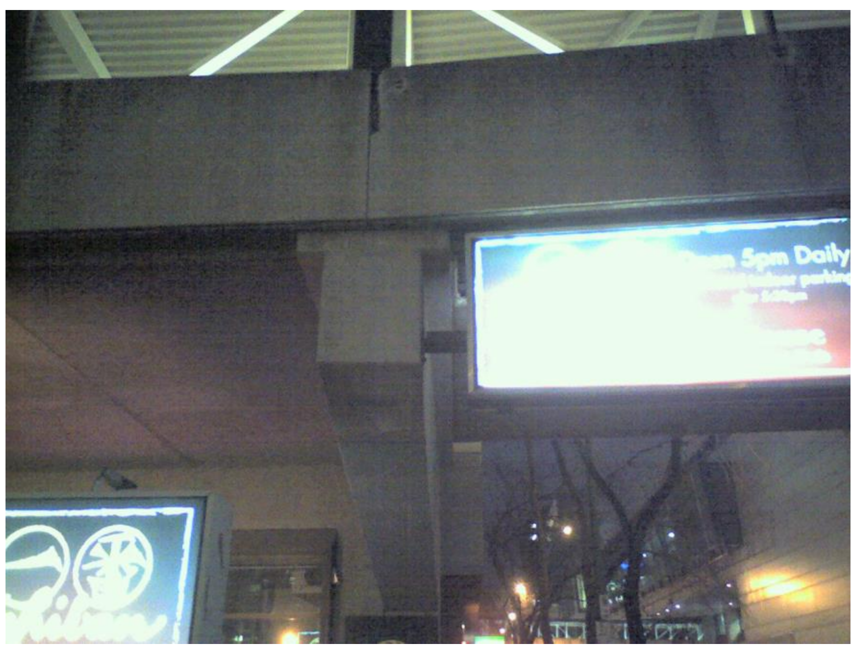
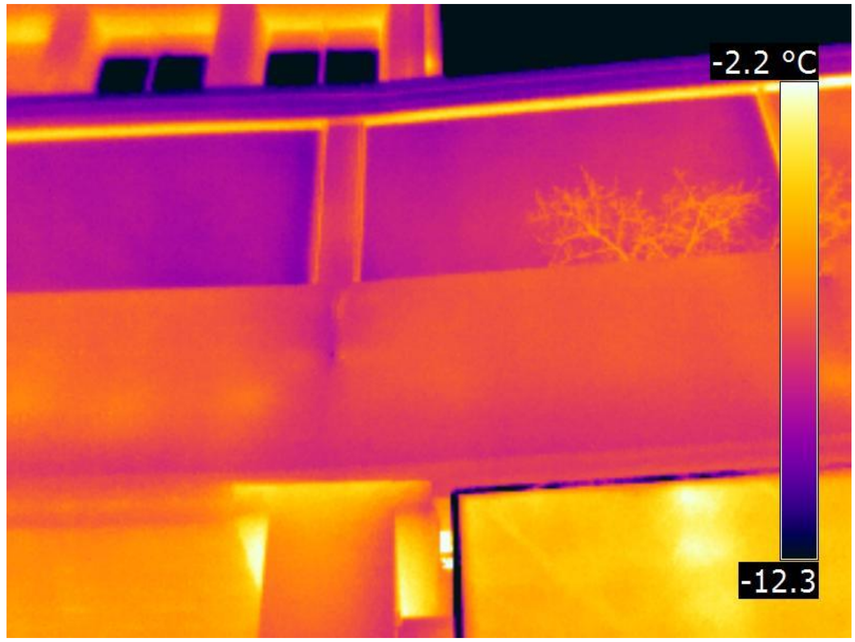


Photograph #45:

Detail view at east support.



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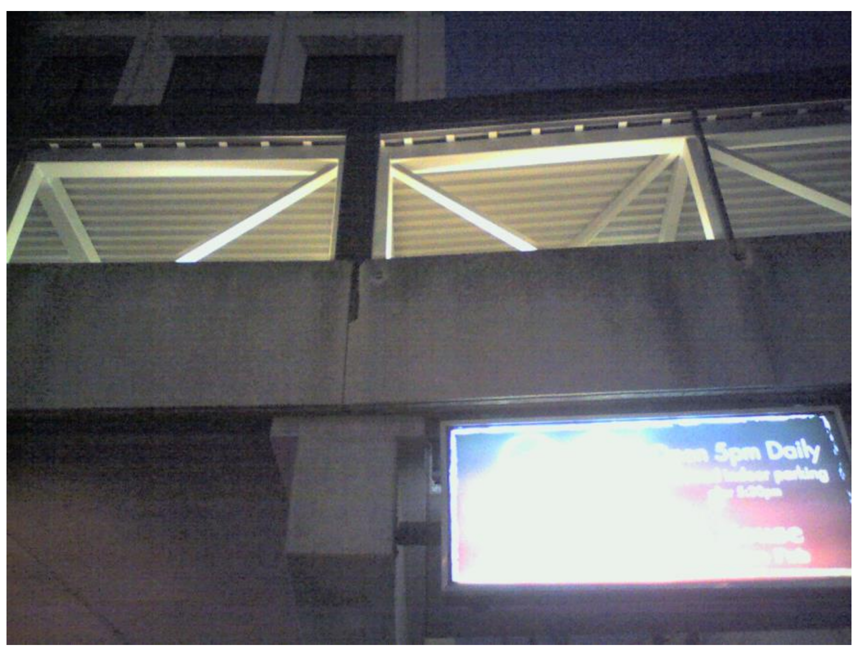
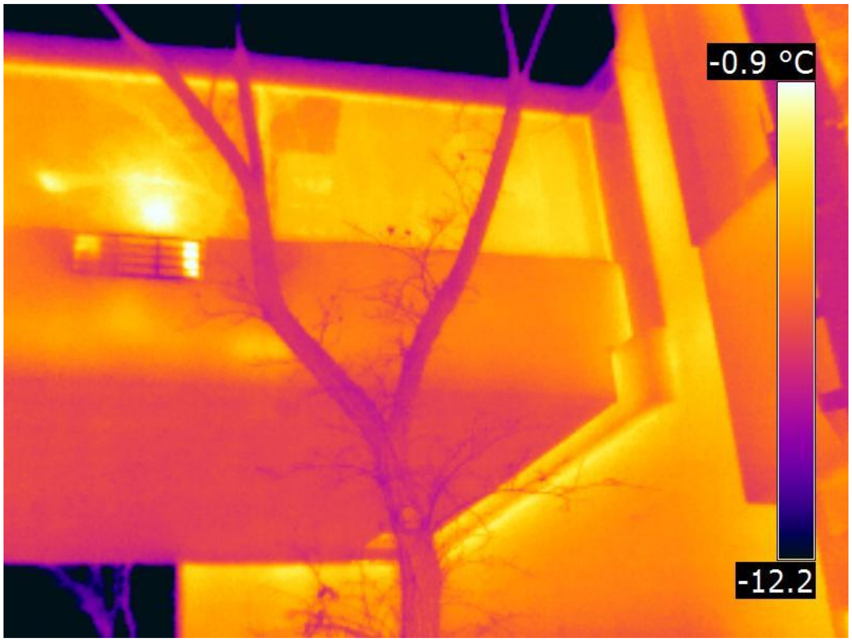
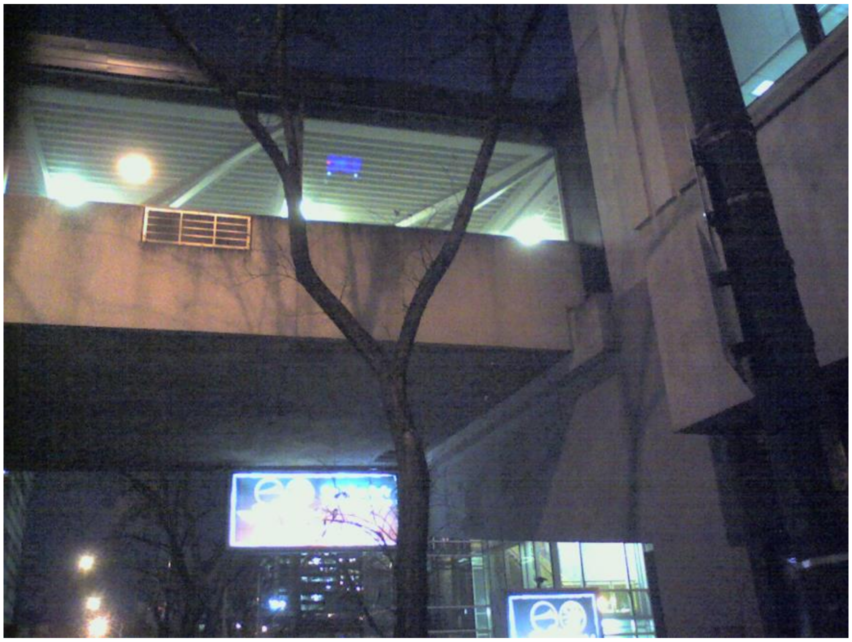


Photograph #47:

Overall view at east end of skywalk.

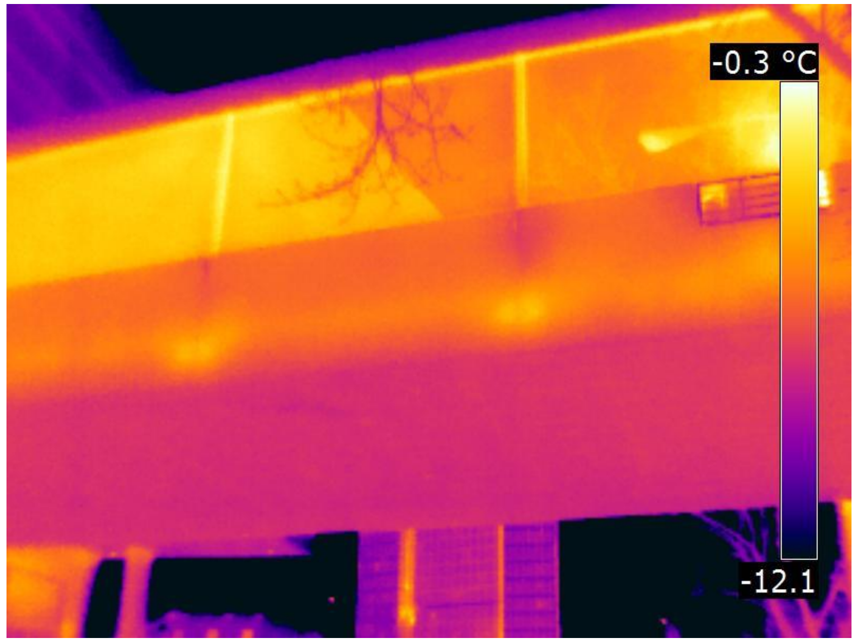


Photograph #48:



Photograph #49:

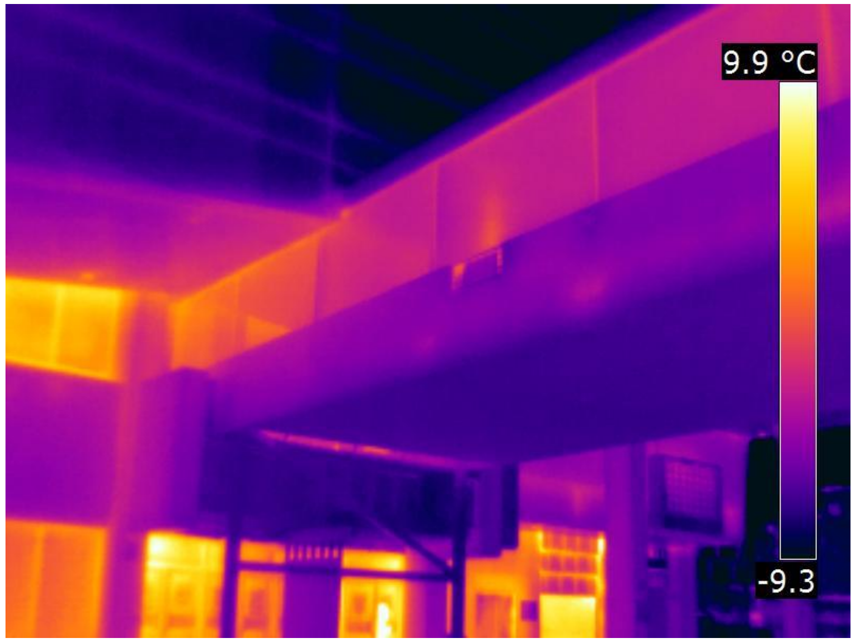
Partial south elevation.



Photograph #50:

Photograph #51:

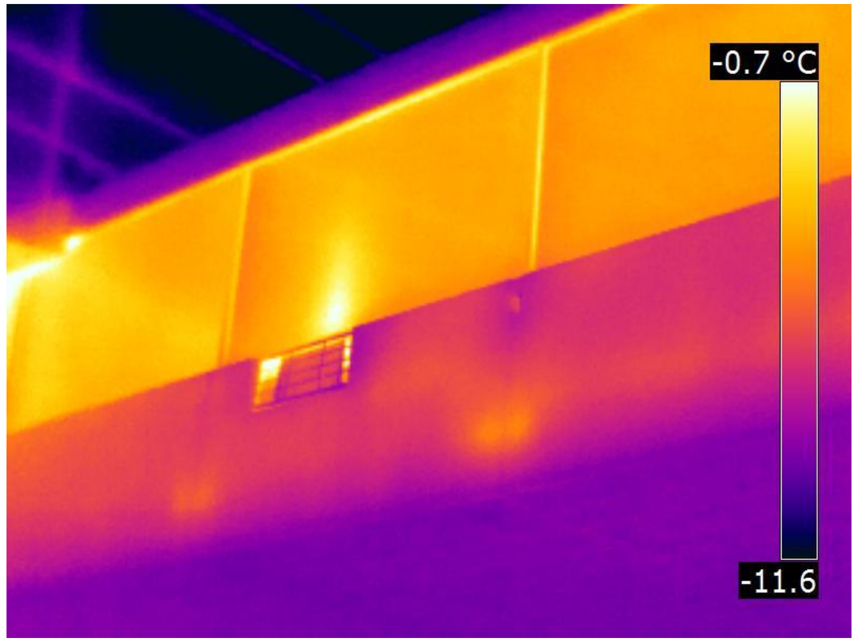
Partial south elevation.



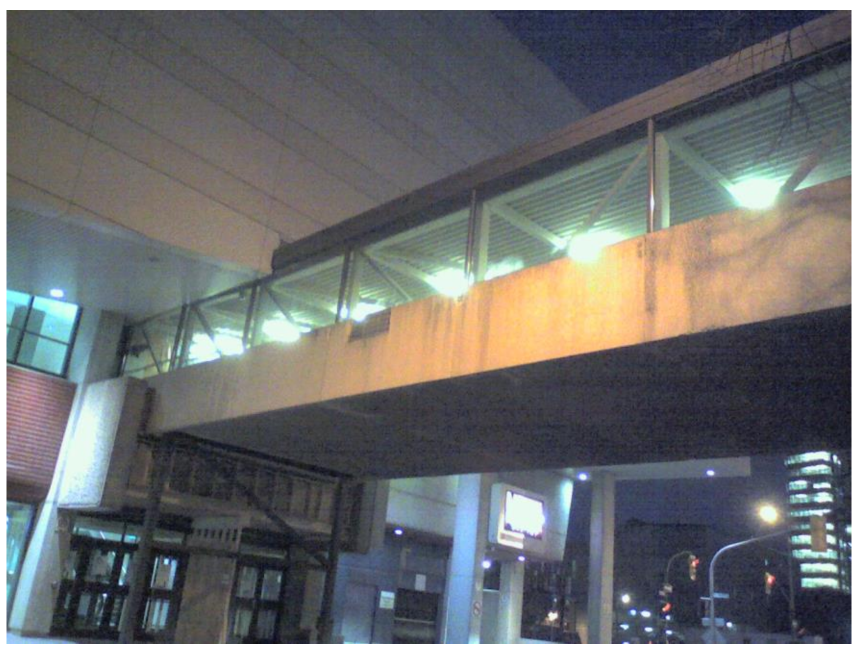
Photograph #52:

Photograph #53:

Detail view of south elevation showing air leakage and thermal brifdging.

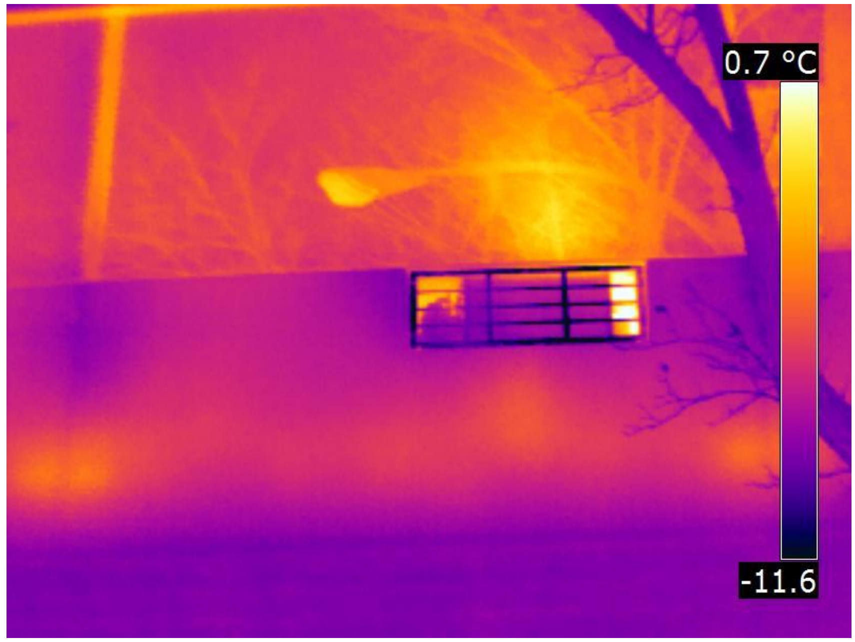


Photograph #54:

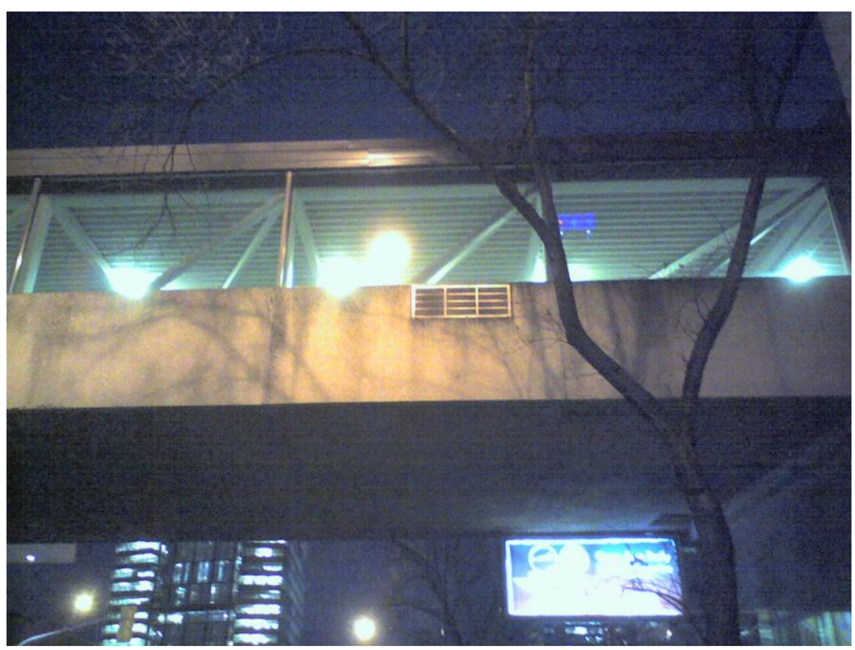


Photograph #55:

Detail view of mechanical unit showing air leakage.

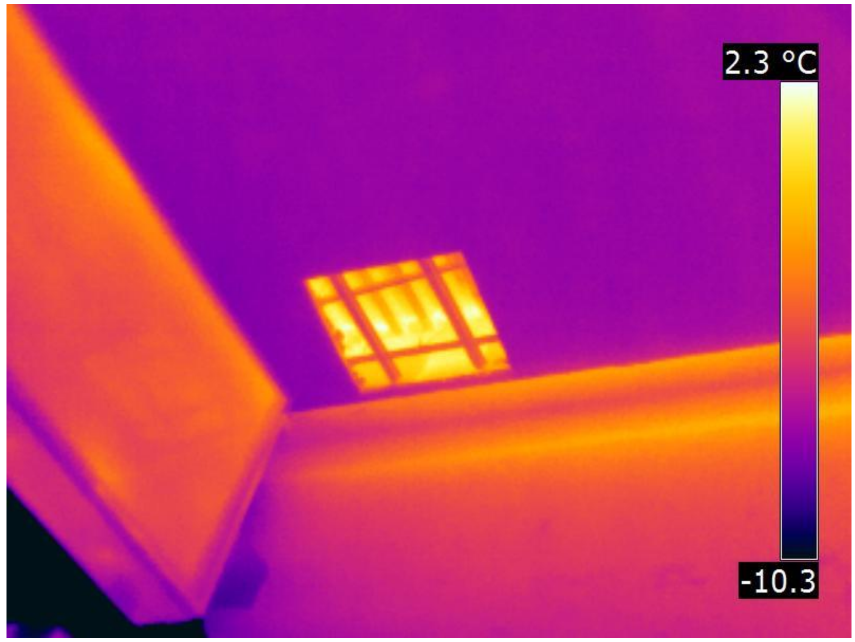


Photograph #56:

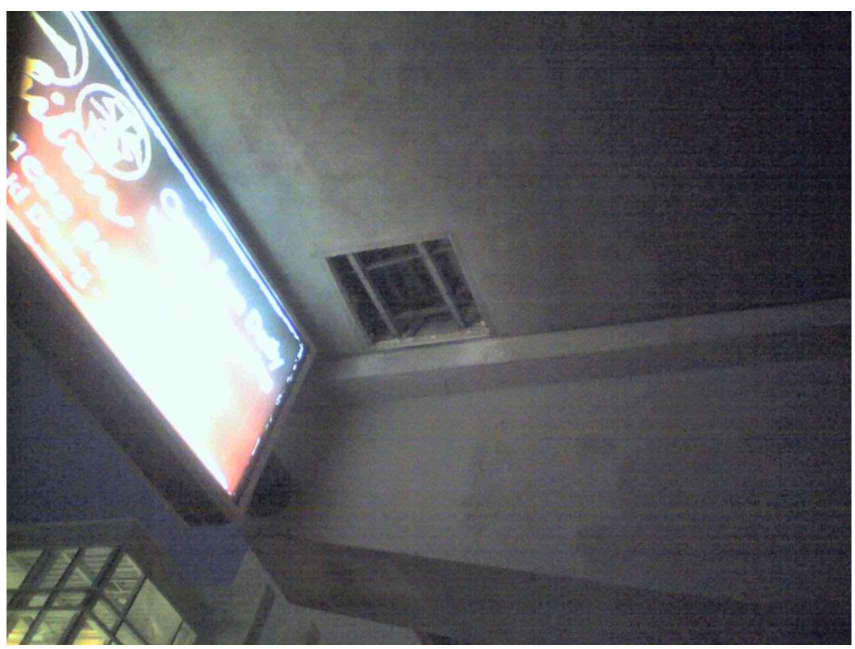


Photograph #57:

Detail view at east end of soffit. Note elevated temperature within soffit.

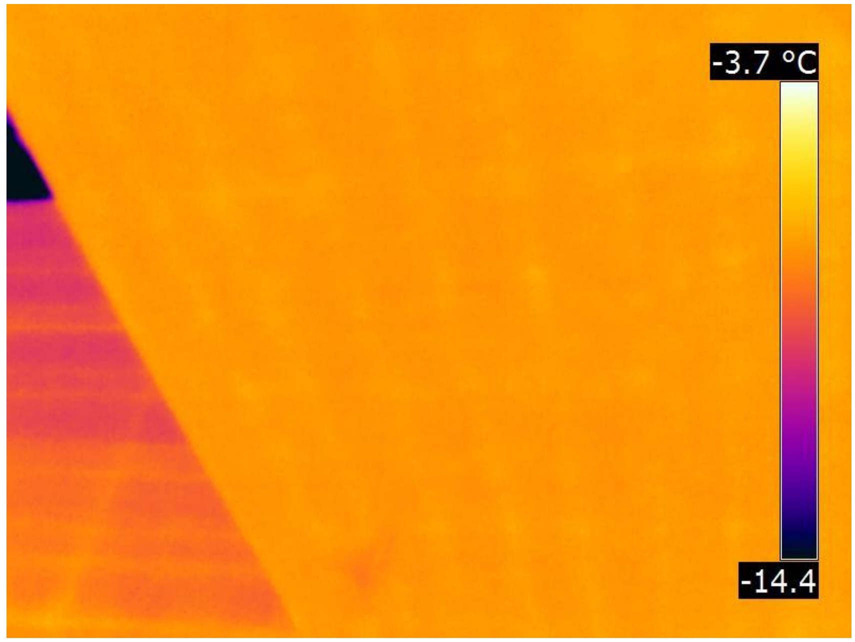


Photograph #58:

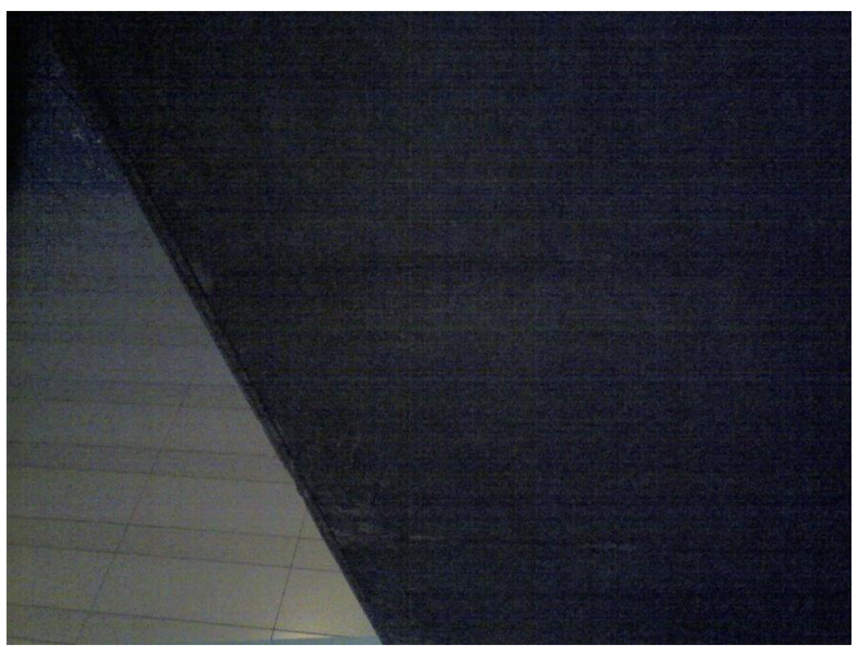


Photograph #59:

Detail view of soffit showing thermal bridging at support members.

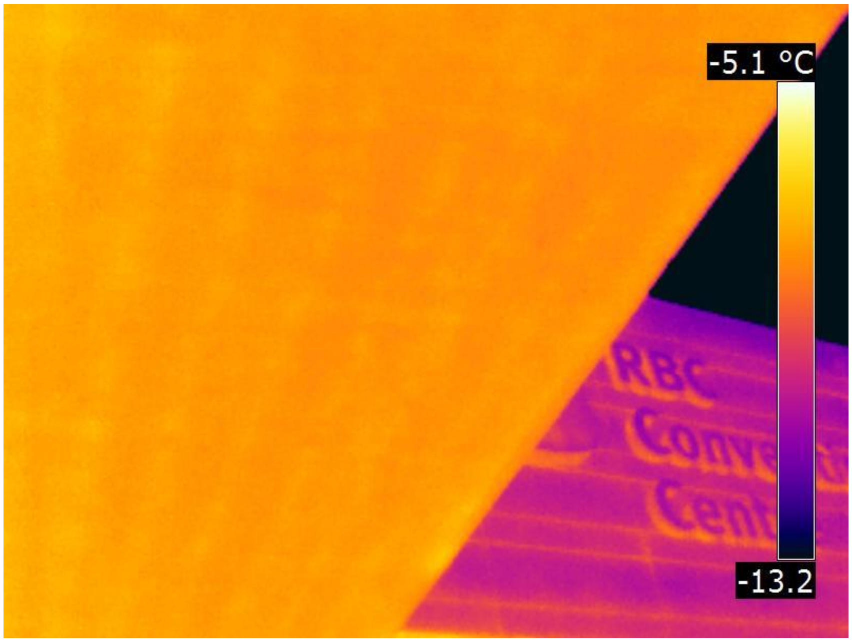


Photograph #60:



Photograph #61:

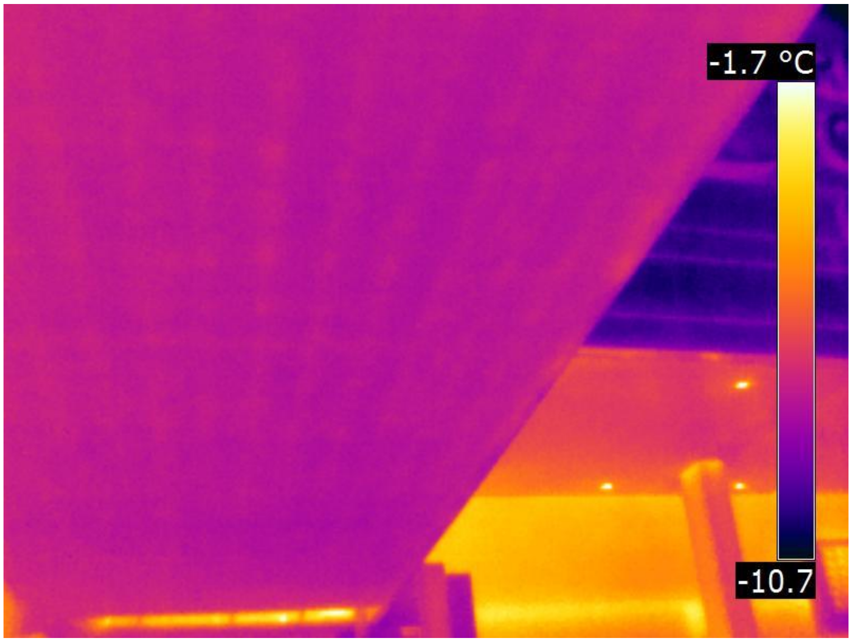
Detail view of soffit showing thermal bridging at support members.



Photograph #62:

Photograph #63:

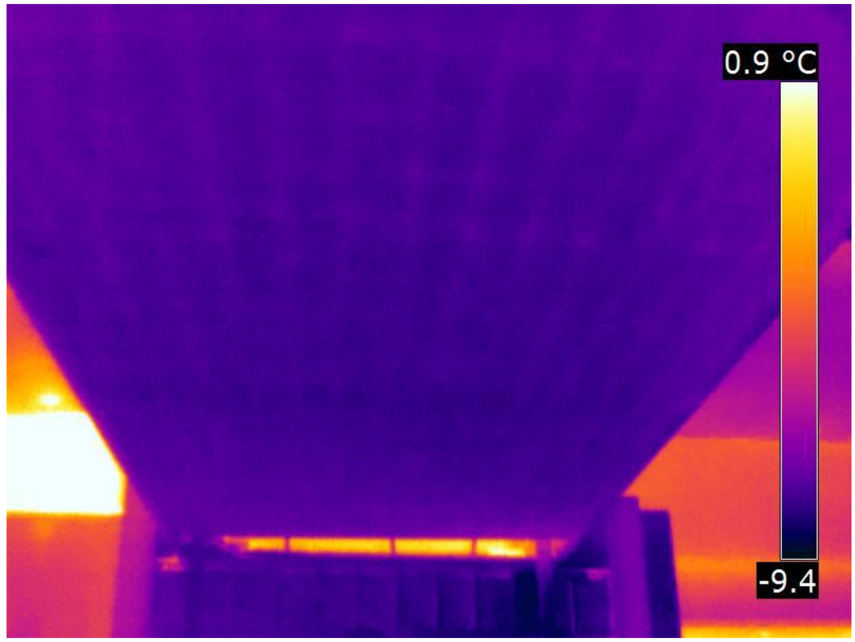
Detail view of soffit showing thermal bridging at support members.



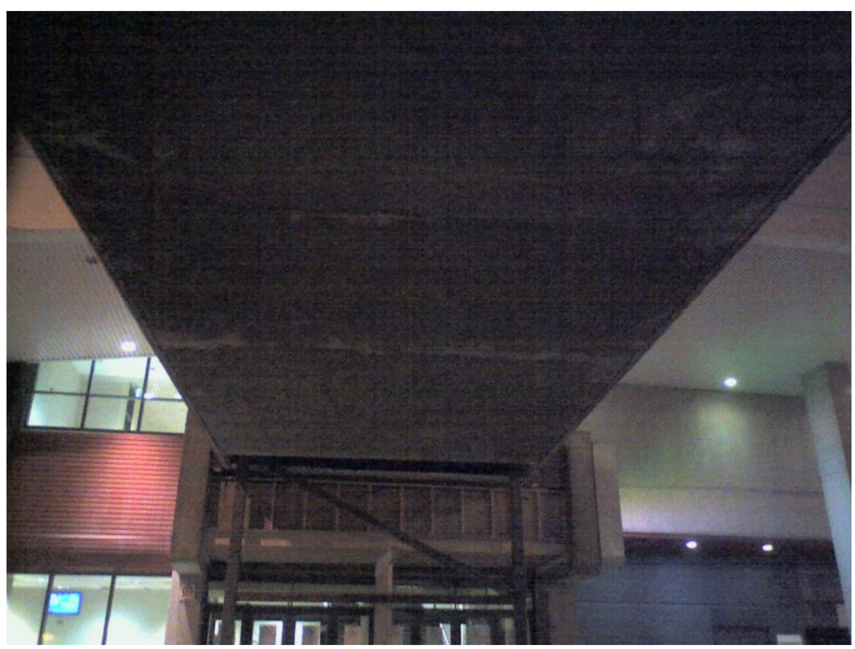
Photograph #64:

Photograph #65:

Detail view of soffit showing thermal bridging at support members.

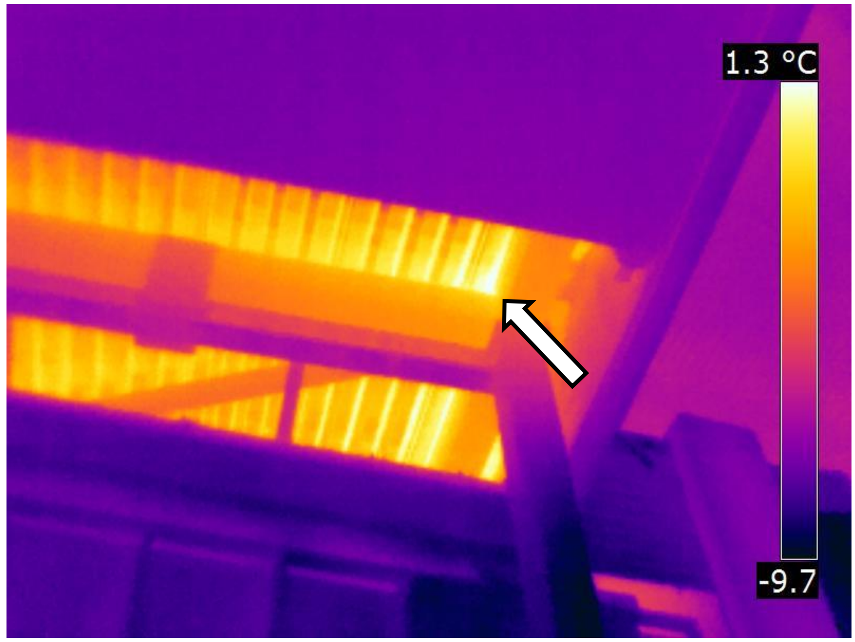


Photograph #66:



Photograph #67:

Detail view of open soffit at west end. Note elevated temperature and probable air leakage location.



Photograph #68:

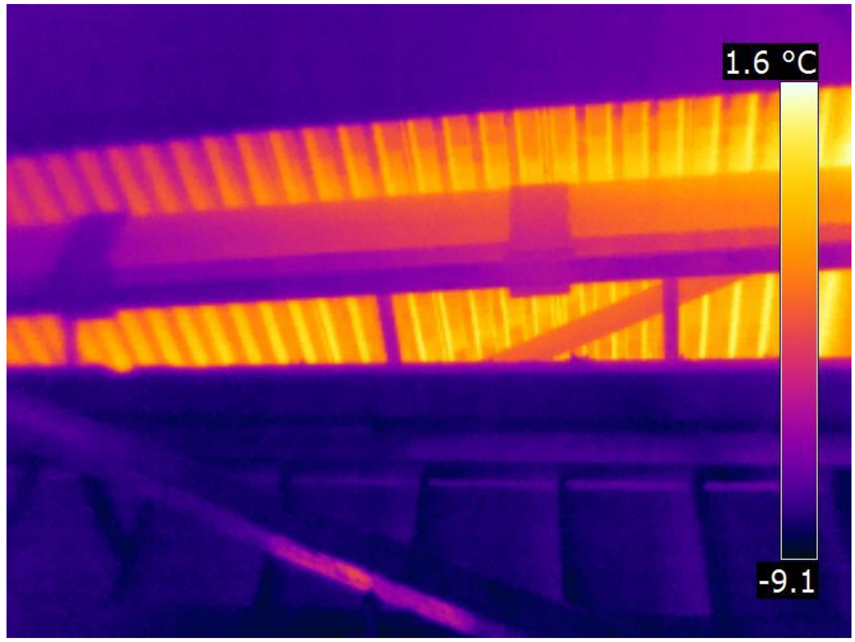
Photograph #69:

Detail view of open soffit at west end.

Photograph #70:

Photograph #71:

Detail view of open soffit at west end.

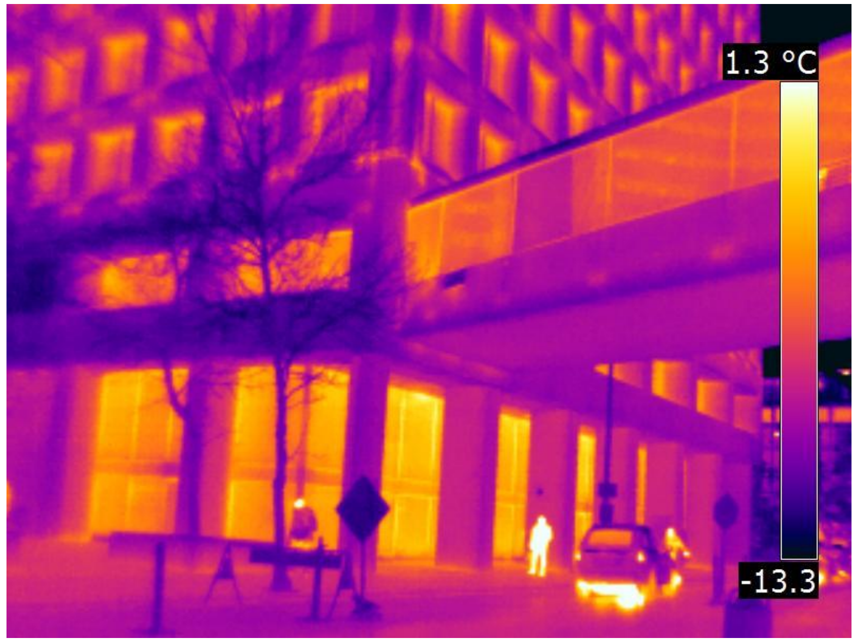


Photograph #72:

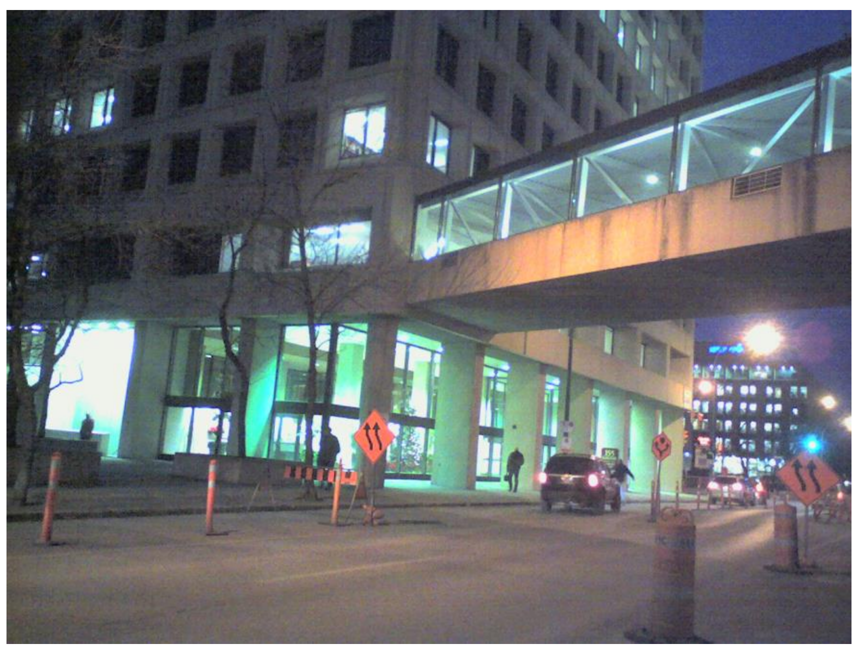
5.2 South Skywalk to Lakeview Building

Photograph #73:

Partial north elevation.

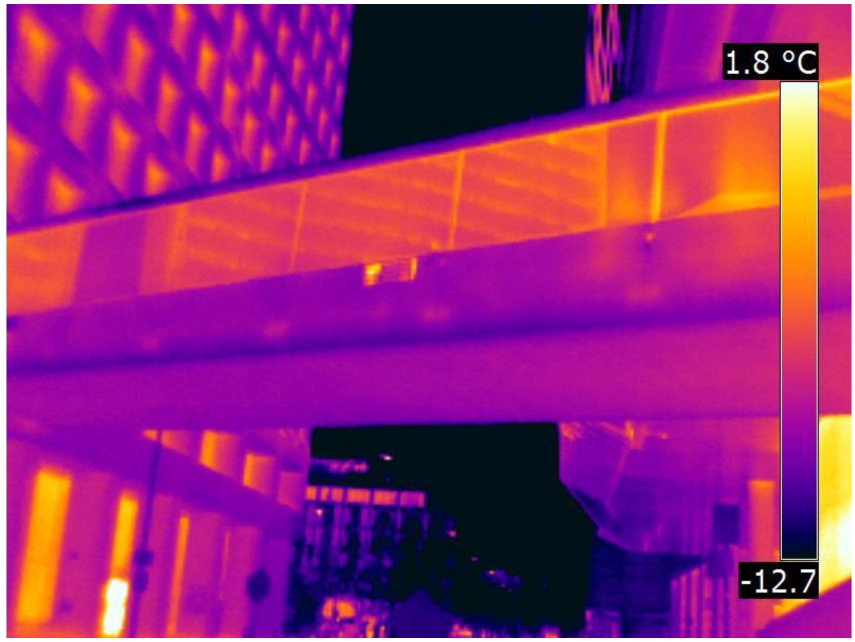


Photograph #74:

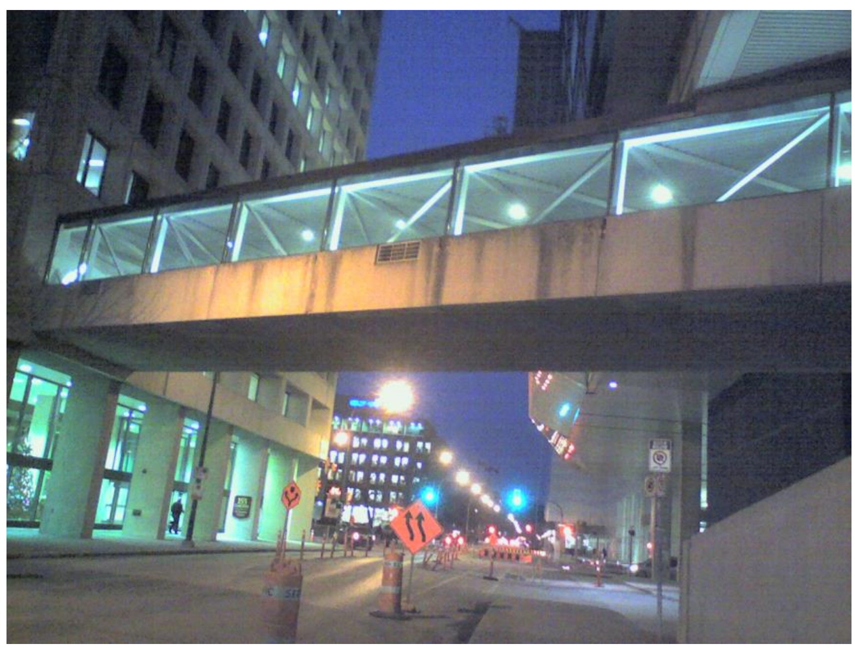


Photograph #75:

Partial north elevation.

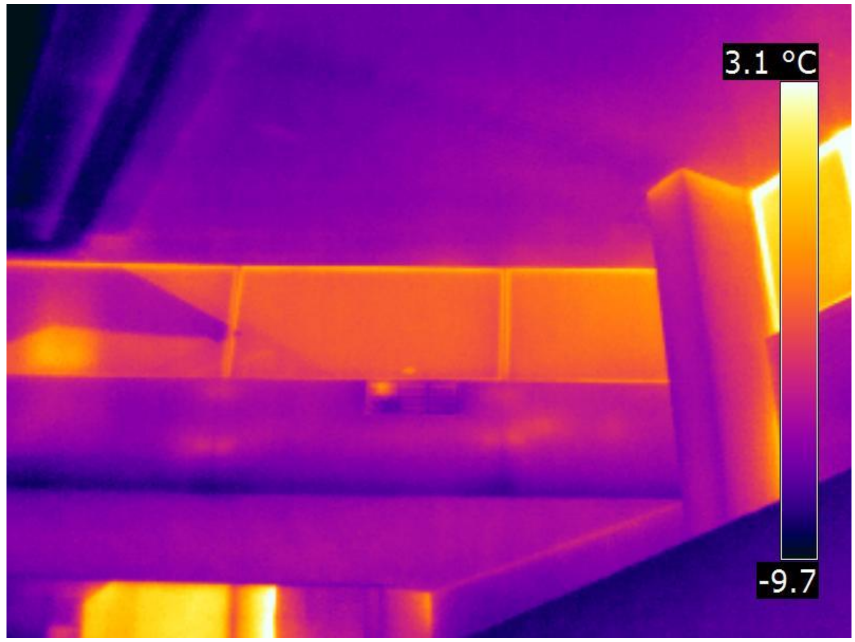


Photograph #76:

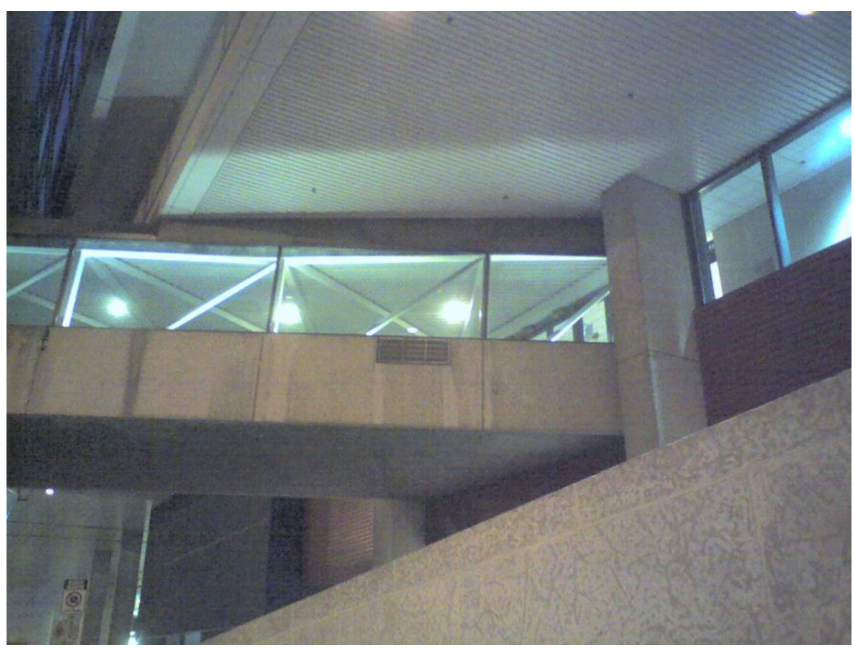


Photograph #77:

Partial north elevation.

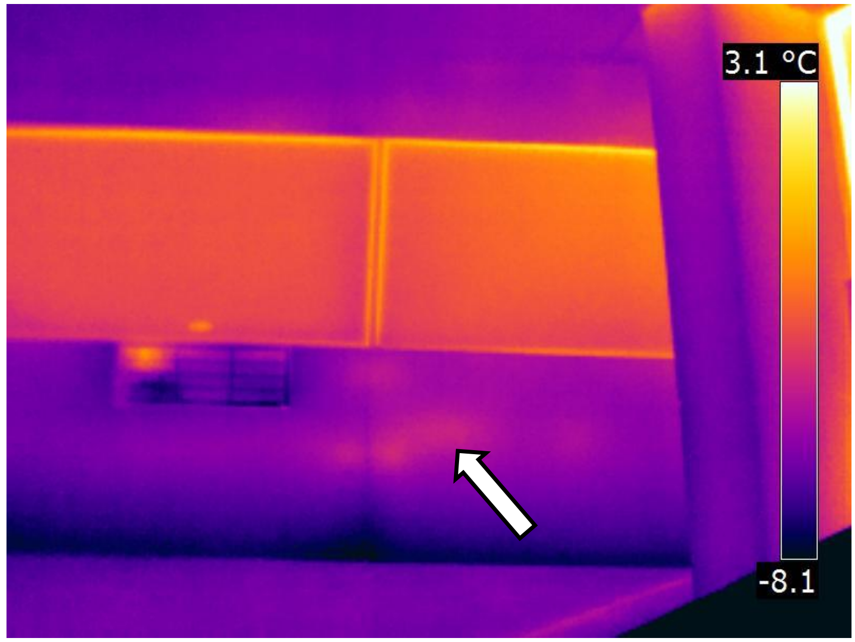


Photograph #78:



Photograph #79:

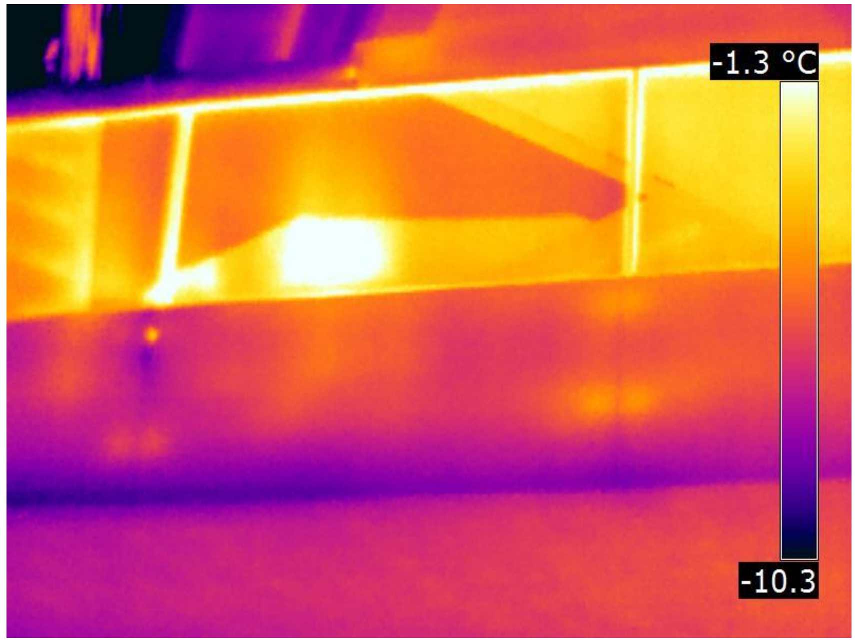
Detailed view of north elevation. Note thermal anomaly likely caused by air leakage into the wall assembly.



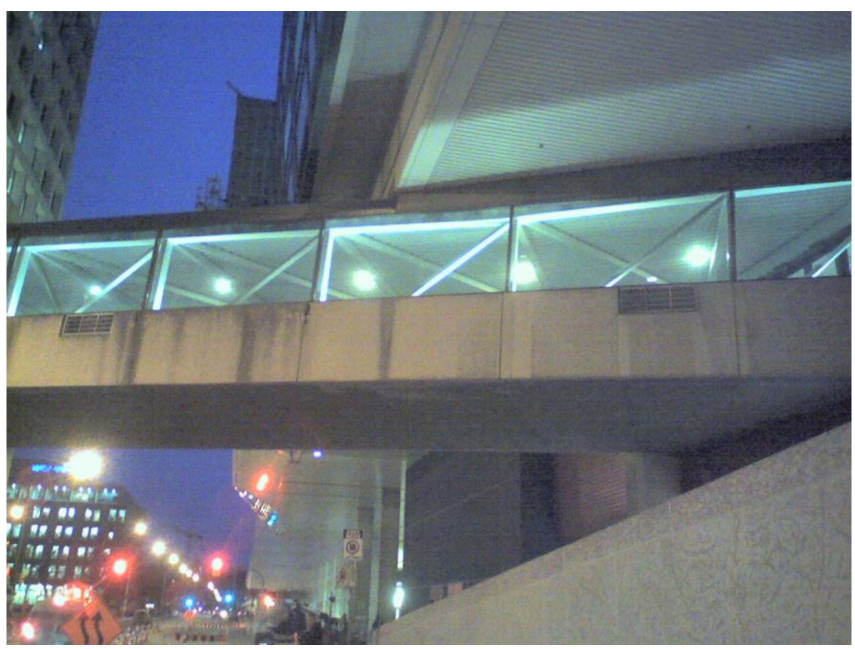
Photograph #80:

Photograph #81:

Detailed view of north elevation.

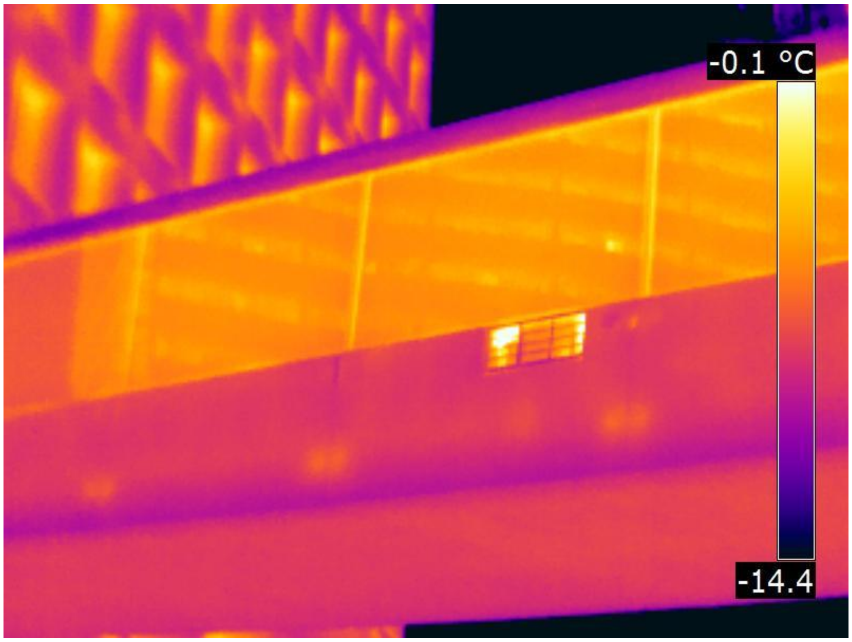


Photograph #82:



Photograph #83:

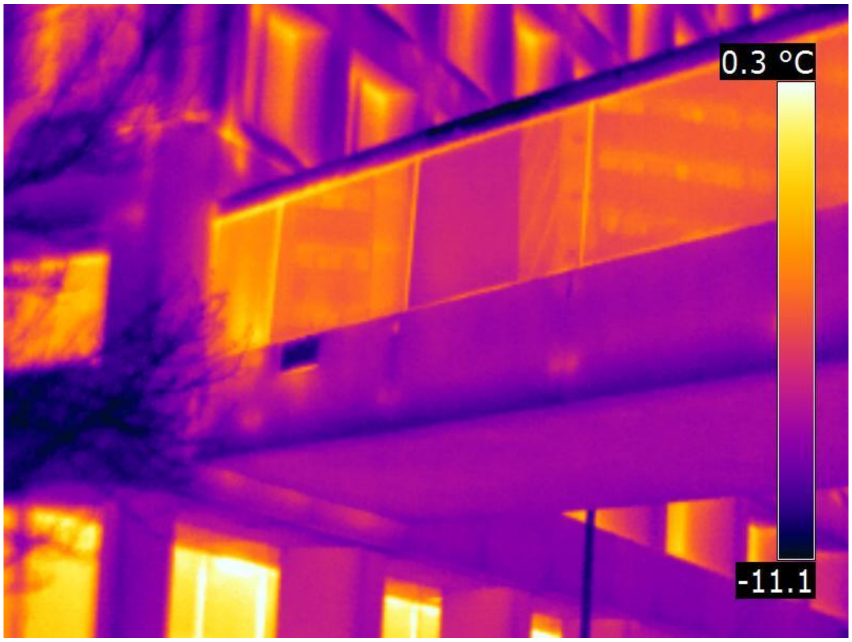
Detailed view of north elevation.



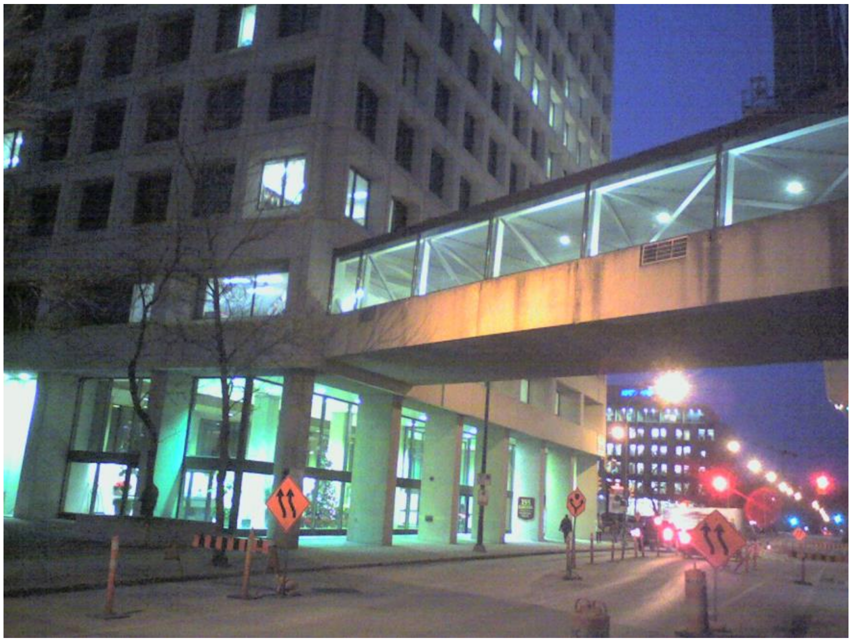
Photograph #84:

Photograph #85:

Detailed view of north elevation.



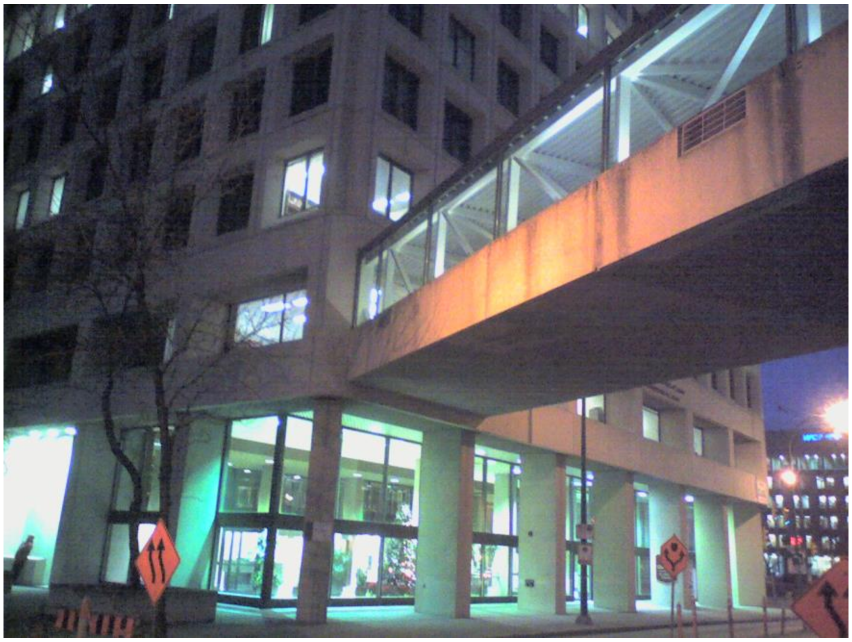
Photograph #86:



Photograph #87:

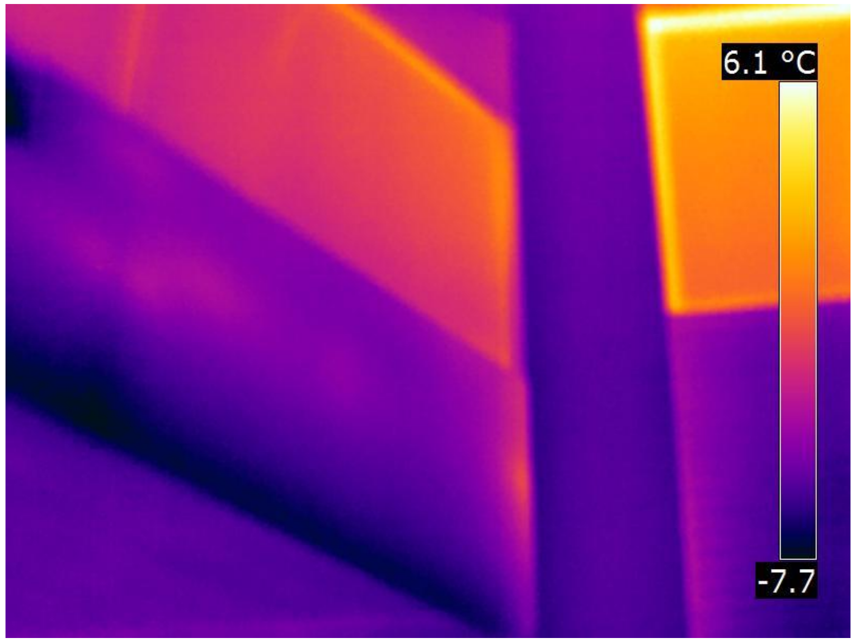
Detailed view of north elevation. Note apparent air leakage at sill of first window.

Photograph #88:



Photograph #89:

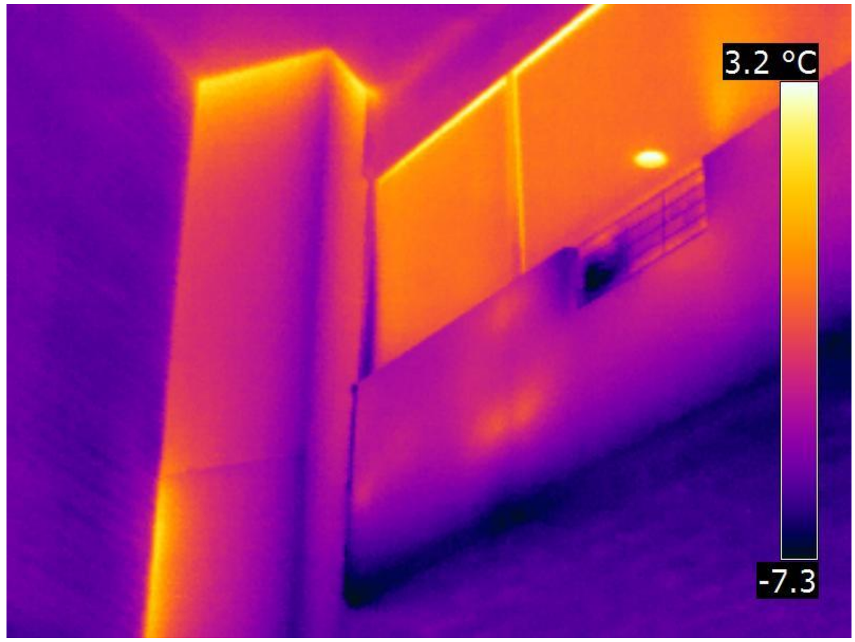
Detail view of north elevation.



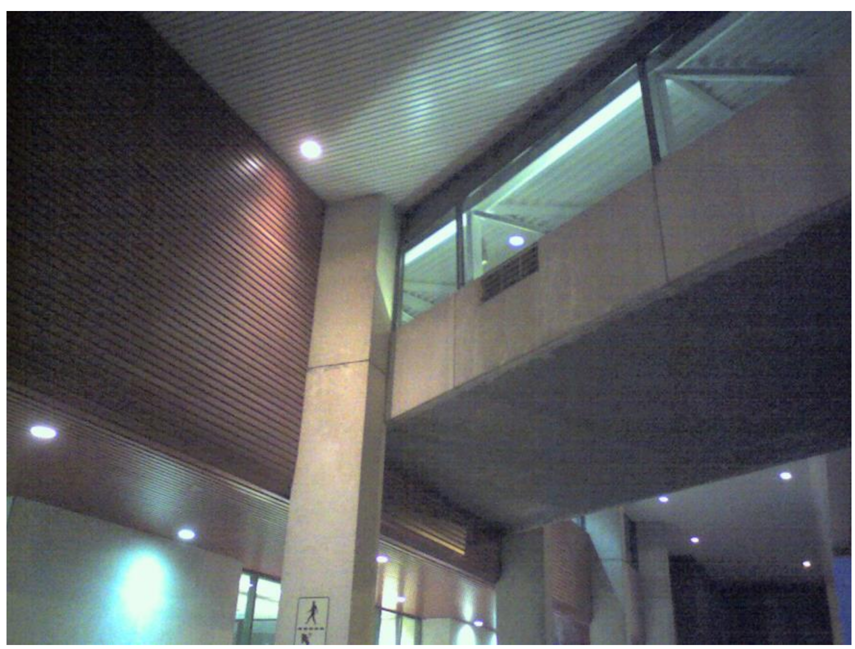
Photograph #90:

Photograph #91:

Detail view of south elevation. Note apparent air leakage at column.

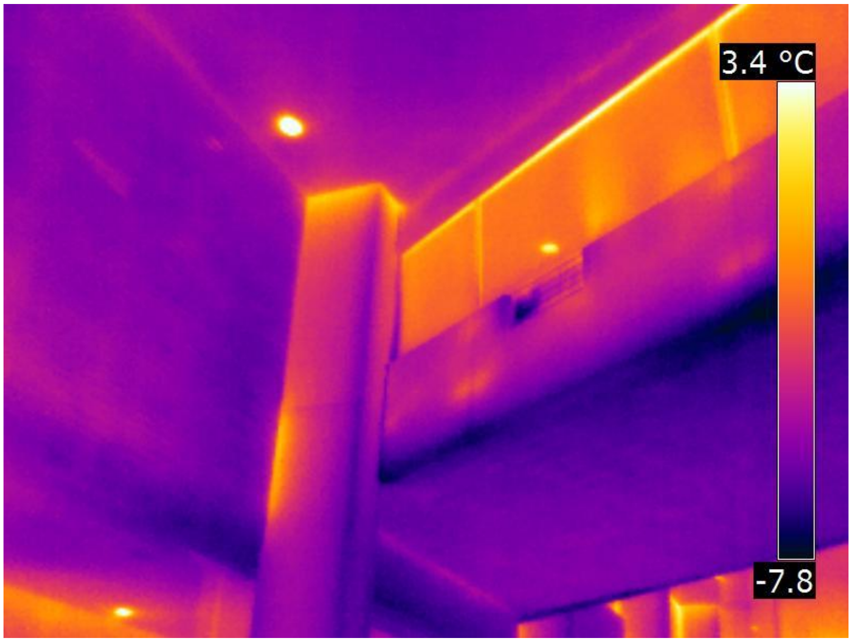


Photograph #92:



Photograph #93:

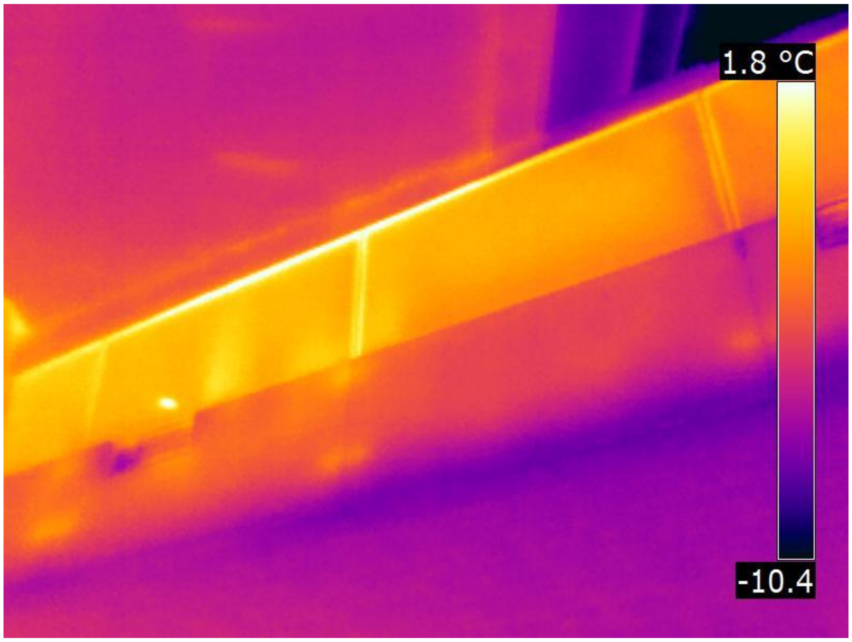
Detail view of south elevation. Note apparent air leakage at column.



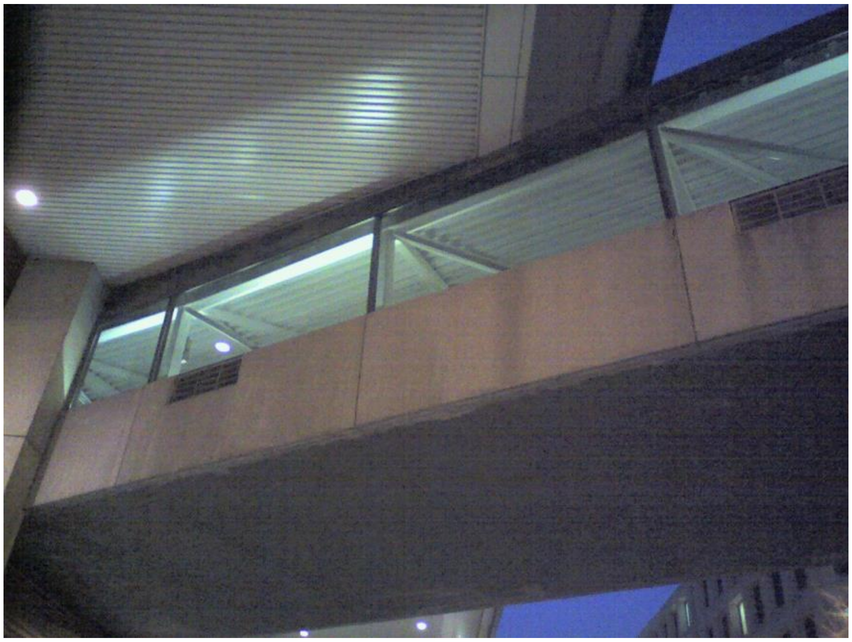
Photograph #94:

Photograph #95:

Detail view of south elevation. Note several thermal anomalies.

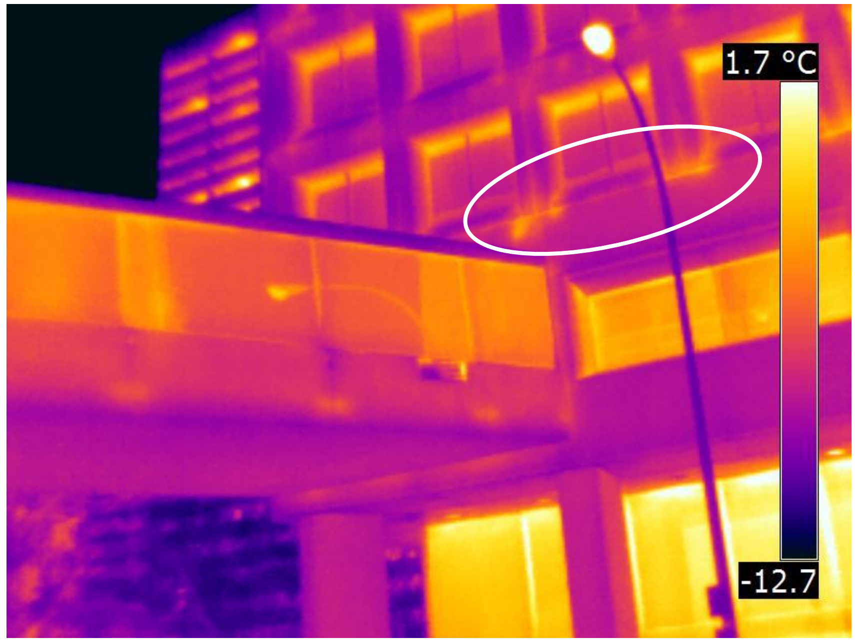


Photograph #96:

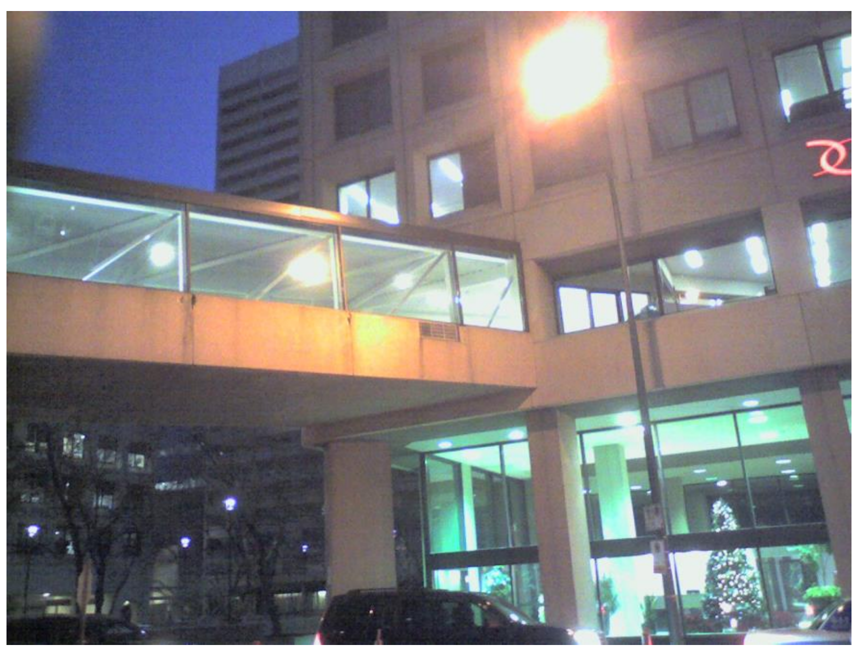


Photograph #97:

Partial south elevation. Note air leakage at precast cladding elements of adjacent building.

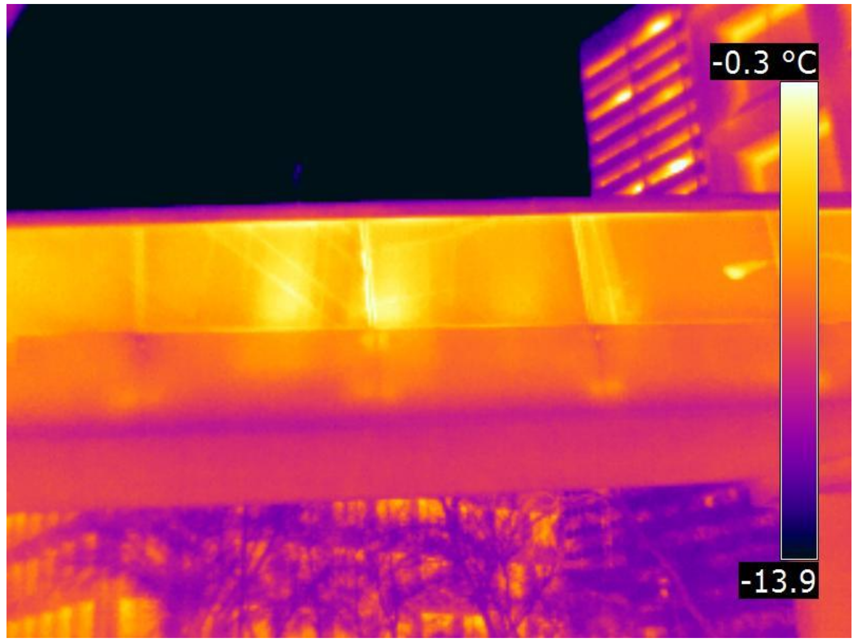


Photograph #98:

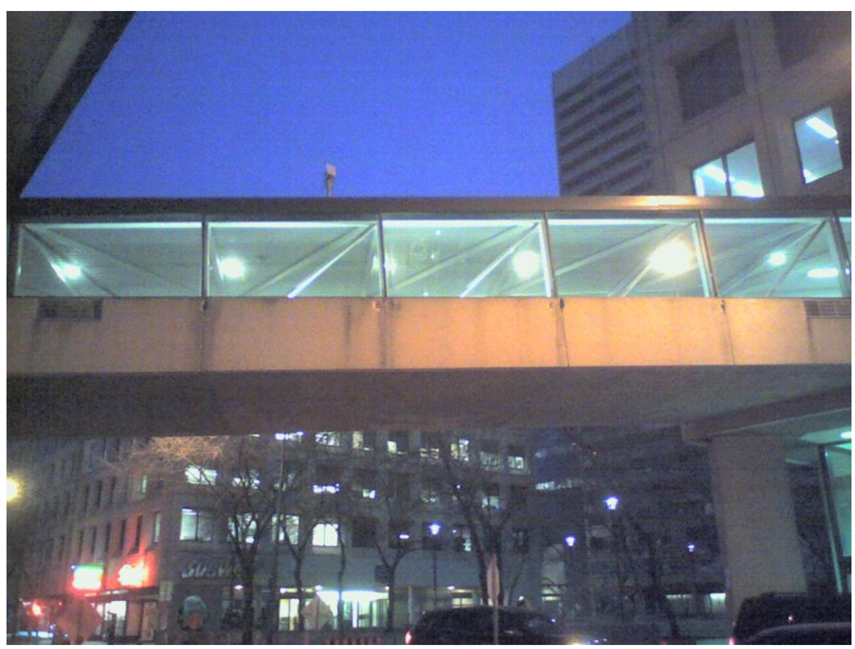


Photograph #99:

Partial south elevation.

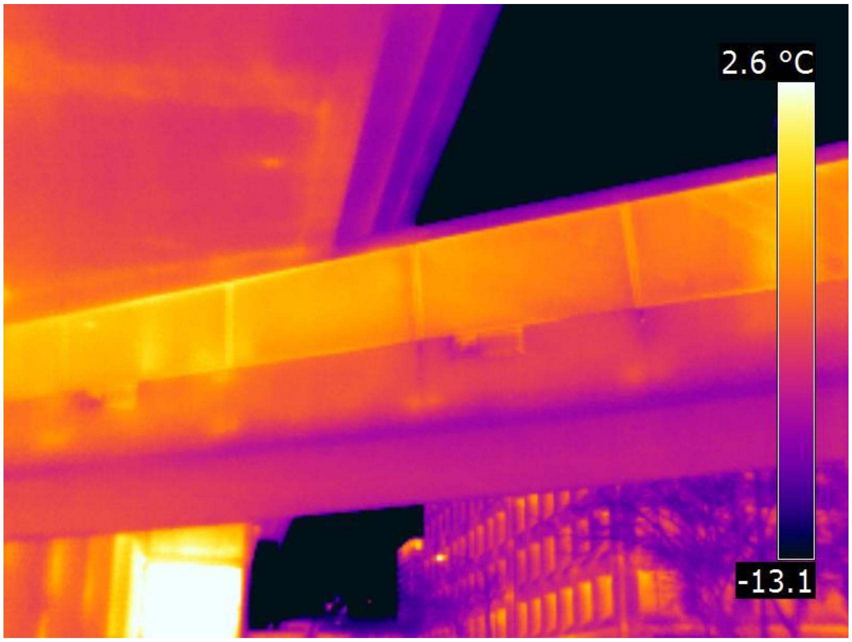


Photograph #100:

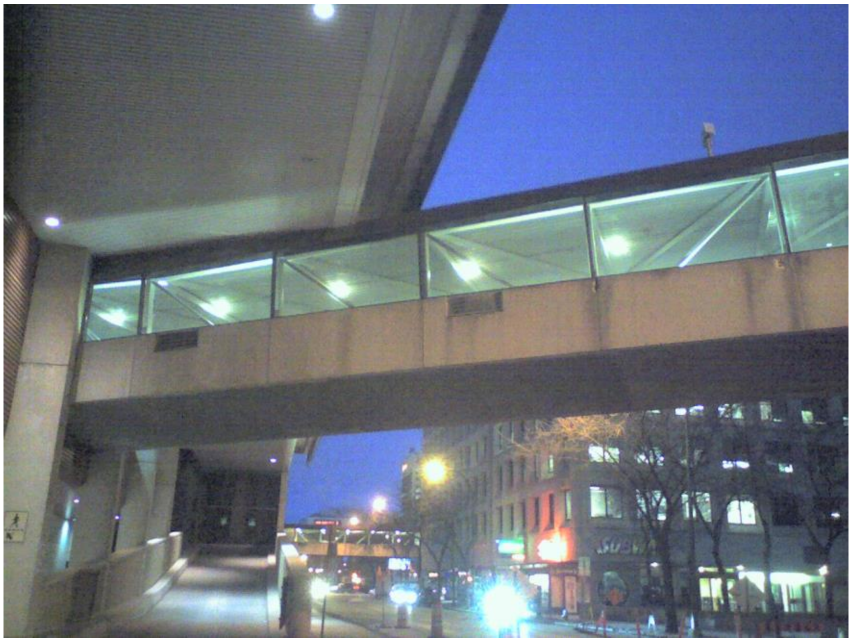


Photograph #101:

Partial south elevation.

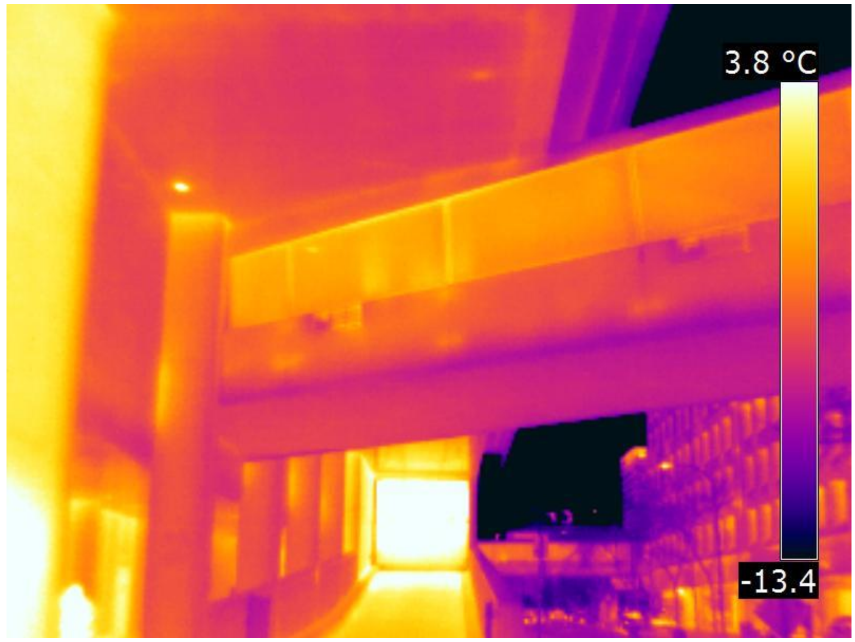


Photograph #102:

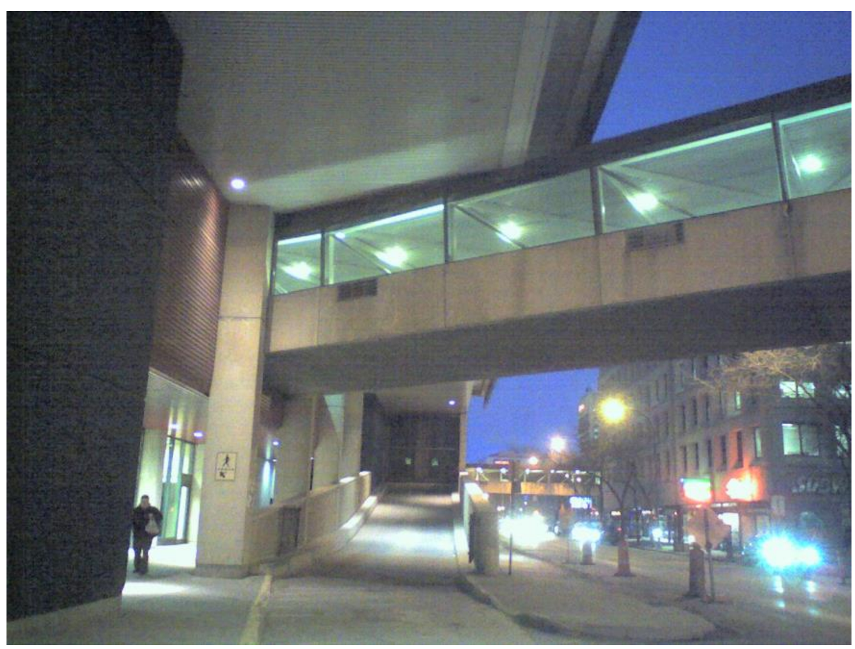


Photograph #103:

Partial south elevation.

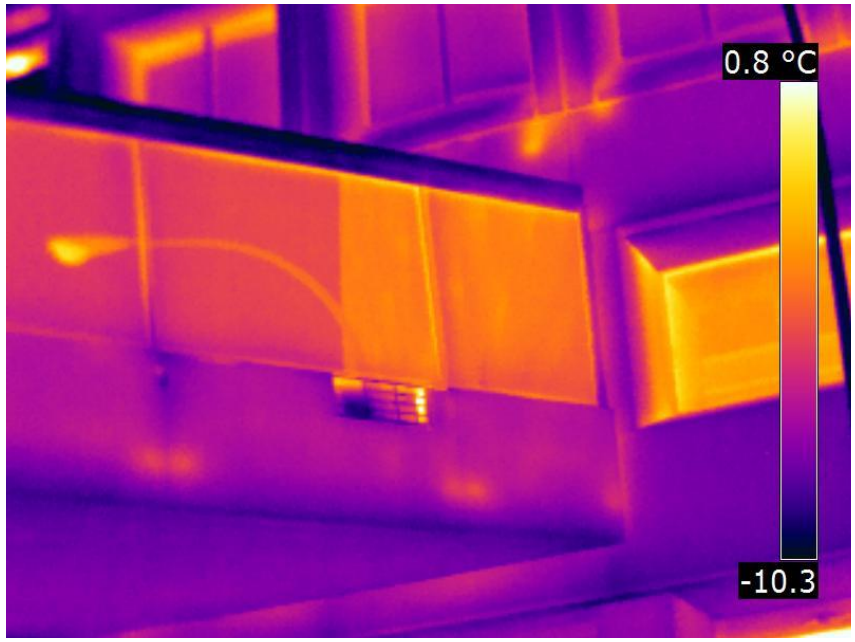


Photograph #104:

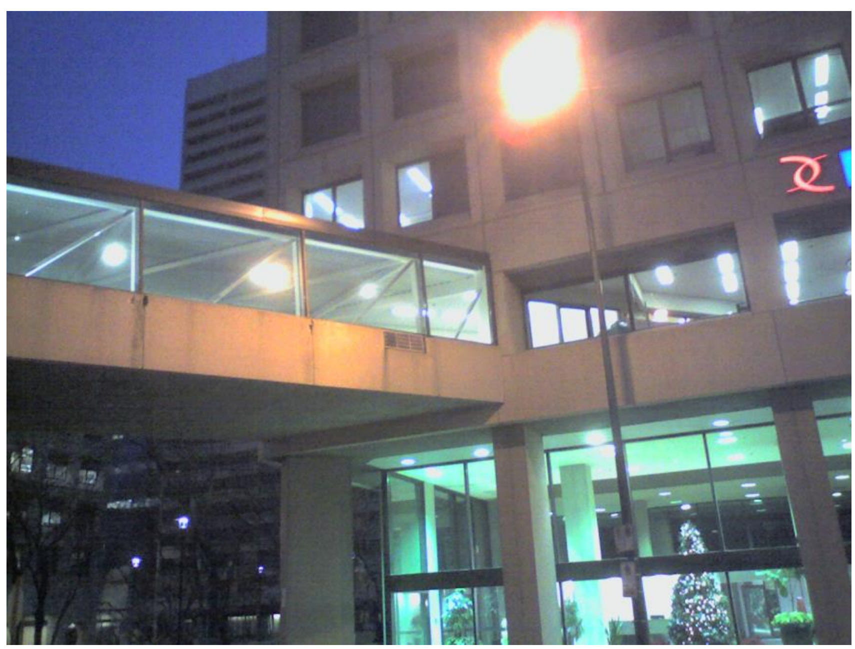


Photograph #105:

Partial south elevation.

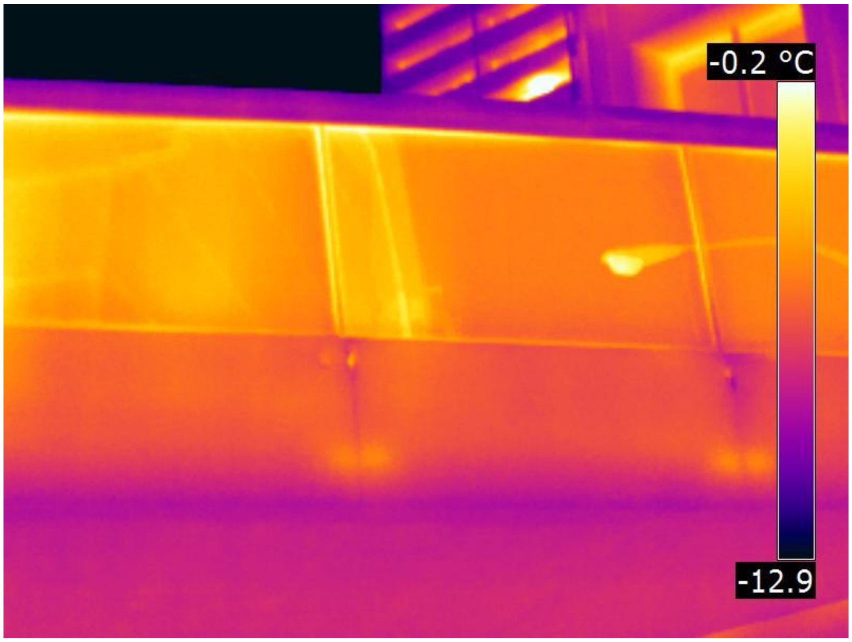


Photograph #106:

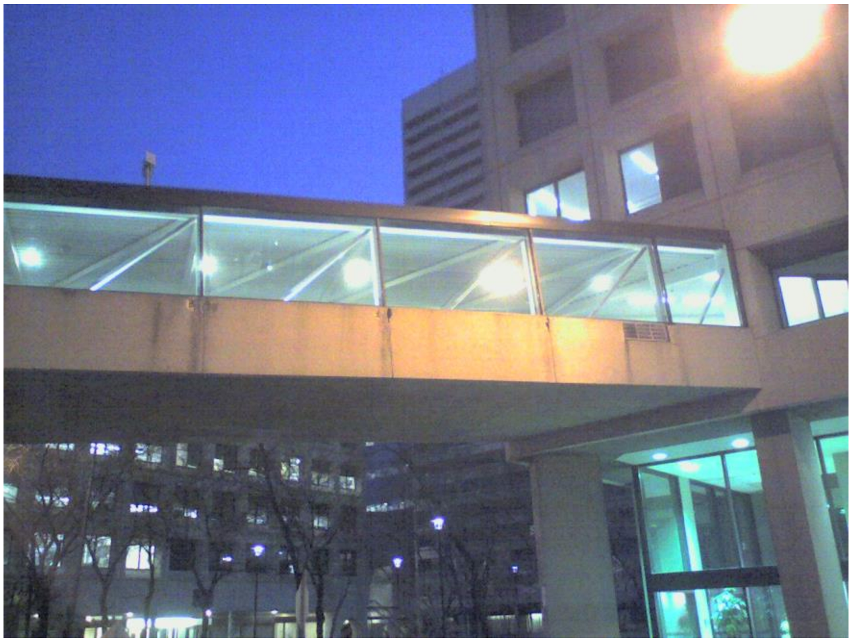


<u>Photograph #107:</u>

Partial south elevation.

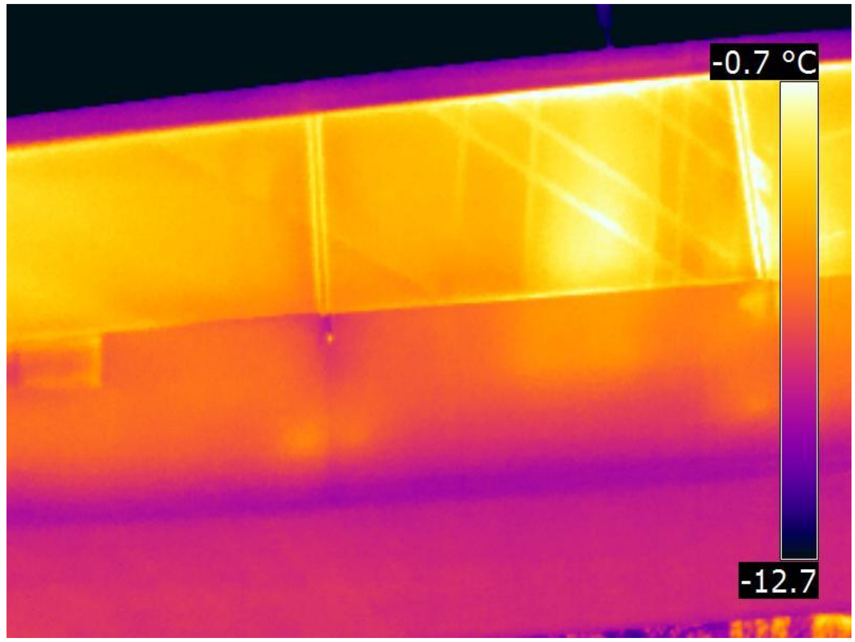


<u>Photograph #108:</u>

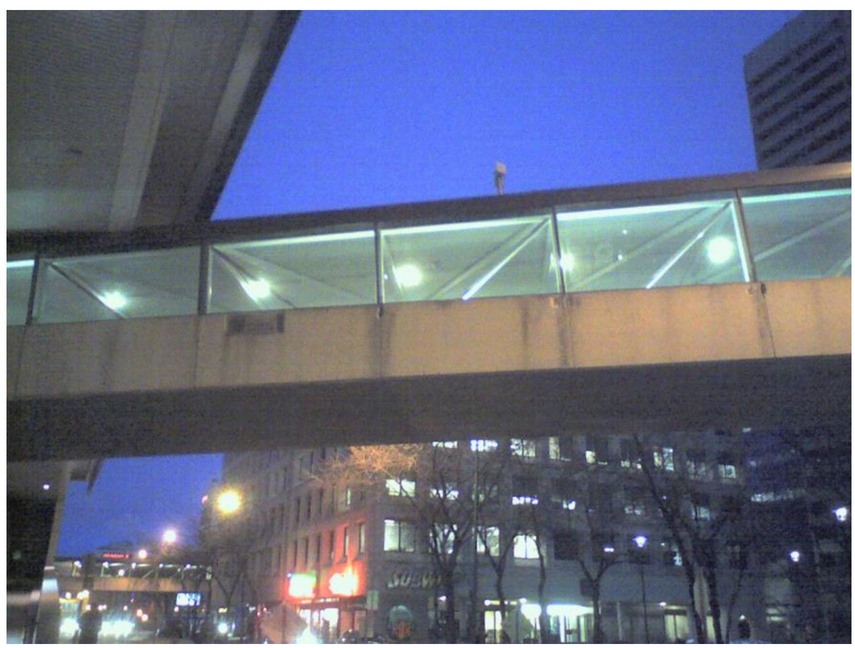


Photograph #109:

Partial south elevation.

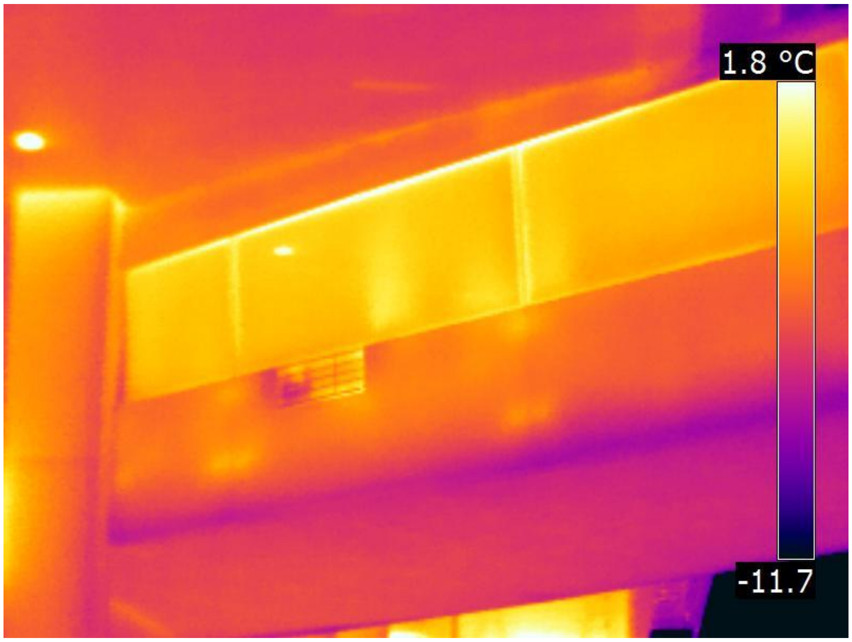


Photograph #110:

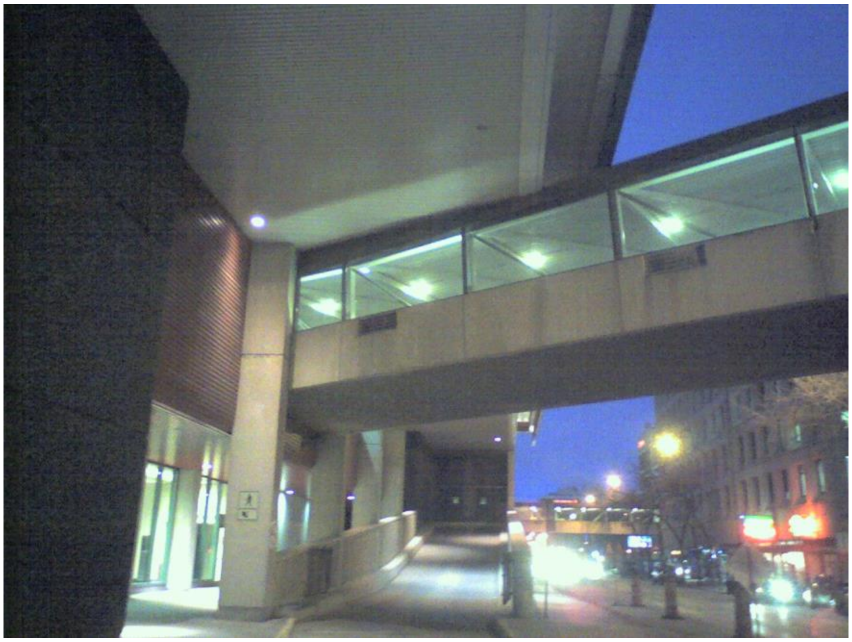


Photograph #111:

Partial south elevation.

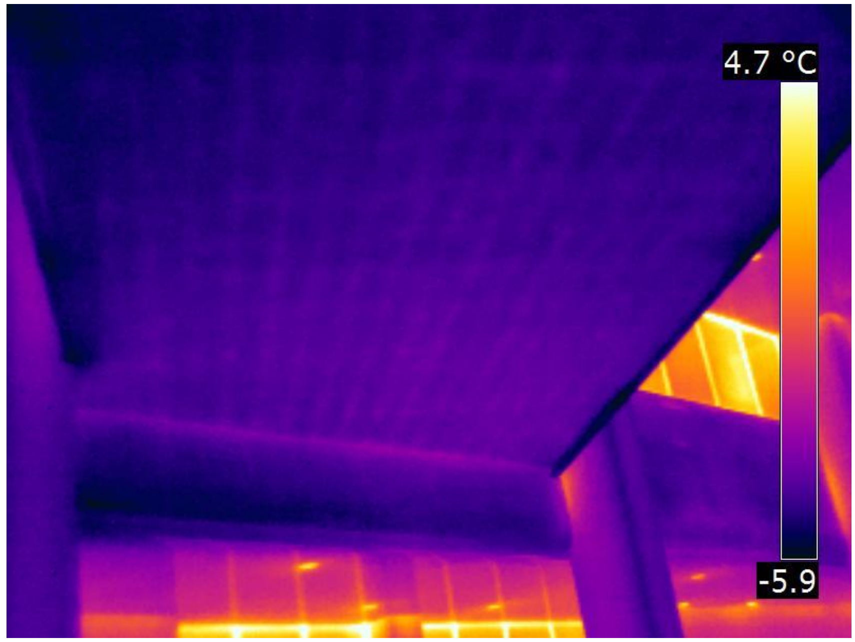


Photograph #112:

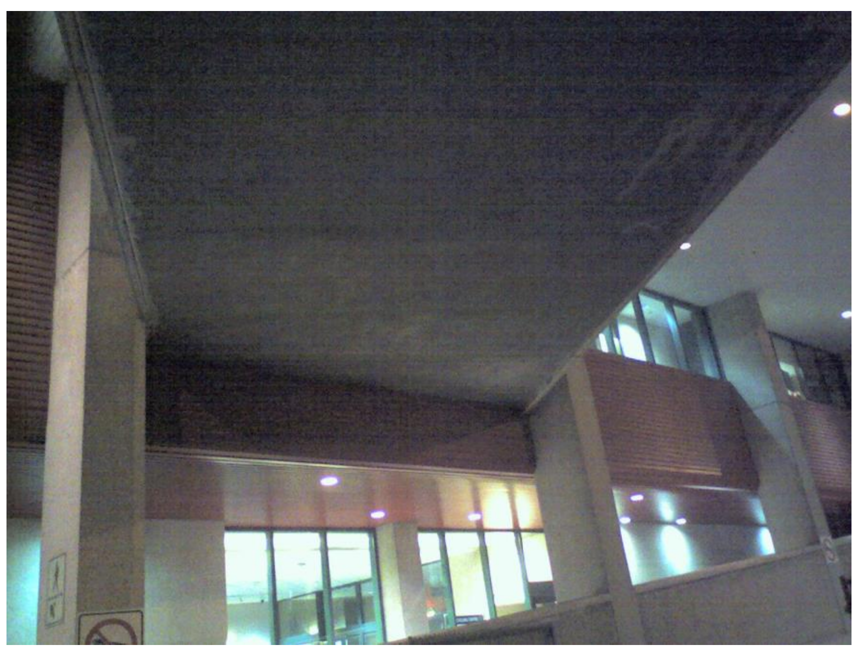


Photograph #113:

West end of soffit showing thermal bridging at support members.

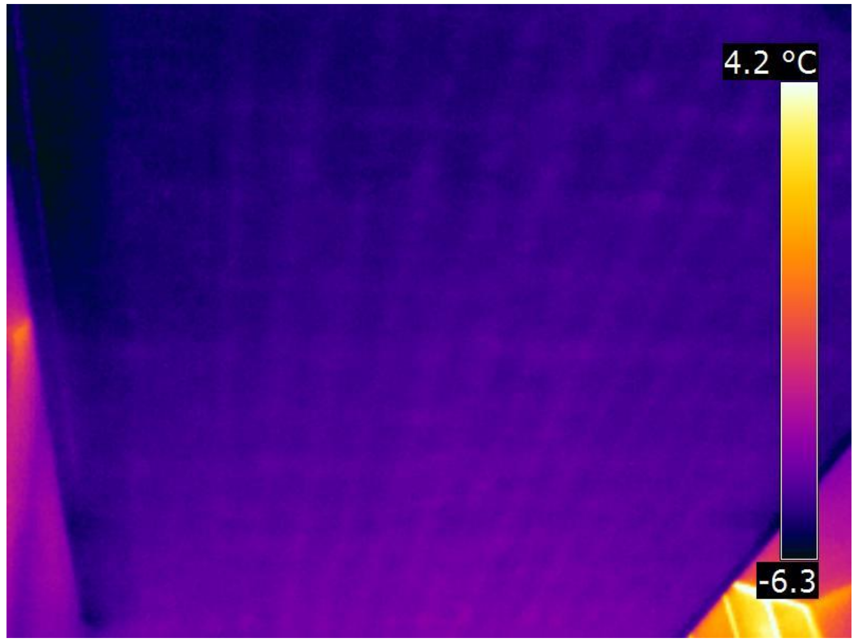


Photograph #114:

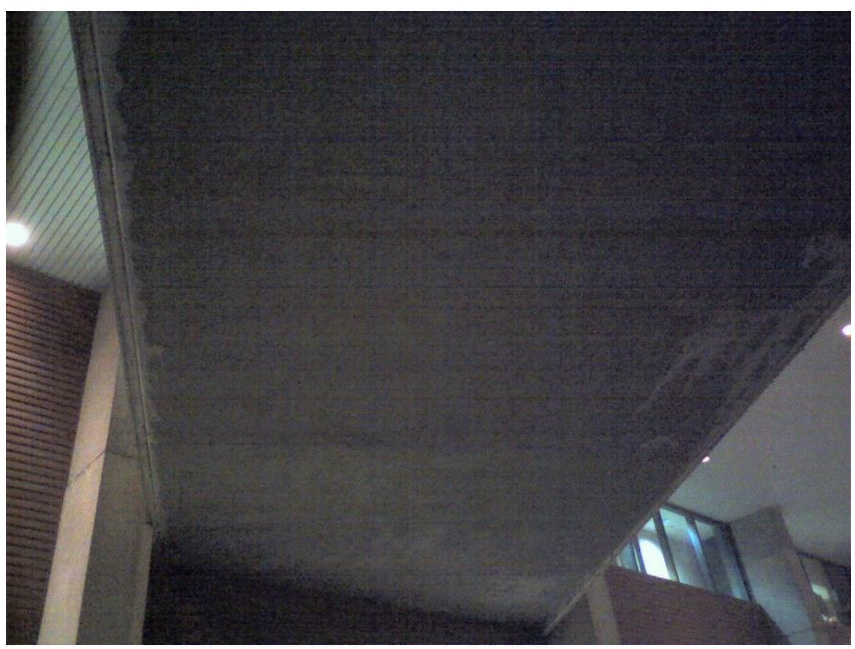


Photograph #115:

West end of soffit showing thermal bridging at support members.

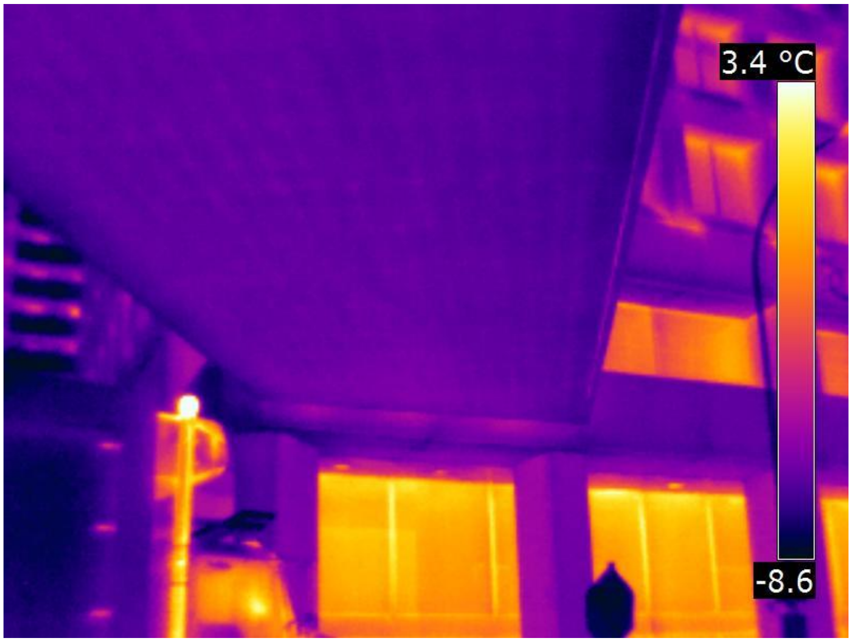


Photograph #116:



Photograph #117:

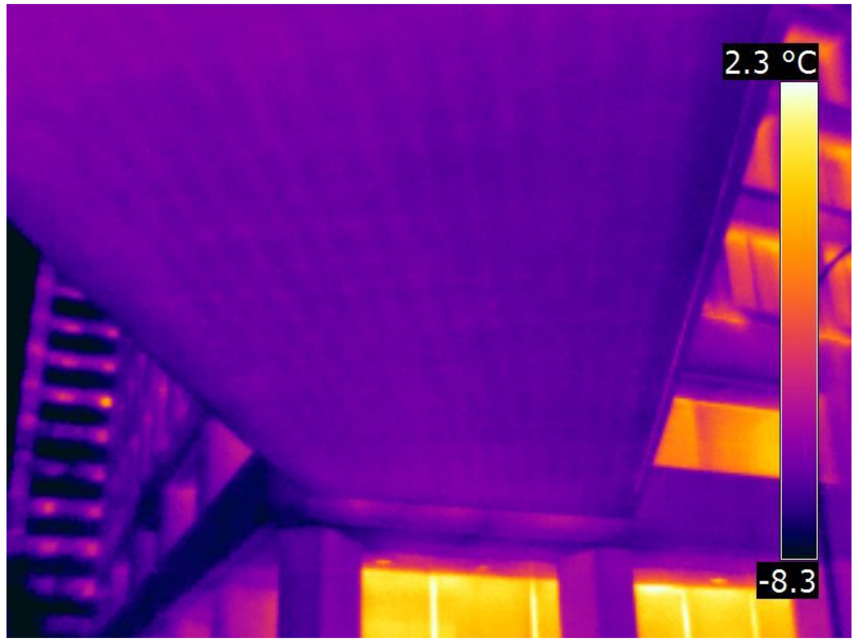
East end of soffit showing thermal bridging at support members.



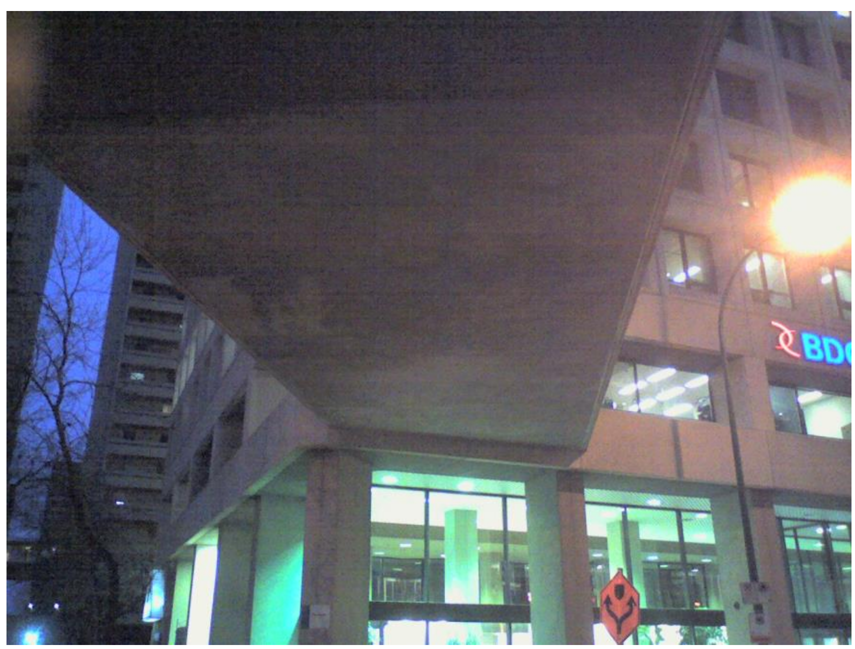
Photograph #118:

Photograph #119:

East end of soffit showing thermal bridging at support members.

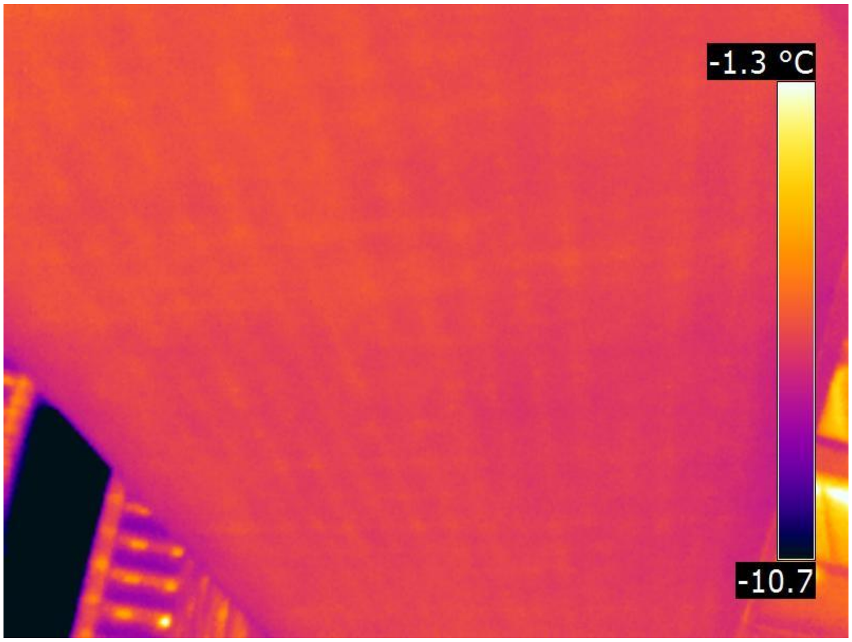


Photograph #120:

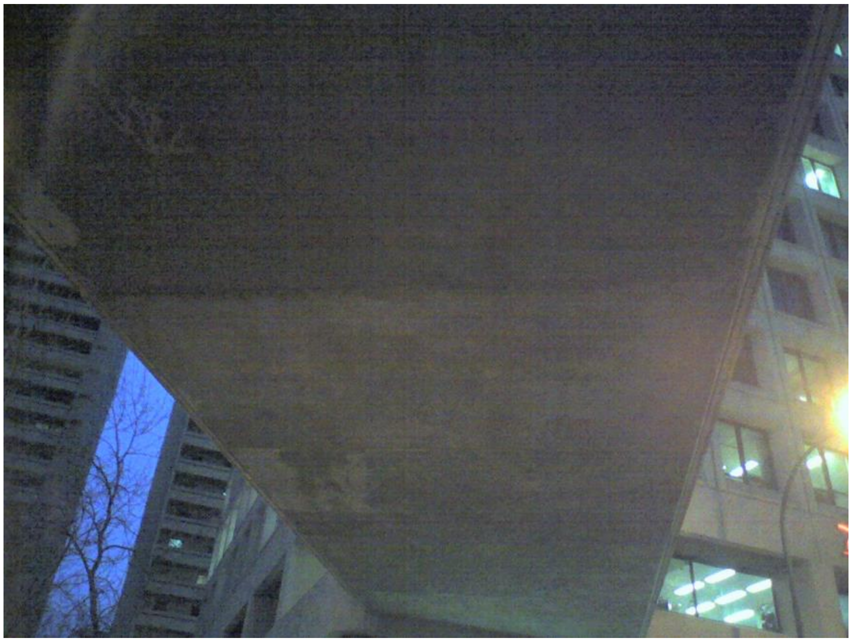


Photograph #121:

East end of soffit showing thermal bridging at support members.

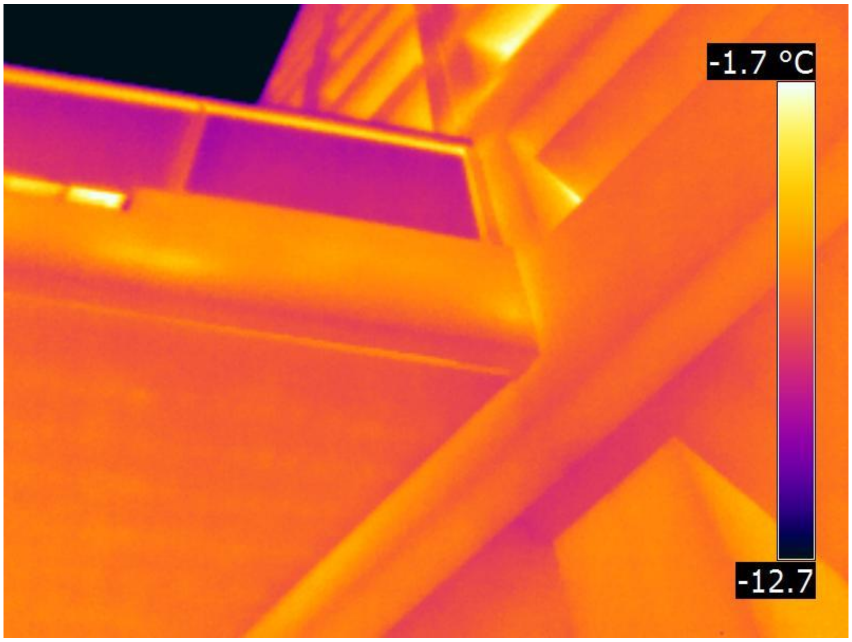


Photograph #122:

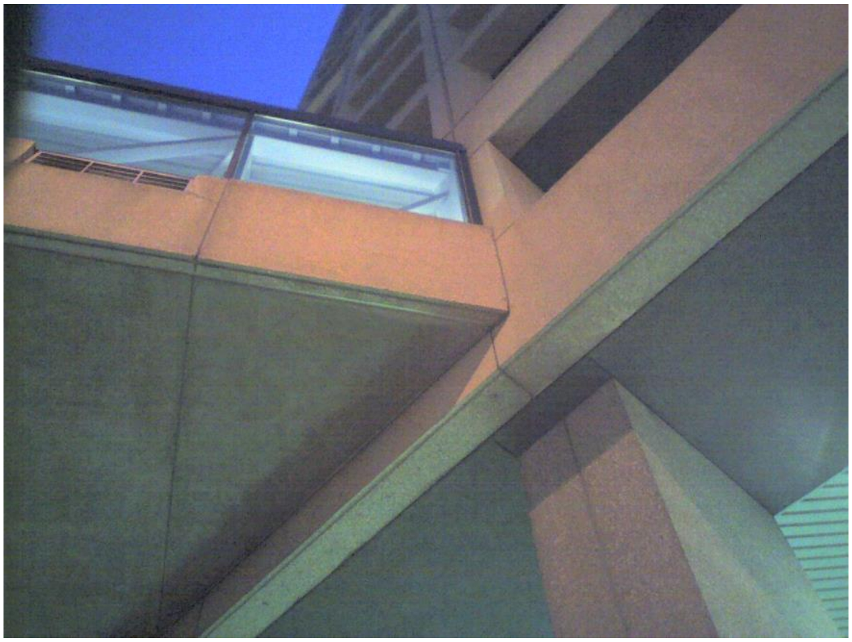


Photograph #123:

East end of skywalk at adjacent building.

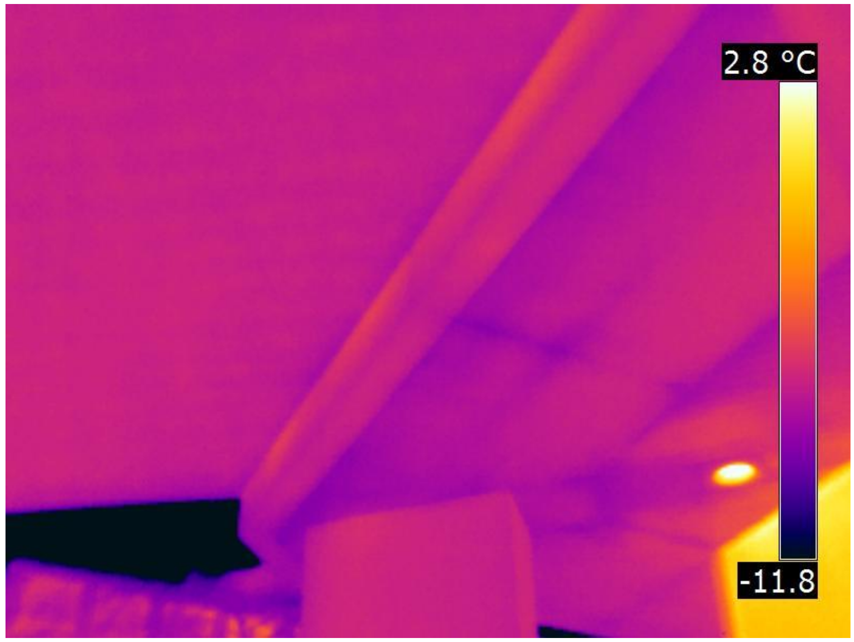


Photograph #124:

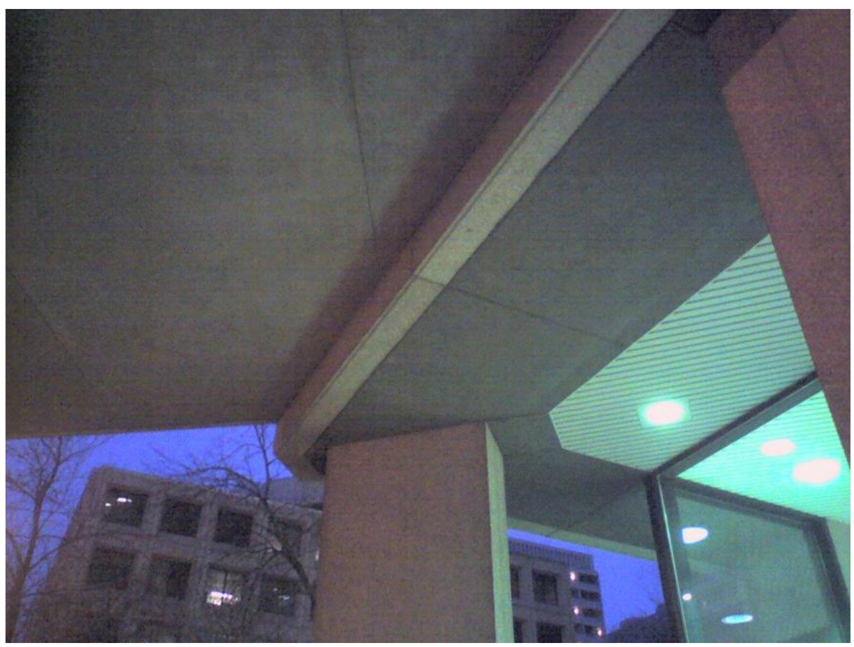


Photograph #125:

Soffit at east end of skywalk.

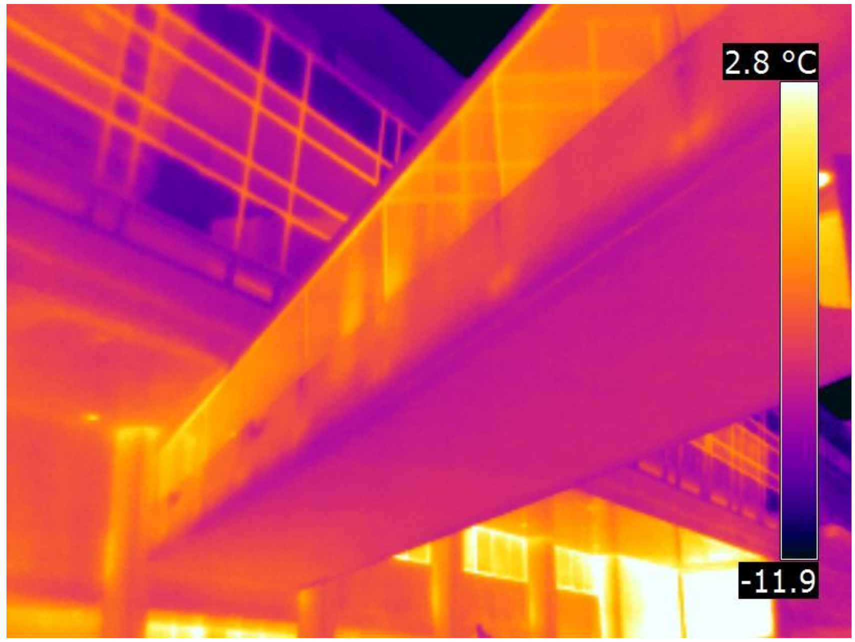


Photograph #126:

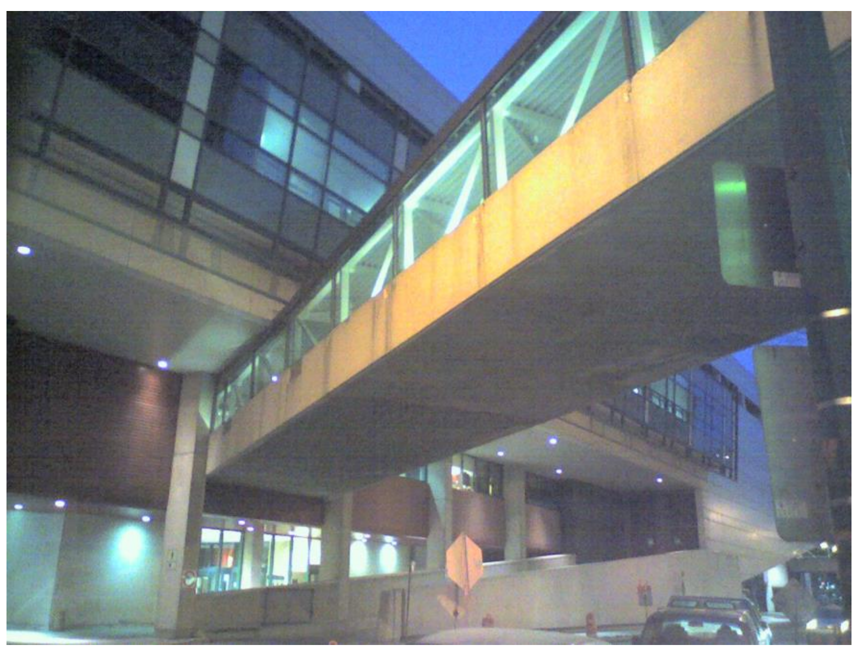


Photograph #127:

Overall south elevation.

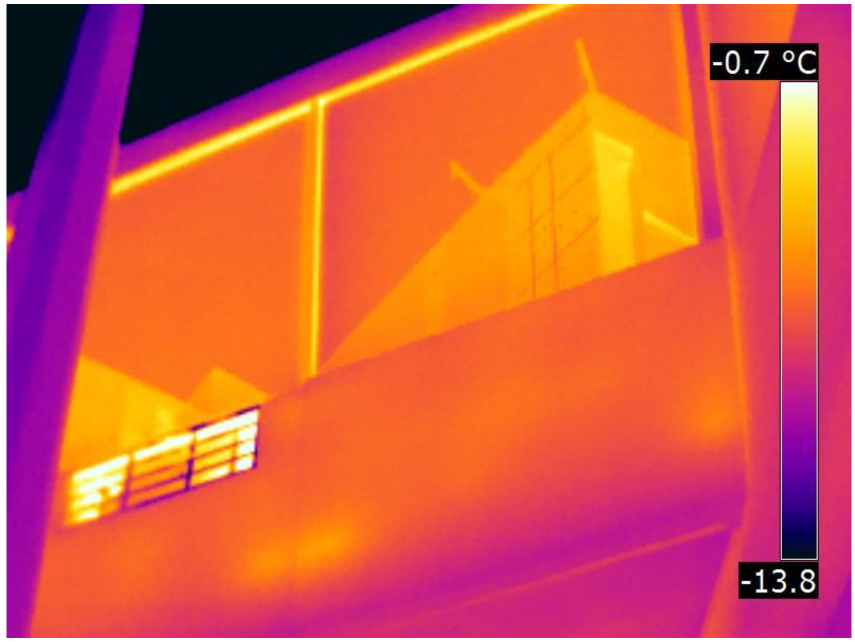


Photograph #128:

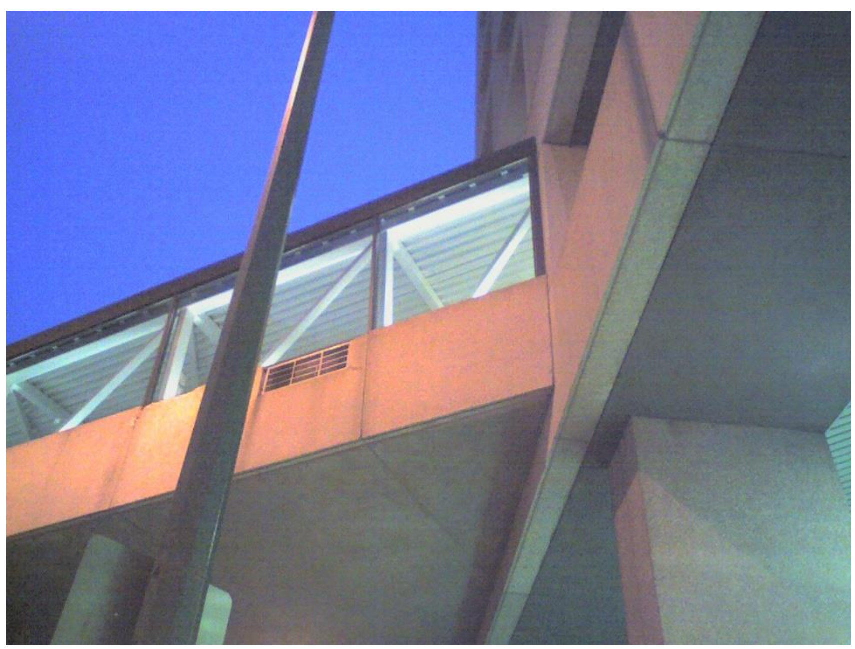


Photograph #129:

Partial south elevation.

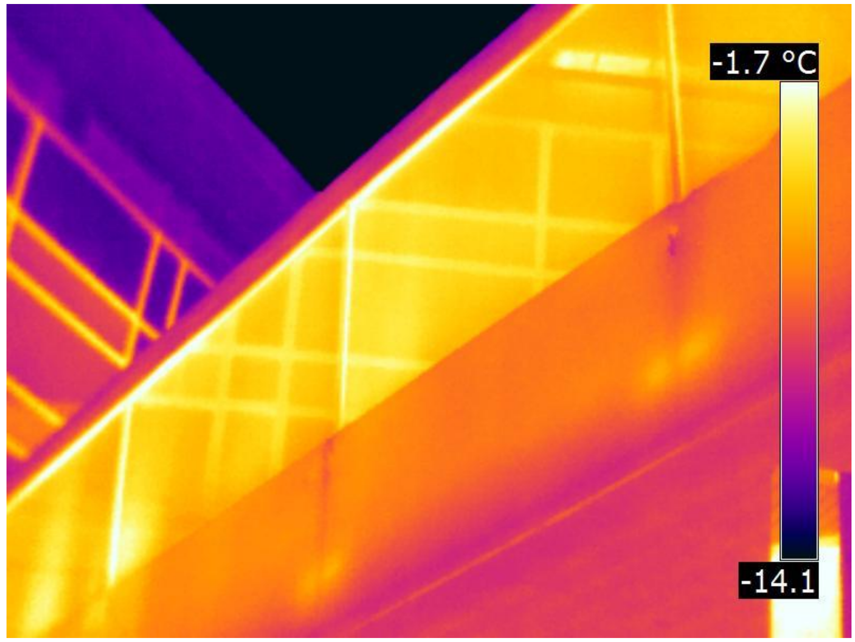


Photograph #130:

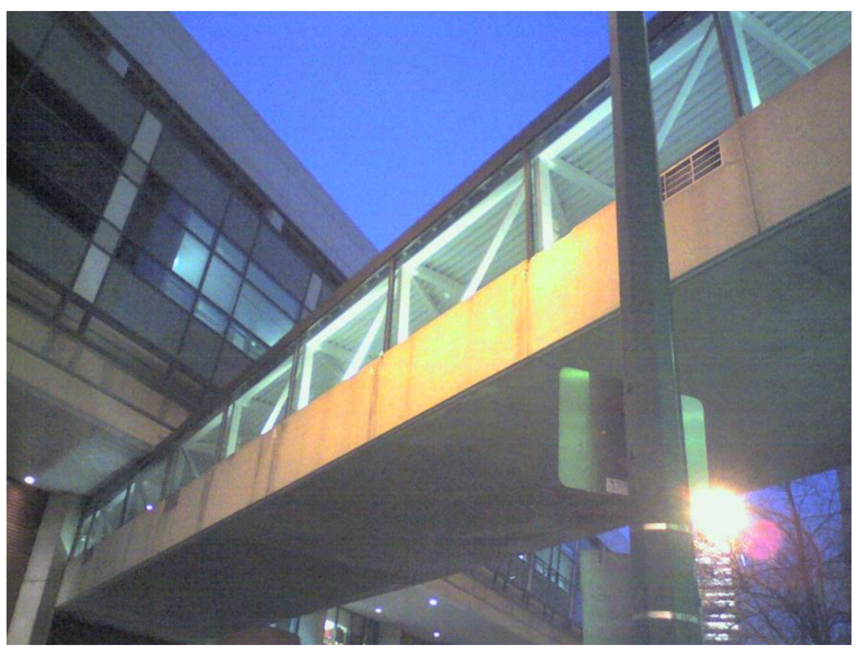


Photograph #131:

Partial south elevation.



Photograph #132:

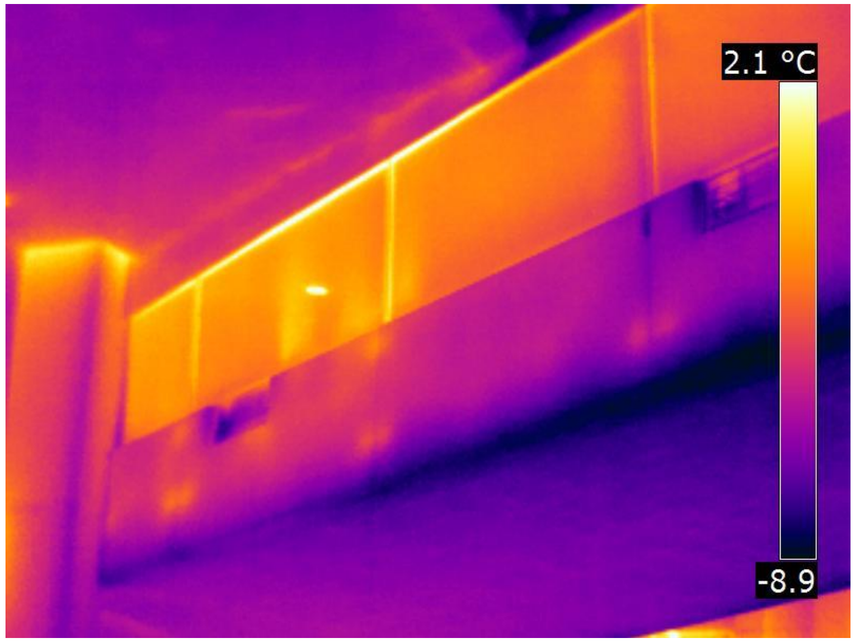


Photograph #133:

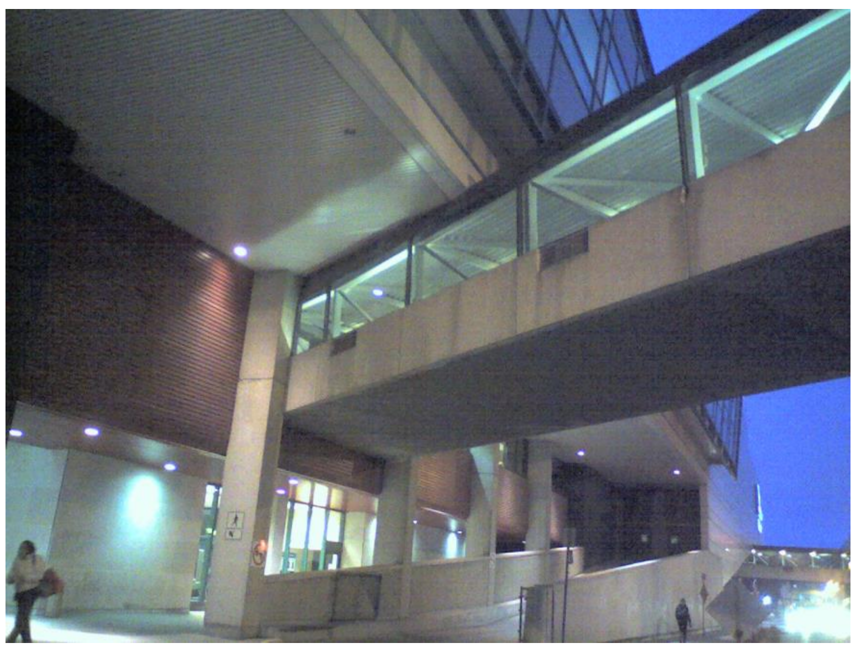
Partial south elevation.

Photograph #134:

Photograph #135:
Partial south elevation.



Photograph #136:



6. Weather Data

Government of Canada Gouvernement du Canada

Canada

Climate

Home > Data

Hourly Data Report for December 15, 2015

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.

WINNIPEG INTL A MANITOBA					
Latitude:	49°54'36.000" N	Longitude:	97°14'24.000" W	Elevation:	238.70 m
Climate ID:	5023227	WMO ID:		TC ID:	YWG

TIME	Temp °C	Dew Point Temp °C	Rel Hum %	Wind Dir 10's deg	Wind Spd km/h	Visibility km	Stn Press kPa	Hmdx	Wind Chill	Weather
00:00	-6.8	-9.2	83	2	10	24.1	98.62		-11	Mainly Clear
01:00	-7.2	-9.8	82	2	13	24.1	98.63		-13	NA
02:00	-7.5	-9.8	84	4	13	24.1	98.66		-13	NA
03:00	-7.7	-10.0	84	4	12	24.1	98.74		-13	Mostly Cloudy
04:00	-7.8	-9.9	85	6	15	24.1	98.74		-14	NA
05:00	-7.9	-10.0	85	6	9	24.1	98.80		-12	NA
06:00	-8.3	-10.4	85	6	10	24.1	98.85		-13	Mostly Cloudy
07:00	-8.8	-10.6	87	7	10	24.1	98.85		-14	NA
08:00	-8.9	-10.7	87	6	12	24.1	98.86		-15	NA
09:00	-8.5	-10.4	86	8	15	24.1	98.86		-15	Mostly Cloudy
10:00	-8.3	-10.5	84	8	16	24.1	98.84		-15	NA
11:00	-8.0	-10.3	84	8	15	24.1	98.87		-14	NA
12:00	-7.7	-10.4	81	7	12	24.1	98.79		-13	Cloudy
13:00	-7.2	-10.4	78	8	8	24.1	98.76		-11	NA
14:00	-6.8	-10.0	78	8	9	24.1	98.72		-11	NA
15:00	-6.8	-9.9	79	10	8	24.1	98.67		-11	Cloudy
16:00	-6.8	-9.2	83	10	8	24.1	98.69		-11	NA
17:00	-6.7	-8.4	88	15	5	24.1	98.71		-9	NA
18:00	-6.6	-8.9	84	5	10	24.1	98.62		-11	Cloudy
19:00	-6.7	-9.0	84	4	9	24.1	98.56		-11	NA
20:00	-6.6	-8.9	84	5	11	24.1	98.53		-12	NA
21:00	-6.1	-8.1	86	8	9	24.1	98.44		-10	Cloudy
22:00	-5.9	-8.0	85	11	10	24.1	98.43		-10	NA
23:00	-5.7	-8.0	84	11	13	24.1	98.35		-11	NA