



June 22, 2018

Benjamin Fletcher
Director of Parking
City of Portsmouth, NH
680 Peverly Hill Road
Portsmouth, NH 03301
bmfletcher@cityofportsmouth.com

Re: Hanover Street Parking Facility
Condition Appraisal Update - 2018
Portsmouth, NH

Dear Benjamin:

Walker Consultants completed a condition re-assessment on the Hanover Street Parking Facility in May 2018 to update the prior 2014 Walker Condition Appraisal and assist the City of Portsmouth in budgeting and planning for implementing a comprehensive restoration program on the Hanover St. Garage in the near future.

This report will provide you with three comprehensive restoration program alternatives for consideration that can be implemented under a multi-year construction phased program.

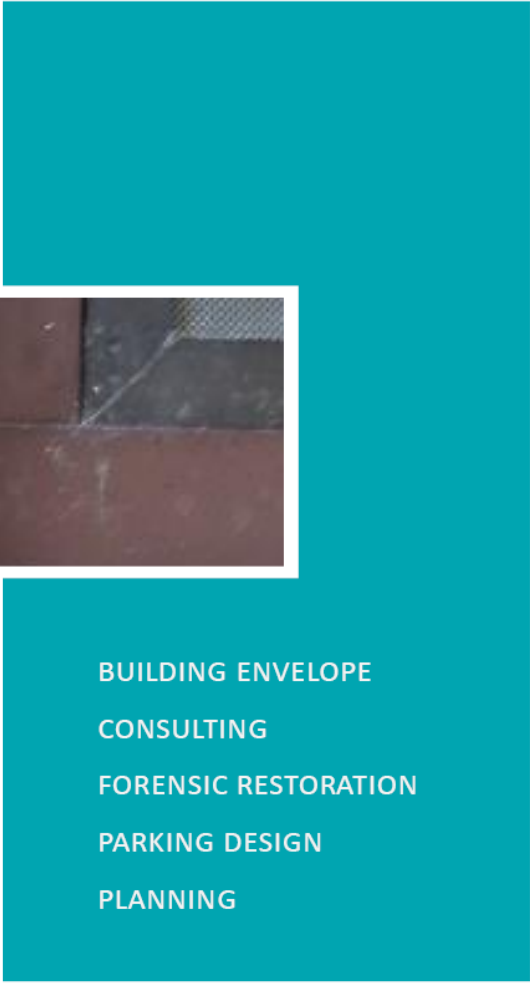
We appreciate this opportunity to be of service to you and the City of Portsmouth on this project. If you have any questions or comments, please do not hesitate to contact us.

Sincerely,

WALKER CONSULTANTS

A handwritten signature in black ink that reads "Mark Zelepsy". The signature is fluid and cursive, with a long, sweeping underline.

Mark Zelepsy
Restoration Consultant II



BUILDING ENVELOPE
CONSULTING
FORENSIC RESTORATION
PARKING DESIGN
PLANNING

CONDITION APPRAISAL REPORT UPDATE - 2018

HANOVER ST. PARKING FACILITY

PORTSMOUTH, NEW HAMPSHIRE

June 2018

Prepared for:
Benjamin Fletcher
Director of Parking for City of Portsmouth, NH
16-2883.00



WALKER
CONSULTANTS

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EXECUTIVE SUMMARY

Walker Consultants completed a Condition Assessment on the Hanover Street Parking Facility located in Portsmouth, New Hampshire in accordance with our proposal dated April 27th 2018 to the City of Portsmouth, NH.

This assessment is intended to update the 2014 Walker Condition Appraisal and recognize relevant changes to prior information on current physical conditions of the Hanover street Parking Facility and to provide and update the construction costs for implementing a comprehensive restoration program in the upcoming years.

Current assessment findings recognized interim repair efforts were completed on the structure consistent to our recommendations in addressing immediate safety concerns and the general appearance. However, the current repair investigation indicates deterioration growth on the floor and framing is continuing to increase due to the unrestored conditions. Based upon our current findings the condition rating of the original 1985 structure remains in “*poor to fair*” overall condition while the 1999 expansion is in “*fair to good condition*”.

Several deficient conditions related to the design, as-constructed conditions, and past repairs and maintenance were identified as contributing factors to the presence of deterioration on the concrete floors, structural steel framing, and masonry façade. However, a key contributing factor to the present worsening conditions is due to a lack of effective waterproofing protection against the environmental exposure to chloride (road salt) and moisture. Failure to address these conditions over time will continue to impact the long-term performance and reduce useful service life expectancy.

Contributing factors that give cause to existing deterioration include:

- Marginal quality/durability characteristics in topping concrete used in the original built structural floor system,
- Chloride contamination profiles in the concrete topping sufficient to cause accelerated corrosion of the steel reinforcement in the concrete and on the structural framing,
- Lack of adequate waterproofing protection for the floor system and masonry walls,
- Marginal to poor drainage profiles on the supported floors giving cause to standing water and through slab leakage,
- Moisture penetration through the masonry façade elements and interior masonry walls sufficient to cause deterioration and distress.
- Deferred repairs and maintenance to the protection systems (structural steel paint coating, waterproofing, sealants, etc.) have led to increases in the deterioration of the concrete and structural steel framing.

Based upon our re-examination of the Hanover Street Garage, the Base Restoration Program Alternatives A, B, and C presented in the 2014 Condition Appraisal Report remain probable options for increasing the service life expectancy by 20+ years on this structure. Service life extension for each program will require continued preventative maintenance during this period. Further, Life cycle replacement of operational equipment and

facilities not under the proposed restoration programs may need to be considered during the 20-year service period.

Three conceptual restoration program alternatives (A, B, C) were developed based upon repair strategies that address the repairs to deterioration and correct the influencing factors that are causes to deterioration where possible. Each program alternative presents an increasing level of repair and protection to extend the service life of the structure. Selection and implementation of these alternatives will need to consider the impact of the construction process on operations and the neighboring community and the difference in future repair and maintenance cycles that become necessary to achieve the 20-year service life extension. An abbreviated summary of each alternative is represented below:

Alternative A represents a baseline restoration approach that addresses selective repairs to existing deteriorated concrete topping and masonry elements. The base level effort includes waterproofing protection to the concrete floors using an application of water repellent surface sealer, and replacement of joint sealants and expansion seals to reduce the rate of future deterioration. The structural steel framing is prepared for an application of a high performance paint protecting system.

Alternative B performs a strip removal of the cast concrete topping along the structural framing where steel reinforcement zones are located and in select areas where a high potential of future deterioration growth exists. The level of protection is augmented by an application of a traffic bearing waterproofing membrane in lieu of a water repellent to provide greater protection against future deterioration.

Alternative C represents a comprehensive process of complete removal and replacement of the cast concrete topping on each floor of the original structure. The topping replacement eliminates the existing chloride potential in the slab, and allows for placement of new high quality concrete overlay. The new overlay is provided with new joint sealants, expansion joint seals and an application of a penetrating water repellent.

Further explanation into the program alternatives are presented in the body of this report and in Appendix D "Repair Strategies". The opinion of probable construction costs associated with each program alternative is shown in the abbreviated Table I below.

TABLE I – OPINION OF PROBABLE CONSTRUCTION COSTS - 2018			
Base Repair Program Alternative(s)	'A'	'B'	'C'
SUBTOTAL	\$3,589,000	\$4,448,000	\$8,364,000
General Conditions / Mob, QC Testing	\$340,000	\$420,000	\$448,000
Construction Contingency @10%	\$393,000	\$486,000	\$705,000
GRAND TOTALS	\$4,322,000	\$5,354,000	\$9,517,000

Source: Walker Consultants 2018

A multiple year construction plan was developed for implementing Alternatives A and B as shown in Table 2. Further discussion into the work requirements and implementation is presented in the following report sections with a cost breakdown for phasing the work provided in Appendix A.

TABLE 2 – BASE REPAIR PROGRAM COSTS – 6-YEAR IMPLEMENTATION PLAN

Construction Program	CY 1	CY 2	CY3	CY4	CY 5	CY 6	TOTAL
Alternative A	\$1,430M	\$1,013k	\$766k	\$696k	\$430k	\$343k	\$4,678M
Alternative B	\$1,672M	\$1,454M	\$1,484M	\$587k	\$393k	\$253k	\$5,843M
Alternative C							\$9,517M

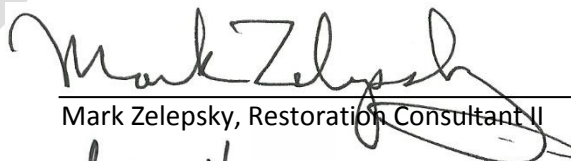
Source: Walker Consultants, 2018

It is our opinion that program ‘B’ offers the most cost effective solution for restoring the facility to a highly serviceable condition and attain the desired 20-year service life extension with expected periodic repair and maintenance. Our recommendation for Program Alternative B based on the following:

- The proposed limits of concrete topping replacement will help minimize the future concrete repair costs and service impacts for floor repairs by eliminating the chloride contamination in the steel reinforcement zones.
- The strip repairs will eliminate most of the flexural and pattern shrinkage cracking along the beam lines and allow for proper control joint placement.
- The complete application of a traffic bearing waterproofing membrane system will effectively block surface moisture penetration over the field cast concrete topped floor areas. This is essential towards extending the service life of the floor slab and protecting the remaining concrete topping, filigree planks, structural steel framing and paint coating system, and the supported utility systems.

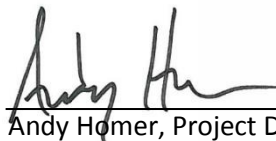
Walker understands that the City of Portsmouth may be considering deferring the implementation of a selected restoration program y for a period of one to two years to avoid the impact to the City’s parking supply until the new parking facility is completed and open. It is Walker’s opinion that deferral is feasible with the understanding that interim repairs are necessary during this period to address ongoing conditions that may have impacts on public safety and parking operations. Walker recommends that the City retain a budget of approximately \$200K per year to address any interim repairs that may become necessary in addition to program costs. Based upon the current examination we predict an increase may be expected in the programs of approximately 4 to 6% per annum to address future increases in deterioration and price escalation.

Please review the following report for a detailed discussion of our assessment update and recommendations for completing a 20-year service life extension of this facility.



Mark Zelepsy, Restoration Consultant II

June 20, 2018



Andy Homer, Project Design Engineer

June 20, 2018



David W. Johnston
David Johnston, Restoration Department Head

June 20, 2018

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01 Introduction
Section

INTRODUCTION

Walker Consultants performed a condition re-assessment on the High/Hanover Street Parking Facility in May 2018 consistent to our proposal dated April 27th 2018 with the City of Portsmouth, New Hampshire. The re-assessment of this parking facility provides an update to the prior 2014 Condition Appraisal completed by Walker.

OBJECTIVE

The report objective is to re-examine the extent of ongoing deterioration and deficiencies that are affecting the structural and operational performance and provide modifications where appropriate to the proposed options and the associated opinion of probable construction costs towards achieving a 20-year+ service life extension. The report also includes certain cost adjustments for implementation of the future program. These adjustments include quantity escalation and inflationary factors applied to multi-year construction phasing to assist in planning, budgeting, and funding a Capital Improvement Project while ensuring efficient use of public funds.

Our evaluation and opinion into the physical conditions affecting this structure are based upon the past and present field re-examination, prior assessment report and material testing data (2014 report), prior and current survey data, and our experience with current industry materials and restoration processes that can maintain structural performance on this type of hybrid structural system. The report topics include:

- Identifies types and causes of deterioration forms present in the structure,
- Current qualitative and quantitative assessment of deterioration forms,
- Evaluation of non-structural service systems for maintenance repairs or replacement,
- Summary of findings and our recommendations for selecting a restoration program,
- Recommended repair and maintenance program alternatives with updated opinion of construction costs for implementation of a selected program over multiple years,
- Implementation plan for phasing the work over a multi-year plan.

FACILITY DESCRIPTION

The Hanover Street Parking Facility was built in 1985 with three supported levels configured in a single thread helix and a pavement on grade level with a capacity to park approximately 680 vehicle spaces. The structure is comprised of a hybrid design using painted structural steel beam and column framing to support composite concrete slabs comprised of 2¼" thick filigree wide slab precast planks overlaid with a 3¾" thick bonded reinforced topping concrete. The garage footprint is approximately 446 to 415 feet in length by 122 feet in width overall. The gross square foot of supported garage floor area is 158,500 square feet. Two stair towers and one stair/elevator tower provide pedestrian access to all levels.

The parking facility was horizontally expanded in 1999 with four levels (single ramp) added to south elevation increasing the capacity by 229 spaces. The expansion footprint is approximately 336 feet by 53 feet overall with a partial floor expansion on the top level (level 4) over the existing structure. The expansion area uses galvanized structural steel framing to support a 5" thick pre-topped filigree wide slab plank system. The expansion included a new stair tower built in the southeast corner serving all floor levels. Garage foundation

consists of steel piles, grade beams, tie beams and spread footings. The expansion included an addition of a stairway at the southeast corner and a vehicle entry from High street. Short-term parking is also provided inside the garage on grade near the High St entrance.

The façade on the original structure is comprised of masonry brick with concrete masonry unit back-up walls attached to the structural framing. Sections of the façade are enclosed in precast panels in lieu of the masonry type of construction. The façade of the expansion area is comprised of masonry brick with concrete masonry unit back-up wall attached to the structural framing. The façade also features stone cornices and stone capstone on the top of wall and at wall openings. Stair towers are comprised of similar masonry construction with glazed storefront provided for passive security.

BACKGROUND INFORMATION

An electronic copy (PDF) of original construction drawings are on file with Walker for both the original the expanded construction for this garage. However, the limited number of drawings for the 1985 construction were not identified as “As-Built” drawings. The following information related to documentation origin is as follows:

October 1999 – 100% Submittal Drawings for: “City of Portsmouth High-Hanover Parking Facility Expansion Portsmouth, New Hampshire” by the Maguire Group Inc. Architects/Engineers/Planners Portsmouth, NH., and Reed & Reed, Inc., Woolwich, ME. The drawing set included: Civil, Architecture, Structural, Plumbing, and Electrical drawings.

February 1984 – Construction Drawings (limited set) for: “Parking Facility High and Hanover Streets for the City of Portsmouth, New Hampshire” by Wright Pierce Architects & Engineers Portsmouth, NH. Drawings were limited to: Site Plan F-2, Structural drawings: S-2,4,6,7,8,10,11,12,14; Architectural A-1,3,5,7,9,11,13,15; Electrical E-2,4; Plumbing P-1,3; Civil C-1,3,4,6; Foundation F-3,4,6,8,10.

Source: Walker Restoration Consultants 2014 Condition Appraisal Report.

ENGINEERING REPORTS:

December 1993 – Inspection/Recommendation Report for High/Hanover Street Parking Garage prepared by Fay, Spofford & Thorndike, LLC. Burlington, MA.

Work consisted of a limited walk-through inspection of each of the floor levels with recommended repair and maintenance work that included: Application of water repellants on exterior stair tower masonry, repaint interior stair tower walls, re-seal crack and joints on supported levels, paint repairs to rusting framing; spalling concrete repairs, and replacement of expansion joint seals with an estimated value of \$96k.

August 2001 - “Letter Report Condition Appraisal on High/Hanover St. Parking Facility” prepared by Fay, Spofford & Thorndike, LLC. Burlington, MA.

Report provided recommendations for performing repair and maintenance work on the structure with a repair cost estimate ranging from \$793k to \$1.458M.

March 2005 - “Technical specifications, plans and details for work at High/Hanover Street Parking Facility prepared by Fay, Spofford & Thorndike, LLC. Burlington, MA.
Work consisted of spall repairs; crack joint repairs, joint sealant replacement, supplemental drain installations, and coping repairs.

September 2009 – “Portsmouth Parking Garage, Evaluation of beam Failure at Fleet St. Stairwell Stair tower #1 level 5) “by PE Paradigm Engineering, LLC, York Maine
Work consisted of investigation into the cause of failure of bearing seat supporting a steel beam on level #5 at stair tower #1. Solutions were presented to rebuild masonry corner, add new steel column, install cross-bracing, install new beam to support slab edge, inspect all welds and bolts in affected areas, and recommended material testing of bolts and welds used in the framing to evaluate capacity in the 1999 addition.

December 2009 – “Portsmouth Parking Garage – Concrete Chloride Testing by PE Paradigm Engineering, LLC, York Maine
Work consisted of obtaining concrete powder samples at depths of 1” and 2” in the concrete topping at various locations to establish the chloride concentration in the concrete topping relative to established threshold levels that would support corrosion of reinforcing steel embedded in the concrete. Samples were taken by Miller Engineering & Testing, Inc. Manchester NH and sent to Modern Industries Inc., materials research division for analytical testing.

December 2014 - “Condition Appraisal of High/Hanover St. Parking Facility Portsmouth, NH” by Walker Restoration Consultants Boston, Massachusetts.
A comprehensive condition assessment of the parking facility was completed. The report included forensic testing of concrete samples for compressive strength, petrographic examination, and chloride analysis. Three alternate restoration programs (A, B, C) were developed and presented using state of the art materials for implementation over a 6-year construction phasing period.

June 2015 – “Parking Operations Study for City of Portsmouth New Hampshire” by Walker Parking Consultants Boston, MA.
The study covered management and staffing, parking operations, revenue rate structuring and collections, branding, and marketing, on street technology review, parking technology, and automated parking guidance, and offered recommendations for efficient parking operation and system upgrades.

HISTORY OF PROGRAM REPAIRS

- 2002 Garage repairs and maintenance (masonry repairs, expansion joint seals, crack joint sealant) approximate value for related work of \$50,000
- 2007 Garage repairs and maintenance by G. S. Bolton Rochester, NH (exp. Joint replacement replace sealant, paint beams, misc.) *approximate value for related work of \$30,000*
- 2010 Repair solutions to stair tower #1 identified in the September 2009 report were reportedly implemented. *Value associated for this work was undisclosed.*

- 2013 Garage relighting program (Fluorescent, LED) completed through PSNH. *Value associated for the work was undisclosed.*
- 2013 Elevator system improvements to maintenance mechanical components (new brakes, guides, communication, etc.). *Value associated for the work was undisclosed.*
- 2016 Garage emergency make safe repairs were completed using construction documents developed by Walker Restoration Consultants to address limited selective repairs to floor deterioration on the supported levels, façade masonry walls and expansion joint seals. *Approximate value of construction costs approximately \$100,000.*
- 2017 Ongoing repair maintenance by the City (Steel framing painting on L2, barrier wall coating L5, and renovations to level 2 entry /exit area from Hanover St., Joint sealant repairs on L5, etc.). A concrete footing and temporary steel tube column were installed on grade level to support severely corroded steel girder connection to beam at the east end of the structure. *Value associated for the work was undisclosed.*

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02 Conclusions & Recommendations
Section

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The current re-assessment findings for the Hanover Street Parking Facility indicates that the original structure (1985) remains in “poor to fair” condition while the 1999 horizontal expansion remains in fair to good condition. The condition rating considers the extent of advanced stages of deterioration present on the structure, the structure age, quality of construction materials uses, past maintenance practices, and other factors which have influenced the performance of this structure over time. Current site observations indicate a noticeable increase into the extent and degree of corrosion damage seen on the framing, metal pan stairs, and corrosion deterioration on the concrete topping.

The garage structure has remained in operation for over 29 years and it is continuously being subjected to harsh environmental conditions in the northeast that has resulted in significant concrete deterioration and corrosion that appears on the structural framing. The environmental conditions combined with poor floor slope and drainage, failing waterproofing components and lack of ample waterproofing protection are some of the key contributing factors to the existing corrosion damage to the concrete floors and structural framing, and observed corrosion damage to the stairs and utility systems within the garage.

Our review of the maintenance history of this structure indicates limited program of repairs combined with deferred structural and preventative maintenance and to a certain degree ineffective repairs indicate a need to undergo a comprehensive restoration program to achieve long-term service life extension. The absence of timely maintenance becomes more critical in the later part of the service life cycle as it can affect economical solutions in achieving the actual service life. The desired service life of 20 Years+ can be achieved using each of the proposed restoration alternatives providing cyclic repairs and preventative maintenance is applied in a timely approach on to the structure. Other service system’s essential to function and operation of the garage such as drain systems, safety barrier guard railings and walls, masonry and precast facade, and other components will also require repair and replacement maintenance due to the current deterioration levels. Safety systems within the structure such as vehicle barrier guardrails should also be given consideration for upgrades to meet current building codes.

Restoration program alternatives for this structure differ greatly in their approach with respect to concrete restoration and waterproofing protection. Further explanations into the proposed base repair program alternatives can be found in the “*Restoration Base Program Alternatives & Opinion of Construction Costs*” section of this report. Further technical information is also provided in Appendix D “Repair Strategies”.

RECOMMENDATIONS

Service life extension can be achieved through each alternative providing preventative maintenance is performed at cyclic intervals during this term. Given the objective of the City to obtain a cost economical solution that provides a 20-year service life extension, it is our opinion and recommendation that Alternate “B’ will provide the City with the most constructive and economical solution towards achieving the desired service life extension while reducing future repair and maintenance costs during this period. Further information regarding the capital cost outlay and work requirements for programming the work is provided in the following sections and in Appendix A.

IMMEDIATE REPAIRS

Our survey and assessment encountered many areas of significant deteriorated conditions however none were identified as needing immediate action to address imminent hazardous conditions to patrons and public while in operation. Walker recommends that the operational staff remain diligent during the current time to monitor and address all conditions which may require interim repairs to reduce the potential risk of incident.

RESTORATION BASE REPAIR PROGRAM ALTERNATIVES

Concrete deterioration and deficiencies encountered during the repair investigation are increasing and significantly affecting the structural performance of the supported floors, structural framing, and masonry façade. Corrective repairs and preventative maintenance are required to restore structural integrity and prevent accelerated deterioration. Each alternative represents a corrective solution to the causes of deterioration where achievable. Base repair alternatives being presented will vary in the level of comprehensive repairs and preventative maintenance to achieve a cost effective program that achieves a service life extension of 20+ years.

Walker's experiences in successful capital improvement planning and construction implementation combined with industry proven methods were incorporated into three alternatives (A, B, & C) which represent an increasing level of restoration while reducing structural maintenance over time. Optional enhancements are available to improve and modernize the structure and are presented separately following this section. Further explanation into the repair methodology and service life application can be found in Appendix D "Repair Alternatives" of this report.

ALTERNATIVE A REPAIR PROGRAM

Alternative A represents a "base-line" repair approach for restoration of the parking facility. An outline of this program is presented below with Table A providing our "Opinion of Probable Construction Cost" for implementation of this program.

Concrete Repairs:

- Topping concrete repairs are made at random and isolated locations where deterioration is present and where topping bond failures exist in large scale areas. Repairs are provided with tooled construction joints and prepared for joint sealant application.
- Surface applied thin set materials that have failed on the top level floor will be removed and repaired by installing profiled concrete washes for improved drainage,
- Deteriorated raised concrete curbing and walkways located near the entrances and at stair tower doorways are removed and replaced with new concrete curbs that provide sufficient step out area and are configured to comply with ADA dimensions.
- Concrete washes are provided to reduce and eliminate certain areas where ponding occurs,
- Concrete repairs are completed on the pre-topped filigree planks where broken corners exist and deterioration appears on field topped areas,



- Concrete repairs are made at random location where deterioration is present on the slab on grade area with a penetrating floor sealer applied to the grade slab area,
- Concrete repairs are provided to deteriorated column piers on level 1 east end of the garage (2018).

Structural Framing Repairs:

- Severely corroded areas on the steel framing will be abrasively cleaned, sectional losses recorded, and repairs made to strengthen the framing where required, Bolted connections are checked for proper thread engagement and replacement high strength bolts are provide where required (2018),
- Spandrel panel connections to the framing are cleaned, inspected, and a zinc rich organic rust inhibitive primer and aliphatic urethane top coat are applied, damaged connectors are replaced where required,
- Filigree plank shear connectors will be re-welded where required.

Waterproofing / Protection:

- All sealant in cracks and joints (control, construction, cove) are systematically removed and replaced with new flexible sealant, unsealed new joints and existing repairs are sealed with sealant,
- The garage expansion area precast filigree plank joints in the floor (panel to panel, beam lines, around floor drains) are systematically removed and replaced with new flexible sealant,
- All topping concrete and pre-topped filigree surfaces areas are cleaned and degreased for an application of protective penetrating sealer,
- A penetrating sealer is applied to all horizontal concrete surfaces to slow the infiltration of surface moisture.
- Expansion joint seals are replaced on each floor level and ramp crossovers,
- Floor penetrations are re-sealed and flashings provide where possible,
- Isolation joint sealant at all stair towers are removed and replaced with flexible sealant or compression seals and properly terminated,
- Diverter angles on level 5 are cleaned and resealed with new sealant.

Plumbing/Drainage:

- Deteriorated and damaged floor drain lines and drain bodies are removed and replaced with new drain and lines levels 3 through 1. The work will entail 100% of the drains and lines in the 1985 structure with the 1999 garage expansion area floor drains and lines replaced where needed,
- Supplementary drains and lines are added to remove large ponding areas on levels 3 and 2,
- Concrete profiling is incorporated into topping concrete work to eliminate poor drainage area and where standing water occurs near column framing.
- The diverter angles installed on level 5 (expansion area) are repaired and resealed to the floor slab.

Architectural Maintenance & Repairs:

- Deteriorated/and displaced masonry on the roof level barrier walls are repaired, damaged areas are reconstructed with proper vents, through wall flashings, capstone coping and cap flashings to proper height,
- Deteriorated/and displaced masonry brick veneer on South elevation will be repaired,



- Cracked and damaged CMU units on the top level façade masonry will be replaced or reconstructed to restore wall integrity,
- Masonry joint control joint sealant is replaced on all elevations,
- Cornices and sills that are displaced in their position are reset, grouted joints that are cracked or bond separated are replaced,
- Façade capstones on levels 5/4 that are deteriorating or not properly flashed will be removed, new top of wall flashing provided and new precast capstones properly secured onto the wall top,
- Floor penetration /openings more than four inches are covered for fall protection,
- Openings on interior wire cable barrier guardrails are covered with a fence fabric to eliminate climbing and fall through openings to below.
- Interior repairs are made to concrete deterioration inside the stair towers, existing waterproofing is restored to steps and landings,
- The exterior stairway steps from level 5 to 4 will be repaired and protected by a waterproofing membrane system,
- Roof leaders are re-directed away from slab to wall joint lines,
- An application of elastomeric coating is applied to the CMU on the interior side top level only,
- Precast spandrel panels are cleaned and protected by a clear sealer,
- Glazing gaskets on storefront at west stair tower will be replaced, and metal covers repaired where required.

Mechanical / Electrical

- Provide replacement of fire protection standpipe system.
- Provide an allowance to replace damaged or relocated light fixtures during construction.
- Replace missing light pole and fixture on level 4.

Paint / Coating Protection

- The exposed paint system on the framing is abrasively cleaned and prepared to receive a high performance paint protection system,
- The galvanized steel framing where efflorescence staining exists will be cleaned and corrosion resistant coating will be applied to spot rusted areas,

Miscellaneous Maintenance:

- New parking striping and graphics are applied to all floor levels,
- Missing light pole and light fixture is replaced, maintenance is performed on non-operable lights, repairs are made to corrosion damaged conduit.
- Barrier cable guardrails will be repaired where required at select locations.
- Repair and repair bollards, snow gates and miscellaneous metal items.
- Rain leader discharge from the stair tower roofs are redirected away from wall joint lines.

ALTERNATIVE B REPAIR PROGRAM

ALTERNATIVE B Incorporates the concrete repairs represented in alternative a into a more comprehensive restoration approach by expanding the repair zones beyond the random spot repairs to include continual strip repairs across the beam framing where concrete topping is removed in uniform strip formations to encompass the existing steel reinforcement and replace it with epoxy coated reinforcing steel thereby eliminating potential future deterioration formations along the framing lines on levels 3 and 2. The process also provides an opportunity to clean the steel beam flange top and apply a corrosion resistant epoxy coating. The new concrete topping is provided with a corrosion inhibitive admixture for added protection to the reinforcement. Repair strips are properly jointed with tooled joints and filled with flexible sealant for watertight floor joints. Field cast concrete topping areas, on levels 4, 3, and 2 in the original structure, are then protected by an application of a traffic bearing waterproofing membrane coating that will greatly reduce the potential for surface moisture and chloride penetration into the new concrete floor slabs. The pre-topped precast filigree floors on levels 5 through 2 floors (1999 expansion) are cleaned and receive a clear penetrating floor sealer. Other repair work and improvements are provided as indicated in the base repairs represented in alternative A. Alternative B will require periodic preventative maintenance to effectively maintain this level of waterproofing protection.

An outline of this program is presented below with Table B providing our “Opinion of Probable Construction Cost” for implementation of this program.

Concrete Repairs:

- Topping concrete is removed in strip repairs along the beam framing lines to replace the existing reinforcing steel with new epoxy coated reinforcement. This method encompasses most of the deterioration and bond failed topping areas including the widespread pattern cracking formations. New epoxy coated reinforcing steel and high quality concrete with corrosion inhibitors are provided in the repair zones and cast with tooled and sealed construction joints for positive watertight control.
- Repairs to deteriorated concrete (thin set materials, curbs, walkways, washes, slab on grade, etc.) are completed as described in Alternative A.

Waterproofing / Protection:

- All topping concrete surface areas are cleaned and degreased for an application of a traffic bearing waterproofing membrane system or traffic topping,
- Waterproofing system component replacement work is completed as shown in Alternative A.

Structural Framing Repairs; Plumbing / Drainage; Architectural; Mechanical/Electrical; Paint /Coating Protection; Miscellaneous Maintenance work is completed as shown in Alternative A.

ALTERNATIVE C REPAIR PROGRAM

The restoration work encompasses the most aggressive solution to remove the chloride contaminated and deteriorated topping concrete within the boundaries of the original structure. The removal technique used for concrete demolition known as hydro-demolition (also known as, hydro blasting, Hydro-milling, water blasting, and water jetting) is utilized to cut into and remove sound and unsound concrete. This option eliminates the chloride contaminated topping concrete and existing deterioration and allows improvements to be made in pitch and profiling to improve drainage in the new concrete overlay. Bond failed concrete areas are also removed down to sound substrate. More importantly the demolition method reduces the rate of fracturing or bruising of the precast and provides a suitable prepared substrate to accommodate the new concrete overlay. The concrete overlay is completed with dense high performance concrete and jointed at all precast lines to allow for proper maintenance of watertight joinery. Flexible sealant is installed in all tooled control construction and cove joints to retain watertight control of the overlay. Joint sealant and expansion joint seal replacement will be performed throughout the facility. A clear penetrating sealer is provided to all supported floor surfaces to reduce moisture and chloride diffusion and improve upon maintenance wash-downs and cleaning. This program will have a greater impact on the operation of the parking facility during the construction process.

An outline of the program is presented below

Concrete Repairs:

- Topping concrete in the original structure is removed and replaced on level 4, 3, and 2 using the hydro-demolition process to remove and prepare the precast floor planks to receive a new bonded concrete overlay. New epoxy coated reinforcing steel and corrosion inhibiting admixture is provided in the overlay.
- Repairs to deteriorated concrete (thin set materials, curbs, walkways, washes, slab on grade, etc.) are completed as described in Alternative A.

Waterproofing / Protection:

- Tooled control and construction joints (control, construction, cove) are cast into the overlay are prepared and flexible sealant installation,
- All floor surfaces (excluding traffic bearing waterproofing membrane coated areas) are prepared for an application of a protective penetrating sealer,
- Waterproofing system component replacement work is completed as shown in Alternative A.

Structural Framing Repairs; Plumbing / Drainage; Architectural; Mechanical/Electrical; Paint /Coating Protection; Miscellaneous Maintenance work is completed as shown in Alternative A.

OPINION OF PROBABLE COSTS

Our opinion of probable construction cost for each base repair alternate is presented in abbreviated form in Tables **A**, **B**, and **C**. Costs were developed using pricing from our database of similar repair projects completed in the New England area during 2013 through 2018 by restoration general contractors with experience in performing structural restoration under construction phasing over single and multiple years through completion.

The opinion of probable construction costs does not include certain ancillary costs and service equipment associated with:

- Extensive construction work phasing and sequencing to reduce the impact on garage operations,
- Winter cycle construction and unsuitable weather conditions,
- Fees for using a professional Construction Manager during the repair program,
- Engineering fees for design and construction documents for a selected repair program,
- Night or weekend shift work and overtime differential for labor costs to increase production levels or perform work during off daytime hours,
- Abatement of any hazardous materials that may be encountered during construction.
- Replacement of current working service utilities or operational equipment such as garage lighting, elevators, parking access and revenue control equipment, power service, generators, transformer, office area, and lavatories.

A construction contingency is provided in each alternative to address unforeseen conditions that may be encountered and require change during construction. Further breakdown of costs for each alternate is provided in Appendix A.

The “Opinion of Probable Construction Cost” for Base Repair Program Alternatives ‘A’, ‘B’, and ‘C’ are shown below. Construction costs shown above are rounded to the nearest \$1,000 and based on 2018 dollars for single-year construction season. Construction costs are based on historical data of similar types of work. Costs are based on a normal daytime workweek, time of year, and other factors. The Tables do not include “Soft Costs” such as, Financial Costs. Costs related to engineering and design development of construction documents, bidding, and construction administration are not included.

A detailed breakdown of costs presented in Appendix A “Repair Alternate Costs & Phasing Plan” of this report.



TABLE A – ALTERNATIVE A OPINION OF PROBABLE CONSTRUCTION COSTS –

REPAIR TYPE	ESTIMATED COST
1. Concrete Floor & Structural Framing Repairs	\$1,470,000
2. Waterproofing / Protection	\$890,000
3. Plumbing / Drainage	\$206,000
4. Architectural Maintenance & Repairs	\$465,000
5. Mechanical / Electrical	\$116,000
6. Painting / Coating Protection	\$374,000
7. Miscellaneous Maintenance Work	\$68,000
Subtotal	\$3,589,000
General Conditions & Mobilization @ 9%	\$323,000
Site QA Testing	\$17,000
Owner Construction Contingency @ 10%	\$393,000
ALTERNATE A TOTAL	\$4,322,000

Source: Walker Consultants 2018

TABLE B – ALTERNATIVE B OPINION OF PROBABLE CONSTRUCTION COSTS –

REPAIR TYPE	ESTIMATED COST
1. Concrete Floor & Structural Framing Repairs	\$1,673,000
2. Waterproofing / Protection	\$1,546,000
3. Plumbing / Drainage	\$206,000
4. Architectural Maintenance & Repairs	\$465,000
5. Mechanical / Electrical	\$116,000
6. Painting / Coating Protection	\$374,000
7. Misc. Maintenance Work	\$68,000
Subtotal	\$4,448,000
General Conditions & Mobilization @ 9%	\$400,000
Site QA Testing	\$20,000
Owner Construction Contingency @ 10%	\$486,000
ALTERNATE B TOTAL	\$5,354,000

Source: Walker Consultants 2018

TABLE C – ALTERNATIVE C OPINION OF PROBABLE CONSTRUCTION COSTS –

REPAIR TYPE	ESTIMATED COST
1. Concrete Repairs –Random Repairs, /Curbs/, Precast.	\$491,000
2. Concrete Overlay – Floor Levels 4, 3, 2	\$5,714,000
3. Structural Framing Repairs	\$75,000
4. Waterproofing / Protection	\$855,000
5. Plumbing / Drainage	\$206,000
6. Architectural Maintenance & Repairs	\$465,000
7. Mechanical / Electrical	\$116,000
8. Painting / Coating Protection	\$374,000
9. Miscellaneous Maintenance Work	\$68,000
Subtotal	\$8,364,000
General Conditions & Mobilization @ 5%	\$418,000
Site QA Testing	\$30,000
Construction Contingency @ 8%	\$705,000
ALTERNATE C TOTAL	\$9,517,000

Source: Walker Consultants 2018

CAPITAL IMPROVEMENT PROGRAM IMPLEMENTATION

Recommendations were established using work prioritization based upon the following order: (1) structural importance, (2) overall protection to the structure, and (3) preventative maintenance to ensure system function and performance.

Base repair program alternatives presented in Tables A, B, and C represent total “single” construction year cost for each program. Although a single year projects generally obtain the greatest cost efficiency, a multi-year construction plan may be needed to allow time for budgeting and funding this project under a Capital Improvement Plan. The parking facility reportedly operates at or near capacity year-round and serves the neighboring community, businesses, and visitors to the area. Based upon the high user demand placed on this structure, single year construction which could require substantial closure would not be a practical consideration. It is our opinion that the economic costs associated with each program alternative will necessitate development of a Capital Improvement Plan that will involve multiple year construction.

Our economic analysis of Alternates A and B indicate a six (6) year construction plan as providing the most cost efficient approach to restoring the structure. Further evaluation into Alternate ‘C’ indicates this option will create the greatest disruption to parking operations during the restoration process and will require much of the garage floor area (approx.60%) to be closed during construction to facilitate the work. Given the operational issues and the impact on parking capacity, a multiple year construction for Alternate C would not provide a cost

effective option. The program if undertaken should be considered for single year construction with substantial closure to facilitate the process. It is our opinion that this alternate presents excessive economic costs to the City and would be an outside consideration.

Multi-year construction implementation requires adjustments and modification to the single year costs that include:

- Cost escalation for yearly Inflation affecting contractor labor, materials, and OH,
- Multiple mobilization and demobilizations on site which translate into additional costs,
- Escalation increases in deterioration growth over the multi-year period,
- Construction sequencing and work phasing through the structure during each year of construction.

Construction phasing will also make limited floor areas inaccessible to parking/circulation and can limit the pedestrian pathways through the stairways. Therefore, phasing plans will require provisions for maintaining life/safety egress requirements at all times during construction. This element is developed into the work phasing sequences that apply appropriate construction controls to accommodate both uninterrupted construction work activity and parking operations.

Cost efficient work phasing will require imposing construction limits. A minimum number of vehicles per phase will allow the contractor to maintain efficient production while maintaining low impact on garage usage during the construction period. Our review of the garage operations, and circulation and current parking trends indicate work phasing will require a minimum of 100 to 125 vehicle spaces or 31% of a given floor area per phase under program A and B to attain cost efficient construction pricing and minimize construction duration. This is reflected in the “Base Repair Program Implementation Plan” provided in Appendix A.

Further if multi-year construction is chosen, it is recommended that multi-year project award be considered in a single contract to a qualified restoration contractor to retain consistent quality of work throughout the complete construction period.

ENHANCEMENT OPTIONS

Garage enhancements represent optional upgrades that can provide beneficial improvements to the aesthetical and operational characteristics of this structure. These items are not considered to be essential in restoring the structure to gain service life extension; therefore, costs are separated from the base restoration program alternatives. Probable construction costs are provided within a range since decisions on the design selection and features would influence the cost for enhancements. The following enhancements are being offered for consideration in this structure:

New Interior Traffic and Wayfinding Signage & Graphics

The current graphics inside the parking facility uses varying painted stencils and limited signage posting that provide a challenging visual identity for user location and direction. The design of a new signage and graphics program can complement the interior finishes and architecture while enhancing the brand experience. New

signage and graphics plan would benefit this structure by improving the user experience in way finding and traffic circulation. The design could include attractive graphics provided at strategic locations on each level to identify the path of travel provide directional information, allow for City branding image, address parking regulations and pay station reminders, recognize featured area such as ADA, and other user information that aides in pleasant and safe travel to and from the structure. The graphics standard could match the new garage signage and graphics package being used at the new parking garage currently under construction.

Precast Façade Panel Color Coat Enhancement

The precast spandrel panels on this structure can benefit from cleaning and application of color pigmented protectants that provide improved architectural appearance and environmental protection. This would be performed on the exterior and interior surfaces to unify the color and improve upon the architectural appearance of this façade component.

Bird Abatement

The garage has several bird roosting areas that continue to be problematic to maintenance. The roosting generally creates nesting's and considerable droppings that are unhealthy and in turn require frequent maintenance cleaning. Bird deterrents such as objects that prevent bird landing and roosting are available and can sufficiently reduce if not eliminate the problem.

LED Lighting System

The garage lighting system was updated in 2013 through an energy rebate from PSNH. The fluorescent tube system and LED lighting on the top level appear to be in good functional condition. However further energy savings and improved lighting performance can be attained using the current technology LED light fixtures. Fixture replacement should consider a photometric study to optimize on achieving proper uniformity of illumination levels. A probable cost was developed in Table D using a one for one fixture replacement.

Ornamental Grille infill along Hanover St.

The street level area along Hanover St. has openings through the north elevation that are provided with a "bar style" grille for security purposes. The aesthetical appearance of these openings along street level appears somewhat detractive and the openings could be enhanced by installing a decorative ornamental grille. The can provide with a complimentary color and retain the security along these openings.

TABLE D

OPINION OF PROBABLE COSTS - ENHANCEMENTS		
REPAIR TYPE	CONSTRUCTION COST RANGE	
	LOW	HIGH
1. New Signage & Graphics – Interior	\$70,000	\$130,000
2. Precast Façade Panel Color Coat Enhancement	\$70,000	\$95,000
3. Bird Abatement	\$15,000	\$25,000
4. New LED Lighting System	\$80,000	\$130,000
5. Ornamental Grille - Hanover St. Façade @ Street level	\$35,000	\$50,000
Subtotal	\$270,000	\$430,000
General Conditions & Mobilization @ 9%	\$24,000	\$38,000
Construction Contingency @ 10%	\$29,000	\$47,000
Probable Construction Costs	\$323,000	\$515,000

Source: Walker Consultants 2018

Notes:

1. Estimated costs are provided in a range due to varying options available for design selection.
2. Estimated cost ranges were provided from historical cost data of similar types of work.
3. Costs are based on work performed during normal daytime workweek and may vary due to time of year, local economy, or other factors.



DRAFT

Discussion
03 Section

DISCUSSION

INTRODUCTION

The following section represents a discussion into the causes of deterioration and other deficient conditions that will impact the service life expectancy of the structure. Repair and maintenance processes are discussed in general for implementing a systematic approach towards fully repair the parking structure. Further explanation into the deterioration mechanisms and terminology used in this report can be found in Appendix H.

CONCRETE FLOOR DETERIORATION

The field sounding survey and visual results indicate the topping concrete shows variability in quality and durability characteristics that continue to be influenced by moisture and chlorides and environmental exposure. These conditions combined with construction deficiencies such as poor drainage slope, cracking, minimal concrete cover over reinforcement, and lack of corrosion protection give cause to the existence of concrete deterioration which is continuing to reduce the service life and performance of the floor slabs and framing, and will increase the demand on maintenance expenditures in this structure. Depending on the alternative restoration program selected for this structure, a redundant level of protection can be provided using cathodic protection of the reinforcing steel area in the slab combined with application of waterproofing treatment to reduce the moisture penetration into the slab.

It is important to understand the benefit of good durability characteristics in concrete. Material properties that greatly influence the susceptibility of concrete to deterioration are freeze-thaw resistance, compressive strength, and permeability or porousness. Concrete is naturally porous which allows the concrete to absorb significant free water during exposure to rain or snow. Concrete that becomes super saturated with water soluble chlorides can penetrate deep into the pore structure and eventually reach the reinforcing steel zone. The corrosion mechanism disrupts the molecular structure of the concrete caused by the expansive forces created from the corrosion process and results in concrete spalling and delaminations.

Concrete topping bond failure ranging from 10 to 350 square feet in area was documented in many areas that include spalling and delaminations and failed patch repairs. Deterioration of the topping is the leading cause to corrosion induced deterioration observed on the precast filigree slabs. The bond failure or separation between the concrete components becomes significant because it affects structural performance and durability. The slab capacity relies upon composite bond action between the cast and precast concrete to reduce overstress and transfer live loads between them. This void separation reduces the slabs load capacity and creates a reservoir which attracts moisture that enters through cracks, joints, and porosity or permeability in the topping concrete. The entrapped moisture creates a corrosion potential on the embedded reinforcement, with salt laden moisture saturation penetrating deeper into the precast filigree planks that produces resultant spalling and delaminations. Other factors contributing to deterioration also include unsealed cracks, failing joint sealants, and failing expansion joint seals, water ponding, and improper drainage flow that allow water penetration through the slab composition. These conditions are a direct cause to the subsequent damage and deterioration seen on the structural framing.

Combined concrete topping deterioration and bond separation appear to have increased over the prior 2014 assessment report. The magnitude of deterioration as extrapolated from survey field data indicates a combined

deterioration rate (factored) of approximately 36% when applied over the gross floor area of the original structure. Field findings recognized the progressive deterioration is extending beyond prior deterioration and repair boundaries with new formations present above the structural framing lines and they can be expected to increase over time. Appropriate repair methods are required to correct the causes of deterioration and provide effective repair or replacement of the topping concrete to effectively eliminate progressive deterioration growth.

The cast concrete topping reveals a limited number of longitudinal and transverse tooled control joints. The limited joint provided have led to crack line formations along the underlying precast panel to panel joints and shows the crack lines which have formed along most of the panel joints. This condition can be corrected depending on the selected repair alternative by installing tooled contraction joints that control shrinkage stresses and deflection during cast concrete placement. Crack lines pose a greater challenge in achieving watertight seal due to their irregular outlines and subsequent distress that extends along the crack lines over time. Joint sealant maintenance will be key and integral part in providing an effective protection system to the floors.

Low points in the floor that do not provide sufficient drainage can be corrected with profiling the new topping or by adding new area floor drains to accommodate surface drainage.

STRUCTURAL FRAMING CORROSION

Visual examination performed on the structural framing recognized advanced stages of corrosion development occurring on the painted structural steel framing. The corrosion forms were recognized in increasing levels of severity and extent of area. The causes to corrosion remain and are continually influenced by road salts and deicers and moisture penetrating the concrete slab mass via saturation and leakage through floor slab joints and openings that frequently wets the framing. In the absence of either, corrosion does not occur. Essentially, the iron in the steel is oxidized to produce rust which occupies 6 times the volume of the original material consumed in the process. The rate at which corrosion progresses depends on several factors relating to the "micro-climate" immediately surrounding the structure, principally the time and cycles of wetness from the atmosphere and operating environment.

Widespread deterioration of the paint coating consisting of pitting and corrosion, oxidation, peeling, chalking, holidays, discoloration, uneven gloss that has compromised the integrity of the paint protection system to a point where it no longer performs as intended. The extent and severity of corrosion have been documented where steel repairs may be warranted. Current assessment findings confirmed the extent of corrosion caused deterioration affecting the paint is growing and the noted paint repair process observed on parts of the framing will not be adequate in restoring long-term protection without repeated maintenance.

Therefore, to provide long-term paint protection to the steel framing, a full and complete paint process will be required. It is being pointed out that the top of steel in contact with the slab cannot be cleaned and repainted which can in turn cause rust staining on the newly protected surface if the slabs are not effectively sealed and waterproofed. The paint process will require abrasive cleaning, primer, intermediate/build coat and finish coat. High performance coating systems such as organic zinc rich primers, epoxy polyimide build coat and aliphatic

urethane top coat systems are recommended for long-term protection. With proper application, service life is estimated at 18 to 20 years based upon the environmental conditions.

MASONRY FAÇADE DETERIORATION

The exterior façade on the original and expansion structures are similar in masonry construction and are comprised of non-load bearing masonry brick with CMU (concrete masonry unit) back-up. The top level of the garage expansion has a precast stone cornice with precast coping. The original structures façade is a combination of masonry brick and block walls and precast prestressed panels attached to the structural framing. A visual re-evaluation was completed on the interior and exterior sides of the façade to identify deficiencies related to deterioration and distress existing on the masonry and precast panels.

a. Precast Panels

The precast spandrels are generally in good condition with limited locations showing hairline cracking at mid-span. The panel crack has led to some efflorescence stains. As these cracks do not pose a structural impairment, cracking processes using epoxy can be performed to stop moisture movement through the cracks. The appearance of the panels has degraded due to environmental staining and discoloration over time. Panel connections to the framing show concerning areas of corrosion of the tie rods and hardware that connect the panel to the structural framing.

b. Masonry Walls

Examination of masonry wall conditions located numerous points of moisture infiltration and damage affecting the integrity of the masonry and cast stone components on the façade and interior barrier walls. The findings indicate areas of loose and broken mortar joints, brick masonry displacement, cracking in the brick and block, brick face spalling, efflorescence staining, and bulged sections of wall and capstone coping occurring on the top of the masonry walls. The precast capstones on top of the façade walls show signs of a material freeze-thaw durability problem. Several conditions where warping, expansive growth, craze cracking, freeze thaw deterioration appear on the walls also pose a safety concern from falling objects. These deficient conditions are identified as requiring "Immediate Repairs and are stated so in this report.

Primary causes to the above deterioration and failure mechanisms appear to be created by moisture penetration and absorption combined with inadequate provisions to accommodate water management, masonry growth, and framing movement. Design and construction methods such as omitted base flashings below the coping, rowlock coursing of masonry atop interior barrier walls, lack of ties between brick veneer and CMU backup, and voids inside the CMU cells are key contributing factors to the masonry damage and distress. It is recommended that the repair design consider performing exploratory openings into the CMU to determine the extent of reparability versus replacement.

The extent of the observed deficiencies point to poor masonry workmanship and materials that will require a substantial effort to resolve these problems. In order to correct these deficiencies and damage, the restoration process will require some reconstruction and replacement. The compromised condition of the coping and lack of cap flashings in most of the wall top will require replacement with new durable units to mitigate the problem. The repair process will also include re-setting on some of the precast stone cornice and headers and sills where

displacement exists. The interior walls show staining and a protectant can be applied to treat the interior with a wall coating that can reduce absorption and infiltration but allows vapor transmission to pass through the wall.

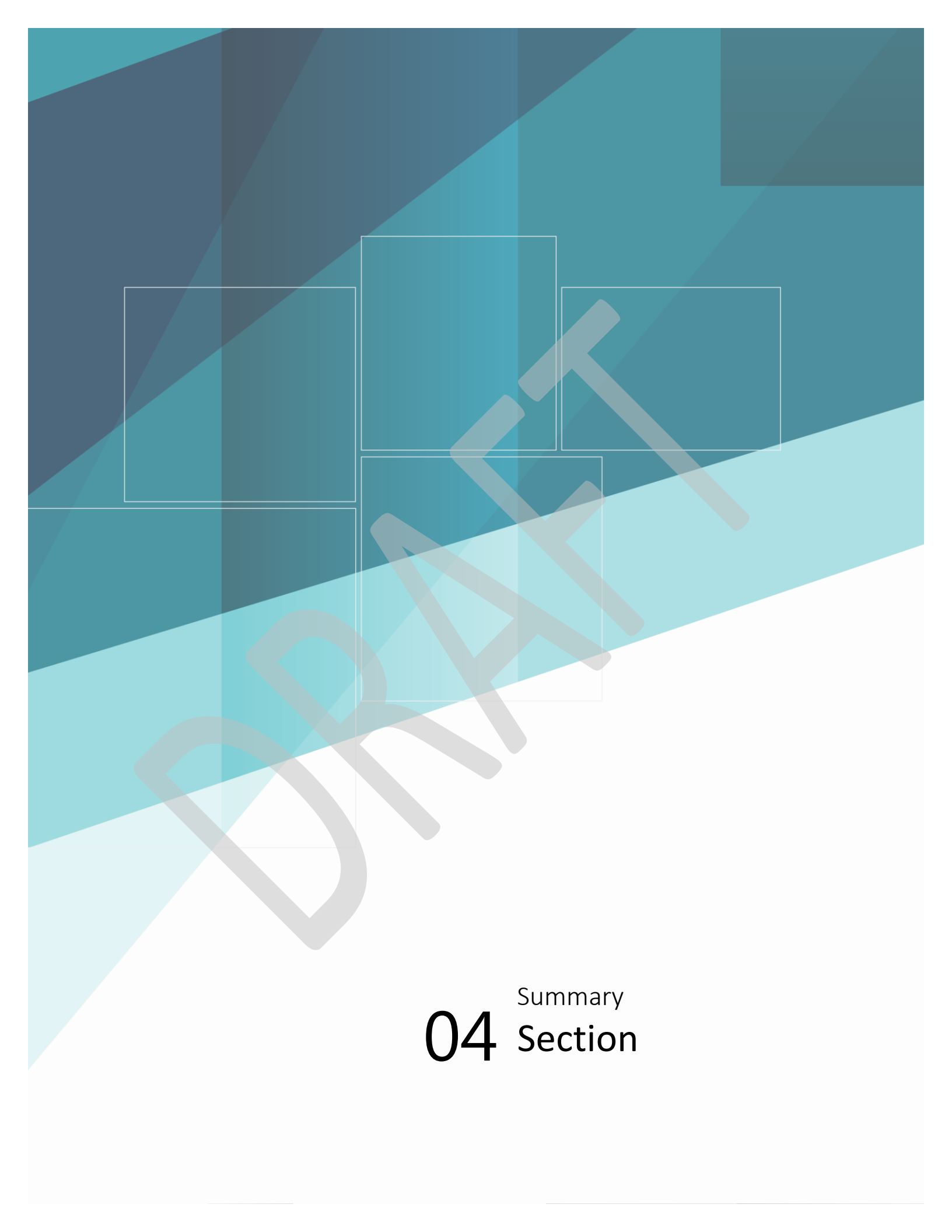
WATERPROOFING PROTECTION

Restoration repairs can correct the present deterioration, but cannot prevent further deterioration without applying effective protection onto the slabs to reduce or eliminate continuing deterioration. Protection systems have become an essential part of the restoration process due to their ability to reduce and eliminate moisture and salt intrusion that leads to expensive corrosion induced concrete deterioration. The initial steps for protecting the floors in all the base repair alternatives will require complete crack and joint sealant replacement. Based upon the survey findings, the vast number of existing sealants have reached the end of service and the significant failure rate now dictates require replacement. The expansion joints also come under replacement as repairs are not practicable based upon the extent of failure and their age.

Selection of waterproofing treatments generally takes into consideration; the extent and significance of deterioration, cracking, chloride content, concrete quality and durability, and the severity of environmental exposure. Each base repair alternative is matched with a level of protection that increases in effectiveness based upon the comprehensive repair process being undertaken.

Clear penetrating sealers can slow the rate of moisture and chloride penetration in the topping but cannot bridge cracks or stop moisture from entering pores in the concrete. The continued migration of both elements reaching the reinforcing steel zone will create new deterioration formations. Sealer performance also diminishes over time and reapplication is critical in maintaining a low rate of deterioration over time. Traffic bearing elastomeric waterproofing membranes also referred to as traffic topping can provide a cost effective level of protection by reducing oxygen, moisture which supports the corrosion process. More importantly the traffic topping stops chloride ion penetration more effectively than penetrating sealers since it blocks the entire concrete pore structure on the surface.

Concrete overlays provide a greater level of protection than topical protection systems by having a dense chloride free concrete matrix provided with corrosion inhibiting admixtures to stop the corrosion process. In addition, the new overlay combined with new epoxy coated reinforcing steel will provide sufficient redundancy in arresting future corrosion from occurring for 20 years.



04 Summary
Section

SUMMARY

A re-assessment and structural evaluation of the Hanover Parking Facility was performed during the weeks of April 30th and May 7th 2018. The assessment re-examined the physical conditions of deterioration affecting the structure, in comparison to the prior 2014 Condition Survey and Report completed by Walker Restoration to identify important changes that would affect operating conditions and expenditure forecast for budgeting, planning and funding of a selected restoration base repair program.

OBSERVATIONS

A limited chain drag survey was completed on approximately 50% of the field cast topping concrete situated on levels 4, 3, and 2 of the 1985 built structure. The limited area of survey would then be used to extrapolate a rate of increased deterioration growth that would be interpolated into the data and cost tables. The survey also included the field cast concrete areas adjacent to the newer expanded horizontal addition to gain a reasonable estimate of floor deterioration increases within the facility. The chain drag sounding technique is used to locate and quantify the limits of deteriorated (spalled, delaminated concrete as well as concrete bond separation in the composite slab areas on each supported floor level. The effort is followed by visual examination of the floors and structural framing, exterior façade, stair towers, and other ancillary components and utilities to identify changes that are being influence by the deterioration rate or require additional maintenance to achieve the 20+ year service life extension.

The following abbreviated summary of key observations and findings are presented below. Further clarification of these and other conditions are provided in Appendix D. A limited inventory of photographs representative of the significant deficient conditions is provided in Appendix A at the end of this report.

SUPPORTED FLOORS

Cast Topping Concrete – Levels 4, 3, 2

- The chain drag survey completed on levels 2 and 3 indicate large areas where concrete topping bond failure is present. Additional field data collected during the survey indicates a combined rate of deterioration affecting approximately 15% of the total gross area for these two levels.
- Larger bond-failure areas (>50sf) exhibit random areas of spalling, delamination, exposed and corroded reinforcement, and failing repair patches.
- Pattern cracking running parallel to the beam framing exists in the cast topping in areas of where deterioration exists and in unaffected areas.
- Spalled concrete was noted with reinforcement near the surface (<1”).
- Floor profiling on the flat ramps show depressions in varying size attributing to ponding on the floors primarily in parking area and near floor framing penetrations.
- Levels 4, 3 and 2 has linear crack lines in the topping concrete that outline the precast filigree plank joints and structural framing below. Most of these crack joints appear with joint sealant. New unsealed crack formations also appear to extend from these joints and many are unsealed.
- Most of the tooled construction joints on each level are provided with sealant.
- The chain drag survey performed on level 4 revealed a minimal amount of spalling, delaminations, and concrete bond failure.

- Level 4 or roof level has several large areas where a thin set cementitious material is applied to the concrete surface. Some of these areas exhibit extensive cracking and partial bond failure between the precast planks and the cast-in-place topping. Repairs made using this material are usually done to address surface deterioration or to eliminate water ponding.

Pre-topped Filigree Floors – Levels 5, 4, 3, 2

- The pre-topped filigree floor planks provided in the garage expansion area are in sound and satisfactory condition. Several locations were noted with damage at the corners of the floor planks.
- The floor plank joints are provided with flange to flange and flange to steel weldments that provide load transfer. The weldments and connection appear to be stainless steel and no broken connections were detected during the survey.
- Plank joints were noted with intermittent edge splintering and sealant failures mostly at the flange connection pockets between filigree planks. The edge splinters are cause to leakage as evidenced by wetting and efflorescence stains observable from below on the galvanized framing.
- Floor framing penetrations were noted with loose fill and failing sealant at many locations. Utility penetrations such as drain line also show poor seal installation with leakage and rust staining below.

STRUCTURAL FRAMING

- The painted structural steel framing that encompasses the original structure exhibits continued corrosion development and rust staining. The extent of corrosion has increased in severity on several areas of column and beam framing at the east end of level 1 and 2. The severity of corrosion appears greater on the level (2) framing due greater water penetration through floor slab deterioration, cracks, and failed joint sealant. Repairs to severe corrosion damage on several columns and beams are probable.
- Openings provided in the floors provided for insertion of columns between the levels also referred to as penetrations are cause to heavy corrosion present on the column and diagonal braces. These penetrations are filled with concrete but lack an effective seal to avert water flow between levels.
- Corrosion damage was observed on a steel girder below level 2 floor where a supplemental steel column and footing was added due to multiple preformation's and sectional loss on the girder web area at a beam connection.
- Rust staining appears lighter on levels 3 and 4 framing. The staining is most prevalent along the top of the beam flanges and at bolted connections between column framing.
- The addition of the horizontal parking expansion area is framed in galvanized steel framing. The framing was noted with efflorescence staining on the beam surfaces in several locations due to water entry through failed joint sealant. Other locations where framing connections are located show surface rusting on the weldments.

WATERPROOFING SYSTEMS

Waterproofing protection on each of the supported levels of both the original and newer addition relies on flexible joint sealant provided on cracks and joints. Visual assessment of the existing sealant and several materials sample taken at random locations indicate significant deterioration (adhesion loss, cracking, hardening, ageing, chalking) and degradation is affecting most of the installed material.

1985 Structure

- Most of the floor joint sealant is installed along crack joints that outline the steel and precast framing lines in the original structure. Leakage was recorded at many of the sealed and unsealed cracks joints on each floor during rainfall events. Evidence of long-term leakage problems bears evidence along the steel framing lines at many locations where corrosion appears on the top flanges and column to beam framing connections.
- Construction and cove joints show considerable material deterioration and intermittent adhesion failures.
- Sealant provided along the precast joint lines within the garage expansion area exhibits significant intermittent sealant adhesion failures along many of these joint lines on each level. The leakage is evidenced by water and efflorescence staining that appears on the filigree underside on the galvanized structural framing below.
- Several utility line penetrations through the floor exhibit moderate to severe corrosion on the drain lines and fire protection standpipe lines located on levels 2 and 1 in the original garage area.
- Isolation joint sealant (2" joint sealant) provided along the boundaries of the interior stair tower have adhesion failure. The roof rain leader also discharges over the seal and along the wall exacerbating the leakage problem.
- The new stair tower built at the southeast corner of the garage expansion also has isolation joint sealant provided at the walls abutting the slab. The sealant is deteriorating and failing. Efforts to stop water entry along the roof level stair tower wall noted a unique 4" buildup of cove sealant material in as a preventative to stop water buildup and leakage against the wall. Corrosion damage at the doorway was noted at the base of the door jamb and the underside of the landing slab metal decking.
- A compression type adhered rubber expansion joint seal is provided on each level across the floor width and between the two structured areas. Examination of the seals found significant deterioration and damage on the concrete edge, the nosing material and rubber gland in the original structure on levels 4,3, and 2.
- The compression type adhered rubber expansion joint seals located in the garage expansion area (levels 4, 3, and 2) are in satisfactory condition.

1999 Structure

- The horizontal addition provides a pre-topped filigree plank system. Joint sealant is provided along each of the panel to panel joint lines. Examination of the joint sealants on each of the supported levels revealed sealant deterioration and intermittent adhesion failure along many of the joint sealant lines. Some of the top level (5) joint lines appear to have undergone sealant replacement. It was indeterminate if the sealant was completely removed and replaced or sealed over as some isolated failures were observed in this area.
- Cove joint sealant provided between the floor to wall (masonry, precast) joint lines also exhibits deterioration and failure.
- Expansion joint seals provided at the end of the ramp where floor crossovers between the garage areas are provided. The expansion seals show signs of damage and deterioration with evidence of leakage below.

- Aluminum diverter angles are installed along level 5 ramp to divert drainage flow from the slab edge and away from column penetration openings. The angles are fastened to the ramps slab and sealed with flexible sealant. Observations noted sealant deterioration along many of the angles.

FAÇADE - MASONRY / PRECAST & INTERIOR BARRIER WALLS

- The interior masonry barrier walls, provided in the original structure on level 4, exhibit signs of deterioration and distress (cracking, mortar bond separation, mortar deterioration, volume change growth and displacement of masonry construction) in both the brick veneer and CMU block backup wall. The top coursing appears to have undergone recent mortar joint and brick repairs. Repair materials used are considered to provide a temporary repair to the masonry condition.
- The interior side of the masonry barrier walls which are part of façade have been recently coating with an elastomeric membrane material in efforts to preserve them. The CMU block along parts of the wall shows considerable reflective cracking through the coating. Deterioration of the mortar joints were also noted in the top coursing where several areas show shifting and displacement.
- Exterior brick veneer coursing in the wall shows several areas of mortar joint erosion and brick veneer displacement. The southwest corner of the structure was observed with further shifting and displacement of the top rowlock coursing of brick.
- Precast capstones, sills, and cornice units are generally in good condition. Some dislodgement of the precast occurs in several locations where they have dislodged or shifting from vertical alignment and position. Mortar cracking and bond separation occurs between these precast elements primarily along the south elevation. Several of the capstones exhibit severe and progressive disintegration likely caused by free-thaw damage from environmental exposure.
- Some scaling of the brick veneer was noted on the interior and exterior sides of the north elevation where arched openings are featured on the roof level. The scaling shows moisture drive through the brick and mortar with efflorescence staining.
- Precast spandrel panels are generally appearing in satisfactory condition with darkened mildew staining from the environmental exposure at most locations. Several panels were noted with hairline transverse cracks exhibiting some light efflorescence along the crack lines.
- Precast panel to framing is done with mechanical connections. The metal rods hardware and some of the attachment angles have corrosion present at many of their locations.
- Vertical masonry building joints and precast sill joints are provided with a flexible sealant. The joint sealants show significant deterioration and failure mostly occurring on the south elevation.

STAIRTOWERS

- The original structure is provided with three stair towers that facilitate access to all levels. The stair towers were reported to have undergone restoration a few years ago. General observations indicate the interior stairs, landings and walls are in good condition because of past restoration work. However, paint blisters and peeling paint were noticed on the interior walls in stairs #1 and #3.
- Steel components for the stairs (stringers, step and landings, hand railing) are painted. The condition of the paint application varies with some areas needing repainting.

- Concrete deterioration was detected on several of the stairs steel pans, risers, nosing's, and on the landings.
- Isolated areas of corrosion appear on the underside of the metal decked landings because of leakage through the concrete fill provided on the landings. These stair steps and landings are bare concrete.
- The southeast stair tower #4 located in garage expansion area is similar to the other three stair towers in its construction. A waterproofing membrane coating or urethane traffic topping material protects these stair steps and landings. Deterioration and heavy wear were noticed on several areas of the waterproof coating applied to the concrete stair steps and landing.

ELEVATOR

- The garages elevator is provided with a single elevator assembly located at the interior center stair tower #2. Maintenance repairs were reportedly completed on the elevator system and the elevator was functioning properly at the time of the survey. Evaluation of the system was not performed as it is not within the current scope of this report.

VEHICULAR BARRIER GUARDRAIL SYSTEM

- The garage internal floor ramps are provided with a braided wire cable barrier railing system that is strung through the columns. The barrier cable guardrail system is provided with cable tensioning to resist impact loads and would likely comply with the original building code during construction. Today, current design requirements for vehicular barrier impact resistance and for barrier railing fall protection require greater capacities than may currently exist in the structure. Structural evaluation of the guardrail system capacity and adequacy was not within the report scope. However, a provision to improve upon fall protection by closing off the cable spacing can be accomplished by installation of a wire fence to the cables to prevent pass through.
- Hanover Street north elevation is provided with a similar barrier cable guardrail system as used in the garage interior but has either precast or CMU wall construction beyond the cabling. In addition, two locations on level 4 which are provided with arched masonry wall openings have greater openness spacing between the top cable and exterior façade and would not comply with spacing and openness criteria set in the current building code for barrier guard railing.

Code upgrades are often considered during major renovation projects to address life/safety items such as barrier guardrail systems and are sometimes mandated during major renovation projects. The aspects of compliance should be further studied and determined if the system requires alteration during the capital improvement planning phase.

NON-STRUCTURAL COMPONENTS

- **Floor Drain System**

Examination of the floor drain system identified many of the floor drains requiring replacement due to corrosion damage. Drain lines on the lower level (level 2 and 1) exhibit moderate to severe corrosion damage and evidence of leakage along the drain lines. Cracking in some of these lines appear at several locations. Drain line cleaning maintenance should be performed weekly as observations noted debris accumulating over the drain lids and inside several of the drain bodies.

➤ **Stair Roof Drain Leaders**

The stair tower roof drain leaders discharge along the masonry stair tower walls where joint seals are provided in the floor. These drain leaders should be diverted for drain flow away from the wall to slab juncture. Sealant failures in these floor joints give cause to water damage to the walls and corrosion on the framing below.

➤ **Fire Protection Stand pipe**

The fire protection standpipe system is suspended below the steel framing below level 2 with vertical risers at several locations to the upper floor levels. Visual inspection of the horizontal run of pipe below level 2 indicates significant and extensive corrosion on the painted surfaces of the pipe. The operability of the system was not within the report scope. However, based upon the severity of corrosion on these lines, system replacement may be necessary.

➤ **General Lighting & Power**

Garage lighting was reportedly changed a few years ago to strip tube fluorescent and LED roof top lighting to gain energy incentives from the power supplier. The general lighting was evaluated during the evening hours of this survey and were found adequate in most all locations. Entry and exit portals which generally provided with greater illumination levels to adjust light levels for vehicles approaching the ambient outdoor light appeared to be less than adequate. The roof level has one location where the light pole has corroded and the pole and light are gone. Replacement of the pole and light are necessary to maintain proper lighting for safety.

TESTING

The following information is reprinted from the prior 2014 Condition Appraisal Report by Walker Restoration Consultants.

A material testing program was developed for this structure to determine the existing concrete quality characteristics and the potential for retaining a long-term service life prediction. Information obtained from the testing reports is summarized below with our interpretation. Copies of the testing reports and results and floor plan locations may be found in Appendix E and F.

Petrographic or microscopic examination can establish baseline concrete quality parameters in the unaffected and affected floor areas supporting corrosion induced deterioration. Petrographic analysis or “microscopic examination” provides information which helps in evaluating the potential for future concrete deterioration due to inherent quality deficiencies that may exist in the concrete mix. The analysis measures; air content, carbonation, cement content, water/cement ratios, paste to aggregate bond, voids, porosity, aggregate composition, and other factors that influence concrete performance.

Concrete core samples were obtained from five (5) locations and tested in accordance to ASTM C-42 for in-situ comprehensive strength testing.

Water soluble Chloride Ion testing of the topping concrete was performed in accordance to ASTM C1218 on varying floor levels and locations by removal of drilled concrete power samples at 1", 2" and 3" depths from five (5) test point locations. Chloride ion testing indicates the potential for future corrosion due to concentrated chloride contamination. Sample identification and locations are shown in the table below:

TABLE 3 - Sample Classification

<i>Sample ID</i>	<i>Location</i>	<i>Testing Program</i>
P-1	Level 3 grid E16	Petrographic – ASTM C856
C-1	Level 3 grid E12	Compressive – ASTM C42
C-2a	Level 2 grid B 3	Compressive – ASTM C42
C-3	Level 2 grid C 16	Compressive – ASTM C42
C-4	Level 2 grid F 5	Compressive – ASTM C42
C-5	Level 2 grid B 3	Compressive – ASTM C42
CL-1	Level 3 grid C 14	Chloride ion ASTM C1218
CL-2	Level 3 grid C 14	Chloride ion ASTM C1218
CL-3	Level 2 grid 8 (garage addition)	Chloride ion ASTM C1218
CL-4	Level 2 grid D 18	Chloride ion ASTM C1218
CL-5	Level 2 grid E 18	Chloride ion ASTM C1218

ANALYSIS

PETROGRAPHIC EXAMINATION

Petrographic analysis was performed on cores P-1, topping concrete by Universal Construction Testing (UCT) Elk Grove, IL, in accordance to ASTM procedure C856-11. General concrete composition and quality indicate no distress or major abnormalities in the sample. Entrained air content by today's standard set forth in the American Concrete Institute (ACI) standard practices recommends concrete exposed to harsh environments and being subjected to freeze-thaw cycles have entrained air content in the range of 5 to 9%. Core sample P-1 was reported with a total air content of 10.8% with a good paste and aggregate volume by percent of sample. The topping concrete which has endured service exposure for 30+ years does not bear significant evidence of any freeze-thaw damage.

Sample P-1 also showed good fine and course aggregate gradation characteristics with uniform distribution. Aggregates used in both the topping concrete appear sound, exhibiting no evidence of deleterious reaction with the cement paste. Paste to aggregate bond was also measured to be moderately tight with freshly fractured surfaces of concrete pass through a majority of aggregate particles indicating good interlocking mechanism.

Concrete topping bond was acknowledged by visual examination of the bond between the topping and precast tee. Bond line interphase was acknowledged with minor irregularity in the profile generally providing marginal

interlock for mechanical bond. Several discontinuities were also identified in the form of micro-cracking, entrapped air, and wire mesh deformation was present at or near the bond line. Bond line separation was acknowledged during core extraction. Bond line characteristics remain important retain good mechanical interlock and composite bond action thereby reducing overstress to the precast filigree members.

CHLORIDE TESTING

Chloride ion testing indicates the potential for continuing and accelerated corrosion induced concrete deterioration growth initiated by calcium chloride or salt and deicer contamination in the topping concrete. Concrete powder samples were taken at various locations and depths of 0" to 1", 1" to 2", and 2" to 3" to establish chloride content as a function of depth. High chloride ion concentrations at the level of steel reinforcement correlate well with the presence of active corrosion. Research by the Federal Highway Administration (FHWA) has established that water soluble chloride concentrations of 280 to 410 parts per million (PPM) (threshold levels for normal weight concrete) at the reinforcement along with the presence of moisture and oxygen will result in accelerated corrosion.

TABLE 4 - Chloride Testing Data

Sample ID	1" ppm	2" ppm	3" ppm	Cum. Ave.
-1 Level 3	740	560	190	497
CL-2 Level 3	470	380	70	307
CL-3 Level 2	360	70	40	157
CL-4 Level 2	2140	2050	1200	1797
CL-5 Level 2	1650	1490	1280	1473
Cumulative Average / depth	1,072	910	556	846

Chloride Ion Analysis

- ✓ *Very high concentrations Above threshold levels,*
- ✓ *High corrosion potential*

Testing results indicate high chloride levels well above the threshold to support corrosion and they will continue to penetrate into the concrete and create further corrosion and deterioration.

COMPRESSIVE STRENGTH TESTING

TABLE 5 - Compressive Strength Data

CORE ID.	LOCATION	COMPRESSIVE STRENGTH (PSI)
C-1a	Level 3 / E 12	4,230
C-2a	Level 2 / B 3	4,980
C-3	Level 2 / C 16	5,610
C-4	Level 2 / F 5	5,690
C-5	Level 2 / B 3	5,600
Average PSI		5,222 psi

Compressive Strength of Concrete

- ✓ *Good Consistent Strength Values*
- ✓ *Consistent values within statistical deviation range*

Compressive strength results were consistently above the design strength of 4,000 psi.

In conclusion the material testing laboratory results indicate adequate concrete quality with generally good material characteristics for entrained air content and comprehensive strength consistent with freeze-thaw resistance. The high chloride concentration combined with the concrete permeability (density) can be expected to continue to cause corrosion of the reinforcing steel and produce concrete deterioration. We have also determined that the existing concrete quality is adequate for implementation of a comprehensive rehabilitation and protection program as represented in Alternatives A and B to achieve serviceability and extend long-term service life.

Refer to Appendix E for further information on materials analysis presented on the laboratory report.

DRAFT

LIMITATIONS

This report contains the professional opinions of Walker Consultants based on the conditions observed as of the date of our site visit and documents made available to us by City of Portsmouth, New Hampshire. This report is believed to be accurate within the limitations of the stated methods for obtaining information.

We have provided our opinion of probable costs from visual observations, limited testing, and field survey work. The opinion of probable repair costs is based on available information at the time of our assessment and from our experience with similar projects. There is no warranty to the accuracy of such cost opinions as compared to bids or actual costs. This condition appraisal and the recommendations therein are to be used by Client with additional fiscal and technical judgment.

It should be noted that our renovation recommendations are conceptual in nature and do not represent changes to the original design intent of the structure thus, this report does not provide repair details or methods, construction contract documents, material specifications, or details to develop the construction cost from a contractor.

Based on the agreed scope of services, the assessment was based on certain assumptions made on the existing conditions. Some of these assumptions cannot be verified without expanding the scope of services or performing more invasive procedures on the structure. More detailed and invasive testing may be provided by Walker Consultants as an additional service upon written request from Client.

The recommended repair concepts outlined represents current generally accepted technology. This report does not provide any kind of guarantee or warranty on our findings and recommendations. Our assessment was based on and limited to the agreed scope of work. We do not intend to suggest or imply that our observation has discovered or disclosed latent conditions or has considered all possible improvement or repair concepts.

A review of the facility for Building Code compliance and compliance with the Americans with Disabilities Act (ADA) requirements was not part of the scope of this project. However, it should be noted that whenever significant repair, rehabilitation, or restoration is undertaken in an existing structure, ADA design requirements may become applicable if there are currently unmet ADA requirements.

Similarly, we have not reviewed or evaluated the presence of, or the subsequent mitigation of, hazardous materials including, but not limited to, asbestos and PCB.

This report was created for the use of Client and may not be assigned without written consent from Walker Consultants. Use of this report by others is at their own risk. Failure to make repairs recommended in this report in a timely manner using appropriate measures for safety of workers and persons using the facility could increase the risks to users of the facility. Client assumes all liability for personal injury and property damage caused by current conditions in the facility or by construction, means, methods and safety measures implemented during facility repairs. Client shall indemnify or hold Walker Consultants harmless from liability and expense including reasonable attorney's fees, incurred by Walker Consultants as a result of Client's failure to implement repairs or to conduct repairs in a safe and prudent manner.



05 Appendices



APPENDIX A - OPINION OF PROBABLE REPAIR COSTS

Description	W.I. Cost	Total Amount
ALTERNATE 'A' BASE REPAIR PROGRAM *		
Floor & Framing Repairs		\$1,470,000
1.1 Floor Repair - Topping Concrete	\$1,073,000	
1.2 Floor Repair - Full Depth (Topping and Precast)	\$10,000	
1.3 Floor Repair - Curbs / Walks/ Column Piers / Washes	\$277,000	
1.4 Floor Repair - Precast Filigree - Shallow Soffit	\$23,000	
1.5 Floor Repairs Slab on Grade	\$12,000	
1.6 Structural Repairs - Steel Framing (L1,L2), Stairs/Landings	\$75,000	
Waterproofing / Protection		\$890,000
2.1 Seal Cracks/Joints (Original Structure)	\$312,000	
2.2 Seal Precast Joints (Expansion Structure)	\$176,000	
2.3 Cove/Isolation Joint Sealant	\$23,000	
2.4 Expansion Joint Replacement (Both Structures/All Levels)	\$195,000	
2.5 Penetrating Floor Sealer - Levels 5 through 2 - ALL	\$165,000	
2.7 Traffic Topping Repair - Stairs, L2 Restroom Area	\$19,000	
Architectural		\$465,000
3.1 Tuckpoint/ Brick Repair/Stone Joint Repairs	\$33,000	
3.2 Masonry Wall Reconstruction / Repairs (CMU+Brick)	\$315,000	
3.3 Capstone Replacement w/ Flashings	\$57,000	
3.4 Vertical Joint Sealant Replacement	\$8,000	
3.5 Clear Sealer - Precast	\$32,000	
3.6 Elastomeric Coating - CMU - Level 5	\$20,000	
Plumbing / Electrical / Mechanical		\$322,000
4.1 Replace Floor Drains	\$81,000	
4.2 Supplementary Drains	\$25,000	
4.3 Replace Drain Pipe & Hangers	\$86,000	
4.4 Floor Drain Cleaning	\$14,000	
4.5 Mechanical - Replace Fire Protection Standpipe	\$91,000	
4.6 Electrical / Lighting Repairs/Maint.	\$25,000	
Painting / Coating Protection		\$374,000
5.1 Paint Traffic Markings	\$17,000	
5.2 New Coating System - Structural Framing & Connections	\$357,000	
Miscellaneous Work		
6.1 Precast Conn. Repairs, Stairway Repairs, Door Jamb	\$28,000	\$68,000
6.2 Barrier Cable Repairs/ add Fenestration, Floor Opening	\$40,000	
Mobilization/Contingency		\$733,000
5.1 9% Mobilization	\$323,000	
5.2 Site QA Testing	\$17,000	
5.3 10% Owner Contingency (Rounded)	\$393,000	
Total		\$4,322,000

TABLE A-1
ALTERNATE A
SINGLE YEAR COSTS

Source: Walker Consultants 2018





Description	W.I. Cost	Total Amount
ALTERNATE 'B' BASE REPAIR PROGRAM		
Base Repair Program - Alternate B		
Structural Repairs		\$1,673,000
1.1 Floor Repair - Topping Concrete / Spot Patch	\$239,000	
1.2 Floor Repair - Topping Concrete Strip Replacement	\$959,000	
1.2 Floor Repair -Partial / Full Depth (Precast Filigree)	\$15,000	
1.3 Floor Repair - Curbs / Walks / Column Piers / Washes	\$277,000	
1.4 Floor Repair - Precast - Shallow	\$23,000	
1.5 Floor Repair - Slab on Grade	\$12,000	
1.6 Reinforcement - Strip Replacement	\$73,000	
1.7 Structural Repairs - Steel Framing (L1,L2), Stairs/Landings	\$75,000	
Waterproofing / Protection		\$1,546,000
2.1 Seal Cracks/Joints (Original Structure)	\$364,000	
2.2 Seal Precast Joints (Expansion Structure)	\$224,000	
2.3 Cove/Isolation Joint Sealant	\$23,000	
2.4 Expansion Joint Replacement (Both Structures/All Levels)	\$195,000	
2.5 Traffic Topping Waterproofing System - Levels 4 through 2	\$661,000	
2.6 Traffic Topping Repair -Stairs, L2 Restroom Area	\$19,000	
2.7 Penetrating Floor Sealer - Levels 5 through 2 (Expansion	\$60,000	
Architectural		\$465,000
3.1 Tuckpoint/ Brick Repair/Stone Joint Repairs	\$33,000	
3.2 Masonry Wall Reconstruction / Repairs (CMU+Brick)	\$315,000	
3.3 Capstone Replacement w/ Flashings	\$57,000	
3.4 Vertical Joint Sealant Replacement	\$8,000	
3.5 Clear Sealer - Precast	\$32,000	
3.6 Elastomeric Coating - CMU - Level 5	\$20,000	
Plumbing / Mechanical / Electrical		\$322,000
4.1 Replace Floor Drains	\$81,000	
4.2 Supplementary Drains	\$25,000	
4.3 Replace Drain Pipe & Hangers	\$86,000	
4.4 Floor Drain Cleaning	\$14,000	
4.5 Mechanical - Replace Fire Protection Standpipe	\$91,000	
4.6 Electrical / Lighting Repairs/Maint.	\$25,000	
Painting / Coating Protection		\$374,000
5.1 Paint Traffic Markings	\$17,000	
5.2 Paint Structural Framing & Panel Connections	\$357,000	
Miscellaneous Work		
6.1 Precast Conn. Repairs, Stairway Repairs, Door Jamb Replacement	\$28,000	\$68,000
6.2 Barrier Cable Repairs/ add Fenestration, Floor Opening Closure	\$40,000	
Mobilization/Contingency		\$906,000
5.1 9% Mobilization	\$400,000	
5.2 Site QA Testing	\$20,000	
5.3 10% Owner Contingency (Rounded)	\$486,000	
Total		\$5,354,000

Source: Walker Consultants 2018

TABLE A-2

ALTERNATE B
SINGLE YEAR COSTS



Description	W.I. Cost	Total Amount
ALTERNATE 'C' BASE REPAIR PROGRAM *		
Floor & Framing Repairs		\$6,280,000
1.1 Floor Repair - Partial / Full, Curb, Walks, Column Piers	\$491,000	
1.2 Floor Repair - Topping Concrete Removal	\$2,883,000	
1.3 Floor Repair - New Concrete Overlay	\$2,831,000	
1.6 Structural Repairs - Steel Framing (L1,L2), Stairs/Landings	\$75,000	
Waterproofing / Protection		\$855,000
2.1 Seal New Control Joints - Overlay	\$293,000	
2.2 Seal Precast Joints (Expansion Structure)	\$125,000	
2.3 Cove/Isolation Joint Sealant	\$58,000	
2.4 Expansion Joint Replacement (Both Structures/All Levels)	\$195,000	
2.5 Penetrating Floor Sealer - Levels 5 through 2 - ALL	\$165,000	
2.7 Traffic Topping Repair - Stairs, L2 Restroom Area	\$19,000	
Architectural		\$465,000
3.1 Tuckpoint/ Brick Repair/Stone Joint Repairs	\$33,000	
3.2 Masonry Wall Reconstruction / Repairs (CMU+Brick)	\$315,000	
3.3 Capstone Replacement w/ Flashings	\$57,000	
3.4 Vertical Joint Sealant Replacement	\$8,000	
3.5 Clear Sealer - Precast	\$32,000	
3.6 Elastomeric Coating - CMU - Level 5	\$20,000	
Plumbing / Electrical / Mechanical		\$322,000
4.1 Replace Floor Drains	\$81,000	
4.2 Supplementary Drains	\$25,000	
4.3 Replace Drain Pipe & Hangers	\$86,000	
4.4 Floor Drain Cleaning	\$14,000	
4.5 Mechanical - Replace Fire Protection Standpipe	\$91,000	
4.6 Electrical / Lighting Repairs/Maint.	\$25,000	
Painting / Coating Protection		\$374,000
5.1 Paint Traffic Markings	\$17,000	
5.2 New Coating System - Structural Framing & Connections	\$357,000	
Miscellaneous Work		
6.1 Precast Conn. Repairs, Stairway Repairs, Door Jamb	\$28,000	\$68,000
6.2 Barrier Cable Repairs/ add Fenestration, Floor Opening	\$40,000	
Mobilization/Contingency		\$1,153,000
5.1 5% Mobilization	\$418,000	
5.2 Site QA Testing	\$30,000	
5.3 8% Owner Contingency (Rounded)	\$705,000	
Total		\$9,517,000

Source: Walker Consultants 2018

TABLE A-3

**ALTERNATE A
SINGLE YEAR COSTS**



Description	Estimated Cost	Without Phasing	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Estimated	Phasing Cost
	Line Item	System							Line Item	System
	Amounts	Amounts							Amounts	Amounts
Phasing allowance factor			1.00	1.05	1.05	1.06	1.07	1.07		
Inflation allowance factor			1.00	1.03	1.06	1.09	1.12	1.15		
Total Allowance Factor			1.00	1.08	1.11	1.15	1.19	1.22		
ALTERNATE 'A' BASE REPAIR PROGRAM										
#										
Floor & Framing Repairs		\$1,470,000								\$1,555,050
1.1 Floor Repair - Topping Concrete	\$1,073,000		\$500,000	\$358,560	\$85,470	\$123,050	\$44,030	\$24,400	\$1,135,510	
1.2 Floor Repair - Full Depth (Topping and Precast)	\$10,000		\$5,000	\$3,240	\$1,110	\$1,150	\$0	\$0	\$10,500	
1.3 Floor Repair - Curbs / Walks/ Column Piers / Washes	\$277,000		\$90,000	\$83,160	\$72,150	\$28,750	\$11,900	\$12,200	\$298,160	
1.4 Floor Repair - Precast Filigree - Shallow Soffit	\$23,000		\$14,000	\$5,400	\$3,330	\$1,150	\$0	\$0	\$23,880	
1.5 Floor Repair - Slab on Grade	\$12,000		\$0	\$12,000	\$0	\$0	\$0	\$0	\$12,000	
1.6 Structural Repairs - Steel Framing (L1,L2), Stairs/Landings	\$75,000		\$75,000	\$0	\$0	\$0	\$0	\$0	\$75,000	
Waterproofing / Protection		\$890,000								\$978,490
2.1 Seal Cracks/Joints (Original Structure)	\$312,000		\$60,000	\$75,600	\$74,370	\$51,750	\$35,700	\$48,800	\$346,220	
2.2 Seal Precast Joints (Expansion Structure)	\$176,000		\$42,000	\$0	\$37,740	\$39,100	\$40,460	\$39,040	\$198,340	
2.3 Cove/Isolation Joint Sealant	\$23,000		\$5,000	\$5,400	\$5,550	\$4,600	\$4,760	\$0	\$25,310	
2.4 Expansion Joint Replacement (Both Structures/All Levels)	\$195,000		\$53,000	\$57,240	\$58,830	\$41,400	\$0	\$0	\$210,470	
2.5 Penetrating Floor Sealer - Levels 5 through 2 - ALL	\$165,000		\$46,000	\$41,040	\$39,960	\$40,250	\$11,900	\$0	\$179,150	
2.7 Traffic Topping Repair - Stairs, L2 Restroom Area	\$19,000		\$0	\$19,000	\$0	\$0	\$0	\$0	\$19,000	
Architectural		\$465,000								\$519,740
3.1 Tuckpoint/ Brick Repair/Stone Joint Repairs	\$33,000		\$0	\$0	\$36,630	\$0	\$0	\$0	\$36,630	
3.2 Masonry Wall Reconstruction / Repairs (CMU+Brick)	\$315,000		\$60,000	\$21,600	\$77,700	\$86,250	\$59,500	\$48,800	\$353,850	
3.3 Capstone Replacement w/ Flashings	\$57,000		\$30,000	\$29,160	\$0	\$0	\$0	\$0	\$59,160	
3.4 Vertical Joint Sealant Replacement	\$8,000		\$0	\$0	\$0	\$9,200	\$0	\$0	\$9,200	
3.5 Clear Sealer - Precast	\$32,000		\$0	\$0	\$0	\$13,800	\$11,900	\$12,200	\$37,900	
3.6 Elastomeric Coating - CMU - Level 5	\$20,000		\$0	\$0	\$0	\$23,000	\$0	\$0	\$23,000	
Plumbing / Electrical / Mechanical		\$322,000								\$332,250
4.1 Replace Floor Drains	\$81,000		\$25,000	\$30,240	\$31,080	\$0	\$0	\$0	\$86,320	
4.2 Supplementary Drains	\$25,000		\$11,000	\$11,880	\$3,330	\$0	\$0	\$0	\$26,210	
4.3 Replace Drain Pipe & Hangers	\$86,000		\$21,500	\$23,220	\$23,865	\$24,725	\$0	\$0	\$93,310	
4.4 Floor Drain Cleaning	\$14,000		\$0	\$0	\$7,770	\$0	\$0	\$8,540	\$16,310	
4.5 Mechanical - Replace Fire Protection Standpipe	\$91,000		\$0	\$84,000	\$0	\$0	\$0	\$0	\$84,000	
4.6 Electrical / Lighting Repairs/Maint.	\$25,000		\$15,000	\$0	\$11,100	\$0	\$0	\$0	\$26,100	
Painting / Coating Protection		\$374,000								\$417,850
5.1 Paint Traffic Markings	\$17,000		\$5,000	\$4,320	\$4,440	\$4,600	\$0	\$0	\$18,360	
5.2 New Coating System - Structural Framing & Connections	\$357,000		\$129,000	\$0	\$0	\$88,550	\$90,440	\$91,500	\$399,490	
Miscellaneous Work		\$68,000								\$78,680
6.1 Precast Conn. Repairs, Stairway Repairs, Door Jamb Replacement	\$28,000		\$0	\$0	\$31,080	\$0	\$0	\$0	\$31,080	
6.2 Barrier Cable Repairs/ add Fenestration, Floor Opening Closure	\$40,000		\$0	\$0	\$0	\$0	\$47,600	\$0	\$47,600	
Mobilization/Contingency		\$733,000								\$796,400
5.1 9% Mobilization	\$323,000		\$107,000	\$69,120	\$64,380	\$51,750	\$32,130	\$26,840	\$351,220	
5.2 Site QA Testing	\$17,000		\$6,000	\$6,480	\$5,550	\$0	\$0	\$0	\$18,030	
5.3 10% Owner Contingency (Rounded)	\$393,000		\$130,000	\$85,320	\$78,810	\$63,250	\$39,270	\$30,500	\$427,150	
Program Cost Total	\$4,322,000	\$4,322,000	\$1,429,500	\$1,013,980	\$766,245	\$696,325	\$429,590	\$342,820	\$4,678,460	\$4,678,460

TABLE A-4
 ALTERNATE 'A'
 6-YEAR
 IMPLEMENTATION PLAN

Description	Estimated Cost	Without Phasing	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Estimated	Phasing Cost
	Line Item	System							Line Item	System
	Amounts	Amounts							Amounts	Amounts
Phasing allowance factor			1.00	1.05	1.05	1.06	1.07	1.07		
Inflation allowance factor			1.00	1.03	1.06	1.09	1.12	1.15		
Total Allowance Factor			1.00	1.08	1.11	1.15	1.19	1.22		

ALTERNATE 'B' BASE REPAIR PROGRAM

#	Estimated Cost	Without Phasing	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Estimated	Phasing Cost
#	Line Item	System							Line Item	System
	Amounts	Amounts							Amounts	Amounts
ALTERNATE 'B' BASE REPAIR PROGRAM										
#										
		\$1,673,000								\$1,839,240
1.1	Floor Repair - Topping Concrete / Spot Patch	\$239,000	\$98,000	\$71,280	\$67,710	\$16,100	\$0	\$0	\$253,090	
1.2	Floor Repair - Topping Concrete Strip Replacement	\$959,000	\$325,000	\$351,000	\$342,990	\$0	\$0	\$0	\$1,018,990	
1.2	Floor Repair - Partial / Full Depth (Precast Filigree)	\$15,000	\$8,000	\$4,320	\$3,330	\$0	\$0	\$0	\$15,650	
1.3	Floor Repair - Curbs / Walks / Column Piers / Washes	\$277,000	\$80,000	\$73,440	\$66,600	\$57,500	\$22,610	\$0	\$300,150	
1.4	Floor Repair - Precast - Shallow	\$23,000	\$14,000	\$5,400	\$3,330	\$1,150	\$0	\$0	\$23,880	
1.5	Floor Repair - Slab on Grade	\$12,000	\$75,000	\$0	\$3,330	\$1,150	\$0	\$0	\$79,480	
1.6	Reinforcement - Strip Replacement	\$73,000	\$25,000	\$24,000	\$24,000	\$0	\$0	\$0	\$73,000	
1.7	Structural Repairs - Steel Framing (L1,L2), Stairs/Landings	\$75,000	\$75,000	\$0	\$0	\$0	\$0	\$0	\$75,000	
Waterproofing / Protection										
2.1	Seal Cracks/Joints (Original Structure)	\$364,000	\$70,000	\$86,400	\$85,470	\$63,250	\$48,790	\$50,020	\$403,930	
2.2	Seal Precast Joints (Expansion Structure)	\$224,000	\$55,000	\$62,640	\$64,380	\$37,950	\$23,800	\$0	\$243,770	
2.3	Cove/Isolation Joint Sealant	\$23,000	\$5,000	\$5,400	\$5,550	\$4,600	\$4,760	\$0	\$25,310	
2.4	Expansion Joint Replacement (Both Structures/All Levels)	\$195,000	\$53,000	\$57,240	\$58,830	\$41,400	\$0	\$0	\$210,470	
2.5	Traffic Topping Waterproofing System - Levels 4 through 2	\$661,000	\$221,000	\$237,600	\$244,200	\$0	\$0	\$0	\$702,800	
2.6	Traffic Topping Repair -Stairs, L2 Restroom Area	\$19,000	\$0	\$20,520	\$0	\$0	\$0	\$0	\$20,520	
2.7	Penetrating Floor Sealer - Levels 5 through 2 (Expansion Area)	\$60,000	\$0	\$16,200	\$16,650	\$17,250	\$17,850	\$0	\$67,950	
Architectural										
3.1	Tuckpoint/ Brick Repair/Stone Joint Repairs	\$33,000	\$0	\$0	\$36,630	\$0	\$0	\$0	\$36,630	
3.2	Masonry Wall Reconstruction / Repairs (CMU+Brick)	\$315,000	\$60,000	\$21,600	\$77,700	\$86,250	\$59,500	\$48,800	\$353,850	
3.3	Capstone Replacement w/ Flashings	\$57,000	\$30,000	\$29,160	\$0	\$0	\$0	\$0	\$59,160	
3.4	Vertical Joint Sealant Replacement	\$8,000	\$0	\$0	\$0	\$9,200	\$0	\$0	\$9,200	
3.5	Clear Sealer - Precast	\$32,000	\$0	\$0	\$0	\$13,800	\$11,900	\$12,200	\$37,900	
3.6	Elastomeric Coating - CMU - Level 5	\$20,000	\$0	\$0	\$0	\$23,000	\$0	\$0	\$23,000	
Plumbing / Mechanical / Electrical										
4.1	Replace Floor Drains	\$81,000	\$25,000	\$30,240	\$31,080	\$0	\$0	\$0	\$86,320	
4.2	Supplementary Drains	\$25,000	\$11,000	\$11,880	\$3,330	\$0	\$0	\$0	\$26,210	
4.3	Replace Drain Pipe & Hangers	\$86,000	\$21,500	\$23,220	\$23,865	\$24,725	\$0	\$0	\$93,310	
4.4	Floor Drain Cleaning	\$14,000	\$0	\$0	\$7,770	\$0	\$0	\$7,770	\$15,540	
4.5	Mechanical - Replace Fire Protection Standpipe	\$91,000	\$0	\$84,000	\$0	\$0	\$0	\$0	\$84,000	
4.6	Electrical / Lighting Repairs/Maint.	\$25,000	\$15,000	\$0	\$11,100	\$0	\$0	\$0	\$26,100	
Painting / Coating Protection										
5.1	Paint Traffic Markings	\$17,000	\$5,000	\$4,320	\$4,440	\$4,600	\$0	\$0	\$18,360	
5.2	Paint Structural Framing & Panel Connections	\$357,000	\$129,000	\$0	\$0	\$88,550	\$90,440	\$91,500	\$399,490	
Miscellaneous Work										
6.1	Precast Conn. Repairs, Stairway Repairs, Door Jamb Replacement	\$28,000	\$0	\$0	\$31,080	\$0	\$0	\$0	\$31,080	
6.2	Barrier Cable Repairs/ add Fenestration, Floor Opening Closeure	\$40,000	\$0	\$0	\$0	\$0	\$47,600	\$0	\$47,600	
Mobilization/Contingency										
5.1	9% Mobilization	\$400,000	\$119,000	\$102,600	\$118,770	\$43,700	\$29,750	\$19,520	\$433,340	
5.2	Site QA Testing	\$20,000	\$7,000	\$7,560	\$6,660	\$0	\$0	\$0	\$21,220	
5.3	10% Owner Contingency (Rounded)	\$486,000	\$145,000	\$124,200	\$145,410	\$52,900	\$35,700	\$23,180	\$526,390	
Program Cost Total		\$5,354,000	\$5,354,000	\$1,671,500	\$1,454,220	\$1,484,205	\$587,075	\$392,700	\$252,990	\$5,842,690

 APPENDIX A
 TABLE A-5

 ALTERNATE B
 IMPLEMENTATION PLAN

 Table A-3 & A-4 Notes:
 1 Table above excludes costs for Immediate repairs and enhancements.

Description	Estimated Cost Without Phasing	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Estimated Cost Including Phasing
Alternate A - Base Repair Program								
Description		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Estimated Cost Including Phasing
###								
Floor & Framing Repairs	\$1,470,000	\$684,000	\$450,360	\$174,060	\$154,100	\$55,930	\$36,600	\$1,555,050
Waterproofing / Protection	\$890,000	\$206,000	\$198,280	\$216,450	\$177,100	\$92,820	\$87,840	\$978,490
Architectural	\$465,000	\$90,000	\$50,760	\$114,330	\$132,250	\$71,400	\$61,000	\$519,740
Plumbing / Electrical / Mechanical	\$322,000	\$72,500	\$149,340	\$77,145	\$24,725	\$0	\$8,540	\$332,250
Painting / Coating Protection	\$374,000	\$134,000	\$4,320	\$4,440	\$93,150	\$90,440	\$91,500	\$417,850
Miscellaneous Work	\$68,000	\$0	\$0	\$31,080	\$0	\$47,600	\$0	\$78,680
Mobilization/Contingency	\$733,000	\$243,000	\$160,920	\$148,740	\$115,000	\$71,400	\$57,340	\$796,400
Program Cost Total	\$4,322,000	\$1,429,500	\$1,013,980	\$766,245	\$696,325	\$429,590	\$342,820	\$4,678,460

TABLE A-6
ALTERNATE A
6-YEAR PROGRAM
SUMMARY

Description	Estimated Cost Without Phasing	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Estimated Cost Including Phasing
Alternate B Base Repair Program								
Description		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Estimated Cost Including Phasing
###								
Structural Repairs	\$1,673,000	\$700,000	\$529,440	\$511,290	\$75,900	\$22,610	\$0	\$1,839,240
Waterproofing / Protection	\$1,546,000	\$404,000	\$486,000	\$475,080	\$164,450	\$95,200	\$50,020	\$1,674,750
Architectural	\$465,000	\$90,000	\$50,760	\$114,330	\$132,250	\$71,400	\$61,000	\$519,740
Plumbing / Mechanical / Electrical	\$322,000	\$72,500	\$149,340	\$77,145	\$24,725	\$0	\$7,770	\$331,480
Painting / Coating Protection	\$374,000	\$134,000	\$4,320	\$4,440	\$93,150	\$90,440	\$91,500	\$417,850
Miscellaneous Work	\$68,000	\$0	\$0	\$31,080	\$0	\$47,600	\$0	\$78,680
Mobilization/Contingency	\$906,000	\$271,000	\$234,360	\$270,840	\$96,600	\$65,450	\$42,700	\$980,950
Program Cost Total	\$5,354,000	\$1,671,500	\$1,454,220	\$1,484,205	\$587,075	\$392,700	\$252,990	\$5,842,690

TABLE A-7
ALTERNATE B
6-YEAR PROGRAM
SUMMARY

APPENDIX B - PHOTOGRAPHS

Photo 2 – View of façade northeast corner @ vehicle entry /exit area.



Photo 1 – View of façade northwest corner. Note staining on masonry veneer.



Photo 3 – View of façade northwest bar grille at street level.



Photo 4 – Hanover St. entry lane and walkway path.

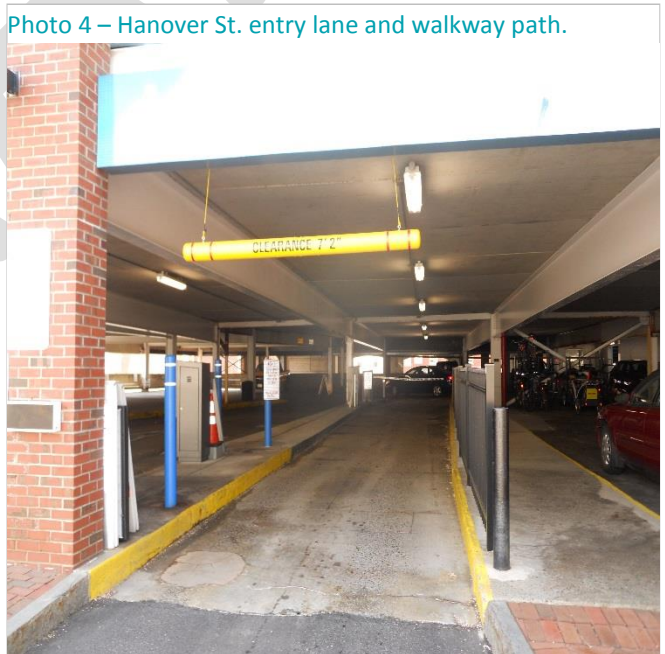


Photo 6 – Hanover St. dual exit lanes

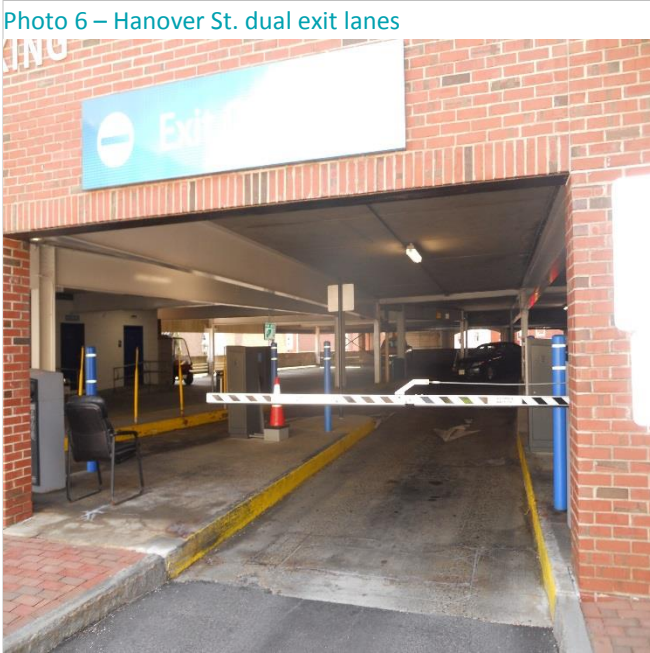


Photo 5 – South façade view of typical lineal cracking on sill stones.



Photo 8 – North elevation interior view of façade masonry. Note protective netting applied to deteriorating masonry.



Photo 7 – North elevation interior view of façade CMU wall. Note progressive cracking on masonry block.



Photo 10 – Waterproofing membrane applied to masonry barrier wall and capstone on level 5.



Photo 9 – deteriorated capstones on level 5 barrier wall. Note debris netting applied to top of wall as a precautionary measure.



Photo 12 – Barrier wall capstone showing progressive pattern cracking.



Photo 11 – Structural framing column and beam corrosion at east end of grade level 1. Note deterioration and staining on floor slab above.



Photo 14 – Level 2 floor underside deterioration and staining on the precast filigree planks. Note corrosion damage to supporting beam.



Photo 13 – Level 1 – Tube column support provided below beam due to sectional loss on steel girder.



Photo 15 – level 1 – Corrosion on column base plate and deterioration of concrete pier.



Photo 16 – Level 1 – Severe corrosion damage to structural steel column at floor perimeter (north elev.).

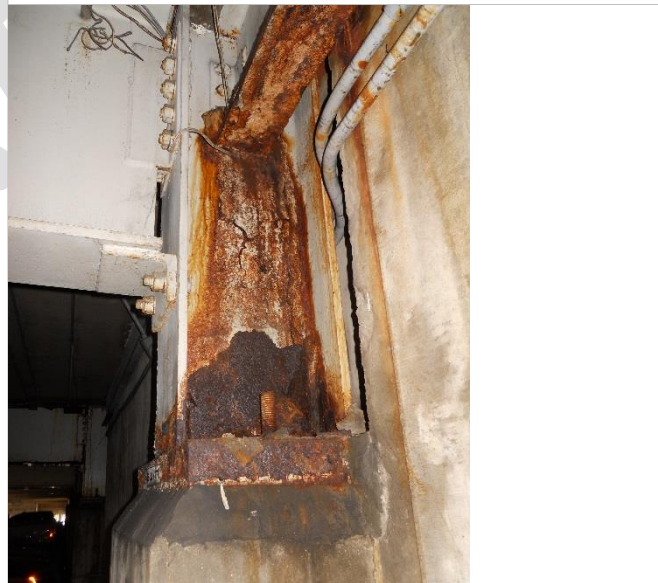


Photo 15 – Level 2 framing connection. Note corroded condition of high strength bolts and nuts.



Photo 16 – Level 1 – corrosion damage to steel column. Note delaminated concrete on column.

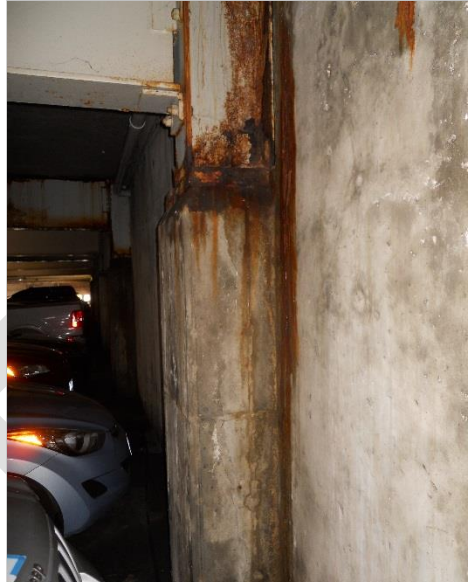


Photo 19 – Level 2 - underside framing corrosion along expansion joint line. Note corrosion on FP line.



Photo 20 – Level 1 - framing corrosion at column base and wind bracing.

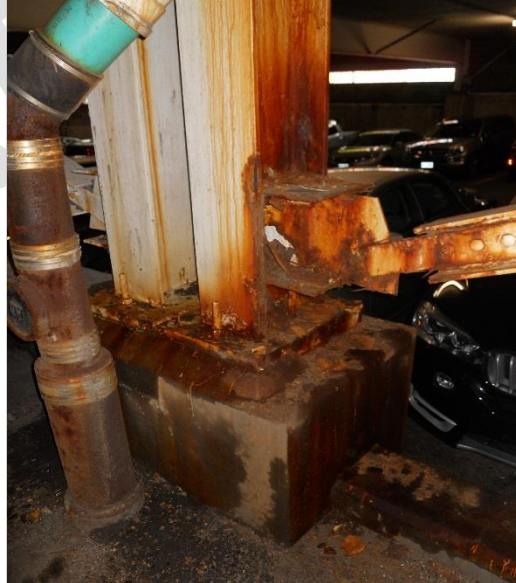


Photo 17 – Level 2 Floor slab deterioration and severe corrosion on structural framing.



Photo 22 – Level 2 floor painted outline of deterioration formation beyond patch repair sites.



Photo 23 – Level 3 painted outline of deterioration formations above structural framing.



Photo 24 – View of corrosion on structural framing below deteriorated floor slab area.



Photo 25 – Level 3 floor drain plugged with debris. Note water staining and corrosion around column and drain line.



Photo 26 – Floor deterioration at drain line penetration. Note corroded condition of drain and line.



Photo 27 – Structural framing in garage expansion area (1999). Note straining and spotted rust on framing.



Photo 28 – Garage expansion area. Note sealant adhesion failure along filigree plank joint line.



Photo 29 – Garage expansion area. View of typical joint sealant adhesion failures.



Photo 30 – Garage expansion area. Corrosion on weldments. Sealant failures noted above framing line.



Photo 31 – Level 4 barrier guard railing. Note size of openness between cable strands.



Photo 32 – Level 3 elevator stair lobby at stair #2. Note non-standard ADA curb drop .



Photo 33 – Bird roosting problem in garage expansion area along south elevation.



Photo 34 – Stair #3 raised walk at doorway. Note deterioration and separation of walk from floor slab.



Photo 35 – Stair #1 interior view of wall. Note blistering and peeling paint on walls.

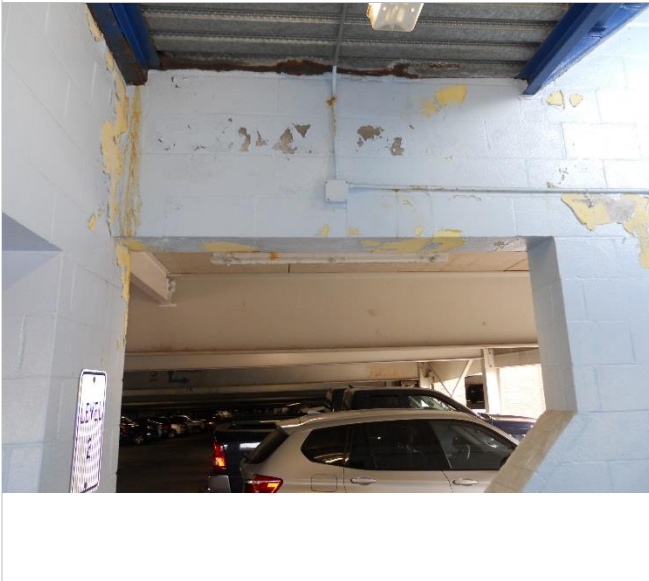


Photo 36 – Stair #1 corrosion damage to stair step pans.



Photo 37 – Sealant deterioration at glazed curtain wall in stair tower #1



Photo 38 – South façade. Note through bolted connection to secure loose cornice.



Photo 39 – Floor directional graphics stenciled on steel framing.



Photo 40 – General floor lighting with strip fluorescent fixtures.



APPENDIX C - VISUAL OBSERVATIONS

VISUAL OBSERVATIONS

*2018 update comments are shown in italicized text.

SUPPORTED FLOORS – CONCRETE TOPPED FILIGREE (1985)

- a. Supported floor levels 2, 3, and 4 (roof Level) of the 1985 original structure are constructed using a hybrid design that is comprised of composite filigree wide slab planks supported on steel framing. The precast filigree planks form the bottom half of the slab and are comprised of precast pre-stressed concrete panels which are prefabricated and installed with a conventionally reinforced cast-in-place topping concrete placed over the entire supported floor areas to create a composite slab system with the structure steel framing.
- b. The 2014 condition assessment encompassed a chain drag sounding survey of approximately 90% of the gross floor area to identify and quantify deterioration formations. The survey efforts identified corrosion induced concrete deterioration in the form of spalling, delaminations, cracking, and topping bond failure present on each level. The formations were mapped and range in size from 1 to 400 square foot in area as noted on levels 2 and 3 and to a significantly lessor extent on level 4 or top level. Visual deterioration (spalls, exposed and corroded reinforcement, failed patch repairs) also appears in scattered formation within sizable areas where bond failure exists. *2018: The current survey efforts encompassed a limited chain drain area primarily covering the drive lanes and select areas within the stalls. The survey findings indicate extension of deterioration continuing beyond the prior survey limits. Most of the deterioration detected extends around the perimeter of existing repair patches or extends beyond the previously mapped locations of located deterioration. The visual examination recognized minimal surface spalling in comparison to the 2014 survey. This can be attributed to the interim repair work completed in 2016.*
- c. Longitudinal pattern cracking appears on the topping concrete primarily above and along main girder framing and in areas where visual indications of deterioration (spalling, delaminations) are at the initial stages of forming and increasing in area. Examination of several open spalls and cracking patterns indicate the reinforcing steel is near the concrete surface and may be cause to the cracking. The cracking formations in this slab of steel frame can also be caused by flexural action in slab and shortening of the deck due to concrete shrinkage and creep.
- d. Several areas on the floor ramps show ponding on level 3 and 2 in the parking areas and near structural column framing where evidence of poor floor drainage exists. The survey noted several conditions where a recognizable lack of floor slope is cause to ponding in areas where the steel framing penetrate the floor. Many of the floor column penetrations show concrete deterioration on the top, underside, and on the structural beam to column framing as seen below.
- e. The roof level has several large areas where a thin-set applied cementitious material is applied to the topping concrete. The material is exhibiting shrinkage cracking and bond separation over partial areas

of application. Thin set material applications are often applied to remedy surface defects such as scaling on the concrete surfaces or used to fill in surface depressions in efforts to elevate water ponding. Performance of thin set materials is variable and generally rated poorly for bond adhesion and freeze-thaw resistance.

- f. Examination of the underside of the filigree plank system found random formations of deterioration in the form of incipient spalls, and delaminations observable along the planks joints where they bear onto the steel framing. These areas generally exhibit moisture staining, rust, and efflorescence and appear at floor areas where they are sloped towards the garage interior for floor drainage.
- g. Random cracking through a few of the filigree planks was observable from below. Water stains and evidence of active leakage was noted along the cracks during rainfall occurrence. *The level 2 and 3 underside reveals several large spalls along the beam framing lines. These areas were removed in a make-safe effort in 2016 to prevent random release and injury*

SUPPORTED FLOORS – PRETOPPED FILIGREE (1999)

- h. The 1999 expansion to the original structure extended over a partial area of the top (level 4) floor creating a level 5 that interconnected the structures on the west side and provided internal circulation between all levels with the exception at grade level. The new addition addressed several design changes to the floor and framing system. The precast filigree planks are a solid single or “pre-topped” precast unit that is connected to the steel framing by welded connections. The plank to plank flanges are also connected to each other by welded connections which form the floors diaphragm. All the panel joints are then sealed with a flexible exterior joint sealant.
- i. Visual examination of the floor planks indicated that they are in good condition overall. Several of the planks show some repairs at the corners resulting from breakage probably during erection. These repairs show failure and leakage below. Other joint lines show repairs made with an excess of flexible sealant to compensate for the loss of the plank joint edge. *Sealant deterioration was also apparent on levels 4, 3, and 2 where signs of efflorescence stains appear on the structural steel framing.*
- j. Some cracking running across the planks was noted at several locations on level 2 and to a lesser extent on the upper levels. The cracking bears evidence of active leakage and efflorescence stains.
- k. Steel framing that passes through the floors are provided with concrete fill and jointed with sealants. Many of these penetrations fall along the drainage lines and are showing moisture leakage and concrete deterioration.
- l. Cast concrete topping is provided along floor boundaries and at floor crossovers. The cast concrete topping was found to be in good condition overall with minor areas of deterioration.
- m. Ponding was acknowledged on the level 4 where additional supplementary drain has been added to alleviate the condition. These drains which are set at the surface provide limited effective relieve of surface water due to flat floor grade in this area.

WATERPROOFING

- a. The field cast concrete topped floors have an exposed broom textured surface. Primary waterproofing mechanism on each of the supported level relies on joint sealants installed along irregular crack lines to control moisture through the floor topping. Post construction crack joints have also formed in the topping along the panel to panel joints and steel framing lines with many having been routed and sealed with flexible sealant. The irregular shape in alignment makes it difficult to ensure proper sealant installation centered over the crack lines. Typically, cast concrete is provided with tooled joints during placement to relieve shrinkage stresses during concrete hardening and allow for proper sealant installation. More importantly, a linear shaped joint allows for proper sealant replacement during preventative maintenance. Close examination and material samples taken from several joint lines indicates substantial material degradation in the form of adhesion loss, elastic loss, chalking and hardening of the material through the garage. Joint leakage as observed from below revealed significant failure on many of these sealed and unsealed joint lines on levels 4, 3, and 2. *Some repairs to joint sealant on level 4 was observed along the crack and control joint lines. The sealant application appears to be placed on top of the old sealant. This process is not used in the industry and may offer a temporary fix to leakage.*
- b. The pre-topped filigree floor planks rely on sealed panel to panel joints to provide watertight floor conditions. Examination of the floor joint sealants on levels 5 through 2 revealed a significant rate of intermittent failure in the form of adhesion loss along many of the plank joint lines, beam framing, and at column penetrations. The sealant material appears to be original installation except on the partial ramp (level 5) covering the original level 4 ramp where replacement was reportedly completed a few year ago. Overall joint sealants on all levels show characteristic signs of degradation consistent with ageing. Water leakage observable on levels 5 and 4 during a rainfall occurrence confirmed loss of watertight floor conditions.
- c. Expansion joint seals are provided on each floor level dividing the floor at grid line 13/14 and 'A' line. The expansion joint seal is comprised of a winged compression type neoprene seal embedded to the slab edges with and elastomeric nosing material. Examination of the joint seals on each level recognized deterioration of the elastomeric nosing material, seal displacement and failure, and physical damage along most of the joint lines. The extent of conditions is not conducive to repairs and replacement of the seals should be performed in their entirety. Vertical displacement of the floor slab expansion joint at 13/14 line was noted during vehicle travel. As excessive vertical displacement can affect seal performance, this condition should be evaluated for beam deflection during the development of restoration documents to ensure that the replacement seal can be properly maintained. *Expansion joint seals were replaced on level 4 in 2016. The seals show some damage from snow removal equipment and require repair.*
- d. The pretopped filigree floor on level 5 and 4 are provided with a series of aluminum angles fastened and sealed on top of the floor near the perimeter to divert drainage flow from entering openings along the

perimeter barrier walls and near column penetrations. The diverters were found intact with some sealant deterioration noted.

STRUCTURAL FRAMING

- a. Structural steel framing in the original structure is painted carbon steel. Visual evaluation of the structural steel framing on all floor levels reveals significant corrosion present on the framing where continual leakage occurs through the floor slab concrete and at slab penetrations. The beam framing exhibits light to moderate corrosion along the top flanges at many locations where drainage flows off the slab edge and where joint sealant and concrete deterioration exist above. Heavy corrosion which appears with rust scaling and delaminations were noted on levels 3 and 2 along beam top and web sections. Several areas where severe corrosion appears on the beam framing will require repair strengthening prior to application of paint protection. Steel columns also exhibit moderate to severe corrosion at several locations where floor drainage problems above allow salt laden water to continuously saturate the columns. Other column locations show light corrosion generally at the floor penetrations. *The painted structural steel framing exhibits continued corrosion development and rust staining. The extent of corrosion has increased in severity on several areas of column and beam framing at the east end of level 1 and 2. The severity of corrosion appears greater on the level (2) framing due greater water penetration through floor slab deterioration, cracks, and failed joint sealant. Repairs to severe corrosion damage on several columns and beams are probable.*
- a. The pre-topped filigree structural expansion built in 1999 is framed with galvanized steel. Visual review of the framing found minor surface rusting on beam flanges where embedment connections are welded to the framing. The framing also bears evidence of continual floor slab leakage where white efflorescence stains appear from water streaking.

EXTERIOR FACADE – PRECAST & MASONRY WALLS

- a. Most the exterior façade is comprised of masonry walls and precast spandrel panels at varying locations on each elevation. The Hanover Street or North elevation has arched masonry wall openings and precast panels that form the architecture of the façade. The masonry construction consists of a brick veneer attached to CMU backup wall. Precast copings, cornices, and sills are provided accentuate the architectural features on each elevation. Interior brick barrier walls are of similar masonry composition but the wall cap is provided with a rowlock course of masonry brick.
- b. The exterior masonry façade components (coping, cornice, brick veneer, CMU block, etc.) show varying degrees of deterioration related to volume-change movement and moisture saturation that has led to freeze-thaw damage. The conditions mostly occur on the North and South elevation on the top or roof level of the structure.
- c. The precast spandrel panels are attached to the floors and framing by threaded rods and hardware. The connection does not appear to be galvanized or adequately protected. Corrosion can be seen on many of these panel connections. Panels are generally found to be in sound condition with no signs of

deterioration or damage. Several panels have transverse cracking visible on the exterior side. The cracking is hairline in width and bears evidence of moisture entry with efflorescence stains along the crack outline. Many of the panels were observed with environmental staining which detracts from the aesthetical appearance.

STAIRTOWERS- SW, SE, NE, CENTER INTERIOR STAIRTOWER

- a. General review of the stair tower interior and exterior was performed by visual examination. The exterior of the masonry walls that enclose the stair towers were found to be in satisfactory condition. The stair tower interiors walls and stairways were observed to be painted and in generally good condition. A few locations were noted to exhibit corrosion on the underside of the metal decking that forms the landings and on a few areas of the steel framing.
- b. Inspection inside the SE stair tower (garage expansion area) found a few locations where deterioration of the concrete appearing on the steps and landings has affected the waterproofing membrane.
- c. The southwest stair tower has a glazed curtain wall on the west elevation. Examination of the glazing found missing gaskets and trim pieces on the framing missing. The stairway interior was noted with some rusting on the metal deck (landing underside) at several of the floor elevations.

VEHICULAR BARRIER GUARDRAIL SYSTEM

- a. The garage floor ramps are provided with a braided wire cable barrier guard railing system that is strung through the columns. Hanover street elevation is provided with the wire cable system where arched masonry wall openings and precast panels form the exterior façade.
- b. Barrier guard railing cable spacing on the interior grid lines is 10" apart with overall height under 40". The guard railing system as it exists does not comply with the current building code for barrier guard railing height, spacing, and potentially for impact resistance. It is assumed that the current system was compliant to the building code during its construction.

NON-STRUCTURAL COMPONENTS

- a. Floor drains
The floor drain system shows some corrosion of the floor drain bowls and corrosion and damage to some of the drain lines primarily on the lower two levels. Some of the drains and lines will require repairs to properly maintain the system. Several locations were also noted where floor ponding occurs and supplemental drains should be considered for installation to properly drain the supported floors.
- b. Fire protection stand pipe
The standpipe lines as observed on levels 4 through 1 show signs of surface corrosion caused by continual leakage through the floor joints. The lines which are painted on the exterior also lack from

routine maintenance to paint and protect them. An assessment of the operating condition of the system is not within the report scope. However, replacement of the system with a new galvanized system should be considered.

- c. Power and lighting conduit system were observed in operating condition. Some corrosion was noted on conduit passing through the structural framing where leakage and heavy corrosion occurs on the framing.
- d. Elevator System (not surveyed) general conditions acknowledged during the survey.

DRAFT

APPENDIX D – REPAIR ALTERNATIVES
REPAIR STRATEGIES
GENERAL

There is a significant amount of literature on concrete repair methods and materials that has been published during the past several years. Many committees of the American Concrete Institute (ACI) and International Concrete Repair Institute (ICRI) have now published reports and manuals that directly relate to the repair and restoration of concrete structures. The results of research and the application of repair methods and materials have been reported in publications presented by the Federal Highway Administration research programs, the Portland Cement Association, the Corps of Engineers, and in articles presented in various trade journals. Therefore, in this section we will only attempt to summarize the basic requirements for durable repair techniques we commonly use to restore a parking structure. Other less frequently used techniques have not been included. The restoration of parking facilities requires the use of several repair methods to address existing deterioration of structural members and provide effective protection to “extend the service life” of the restored structure. Table D.1 summarizes the repair objectives and the methods we commonly utilize to repair various structural elements. The horizontal floor-slabs generally experience the most deterioration and usually require implementing a combination of repair methods to develop an approach that will effectively restore the structure. For instance, the approach might consist of a combination of repair methods that includes patching to restore floor-slab integrity and membrane protection to effectively waterproof and minimize future corrosion induced concrete deterioration.

TABLE D.1 – REPAIR OBJECTIVES AND METHODS

REPAIR OBJECTIVE	REPAIR METHOD	PRIMARY APPLICATIONS
Restore Integrity	Patching a. Partial-depth b. Full-depth c. Replacement	Floor-slab, beam, column, wall, etc. Floor-slab Floor-slab, beam, columns
Provide protection Abrasion Freeze-Thaw	Coating Replacement a. Partial-depth b. Full-depth	Floor-slab Floor-slab
Corrosion	Coating Cathodic protection Replacement	Floor-slab Floor-slab Floor-slab
Waterproofing	Coating Sealing	Floor-slab, beam, columns, wall Floor-slab, joints, cracks

A repair is generally successful if the repair material is compatible with the original substrate and has the required strength and durability. Other considerations are appearance and economy. The four basic requirements for a satisfactory concrete repair are:

- Concrete removal and surface preparation

- Application of bonding medium
- Proper selection of repair material
- Proper material application

BASIC REQUIREMENTS FOR CONCRETE REPAIRS

CONCRETE REMOVAL

For all concrete repair situations, regardless of the type of structural member, a basic requirement is to remove all the deteriorated, delaminated, and unsound concrete prior to placing any new patch material. When complete removal of the deteriorated concrete is not accomplished, there is a good probability of patch failures.

Concrete removal in parking structures is more commonly performed by light (15 lbs. maximum) chipping hammers. These light chipping hammers are very convenient for concrete removal around and below the existing reinforcement. The size of the chipping hammer is limited to minimize damage to the surrounding area.

Removal of relatively thin layers of concrete over large areas, such as shallow concrete removal from the surface in preparation for placement of an overlay, may be more effectively done with a scabber, scarifier or planer, than with chipping hammers. These machines are particularly effective in cleaning the surface by removing the top surface contamination of traffic oils and greases. In addition, high-pressure sand and water blasters are capable of removing deteriorated concrete and many surface contaminants. Scarification of concrete surfaces using an abraded metal-shot-rebound method has also been used in the preparation of surfaces for installing a membrane or overlay. Some other methods utilized for very extensive full-depth slab removals include saw cutting and large, mechanically operated breakers.

An alternative to the manual methods of concrete demolition can be accomplished by Hydrodemolition also known as "Hydromilling" to remove concrete to a prescribed depth. This process requires specialized equipment and skilled operators to accomplish the concrete removal. The concrete removal technique utilizes high pressure water to remove deteriorated and sound concrete.

Hydrodemolition is not used as much for demolition as it is for surface restoration and protection projects. When concrete has deteriorated or the reinforcing steel has begun to corrode, it is necessary to remove any unsound concrete and reinforcing bars (rebar) in order to replace it with new concrete and maintain the integrity of the structure. This process has also been used to remove sound concrete that is not compromised in any way. This may be done to install a preventive cathodic protection system, or to remove concrete in structures in which vibration is a concern. Unlike jackhammers, hydrodemolition does not produce vibrations throughout a structure and therefore does not introduce micro fractures.

Partial depth removal involves the selective removal of deteriorated concrete to a certain depth or for a concrete overlay to a depth exceeding 3/4". It is usually done in the case of concrete restoration projects where embedded objects such as rebar are substantial and need to be preserved.

SURFACE PREPARATION

Another important step in the repair of concrete structures is the preparation of the surface to be repaired. The repair is only as good as the surface preparation, regardless of the repair method or materials selected. For reinforced concrete structures, repairs must include proper preparation of the reinforcing steel in order to develop a bond with the replacement concrete.

BONDING MEDIUM

Bonding of the new patch or overlay to the concrete substrate is essential for a durable repair. An adequate bond between the patch or overlay material is required to resist stresses due to differential volume change between the patching material and the substrate. The failure can occur either at the bond interface or adjacent to the interface within the section of the lower strength material.

Once debonding is initiated, the effects of freeze-thaw cycling and dynamic impact of vehicle wheel loads can contribute to the progressive deterioration of the repaired area. Debonded areas are generally prone to cracking. The cracking is usually through the entire thickness of the patch or overlay material, which can permit water leakage to the interface and the underlying substrate.

MATERIAL APPLICATION

Concrete repair materials must be properly placed, consolidated, and cured. A good repair specification will include specific requirements for concrete placement, consolidation, and curing for patches and overlay. The most common application and placement methods include the following:

- Cast-in-place concrete for patches, overlays, and floor-slab replacements.
- Shotcrete repairs for overhead and vertical patches.
- Formed and pumped concrete or mortar for deep repairs to slab, beam and columns sections.
- Trowel applied mortars for shallow overhead and vertical patches.

PATCHING

Patching replaces deteriorated concrete on the surface of horizontal and vertical members. When properly implemented, patching will restore structural integrity, as well as improve serviceability or correct cosmetic damage.

Patching can be referred to as "partial-depth" or "full-depth" based on the extent of concrete removed. Quite often, for thin slab sections (less than 5 inches thick) it is difficult to perform shallow concrete removals and usually results in full-depth concrete removal.

As a general rule of thumb, a full-depth patch is specified when concrete removal equals or exceeds half the slab's thickness.

Patching consists of removing the unsound concrete, cleaning the reinforcing steel exposed by removals, preparing the exposed surface, and installing a specialty concrete patching material. Patch edges for partial-depth removals are often chipped or saw-cut to near vertical to a depth of at least 3/4-inch, as opposed to leaving a "feather-edge".

Although patches of high-quality (low permeability) material are installed, the adjacent surface tends to have lower durability. In chloride-contaminated slabs, the durability of this repair system is adversely affected by delamination and spalling of floor-slab areas due to continuing corrosion of reinforcement beyond the patch limits. Patching can, however, rapidly restore the structural integrity of the member and limit further damage to embedded reinforcement. The emphasis is on repairs that address only existing damage.

REPLACEMENT

When a floor slab is extensively deteriorated, removal and replacement of the slab may be a viable repair alternative, provided the underlying members are in relatively good condition. This is referred to as "partial-depth" replacement. Floor-slabs that are less than 5 inches thick are difficult to repair. Concrete removals on pan-joint, waffle-slab, and one-way slab systems usually result in complete removal of the thin slab. The existing underlying beams and waffle or pan-joint ribs are used to support the new slab, provided adequate measures are taken to ensure composite behavior of the rebuilt floor system. The new slab can be reconstructed with durable concrete and epoxy-coated reinforcement and other internally-built corrosion protection systems to extend the service life of the facility. However, the new slab is susceptible to cracking due to volume-change restraint offered by the existing underlying members. In extreme cases, "full-depth" replacement of the floor system (slab and underlying elements) may be necessary.

CATHODIC PROTECTION

In concept, the only method that will effectively stop the corrosion of embedded reinforcement in chloride-contaminated slabs is cathodic protection. Cathodic protection works by putting energy in the form of electrical current into the concrete to be protected. The introduced energy prevents corrosion in the steel reinforcement. Corrosion of metal is, put simply, a loss of energy from that metal. Feeding in more energy prevents that corrosion. Cathodic protection is the only protective measure that prevents corrosion from starting. If corrosion has already started before cathodic protection is introduced, it is the only protective measure, which will stop corrosion. All other measures described are but delaying actions, though some are very effective; they will slow corrosion, but not stop it.

Application of cathodic protection can only mitigate corrosion; repairs to restore structural integrity and serviceability must still be performed. Therefore, a cathodic protection system is more cost-effective when it is applied to structures with limited concrete deterioration, such as floor-slabs in the initial stages of deterioration. Also, a cathodic protection system is not economical when applied to structures with less than 10 years of planned or anticipated life expectancy. Presently, only conventionally reinforced concrete structures have been cathodically protected. Cathodic protection of prestressing steel is still in a developmental stage. The concern is due to evolution of hydrogen ions as a result of application of cathodic protection to concrete structures.

Hydrogen ions can potentially contribute to embrittlement of the high strength prestressing steel and abrupt tendon failures. Hydrogen embrittlement is not a concern for conventional mild steel reinforcement.

SEALING

Sealing consists of performing repairs that will reduce water leakage through floor-slab cracks and joints. Since sealing by itself cannot be considered a repair method, it must always be performed in conjunction with the other repair methods described earlier. Potential sources of water leakage are:

1. expansion joints,
2. construction joints,
3. control or isolation joints, and
4. construction- or service-related cracks.

Under certain circumstances, cracks can be repaired by epoxy injection. The material and its application are described in ACI 224.1R. Epoxy injection of service-related (active) cracks usually results in cracking adjacent to previously injected cracks. Active cracks should be treated with a flexible joint sealant material.

Surface or pattern cracks that are inactive can be treated by application of high molecular weight methacrylate (HMWM). The concrete surface is soaked to fill and heal the cracks. These "crack healers" have a viscosity slightly greater than water. Surface cracks can also be treated with a traffic bearing elastomeric membrane. In addition, these membranes also have the ability to bridge and protect the surface from active cracks. Application of silane sealer is also sometimes effective in keeping moisture out of fine hairline surface cracks that are not active.

SUMMARY

The intent of these sections was to discuss our commonly used repair approaches and methods for restoring parking structures. Construction and design deficiencies, along with errors in design or construction, may require strengthening or stiffening of the structural element. Also, severely deteriorated structural elements in a parking facility may require strengthening. In these instances, the primary cause of the distress must be first determined, and the appropriate corrective actions taken. These situations are generally uncommon. If construction and design deficiencies are present, then repair and/or strengthening methods must address the specific conditions encountered.

REPAIR MATERIALS

Patching Materials

The selection of patching and concrete material is based on the consideration of the following five characteristics, as they relate to the member being repaired:

- Thermal compatibility or incompatibility
- Shrinkage
- Strength of repair material and the substrate
- Durability of the repair material and the substrate
- Ability to permit vapor transmission

The compatibility of the repair materials with the existing concrete is an important concern in the selection of appropriate repair materials. Since parking structures are exposed to temperature extremes, a difference in thermal properties of the repair material and the existing concrete will contribute to the debonding and failure of repaired areas. For parking structures, Portland cement-based patching and overlay materials generally perform better than any other material. Portland cement-based materials also reduce failures associated with a difference in the modulus of elasticity between the repaired material and existing concrete.

The differential shrinkage between the original concrete and the repair material can also contribute to debonding and cracking due to development of shear stresses along the interface. Reducing the shrinkage potential of the concrete repair material is particularly important for full-depth patches and floor-slab replacements. Cracking of full-depth patching and floor-slab replacements is a common occurrence.

For horizontal floor-slab surfaces, low-slump high-density and microsilica modified concrete patching materials that are properly proportioned and adequately air entrained tend to perform well. Also, latex-modified concrete patching materials perform well since they are not as susceptible to freeze-thaw damage. For full-depth floor-slab replacements we specify a concrete mix with low potential for shrinkage.

The patching material used for overhead and vertical surfaces is less susceptible to freeze-thaw deterioration than that used for the floor-slab or horizontal surface. For areas that are protected from direct exposure to moisture, such as the ceiling, rapid-setting prepackaged Portland cement-based repair materials have been used successfully. Other successfully, but not widely used patching materials are various epoxy and polymer concretes. Polymer concretes are classed as thermosetting and hydrating. Examples of thermosetting polymer concretes are those containing epoxy and those containing methyl methacrylate. Examples of hydrating polymer concretes are those containing styrene-butadiene ("latex") additives which enhance the bond and reduce permeability. Limit the use of thermosetting polymer concrete materials for cosmetic or aesthetic repairs. For large shallow areas, pneumatically applied concrete (shotcrete) has also been used effectively. We specify the wet process with air-entrainment when there is a potential for saturation of the surface by moisture.

SEALERS

Concrete sealer is a liquid that is sprayed, squeegeed, or brushed onto the concrete surface. A sealer makes the concrete less permeable to keep chloride ions, moisture and water out of the concrete. However, it cannot completely screen out the chloride ion or moisture like a traffic topping. Many generic types and brands of sealers are available with considerable variation in effectiveness and performance. It is important to select a sealer that will perform. Silanes are considered to be most effective because of their ability to penetrate deeper into the concrete. However, all silanes do not perform equally. The desirable properties of a good sealer are:

- Reduce water absorption
- Effective chloride ion screen and chemical stability when exposed to road salt
- Ability to "breathe" which permits moisture vapor transmission
- Resist ultraviolet exposure
- Provide a skid resistant surface after application
- Ability to penetrate to the concrete surface

The better performance of silanes is due to their smaller molecular structure. These sealers can penetrate as much as 1/8 inch into the concrete surface. Depth of penetration is obviously related to the concrete porosity and permeability. Concrete with a higher water-to-cement ratio is more porous and will permit greater sealer penetration than a concrete that is less porous. Also, the sealer effectiveness is influenced by the sealer application rate and the concrete porosity. Some other factors that can affect sealer performance are condition of the surface at the time of sealer application, surface preparation, moisture content of the concrete and sealer concentration. The effectiveness of the sealer under service condition and/or frequency of reapplication can be monitored.

One recent development is the use of water-based solvents for silanes. The more volatile alcohol based solvent carriers that were traditionally required have been replaced by water-based solvents. This is due to the very stringent regulations for Volatile Organic Compounds (VOC) that have been imposed by several states. These state standards exceed the current Environmental Protection Agency's Clean Air Act Amendment standards. Therefore, some manufacturers have already developed solvent-free 100% silane sealers. This highly concentrated sealer is obviously more expensive than current sealers packaged at 20 to 40% silane content. The new sealers can potentially last longer due to greater penetration into the concrete surface and provide better corrosion protection due to their high solids content.

MEMBRANES (TRAFFIC TOPPING)

The present ASTM test methods for testing properties of traffic-bearing membranes are not adequate to evaluate the performance and the abrasion resistance of systems. There are many manufactures that supply the membrane but all membrane systems do not perform equally. Some basic characteristics that help to evaluate the systems are:

- Impermeability - Should be impermeable to water under normal use.
- Tear Resistance - Membrane should be capable of bridging cracks under normal as well as cold-weather conditions.
- Adhesion - Intercoat as well as adhesion to the substrate.
- Moisture Vapor Transmission - The membrane should be capable of breathing.
- Material Stability - Stability under service-exposure conditions to perform over extended time period.
- Chemical Resistance - Should be resistant to gasoline, oil, and antifreeze spills.
- Ease of Installation - The waterproofing material and installation procedures must be tolerant of site conditions, as opposed to ideal laboratory conditions.

We select membrane systems based on performance history, compatibility with other sealant systems, cost and the manufacturer's reputation to properly install and service the topping. Improper application of polyurethane membranes can result in localized imperfections, such as blistering and pinholes. Therefore, the performance of the membrane systems is affected by the care taken to install the systems. These systems require more frequent maintenance in high traffic areas. The service life and the level of maintenance are affected by the abrasion resistance of the system.

The stricter VOC regulations imposed by several states have led to the recent development of some solvent-free (100% solids) membrane systems. Currently, most of the urethane membrane systems are solvent based. Also, low-odor systems are offered by many manufacturers for membrane installation in enclosed areas or areas adjacent to occupied spaces in buildings. Presently, there are no standards to measure or compare the odor characteristics. After all, odor is a very subjective issue and cannot be defined. The life expectancy of a properly applied and maintained state-of-the-art traffic topping is approximately 15 years, requiring top coat reapplication to the entire surface to further extend the service life. For surfaces exposed to direct sunlight and ultraviolet lights, the life expectancy is reduced to 10 years.

Traffic topping has a high initial application cost that is 6 to 8 times the cost of a protective concrete sealer. The membrane is susceptible to traffic abrasion and wear, requiring more frequent maintenance in heavy traffic areas such as entry/exit points, drive aisles and turn areas. Also, traffic topping will require use of mechanized scrubbers and sweepers to clean the surface. It is normal for the traffic topping to gradually discolor when directly exposed to sunlight. Black or dark membranes will reduce the light levels within the facility, particularly in the lower covered levels.

SELECTION OF REPAIR APPROACH AND METHOD

OVERLAYS

The most widely used specialty concrete overlay systems that have demonstrated a satisfactory long-term performance history are latex-modified concrete (LMC) and low-slump high-density concrete (LSDC). LMC is more effective at preventing additional water and salt penetrations into the base slab than LSDC. However, the long-term durability of both systems appears to be equivalent. Polymer-concrete overlays have been used only on a limited scale and have not been fully evaluated. Such systems, whether referred to as polymer or epoxy concrete, can offer solutions to surface deterioration problems and should not be excluded from consideration. Another specialty concrete overlay utilizing silica-fume-modified, high-density concrete is currently available. The installation cost of the silica-fume modified overlay is lower than that of the LMC system.

GENERAL

The selection of repair schemes to restore a parking structure is related to the following six basic issues:

- Nature of distress
- Extent of deterioration

- Type of structure
- Repair alternatives
- Life expectancy of the repaired structure
- Economics

The same repair approach cannot be used for all structures. The approach selected to restore a structure damaged by corrosion of embedded reinforcement will be different from that selected for a slab damaged by freezing and thawing. In addition, the repair approach selected must address the adverse effect of other contributing factors, such as the quality of the concrete, poor drainage, floor-slab cracking, shallow concrete cover over reinforcement, and lack of adequate air-entrainment.

The extent of the deterioration and type of structural system will also influence the selection of the repair scheme. For instance, if a 4-inch thick slab of a pan-joist system is extensively damaged due to corrosion, then patching, sealing, or cathodic protection may not be an acceptable solution. The appropriate repair scheme in this instance is probably going to be the replacement of the slab of the floor system. Slab replacement will be required, since it is difficult to perform partial-depth repair of slabs that are less than 5 inches thick. On the other hand if the 4-inch slab is damaged by surface scaling, an elastomeric-waterproofing membrane or an overlay may be acceptable solutions. However, if the extent of the freeze-thaw damage extends 1-2 inches below the surface, replacement may be a more appropriate repair method.

In summary, from a technical standpoint, we consider the nature and extent of the deterioration, the pros and cons of the repair methods that are technically acceptable, and the impact of the repair on factors contributing to the deterioration. Also, we make certain that the structure can be repaired (as opposed to replaced), and that all elements of the structure will support additional loads imposed by the repair work.

LIFE EXPECTANCY OF REPAIRS

The life expectancy of repair methods is at best an estimate. Also, estimating the service life of repaired structures is only an educated opinion, based on experience gained from conditions observed in structures with a similar framing system. Therefore, difficulty in estimating the service life of repaired structures complicates the selection of a cost effective repair method. Removal of sound, but chloride contaminated concrete has a significant impact on the life expectancy of repairs. The impact of concrete removal on the various repair methods can be best illustrated by considering the life expectancy of structures repaired by patching.

A distinction can sometimes be made between temporary and permanent repair patches. However, because of the progressive nature of corrosive processes, the service life of even a "permanent" patch is limited. In a temporary patch the concrete is removed only to the level of reinforcement. This situation contributes to progressive deterioration within and adjacent to the patch. Also, the life expectancy of the patch may be limited to only 1 or 2 years. This method of patch repair may be appropriate for structures when serviceability is to be maintained for a limited time, or when constraints are imposed due to available funds or weather conditions.

In the instance of a relatively permanent patch, the concrete is removed below the existing reinforcement to minimize potential for corrosion within the patch boundary. Also, to control corrosion adjacent to the patch

boundary, the existing reinforcement may be epoxy coated. The entire floor surface is then sealed to reduce the deterioration rate of areas beyond the patch boundary. Under these conditions, the life expectancy of the patch repairs is 3 to 5 years.

In certain instances, where longer life expectancy is desirable, concrete removal along the entire length of reinforcement can be specified. The life expectancy of the "strip-patch" repair may be estimated at 10 - 20 years, limited primarily by other contributing factors, such as cracking, lack of air-entrainment and poor drainage that may adversely affect the service life of the structure. However, it is not feasible to implement the strip-patch-repair approach in structures with relatively thin slabs (less than 5 inches thick). Therefore, considerations, such as the structural system involved and the existing reinforcement, size, placement and pattern, will limit the ability to implement this repair approach.

At present, the only way to be assured of a "permanent" repair requiring little maintenance is to remove all concrete that contains chlorides in excess of the corrosion threshold. The emphasis should be on selective, but cost-effective, removals of chloride-contaminated concrete, based on consideration of overall repair strategies and the desired life expectancy of the repairs.

Based on the extent of concrete removals, the structural system involved, and the concrete cover over existing reinforcement, patching and then coating the floor-slab with a waterproofing membrane is likely to extend the service life of the structure 5 - 10 years. An overlay can extend the service life of structures 10 - 20 years. In concept, the only method that will mitigate corrosion of the embedded reinforcement without removal of sound concrete is cathodic protection. Application of cathodic protection is estimated to extend the service life of structures beyond 20 years. Full-depth slab and floor removal can be designed to be rebuilt with a life expectancy of 20 - 40 years. A probable estimate of repair service life of various repair approaches is summarized in Table D.2. As previously mentioned, estimating the service life of repairs is not easy. Currently there is no industry standard or guide to assess service life of repairs. The only avenue we rely on is experience gained from past performance of the repairs under actual service conditions. Therefore, the table should only serve as a guide. Some of the factors that can influence the service of the repairs include:

- Age of the facility
- Type of structural system and pattern of reinforcement
- Quality of material specified for the original construction and for the repairs
- Extent of deterioration
- Degree of chloride contamination
- Nature of the deterioration
- Adverse conditions
- Geographic location of the structure
- Exposure conditions
- Preventive maintenance

TABLE D.2 – ESTIMATE OF REPAIR SERVICE LIFE

REPAIR APPROACH	SERVICE LIFE (YEARS)
Patching (shallow)	1 - 2
Patching (deep)	3 - 5
Patching and Sealer	3 - 5
Patching and Traffic Topping	5 - 8
Strip Patching and Sealer	10 - 15
Strip Patch and Traffic Topping	15 - 20
Partial Depth Slab Removal and Concrete Overlay	20 - 25
Full-depth Slab Removal and Replacement	25 - 35+

The table suggests that it is possible to match the service life of the repairs to meet the strategic objectives of the Owner. For instance, patching cannot be considered as the primary repair method if the strategic objective is to keep the structure in service for long term (20 years or more). It is also apparent that repair schemes with longer service life will incur higher repair costs. The repair methods also tend to get more aggressive and disruptive with increased service life expectancy. Therefore, the selection of the repair approach will have an impact on the repair budget, construction schedule, and operations of the facility.

REPAIR ALTERNATIVES

It is not uncommon that we develop several technically acceptable repair alternatives for a structure based on the following overall repair strategies:

- 1) Do nothing and use up the remaining useful life of the structure.
- 2) Perform repairs to address only potentially unsafe conditions that presently exist. This approach amounts to performing only "band-aid type" repairs either prior to implementing a comprehensive restoration program or demolishing the structure.
- 3) Perform necessary repairs to extend the life of the structure 5 - 10 years.
- 4) Perform necessary repairs to extend the life of the structure 10 - 20 years.
- 5) Perform repairs to extend the life of the structure 25 years or more.

We have select repair alternatives based on the overall strategies. This process assists in selecting schemes that will address future plans for use of the structure based on funds that are presently available or obtainable. However, we do not consider technically unacceptable alternatives primarily to limit restoration costs.

The nature and the extent of the deterioration will also limit the selection of repair alternatives. For instance, it may not be appropriate to extend the life of a structure 5 - 10 years simply by patching, if the slab is likely to undergo progressive damage due to freezing and thawing. Also, it may not be possible to assure safe operating conditions by performing only limited repairs to a structure that is extensively damaged.

Two important objectives to restore parking structures are:

- Restore structural integrity, and
- Provide protection to extend the life of the repairs and the service life of the structure.

The above objectives provide an opportunity to generate repair alternatives, individually and in combination.

SELECTION OF REPAIR APPROACH

The mechanics of selecting the repair approach involves generating technically feasible repair schemes that are applicable to the structure. This will require the understanding and knowledge of the following:

- Existing Conditions
- Repair methods
- Repair materials
- Advantages and Disadvantages of Repair Methods
- Repair Alternatives
- Life Expectancy of Repairs

The information covered by the items shown above can be conveniently qualified to assist in the selection of a technically appropriate repair approach by using a decision matrix as shown in Table 9. The concept of the decision matrix was developed by the Ontario Ministry of Transportation, Research and Development Branch. This decision matrix concept has been used for selection of bridge-deck rehabilitation methods. The decision matrix presented in Table 9 has been adapted from the material published in the Ministry of Transportation's manual. The table assists in the selection of a repair approach with the least amount of technically unfavorable elements. Note that patching or sealing, as a repair approach by itself, will be ineffective in restoring the slab. Patching and sealing is usually done in conjunction with application of a surface sealer, traffic topping, or an overlay. The exception could be the use of patching and sealing by itself for the purpose of preventive maintenance.

The decision matrix leads, by elimination, to the selection of repair approaches with the least disadvantages. In some cases, most of the schemes considered may be inappropriate. For instance, a structure that is extensively cracked, consisting primarily of active cracks and delaminated over 30% of the floor area, will necessitate working through the selection process and examining the implication of violating each criterion in turn for the selected alternatives. If the structure is considered to be important, then the scheme may consist of slab replacement with a traffic topping to minimize leakage through active floor-slab cracks. The criteria contained in Table B.3 is not rigid, but serves only as a useful starting point from a technical standpoint. Repair strategies, life expectancy, and economic issues usually influence the selection of the final repair scheme.

ECONOMICS

The selection of a cost-effective repair method consists of:

- 1) Preparing cost estimates of technically acceptable repair alternatives, and
- 2) Estimating the service life of the repaired structure.

Repair costs can vary significantly even for the same method of repair. Factors contributing to cost variations are geographic location of the structure, scope of the overall contract, size and volume of the repair work, and availability of materials and qualified contractors. Constraints associated with maintaining traffic during construction and the overall volume of construction work at the time of bidding can also vary the overall repair costs. Realistic estimates are obtained by using costs from an historical record and assigning appropriate contingency factors to the total cost of the work.

In some instances life cycle cost analysis of repair methods is also performed to select an economical repair method. Once again, the economics are difficult to estimate due to the possible inaccuracy in assessed costs and assumed service life of the repaired structure.

TABLE D.3 SELECTION OF A FLOOR-SLAB REPAIR APPROACH

Criterion	Patching (Partial or Full-Depth)	Protective Coatings			Replacement (Partial or Full-Depth)	Cathodic Protection ^{1,2}
		Sealer	Traffic Topping	Overlay		
1. Corrosion-induced deterioration --- > 10% of the floor area	No	No				
2. Corrosion-induced deterioration --- > 30% of the floor area	No	No	No	No		No
3. Moderate scaling --- 10% of the floor area	No	No				Yes/No
4. Non air-entrained concrete	No	No	No			Yes/no
5. High concrete permeability	No	No				Yes/no
6. Need to improve drainage	No	No	No			Yes/no
7. Shallow concrete cover	No	No	No			Yes/no
8. Limited structural capacity				No		Yes/no
9. Limited floor clearance				No		Yes/no
10. Remaining life less than 10 yrs.				No	No	No
11. Active cracks	No	No		No	No	

¹ Items 3, 4, and 7 are appropriate if the C.P. system selected consists of anode embedded in a concrete overlay.
² Items 8 and 9 will be appropriate if the C.P. system consists of anode embedded in slots cut in the structure.
 Adapted from: "Bridge Deck Rehabilitation Manual," Part Two: Contract Preparation, Ontario Ministry of Transportation.



APPENDIX E - TESTING

DRAFT



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Mr. Austin T. Cowles
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Re: Laboratory Studies of Concrete Samples
High Hanover Parking Facility
Portsmouth, New Hampshire
WRC Project No. 16-2575.00

Dear Mr. Cowles:

Universal Construction Testing, Ltd. (UCT) has completed laboratory studies of six (6) concrete core samples and fifteen (15) concrete powder samples from the referenced project which were delivered to our laboratories on November 7, 2014.

The scope of our work, as outlined in your transmittal letter of November 5, 2014, consisted of compressive strength testing, chloride content analysis profile: 0 to 1 in. (0 to 25 mm), 1 to 2 in. (25 to 51 mm) and 2 to 3 in. (51 to 76 mm) depths and petrographic examination with air-void system analysis.

LABORATORY STUDIES

Compressive Strength Test

Compressive strength testing was determined in accordance with ASTM C42, *Standard Test Method for Obtaining and Testing Drilled Cores of Concrete*.

Chloride Content Analysis

Chloride content analysis was determined in accordance with ASTM C1218, *Standard Test Method for Water-Soluble Chloride in Mortar and Concrete*.

Air-Void System Analysis

Air-void system analysis was performed in accordance with modified point-count method of ASTM C457, *Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete*.

Petrographic Examination

Petrographic examination was conducted in general accordance with ASTM C856, *Standard Practice for Petrographic Examination of Hardened Concrete*.

PROJECT NUMBER:	14254	PAGE 1
PROJECT NAME:	High Hanover Parking Facility, Portsmouth, NH Walker N.: 16-2575.00 : Laboratory Studies of Samples	
DATE:	11-24-2014	

Refer to Table 1 below for individual sample identification, location and testing performed.

Table 1. Core Sample Identification, Location and Test Program

Core ID	Location	Petrographic Examination (ASTM C856)
P-1	Level 3 Grid Location E 16	X
Core ID	Location	Compression Test (ASTM C42)
1	Level 3 Grid Location E 12	X
2	Level 2 Grid Location B 3	X
3	Level 2 Grid Location C 16	X
4	Level 2 Grid Location F 5	X
5	Level 2 Grid Location B 3	X
Sample ID	Location	Chloride Content Analysis (ASTM C1218)
CL-1	Level 3 Grid Location C 14	X
CL-2	Level 3 Grid Location C 14	X
CL-3	Level 2 Grid Line 8 in Garage Addition	X
CL-4	Level 2 Grid Location D 18	X
CL-5	Level 2 Grid Location E 18	X

SUMMARY OF FINDINGS

The test results obtained indicate that the in-situ compressive strength of concrete ranges between approximately 4,000 psi and 6,000 psi.

The chloride content analysis revealed excessively high chloride ion content in the top 1 in. of concrete. There is a drop off in chloride levels below this depth which is an indication that there may have been an external source for the chloride; a likely source would be de-icing salts.

The Chloride content in the concrete ranges from 0.24% to 1.35% at the top surface. These levels exceed the American Concrete Institute's (ACI) acceptable corrosion threshold of 0.15% for reinforced concrete. At the depth of 2" to 3" (51-76 mm), the chloride levels are found to be below the corrosion threshold in three core samples, however, the chloride content in other two core samples still dramatically exceeds the corrosion threshold.

Based on petrographic findings of the single core sample examined petrographically, no distress or major abnormalities are observed; particularly for 30-year-old concrete.

Both ends (surfaces) of the core appear similar in general appearance. Prolonged wear has removed surface paste exposing aggregate particles. The exposed sand grains appear somewhat polished (smooth with slick surface texture).

The concrete was produced using a relatively well graded, 1/2-in. top size, crushed siliceous rock coarse aggregate and a natural sand fine aggregate dispersed fairly uniformly in a hardened paste of portland cement. No signs of supplementary cementitious material, fly ash for example, are observed in hardened paste matrix. The aggregate appears sound and in good condition.

The paste is carbonated to a depth of up to 0.70 in. (18 mm) on one end of the core and 0.50 in. (13 mm) on the other end. Carbonation is a normal chemical reaction that occurs when hydrated portland-cement concrete paste is exposed to carbon dioxide from the atmosphere. The reaction process that takes place is portland cement hydrates forming calcium hydroxide, (Ca(OH)₂) in the presence of moisture; portions of this hydration product are converted during carbonation into calcium carbonate, (CaCO₃) when exposed to carbon dioxide (CO₂).

A nearly horizontal (to somewhat diagonal) fracture is located approximately 2.5 in. (64 mm) from one end of the core and approximately 2 in. (38 mm) from the other end. The fracture passes through and around aggregate particles. The origin of this crack is unknown and could have been induced during the coring process or during shipment or handling.

A 0.2-in. (5 mm) diameter wire impression has approximately 2.5 in. (64 mm) of concrete cover from one end of the core and approximately 2 in. (38 mm) of concrete cover from the other end. The relatively clean impression of the reinforcement is located in the fracture or just off-center of core midsection.

Refer to Table 2 below for the measured proportions of major components, by volume of concrete, as determined for the core sample (constituents rounded to the nearest whole number).

Table 2. Major Concrete Constituents

Aggregate Volume, %	Paste Volume, %	Total Air Content, %
57	32	11

Due to the age of the concrete (circa early 1980's) and continued hydration since placement, interpreting the original water-cement ratio is highly speculative; therefore a numeric estimation will not be reported. Based on physical paste properties and compressive strength results, the water-cement ratio for this concrete is most likely moderate.

Refer to Table 3 below for the results of compression testing as determined for the cores.

Table 3. Compressive Strength Test Results

Core No.	Length L (in.)	Diameter D (in.)	$\frac{L}{D}$ K	Total Load (lbs)	Uncorrected Compressive Strength (psi)	Corrected Compressive Strength (psi)
1	1.72	1.77	$\frac{0.97}{0.86}$	12,090	4910	4230
2	2.13	1.77	$\frac{1.20}{0.92}$	13,320	5410	4980
3	2.25	1.77	$\frac{1.27}{0.93}$	14,830	6030	5610
4	2.34	1.77	$\frac{1.32}{0.94}$	15,740	6050	5690
5	2.32	1.77	$\frac{1.31}{0.94}$	14,650	5960	5600

Remarks: The cores were tested in air-dry conditions.

Refer to Table 4 below for the results of chloride analysis as determined for the samples.

Table 4. Chloride Content Analysis Results

Sample ID	Level tested, inch from top	Chloride ion (CL ⁻) Content		
		by weight of concrete %	by weight of cement* %	by weight of concrete (PPM)*
CL-1	0-1	0.074	0.50	740
	1-2	0.056	0.37	560
	2-3	0.019	0.13	190
CL-2	0-1	0.047	0.31	470
	1-2	0.038	0.25	380
	2-3	0.007	0.04	70
CL-3	0-1	0.036	0.24	360
	1-2	0.007	0.04	70
	2-3	0.004	0.03	40
CL-4	0-1	0.214	1.35	2140
	1-2	0.205	1.30	2050
	2-3	0.120	0.76	1200
CL-5	0-1	0.165	1.04	1650
	1-2	0.149	0.94	1490
	2-3	0.128	0.81	1280

Remarks: *cement content = 600 pcy and unit weight = 3800 pcy (141 pcf).

Refer to Table 5 below for the parameters of the air-void system as determined for the core.

Table 5. Parameters of Air-Void System

Parameters \ Core ID	P-1	Recommended Parameters (ACI 318/201)
Total Air Content (%)	10.8	6.0% (-1 to +2%)
Spacing Factor (in.)	0.014	0.008 in. or less
Specific Surface (in²/in³)	390	600 (in ² /in ³) or greater
Void Frequency (voids per in.)	9.3	1.5 to 2 times air content

The core sample is composed of improperly air-entrained concrete. The air content is measured at approximately 11%, by volume of concrete. Properly air-entrained concrete with 1/2-in. (13 mm) coarse aggregate is expected to have an air content of approximately 7%.

Spacing factor is the shortest distance to an air void. Properly entrained concrete should have a maximum spacing factor of 0.008 in. The spacing factor of the concrete represented by the core sample examined is calculated to be 0.014 in.

Specific surface gives an indication of the surface area or size of the air voids. Given the same air content, concrete that contains many small air voids has a higher specific surface than concrete that contains a few large air voids. For properly air-entrained concrete, specific surface is usually above 600 in²/in³, whereas the specific surface of the core examined was calculated to be 390 in²/in³. This value for specific surface is an indication that the air-void system is coarse with some entrapped air.

Number of voids/inch, which is expected to be 1.5 to 2 times the determined air content, was found to be 9.3.

Air-void distribution is non-uniform. The air content is significantly lower at the top surface as compared to the air-void volume at core depth. Below the zone of reduced air content noted surficially, voids are observed in clusters or coalesced and some are slightly deformed. A reduction in air content at the surface is most often related to finishing of the surface.



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Individual results of the petrographic examination are summarized below.

Core Sample P-1

General

The core sample is 1.75 in. (44 mm) diameter and approximately 4.80 in. (122 mm) long; full deck thickness. The ends of the core sample are worn surfaces exhibiting exposed aggregate particles; the exposed sand grains appear polished (smooth and slick surface texture). Water droplets applied to the existing surface in the laboratory tend to bead. The consolidation of the concrete is good with no signs of segregation.

Reinforcement

An impression from what appears to have been a single 0.2-in.- (5-mm) diameter steel wire is located approximately 2.5 in. (64 mm) from one end of the core and approximately 2 in. (51 mm) from the other end (impression is in the fracture); the impression is relatively clean.

Cracks

A nearly horizontal/diagonal fracture is located just off center of the core sample passing through and around aggregate particles; fracture has the same distance from core ends as wire impression.

A short sub-surface microcrack is observed at a depth of approximately 0.10 in. (3 mm); microcrack seems to interconnect a few air voids.

Other cracking is present in this core sample; microcracks were observed and are randomly oriented in the body of the concrete, or extend from the surface; depth of surface cracks is approximately 0.20 in. (5 mm).

Unit Weight

Sample size was insufficient (too small) to acquire reliable density results; although, it appears that the core sample was produced using normal-weight concrete.

Air Content

The air content is 10.8% and the concrete is considered to be air-entrained, however, air-void distribution is non-uniform. The air voids are locally non-existent at the surface and occurring in clusters or coalesced and deformed. The air-void system is considered coarse.

The following parameters of the air-void system were determined:

- Spacing factor* - 0.014 in.
- Specific surface* - 390 in²/in³
- Void frequency (voids/inch)* - 9.3

Secondary Deposits

No secondary deposits, such as ettringite, are observed in air voids, cracks or other available surfaces.

Carbonation

The paste is carbonated to a depth of up to 0.70 in. (18 mm) on one end of the core and 0.50 in. (13 mm) on the other end.

Depth of carbonation; phenolphthalein method:

- high alkalinity (pH), noncarbonated paste turns magenta
- low alkalinity (pH), carbonated paste remains unaffected

Water-Cement Ratio

The water-cement ratio is probably moderate.

Paste Properties

<i>Color</i>	<i>Medium-light gray; darker surface</i>
<i>Hardness</i>	<i>Moderately hard to hard</i>
<i>Luster</i>	<i>Dull to subvitreous</i>
<i>Paste Volume</i>	<i>Paste content is 32.2%</i>
<i>Morphology of Calcium Hydroxide</i>	<i>Medium-size crystals</i>
<i>Mineralogy of the Cement</i>	<i>Portland cement (C-S-H)</i>
<i>Hydration</i>	<i>Normal</i>
<i>Residual Portland Cement Grains</i>	<i>3% to 6% clinker particles</i>
<i>Supplementary Cementitious Materials</i>	<i>None observed</i>

Paste-Aggregate Bond

The paste-aggregate bond is moderately tight.

Aggregate

The aggregate is relatively well graded and distribution is fairly uniform. Aggregate volume is 57%. The aggregate appears sound, exhibiting no evidence of deleterious reactions with the paste.

The coarse aggregate is 1/2-in. (13 mm) top size crushed volcanic and metamorphic rocks (i.e. granite, granodiorite and gabbro). Visual estimation of roundness: angular to sub-rounded; and sphericity: bladed to elongate.

The fine aggregate is natural sand composed mainly of quartz, feldspar, mica, amphibole, granite and small amounts of various other rocks and minerals. Individual sand grains are angular to rounded and elongate or bladed to equidimensional.

Photographs and Photomicrographs of the core sample examined petrographically.

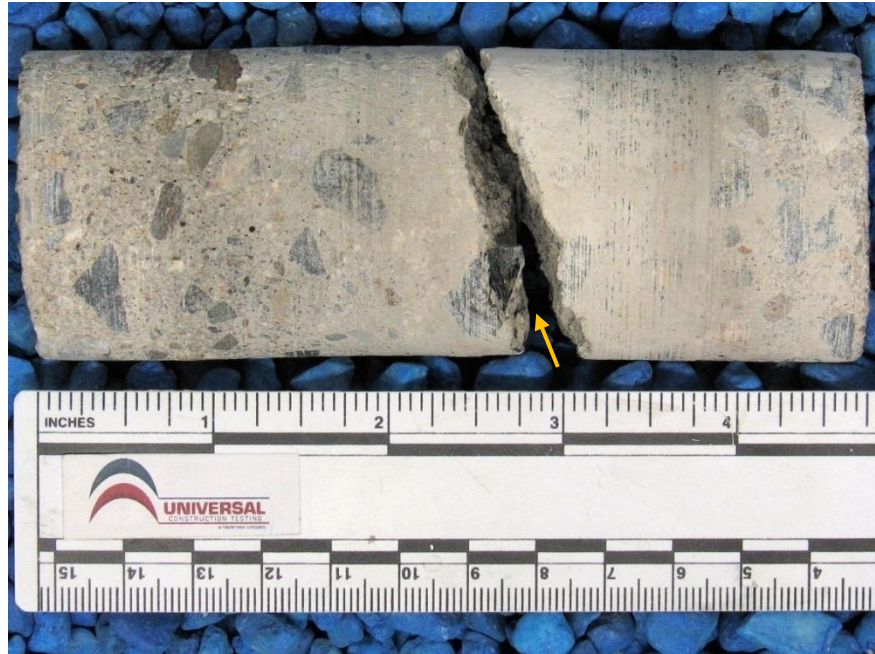


Figure 1 – Side view of core sample as-received for examination. The quality and integrity of the concrete appears relatively good; arrow clearly indicates the general characteristics of the open fracture.



Figure 2 – One core end of the sample as-received for examination; the opposing end exhibits similar features (worn surface with little to no texture; smooth and polished sand grains). Scale is marked in 1/16-in. increments.

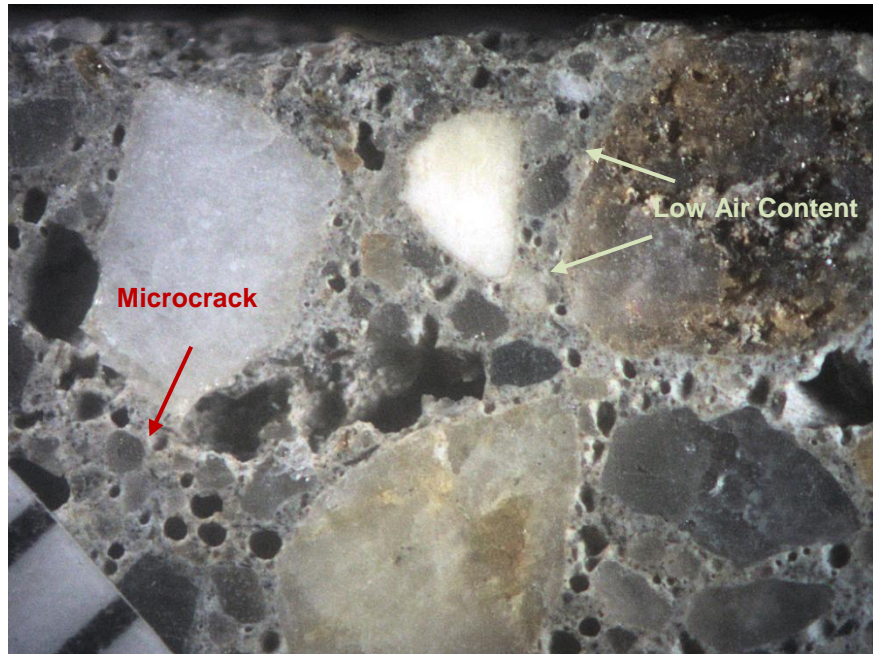


Figure 3 – Photomicrograph showing the air-void system in the near-surface region (millimeter scale). Note coalesced and deformed air voids just below the zone of low air content concrete at the surface; the paste of the low air-content concrete is darker gray (densified). A sub-surface microcrack appears to interconnect a few voids.

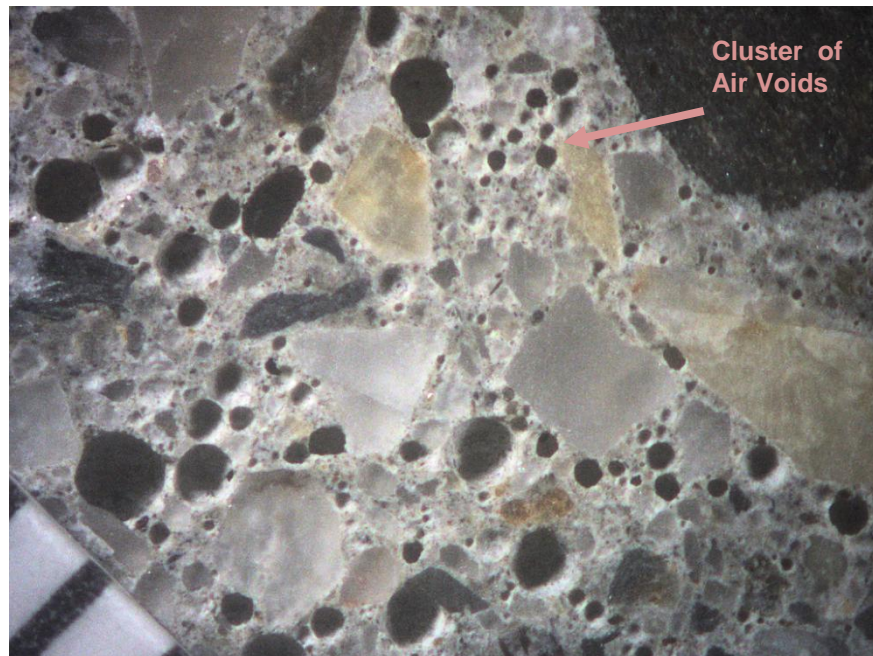


Figure 4 – Photomicrograph showing the air-void system at depth (millimeter scale). Air-void distribution is non-uniform, occasionally occurring in clusters surrounded by concrete paste where air voids are scarce. Overall the air-void system is coarse.

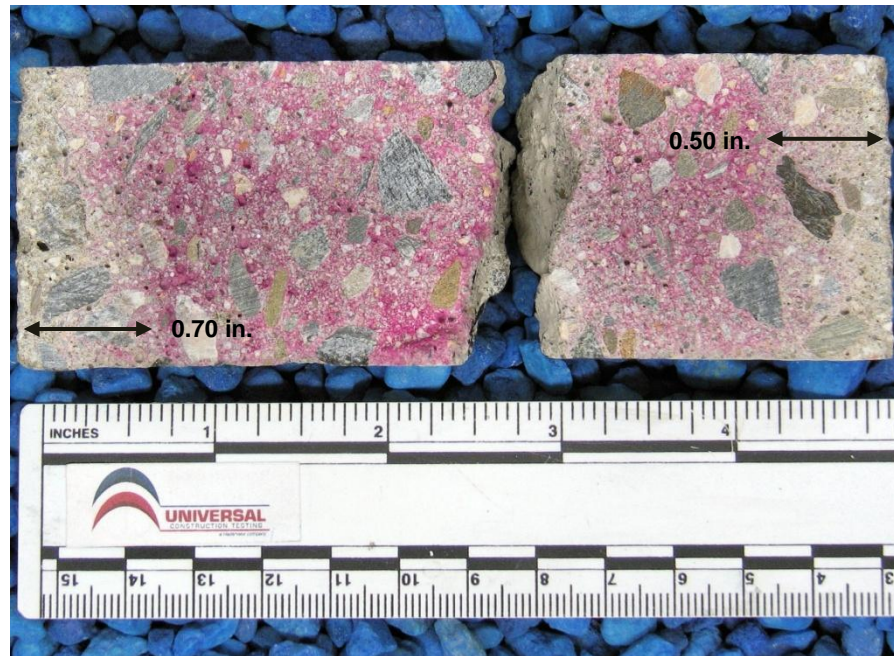


Figure 5 – Cross section showing the depth of carbonation at both ends of the core.

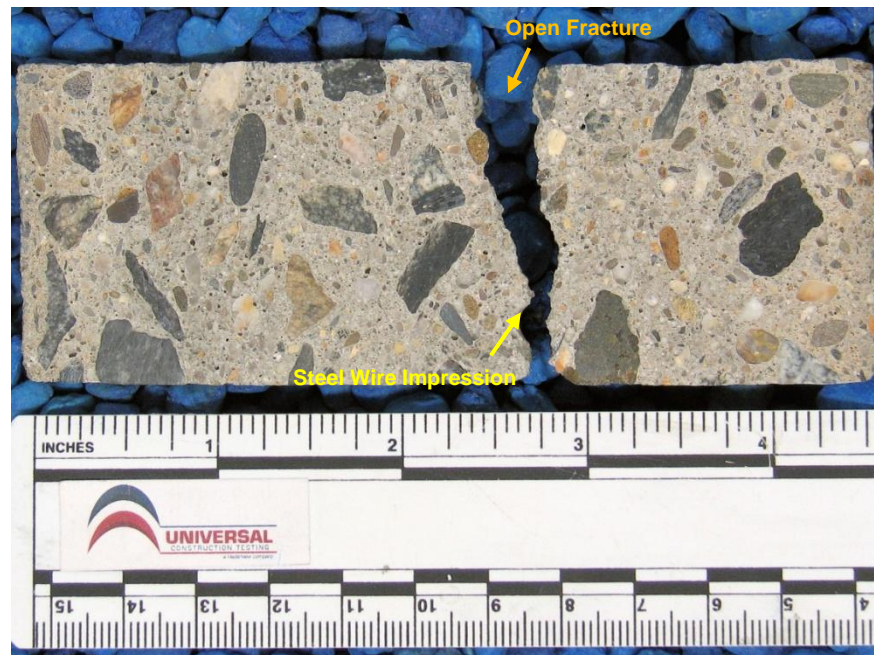


Figure 6 – Cross section of the core sample showing the general characteristics of the concrete. Coarse aggregate content is slightly low and paste content is slightly high.

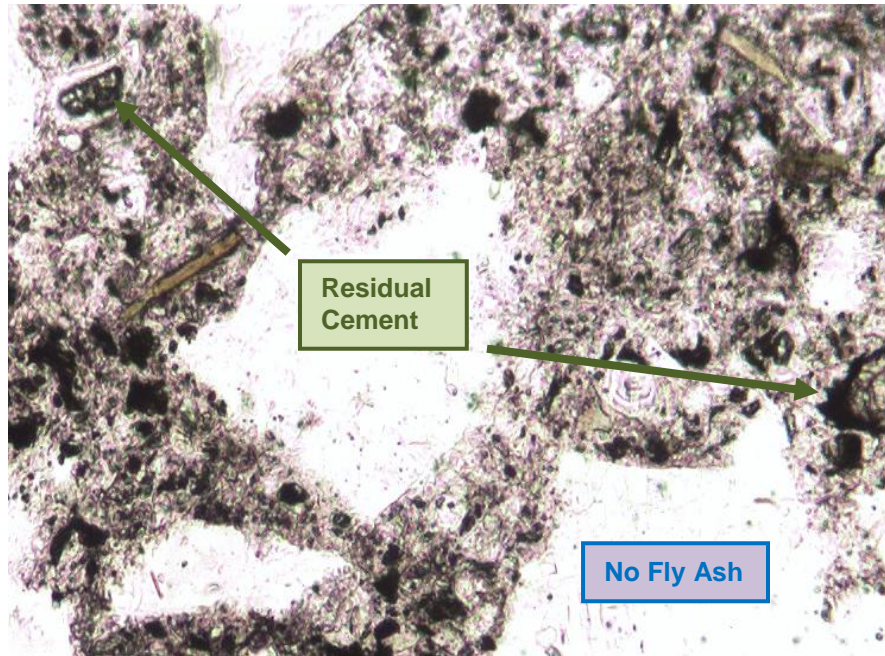


Figure 7 – Thin-section photomicrograph showing the cement-paste microstructure. 100X, plane light. The concrete was produced using portland cement; no supplementary cementitious material, such as fly ash, is present.

We appreciate the opportunity to be of service to you. Should you have any questions, please do not hesitate to contact us.

Sincerely yours,
Universal Construction Testing, Ltd.



Elena Emerson
Director of Laboratory



David B. Vollmer
Senior Consultant - Petrographic Services



Mark E. Hughes, P.E.
General Manager

mh-dv-ee / Report 14254

Samples will be discarded after ninety (90) days unless other disposition is requested by you.

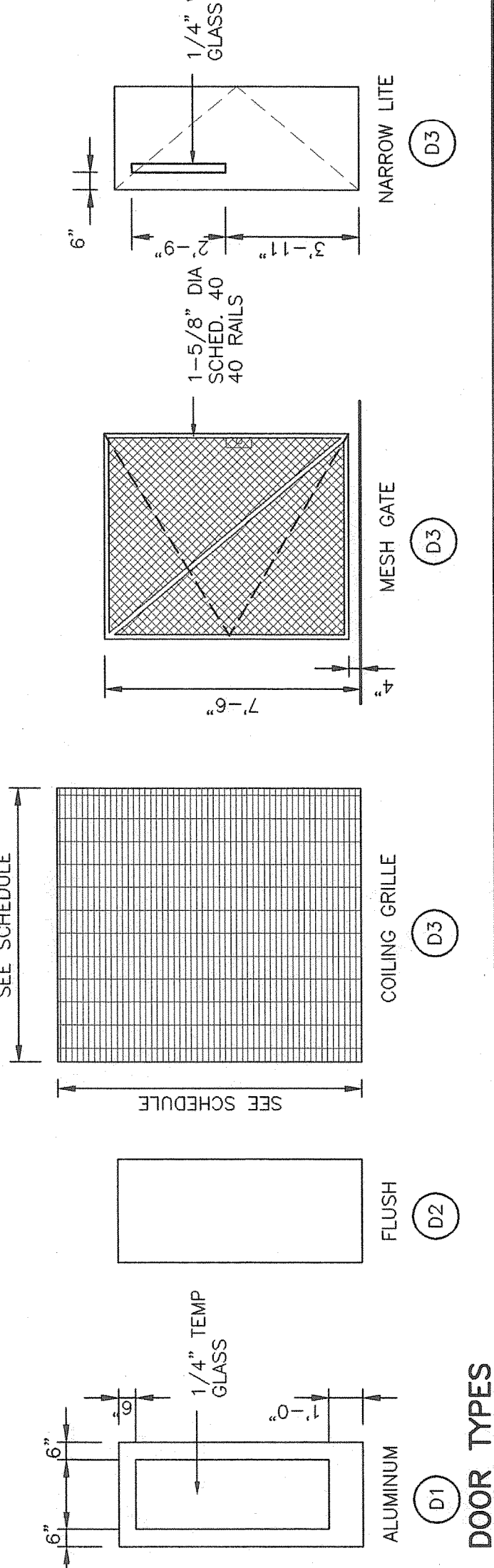
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PROJECT NAME:	High Hanover Parking Facility, Portsmouth, NH Walker N.: 16-2575.00 : Laboratory Studies of Samples	
DATE:	11-24-2014	



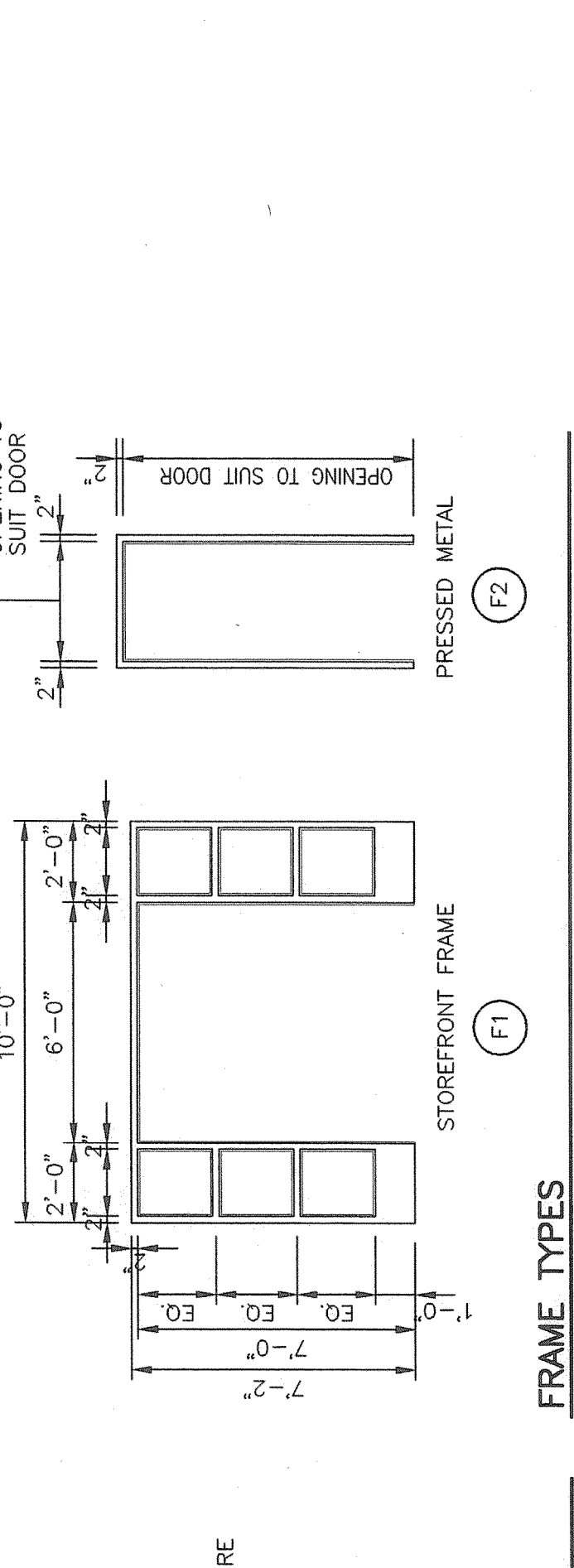
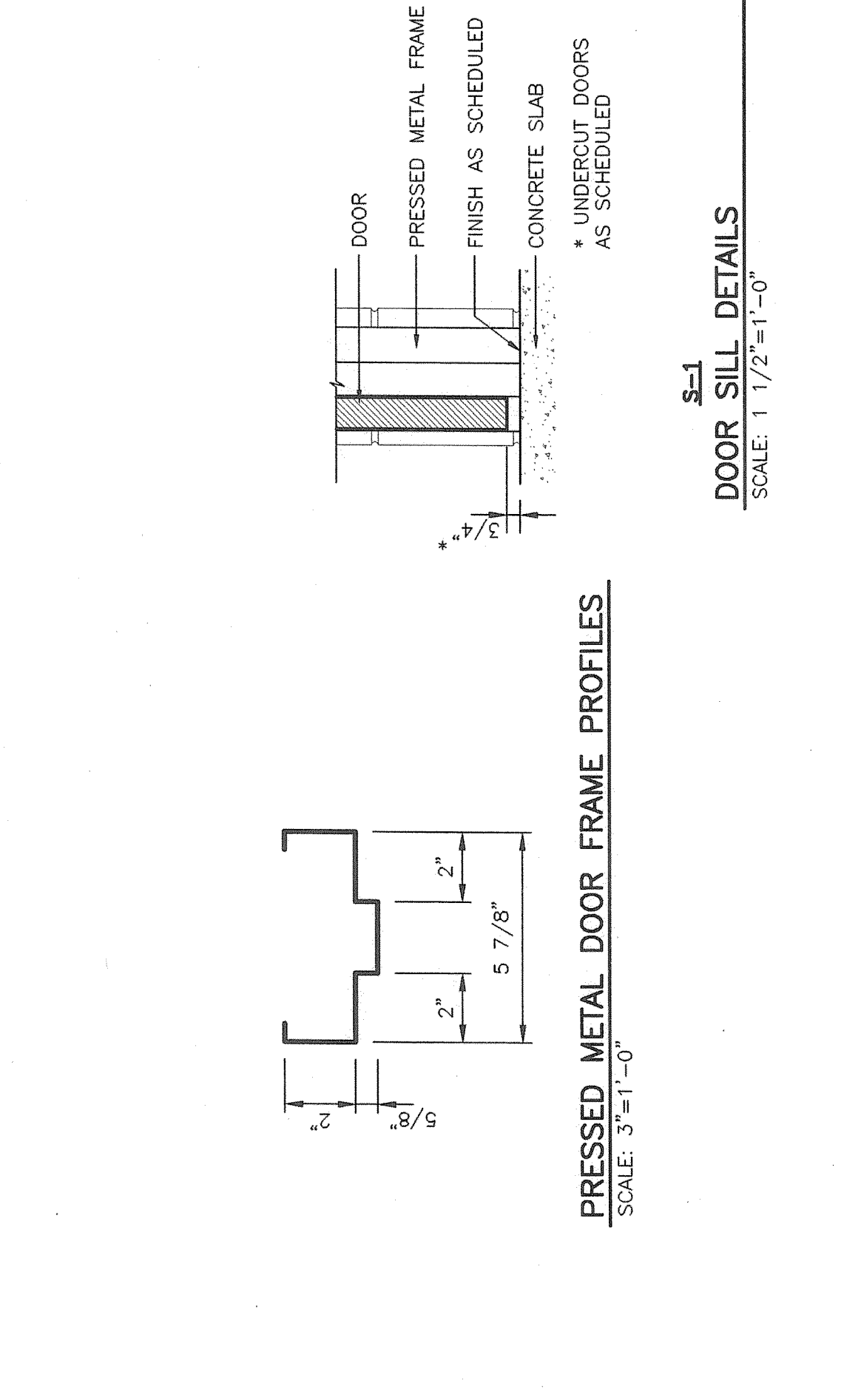
APPENDIX F – TYPICAL FLOOR PLAN DRAWINGS

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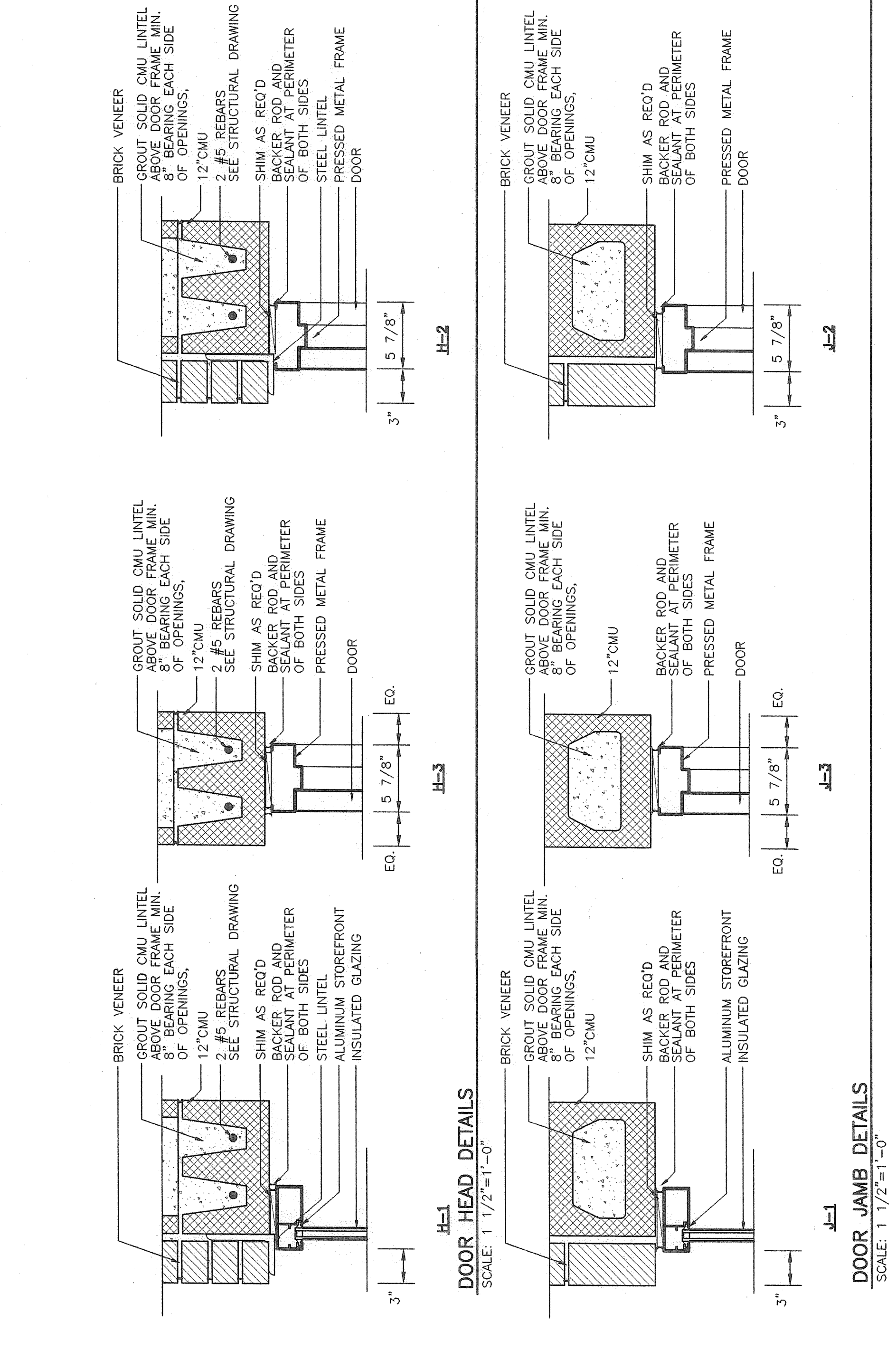
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NUMBER	SIZE	TYPE	MAT.	FIN.	U.L. LABEL	HEAD JAMB SILL	
101	3'-0" x 7'-0" x 1'-3/4"	D1	ALUM.	FAC.FIN.	F1	ALUM.	S-1
102	3'-0" x 7'-2" x 1'-3/4"	D2	METAL	PAINT	F2	METAL	S-1
103	3'-0" x 7'-2" x 1'-3/4"	D2	METAL	PAINT	F2	METAL	S-1
104	16'-0" x 0"	D3	STL	-	-	-	RELOCATED EXISTING DOOR
105	6'-0" x 7'-0"	D4	GAL.	STL	-	-	-
106	16'-0" x 12'-0"	D3	STL	-	-	-	-
301	3'-0" x 7'-2" x 1'-3/4"	D5	METAL	PAINT	F2	METAL	S-1
401	3'-0" x 7'-2" x 1'-3/4"	D5	METAL	PAINT	F2	METAL	S-1
501	3'-0" x 7'-2" x 1'-3/4"	D5	METAL	PAINT	F2	METAL	S-1



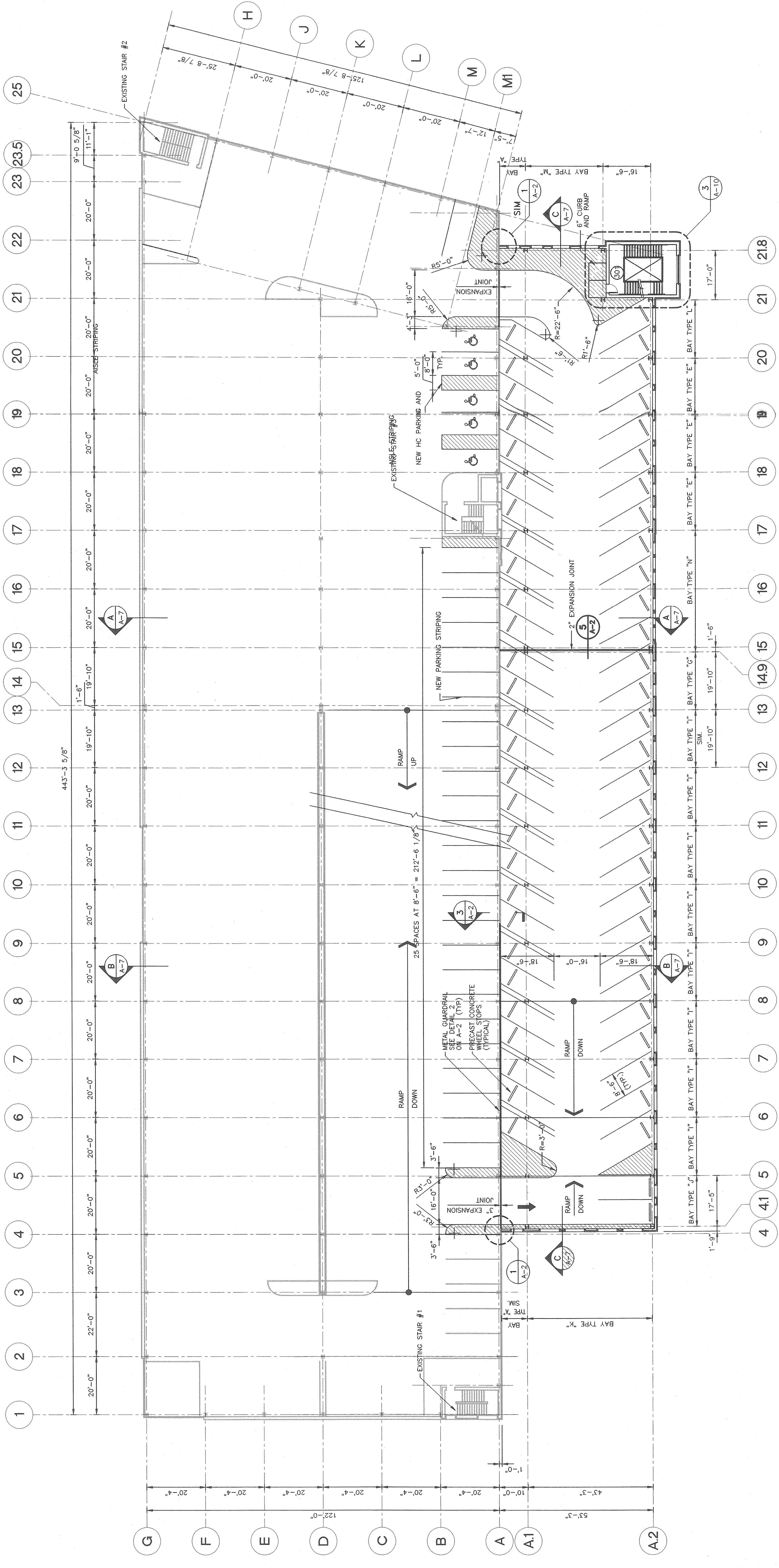
DOOR TYPES SCALE: 1/4"=1'-0"



SCALE: 3/4"=1'-0" SCALE: 1/2"=1'-0"

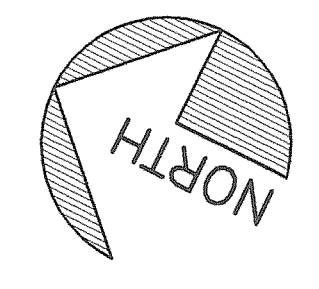


SCALE: 1/2"=1'-0"



A. THIRD LEVEL FLOOR PLAN SCALE: 1/16"=1'-0"

Revisions:
Approved:



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Proj. Mgr.: H.S.
Designed: EF
Drawn: FC
Checked: HCS
Scale: AS NOTED
Date: 10-29-99

CITY OF PORTSMOUTH
HIGH-HANOVER PARKING FACILITY EXPANSION
ARCHITECTURAL
THIRD LEVEL PLAN

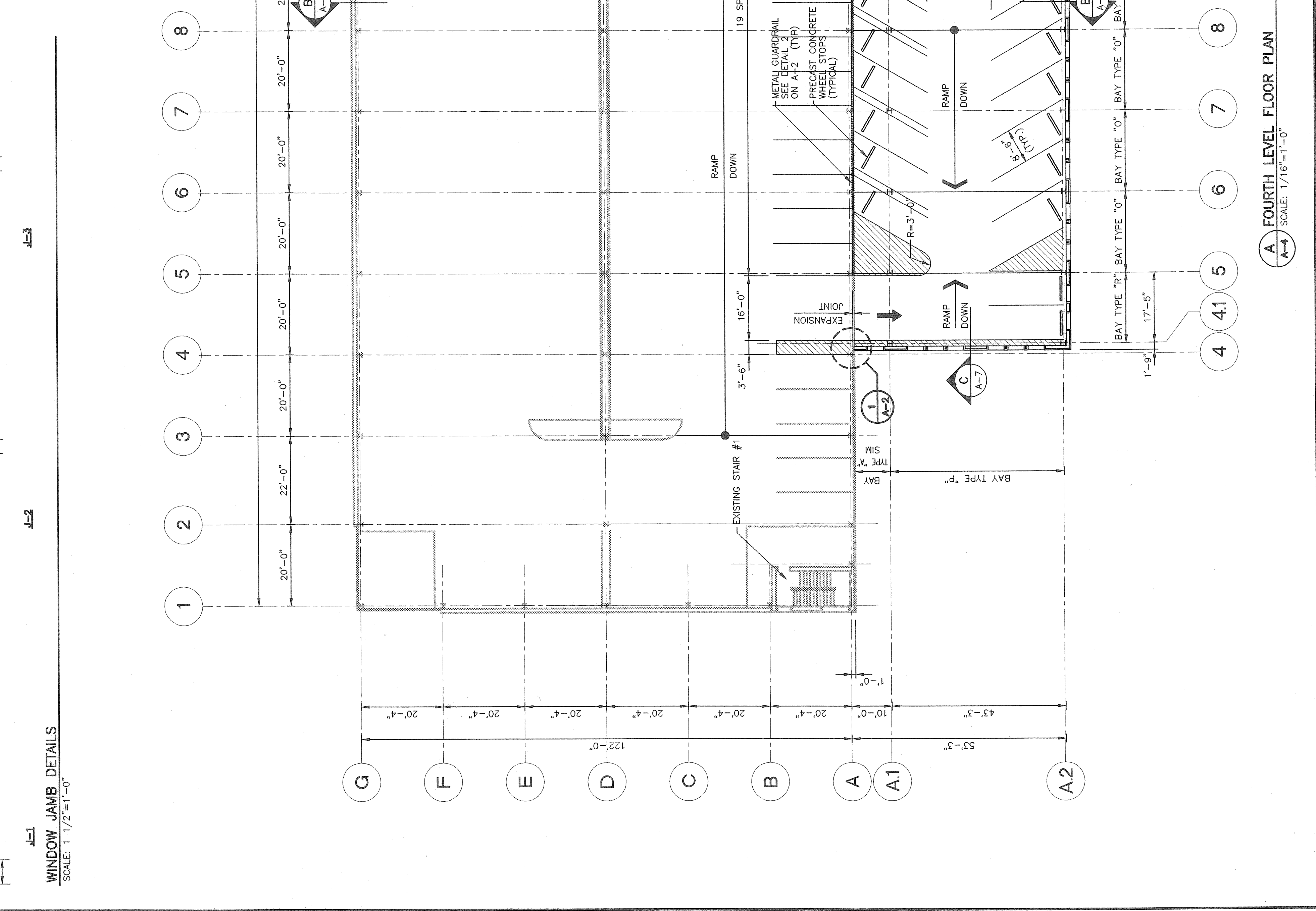
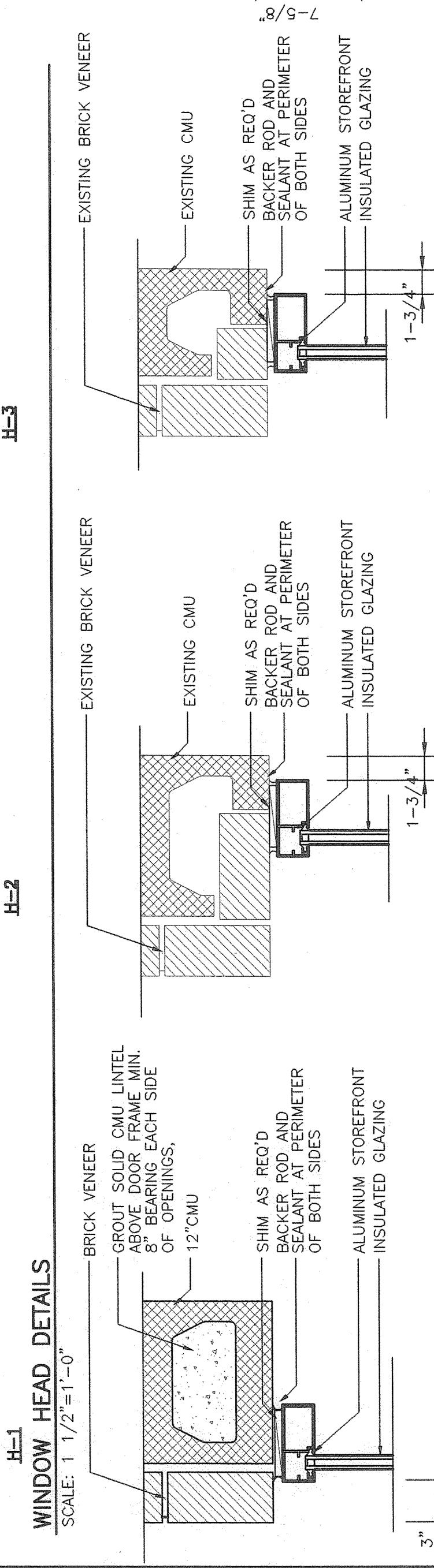
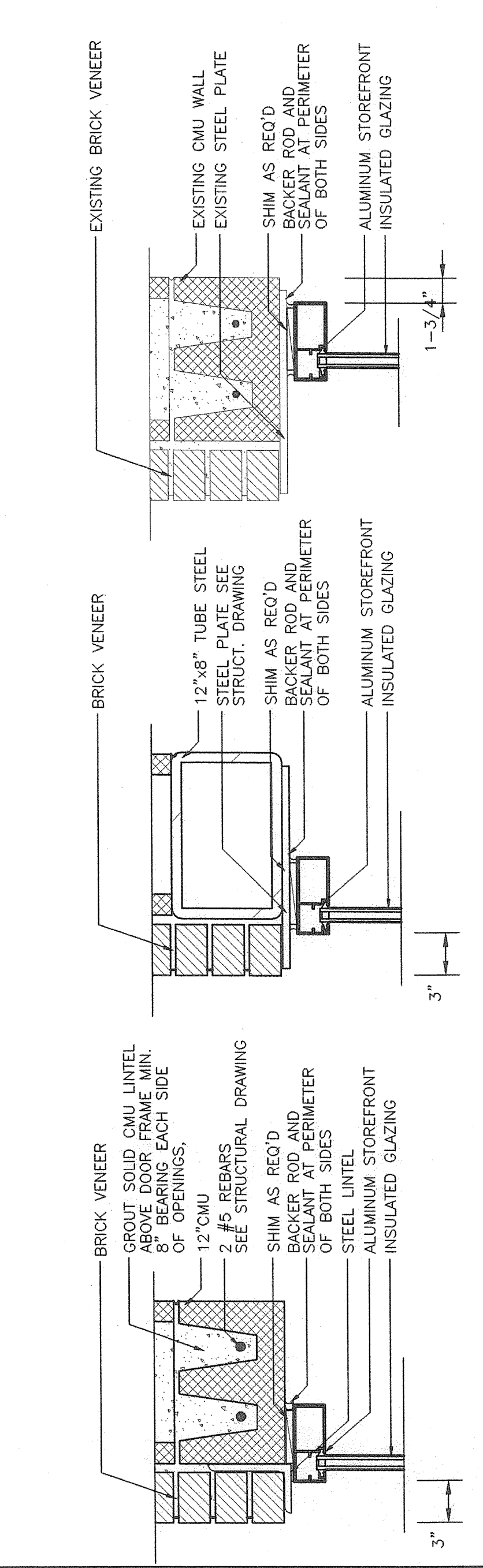
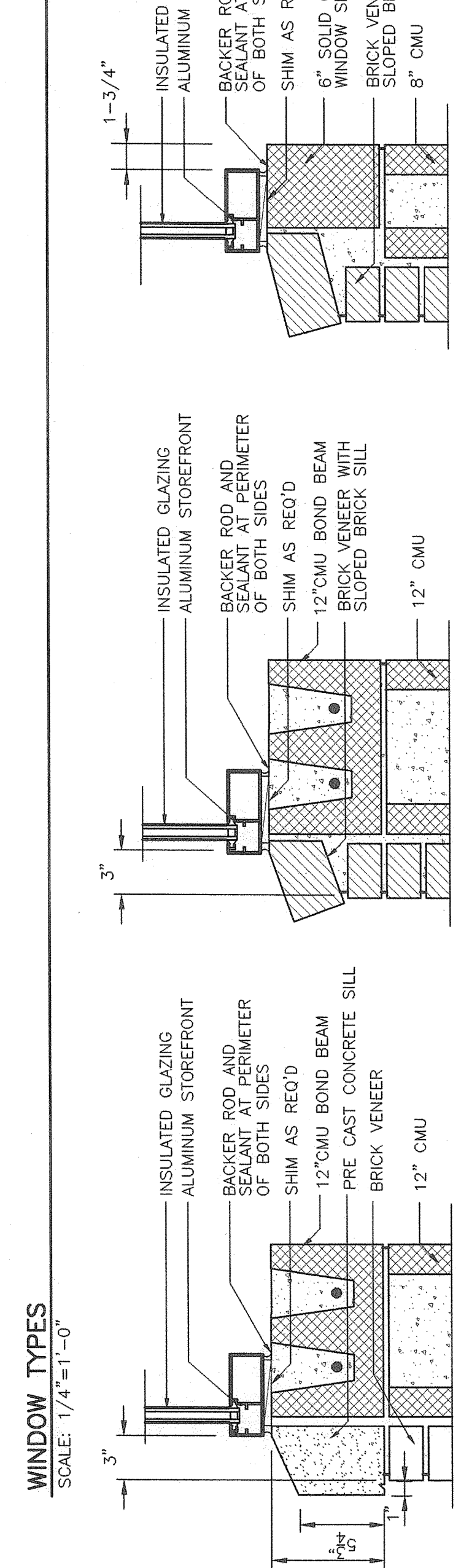
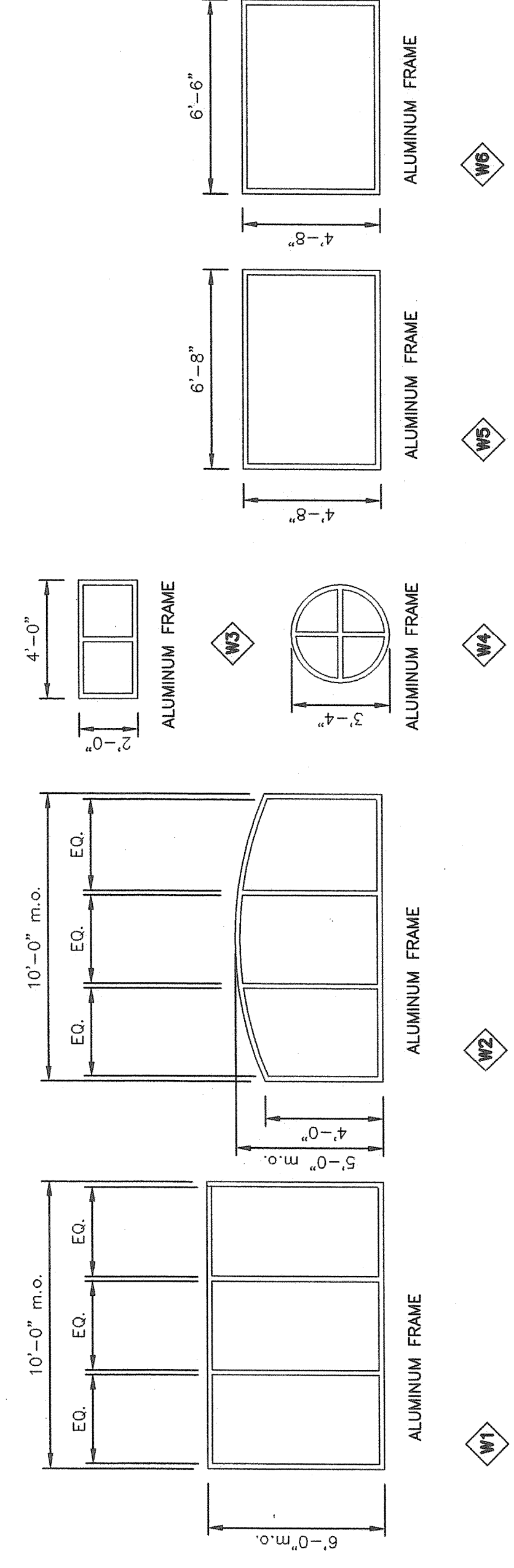
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Dwg. No.

A-3

100% SUBMITTAL - ISSUED FOR GMP OCT. 29, 1999

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ROOM FINISH SCHEDULE									
ROOM NUMBER	ROOM NAME	FLOOR MAT.	FLOOR FIN.	BASE MATERIAL	WALLS MAT.	WALLS FIN.	CEILING MAT.	CEILING FIN.	REMARKS
101	STAIR #4	CONC.	SEALER	CMU	CMU	PANT	EXP.	PANT	-
102	ELECTRICAL ROOM	CONC.	SEALER	CMU	CMU	PANT	G.W.B.	PANT	-
103	FUTURE ELEVATOR MACHINE RM	CONC.	SEALER	CMU	CMU	PANT	G.W.B.	PANT	-
104	STAIR #1 - FIFTH FLOOR	CONC.	SEALER	CMU	CMU	PANT	EXP.	PANT	-



A-4 FOURTH LEVEL FLOOR PLAN
SCALE: 1/16"=1'-0"

APPENDIX G – SCOPE OF SERVICES

I. SCOPE OF SERVICES

CONDITION ASSESSMENT & REPORT UPDATE

Walker will conduct a re-survey and detailed evaluation of the Hanover garage to update our opinion on the general conditions and determine what interim repairs and maintenance may be required to maintain safe continual operation over the next few years. The survey efforts will include a visual re-examination and sounding effort to acquire updated data on deterioration and deficiencies that have changed since the 2014 condition assessment with current conditions and findings. The information will be used to update and changes necessary in the conceptual repair approach and probable construction costs. The report update resulting from our evaluation and assessment will facilitate planning and funding for the project and will essentially be the "plan of action" and basis for advancing the and implementing the restoration program.

The condition assessment will be carried out by a team of experienced engineers from our Boston office, who are assigned full-time to Walker's restoration group.

The proposed scope includes the following:

1. Meet or teleconference with you prior to our survey to review scope, schedule, plan of action for work hours, and to coordinate our efforts with garage operations.
2. Review available original construction plans, specifications, previous repair documents and reports completed for this garage to re-familiarize our understanding of the garage design, construction, and repair history.
3. Conduct a field examination of the physical condition of the structural elements that include:
 - a. Review of all supported parking levels by visual examination of floor surfaces and underside to locate and document concrete deterioration (spalling, scaling, cracking formations, leaching, leaking, joint conditions,) and other deficiencies that are effecting the performance of the parking structure.
 - b. Performing a limited "chain drag" sounding (delamination) survey of the accessible areas of the supported parking levels to identify and quantify subsurface, corrosion-induced delamination that may not yet be visible. The sounding will also be used to examine the extent of areas of the concrete topping bond separation with the precast floor panels in comparison to the prior report findings.
 - c. A visual examination and selective hammer tap sounding will be performed on columns and walls to identify and quantify cracking, leakage, and concrete deterioration.
 - d. Visually examining the structural steel framing to determine the locations and extent of corrosion and paint damage that may be cause to potential loss of cross-sectional area of the structural steel where immediate repairs may be required.
 - e. Visually examine the cast foundation walls to identify cracking, and leakage if present and other concrete deterioration forms.

4. Perform a visual examination of non-structural systems of the facility including:
 - a. The exterior masonry façade, bumper walls, and similar construction.
 - b. Waterproofing components such as traffic topping, crack and joint sealants, and expansion joint seals that are in place to determine their condition and remaining service life.
 - c. Stairs and elevator tower, hand railing, guardrails and other architectural features for visual deterioration that require corrective repairs.
 - d. Examine the condition of floor drains and drain risers and identify any areas where interim repairs may be necessary and where supplemental drainage improvements are appropriate.
 - e. General review of the electrical system.
 - f. Examine the condition of fire protection lines to identify any areas where corrosion damage may require repair to these lines.
5. Prioritize interim repairs required to maintain safe operations.
6. Following the completion of our field examination, Walker Consultants will issue a Draft Report of the Condition Appraisal Update to the City of Portsmouth for their review and comments. The report will include:
 - Executive Summary
 - Observations and findings
 - Discussion on repair requirements and program alternatives
 - Comparison of repair alternative methods
 - Updates to the Opinion of Probable Construction Costs
 - Priorities associated with the recommended repairs
 - Recommendations on selection of a repair alternative
 - Schedule for implementation of repairs including phasing concepts over a multi-year plan
 - Maintenance recommendations to extend the service life of the structure and protect the investment following program implementation.

END OF REPORT

DRAFT