# REPORT FOR:

## Millennium Library Parkade – 251 Donald St.
## Parkade Condition Assessment

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|---|---|
| Submitted to: | City of Winnipeg |
| Attention: | Mr. Jason Wiebe C.E.T. |
| Date: | April 1, 2021 (Revised April 8, 2021) |
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| Our File No. | 2020-1183 |

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CONSULTING STRUCTURAL ENGINEERS

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# Executive Summary

A multi-disciplinary building condition assessment of the Millennium Library Parkade – 251 Donald Street, was completed by Crosier Kilgour & Partners Ltd. and SMS Engineering Ltd. The purpose of the assessment was to provide an opinion on the current condition of the building and its components and present recommendations for immediate, short, mid, and long-term repair/replacement costs.

The results of the investigation indicate that the parkade structure is in fair condition as defined by the CIRC 5-Point Scale for Rating Asset Condition, it shows general signs of deterioration and requires attention. A significant quantity of concrete deterioration has been identified on the top surface of the Level P1 structural slab. Although concrete deterioration was anticipated, the quantity of deterioration identified during the investigation is greater than expected given the recent structural restoration. The structural analysis of a representative design strip indicates that the structural slab remains suitable for continued use, however concrete repairs will be required in the short-term.

The results of the core sampling and testing indicate that the top surface of the structural slab is chloride contaminated and will require a large-scale remediation to address existing deterioration. A restoration option was presented as the minimum scope of work at an estimated cost of $1.6 million and an expected service-life of 5 to 7 years (Option 1). An alternative restoration option was also presented which includes replacement of the contaminated top surface through hydro-demolition at an estimated cost of $3.77 million (Option 2). This option is expected to have an effective service-life in the order of 20 years with normal maintenance.

The existing Level P2 slab-on-grade is in good overall condition. Installation of column swales are recommended as preventative maintenance to address areas of ponding water and reduce the rate of future deterioration.

The condition of the existing waterproofing varies throughout the parkade. The waterproofing on Level P1 is generally in fair condition with localised repairs required. However, the existing coatings in the mechanical rooms, vestibules and stairwells is in poor condition, replacement with a similar coating is recommended as a non-mandatory maintenance item.

SMS performed a building condition assessment of the Millennium Library Parkade. The condition assessment included a review of record information and annual test reports. A brief visual review was performed for the two parkade levels. The scope of work was limited to elements in the parkade and excluded the plaza or the Library building.

The majority of the mechanical systems are original to the facility with the exception of some piping, drains and the snow-melt systems for the entrance and exit ramps, and are in poor condition as defined by the CIRC 5-Point Scale for Rating Asset Condition. There are two elements which require repairs in the short term. These elements include the addition of the generator room fuel oil ventilation fan and the addition of $NO_2$ detection throughout the Parkade levels. The main ventilation systems, which are dedicated to the parkade, are beyond the expected service life and carry the largest opinion of probably costs for replacement. The added cost is due to the need for a code compliant upgrade which will require larger systems be installed. The total opinion of probable cost for the repairs over the next 10 year period is estimated to be $9,965,000.00 with an additional $1,289,000.00 estimated beyond the 10 year period.

The majority of the electrical systems are original to the facility with the exception of lighting and select electrical systems (CCTV, card access, fire alarm, etc), and are in poor condition as defined by the CIRC 5-Point Scale for Rating Asset Condition. There are two elements which require repairs in the short term. These items include changing the remaining red exit signs to green pictogram and installing covers on junction boxes and splitters in a few of the electrical and mechanical rooms. The total opinion of probable

cost for the repairs over the next 10 year period is estimated to be $8,505,500.00 with an additional $350,000.00 estimated beyond the 10 year period.

The following table provides a breakdown of the anticipated repair costs in 2021 dollars. Based on the level of investigation and available information, the budget estimates are considered Class 4 (-30% to +50%) for years 1 through 6 and Class 5 (-50% to +100%) for years 7 through 10. The budget estimates are prepared based on limited information with no engineering work completed and preliminary scope determination. Please note that the costs presented are for construction only, and excludes taxes, contingencies, and professional fees.

Summary of All Priorities

| Category | Estimated Costs | |
|---|---|---|
| | **Structural Option 1** | **Structural Option 2** |
| Total Required Repairs (within 3 months) | $103,000 | $103,000 |
| Total Short Term Recommendations (within 1 year) | $1,967,000 | $4,140,000 |
| Total Medium Term Recommendations (Year 1 to 5) | $12,510,000 | $12,510,000 |
| Total Long Term Recommendations (Year 5 to 10) | $17,080,000 | $15,240,000 |
| Long Term Considerations/Recommended Improvements (not time critical) | $1,739,000 | $1,739,000 |
| **Total of All Recommendations** | **$33,399,000** | **$33,732,000** |

# 1. Introduction

At the request of the City of Winnipeg, a multi-disciplinary parkade condition assessment of the Millennium Library Parkade – 251 Donald Street, Winnipeg, Manitoba was completed by Crosier Kilgour & Partners and SMS Engineering personnel. The purpose of the assessment was to provide an opinion on the current condition of the parkade and its components and present recommendations for immediate, short, mid, and long-term repair/replacement costs. The assessment involved a visual walk-through survey of the parkade structure and the mechanical and electrical systems. The walk-through survey consisted of nonintrusive visual observations of readily accessible, easily visible components and systems of the property and excludes the operation of equipment, exploratory probing, removal or relocation of materials, testing, or the use of equipment, etc. In addition, a sounding survey, membrane condition survey and core testing were completed on the upper parking level. Where applicable, opinions of probable construction costs for suggested remedial work have been provided. The following report summarizes our significant observations, findings, and recommendations.

## 1.1 Limitations

Our assessment is based on an examination of representative portions of the building under review which were easily visible, exposed and could be examined. We cannot warrant any different conditions that may exist, but which are covered by finishes, or other materials, or not accessible at the time of the site visit.

This report has been prepared for the sole benefit of City of Winnipeg. The 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.

## 1.2 Scope of Investigation

The intent of this project is to complete a condition assessment of the parkade structure, mechanical and electrical systems, and provide recommendations for immediate, short, medium, and long term repairs.

The investigation included, a review of available documentation such as original construction drawings, engineering reports, maintenance reports, and discussions with personnel familiar with the facility.

A visual review was completed throughout representative portions of the parkade which were exposed and readily accessible including parking decks, stairwells, and representative non-public areas such as accessible mechanical rooms.

A sounding survey of the readily accessible upper parking level, including a chain drag of the top surface and representative hammer sounding of the exposed soffit.

Core sampling and testing of the upper parking structural slab, including chloride testing, carbonation testing and compressive strength.

A membrane condition survey of the upper parking level, including visual assessment to identify areas of wear and bond testing.

## 1.3 Priority of Recommendations

All recommendations for parkade systems or components identified in the following sections have been assigned a priority based on the following criteria for the purposes of scheduling and budgeting in accordance with the following:

- Required Repairs (within 3 months) – Items that require immediate action as a result of any of the following: potential unsafe conditions, material building or fire code violations, or conditions that if left unremedied, uncorrected, have the potential to result in or contribute to critical element or system failure within one year or will result most probably in a significant escalation of its remedial cost. Repairs required within 3 months.
- Short Term Recommendations (within 1 year) – High priority for repairs/maintenance including code and regulatory issues.
- Medium Term (within 5 Years) – Repairs required to address ongoing or low-risk deterioration, replacement of end of service-life building components, regular and/or proactive maintenance.
- Long Term (within 10 years) – Repairs required to address ongoing or low-risk deterioration, replacement of end of service-life building components.
- Long Term Considerations/Recommended Improvements (not time critical) – Optional work including recommended improvements presented for future consideration and planning.
- Maintenance (ongoing) – Repairs required to address ongoing, or routine maintenance. Work considered to be normal maintenance has not been included.

# 2. Property Description

The following sections are based on a review of the existing architectural and structural drawings, and visual observations made during the site review. The following drawings were available for review:

- Architectural drawings A-1 through A-29 by Macdonald Cockburn McLeod McFeetors Architects dated Dec 30, 1974. The drawings include the library and attached parkade.
- Electrical drawings E-1 through E-12 by Scouten Mitchell Sigurdson & Assocs. Ltd. Consulting Engineers dated Dec. 30, 1974. The drawings include the library and attached parkade.
- Mechanical drawings M-1 through M-16 by Scouten Mitchell Sigurdson & Assocs. Ltd. Consulting Engineers dated Dec. 30, 1974. The drawings include the library and attached parkade.
- Structural drawings S-1 through S-18 by Crosier, Greenberg & Partners Consulting Civil and Structural Engineers dated Dec. 30 1974. The drawings include the library and attached parkade.
- Repair drawings S1 through S10, M1 through M2 and P1 and specifications by Concentric Associates International Incorporated dated, November 7, 2012.
- Repair drawings S0 through S2, M1 through M4, E1, Addendum drawings S1, S2 and M2, and specifications by Concentric Associates International Incorporated dated June 4, 2018.

Testing reports, including but not limited to; VFA Report (2020), Annual Backflow Device Test Report (2020), Sprinkler Inspection Report (2020), Emergency Lighting Annual Inspection (2020), Annual Generator Report (2020), and Fire Alarm System Annual Test & Inspection Report (2020) were also made available for review and reference.

### 2.1 Structural System

The Millennium Library Parkade was designed in late 1974 and constructed shortly thereafter. It consists of two underground, interior, heated parking levels. The structural system for the upper parking level (P1) consists of a 9” thick, conventionally reinforced two-way concrete slab with 10’-0” x 10-0” x 6” deep drop panels at column locations. The slab has a design live load capacity of 50 psf which is consistent with current code requirements. The total area of Level P1 is approximately 98,000 ft². The lower parking level (P2) occupies approximately 100,000 ft² and was originally constructed of a 5” thick concrete slab on compacted granular fill.

Based on the information available, Levels P1 and P2 were waterproofed with a coal-tar based membrane in 1985, replaced with a presumed urethane-based membrane in 1988, and periodically repaired/recoated. The available 2012 repair drawings suggest that the existing waterproofing system was removed down to concrete substrate and replaced in the drive aisles. Whereas the existing waterproofing system was recoated with localised base coat repairs for the parking stalls. The 2012 repair drawings also indicate that the existing slab-on-grade on Level P2 and interior ramps between Levels P1 and P2 was removed and replaced with a 4” concrete slab on existing granular.

The parkade is accessed by structural ramps off Smith Street and Donald Street, each incorporating a heating system in the concrete topping for de-icing control. Interior, inter-level access is provided by a one-way cast-in-place concrete ramp structure.

### 2.2 Background of Structural Deterioration

Deterioration may be defined as any internal or external process, which may adversely affect the structural integrity or function of an individual member or of the structure as a whole. The processes of deterioration can include items such as internal material reactions, the external environment, as well as aging. The manifestation of deterioration may range from aesthetic concerns, through serviceability issues, to complete failure.

Deterioration of concrete structures exposed to moisture and chlorides has become a widespread problem throughout the world. In areas of steel reinforcing, long term moisture and chloride penetration can cause corrosion of both structural steel and embedded steel reinforcing within the concrete. Moisture arises from many sources; however, the main sources are rain, melting snow, and the deposition of moisture and salts brought in by vehicles. In the absence of a protective cover on the top surfaces of the concrete, moisture will permeate through the concrete and eventually induce corrosion in the presence of oxygen. As chloride contamination increases and carbonation of the soffit continues, there is a potential for the rate of deterioration to increase. Chlorides brought onto the deck by vehicles significantly accelerate the deterioration processes.

The exact level of chloride concentration required in reinforced concrete to promote corrosion varies, as many variables exist. However, extensive research and field experience has suggested that approximately 0.15 to 0.20% chlorides by weight of cement content, represents the corrosion threshold for normal reinforcing steel. That is, the concrete is no longer capable of protecting the embedded steel from corrosion in the presence of an electrolyte, such as moisture. Note that moisture in the liquid phase is not necessarily required for the corrosion process; research has suggested that a relative humidity above 50% is all that is required to provide sufficient electrolyte to facilitate corrosion.

The relatively high alkalinity or pH of concrete normally protects embedded steel from corrosion. The high pH, or alkaline environment of concrete facilitates the formation of a protective film on the steel, which prevents corrosion. Once the pH drops below approximately 9 due to the process of carbonation, destruction of this protective film ensues; thereby creating the potential for corrosion.

Unfortunately, chloride-laden moisture destroys the protective film, thereby initiating corrosion of the steel. Carbon dioxide present in the atmosphere can penetrate the concrete over time and lower its naturally high pH through a process termed carbonation. Cracks aggravate corrosion by providing a more direct path for the penetration of moisture, carbon dioxide, and oxygen.

Corrosion of the reinforcing steel is an electrochemical process, in which metallic iron is oxidized, converting iron to rust. This process of converting iron to rust is expansive; that is, the rust occupies a much larger volume than the steel. Depending on the state of oxidation, the volume increase may be as large as 600% of the original metal. This volume increase causes cracking of the concrete and delamination of the adjacent concrete surface. In severe cases, loss of steel/concrete bond and

reduction of cross-section can lead to structural failure. Obviously, as concrete cracking occurs, the rate and depth of penetration of chloride-laden moisture increases dramatically.

This moisture will not only cause problems due to corrosion of the steel within the concrete, but it will also dissolve certain constituents of the concrete, specifically calcium hydroxide. The calcium hydroxide-laden moisture reacts with the carbon dioxide present in air, forming a white crust. This white precipitate is calcium carbonate. The problem typically manifests itself through white stalactites emanating from cracks within the concrete. The phenomenon is termed efflorescence and is usually considered an aesthetics problem rather than a structural problem. However, the high alkalinity of water leaching through cracks and joints has been known to cause damage to vehicle paint if not removed in a timely manner.

Cracks presumably exist in all reinforced concrete structures and can occur as a result of numerous factors. In most instances, cracks only become significant if by their presence, they allow moisture or deleterious substances to penetrate the concrete, thereby hastening deterioration. In some instances, however, cracking can be an indicator of more significant structural concerns such as, delamination due to corrosion of the embedded reinforcing steel, freeze-thaw deterioration, or even structural failure. It is for the above reason that an accurate evaluation of the causes of the visible cracking is essential.

# 3. Observations and Findings

The following summarizes the results of the November 25, 2020 walk-through survey including significant observations, findings, and recommendations. The results of the sounding survey, membrane condition survey, core sampling and testing, and representative structural analysis are also summarized below. Copies of SMS Engineering's mechanical and electrical report have been included in Appendix B.

The structural assessment of the parkade included a visual review of accessible areas of the parkade structure, a sounding survey of the top surface and soffit of the upper parking level (P1), a membrane condition survey of the existing coating on Level P1, core sampling and testing of the Level P1 slab and a structural analysis of representative sections.

## 3.1 Visual Observations

The visual review consisted of a walkthrough of the exposed and readily accessible sections of the parkade including the parking decks and stairwells, as well as representative non-public areas such as mechanical rooms.

### 3.1.1 Level P1

The waterproofing membrane appears to be in overall good condition. Three locations of severe deterioration were observed along the north drive aisle, where the waterproofing is either loose or has been worn away (Photograph #1). It was also noted that a few localized waterproofing repairs have been completed (Photograph #2).

Although not apparent due to the presence of the waterproofing membrane, widespread top surface concrete deterioration is present throughout Level P1. The approximate extents of deterioration were identified during the sounding survey and marked onsite to allow a visual review of the locations and general scale of the deterioration (Photographs #3 & #4). The locations of deterioration appear to be sporadic in location and size (Photograph #5).

Localized areas of deterioration were also identified on the soffit (underside) of Level P1 during the sounding survey (Photograph #6). In general, the observed soffit deterioration consisted of relatively small locations ranging from 1 to 4 sq.ft. and sporadically located throughout the parkade.

The concrete walls and columns are in overall good condition. Localized spalling and evidence of concrete deterioration were identified at a few columns (Photograph #7).

The existing drains appear to be in good condition (Photograph #8). It was noted that several drains have been installed in the drive aisles and along the center of the parking aisles. It is our understanding that these were added during the 2012 repairs presumably to help address the minimal existing drainage profile.

The rubber curbs installed in the parking stalls appear to be in good condition. A few curbs were observed to be damaged but are likely due to isolated vehicle impacts (Photograph #9). The condition of the concrete curbs at the entrance and exit ramps varies (Photograph #10). Approximately 85 sq.ft. of curb deterioration was observed. Localized repairs and or full depth replacement is recommended in the short term to minimize the risk of tripping hazards and damage to vehicles.

### 3.1.2 Level P2

It is our understanding that the entirety of the Level P2 slab-on-grade was replaced during the 2012 repairs with the exception of the mechanical pits and slabs-on-grade within the stairwells. The slab-on-grade generally appears to be in good condition. However, the original waterproofing and slab-on-grade that were not replaced at the mechanical pits are in poor condition (Photograph #11). Installing waterproofing membranes on slabs-on-grade is generally not recommended due to concerns of vapour drive, which can result in premature failure of the membrane and deterioration of the underlying concrete. The membrane that had been installed on the lower level slab failed in this manner. Recoating of the slab-on-grade is not recommended. Localized replacement of the concrete slab-on-grade is recommended in the short term as required to address tripping hazards and to maintain functionality. As these locations are not accessible to the general public, full replacement is discretionary but could be considered in the long term.

The concrete walls and columns are in overall good condition. Localized spalling and scaling were identified at a few of the columns. Localized cracking, spalling, and scaling were noted along the perimeter concrete walls (Photograph #12). Concrete repairs to address spalling and concrete deterioration is recommended in the short term.

Multiple locations of ponding water were observed at the bases of concrete columns and along the walls (Photograph #13). Chloride laden moisture ponding against structural members is a primary cause of concrete deterioration and delamination. Multiple locations of scaling are present along the base of the wall and at columns with observed ponding (Photograph #14). It is recommended that concrete swales be installed at known locations of ponding in the medium term with consideration for installation of concrete swales at all columns and walls in the long term.

It was also noted that the concrete column jackets at 5 locations did not extend down to the pile caps. As a result, the new slab-on-grade elevation has caused a gap between the slab-on-grade and bottom of the pile cap (Photograph #15). Although the gap itself is not a structural concern, its presence allows moisture to flow into the cut-out and pond against the column and pile cap. The gap has been partially closed with plywood formwork; however, this is not an effective protective measure against moisture. It is recommended that concrete swales be installed at these locations in the short term.

The drains on Level P2 are in fair condition. The presence of corrosion was noted on the drain covers and suggests the drains will need to be replaced in the long term.

Random cracking was observed throughout the slab-on-grade (Photograph #16). Chloride laden water can penetrate into these random cracks and lead to localized deterioration of the concrete. It is recommended that these cracks be routed and sealed in the short to medium term. It is also recommended that failed sealant along control joints be removed and replaced in the short to medium term.

### 3.1.3 Mechanical Rooms

In general, the mechanical rooms are in fair condition. Although not sounded, localized top surface deterioration, was apparent in the mechanical rooms (Photograph #17). Locations of concrete deterioration were also noted on the walls, ramps, columns, soffits, and curbs (Photograph #18). It is recommended that localized concrete repairs be completed in the short term.

The existing coating, present in most of the Level P1 mechanical rooms, is in poor condition and is at or near the end of its service life (Photograph #19). Replacement of end-of-life

coatings outside of areas exposed to moisture and road salts, such as within the mechanical rooms, is recommended but not required for durability and has been identified as a non-mandatory maintenance item. However, replacement of the coatings on Level P2 are not recommended due to concerns of moisture vapour drive causing debonding and premature failure of the coating.

Locations of efflorescence were observed to be present in the corners and soffits beyond the footprint of the library and plaza (Photograph #20). The building representative indicated that ongoing leakage has not been noticed at these locations. However, the presence of efflorescence is indicative of moisture seepage through the concrete and suggests that the existing waterproofing is at or nearing the end of its service life.

It is our understanding that the exterior waterproofing beyond the footprint of the library and plaza is original and has been in service for 45+ years. Replacement of the waterproofing will likely be required in the medium term. In the short term, locations of known leakage could be injected with a polyurethane resin to prevent further moisture ingress until the exterior waterproofing can be replaced.

Evidence of leakage was noted at the penetrations for the heated ramps (Photograph #21). The building representative indicated that periodic leakage has been observed in the past. The penetrations can be injected with a polyurethane resin to prevent further moisture ingress.

The existing drains, where present, were observed to be in poor condition (Photograph #22). It is recommended that replacement of the drains be scheduled with the localized concrete repairs or prior to application of a waterproofing membrane.

### 3.1.4 Stairwells

The stairwells at approximate Gridlines Q-3 and O-10 are of concrete construction and appear to be in good condition. Localized cracks were observed on the landings, routing and sealing of the cracks is recommended in the short term (Photograph #23). The coating in the vestibules on P1 appear to be at the end of its service life, replacement with a waterproofing membrane is recommended in the medium term (Photograph #24). It was also noted that a few guardrail anchors were not installed during installation of the guardrails (Photograph #25). Installation of the anchors is recommended in the short term.

The stairwell at approximate Gridlines A-8 is a combination of concrete construction (lower portion) and steel pan construction (upper portion). The lower portion of the stairwell is in fair condition. Locations of concrete deterioration were noted, and repairs are recommended in the short term. The existing coating has been worn down to the concrete substrate along the center of the landings and treads.

Although not within scope, the upper portion of the stairwell was reviewed for informational purposes. The structural steel and steel pans of the upper portion appear to be in good condition (Photograph #26). Cracking and minor deterioration of the concrete treads was noted at some locations (Photograph #27). Replacement of deteriorated concrete treads is recommended in the medium term. The costs to complete this work are not included in the tables below.

Full review of the stairwell at approximate Gridlines F-5 was not completed as the upper portion (steel pan) was not accessible at the time of the site visit. The lower portion (concrete construction) appears to be in good condition.

Consideration should be given to application of a waterproofing membrane on the concrete stairwells. Application of a waterproofing membrane will protect the concrete from chloride laden moisture tracked by pedestrians.

### 3.1.5 Other Observations

Localized areas of efflorescence and concrete deterioration were observed on the plaza deck soffit (underside)(Photograph #28). Repair of the deteriorated concrete locations is recommended in the short-term. Our records indicated that the plaza deck was remediated in 2007 and included replacement of the existing waterproofing membrane. It is not anticipated that the plaza deck waterproofing will require replacement within the timeframe considered in this report.

The four exterior ramps generally appear to be in good condition. Of the four exterior ramps, three are uncoated, whereas the Smith Street entrance is coated with a waterproofing system. A few cracks were observed in the waterproofing but appear to only penetrate the wear coarse layer (topcoat). Random cracking in the concrete topping was observed at the other three ramps. Localised repairs are recommended in the short term. The two interior ramps were also observed to be in good overall condition.

## 3.2 Sounding Survey

Delamination and/or deterioration of the exposed concrete surfaces can be readily identified by sounding surveys. Although crude in appearance, sounding surveys are a powerful tool for identifying, mapping, and quantifying corrosion-related deterioration within cast-in-place concrete. This test method is recognized by such agencies as the American Concrete Institute and the International Concrete Repair Institute (ICRI) as a primary investigative technique.

A sounding survey was completed throughout the accessible sections of the parkade. Areas of delamination were identified on-site, quantified, and recorded on drawings for future reference. The following tables provide a summary of our findings.

### 3.2.1 Top Surface

A chain drag sounding survey of the accessible Level P1 structural slab was completed. The following table summarizes the results of the top surface sounding survey.

Table 1: Top Surface Sounding Survey

| Location | Area | | Top Surface Delamination | |
|---|---|---|---|---|
| | Total | Sounded | ft² | % |
| Level P1 | 86,000 ft² | 86,000 ft² | 8,696 ft² | 10.1% |

As can be seen in Table 1 above, the sounding survey found 8,696 ft$^2$ of deteriorated top surface concrete which represents 10.1% of the surface. In total approximately 950 top surface concrete repair locations were identified providing an average size of approximately 9.1 ft$^2$. Although this may be surprising considering localised concrete repairs were completed starting in 2012, it is consistent with available records which indicate that the structural slab was exposed to moisture and chlorides for 10+ years before any waterproofing was applied, and thus prone to corrosion-related deterioration.

During concrete repairs, the demolition will inevitably grow beyond the extents of deterioration to provide a sound substrate. Although it is difficult to predict the increase in patch size, it is estimated that the patch could grow from 2 to 6 inches in each direction. For budgeting and planning purposes we recommend allowing for a growth of in area of 40%. Therefore, the total top surface concrete repair area is estimated to be in the order of 12,250 ft$^2$.

### 3.2.2 Soffit Sounding Survey

A hammer sounding survey of the accessible Level P1 structural slab was completed. The following table summarizes the results of the top surface sounding survey.

Table 2: Soffit Sounding Survey

| Location | Area | | Slab Soffit Delamination | |
|---|---|---|---|---|
| | Total (ft²) | Sounded | ft² | % |
| Level P1 | 95,000 ft² | 95,000 ft² | 582 ft² | 0.6% |

The sounding survey found 582 ft² of slab soffit delamination which represents 0.6% of the surface area. In total approximately 170 soffit repair locations were identified providing an average size of approximately 3.4 ft². For the purposes of budgeting and planning we recommend allowing for a 40% increase in area to account for growth in the patch area. The total area of concrete soffit repairs is therefore estimated to be in the order of 800 ft².

## 3.3 Core Sampling and Testing

To help determine the existing condition of the structure and the potential for further corrosion, core samples were taken and tested to determine compressive strength, chloride content and carbonation penetration. In total twelve cores were taken as follows: 3 for compressive strength testing, 6 for chloride ion concentration testing and 3 for carbonation testing. The results of the testing can be found in the tables below.

### 3.3.1 Compressive Strength

Concrete typically slowly strengthens overtime if it is kept in pristine condition and is not allowed to deteriorate. Unfortunately, this is very rarely the case and the penetration of substances such as chlorides, moisture, oxygen, and carbon dioxide will cause deterioration. It can also provide an indication of the overall quality of the original construction. The current compressive strength of an existing concrete is therefore important when conducting a structural analysis. The report submitted by the third-party testing agency can be found in Appendix D.

Table 3: Summary of Compressive Strength Testing

| Test No. | Location | Compressive Strength | |
|---|---|---|---|
| | | psi | MPa |
| TH 1B | Drive Aisle – Between Gridlines 7 to 8 and G to H | 5,192 | 35.8 |
| TH 2B | Parking Stall – Between Gridlines 10 to 11 and C to D | 2,350 | 16.2 |
| TH 6B | Parking Stall – Between Gridlines 2 to 3 and N to O | 2,944 | 20.3 |
| $f'_{c(eq)}$ | Equivalent Compressive Strength (ACI 562) | 1,668 | 11.5 |

The results of the compressive strength testing are used to calculate the equivalent compressive strength in accordance with ACI 562, *Code Requirements for Assessment, Repair, and Rehabilitation of Existing Concrete Structures.* ACI 562 requires the calculation of an equivalent compressive strength that considers the number of results, safety factors and the standard deviation. The three results were used to calculate an equivalent compressive strength of 1668 psi (11.5 MPa) which is considerably lower than the design concrete strength of 3000 psi (20.7 MPa).

### 3.3.2 Chlorides

Since the presence of chlorides in concrete is one of the primary causes of corrosion, the results of the testing help to establish the potential for corrosion and determine if existing chloride concentrations are high enough to induce or enhance corrosion of the embedded reinforcing steel. Although the actual quantity of chlorides required to initiate corrosion varies from site to site, the industry accepts that chloride concentrations above 0.15 to 0.20% by weight of cement are sufficiently high to induce corrosion of the reinforcing steel in the presence of moisture and oxygen. Note that considerable variations can occur depending upon the mix constituents, moisture levels, and temperature. The reports submitted by the third-party testing agency can be found in Appendix D.

Table 4: Summary of Chloride Testing

| Test No. | Location | Sample Depth (mm) | Water Soluble Chloride Content | |
|---|---|---|---|---|
| | | | % by mass concrete | % by mass cement |
| TH 1A | Drive Aisle – Between Gridlines 7 to 8 and G to H | 20 to 30 | <0.010 | <0.08 |
| TH 2A | Parking Stall – Between Gridlines 10 to 11 and C to D | 20 to 30 | 0.086 | 0.67 |
| TH 3A | Drive Aisle – Between Gridlines 3 to 4 on C | 20 to 30 | 0.288 | 2.2 |
| TH 4A | Drive Aisle – Between Gridlines 7 to 8 and H to J | 20 to 30 | 0.025 | 0.20 |
| | | 100 to 110 | <0.010 | <0.08 |
| TH 5A | Drive Aisle – Between Gridlines 8 to 9 and M to N | 20 to 30 | 0.081 | 0.63 |
| TH 6A | Parking Stall – Between Gridlines 2 to 3 and N to O | 20 to 30 | 0.086 | 0.67 |
| | | 100 to 110 | 0.010 | 0.08 |

The testing agency submitted the chloride concentrations as percentage by mass of concrete. These values were converted to percentage by mass of cement as this is a better representative for comparison. All six of the core samples were tested for chlorides at a depth of 20 to 30 mm. This depth was selected as it is the approximate depth of the top level of reinforcing in the structural slab. As can be seen in the table the chloride concentration results for five of the six cores are sufficiently high to induce corrosion. Two of the cores were also tested at a depth of 100 to 110 mm to provide an indication of the embodied chlorides when the structural slab was originally cast. As can be seen in the table above in both cases, the embodied chlorides are well below the threshold indicating that the concrete has been exposed to chlorides prior to application of the waterproofing membrane.

### 3.3.3 Carbonation

Carbon dioxide in the air, from processes such as combustion, will penetrate the concrete, react with the calcium hydroxide in the cement paste producing calcium carbonate and cause the alkalinity of the paste to decrease. In this manner the naturally protective film around the reinforcement will be lost at a pH of about 9, and corrosion will start in the presence of sufficient moisture and oxygen. For this investigation, a proprietary chemical solution was applied to the surface which reacts with the concrete and changes colour depending on pH. To measure the pH of the cement paste, a newly cut out core is split in half and sprayed with the indicators and allowed to dry. The pH is then revealed by comparison with the pH color spectrum.

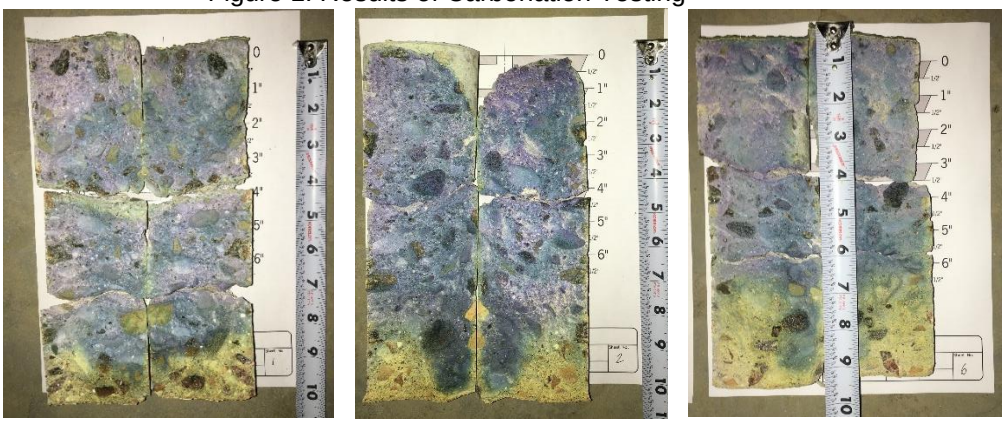
| Colour: | | | | | |
|---|---|---|---|---|---|
| pH | 5 (Orange) | 7 (Yellow) | 9 (Green) | 11 (Purple) | 13 (Blue) |

Table 5: Summary of Carbonation Testing

| Test No. | Location | pH | Carbonation Depth | |
|---|---|---|---|---|
| | | | Inch | mm |
| TH 1C | Drive Aisle – Between Gridlines 7 to 8 and G to H | 7 - 9 | 1.25 | 32 |
| TH 2C | Parking Stall – Between Gridlines 10 to 11 and C to D | 7 - 9 | 1.5 | 38 |
| TH 6C | Parking Stall – Between Gridlines 2 to 3 and N to O | 7 - 9 | 2 | 51 |

For this investigation, the cores were extracted full depth to provide results at the top surface and soffit of the structural slab. The results of the carbonation testing indicated a pH ranging from 7 to 9 on the bottom of the structural slab core samples. The depth ranges from 1 ¼" to 2" which suggests the carbonation has reached the bottom reinforcing steel and the protective film is no longer present. The pH at the top surface generally appears to be above 9. The results of the carbonation testing confirm that the passive protective film provided by a high pH is no longer present at the bottom reinforcing and the reinforcing steel is vulnerable to corrosion in the presence of moisture and oxygen.

Figure 1: Results of Carbonation Testing



### 3.3.4 Summary

The results of the core sampling reflect that the Level P1 structural slab is heavily contaminated. The chloride testing indicates that the top layer of reinforcing steel is vulnerable to rapid corrosion in the presence of moisture due to the high chloride concentration. The carbonation testing indicated that the bottom reinforcing is also vulnerable to corrosion in the presence of moisture due to a pH below 9. Taking both of the results into consideration combined with the low compressive strength, moisture protection of the structural slab is crucial.

Localized repairs to address the known locations where the waterproofing membrane has exhibited excessive wear and/or debonded exposing the underlying concrete is recommended in the short term. It should also be noted that top surface concrete repair locations will need to be recoated and lapped onto the existing waterproofing.

In addition to general wear caused by vehicular traffic, waterproofing membranes tend to become more brittle over time due to oxidization of the constituents and loss of volatiles such as plasticizers and extender oils. This results in shrinkage and cracking which can affect bond of the membrane, reduce flexibility and the ability to bridge cracks in the structure. Although the parking stalls may not need recoating until the long-term, it is recommended that the drive aisles and turning zones be recoated in the medium term.

### 3.4 Structural Analysis

A structural analysis was completed to evaluate the theoretical capacity of the structure and determine the implications of concrete deterioration. The analysis was based on the design methods in the latest edition of CSA A23.3, *Design of Concrete Structures.* The results were then used to calculate the demand-capacity ratio in accordance with ACI 562-19, *Code Requirements for Assessment, Repair, and Rehabilitation of Existing Concrete Structures.* ACI 562 is published by the American Concrete Institute (ACI) and provides design professionals a code for the assessment and repair of existing concrete structures. Although this code is written for concrete construction in the United States and has not been adopted in Canada, the concepts described in the document are still relevant.

The demand-capacity ratio (D/C) compares the strength required to support the design loads (demand), to the strength of the structure in its deteriorated state (capacity). In general, structural repairs are necessary whenever the demand-capacity ratio of the deteriorated member exceeds 1.0. When the D/C is equal to or exceeds 1.5, ACI 562 defines this as an unsafe structural condition. The following summarizes the interpretation of D/C.

| | |
|---|---|
| D/C < 1.0 | The structure is not unsound or structurally deficient. |
| 1.0 ≤ D/C < 1.5 | The structure is considered safe. Structural repairs are required but the structure is suitable for continued use on an interim basis as deemed necessary by a professional engineer. |
| D/C ≥ 1.5 | Unsafe structural condition (ACI 562). Temporary measures, such as shoring may be necessary, as determined by a professional engineer, until repairs can be made. |

Since Level P1 is a two-way structural slab the slab spans in both the north-south and east-west directions. The column spacing and reinforcing also appear to be the same in both directions. Therefore a design strip along the center parking stall bay (Gridline 6) was selected as a representative design strip. Deterioration was estimated based on the results of the sounding surveys.

Design Assumptions

| | |
|---|---|
| Typical Slab: | 9” structural concrete slab<br>10’-0” x 10’-0” x 6” drop panels |
| Design Dead Loads: | 5.4 kPa Uniform Dead Load (DL)<br>9.0 kPa at drop panels |
| Design Live Loads | 2.4 kPa Uniform Live Load (LL) |
| Concrete Strength: | $f'_c$ = 20.7 MPa (3,000 psi), typical<br>$f'_{ceq}$ = 11.5 MPa (1668 psi) |
| Steel Strength: | $f_y$ = 414 MPa (60 ksi) |

Table 6: Column Strip Demand-Capacity Ratio (Bending)

| Column Strip as Designed | | | | | Current Condition | | |
|---|---|---|---|---|---|---|---|
| Grids | Location | D ($M_f$) | C ($M_r$) | D/C | % Delam | $C_{det}$ (Mr) | $D/C_{det}$ |
| **D** | Support | 443.09 | 510.24 | **0.87** | 28% | 349.15 | **1.27** |
| | Midspan | 206.78 | 328.22 | **0.63** | 0% | 302.75 | **0.68** |
| **E** | Support | 443.09 | 510.24 | **0.87** | 25% | 363.70 | **1.22** |
| | Midspan | 206.78 | 328.22 | **0.63** | 0% | 301.54 | **0.69** |
| **F** | Support | 443.09 | 510.24 | **0.87** | 13% | 421.89 | **1.05** |
| | Midspan | 206.78 | 328.22 | **0.63** | 0% | 301.54 | **0.69** |
| **G** | Support | 443.09 | 510.24 | **0.87** | 16% | 409.28 | **1.08** |
| | Midspan | 206.78 | 328.22 | **0.63** | 1% | 300.09 | **0.69** |
| **H** | Support | 443.09 | 510.24 | **0.87** | 10% | 438.86 | **1.01** |
| | Midspan | 206.78 | 328.22 | **0.63** | 1% | 298.72 | **0.69** |
| **J** | Support | 443.09 | 510.24 | **0.87** | 21% | 383.09 | **1.16** |
| | Midspan | 206.78 | 328.22 | **0.63** | 8% | 279.86 | **0.74** |
| **K** | Support | 443.09 | 510.24 | **0.87** | 22% | 378.25 | **1.17** |

Table 7: Middle Strip Demand-Capacity Ratio (Bending)

| Middle Strip as Designed | | | | | Current Condition | | |
|---|---|---|---|---|---|---|---|
| Grids | Location | D ($M_f$) | C ($M_r$) | D/C | % Delam | $C_{det}$ (Mr) | $D/C_{det}$ |
| **D** | Support | 147.70 | 200.26 | **0.74** | 26% | 141.76 | **1.04** |
| | Midspan | 143.16 | 200.26 | **0.71** | 1% | 189.88 | **0.75** |
| **E** | Support | 147.70 | 200.26 | **0.74** | 41% | 113.03 | **1.31** |
| | Midspan | 143.16 | 200.26 | **0.71** | 0% | 191.57 | **0.75** |
| **F** | Support | 147.70 | 200.26 | **0.74** | 18% | 156.90 | **0.94** |
| | Midspan | 143.16 | 200.26 | **0.71** | 1% | 189.44 | **0.76** |
| **G** | Support | 147.70 | 200.26 | **0.74** | 33% | 128.93 | **1.15** |
| | Midspan | 143.16 | 200.26 | **0.71** | 0% | 191.57 | **0.75** |
| **H** | Support | 147.70 | 200.26 | **0.74** | 11% | 170.50 | **0.87** |
| | Midspan | 143.16 | 200.26 | **0.71** | 4% | 183.06 | **0.78** |
| **J** | Support | 147.70 | 200.26 | **0.74** | 45% | 105.36 | **1.40** |
| | Midspan | 143.16 | 200.26 | **0.71** | 1% | 190.31 | **0.75** |
| **K** | Support | 147.70 | 200.26 | **0.74** | 29% | 135.44 | **1.09** |

The results of the structural analysis indicate that the two-way structural slab as designed has a D/C ratio below 1.0. This suggests that the structural slab can accommodate minor top surface and soffit deterioration without being overstressed.

The volume of delamination was estimated for each section of the representative design strip based on the results of the sounding survey. As can be seen in the tables above, when taking the estimated deterioration into consideration, the D/C ratio at the supports ranges from 1.01 to 1.27 for the column strip and from 0.87 to 1.40 for the middle strip. Although the D/C ratio has exceeded 1.0 at most of the supports it does not exceed 1.5 and thus is considered safe and suitable for continued use in the short term until repairs can be considered.

The current condition capacities above were calculated using the ACI 562 equivalent compressive strength of 11.5 MPa. This is a very low value that was greatly reduced by the low number of compressive strength cores tested and the large variation between the compressive strength results. If additional compressive strength tests were taken, we expect the equivalent compressive strength would approach the design strength of 20.7 MPa. Note that the D/C ratio at the supports range from 0.96 to 1.21 for the column strip and from 0.83 to 1.34 for the middle strip when a compressive strength of 20.7 is used. Furthermore, the D/C ratio could be further reduced if a reduced live load that is more consistent with actual loads for parking structures were considered.

Notwithstanding the prior, it is recommended that all known locations of concrete deterioration be repaired in the short term. Concrete deterioration is an ongoing process that will continue to grow in size and severity if not addressed.

Table 8: Demand-Capacity Ratio (Shear)

| **Two Way Shear as Designed** | | | | | **Current Condition** | | |
|---|---|---|---|---|---|---|---|
| Grids | Location | D ($V_f$) | C ($V_r$) | D/C | % Delam | $C_{det}$ (Vr) | $D/C_{det}$ |
| **D** | Panel Edge | 907.91 | 1664 | **0.55** | 11% | 1102.01 | **0.82** |
| | Column | 907.91 | 1417 | **0.64** | 16% | 884.71 | **0.98** |
| **G** | Panel Edge | 907.91 | 1664 | **0.55** | 4% | 1195.08 | **0.76** |
| | Column | 907.91 | 1417 | **0.64** | 0% | 1057.00 | **0.86** |
| **One Way Shear as Designed** | | | | | **Current Condition** | | |
| Grids | Location | D ($V_f$) | C ($V_r$) | D/C | % Delam | $C_{det}$ (Vr) | $D/C_{det}$ |
| **D** | Panel Edge | 431.60 | 927 | **0.47** | 22% | 542.07 | **0.80** |
| **G** | Panel Edge | 431.60 | 927 | **0.47** | 19% | 559.33 | **0.77** |

The D/C ratios were also calculated for shear capacity at two column locations. For this calculation it was assumed that the depth of deterioration would extend beyond the top layer of reinforcing in the slab (panel edge) or drop panel (column) for the length of deterioration intercepting the shear plane. As can be seen in the table above, the D/C ratio remains below 1.0. Again these values were calculated using the equivalent compressive strength of 11.5 MPa. The D/C ratio for the column at Gridlines D-6 is reduced to 0.73 if the design compressive strength of 20.7 MPa is used. Therefore the structural slab is considered safe and suitable for continued use, however concrete repairs will be required and are recommended in the short term.

## 3.5 Membrane Condition Survey

Protection of the Level P1 structural slab is provided by a traffic-bearing waterproofing membrane. According to available information, the existing membrane was removed from the drive aisles and replaced with a new multicoat membrane system in 2012. However the information also suggests that the membrane in the parking stalls was repaired where required and recoated with a new wear coarse coating.

### 3.5.1 Visual Review

A visual review of the traffic bearing membrane was completed throughout the parkade. The existing waterproofing membrane on Level P1 is in overall good condition. However, the existing coatings in the mechanical rooms, vestibules, and lower-level mechanical pits are in poor condition.

The parking stall areas are generally in good condition with visible aggregate remaining in the top coat. The drive aisles and turning zones are also generally in good condition however the aggregate appears to be worn down in the high traffic areas.

Three locations of severe deterioration were observed in the high-traffic north drive aisle where the waterproofing is missing. It appears as though the waterproofing debonded and was worn away at these locations. Additional localized areas of deterioration were noted adjacent to drains and at a few concrete delamination locations. It was also noted that a few localized waterproofing repairs have been completed after the 2012 repairs.

### 3.5.2 Bond Testing

Membrane adhesion pull tests were completed at six locations on Level P1: three locations in the drive aisles and three locations in the parking stalls. The tensile bond strength test is a good indicator of the service life condition of the existing traffic bearing membrane. The results of the bond tests are shown in Table 9 below.

Table 9: Membrane Bond Test Summary

| Test No. | Location | Bond Failure Plane | Bond Stress | | Mil Thickness |
|---|---|---|---|---|---|
| | | | psi | MPa | |
| BT 1 | Drive Aisle | Failure in membrane between layers | 320 | 2.21 | 63 |
| BT 2 | Parking Stall | Failure in membrane between layers | 300 | 2.07 | 64 |
| BT 3 | Parking Stall | Failure in membrane between layers | 327 | 2.25 | 61 |
| BT 4 | Drive Aisle | Failure in membrane between layers | 317 | 2.19 | 53 |
| BT 5 | Drive Aisle | Failure in membrane between layers | 405 | 2.79 | 56 |
| BT 6 | Parking Stall | Failure in membrane between layers | 323 | 2.23 | 62 |
| **Average** | | | **332** | **2.29** | **60** |

The current Standard CSA S413 “Parking Structures” indicates “The strength of the bond between elastomeric membrane and the substrate shall be not less than 1.4 MPa when tested in accordance with CSA A23.2-6B.”. As can be seen in the table above the existing waterproofing membrane appears to be well bonded with bond stresses in excess of 2.0 MPa.

The thickness of the existing waterproofing was also measured at each of the test locations using a digital caliper. The average mil thickness was measured to be 60 dry mils, which is slightly less than typical waterproofing membrane systems.

### 3.5.3 Summary

The results of the membrane condition survey indicate that the existing traffic bearing membrane is in fair condition given its age. Notwithstanding the prior, it should be noted that localized repairs will be required periodically to address areas of excessive wear, debonding and/ or concrete deterioration. An annual visual inspection, localized chain-drag sounding survey and maintenance program are recommended to ensure the effectiveness of the traffic bearing membrane system.

# 4. Analysis and Structural Recommendations

The results of the investigation indicate that the parkade structure is in overall fair condition considering age and exposure conditions over its service life. The Level P2 slab-on-grade and Level P1 waterproofing membrane that were installed during the 2012 repair project are generally in good condition. However, the Level P1 structural slab is generally in fair condition.

Although the representative structural analysis that was completed suggested that immediate repairs are not required, localised removal of loose concrete and patching of tripping hazards are recommended. Loose concrete can become dislodged and potentially fall on vehicles and/or pedestrians. In addition, localised patching of top surface repairs that are considered tripping hazards is also recommended. Several locations of loose overhead concrete and two potential tripping hazards were identified during the visual review and sounding survey. It is recommended that these locations be addressed as soon as reasonably possible.

## 4.1 Option 1: Structural Recommendations - Concrete Repair and Waterproofing

The lower parking level (Level P2) was found to generally be in good condition. The concrete slab-on-grade installed during the 2012 repair project appears to be holding up well with minimal random cracking and deterioration of joint sealant. Failed control joint sealants and random cracks can allow chloride laden moisture to penetrate along the cracks and lead to premature deterioration. Random cracks can be addressed by routing out a groove along the crack and installing a sealant complete with a bond breaker at the base of the groove to allow movement. Failed control joints sealants can be removed, the joints cleaned, and new sealant installed along the joints. It is our recommendation that these be addressed in the short to medium term. It should also be noted that periodic maintenance of the joint sealants will be required throughout the service life of the slab-on-grade and repairs should be anticipated every 2 to 3 years.

During the visual review of Level P2 it was noted that there is an existing gap between the top of the slab-on-grade and the bottom of the column jacket that was installed at 5 locations. This existing gap a low spot against the existing column and pile cap and provides a direct path for chloride laden moisture to pool. In order to protect and direct moisture away from the columns, it is our recommendation that concrete swales be installed in the short term. In addition, ponding was observed at the base of columns at several other locations. The presence of scaling at some these locations suggests that concrete deterioration has begun and will continue to grow in extent and severity if not addressed. It is our recommendation that consideration be given to installation of concrete swales at all columns in the medium term. This could be phased over several years beginning with areas of known ponding.

Considering concrete repairs and waterproofing replacement were completed on Level P1 in 2012, the extents of concrete deterioration identified during the sounding surveys may come at a surprise. In total, approximately 8,700 $ft^2$ of top surface concrete deterioration and 600 $ft^2$ of soffit deterioration were marked. To account for the inevitable growth in patch area during demolition we recommend that the estimated total be increased by approximately 40% to 12,250 $ft^2$ of top surface repair and 800 $ft^2$ of soffit repair. Typical concrete repairs would include the following: removal of all delaminated and loose concrete; trenching of exposed and corroded reinforcing steel; sand blasting of the reinforcing steel to remove corrosion from the bars, sandblasting of the concrete substrate to clean and texture the surface of the concrete; and infilling with new concrete or repair material. Where top surface repairs align with soffit repairs, through-slab replacement tends to be more economical and provides a better repair. Upon adequate cure of the patches, a waterproofing membrane would be installed in repair areas and lapped with the existing.

The concrete walls, columns and curbs throughout the parkade are generally in good condition. In total, 15 $ft^2$ of column deterioration, 25 $ft^2$ of wall deterioration and 85 $ft^2$ of curb deterioration were identified. To account for the inevitable growth in patch area during demolition we recommend that the estimated

total be increased by approximately 50% to an estimated 25 ft² of column deterioration, 40 ft² of wall deterioration and 125 ft² of curb deterioration. The process for column and wall repairs would involve removal of the deteriorated concrete to a sound substrate, sandblasting of exposed reinforcing steel and concrete substrate, forming the repairs to match existing profiles and infilling with a repair material. Curb repairs would consist of full depth removal to the concrete slab top surface, sandblasting of exposed reinforcing steel and concrete substrate, and infilling with new concrete or repair material.

The table below summarizes the estimate of probable construction costs for the recommendations discussed in this section. Based on the level of investigation and available information, the budget estimates are considered Class 4 (-30% to +50%) and excludes taxes, contingencies, and professional fees for design and specification preparation, tendering, field reviews, and contract administration services.

Table 10: Option 1: Concrete Repair and Waterproofing

| | Description | Est. Qty | Unit Price | Estimated Total Price |
|---|---|---|---|---|
| 1 | Top Surface Repairs | | | |
| | 1.1 0" to 3" | 12,250 ft² | $35.00 /ft² | $428,750 |
| | 1.2 3" to 6" | 6,000 ft² | $30.00 /ft² | $180,000 |
| | 1.3 Through slab | 300 ft² | $65.00 /ft² | $19,500 |
| 2 | Soffit Repairs | | | |
| | 2.1 0" to 3" | 800 ft² | $120.00 /ft² | $96,000 |
| | 2.2 3" to 6" | 200 ft² | $60.00 /ft² | $12,000 |
| 3 | Column and Wall Form and Pour Repairs | | | |
| | 3.1 0" to 3" | 75 ft² | $115.00 /ft² | $8,625 |
| | 3.2 3" to 6" | 40 ft² | $90.00 /ft² | $3,600 |
| 4 | Concrete Curb Repairs | 125 lin.ft. | $60.00 /lin.ft. | $7,500 |
| 5 | Concrete Column Swales | 5 locations | $2,000 /loc. | $10,000 |
| 6 | Galvanic Anodes | 5,000 anodes | $75.00 /loc. | $375,000 |
| 7 | Membrane Repairs and Recoating | 13,000 ft² | $12.00 /ft² | $156,000 |
| 8 | Crack Routing and Sealing | 4,000 lin.ft. | $14.00 /lin.ft. | $56,000 |
| 9 | Crack Polyurethane Injection | 50 lin.ft. | $150.00 /lin.ft. | $7,500 |
| 10 | Miscellaneous Concrete Repairs | Allowance | | $30,000 |
| 11 | General Conditions | Allow Approximately 15% | | $209,525 |
| **Total Estimated Price (not including GST)** | | | | **$1,600,000** |

Based on the table above, an estimated budget in the order of $1.6 million is recommended to address the known locations of concrete and waterproofing deterioration. Although this budget estimate includes an allowance for the installation of galvanic anodes, it should be noted that this will not address the existing structural slab contamination. The galvanic anodes will only slow ongoing deterioration at the locations where they are installed. Concrete deterioration will continue outside of these repair locations and repairs of a similar magnitude should be expected every 5 to 7 years unless a more aggressive restoration is implemented which addresses the underlying causes of the deterioration. For comparison purposes, an allowance for a second structural restoration of equal magnitude has been included in the summary table in Section 5.6 of this report. Thus, the total costs for structural repairs that would be necessary within the timeframe considered in this report would be in the order of $3.2 million if the recommendations in Table 10 are implemented.

### 4.2 Option 2: Structural Recommendations - Top Surface Removal, Resurfacing and Waterproofing

When taking the results of the core sampling and testing into consideration, the estimated top surface and soffit repair quantities are not overly surprising. The chloride concentration tests indicate that the top surface is contaminated with chloride concentrations well above the threshold required to induce corrosion of the top reinforcing steel. Whereas the carbonation tests indicate that the soffit has been carbonated to a pH between 7 and 9 and has likely lost the naturally protective film protecting the bottom reinforcing steel. These results indicate that the structural slab is contaminated and prone to further deterioration.

While it is recommended that all the known locations of concrete deterioration be addressed in the short term, the repairs will likely have a short life expectancy due to the existing contamination of the slab. It is likely that this is in part due to a phenomenon known as the anodic ring or “halo” effect. The anodic ring effect is a process which commonly occurs when concrete repairs are cast with new concrete with low chloride concentrations into repair areas surrounded by existing concrete with high chloride concentrations. The difference in chloride concentrations creates an electrochemical imbalance between the existing concrete and repair material. This potential difference in turn causes accelerated deterioration of the concrete along the perimeter of the repairs due to rapid corrosion of the embedded reinforcing steel. The anodic ring effect is likely one of the primary causes of the considerable extents of concrete deterioration that has occurred following the repairs in 2012.

There are a few options to address the slab contamination that warrant consideration; however they range substantially in effectiveness, invasiveness and in cost. In our experience the most effective method is to remove as much of the chloride contaminated material as possible, implement galvanic protection where chloride contaminated material remains and install a protective moisture barrier to eliminate moisture which is necessary for corrosion.

The least invasive and least expensive method is to introduce galvanic protection as concrete repairs are being completed. This would include the installation of sacrificial zinc anodes into concrete repair patches. Sacrificial zinc anodes are electrically more active than typical reinforcing steel and will dissolve preferentially in lieu of corrosion of the reinforcing steel. Although galvanic protection is effective at reducing the rate of corrosion it does not stop corrosion, nor does it affect areas beyond the repair patches in which they were installed. It would also be recommended that any repair areas be coated with a protective waterproofing membrane system and lap onto the existing system. It should be noted that periodic maintenance and repairs would be required to address new locations of concrete deterioration and locations where the existing repairs and/or protection has failed.

Full depth replacement of the structural concrete slab would effectively address the contaminated concrete, however, the capital costs and invasiveness to the parkade would be high. A possibly more cost-effective alternative is partial depth removal of the top surface across the entire structural slab. The chloride testing suggests that the chloride concentration drops to near negligeable at a depth of 100-110mm (4-4.5 inches). Therefore, removal and replacement of the top three to four inches from the structural slab could effectively eliminate the majority of the chloride contamination from the structural slab. Although this would also have a large upfront capital cost and be invasive to the parkade, the benefits of a new concrete overlay may be justified by substantially greater anticipated effective service life compared to localized repairs only. For this option we anticipate that a service life in the range of 20 to 25 years with significantly reduced annual repairs and maintenance costs.

When considering the existing condition of the structural slab and the extents of concrete deterioration that have occurred since the last restoration in 2012, a localised repair program of the same magnitude should be expected every 5 to 7 years. Therefore, including the short term recommendations for 2021, four to five large scale remediations would be anticipated over the next 20 to 25 years.

In lieu of traditional percussion-type demolition (electric chipping hammers), the removal could be completed using hydro-demolition. Hydro-demolition uses water jets with pressures upward of 17,000 psi to pulverize the concrete. Although the noise generated by hydro-demolition equipment is considerably loud in the area of work, the decibel level decreases significantly with distance. Since hydro-demolition is non percussive, the noise does not tend to travel through the structure and would therefore limit noise transmission and disturbance to the library above. In addition, hydro-demolition can be relative quick in comparison to traditional percussing-type demolition resulting in a quicker turn over of repair phases.

Although the existing waterproofing installed on Level P1 is generally in good condition, it should be noted that the concrete repairs will require localised waterproofing repairs to protect the new concrete. This will result in a large number of waterproofing patches spread throughout the parkade. While waterproofing patches are effective at preventing water infiltration, colour and texture matching is not always possible and may not be aesthetically pleasing. It was also noted during the visual review that the drive aisles and turning zones appear to be wearing faster than the parking stalls, which is a typical wearing pattern for parkades. To maintain the protective coating, it is recommended that recoating of the drive aisles and turning zones be scheduled to occur in the medium term. It is also recommended that budgeting be retained for recoating of the parking stalls within the long term.

The existing coatings in the mechanical rooms, stairwells, and vestibules, are at the end of their service life. Although these areas will not be exposed to the same level of chloride laden moisture as the parking deck, they will be exposed to contaminants being tracked by pedestrians and mechanical spills. Though limited, these contaminants will cause deterioration overtime as can be confirmed by the concrete deterioration identified in the mechanical rooms. It is our recommendation that the existing coatings in these areas, where present, be removed and replaced with a waterproofing membrane system. We recommend that this be completed in the medium term.

The table below provides estimated construction costs for removal of approximately 2½” to 3” of the top surface across the entire structural slab using hydro-demolition and includes all of the recommendations listed in Table 10 above. Note that hydro-demolition would not be feasible within the stairwells, vestibules nor within the mechanical rooms. Repairs in these areas would be completed via conventional demolition. Based on the level of investigation and available information, the budget estimates are considered Class 4 (-30% to +50%) and excludes taxes, contingencies, and professional fees.

Table 11: Option 2: Top Surface Removal, Resurfacing and Waterproofing

| | Description | Est. Qty | Unit Price | Estimated Total Price |
|---|---|---|---|---|
| 1 | Hydro-Demolition 0” to 3” | 86,000 ft² | $25.00 /ft² | $2,150,000 |
| 2 | Top Surface Repairs | | | |
| | 2.1 0" to 3" | 500 ft² | $35.00 /ft² | $17,500 |
| | 2.2 3" to 6" | 6,000 ft² | $30.00 /ft² | $180,000 |
| | 2.3 Through slab | 300 ft² | $65.00 /ft² | $19,500 |
| 3 | Soffit Repairs | | | |
| | 3.1 0" to 3" | 800 ft² | $120.00 /ft² | $96,000 |
| | 3.2 3" to 6" | 200 ft² | $60.00 /ft² | $12,000 |
| 4 | Column and Wall Form and Pour Repairs | | | |
| | 4.1 0" to 3" | 75 ft² | $115.00 /ft² | $8,625 |
| | 4.2 3" to 6" | 40 ft² | $90.00 /ft² | $3,600 |
| 5 | Concrete Column Swales | 5 locations | $2,000 /loc. | $10,000 |
| 6 | Traffic bearing membrane | 86,000 ft² | $8.00 /ft² | $688,000 |
| 7 | Crack Routing and Sealing | 4,000 lin.ft. | $14.00 /lin.ft. | $56,000 |

| | Description | Est. Qty | Unit Price | Estimated Total Price |
|---|---|---|---|---|
| 8 | Crack Polyurethane Injection | 50 lin.ft. | $150.00 /lin.ft. | $7,500 |
| 9 | Miscellaneous Concrete Repairs | Allowance | | $30,000 |
| 10 | General Conditions | Allow 15% | | $490,000 |
| **Total Estimated Price (not including GST)** | | | | **$3,770,000.00** |

Though replacement of the top surface via hydro-demolition as a short-term option has a large estimated upfront cost, in the order of $3.77 million when including the remaining structural short-term recommendations, the potential benefits warrant its consideration as a short-term option. As described above, replacement of the contaminated top surface and installation of a new waterproofing membrane would be expected to extend the service life of the existing structural slab by an order of 20 years with proper maintenance. It should also be noted that replacement of the structural slab top surface and installation of a new traffic bearing waterproofing membrane, will reduce the extents and costs of yearly maintenance.

### 4.3 Regular Maintenance and Inspections

The processes which cause deterioration are inherently present within the structure and will continue to occur over the life of the structure. It has been our experience, and that of research conducted by the NRC, that regular maintenance will reduce overall life-cycle costs. It has also been our experience that when a regular maintenance program is adopted, the annual expenditures for repairs tend to lessen from year to year once all areas of existing deterioration are addressed. Therefore, to minimize the cumulative effects of the deterioration process, extend the service-life of the repairs, and maximize time between major restorations, it is strongly recommended that an annual maintenance program be adopted. The following table summarizes typical maintenance work required over the next ten years.

In order to reduce the potential for infiltration of chlorides, and reduce wear on the surface and joints, regular cleaning of the parkade is recommended. In general, sweep cleaning of all levels is recommended each fall and more thorough cleaning using copious amounts of water every spring. Monthly cleaning of floor drains is also recommended to ensure that water does not have a chance to pond on the surface. Mechanically cleaning of drain lines is recommended annually.

Table 12: Maintenance Recommendations

| | Description | Priority | Timing |
|---|---|---|---|
| 1 | Removal of concrete which is loose and in danger of falling. | Safety | As required |
| 2 | Structural concrete repairs. | High Priority | As required |
| 3 | Joint and crack sealing including replacement of existing joints. | Maintenance | Required on an annual and/or periodic basis |
| 4 | Membrane repairs to address snow clearing damage and wear-and-tear. | Maintenance | Complete annually (spring) |
| 5 | Check floor drain operation cleaning and clean sediment buckets. | Maintenance | Complete at monthly intervals |
| 6 | Mechanically clean drain lines. | Maintenance | Maintenance |
| 7 | Power washing parkade floors. | Maintenance | Complete annually (spring) |
| 8 | Repaint traffic marking and stall lines. | Maintenance | Complete annually (spring) |
| 9 | Visual walk-through structural inspection. | Recommended | Complete annually (fall) |
| 10 | Sounding survey | Recommended | Complete every three (3) years |

# 5. 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 results of our investigation and combined with the experience of restoration on similar projects, the following summarizes the estimate of probable construction costs for the recommendations discussed within this report. Based on the level of investigation and available information, the budget estimates are considered Class 4 (-30% to +50%) for years 1 through 6 and Class 5 (-50% to +100%) for years 7 through 10. The budget estimates are prepared based on limited information with no engineering work completed and preliminary scope determination.

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. In addition, the estimates provided do not include soft costs related site-specific requirements such as security, protection, phasing, etc. which can affect total construction costs. For this reason, further investigation and updating of budget construction costs should be completed prior to finalizing repair options. All costs are presented in 2021 dollars.

## 5.1 Required Repairs

Items that require immediate action as a result of any of the following: potential unsafe conditions, material building or fire code violations, or conditions that if left unremedied, uncorrected, have the potential to result in or contribute to critical element or system failure within one year or will result most probably in a significant escalation of its remedial cost. Repairs required within 3 months. Localized areas of loose concrete and potential tripping hazards were observed during our investigation. To reduce the potential for concrete to dislodge and fall, it is recommended that any loose concrete be removed as soon as reasonably possible. It is also recommended that potential tripping hazards be patched as soon as reasonably possible. We recommend a budget of $10,000.00 to complete this work.

Table 13: Required Repairs

| | Description | Allowance | Estimated Total Price |
|---|---|---|---|
| **Structural** | | | |
| 1 | Loose Overhead Concrete | | $7,500 |
| 2 | Tripping Hazards | | $2,500 |
| | | ***Subtotal Structural*** | ***$10,000*** |
| **Mechanical** | | | |
| 3 | Fuel Oil Ventilation Fan Installation | | $80,000 |
| | | ***Subtotal Mechanical*** | ***$80,000*** |
| **Electrical** | | | |
| 4 | Exit Lighting Repairs | | $3,000 |
| 5 | Distribution Repairs | | $10,000 |
| | | ***Subtotal Electrical*** | ***$13,000*** |
| **Total Estimated Required Repairs (not including GST) – Within 3 Months** | | | **$103,000** |

### 5.2 Short Term Recommendations

Recommendations in this section address high priority repairs and/or maintenance items including code and regulatory issues which should be implemented within 1 year.

With respect to the structural recommendations described in Section 4.1 of this report, repairs under Structural Option 1 do not address the underlying cause(s) of the deterioration which will limit their durability and performance over the long term. In contrast, Option 2 in Section 4.2 of this report, includes additional recommendations aimed at addressing the underlying causes of the deterioration and improving long term durability. If required to meet budgetary or phasing constraints, these repairs could be phased over a period of two to three years, however deferral beyond 2021 is not recommended. The following table summarizes the proposed scope of work for the short-term recommendations and associated construction costs.

Table 14: Summary of all Short Term Recommendations

| Description | | Estimated Costs | |
|---|---|---|---|
| | | **Structural Option 1** | **Structural Option 2** |
| **Structural** | | | |
| 1 | Tables 10 and 11 Above – *Note: General Conditions have been removed* | $1,390,475 | $3,280,000 |
| | ***Subtotal Structural*** | ***$1,390,475*** | ***$3,280,000*** |
| **Mechanical** | | | |
| 2 | Natural Gas Piping - Painting | $10,000 | $10,000 |
| 3 | Fuel Oil Tanks – Seal Tappings | $3,000 | $3,000 |
| 4 | Parking Booth Ventilation Addition | $40,000 | $40,000 |
| 5 | Ventilation Addition for Office Spaces | $45,000 | $45,000 |
| 6 | Addition of NO2 detection at all required locations | $180,000 | $180,000 |
| | ***Subtotal Mechanical*** | ***$278,000*** | ***$278,000*** |
| **Electrical** | | | |
| 7 | Improved labeling for electrical equipment | $15,000 | $15,000 |
| 8 | Creation of Single Line Diagram | $7,500 | $7,500 |
| 9 | Emergency Generator – Battery Replacement | $10,000 | $10,000 |
| 10 | Alarm System Replacement (Booth Only) | $10,000 | $10,000 |
| | ***Subtotal Electrical*** | ***$42,500*** | ***$42,500*** |
| 10 | General Conditions – Allow Approximately 15% | $256,025 | $539,500 |
| **Total Estimated Short Term Recommendations (Within 1 Year)** | | **$1,967,000** | **$4,140,000** |

### 5.3 Medium Term Recommendations

Medium term recommendations include repairs to address ongoing or low-risk deterioration, maintenance of existing protective systems and repairs designed to improve long term durability. It is recommended that repairs in this category be implemented within 5 years. Please note that there is no cost difference between the two structural options and is presented for consistency.

Table 15: Summary of all Medium Term Recommendations

| Description | | Estimated Costs | |
|---|---|---|---|
| | | **Structural Option 1** | **Structural Option 2** |
| **Structural** | | | |
| 1 | Staircase Concrete Repairs | $10,000 | $10,000 |
| 2 | Concrete Column Swales ~ 100 locations | $200,000 | $200,000 |
| 3 | Crack Routing and Sealing ~ 6,000 lin.ft. | $85,000 | $85,000 |
| 4 | Membrane Recoating - Drive Aisles / Turn Zones ~ 44,000 ft² | $350,000 | $350,000 |
| | ***Subtotal Structural*** | ***$645,000*** | ***$645,000*** |
| **Mechanical** | | | |
| 5 | Storm Drainage Piping Replacement | $900,000 | $900,000 |
| 6 | Sump Pump Discharge Piping Replacement | $20,000 | $20,000 |
| 7 | Sanitary Drainage System – Original System Replacement | $900,000 | $900,000 |
| 8 | Domestic Cold Water – Insulation Repair | $70,000 | $70,000 |
| 9 | Carwash Pumps Replacement | $8,000 | $8,000 |
| 10 | Terminal Heating Units Replacement | $80,000 | $80,000 |
| 11 | Hydronic Heating Piping Replacement | $600,000 | $600,000 |
| 12 | Stairwell Force Flow Units - Replacement | $24,000 | $24,000 |
| 13 | Make-up Air Unit Replacement | $4,200,000 | $4,200,000 |
| 14 | Main Exhaust Fans - Replacement | $1,350,000 | $1,350,000 |
| 15 | Hydro Vault Exhaust Fan Replacement | $100,000 | $100,000 |
| 16 | Upgrade Controls from Pneumatic to DDC | $80,000 | $80,000 |
| | ***Subtotal Mechanical*** | ***$8,332,000*** | ***$8,332,000*** |
| **Electrical** | | | |
| 17 | Emergency Lighting Replacement | $100,000 | $100,000 |
| 18 | Exit Lighting Replacement | $50,000 | $50,000 |
| 19 | Fire Alarm Replacement and Upgrade | $1,750,000 | $1,750,000 |
| | ***Subtotal Electrical*** | ***$1,900,000*** | ***$1,900,000*** |
| 20 | General Conditions – Allow Approximately 15% | $1,633,000 | $1,633,000 |
| **Total Estimated Medium Term Recommendations (Years 1 to 5)** | | **$12,510,000** | **$12,510,000** |

### 5.4 Long Term Recommendations

Long term recommendations include repairs to address ongoing or low-risk deterioration and replacement of end of service life components. It is recommended that repairs in this category be implemented within 10 years. Note that Table 16 assumes that the short term structural recommendations are implemented and includes an allowance for a second structural restoration as discussed in Section 4.1.

Table 16: Long Term Recommendations

| Description | | Estimated Costs | |
|---|---|---|---|
| | | **Structural Option 1** | **Structural Option 2** |
| **Structural** | | | |
| 1 | Allowance for second structural restoration | $1,600,000 | $0 |
| 2 | Slab-on grade replacement at pits/ stairwells/vestibules ~ 3,000 ft² | $90,000 | $90,000 |
| 3 | Exterior waterproofing ~ 10,000 ft² | $5,000,000 | $5,000,000 |
| 4 | Membrane recoating of parking stalls ~ 42,000 ft² | $336,000 | $336,000 |
| | ***Subtotal Structural*** | ***$7,026,000*** | ***$5,426,000*** |
| **Mechanical** | | | |
| 5 | Sanitary Drainage System – Original System Replacement | $900,000 | $900,000 |
| 6 | Sanitary Drainage – Parkade System – Localized Repairs | $5,000 | $5,000 |
| 7 | Natural Gas Piping – Replacement | $300,000 | $300,000 |
| 8 | Fire Protection – Dry Valves Replacement | $70,000 | $70,000 |
| | ***Subtotal Mechanical*** | ***$1,275,000*** | ***$1,275,000*** |
| **Electrical** | | | |
| 9 | General Lighting Replacement | $2,000,000 | $2,000,000 |
| 10 | Main Distribution Replacement | $1,500,000 | $1,500,000 |
| 11 | Distribution Replacement (CDPs. Panelboards, transformers, etc.) | $1,500,000 | $1,500,000 |
| 12 | Branch Circuit Wiring Replacement | $1,300,000 | $1,300,000 |
| 13 | CCTV Replacement | $250,000 | $250,000 |
| | ***Subtotal Electrical*** | ***$6,550,000*** | ***$6,550,000*** |
| 14 | General Conditions – Allow Approximately 15% | $2,229,000 | $1,989,000 |
| **Total Estimated Long Term Recommendations (Years 6 to 10)** | | **$17,080,000** | **$15,240,000** |

### 5.5 Long Term Considerations / Recommended Improvements

Long term considerations and recommended improvements include optional repair work and recommended improvements for future consideration and planning.

Table 17: Long Term Considerations

| Description | | Estimated Total Price |
|---|---|---|
| **Structural** | | |
| 1 | Coating Replacement in Mech, Stairwells and Vestibules ~ 10,000 $ft^2$ | $120,000 |
| | ***Subtotal Structural*** | ***$120,000*** |
| **Mechanical** | | |
| 2 | Parkade Drains – Lower Level – Monitor Corrosion | $45,000 |
| 3 | Sprinkler Systems - Piping Replacement | $1,224,000 |
| | ***Subtotal Mechanical*** | ***$1,269,000*** |
| **Electrical** | | |
| 4 | Emergency Generator Replacement | $350,000 |
| | ***Subtotal Electrical*** | ***$350,000*** |
| **Total Estimated Long Term Considerations (not time critical)** | | **$1,739,000** |

### 5.6 Summary

The following table provides a summary of the budget estimates by order of priority. 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. In addition, the estimates provided do not include soft costs related site-specific requirements such as security, protection, phasing, etc. which can affect total construction costs. All costs are presented in 2021 dollars.

Table 18: Summary of All Priorities

| Category | Estimated Costs | |
|---|---|---|
| | Structural Option 1 | Structural Option 2 |
| Total Required Repairs (within 3 months) | $103,000 | $103,000 |
| Total Short Term Recommendations (within 1 year) | $1,967,000 | $4,140,000 |
| Total Medium Term Recommendations (Year 1 to 5) | $12,510,000 | $12,510,000 |
| Total Long Term Recommendations (Year 5 to 10) | $17,080,000 | $15,240,000 |
| Long Term Considerations/Recommended Improvements (not time critical) | $1,739,000 | $1,739,000 |
| **Total of All Recommendations** | **$33,399,000** | **$33,732,000** |

# 6. Closure

At the request of the City of Winnipeg, a multi-disciplinary parkade condition assessment of the Millennium Library Parkade was completed by Crosier Kilgour & Partners Ltd. and SMS Engineering Ltd. The purpose of the assessment was to provide an opinion on the current condition of the parkade structure, mechanical, and electrical systems.

The assessment involved a visual walk-through survey of the parkade structure and the mechanical and electrical systems. In addition, a sounding survey, membrane condition survey and core testing were completed on the upper parking level. Recommendations for immediate, short, mid, and long-term repair/replacement costs were provided along opinions of probable construction costs for suggested remedial work.

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.

Structural
CROSIER KILGOUR & PARTNERS LTD.

Reviewed by,

Jean Sawatzky, E.I.T.

Originally Sealed April 1, 2021
Derek J. Mizak, P.Eng.
Principal

https://ckpeng.sharepoint.com/sites/2020-1183/Shared Documents/General/01 Corres/2020-1183Report_01.docx

# Appendix A

Photographs

Photograph #1:

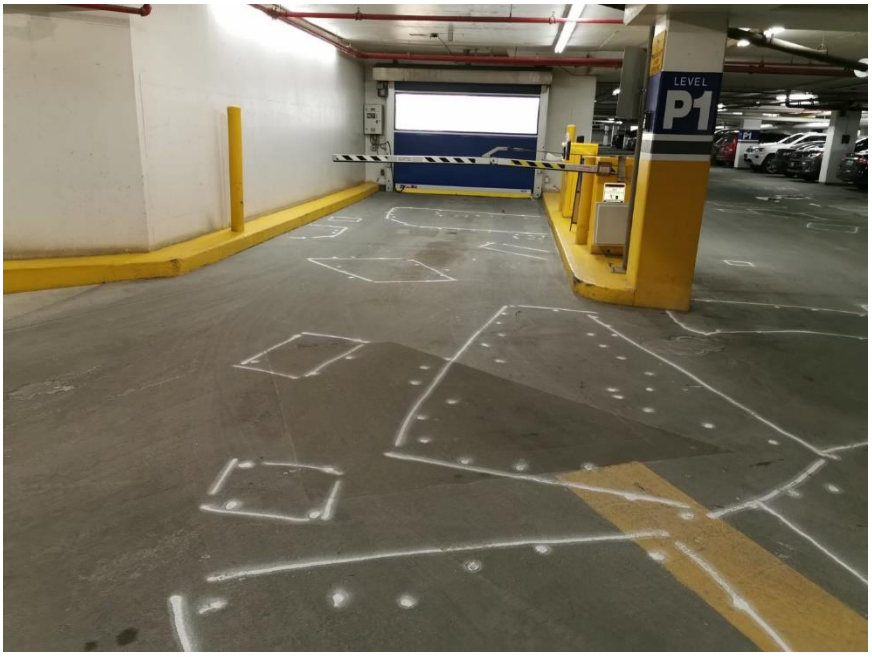
Waterproofing worn down to concrete in north drive aisle

Photograph #2:

Previous waterproofing repair location.

Photograph #3:

Approximate extents of apparent concrete delamination marked onsite.



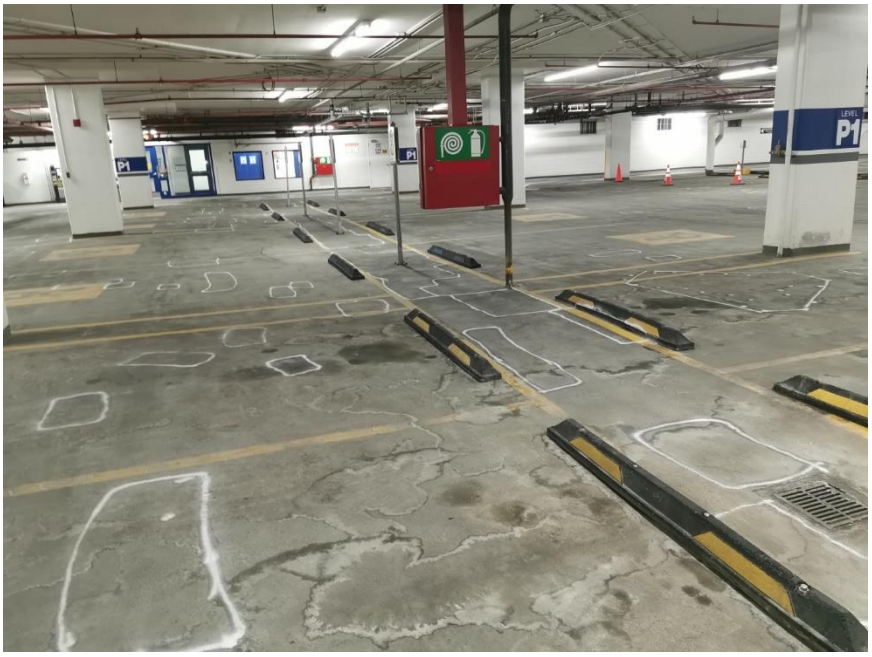

Photograph #4:

Approximate extents of apparent concrete delamination marked onsite.

Photograph #5:

Approximate extents of apparent concrete delamination marked onsite.

Note variation in location and size.




Photograph #6:

Soffit deterioration at mechanical.

Photograph #7:

Approximate extents of apparent concrete delamination marked on column.

Photograph #8:

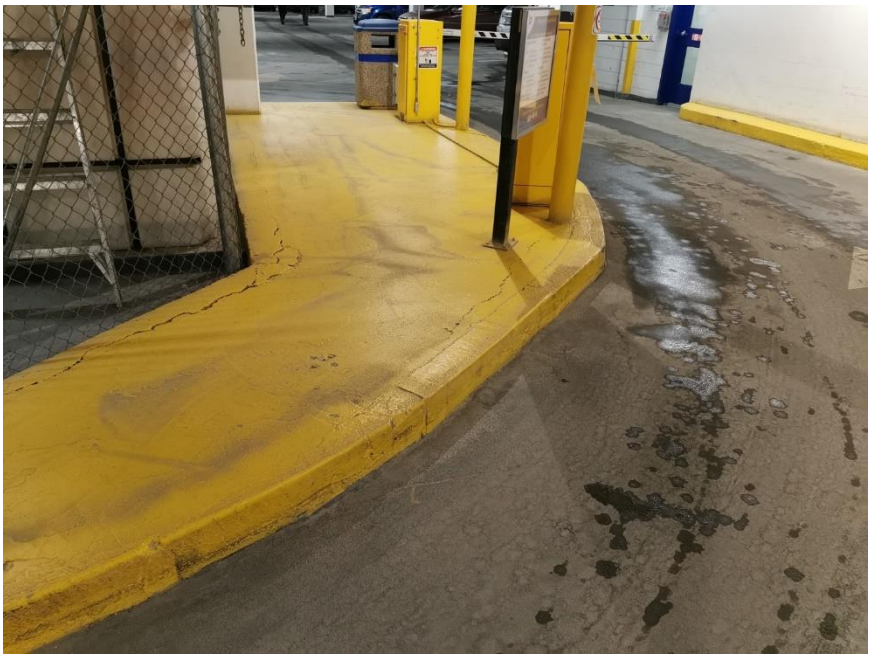
Typical condition of observed drains.

Photograph #9:

Typical condition of existing asphalt curbs.

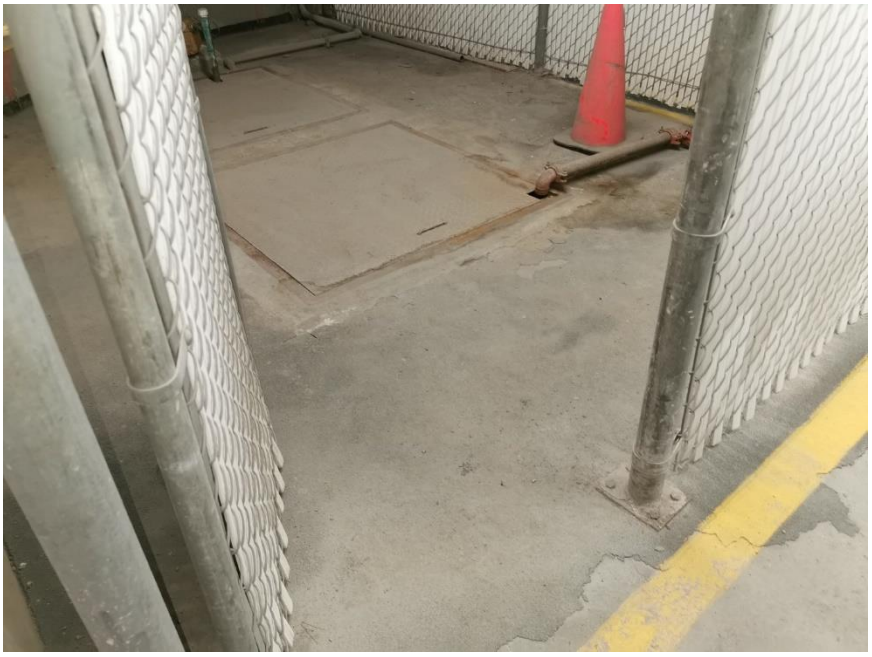

Photograph #10:

Existing concrete curb at Donald street entrance.



Photograph #11:

Existing waterproofing in Level P2 mechanical pit enclosure in poor condition.



Photograph #12:

Typical scaling along base of wall on Level P2.

Photograph #13:

Water ponding against base of column on Level P2.

Photograph #14:

Visible scaling and efflorescence along base of column on Level P2.

Photograph #15:

Plywood formwork installed to cover gap between existing concrete column jacket and slab-on-grade.

Photograph #16:

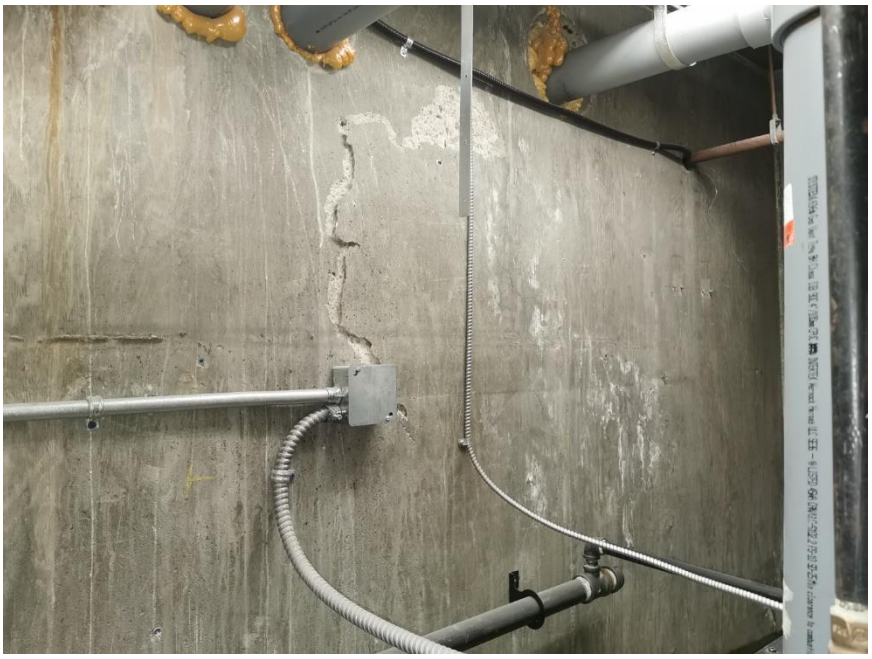
Random cracking in slab-on-grade.

Photograph #17:

Visible concrete delamination in washroom.

Photograph #18:

Visible concrete wall delamination in mechanical room on side of ramp.



Photograph #19:

Typical condition of existing coating in mechanical rooms.

Note apparent concrete delamination beneath coating.

Photograph #20:

Efflorescence visible in top exterior corner of mechanical room.

Photograph #21:

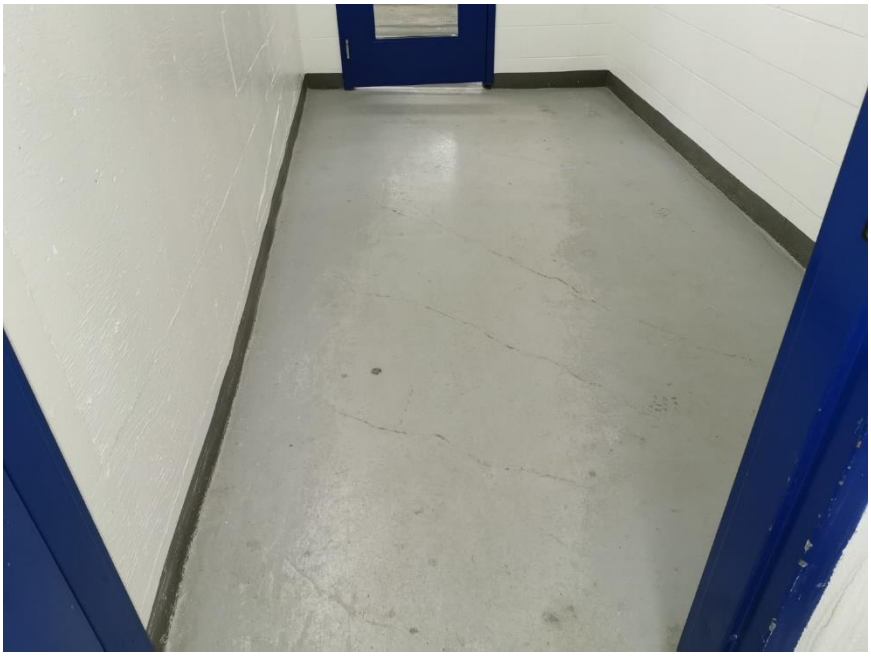
Typical observed condition of drains in mechanical rooms.

Photograph #22:

Existing crack in concrete stair landing.

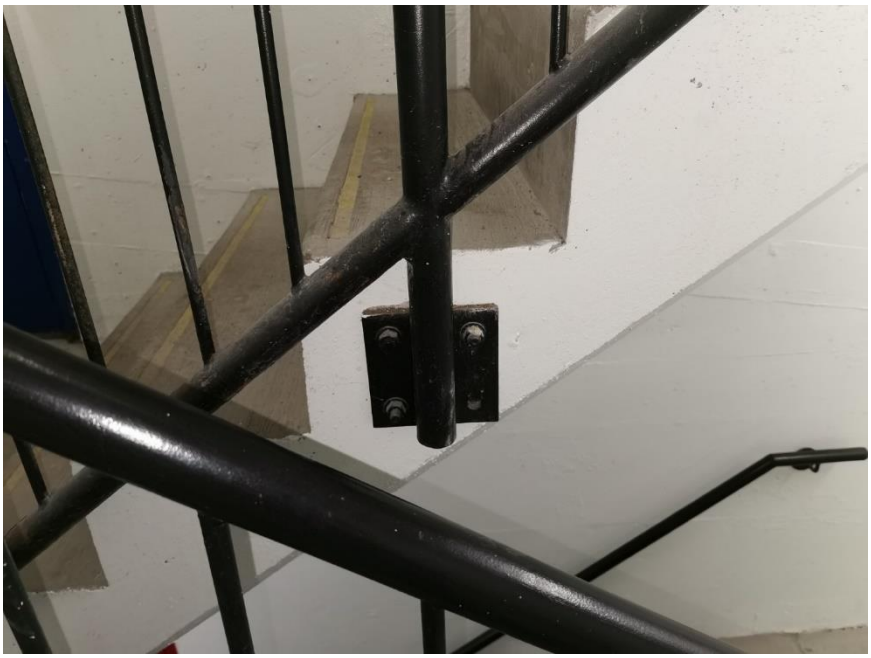
Photograph #23:

Existing coating in stairwell vestibule. Note cracking and apparent concrete delamination visible beneath coating.



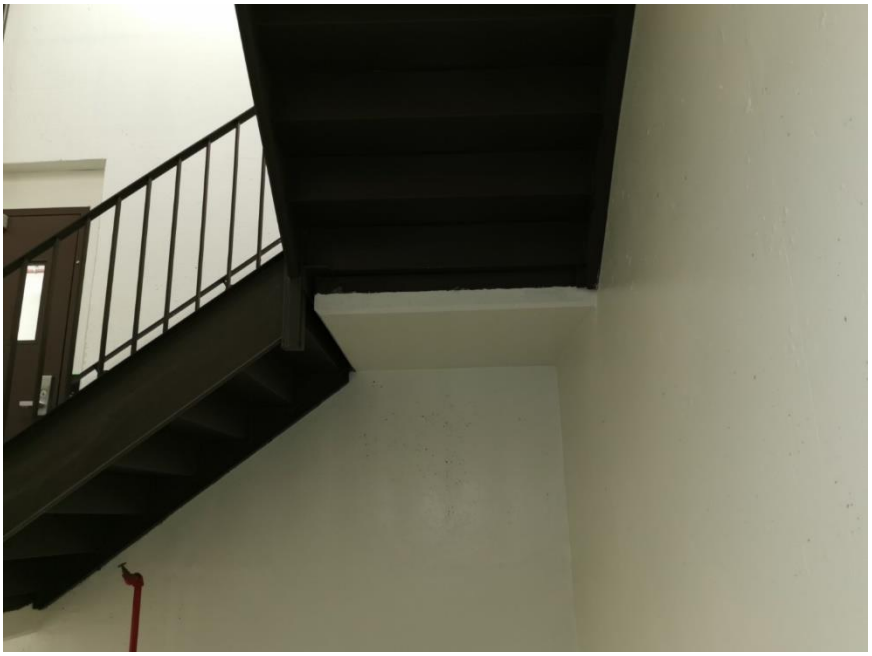
Photograph #24:

Anchor missing from existing stair guardrail.



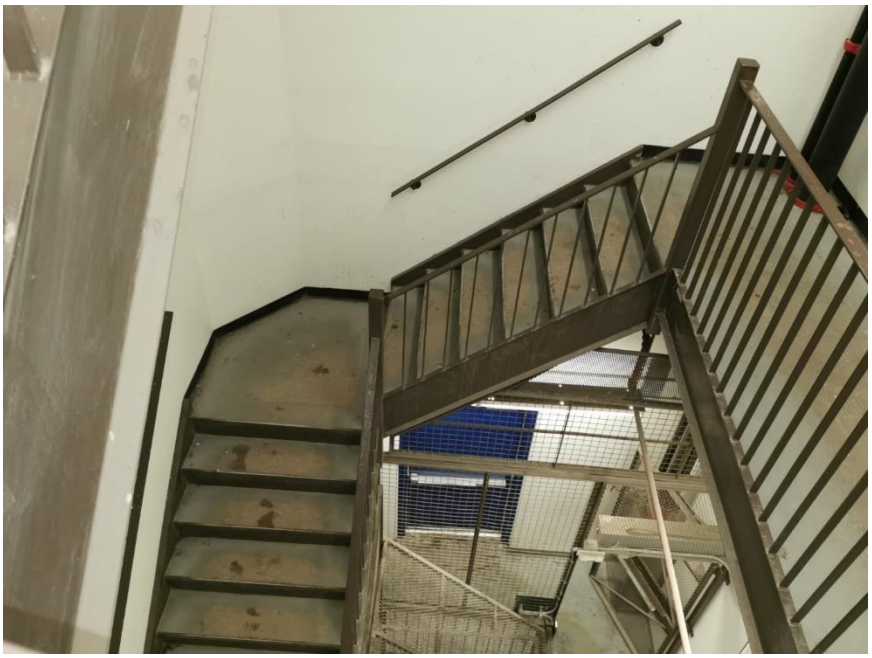
Photograph #25:

Typical condition of structural steel and steel stair pans.



Photograph #26:

Typical condition of concrete stair treads.



Photograph #27:

Cracking and minor deterioration of treads.

Photograph #28:

Concrete soffit deterioration at underside of exterior plaza.

# Appendix B

Mechanical and Electrical Report by SMS Engineering Limited

# Millennium Library Parkade Condition Assessment – Mechanical and Electrical

March 11, 2021

City of Winnipeg
4th Floor, 185 King Street
Winnipeg, MB, R3B 1J1

SMS Project No.: 20-337-01

**SMS Engineering Limited** 770 Bradford Street, Winnipeg, MB, Canada R3H 0N3 **T** 204 775 0291 SMS@SMSeng.com **SMSeng.com**



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ELECTRICAL

Prepared by:

Gordon Whiffen, P.Eng.
Electrical Engineer

INDEX

# 1 INTRODUCTION AND SCOPE OF REPORT

## 1.1 INTRODUCTION

The Millennium Library Parkade is a two level parkade below the Millennium Library in downtown Winnipeg, located at 251 Donald Street. The parkade is owned and managed by the City of Winnipeg. The library and parkade were originally constructed in 1977. A large project started in 2002 and was completed in 2005 to renovate the library which impacted the parkade and saw the installation of the large Erlenmeyer flask art, "Emptyful". The art installation is a water feature which has all the equipment housed in the upper parkade level. In 2012 the parkade started a multi-year renovation which included some plumbing modifications, stairwell replacement and one entrance slab replacement including in-slab heating.

## 1.2 GENERAL BUILDING DESCRIPTION

The parkade is approximately 204,000 $ft^2$ over two parking levels. Most of the parkade is located below the plaza area above. There are four ramps into the facility, two located on Donald Street and two located on Smith Street. The ramps have in-slab heating systems. One entrance ramp was replaced in 2021 and the remaining three in 2017. The Parkade houses an office for the City of Winnipeg Parking Authority. The facility also has a car-wash bay which is located on the upper level. For the most part, mechanical systems between the parkade and the library are separate with the exception of:

- The boiler system from the library serves the unit heaters in the parakade.
- The sanitary drainage from the library passes through the parkade.
- The domestic water services for both portions of the facility are within the upper level of the parkade.
- Portion of the fire protection systems serving the library pass through the upper parkade.

## 1.3 SCOPE

The scope of this report was to perform a site review to identify and observe conditions of the existing mechanical and electrical systems. This review is limited to a visual review of the systems and equipment to determine apparent condition and evaluate the age against industry standard service life information. Current code compliance has been reviewed and where deficiencies are noted they have been identified in the report. The scope of work does not include any physical testing of equipment or systems and excludes any assessment for hazardous material or environmental concerns.

By providing this building condition assessment report, SMS is providing an opinion and does not warranty or guarantee the present or future condition of the subject property including all systems and components. The opinions are based on historical and professional judgment based on the brief visual review of the system. The report is not a

code compliance audit but does identify those items found during our site visit and visual review. SMS cannot be held liable for any loss, or damages which may arise from the results of any recommendation in the report.

## 1.4 EXCLUSIONS

This report is based on a review of the available construction drawings and a brief visual review of the site to determine general quality of the systems.

The performance levels of the systems were not verified and the references to system capacities are based on information from the original design documents, where available, or our site review.

When this building was built it was common to use materials that are now considered hazardous. Such material included PCBs and a number of asbestos products. It might be assumed that such materials exist in the mechanical and electrical system. We would expect that special precautions will be required when removal of hazardous material takes place during alterations, all in accordance with existing regulations that are practiced by competent contractors. All hazardous material assessments have been excluded from our review.

The drawings reviewed are not considered as-built and site verification of the as-built condition is not included in this report.

The scope of work extents were limited to systems within the parkade. Since the plaza level is above, drainage piping and electrical services that serve the plaza are reviewed just for the interior condition of the systems. The devices or equipment on the plaza are excluded from review. In addition, the “emptyful” sculpture and the fountain system associated with the sculpture are excluded from the scope. The entrance and exit ramps have been included. Where services from the library pass into the parkade, the visual condition has been reviewed but any services or systems above the parkade have been excluded.

# 2 SUMMARY

## 2.1 GENERAL

2.1.1 The recommendations made below are based on code deficiencies, life safety items and expected service life of the equipment. The recommendations do not mean that the equipment will not operate, or that immediate failure will occur but aim to target the critical items. The table below outlines the deficiency and the potential repair or solution. All systems were visually reviewed, and no physical testing was complete. All conditions were reviewed based on the "as is" condition. Our summary excludes any mention of hazardous materials in the building. The tables below provides a brief summary of our findings related to items which would have costs associated with them or are life safety issues. The following categories are provided.

.1 Required Repairs (within 3 months) – Repairs necessary to address specific safety issues.
.2 Short Term Recommendations (within 1 year) – High priority for repairs/maintenance including code and regulatory issues.
.3 Medium Term (Year 1 to 5) – Repairs required to address ongoing or Medium-risk deterioration, replacement of end of service-life building components.
.4 Long Term (Year 5 to 10) – Repairs required to address ongoing or low-risk deterioration, replacement of end of service-life building components.
.5 Long Term Considerations and Recommended Improvements (not time critical). Optional work including recommended improvements presented for future consideration and planning.
.6 Maintenance (ongoing) – Repairs required to address ongoing, or routine maintenance.

## 2.2 MECHANICAL

| Item | Description | Code Req. | Recommendation | Time Frame |
|---|---|---|---|---|
| PARKADE | | | | |
| 1 | Storm Drainage Piping Replacement | No | Replace the aging storm drainage piping which is nearing the expected service life. | Medium Term |
| 2 | Sump Pump Discharge Piping Replacement | No | Replace galvanized sump pump discharge piping. | Medium Term |

| | | | | |
|---|---|---|---|---|
| 3 | Sump Pump Replacement | No | On-going maintenance for sump pump replacements. | Maintenance |
| 4 | Sanitary Drainage System – Original System Replacement | No | The sanitary drainage piping in the facility that is original is nearing the expected service life of 50 years and will start to require additional maintenance. Sections should start to be replaced with the goal of replacing the entire system in the long-term horizon. | Medium/Long Term |
| 5 | Sanitary Drainage – Parkade System – Localized Repairs | No | Localized repair of corroded pipe sections. | Long Term |
| 6 | Parkade Drains – Lower Level – Monitor Corrosion | No | Monitor condition of lower level drains for corrosion. The drains appear to be corroding quickly. | Long Term Consideration |
| 7 | Domestic Cold Water – Insulation Repair | No | Replace the insulation on the domestic cold-water piping as it is in poor condition. | Medium Term |
| 8 | Carwash Pumps Replacement | No | Replace the high-pressure pumps serving the carwash as they are at the expected service life. | Medium Term |
| 9 | Natural Gas Piping - Painting | No | The piping is getting older and sections have corrosion. Portions have been painted but sections are bare. Paint bare sections. | Short Term |
| 10 | Natural Gas Piping – Replacement | No | Replace the natural gas piping in the parkade | Long Term |
| 11 | Fire Protection – Dry Valves Replacement | No | Replace the dry valves for the sprinkler system as they near the end of their expected service life. | Long Term |
| 12 | Sprinkler Systems - Piping Replacement | No | The piping is getting older and will need to be replaced. It is expected some section will need to be replaced before others but at this time it is a long-term consideration. | Long Term Consideration |
| 13 | Terminal Heating Units Replacement | No | The unit heaters in the parkade are dated and believed to be original and are beyond the expected service life. The units are in poor condition and expected to need replacement. | Medium Term |

| | | | | |
|---|---|---|---|---|
| 14 | Hydronic Heating Piping Replacement | No | The heating piping serving the terminal units is believed to be original, is nearing the expected service life and in poor condition. The insulation and piping is recommended for replacement. It is noted the piping is fed from the Library boiler plant. | Medium Term |
| 15 | Stairwell Force Flow Units - Replacement | No | The force flow units in the stairwells are in varying degree of condition. Two are new while the others are original. Replace the original units. | Medium Term |
| 16 | Fuel Oil Tanks – Seal Tappings | No | The fuel oil tanks appear to be leaking a small amount of fuel oil at the tappings. Replace connections and re-seal piping. | Short Term |
| 17 | Fuel Oil Ventilation Fan Installation | Yes | A ventilation fan is required for any are where fuel oil is stored. | Required Repair |
| 18 | Make-up Air Unit Replacement | Yes | The existing make-up air unit is beyond the expected service life and should be scheduled for replacement. As part of the replacement the unit would need to be upsized to meet current code requirements | Medium Term |
| 19 | Main Exhaust Fans - Replacement | Yes | The main exhaust fans are beyond the expected service life and should be scheduled for replacement. The fans are undersized based on current code requirements for a $CO/NO_2$ purge system | Medium Term |
| 20 | Parking Booth Ventilation Addition | Yes | The parking attendant booth is required to have ventilation air by current code. The booth currently does not. Air cannot be taking from the parkade for this occupancy. | Short Term |
| 21 | Ventilation Addition for Office Spaces | Yes | The use of parkade air for ventilating office spaces does not meet code requirements. | Short Term |
| 22 | Hydro Vault Exhaust Fan Replacement | No | The fan is beyond the expected service life and should be replaced to ensure conditioning for the hydro vault can be maintained. | Medium Term |

| | | | | |
|---|---|---|---|---|
| 23 | Addition of $NO_2$ detection at all required locations | Yes | The system is currently predominantly CO system. As part of current code requirements for parking garages where diesel vehicles could enter $NO_2$ detection is required. | Short Term |
| 24 | Upgrade Controls from Pneumatic to DDC | No | This should be done at the same time as the make-up air and exhaust fan replacement to both save energy on compressor power as well as connect all systems to the central monitoring systems for the City of Winnipeg. | Medium Term |

## 2.3 ELECTRICAL

| Item | Description | Code Req. | Recommendation | Time Frame |
|---|---|---|---|---|
| PARKADE | | | | |
| 1 | General Lighting Replacement | No | As this equipment is aging, replacement for these systems should be planned. | Long Term |
| 2 | Emergency Lighting Replacement | No | As this equipment is aging, replacement for these systems should be planned. | Medium Term |
| 3 | Exit Lighting Repairs | Yes | Replace remaining red exit signs with green pictogram signs | Required Repairs |
| 4 | Exit Lighting Replacement | No | As this equipment is aging, replacement for these systems should be planned. | Medium Term |
| 5 | Main Distribution Replacement | No | As this equipment is aging, replacement for these systems should be planned. | Long Term |
| 6 | Improved labeling for electrical equipment | No | Provide new labels for all equipment. | Short Term |
| 7 | Creation of Single Line Diagram | No | Provide a new single line for the facility mounted in the amin electrical room. | Short Term |
| 8 | Emergency Generator Replacement | No | As this equipment is aging, replacement for these systems should be planned. | Long Term consideration |
| 9 | Emergency Generator – Battery Replacement | No | Replace generator batteries. | Short Term |

| | | | | |
|---|---|---|---|---|
| 10 | Distribution Replacement (CDPs. Panelboards, transformers, etc.) | No. | As this equipment is aging, replacement for these systems should be planned. | Long Term |
| 11 | Distribution repairs | Yes | Re-install junction box covers and missing panel covers throughout. | Required Repairs |
| 12 | Branch Circuit Wiring Replacement | No | As this infrastructure is aging, replacement for these systems should be planned. | Long Term |
| 13 | Fire Alarm Replacement and Upgrade | Yes | Install new Fire alarm system and add new strobes through out | Medium Term |
| 14 | CCTV Replacement | No | Replace entire system | Medium Term |
| 15 | Alarm System in Attendants Booth | No | Replace entire system | Short Term |

# 3 OPINION OF PROBABLE CONSTRUCTION COSTS

## 3.1 NOTES

3.1.1 The cost estimates are an opinion of probable cost for the mechanical and electrical work only. The costing Class for years 1-5 are Class 4 and Class 5 for years 6-10 as outlined in the City of Winnipeg Cost estimate guidelines. All related architectural, structural or other discipline work is not included. All estimates do not include applicable taxes and contain no contingency or consulting fees. All estimates do not include soft costs such as permitting etc….

## 3.2 MECHANICAL

The table below references the item outlined in the summary above and opinion of probable cost.

| Item | Description | Cost ($) | Time Frame |
|---|---|---|---|
| | PARKADE | | |
| 1 | Storm Drainage Piping Replacement | $900,000 | Medium Term |
| 2 | Sump Pump Discharge Piping Replacement | $20,000 | Medium Term |
| 3 | Sump Pump Replacement | N/A | Maintenance |
| 4 | Sanitary Drainage System – Original System Replacement | $1,800,000 | Medium/Long Term |
| 5 | Sanitary Drainage – Parkade System – Localized Repairs | $5,000 | Long Term |
| 6 | Parkade Drains – Lower Level – Monitor Corrosion | $45,000 | Long Term Consideration |
| 7 | Domestic Cold Water – Insulation Repair | $70,000 | Medium Term |
| 8 | Carwash Pumps Replacement | $8,000 | Medium Term |
| 9 | Natural Gas Piping – Painting | $10,000 | Short Term |
| 10 | Natural Gas Piping – Replacement | $300,000 | Long Term |
| 11 | Fire Protection – Dry Valves Replacement | $70,000 | Long Term |
| 12 | Sprinkler Systems – Piping Replacement | $1,224,000 | Long Term Consideration |
| 13 | Terminal Heating Units Replacement | $80,000 | Medium Term |
| 14 | Hydronic Heating Piping Replacement | $600,000 | Medium Term |
| 15 | Stairwell Force Flow Units – Replacement | $24,000 | Medium Term |
| 16 | Fuel Oil Tanks – Seal Tappings | $3,000 | Short Term |
| 17 | Fuel Oil Ventilation Fan Installation | $80,000 | Required Repair |
| 18 | Make-up Air Unit Replacement | $4,200,000 | Medium Term |
| 19 | Main Exhaust Fans – Replacement | $1,350,000 | Medium Term |
| 20 | Parking Booth Ventilation Addition | $40,000 | Short Term |
| 21 | Ventilation Addition for Office Spaces | $45,000 | Short Term |
| 22 | Hydro Vault Exhaust Fan Replacement | $100,000 | Medium Term |
| 23 | Addition of NO2 detection at all required locations | $180,000 | Short Term |
| 24 | Upgrade Controls from Pneumatic to DDC | $80,000 | Medium Term |
| | Sub-Total | $11,234,000 | |

The breakdown based on time frame can be seen in the chart below. Where items span multiple time frames the cost have been prorated to each category.

| Time Frame | Corresponding Year Range | Cost ($) |
|---|---|---|
| Required Repairs | 3 Months | $80,000 |
| Short Term | 0-1 Year | $278,000 |
| Medium Term | 1-5 Years | $8,332,000 |
| Long Term | 5-10 Years | $1,275,000 |
| Long Term Consideration | >10 Years | $1,269,000 |
| Maintenance | On-Going | N/A |

## 3.3 ELECTRICAL

The table below references the item outlined in the summary above and opinion of probably cost.

| Item | Type | Cost ($) | Time Frame |
|---|---|---|---|
| | PARKADE | | |
| 1 | General Lighting Replacement | $2,000,000 | Long Term |
| 2 | Emergency Lighting Replacement | $100,000 | Medium Term |
| 3 | Exit Lighting Repairs | $3,000 | Required Repairs |
| 4 | Exit Lighting Replacement | $50,000 | Medium Term |
| 5 | Main Distribution Replacement | $1,500,000 | Long Term |
| 6 | Improved labeling for electrical equipment | $15,000 | Short Term |
| 7 | Creation of Single Line Diagram | $7,500 | Short Term |
| 8 | Emergency Generator Replacement | $350,000 | Long Term Consideration |
| 9 | Emergency Generator – Battery Replacement | $10,000 | Short Term |
| 10 | Distribution Replacement (CDPs. Panelboards, transformers, etc.) | $1,500,000 | Long Term |
| 11 | Distribution repairs | $10,000 | Required Repairs |
| 12 | Branch Circuit Wiring Replacement | $1,300,000 | Long Term |
| 13 | Fire Alarm Replacement and Upgrade | $1,750,000 | Medium Term |
| 14 | CCTV Replacement | $250,000 | Long Term |
| 15 | Alarm System Replacement (Booth Only) | $10,000 | Short Term |
| | Sub-Total | $8,855,500 | |

The breakdown based on time frame can be seen in the chart below. Where items span multiple time frames the cost have been prorated to each category.

| Time Frame | Corresponding Year Range | Cost ($) |
|---|---|---|
| Required Repairs | 3 Months | $13,000 |
| Short Term | 0-1 Year | $42,500 |
| Medium Term | 1-5 Years | $1,900,000 |
| Long Term | 5-10 Years | $6,550,000 |
| Long Term Consideration | >10 Years | $350,000 |
| Maintenance | On-Going | N/A |

## 3.4 VFA REPORTS REVIEW

3.4.1 The VFA report for the Millennium Library parkade was provided to SMS as part of the background information for the parkade. The reports are dated November 24, 2020 and consisted of the following documents:

.1 2020 VFA Asset – Detailed Report – Millennium Parkade (PK-01) - November 24, 2020

.2 2020 VFA Asset – Requirement Forecast Report – Millennium Parkade (OK-01) – November 24, 2020

.3 The forecast requirement was also submitted in excel format.

3.4.2 The reports are all based on an assessment of the facility performed in 2015 and have not been updated for recent projects which have occurred.

3.4.3 A number of items are outside the scope of mechanical and electrical review but for the items within the mechanical and electrical scope of work the total cost for the next 10 years is 27,453,431.32, of which $14,489,739.86 is associated with mechanical leaving $12,963,691.46 for the electrical scope. The distribution is broken down in the chart below.

| Year | Total Cost | Mechanical Cost | Electrical Cost |
|---|---|---|---|
| **2020** | $ 21,968,732.00 | $ 13,597,240.00 | $ 8,371,492.00 |
| **2021** | $ 77,103.24 | $ 77,103.24 | $ - |
| **2022** | $ 1,767.59 | $ - | $ 1,767.59 |
| **2023** | $ 765,872.71 | $ 765,872.71 | $ - |
| **2024** | $ 314,421.96 | $ - | $ 314,421.96 |
| **2025** | $ 108,116.09 | $ 49,523.92 | $ 58,592.18 |
| **2026** | $ - | $ - | $ - |
| **2027** | $ - | $ - | $ - |
| **2028** | $ 4,217,417.72 | $ - | $ 4,217,417.72 |
| **2029** | $ - | $ - | $ - |
| **2030** | $ - | $ - | $ - |

It is our recommendation that a number of the large costs associated with full system replacements for the sanitary piping, storm piping, domestic water systems, branch circuiting can be relocated into later years or addressed as part of on-going repair work.

# 4 MECHANICAL SYSTEMS DESCRIPTION

## 4.1 GENERAL

4.1.1 The parkade is below grade and heated by one central air handler and localized terminal heating units. The systems have been partially upgraded but some are original to the construction of the building. All references to expected remaining service life are based on ASHRAE – HVAC Application Handbook - 2019.

## 4.2 PLUMBING

### 4.2.1 Storm Drainage

.1 There is storm drainage piping which serves the plaza above. The condition is unknown as the piping is mostly insulated and re-covered with PVC jacketing. Most of the piping connected to the drains serving the plaza level were replaced when the plaza was redeveloped but the mains and branch piping is believed to be original. The new piping is within the expected service life but any original piping would be nearing the expected service life of 50 years. The storm drainage piping runs to the south end of the parkade where it is connected to the municipal main on the lower level.

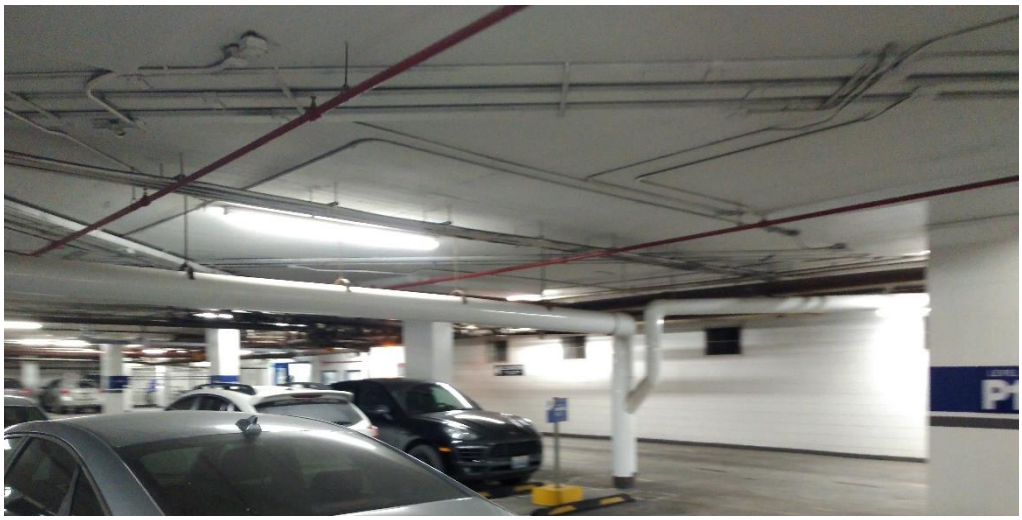


Figure 1: Storm drainage piping fully insulated.

### 4.2.2 Sump Pumps

.1 There are several sump pumps located in the facility. The pits are located mostly on the lower level of the parkade. There are several localized pits which serve applications like weeping tile or localized drainage. There are however, two larger interceptors which capture the drainage from

the upper and lower parkade sanitary drainage system. The pit in the Northwest corner of the lower level is a three compartment arrangement and discharge to the sanitary drainage on the lower level. The second large pit is a double compartment arrangement located in the Southwest corner of the lower parkade and discharges to the sanitary drainage system. All the pumps reviewed appeared to be in fair condition. The exact age is not known but the pumps should be monitored and confirmed operational. Facility staff have indicated they have not had any issues with the pumps recently. The pit condition was not reviewed but facility staff indicated they have not had any issues.

.2 Some of the sump pump discharge piping is galvanized and is showing signs of corrosion on the pipe and fittings. The piping is believed to be original to the facility and nearing the expected service life of 50 years. Once galvanized piping starts to fail it will fail quickly. It is recommended to replace the galvanized piping.

Figure 2: Galvanized discharge piping from lower level sump pits.

### 4.2.3 Sanitary Drainage

.1 The sanitary drainage system for the parkade consists of piping from the library and plaza above as well as the piping serving the drainage for the parkade. Most of the piping for the facility is original with some sections

having been replaced. The piping is in poor condition, is nearing the expected service life of 50 years and it is recommended for replacement. The condition of the piping in the library above is not included in the scope.

.2 Piping serving the parkade level drainage is in good condition with the majority of it replaced as part of the parkade renovation work in 2015. The piping serving the upper level was mostly cast iron and is in good condition with some local signs of corrosion. The drains on the upper level are all new galvanized drains and appear in good condition. The drains are well within the expected service life.

Figure 3: Localized corrosion on new cast iron pipe around drain.

Figure 4: Galvanized drain on upper parkade level.

.3 The drains on the lower level are noted to have been replaced as part of the renovation project in 2015 but show signs of significant corrosion. The drain type form the record drawings appears to be different from the lower level and are not a galvanized rain body. We would recommend monitoring the drains to confirm if the condition worsens.

Figure 5: Drain on lower level showing signs of corrosion.

.4 There is a grit interceptor on the lower level for the carwash. The interceptor is in fair condition and is required by code. No further recommendation.

.5 The piping below the slab on grade section below appears to be plastic and is expected to have been replaced during the parkade renovation based on record information and section of visible plastic piping extending below the slab. All plastic piping as it passes below the slab is equipped with expansion joints as required by current plumbing code.

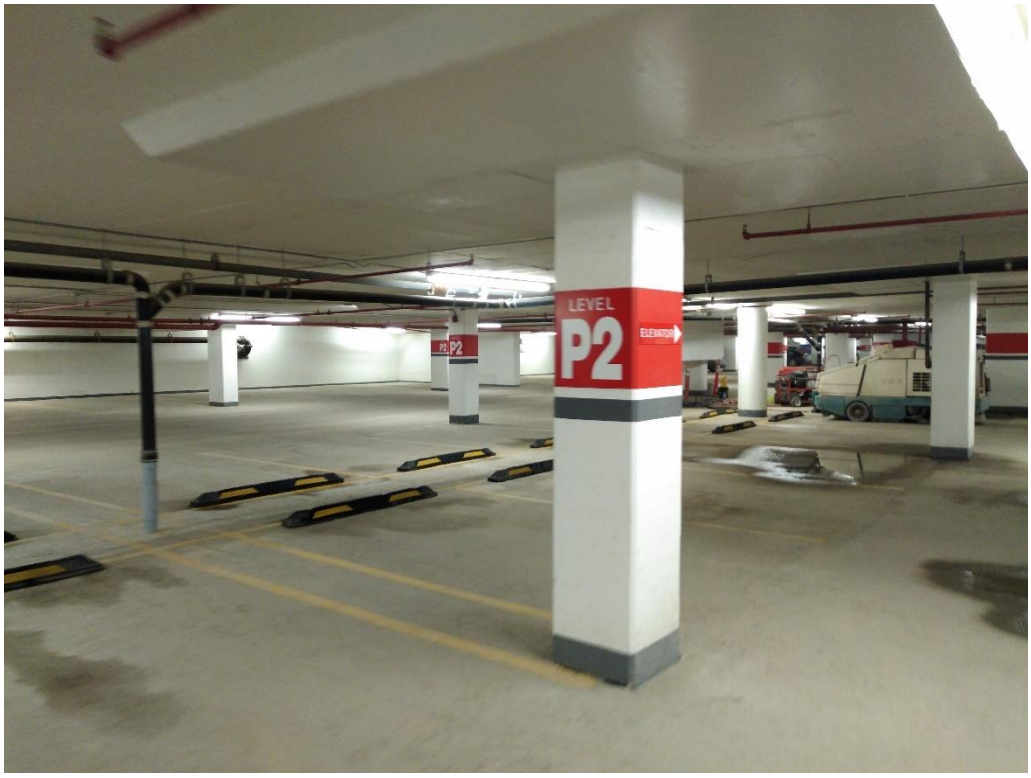



Figure 6: Lower level sanitary piping serving the parkade drainage with plastic piping passing below grade.

.6 There are two sanitary services on Donald and one on Smith street. Both appear to be original and would fall into the same category for replacement as the original piping in the parkade.

.7 The trench drains for the ramps were replaced as part of the ramp replacement. They are only a few years old and are in good condition.

Figure 7: Trench drain on one of the four entrance ramps.

### 4.2.4 Domestic Water Systems

.1 The domestic water system serves hose bibbs, the one washroom and the car wash on the parkade levels. There is other processes that use domestic water like “emptyful”, but it is not within the scope of this report.

.2 The domestic water piping is believed to be mostly original to the facility. The insulation is in poor condition. The piping looks to be mostly copper and is within the service life of 80 years. It is recommended to replace the insulation to prevent condensation and possible mould growth.

.3 The carwash area has a dedicated hot water tank which was replaced in 2017. The pumps for the high-pressure wash system are roughly 10 years old according to facility staff and would be nearing the end of their expected service life of 14 years. The pumps appear in fair condition and should be slated for replacement in coming years.


Figure 8: High pressure car wash pumps and dedicated hot water tank.

.4 The carwash system is separated from the rest of the piping by a reduced pressure backwater flow preventer which is required by code. The backflow has been tested and is operational according to the service tag.

.5 There are two main water service entrances into the building. The main domestic water service entry for the library and parkade enters on the upper level in the northwest corner. The water service entry room has several take offs for the various uses in the facility. The main service comes in and is protected by a double check valve assemble as required by code. The backflow preventer was included in the test report and passed. The manifold splits the incoming service to two metered take-offs. One serves the parkade and plaza and the second serves the library building. The water service also feeds the fire pump for the building which is separated from the domestic water by a backflow assembly. The service entrance appears to be in good condition.

Figure 9: Separate meters for the library and parkade.

.6 There is one washroom located in the parkade. The washroom is in the upper parkade located in the Northwest corner. The washroom is dated and although the age of the fixtures is unknown, they are in fair condition. The washroom fixtures do not meet barrier free requirements. The washroom would be an existing condition which can remain but should any modifications occur it would likely be required to be brought up to current barrier free requirements. The fixtures are considered to be maintenance items and should be monitored for leaking or failure.

### 4.2.5 Natural Gas Piping

.1 The natural gas piping in the facility comes in on the West wall of the lower parkade and is routed over to the South wall of the upper parkade. It is protected by metal posts connected to the floor and ceiling. The natural gas piping appears to be original to the facility but has a new meter upgrade by MB Hydro. The piping is in fair condition with sections that are painted and expected to be within the service life. Localized corrosion was noticed and should be painted, or the pipe section replaced in the near future. Long term recommendations would be to replace the entire natural gas piping systems but this would be outside the window of review for this report.

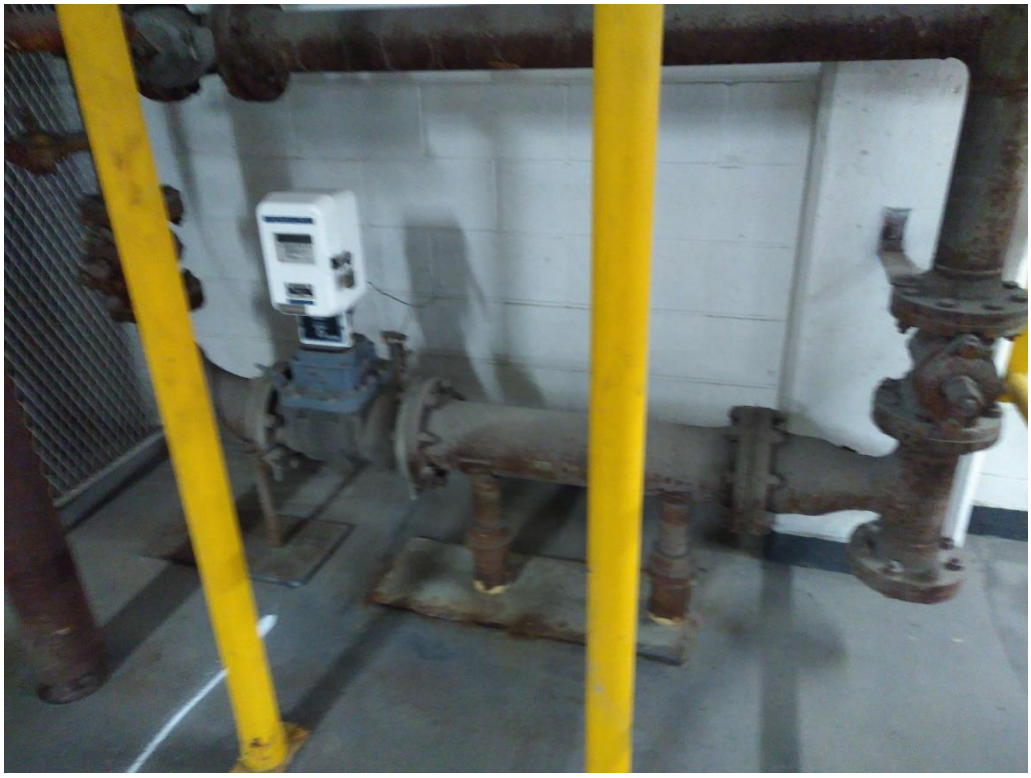


Figure 10: Natural Gas Main.

.2 The natural gas piping in the parkade only appears to serve the make-up air unit and the boilers within the parkade.

## 4.3 FIRE PROTECTION

### 4.3.1 General

.1 The entire parkade is sprinklered. There are wet sprinkler systems in the facility but the parkade is entirely served by dry systems. From the annual test report prepared by Vipond Fire Protection, only hoses failed due to the age or they were missing. All other devices passed.

### 4.3.2 Wet Sprinkler System

.1 The parkade does not have any wet sprinkler systems.

### 4.3.3 Dry Sprinkler System

.1 The parkade is split up into four sections. Two dry sprinkler zones exist per level and are separated north and south.

.2 The North zones are served by a water service which enters in the northeast corner of the upper level. The sprinkler system is equipped with a main flow switch for indication and backflow preventer.


Figure 11: Sprinkler Header in Northeast service entrance room.

.3 The header in the Northeast corner has three dry zones. The two zones are for the P1 and P2 north zones and the third is for the main floor dry zone.

.4 The header which serves the south portion of the parkade is located on the Donald Street side in the Southwest corner of the upper level. The boiler system for the ramp heating is also installed in this room. The water service entrance comes from the level below. The vintage appears to be the same as the Northeast sprinkler system and would have the same recommendations.

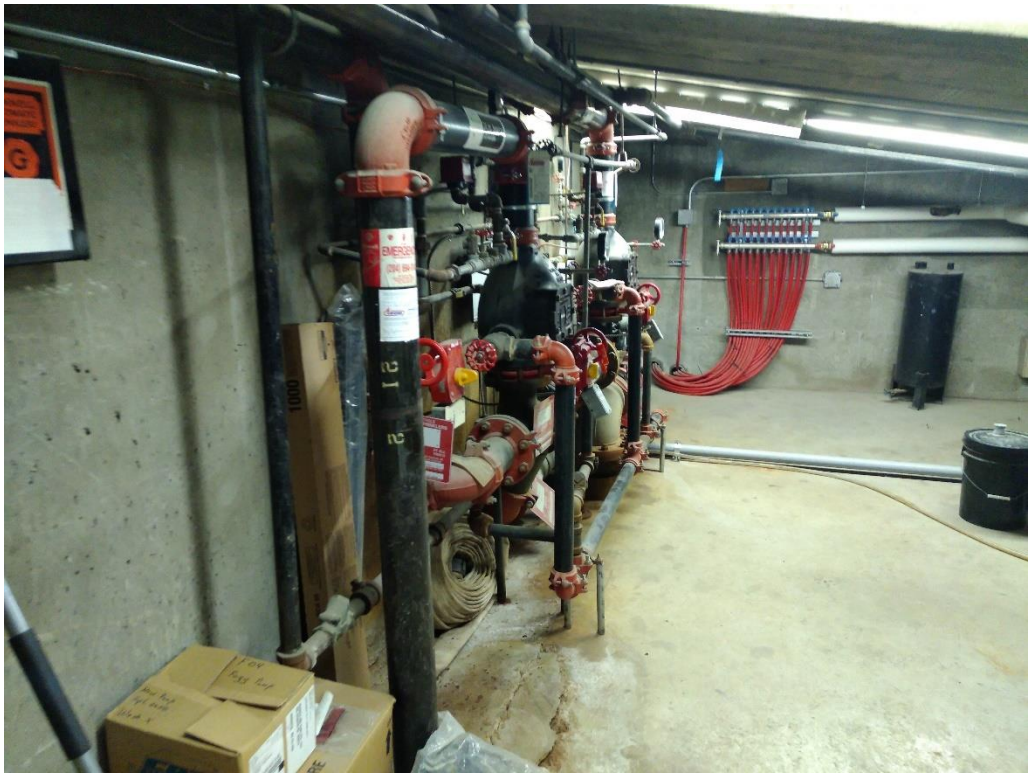


Figure 12: Sprinkler header in the Southwest corner of the upper parkade.

.5 The exact age of the sprinkler system is unknown, but it appears to have been modified recently. It is expected parts were updated as part of the renovation project. The valves are in fair condition with some signs of corrosion. It is expected parts of the piping system are nearing the expected service life of 25-30 years for black steel pipe as part of a dry sprinkler system. It is recommended to monitor the piping systems and schedule replacement of sections annually once leaks become a larger concern.

.6 The sprinkler heads in the parkade were all replaced as part of the Millennium Library renovation project. The heads would therefore be within the expected service life and no additional testing is expected to be required for an additional 35 years. Some heads were observed to have dust and debris on them. It is recommended that all heads be cleaned to ensure spray pattern or discharge are not affected by debris build-up. This would be a maintenance item.

.7 The fire department connection is in a pedestal on Donald Street near Graham. There is a second fire department connection for the Library located on the building at the corner of Graham Avenue and Smith Street.


Figure 13: Fire department connection on building face.

### 4.3.4 Standpipe Systems

.1 The stairwells have a wet standpipe system installed at the lowest, intermediate and the upper landing where they open to the plaza level. The standpipe system was installed as part of the renovation project for the library and therefore is within the expected service life of 30 years for a wet sprinkler system.

.2 There are some additional hose cabinets installed on the upper and lower parkade levels. The cabinets are located roughly on the north end, middle and south end of the parkade and are typically three wide with one on the east, one on the west and one down the centre. These cabinets are in good condition and within the expected service life.


Figure 14: Hose cabinet and fire extinguisher installed as part of renovation project for Library

## 4.4 HYDRONICS

### 4.4.1 In-slab Heating Systems

.1 The ramp snow melt systems were replaced in two phases. In 2013 one ramp was replaced with all new in-slab piping and manifold. In 2018 the remaining three ramps were replaced including new in-slab piping, manifolds, boiler systems and hydronic accessories. There are two boiler plants on the upper level of the parkade; one on the Donald Street side which serves the two ramps located there and one on the Smith Street side which serves the two remaining ramps.

.2 The boiler systems were replaced in 2018 and consists of three Weil-McLean Evergreen 299 MBH high-efficiency boilers per system. The combined output for all three boilers is 807 MBH for both snow melt systems, based on name plate data. The system type is identical between the two boiler plants and they were installed at the same time. The boilers are all equipped with a condensate neutralizer on the drain line as required by code. The boilers all have injection pumps to feed hot water into the secondary heating loop. The boilers are within the expected service life of 19 years and are in good condition.

Figure 15: Boiler plant on Smith Street side of parkade.

.3 The boilers are manifolded together with a common circulating pump system and operate in a primary-secondary loop arrangement, the pumps are inline vertical style pumps with sensorless VFD drives. The pumps were installed as part of the modification in 2018, are within the expected service life of 19 years for hydronic pumps, and in good condition.

Figure 16: VFD driven pumps on hydronic system, in-line separator and glycol fill tank

.4 The hydronic system is equipped with an in-line tangential air separator, glycol fill tank and expansion tank. The pieces of equipment were all installed at the same time as the boiler modification and are in good condition.

.5 The main hydronic loop connects to two sets of manifolds for the in-ramp heating system. The manifolds are of different material types on the Smith Street side due to the varying ages of installation. One set is brass while the other is stainless steel. Whether or not it was replaced in 2013 or 2018 both are within their expected service life of 25 years and are in good condition. The manifolds for the other side of the facility were both installed in 2018 and are in good condition.

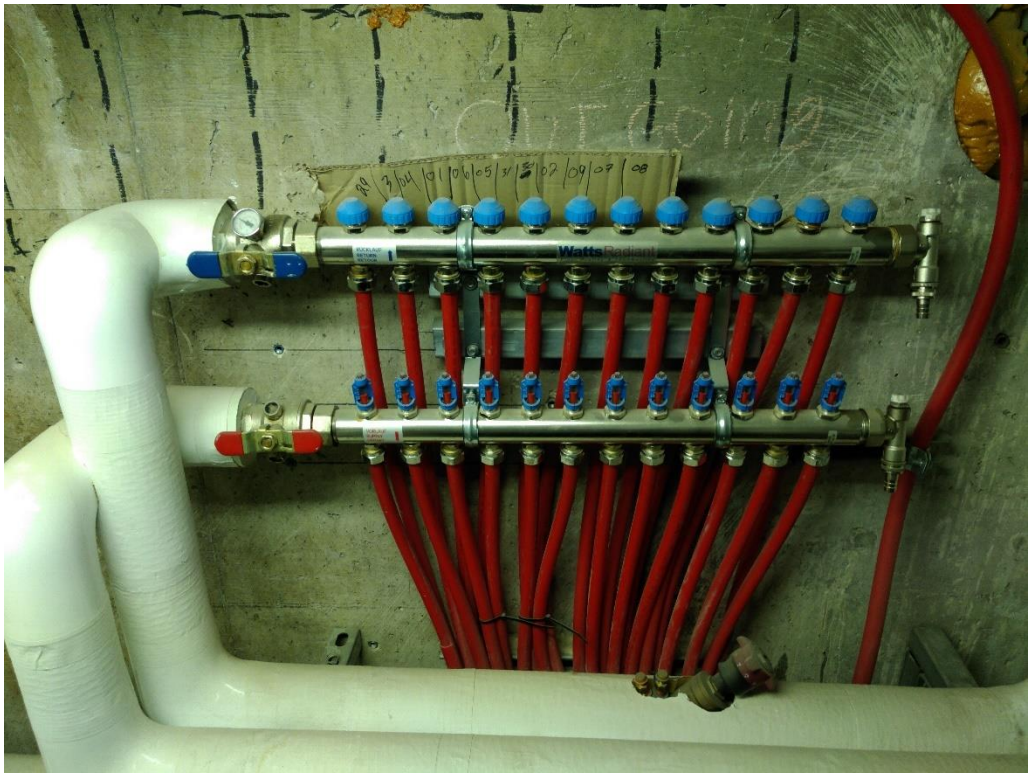



Figure 17: Stainless steel snow melt manifold installed in 2018.

### 4.4.2 Terminal Heating Systems

.1 There are several unit heaters located on both the upper and lower levels for terminal heat. The unit heaters are mostly hydronic and are fed from the library boiler plant. The insulation on the piping is in poor condition and should be replaced. The unit heaters vary in condition from fair to poor. The unit heaters appear to be original to the facility and are beyond the expected service life of 18 years. Replacement is recommended.

Figure 18: Unit heater located on the upper level of the parkade.

.2 The hydronic piping is expected to be original to the facility and would be nearing the expected service life of 50 years. It is recommended to perform destructive testing on the piping to confirm the condition. In the long term the piping would need to be replaced in its entirety.

.3 The stairwells have force flow units at the top of most and a few have electric unit heaters installed as additional heat. These unit heaters are relatively new but an exact age is unknown. The new unit heaters are within the expected service life. The other two stairwells have force flow heaters which are original and need to be replaced. The units are in poor condition. Replacement is recommended.

### 4.4.3 Generator

.1 There is an emergency generator located on the upper level. The generator will be reviewed as part of the electrical scope, but the fuel oil supply and ventilation will be reviewed under this section.

.2 The fuel oil for the facility is fed from two-day tanks next to the generator. The tanks appear to be Westeel double wall tanks with a storage capacity of 200 gallons each. The tanks are manifolded together. There

are two supply pumps to the generator and a fill station up on Graham Avenue. There are signs of leaking on the fittings as there is staining on the concrete. The tanks appear have a manufacture date of 2004 on them and would be within the expected service life. Repairs to the piping and cleaning of the spilled fuel oil are recommended.


Figure 19: Double wall tank with signs of fuel oil leaking at tapings.

.3 There is an abandoned fuel oil tank and pumps on the lower levels which are no longer used.

.4 The generator ventilation system works on a recirculation and exhaust strategy. The unit will run in recirculation until the room is warm at which time the dampers will modulate and discharge air to the outdoors. The test reports indicate this system appears to be operating correctly.

## 4.5 HVAC

### 4.5.1 Ventilation

.1 The generator room does not have a dedicated ventilation system. The system is required by code to prevent the diesel fume accumulation to a point where an explosion could occur. Current code requirements indicate either the fan has to run continuously or be controlled on a sensor. It is recommended a ventilation fan and detection system be installed.

.2 The parkade is ventilated and partially heated by one main direct natural gas fired make-up air unit that is installed on the upper parkade in the north mechanical room. The unit is manufactured by B.M.S and has an input of 8,200MBH per burner for a total input of 16,400MBH. The name plate data indicates the unit is capable for 71,000cfm. The original control diagrams for the unit indicate that the fresh air is drawn from the area well on Graham Avenue. The unit arrangement from intake to discharge is as follows.

.1 Intake
.2 Glycol Heat reclaim coil (run-around loop) – No longer in operation
.3 Stage one electric heating
.4 Stage two electric heating
.5 Natural gas direct fired heating section
.6 Supply fan 1 and 2
.7 Electric re-heat coils (one per level)
.8 Exhaust fan system (separate)

.3 The original intent of the unit was that on intake temperature of 35 F the first stage heating for glycol heat reclaim and for electric pre-heat would be engaged. When the intake air was below 0F the second stage of glycol heat reclaim and electric heat would be engaged as well as the natural gas burner to raise the temperature. The electric re-heat coils would be controlled based on level temperature and discharge air. The fans are controlled based on timeclocks and $CO/NO_2$ sensors on each level. SF-1 serves the upper level and SF-2 serves the lower level. Damper arrangements allow for air to be directed to the corresponding level and shut-off if there is only a call from one level.

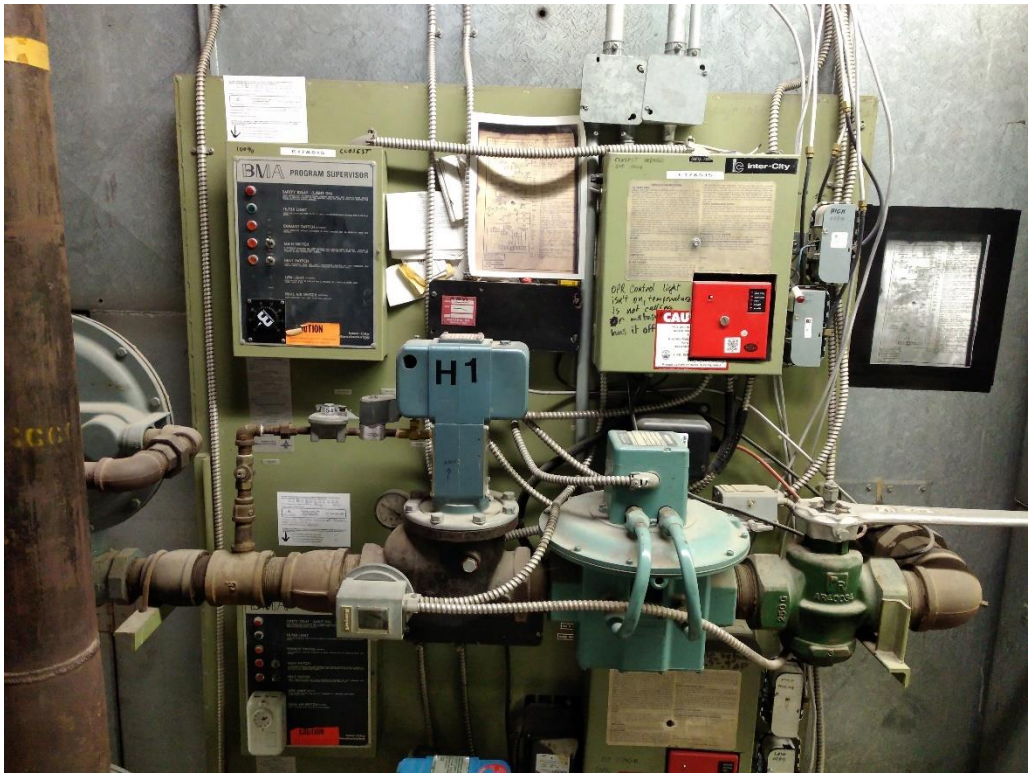



Figure 20: Natural gas manifold for direct fired burner on make-up air unit

.4 The glycol heat reclaim coil is no longer in operation and has been capped on both ends.


Figure 21: Capped glycol heat reclaim system.

.5 The remainder of the unit is original to the parkade and is beyond the expected service life. Parts appear to have been upgraded but the exact age of these modifications is unknown. The expected service life for direct fired make-up air units is 23 years. The unit is beyond the expected service life and appears to be in fair condition. Under current code the unit would not be sufficiently sized to meet minimum purge ventilation for a $CO/NO_2$ system and therefore would need to be increased in size.

### 4.5.2 Exhaust Fans

.1 The make-up air is interlocked to two exhaust fans located on the upper level of the parkade. The exhaust fans are staged similar to the make-up air unit and can be controlled for upper and lower levels. The glycol run-around loop is disconnected similar to the make-up air unit. The fans are installed in a sealed room which acts as a negative air plenum with ductwork connections for the lower level and two branches for the upper level. The exhaust fans are original to the facility and appear to be in fair to poor condition. The fans are undersized based on current code requirements for CO/NO2 purge systems. The capacity would need to be upgraded. Replacement is recommended.

Figure 22: Exhaust fan serving parkade ventilation system.

### 4.5.3 Localized systems

.1 There are several localize systems within the parkade. These systems recirculate air from the parkade to the space and back into the parkade.

.2 The attendant booth is located on the Smith Street side of the facility. It is equipped with a cooling and heating unit on top. The unit does not have ducted outdoor air which is a code requirement. The heating and cooling unit appears to be new and in fair condition. It is recommended to install dedicated supply air to the attendant booth to provide proper ventilation and comply with current code requirements.

.3 The Parking Authority offices in the centre of the upper parkade are equipped with fans and filters that draw air from the parkade into the office area and exhaust it to the parkade. There is a portable A/C unit installed in the office area with the heat discharge to the parkade. Ventilating the office area with parkade air is not permissible by current code requirements. It would be recommended to provided dedicated make-up air to the office space in order to meet indoor air quality and current code requirements.


Figure 23: Intake and portable AC unit for Parking Authority office

.4 Adjacent to the Parking Authority office is the main server room and small electrical room. The room is equipped with a small exhaust fan which is not connected to anything and appears to not be operational. The room was quite warm during our visit. It would be recommended to install a ventilation fan or connect ductwork to the existing in order to maintain the temperature of the room.

Figure 24 Exhaust fan not connected to anything in electrical room next to Parking Authority office.

.5 There are two elevator machine rooms located on the upper parking level. Both machine rooms are equipped with a ventilation fan that draws air from the parkade and exhausts back to the parkade. The fans appear to have been changed recently but an exact age is unknown. The fans appear to be in fair condition.

.6 The main hydro vault is equipped with a large exhaust fan and ductwork. The fan was in fair condition but is beyond the expected service life of 19 years. It is recommended to replace the fan to maintain conditioning in the electrical room.

### 4.5.4 $CO/NO_2$ Detection

.1 The entire parkade utilizes a CO detection system to control the make-up air unit and interlocked exhaust fans. It appears that the CO detection system is throughout the parkade and spaced in accordance with typical manufacturer requirements. The systems have been tested recently.

.2 It was noted that there were lower and upper detection in some locations but not consistently throughout the parkade. Typically, CO detection is at the occupied breathing height with $NO_2$, another common hazardous gas generated by diesel vehicles located at high level. There

were high level detectors in only portions of the parkade and most detector inspection tags only indicated CO detection. It is recommended that $NO_2$ detectors be installed to align with proper spacing requirements per manufacturer recommendations.


Figure 25: CO detector located on column in parkade.

### 4.5.5 Intake and Louvers

.1 The intake louver for the make-up air serving the parkade is in an area well on Graham Avenue. The intake is approximately 10 feet from the street and therefore is not an ideal location to pull ventilation air from due the consistent bus traffic on Graham Avenue. It is an existing condition which will remain.

Figure 26: Intake louver for parkade make-up air unit.

.2 The exhaust louver is located on the plaza area and is a concrete structure which is approximately 10 feet above the plaza . The location is adequate and would discharge air above pedestrian level.

## 4.6 CONTROLS

### 4.6.1 General Building Systems

.1 The majority of the building systems had pneumatic controls. The make-up air unit, the exhaust fans and several local items were on the pneumatic system. The existing pneumatic system is original to the facility and is recommended to be replaced with a DDC system.

.2 There are two new panels located by the new boilers that serve the ramps on the upper levels. The control system is a DDC system installed by Johnson Controls and connects to the City of Winnipeg Remote Monitoring station. The control system was installed at the same time as the boiler and is in good condition.

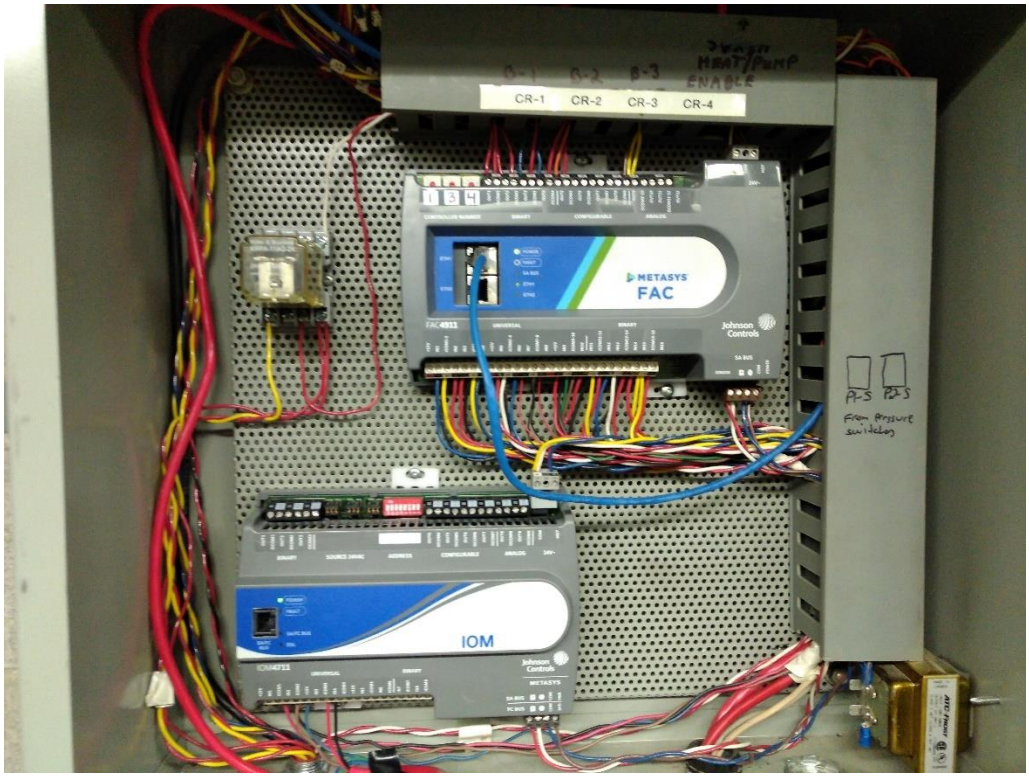



Figure 27: New Johnson Controls system for ramp snow melt.

# 5 ELECTRICAL SYSTEMS DESCRIPTION

## 5.1 LIGHTING AND CONTROLS

Lighting is mainly recessed surface mounted fluorescent fixtures with electronic ballasts and Led tubes. Stairwells ramps and general entrances all appear to be similar type fixtures.

Figure 28: Parkade Lighting

Back of house areas including service rooms are 2 lamp T8 fixtures with on/off switches.

Figure 29: Back of house lighting

All observed light fixtures were in fair to good condition.

Illuminating Engineering Society (IES) guidelines recommend parkade light levels are the following from RP-20-98.

**Table 1.** RP-20-98 Parking Structure Illuminance Recommendations.

| | | Minimum Horizontal Illuminance | Maximum/Minimum Horizontal Uniformity Ratio | Minimum Vertical Illuminance |
|---|---|---|---|---|
| Basic | | 1 fc | 10:1 | 0.5 fc |
| Ramps | | | | |
| | Day[1] | 2 fc | 10:1 | 1.0 fc |
| | Night | 1 fc | 10:1 | 0.5 fc |
| Entrance Areas[2] | | | | |
| | Day[1] | 50 fc | | 25 fc |
| | Night | 1 fc | 10:1 | 0.5 fc |
| Stairways | | 2 fc | | 1.0 fc |

[1]Daylight may be considered in the design calculation.

[2]A high illuminance level for about the first 65 feet inside the structure is needed to help with the transition from bright daylight to a lower internal level.

No light levels were recorded but appeared above adequate levels in all observed spaces.

Lighting control in general parkade is on 24 hours a day, 7 days a week. Lighting appears to be maintained well throughout the parkade, but planning should be in place for potential replacement in the next 5 years.

## 5.2 EMERGENCY AND EXIT LIGHTING

5.2.1 Emergency lighting is provided by connecting general lighting fixtures to the emergency generator located on Level P1. There are also 10 battery banks located in the generator room, stairwells and electrical rooms. These are tested annually, and reports are generated for the site record.

Exit signs are a green pictogram throughout the parkade and appear to be in fair to good condition. There was one red exit sign leading from the elevator room to the general parkade.

The emergency lighting appears to be in good condition.

All exit signs appeared to be over exits and in the path of egress. The one red exit sign needs to be replaced with a green pictogram type exit sign to match the rest of the building.

Emergency and exit lighting appears to be maintained well throughout the parkade, but planning should be in place for potential replacement in the next 5 years.

## 5.3 DISTRIBUTION

5.3.1 The main electrical distribution is located on level P2. The equipment appears original to the building but is still in fair working condition. Electrical equipment has a normal service life of 35 years. Although the equipment is still functioning, provisions should be made for replacement in the near future.

Figure 30: Part of the main distribution.

5.3.2 Additional labelling of equipment and the creation of a single distribution schmatic is strongly recommended. The single line should be mounted in the main electrical room under a plexi-glass cover.

5.3.3 The parkade also houses the emergency generator for the library and the parkade. Based on the latest annual inspection report the only recommendation for the generator at this time is to replace the batteries. It is recommended that batteries get replaced every 4 years. It is not anticipated that this generator would require replacement for the next 10 years. Please note that general maintenance will still be required on an ongoing basis.

5.3.4 Electrical panels and transformers are placed in mechanical/electrical rooms throughout the parkade. There is a significant amount of dust accumulation on the equipment and most equipment requires cleaning. One panel was missing a wireway along the top of the panel exposing the branch circuit wiring. The cover needs to be re-installed to conceal this wiring.

Figure 31: Wire-way missing cover

5.3.5 Panel, transformers, splitters are strategically spaced throughout the parkade and display a varying degree of age and condition. Most equipment appears operational and in fair condition but are nearing the end of their useful life. Replacement should be considered in the next 5-10 years.

5.3.6 Feeder wiring is a mixture of wire in conduit and armoured teck cable. Branch circuit wiring within the building is typically RW90 conductors in EMT conduit. It is not anticipated that branch circuit wiring require replacement at this time. Based on the typical life span of electrical equipment, replacement should be considered in the next 10 years.

5.3.7 There were select junction boxes that were missing covers. Covers are to be installed on all junction boxes.

Figure 32: Junction box missing cover.

In the general parkade areas, various junction boxes require new supports or need to be re-fastened to the concrete.

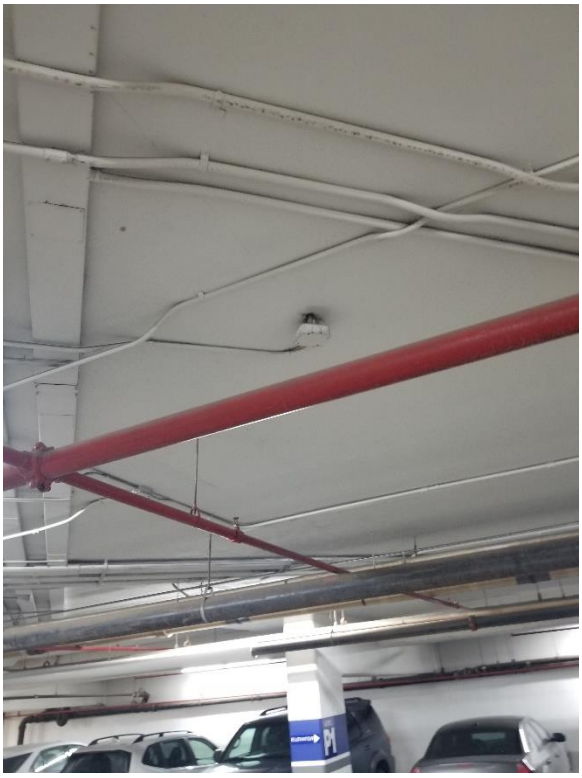


Figure 33: Conduit missing supports and anchors.

## 5.4 FIRE ALARM SYSTEM

5.4.1 The fire alarm system consists of a single stage addressable system and is located in the main electrical room. The existing system manufacturer is Simplex and model is 4100U. Internal batteries provide power to the fire alarm panel during power outages. The initiating devices consist of smoke detectors, heat detectors, monitoring devices (flow, supervisory, tamper) and pull stations. Annunciation devices consist of horns and combination horn strobes. The notification devices are all horns with no strobes. The fire alarm system is monitored by a third-party agency.

Figure 34: Main fire alarm panel

5.4.2 The fire alarm system is in fair to good condition and meets NBC fire alarm code requirements. The system does not have strobe devices which are now required by code for new construction, but as this system was installed prior to this code requirement was adopted, the system is grandfathered, and upgrades are not required at this time. When the fire alarm system is replaced, strobes will need to be added throughout the parkade. Based on the latest verification report, the system is still functional. It is recommended that it be upgraded/udated in the next 1-5 years. Strobes could be added to the system at that time and the system would be ready for the next expected service life.

## 5.5 SECURITY SYSTEM

5.5.1 The parkade has a number a CCTV cameras installed throughout the general areas. Cameras are controlled at the attendant's booth, parking authority's office, and WPA Dispatch. The CCTV system appears to be working order and in good condition.

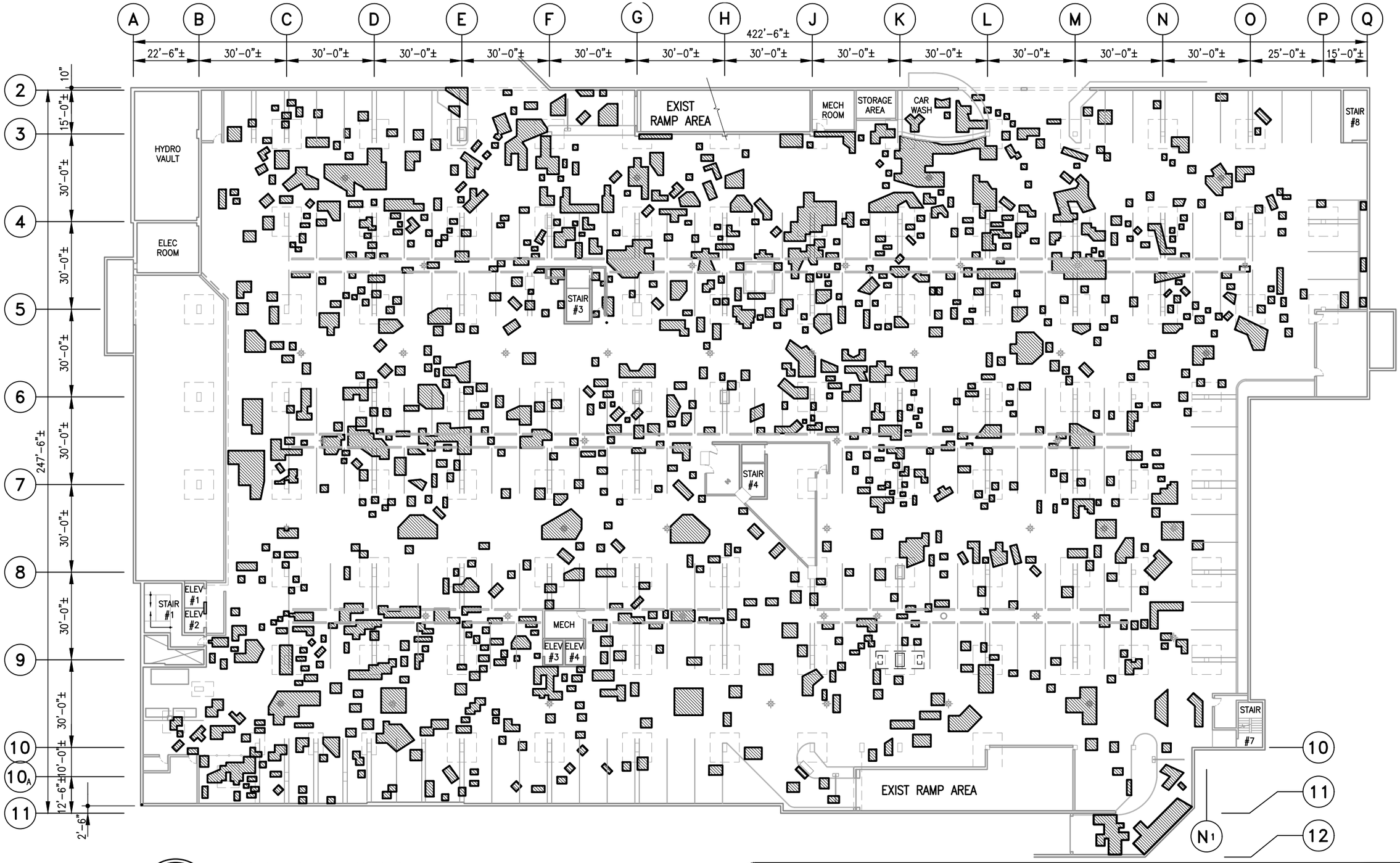
5.5.2 Anticipated upgrades/replacement should be planned for in the next 5 years.

5.5.3 The building contains an alarm system in the attendant's booth. The booth's door and window both have sensors in the event they are opened when the alarm system is active. The keypad for the system is located within the booth. This system appears to be deficient and should be replaced.

**SMS Engineering Limited** 770 Bradford Street, Winnipeg, MB, Canada R3H 0N3 **T** 204 775 0291 SMS@SMSeng.com **SMSeng.com**

# Appendix C

Drawings




# UPPER FLOOR PARKING PLAN

1/32" = 1'-0"

## LEGEND

DENOTES APPROX EXTENT OF TOP SURFACE CONCRETE DETERIORATION


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

Crosier Kilgour & Partners Ltd.
CONSULTING STRUCTURAL ENGINEERS


Project: MILLENNIUM LIBRARY PARKADE
PARKADE INVESTIGATION — WINNIPEG, MANITOBA

| Sheet Title | Sheet No. |
|---|---|
| UPPER FLOOR PARKING PLAN | S1.1 |

| Design | Drawn | Date | File |
|---|---|---|---|
| JLS | LOL | 2021-01-06 | 2020-1183 |

# Appendix D

Test Results

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg MB R3Y 1G4

December 10, 2020
File: 123315240

**Attention: Mr. Richard Lobban**
Crosier Kilgour & Partners Ltd.
300-275 Carlton Street
Winnipeg, MB R3C 5R6

Good day Richard,

**Reference: Millennium Library Parkade – Core Testing**

On November 26, 2020, Stantec Consulting was retained to recover twelve (12) core samples from the structural slab on level 1 of the Millennium Library Parkade located at 251 Donald Street in Winnipeg, Manitoba. The core sample locations are summarized in the attached Table 1. Three (3) core samples were handed over to Crosier Kilgour personnel on site for Petrographic analysis. Photographs of the nine (9) core samples returned to our office are attached to this report. The testing performed and the corresponding results for each core sample are identified below.

## CHLORIDE ION CONENT

Six (6) core samples were prepared for chloride ion content determination by trimming 10 mm slices at prescribed depths on the core samples. Testing of the 10 mm slices were performed by CARO Analytical Services in accordance with *CSA A23.2-4B; Sampling and Determination of Water-Soluble Chloride Ion Content in Hardened Concrete.*

The Chloride ion content results ranged from <0.010 to 0.286% (by mass of concrete), with an average of 0.075%. A summary of the chloride ion content test data is provided in the attached Table 2. A copy of CARO's analytical report is also attached.

## COMPRESSIVE STRENGTH

Three (3) core samples were tested for compressive strength in accordance with *CSA A23.2-14C; Obtaining and Testing Drilled Cores for Compressive Strength*. The core sample were conditioned in air at room temperature for 24 hours prior to testing. The compressive strength test results ranged from 16.2 to 35.8 MPa, with an average of 24.1 MPa.

A summary of the compressive strength test data is provided in the attached Table 3.

## PETROGRAPHIC ANALYSIS

As stated above, three (3) core samples (identified as 1C, 2C, and 6C) were relinquished to Crosier Kilgour site personnel for petrographic analysis.

**Reference:** **Millennium Library Parkade – Core Testing**

## CLOSING

We appreciate the opportunity to assist you on this project. Please contact the undersigned if you have any questions regarding this report.

Regards,

**Stantec Consulting Ltd.**

**Jason Thompson** C.E.T.
Principal - Manager, Materials Testing Services

Phone: 204 928 4004
Mobile: 204 981 8445
jason.thompson@stantec.com

Attachment: Table 1 – Core Location Details
Table 2 – Chloride Ion Content Test Data
Table 3 – Compressive Strength Test Data
Photographs

**Reference:** **Millennium Library Parkade – Core Testing**

## TABLE 1 – CORE LOCATION DETAILS

| Core No. | Core Location |
|---|---|
| 1A, 1B, 1C | Parking stall - between gridlines 7 to 8 and G to H |
| 2A, 2B, 2C | Parking stall - between gridlines 10 to11 and C to D |
| 3A | Drive aisle – on gridline C between gridlines 3 to 4 |
| 4A | Drive aisle - between gridlines 7 to 8 and H to J |
| 5A | Drive aisle – between gridlines 8 to 9 and M to N |
| 6A, 6B, 6C | Parking stall – between gridlines 2 to 3 and N to 0 |

## TABLE 2 – CHLORIDE ION CONTENT TEST DATA

| Core No. | Sample Depth (mm) | Water-Soluble Chloride Ion Content (% by mass of concrete) |
|---|---|---|
| 1A | 20 to 30 | <0.010 |
| 2A | 20 to 30 | 0.086 |
| 3A | 20 to 30 | 0.288 |
| 4A | 20 to 30 | 0.025 |
| | 100 to 110 | <0.010 |
| 5A | 20 to 30 | 0.081 |
| 6A | 20 to 30 | 0.086 |
| | 100 to 110 | 0.010 |

**Note:**
The threshold necessary to permit corrosion in the reinforcing steel with the presence of oxygen and water must be greater than 0.025% by mass of concrete. The chloride results that exceed this threshold are noted in red in Table 3 above.

## TABLE 3 –COMPRESSIVE STRENGTH TEST DATA

| Core No. | Diameter (mm) | Length (mm) | LD Ratio | Correction Factor | Peak Load (kN) | Compressive Strength (MPa) | |
|---|---|---|---|---|---|---|---|
| | | | | | | Measured | Corrected |
| 1B | 76 | 139 | 1.83 | 0.986 | 164.8 | 34.3 | 35.8 |
| 2B | 76 | 123 | 1.43 | 0.952 | 77.3 | 17.0 | 16.2 |
| 6B | 76 | 143 | 1.88 | 0.990 | 92.8 | 20.5 | 20.3 |

**Reference:** **Millennium Library Parkade – Core Testing**

**Figure 1 - Core no. 1A**

**Figure 2 - Core no. 1B**

**Reference:** **Millennium Library Parkade – Core Testing**

**Figure 3 - Core no. 2A**

**Figure 4 - Core no. 2B**

**Reference:** **Millennium Library Parkade – Core Testing**

**Figure 5 - Core no. 3A**

**Figure 6 - Core no. 4A**

**Reference:** **Millennium Library Parkade – Core Testing**

**Figure 7 - Core no. 5A**

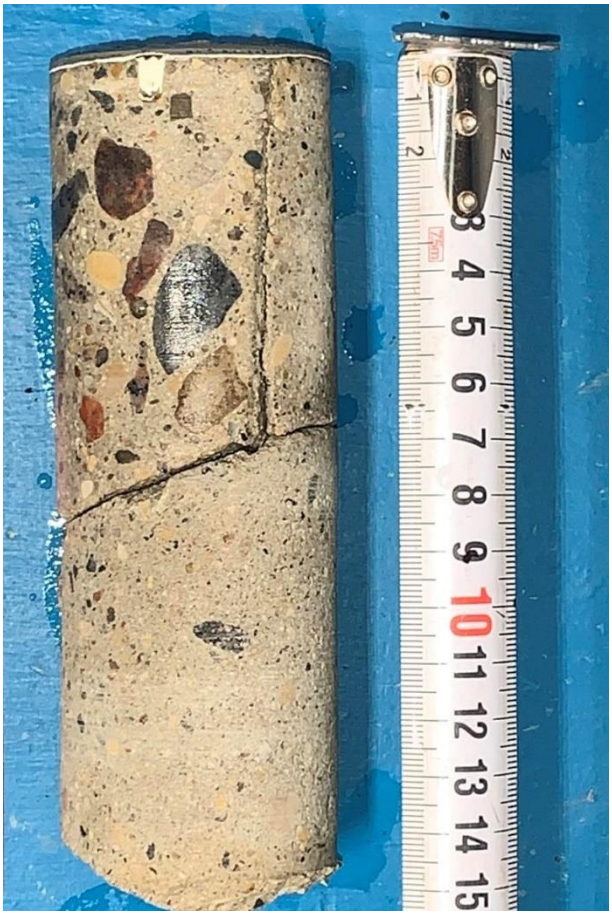


**Figure 8 - Core no. 6A**

**Reference:** **Millennium Library Parkade – Core Testing**

**Figure 9 - Core no. 6B**

# CERTIFICATE OF ANALYSIS

| | | | |
|---|---|---|---|
| **REPORTED TO** | Stantec Consulting Ltd. (Winnipeg)<br>199 Henlow Bay<br>Winnipeg, MB R3Y 1G4 | | |
| **ATTENTION** | Jason Thompson, C.E.T | **WORK ORDER** | 20L0161 |
| **PO NUMBER** | | **RECEIVED / TEMP** | 2020-12-01 11:00 / NA |
| **PROJECT** | 123315240 | **REPORTED** | 2020-12-10 11:54 |
| **PROJECT INFO** | | **COC NUMBER** | No # |

**Introduction:**

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

*Big Picture Sidekicks*

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

*We've Got Chemistry*

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

*Ahead of the Curve*

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

*If you have any questions or concerns, please contact me at nyipp@caro.ca*

**Authorized By:**

Nicole Yipp
Team Lead, Client Service

# TEST RESULTS

| | | | |
|---|---|---|---|
| **REPORTED TO** | Stantec Consulting Ltd. (Winnipeg) | **WORK ORDER** | 20L0161 |
| **PROJECT** | 123315240 | **REPORTED** | 2020-12-10 11:54 |

| Analyte | Result | RL | Units | Analyzed | Qualifier |
|---|---|---|---|---|---|
| **5789 20-30mm (20L0161-01) \| Matrix: Solid \| Sampled: 2020-11-30** | | | | | |
| ***General Parameters*** | | | | | |
| Chloride, Water-Soluble | < 0.010 | 0.010 | % dry | 2020-12-10 | |
| **5791 20-30mm (20L0161-02) \| Matrix: Solid \| Sampled: 2020-11-30** | | | | | |
| ***General Parameters*** | | | | | |
| Chloride, Water-Soluble | **0.086** | 0.010 | % dry | 2020-12-10 | |
| **5793 20-30mm (20L0161-03) \| Matrix: Solid \| Sampled: 2020-11-30** | | | | | |
| ***General Parameters*** | | | | | |
| Chloride, Water-Soluble | **0.288** | 0.010 | % dry | 2020-12-10 | |
| **5794 20-30mm (20L0161-04) \| Matrix: Solid \| Sampled: 2020-11-30** | | | | | |
| ***General Parameters*** | | | | | |
| Chloride, Water-Soluble | **0.025** | 0.010 | % dry | 2020-12-10 | |
| **5794 100-110mm (20L0161-05) \| Matrix: Solid \| Sampled: 2020-11-30** | | | | | |
| ***General Parameters*** | | | | | |
| Chloride, Water-Soluble | < 0.010 | 0.010 | % dry | 2020-12-10 | |
| **5795 20-30mm (20L0161-06) \| Matrix: Solid \| Sampled: 2020-11-30** | | | | | |
| ***General Parameters*** | | | | | |
| Chloride, Water-Soluble | **0.081** | 0.010 | % dry | 2020-12-10 | |
| **5796 20-30mm (20L0161-07) \| Matrix: Solid \| Sampled: 2020-11-30** | | | | | |
| ***General Parameters*** | | | | | |
| Chloride, Water-Soluble | **0.086** | 0.010 | % dry | 2020-12-10 | |
| **5796 100-110mm (20L0161-08) \| Matrix: Solid \| Sampled: 2020-11-30** | | | | | |
| ***General Parameters*** | | | | | |
| Chloride, Water-Soluble | **0.010** | 0.010 | % dry | 2020-12-10 | |

# APPENDIX 1: SUPPORTING INFORMATION

| | | | |
|---|---|---|---|
| **REPORTED TO** | Stantec Consulting Ltd. (Winnipeg) | **WORK ORDER** | 20L0161 |
| **PROJECT** | 123315240 | **REPORTED** | 2020-12-10 11:54 |

| Analysis Description | Method Ref. | Technique | Accredited | Location |
|---|---|---|---|---|
| Chloride, Water-Soluble in Solid | CSA A23.2-4B | Hot Water Extraction / Potentiometric Titration | | Richmond |

**Glossary of Terms:**

| | |
|---|---|
| RL | Reporting Limit (default) |
| % dry | Percent (dry weight basis) |
| < | Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors |
| CSA | Canadian Standards Association Chemical Test Methods |

**General Comments:**

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

*Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline (s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.*

# APPENDIX 2: QUALITY CONTROL RESULTS

| | | | |
|---|---|---|---|
| **REPORTED TO** | Stantec Consulting Ltd. (Winnipeg) | **WORK ORDER** | 20L0161 |
| **PROJECT** | 123315240 | **REPORTED** | 2020-12-10 11:54 |

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in “batches” and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

| Analyte | Result | RL | Units | Spike Level | Source Result | % REC | REC Limit | % RPD | RPD Limit | Qualifier |
|---|---|---|---|---|---|---|---|---|---|---|
| ***General Parameters, Batch B0L0798*** | | | | | | | | | | |
| **Blank (B0L0798-BLK1)** | | | | Prepared: 2020-12-09, Analyzed: 2020-12-10 | | | | | | |
| Chloride, Water-Soluble | < 0.010 | 0.010 | % dry | | | | | | | |