SIMPSON GUMPERTZ & HEGER
Engineering of Structures
and Building Enclosures

4 October 2016

Mr. Jeffrey Novak
Construction Project Manager
Office of Planning, Design and Construction
Division of Capital Asset Management and Maintenance
One Ashburton Place
Boston, MA 02108

Project 111409.71 – Structural Conditions Assessment, McCormack Building Garage, One Ashburton Place, Boston, MA

Dear Mr. Novak:

At your request, we conducted a condition assessment of garage Levels 1, 2, 3 and 4 at One Ashburton Place in Boston, Massachusetts. This report summarizes our findings, conclusions, and recommendations.

1. INTRODUCTION

The parking garage was constructed in 1972, and is a four-level underground reinforced concrete structure below the McCormack Building. Level 1 is at street elevation, and Level 4 is the lowest level on grade. According to the original structural drawings, prepared by Hoyle, Doran, and Berry Inc., dated 1 June 1970, the parking garage is mainly constructed of cast-in-place waffle slabs supported on concrete columns and concrete walls. However, at the parking garage entrance/exit and the loading dock, the deck is constructed with a one-way concrete slab supported on concrete beams and columns. There is an internal ramp connecting all levels. Vehicular entry/exit to the parking garage is located on Bowdoin Street. The loading dock area is located adjacent to the parking garage entrance/exit.

As part of the parking garage repair construction in 1992, an impressed-current cathodic protection system was installed in a topping slab at all areas of Levels 1, 2, and 3, except the vehicular entry/exit area, connecting ramps, and loading dock.

We conducted a survey of the garage, including visual observations and sounding with chains and hammers of the topside and underside of all levels, columns, walls, and stairwells. We extracted four concrete core samples to test for chloride content. Vector Corrosion Services (Vector) evaluated the impressed-current cathodic protection system (ICCP) on Levels 1, 2 and 3.

2. FIELD INVESTIGATION

In July 2016, Simpson Gumpertz & Heger Inc. (SGH) visited the site to survey the condition of the concrete slabs, columns, walls, and stairwells on Levels 1, 2, 3, and 4 of the parking garage. Our methods included visual inspection, as well as sounding with chains on the topside of the slabs, and sounding with hammers on the columns and walls to identify and locate the extent of deteriorated concrete. We documented our findings on the drawings and with photographs. Included in this report are representative photos that depict typical conditions we observed during our survey. Our condition survey findings are summarized below.

We documented 9,014 sq ft of topping slab concrete that is debonded (6% of the total slab area) and 1,829 sq ft of underside concrete delamination of the slabs (1% of the total slab area). We also documented 1,065 sq ft of topside concrete delamination of the ramps (13% of the total ramp area) and 29 sq ft of underside concrete delamination of the ramps (1% of the total slab area). The table below summarizes our observations per floor.

Floor	Total Area (sq ft)	Debonded Topping Slab (sq ft)	%	Underside Delamination (sq ft)	%
1	50,790	2,576	5	448	0.9
2	44,590	2,286	5	519	1.2
3	44,590	4,152	9	862	1.9
Total	139,970	9,014	6	1,829	1.3

Ramp	Total Area (sq ft)	Topside Delamination (sq ft)	%	Underside Delamination (sq ft)	%
1 to 2	2,760	186	7	0	0
2 to 3	2,760	411	15	29	1
3 to 4	2,760	468	17	0	0
Total	8,280	1,065	13	29	

- There is unsound concrete topping at many locations on the topsides of the parking garage floor slabs where the topping is debonded from the structural slab. Some areas are significant in size ranging from 1 sq ft to 900 sq ft (Photos 1 and 2). Refer to Figures 1 through 3 for locations.
- There are many locations on the underside of the slabs where the concrete ribs are delaminated or spalled, with exposed steel reinforcement ranging from 1 sq ft to 25 sq ft (Photos 3 and 4). Refer to Figures 1 through 3 for locations.
- Many previous concrete repairs are failed on the undersides of the slabs. At some locations, the concrete deterioration extends beyond the edge of the previous repair (Photo 5).
- There are cracks with efflorescence on the undersides of the concrete slabs (Photo 6).
- There are locations where the walls and columns are deteriorated (Photo 7).
- There is concrete deterioration in the stairwells at topside and underside of landings, at walls (Photos 8 and 9).
- There is no vehicular-traffic-bearing waterproofing (VTBW) on the slabs.

On July 11 and 12, 2016 Mr. Matthew Miltenberger, P.E. and Certified CP specialist, visited the garage to conduct the ICCP system evaluation. Mr. Miltenberger met with SGH representatives

Paul Millette and Tyler Meek, along with the building maintenance electricians who opened the rectifier cabinets to allow observations of the overall condition of the rectifier units, and to identify the electrical panel and circuit breakers providing electrical power to the rectifiers.

In each cabinet, a circuit diagram, a floor plan, and a rectifier manual were present. These documents were reviewed and photographed for reference. A marked-up floor plan for each level identifying the zone layout is included in Appendix A of the Vector report.

At each rectifier, the general assessment included the following:

1. Obtain the manufacturer, manufacture date, model, and serial number of the rectifier.
2. Review the documents to identify the wiring and zone layout.
3. Evaluate the "As-Found" condition and collect measurements using the rectifier meters.
4. Conduct basic troubleshooting steps to identify if the rectifiers were functional.
5. Conduct electrical continuity tests to determine if the system wiring in the slab is functional.
6. Conduct energizing tests using an external power supply to evaluate system performance using the embedded reference electrodes.

Vector's noted the following regarding the rectifiers at each level:

- On Level 1, the rectifier was operating, but neither the DC voltage nor DC current supplied could be adjusted.
- On Level 2, the rectifier was not operating. AC power was turned on, but the main breaker had melted and the AC wiring is severely corroded.
- On Level 3, the rectifier was not operating. AC power was turned off. Once energized, neither the DC voltage nor DC current supplied could be adjusted.
- Level 1 and Level 3 measurements were obtained using the meters housed on the rectifiers with confirmation using a portable calibrated Fluke 289 multimeter. The Level 2 rectifier meters were unstable, but measurements were not obtained due to the melted main.
- The rectifier meters for Level 1 were not stable. The values obtained from the rectifier meter fluctuated widely by more than +/- 0.2V or +/- 0.05A. The meter switch appeared to have been overheated at some point in time based on a brown discolored spot on the back of the meter. Values obtained with the portable multimeter were stable, so the meter appears to have been compromised.
- The rectifier meters for Level 3 were stable and accurate compared to the multimeter.

- Wiring for the structure (DC system negative) connections was found to be continuous with the exception of Zone 2 on Level 1 and Zone 6 on Level 2.
- Structure connections were mostly continuous with the reference electrode sense, test, or ground connection. Failed test connections were located on Level 1, Zone 4A; and Level 2, Zones 6A and 6B.
- The anode wiring on each level was found to be functional and no short circuits were identified.
- Reference electrodes were functional, with the exception of Level 1, Zones 2A and 2B; Level 1, Zone 4A; Level 2, Zone 6A; and Level 3, Zone 4B. The construction submittal indicated the reference electrodes were silver/silver chloride, but the electrolyte concentration was not noted.
- Rectifier control circuits were not operable. The adjustment is conducted using a multi-turn potentiometer with the control circuits housed on a circuit board. This circuit board has a remote dial up functionality, that appears to be operable, but no one knew of any data or how to communicate with the unit. During testing, the switch was in the "Manual" position, and no channel on any rectifier responded to manual adjustment. The rectifier is rated at 24V, but the maximum voltage measured at any time was 3.3V.

Vector's full evaluation method, findings, and recommendations are included in their 18 July 2016 report, attached.

3. LAB EVALUATION

On 24 August 2016, SGH visited the site to core four samples of the concrete slabs. We cored one sample in each of the three ramps (Photos 10 through 15) and one in the loading dock (Photos 16 and 17). We tested the cores in accordance with ASTM C1152/C1152M-04(2012)e1 – Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete with one modification. ASTM C1152 designates the use of methyl orange to check the pH. Methyl orange changes color from yellow to red across pH 4 to 3, which we have found difficult to accurately detect. Instead, we use litmus paper with a range of pH 0 – 3, which dramatically changes color from blue to yellow, to check the acidity of each solution.

Our calculated chloride ion contents for each test sample are as follows:

Sample ID	Depth (in.)	Chloride Content in Sample (% by weight)
L1	1/4 – 3/4	0.1424
L1	1-1/4 – 1-3/4	0.0761
R2	1/4 – 3/4	0.2108
R2	1-1/4 – 1-3/4	0.0655
R3	1/4 – 3/4	0.0473
R3	1-1/4 – 1-3/4	0.0273
R4	1/4 – 3/4	0.1523
R4	1-1/4 – 1-3/4	0.2122

Refer to the attached SGH 25 August 2016 Laboratory Report for information.

4. DISCUSSION

4.1 Deterioration Mechanisms

In our 6 January 2016 letter, we give a detailed explanation of how chlorides in deicing salts react with the reinforcing steel, resulting in bursting tensile stresses within the concrete. These tensile stresses cause delamination and eventually spalling of the concrete. Delamination is an indication that corrosion is present and spalling imminent. Once delamination occurs and spalling begins, air, moisture, and chlorides can attack the bar surface and deeper regions of the concrete more easily, and the deterioration process accelerates.

In parking structures that are exposed to deicing salts, the chloride concentration at the depth of the reinforcing steel increases with time. Corrosion begins in the presence of oxygen and moisture above a threshold chloride amount. The generally accepted threshold for accelerated corrosion of uncoated reinforcement is roughly 1.25 lbs of chlorides per cubic yard of concrete, or 0.029% chloride by weight of cement (assuming a six cement bag mix). Once the concrete is chloride-contaminated, further ingress of chlorides and moisture increases the rate of corrosion.

All of the concrete core samples show chloride content above the 0.029% threshold. We analyzed each core at two depths, one depth near the surface and one depth near the location of the steel reinforcement. We anticipate that the chloride content would be higher at shallower depths, as shown from Samples L1, R2, and R3. The chloride concentration trend was reversed for Sample R4, meaning the chloride content was higher at the deeper test depth.

Impressed-current cathodic protection is a technique used to control the corrosion of the embedded steel reinforcement by making it the cathode of an electrochemical cell, essentially reducing the corrosion rate of the steel by reducing its corrosion potential. Impressed-current systems employ inert anodes and use an external source of DC power to impress a current from an external anode onto the cathode surface. The impressed current cathodic protection system employed in the garage was a mixed metal oxide (MMO) coated titanium mesh embedded in a latex-modified concrete. The MMO mesh used was an Elgard 150 mesh with a current capacity of 1.75 mA/SF. The concrete overlay was installed to protect the MMO that was installed at the top of the structural slab and varies in thickness. The ICCP system was designed to protect only the top layer of reinforcing steel, the bottom reinforcing steel in the ribs was not intended to receive cathodic protection, but may have received some benefit when the system was operating properly.

The ICCP system on each floor was powered by a central rectifier with multiple channels. Each channel powered an independent zone, which ranged in floor surface area between 3,550 SF to 6,450 SF. The quantity of zones and zone numbering sequence varied by floor. A remote monitoring system was also installed to monitor the ICCP system. It is not known when the remote monitoring system was taken out of service. No records were available for review.

The topping slab that protects the MMO is debonded from the structural slab in many areas. It is not know at this time if there is deterioration of the steel reinforcement in the structural slab that causes the topping to debond. A renovation project that includes removal of debonded topping and the securing of the MMO to the structural slab is needed to extend the useful life of the garage.

Refer to the attached Vector report for further information on the existing impressed-current system.

4.2 Rehabilitation

Localized repair of deteriorated and delaminated concrete is necessary to maintain the parking garage slabs and extend the useful life of the structure. The repairs identified during our investigation are typical for garages in cold climates.

Cathodic protection and vehicular-traffic-bearing waterproofing (VTBW) are two of the methods often employed for concrete protection. A cathodic protection system (either impressed-current or galvanic) promotes the chloride ions to migrate away from reinforcing steel and toward a sacrificial element. The sacrificial elements keep the concrete in its alkaline environment and reduce steel corrosion. A VTBW system reduces the amount of salt-laden water that permeates the concrete, and therefore reduces corrosion. Parking garages with significant traffic should implement and maintain a concrete protection system to reduce ingress of salt-laden water to extend the useful life of the structure.

In our experience, the heavy traffic areas will lead to ever-increasing amounts of corrosion damage until a new protection system is installed. Repair of the ICCP system in localized areas will also slow the rate of deterioration and extend the useful life of the structure. Consequently, postponing installation of new protection system and repair of the ICCP system will result in higher concrete repair costs.

Based on our inspection, we identify the following scope of remedial work:

- Repair deteriorated/delaminated concrete on the topsides and undersides of concrete slabs. At some locations where the topside and underside damage overlaps, full slab thickness repairs are likely. Install sacrificial galvanic anodes within some of the repair underside repair areas.
- Remove and replace areas with debonded topping. Repair MMO in areas with debonded topping.
- Repair deteriorated concrete at concrete walls, columns, and stair landings. Install sacrificial galvanic anodes within the repair area.
- Rout and seal the cracks at the topside of the parking deck.
- Install a VTBW system at all areas of Levels 1, 2, 3 and ramps
- Install a penetrating sealer on Level 4.
- Repair or replace the ICCP system at each of the parking garage slabs. Repair ICCP system at certain zones where chloride contamination is low and corrosion potential is high.

- Implement an ICCP system and/or heavy-duty VTBW at the garage entrance/exit area and loading dock slab.

5. COST ESTIMATES

We estimate the cost of construction for concrete repairs and waterproofing to be $3,150,000. This includes concrete repair and a new VTBW system at each level. We include the option of repairing and upgrades to the existing cathodic protection system. Our estimated work sheet is attached. Please note that these costs are based on conceptual designs. The actual construction cost may vary from these estimates for many reasons, including, but not limited to, changes during design development and final design and the business climate at the time of bidding and construction.

6. CONCLUSIONS

Based on the current conditions of the concrete slabs at the parking garage, repairs to the existing areas of concrete deterioration are required at this time to limit the future extent (acceleration) of deterioration of the slabs and increase the remaining useful life of the structure.

7. RECOMMENDATIONS

We recommend the following repairs:

- Implement the remedial work described in Section 4.2 of this report.
- Prepare drawings and specifications for repairs suitable for pricing and bidding.
- Specify materials with a proven track record of performance in similar applications.
- Follow the manufacturer's written instructions on surface preparation of the substrate surface before implementing repair.

Sincerely yours,

Greggrey G. Cohen, P.E.
Principal
MA License No. 37140

Paul M. Millette
Senior Project Supervisor

I:\BOS\Projects\2011\111409.71-ASHB\WP\001GGCohen-L-111409.71.sco.docx

Encls.

Photo 1

Area of debonded topping slab.

Photo 2

Area of debonded topping slab.

Photo 3

Underside deterioration at rib.

Photo 4

Underside deteioration with exposed steel reinforcement.

Photo 5

Underside concrete deterioration at previous repair.

Photo 6

Crack on underside of slab with efflorescence.

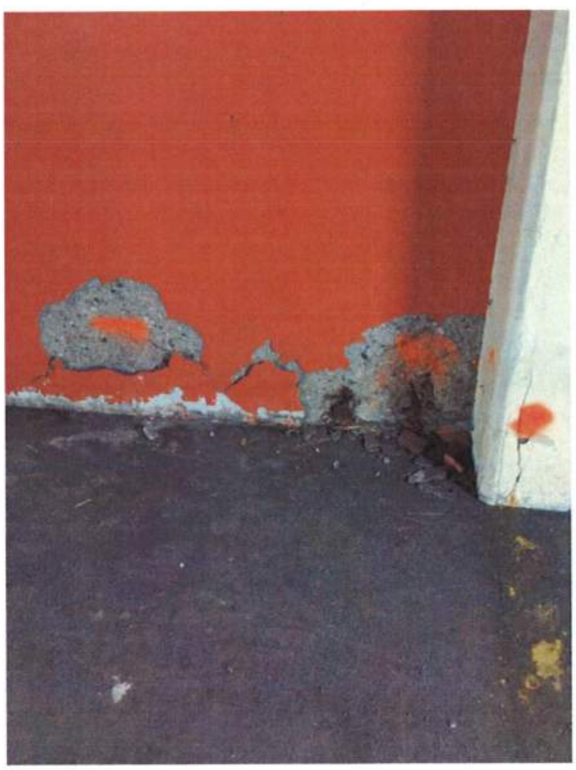


Photo 7

Deterioration at base of concrete wall and column.

Photo 8

Deteriorated concrete at topside of stair landing.

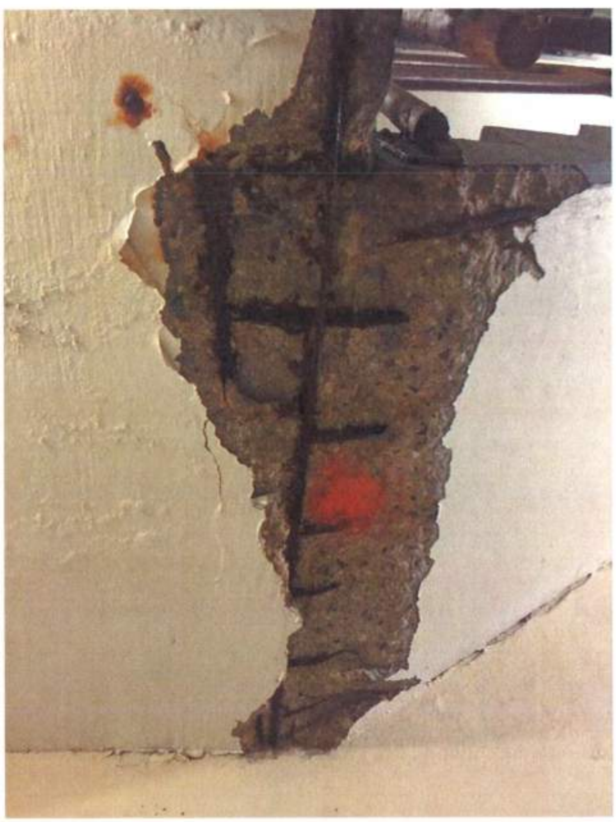


Photo 9

Deteriorated concrete at underside of stair landing.

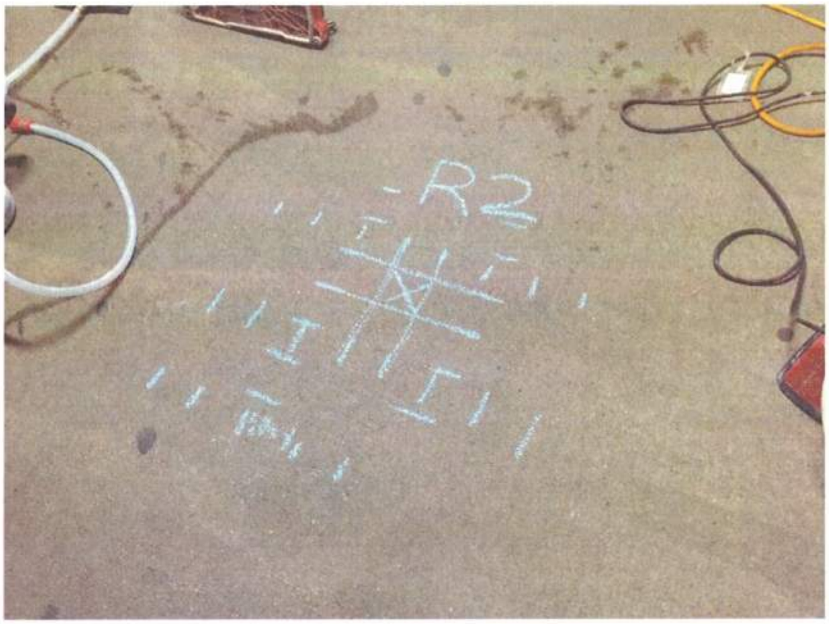


Photo 10

Ramp 2 core location.

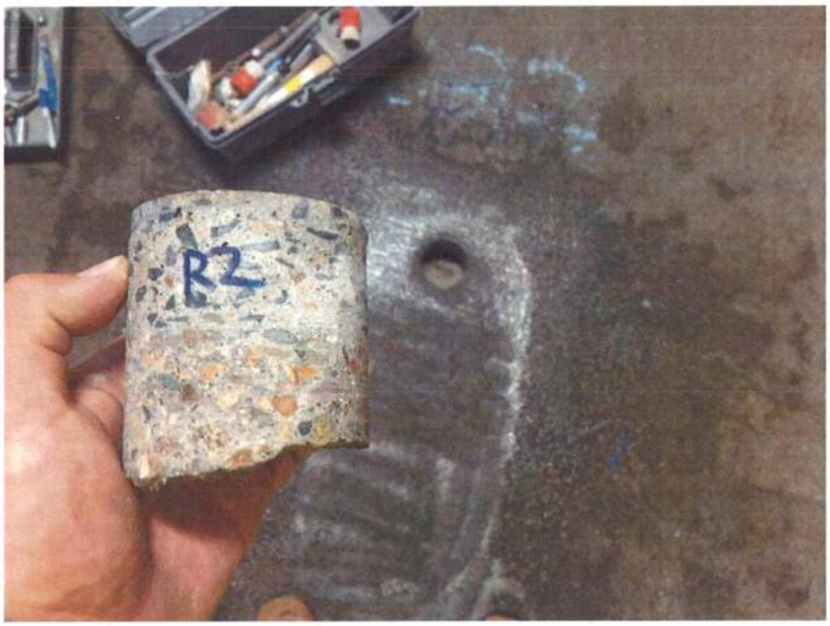


Photo 11

Ramp 2 core sample.

Photo 12

Ramp 3 core location.

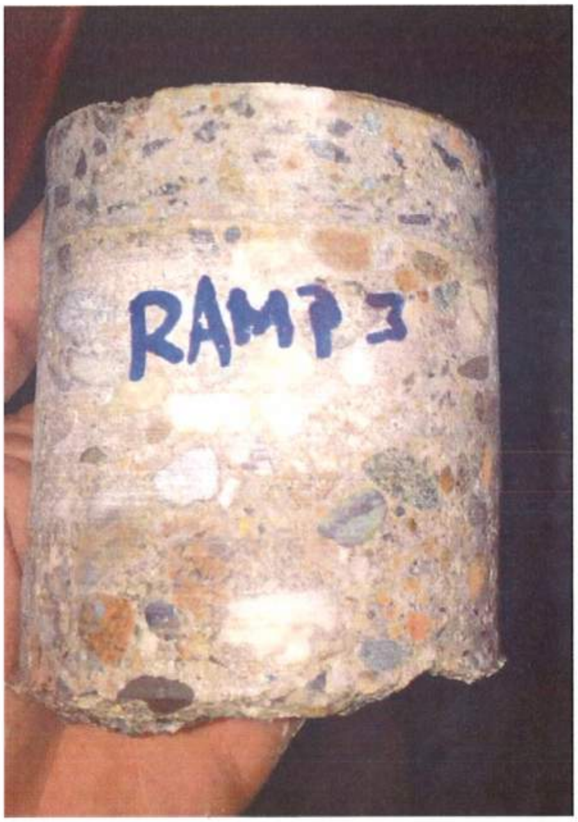


Photo 13

Ramp 3 core sample.

Photo 14

Ramp 4 core location.

Photo 15

Ramp 4 core sample.

Photo 16

Loading dock core location.

Photo 17

Loading dock core sample.

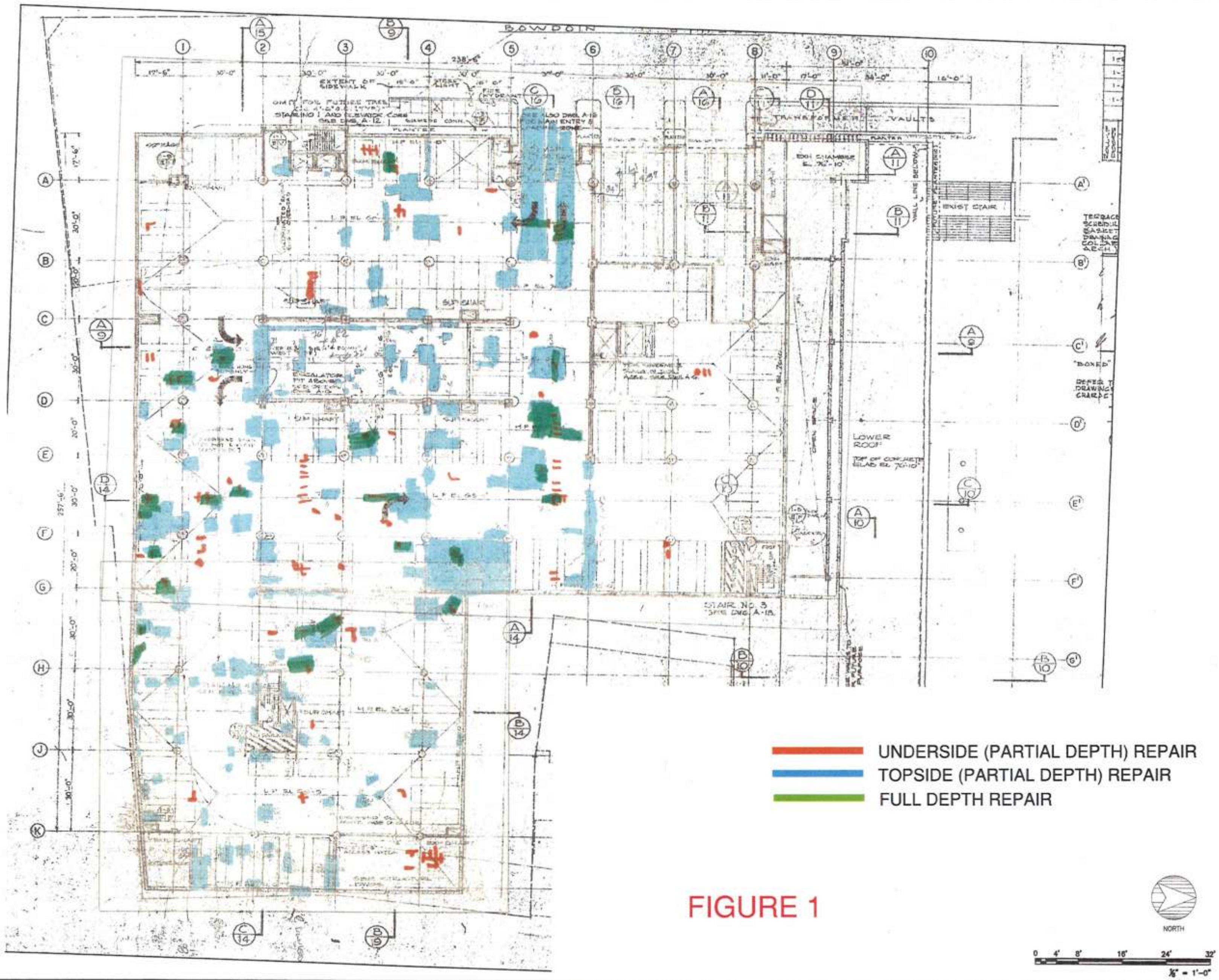


FIGURE 1

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures
Simpson Gumpertz & Heger Inc.
41 Seyon Street, Building 1, Suite 500
Waltham, Massachusetts 02453
main: 781.907.9000 fax: 781.907.9009
www.sgh.com
Boston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

CONSTRUCTION DOCUMENTS

No.	Date	Description	By

Project

McCORMACK BUILDING

2016 PARKING GARAGE REPAIRS

1 Ashburton Place
Boston, MA 02108

Drawing Title

FIRST LEVEL FLOOR PLAN

Project No. 111409.71	Checked PPM	Date 08.17.2016
Drawn BBR	Approved	Scale AS SHOWN

Drawing No.

GR-9

Seal

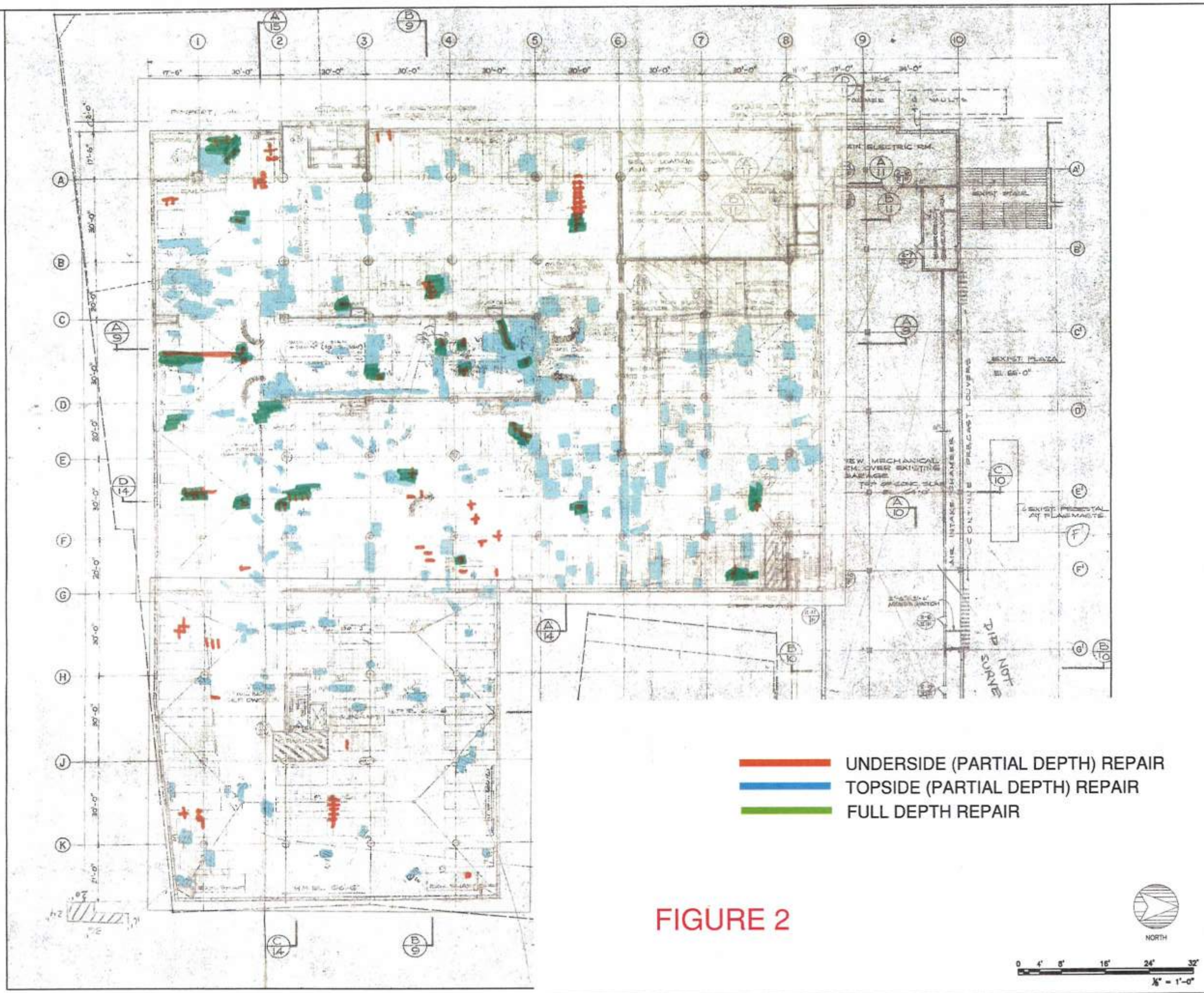


FIGURE 2

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
41 Seyon Street, Building 1, Suite 500
Waltham, Massachusetts 02453
main: 781.907.9000 fax: 781.907.9009
www.sgh.com
Boston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

CONSTRUCTION DOCUMENTS

No.	Date	Description	By

McCORMACK BUILDING

2016 PARKING GARAGE REPAIRS

1 Ashburton Place
Boston, MA 02108

Project

SECOND LEVEL FLOOR PLAN

Drawing Title

Project No. 111409.71	Checked PPM	Date 08.17.2016
Drawn BBR	Approved	Scale AS SHOWN

Drawing No.

GR-10

Seal

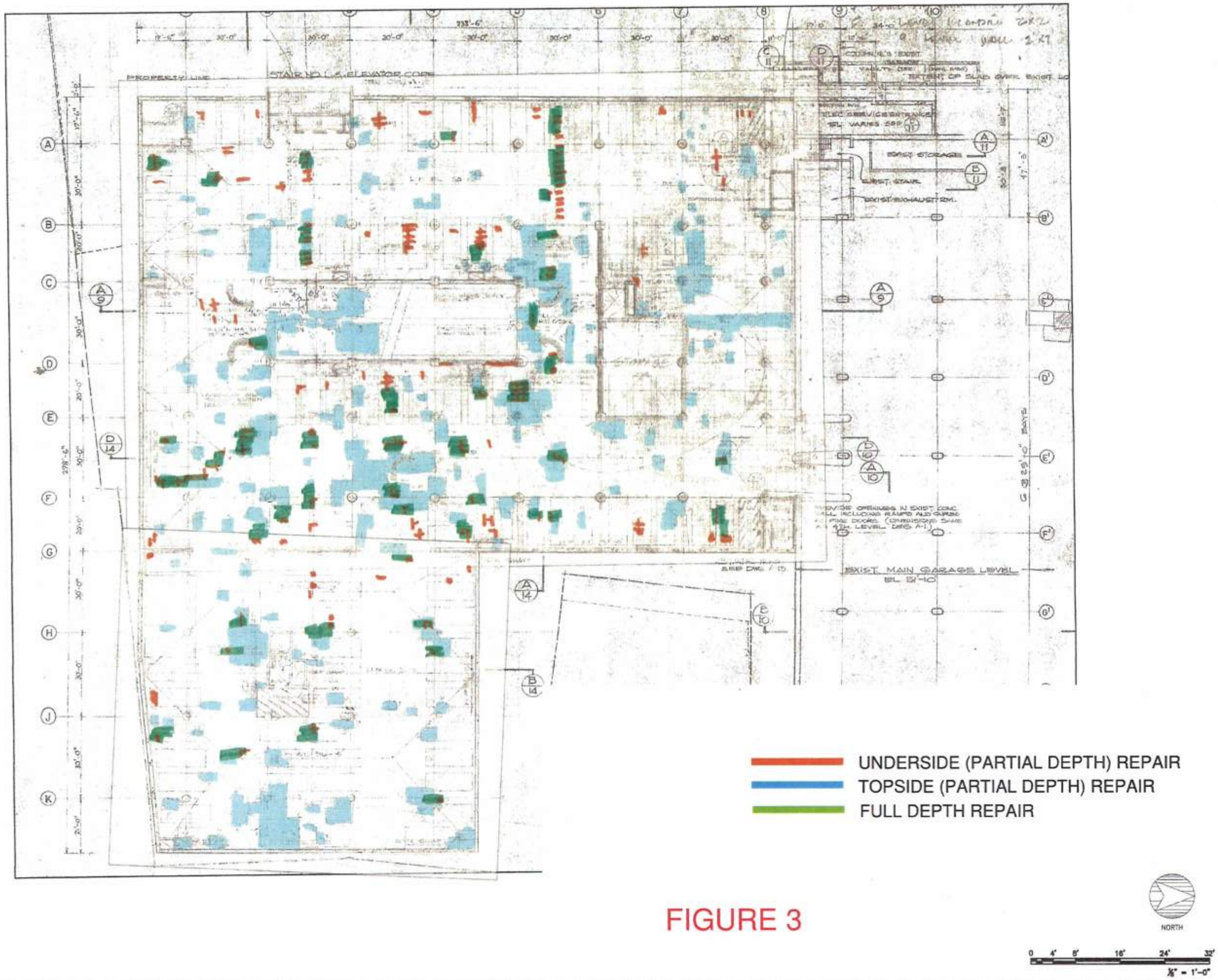


FIGURE 3

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

Consultant

CONSTRUCTION DOCUMENTS

No.	Date	Description	By

McCORMACK BUILDING

2016 PARKING GARAGE REPAIRS

1 Ashburton Place
Boston, MA 02108

Project

THIRD LEVEL FLOOR PLAN

Drawing Title

Project No. 111409.71	Checked PPM	Date 08.17.2016
Drawn BBR	Approved	Scale AS SHOWN

Drawing No.

GR-11

Seal

ICCP OVERLAY EVALUATION REPORT
MCCORMACK BUILDING GARAGE,
1 ASHBURTON PLACE, BOSTON, MA 02108

Prepared for:
Paul Millette
Simpson Gumpertz & Heger
41 Seyon Street, Building 1, Suite 500
Waltham, Massachusetts 02453

Prepared by:
Matt Miltenberger, P.E.

VCS Project 12W16038MA

Vector Corrosion Services, Inc.
1936 Bruce B. Downs Blvd, Suite 315
Wesley Chapel, FL 33544
Phone: (813) 501-0050
www.vectorcorrosionservices.com

July 18, 2016

Background

The McCormack Building is a Government Center building with an underground garage. The building was built in 1972. The garage floor system is a two-way 24x24 inch waffle slab with 14-inch total slab depth. The slab is 4 inches thick with 19x19x10 inch pans that form ribs. The waffle ribs are 5 inches wide and contain two bottom bars of various sizes from #5 to #9 based on the location in the slab. The top slab reinforcing is primarily #5 at 24 inches on center with additional #5 to #9 reinforcing bars every 12 to 24 inches on center over the column strips. The calculated top reinforcing steel surface area ratio varies between 0.2 $ft^{2/}$ ft^2 at mid span to over 0.7 ft^2 of steel surface area for every 1.0 ft^2 concrete surface area over columns.

An impressed current cathodic protection (ICCP) system was installed in 1992. The three structural waffle slabs in the garage were included, but the fourth lowest level slab on grade was excluded from the system. The impressed current cathodic protection system employed was a mixed metal oxide (MMO) coated titanium mesh overlay using latex-modified concrete. The MMO mesh used was an Elgard 150 mesh with a current capacity of 1.75 mA/SF. The concrete overlay thickness was not known at the time of the evaluation. The ICCP system was designed to protect only the top layer of reinforcing steel, the bottom reinforcing steel in the ribs was not intended to receive cathodic protection, but may have received some benefit when the system was operating properly.

The ICCP system on each floor was powered by a central rectifier with multiple channels. Each channel powered an independent zone, which ranged in floor surface area between 3550 SF to 6450 SF. The quantity of zones and zone numbering sequence varied by floor. A remote monitoring system was also installed to monitor the ICCP system.

VCS was requested by SGH to evaluate the ICCP system to determine its functionality, and to provide recommendations for repair or refurbishment, if necessary.

Evaluation

On July 11 and 12, 2016 Mr. Matthew Miltenberger, PE and Certified CP specialist, visited the structure to conduct the ICCP system evaluation. Upon arrival, SGH representatives Paul Millette and Tyler Meek, along with the building maintenance electricians opened the rectifier cabinets to observe the overall condition of the rectifier units, and to identify the electrical panel and circuit breakers providing electrical power to the rectifiers. The electricians had to cut off padlocks to open the rectifier cabinets.

In each cabinet, a circuit diagram, a floor plan, and a rectifier manual were present. These documents were reviewed and photographed for reference. A marked-up floor plan for each level identifying the zone layout is included as Appendix A.

At each rectifier, the general assessment conducted involved:

1. Obtain the manufacturer, manufacture date, model, and serial number of the rectifier.
2. Review the documents to identify the wiring and zone layout.
3. Evaluate the "As-Found" condition and collect measurements using the rectifier meters.
4. Conduct basic troubleshooting steps to identify if the rectifiers were functional.
5. Conduct electrical continuity tests to determine if the system wiring in the slab is functional.
6. Conduct energizing tests using an external power supply to evaluate system performance using the embedded reference electrodes.

Findings

AS-FOUND

Level 1 - The rectifier was operating, but neither the DC voltage nor DC current supplied could be adjusted.

Level 2 - The rectifier was not operating. AC power was turned on, but the main breaker had melted and the AC wiring was severely corroded.

Level 3 - The rectifier was not operating. AC power was turned off. Once energized, neither the DC voltage nor DC current supplied could be adjusted.

METERS

Level 1 and Level 3 measurements were obtained using the meters housed on the rectifiers with confirmation using a portable calibrated Fluke 289 multimeter. The Level 2 rectifier meters were unstable, but measurements were not obtained due to the melted main.

The rectifier meters for Level 1 were not stable. The values obtained from the rectifier meter fluctuated widely by more than +/- 0.2V or +/- 0.05A. The meter switch appeared to have been overheated at some point in time based on a brown discolored spot on the back of the meter. Values obtained with the portable multimeter were stable, so the meter appears to have been compromised.

The rectifier meters for Level 3 were stable and accurate compared to the multimeter.

WIRING

Wiring for the structure (DC system negative) connections was found to be continuous with the exception of Zone 2 on Level 1 and Zone 6 on Level 2.

Structure connections were mostly continuous with the reference electrode sense, test, or ground connection. Failed test connections were located on Level 1, Zone 4A; and Level 2, Zones 6A and 6B.

The anode wiring on each level was found to be functional and no short circuits were identified.

REFERENCE ELECTRODES

Reference electrodes were functional, with the exception of Level 1, Zones 2A and 2B; Level 1, Zone 4A; Level 2, Zone 6A; and Level 3, Zone 4B. The construction submittal indicated the reference electrodes were silver/silver chloride, but the electrolyte concentration was not noted.

CONTROL CIRCUITRY

Rectifier control circuits were not operable. The adjustment is conducted using a multi-turn potentiometer with the control circuits housed on a circuit board. This circuit board has a remote dial up functionality, that appears to be operable, but no one knew of any data or how to communicate with the unit. During testing the switch was in the "Manual" position, and no channel on any rectifier responded to manual adjustment. The rectifier is rated at 24V, but the maximum voltage measured at any time was 3.3V.

AC power to the rectifiers and remote monitoring panel was turned off upon leaving.

Datasheets containing recorded measurements are included in Appendix B.

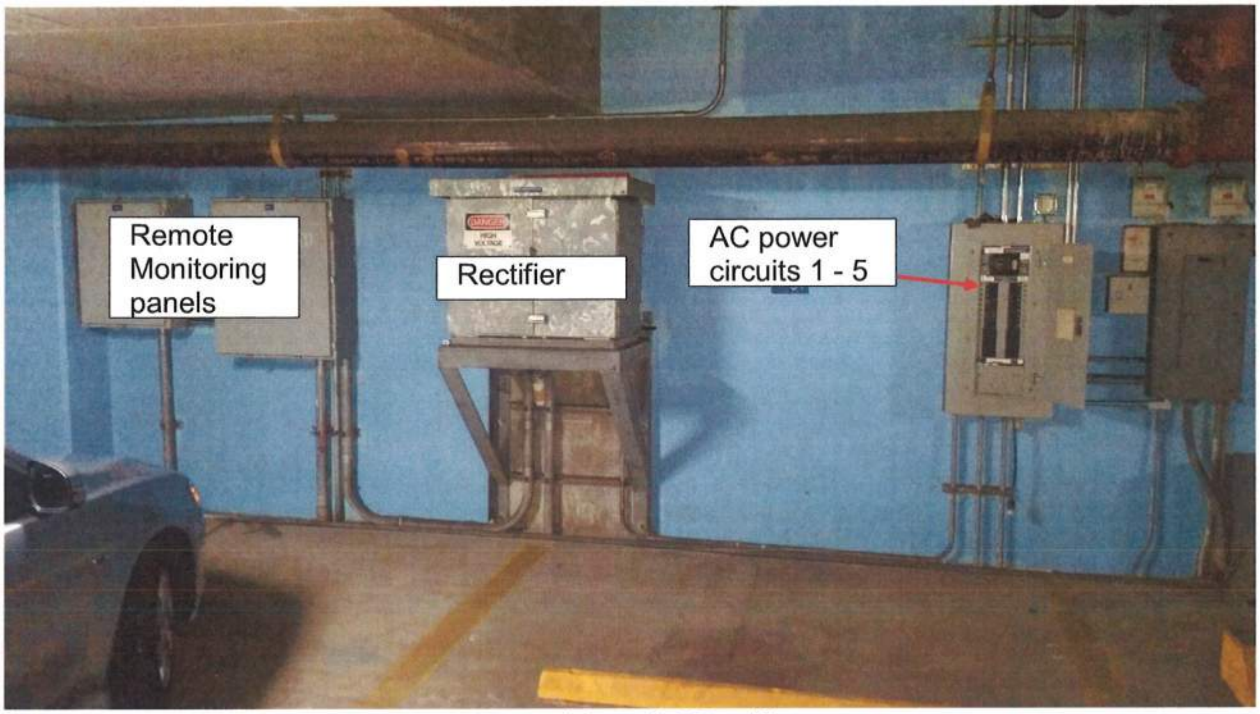


Figure 1: Level 1 Rectifier

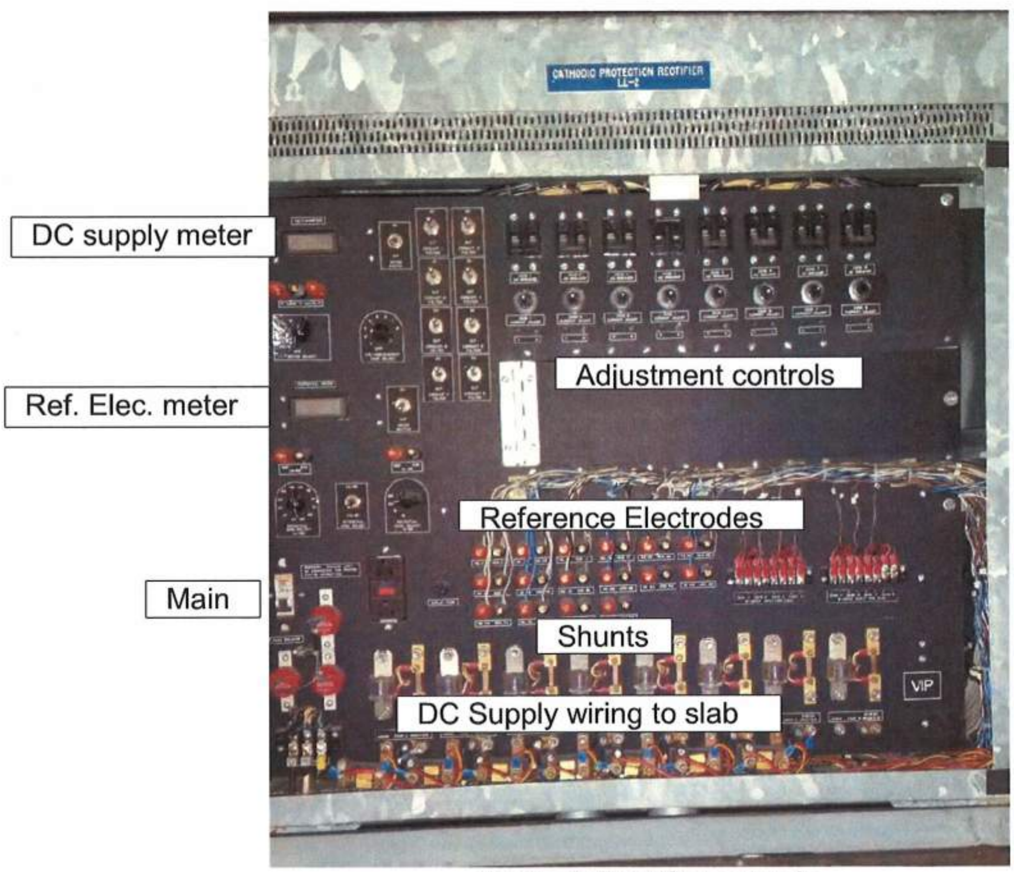


Figure 2: Rectifier controls

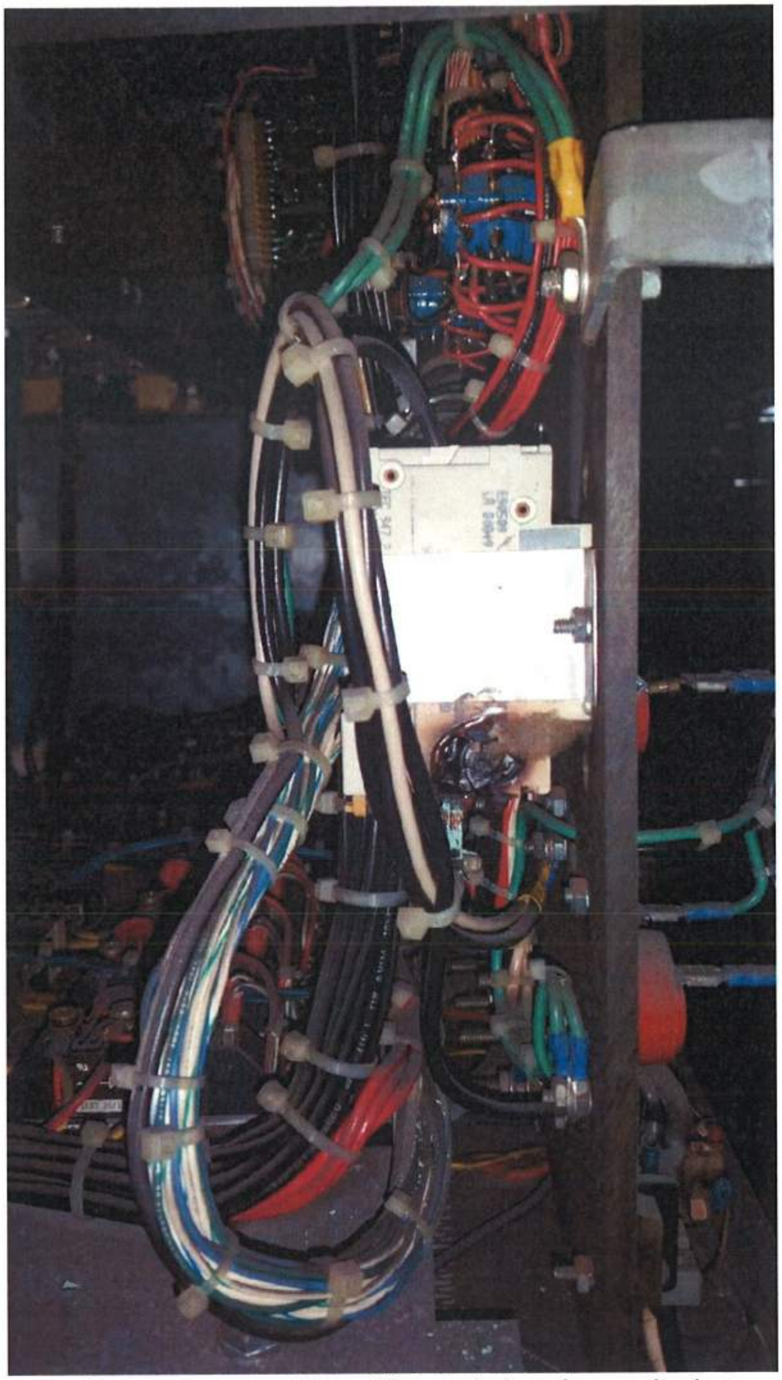


Figure 3: Level 2 Rectifier main breaker melted

Recommendations

1. The ICCP system in the garage can be returned to functional condition. The internal wiring in the slab is mostly intact, and functional. System functionality was confirmed by temporary energizing of each zone using a portable laboratory power supply.
2. All three rectifiers need to be replaced. Internal parts for the rectifier may be available, but even if the parts could be located, other parts would be near the end of their functional life and would likely fail in short order.
3. All reference electrodes should be replaced because existing electrodes should be at, or nearly at, the end of their functional life. New reference electrodes can be installed in holes drilled in the top of the ribs, or hand packed into overhead excavations made into the slab.
4. New reference electrodes should be 30-year silver/silver chloride or manganese dioxide versions for long life.
5. New test connections should be made for each new reference electrode.
6. Wiring for new reference electrodes and test connections can be routed to the zone junction box using surface mounted PVC conduit.
7. Level 1 circuit 2 needs a new structure negative connection.
8. A modern remote monitoring system should be employed to allow the system to be maintained by a CP professional.
9. Damage to the entry slab appears to require replacement of the overlay containing the ICCP anode mesh. Replacement of the ICCP system in this area should be conducted by a CP specialty contractor under the supervision of a CP specialist.
10. Replacement of the rectifiers will involve careful removal and re-labeling of the wiring. This work should be conducted by a CP specialty contractor under the supervision of a CP specialist.

Prior to installing new rectifiers, the following information should be collected.

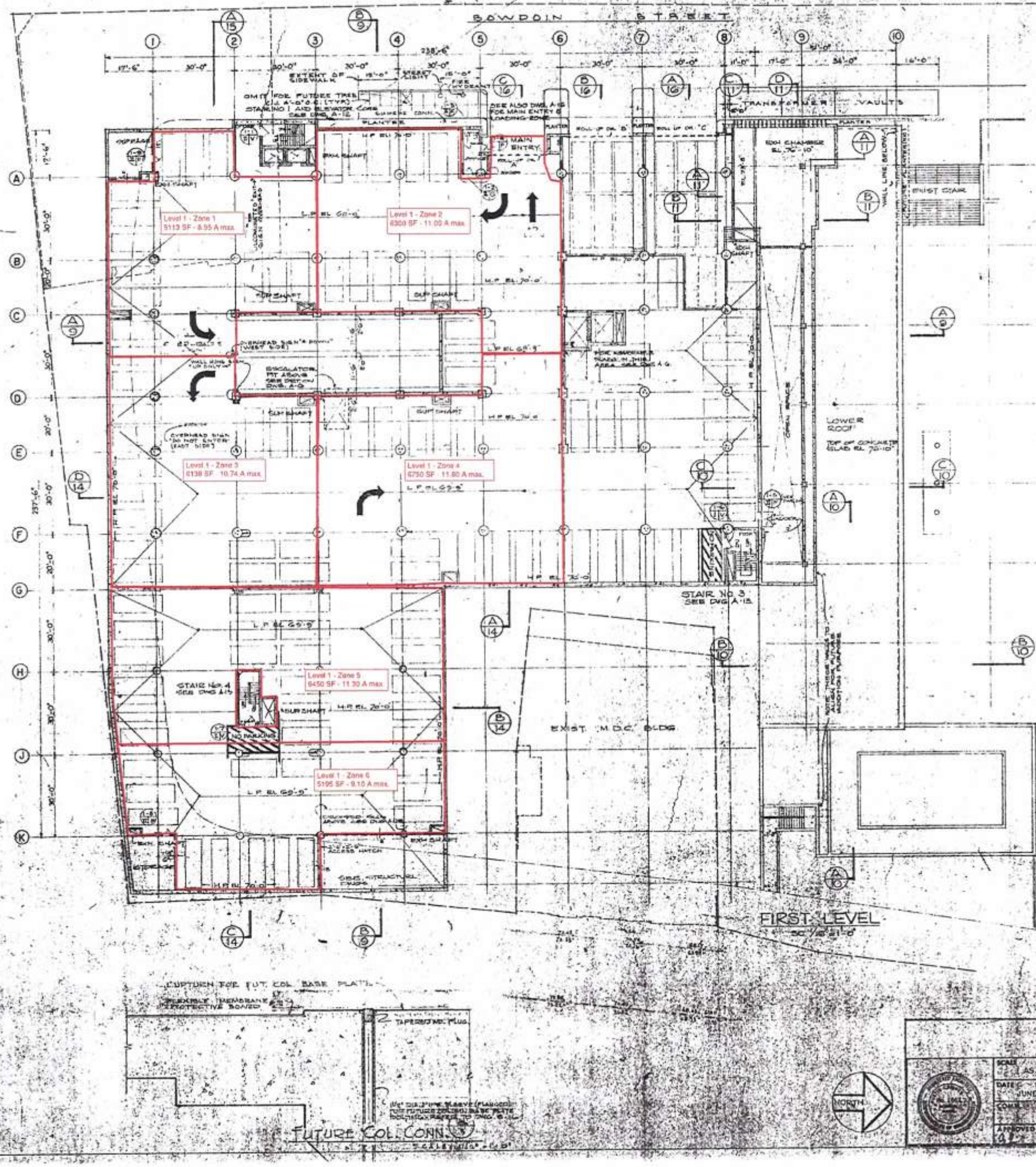
1. Conduct a 100% corrosion potential survey on the soffit of each suspended waffle slab to establish base-line potentials and to identify the most anodic areas. A 4 ft x 4 ft grid could be used, but a 2 ft x 2 ft grid is preferred. Reference electrodes and new test connections should be placed in the most anodic area in each zone.
2. Collect chloride contamination profiles for the entry, each ramp, and a few locations on each level to establish current chloride contamination levels in the overlay down to the depth of the top steel in the substrate.

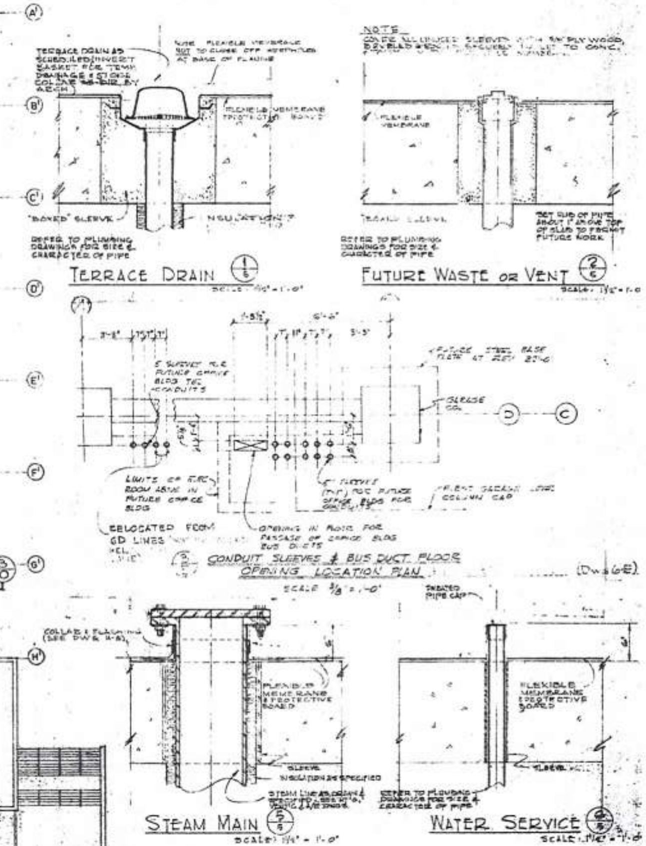
Please feel free to contact me if you have any questions.

Sincerely,

Matt Miltenberger, P.E. (FL, IL, MA, MD, MI, MN, MO, OH, OR, VA)
NACE Cathodic Protection Specialist No. 9470
Vector Corrosion Services, Inc.
mattm@vcservices.com
Mobile (269) 251-1347

Appendix A – Zone Layouts





DOOR SCHEDULE

DOOR NO.	SIZE	MATERIAL	DOOR TYPE	GLAZING	FRAME TYPE	THRESHOLD	REMARKS
1-1	3'-6" x 7'-0"	H.M.	V	1/4" WIRED GLASS	I		B LABEL F.R.S.C.
1-2	2'-8" x 7'-0"	H.M.	G	1/4" PLATE GLASS	II		
1-3	2'-6" x 7'-0"	H.M.	F		II		
1-4	2'-8" x 7'-0"	DURANODIC ALUM	F			[illegible]	FRAME AS T-1, SEE DWG A-15
1-5	[illegible] x 7'-0"	H.M.	E		I		
1-6	3'-6" x 7'-0"	H.M.	V	1/4" WIRED GLASS	I		B LABEL F.P.S.C.
1-7	3'-6" x 7'-0"	H.M.	V	1/4" WIRED GLASS	I		B LABEL F.R.S.C.
1-8	3'-0" x 7'-0"	H.M.	F		II		
1-9	3'-0" x 7'-0"	H.M.	F		II		
ROLL-UP DOORS "A"	20'-0" x 9'-0"	STEEL		VISION PANES			
ROLL-UP DOORS "B"	73'-0" x 12'-9"	STEEL		VISION PANES			
ROLL-UP DOORS "C"	29'-0" x 15'-0"	STEEL		VISION PANES			

NOTES.

1. SLEEVES REQUIRED BY THE VARIOUS TRADES PERFORMING THE WORK SHALL BE PROVIDED BY THAT TRADE USING THE SLEEVE. THE RESPONSIBILITY FOR THE SETTING OF SLEEVES SHALL DEVOLVE UPON THE GENERAL CONTRACTOR.
2. COMPARABLE DETAILS NOT SPECIFICALLY SHOWN SHALL BE SIMILAR.
3. SEE ALSO DWG. A-3 FOR GENERAL NOTES.

NO.	REVISIONS	DATE
2	AS BUILT DWG	11/6/72
1	GENERAL [illegible] DIRECTION INDICATORS	[illegible]

FIRST LEVEL (EL. 70'-0")

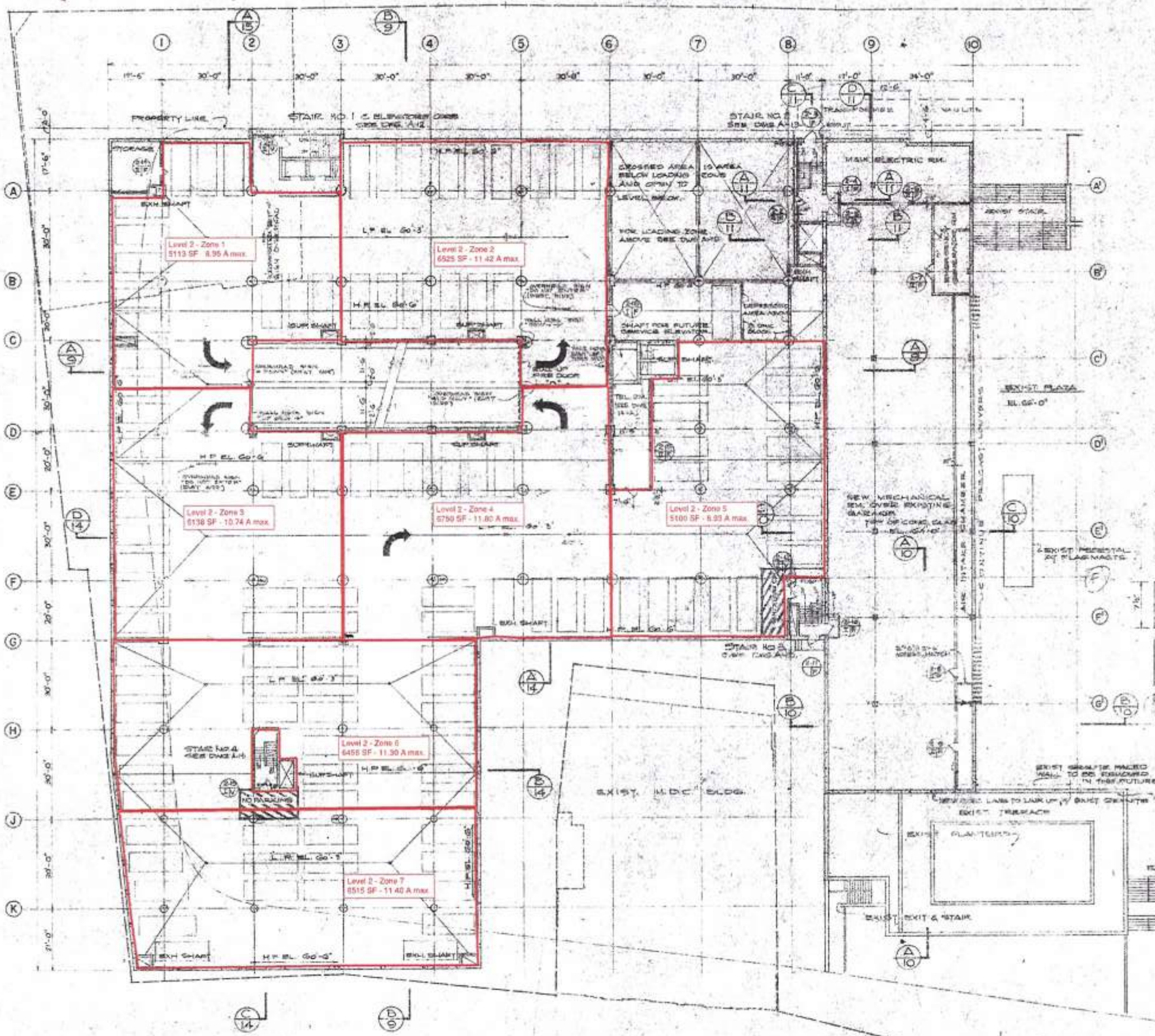
SCALE AS NOTED | DATE JUNE 1A 1970 | COMM. 1343 | APPROVED

HOYLE, DORAN AND BERRY INC. ARCHITECTS BOSTON, MASSACHUSETTS
UNIVERSAL ENGINEERING CORPORATION CONSULTING ENGINEERS

ASHBURTON PLACE GARAGE

GOVERNMENT CENTER COMMISSION

A-5



DOOR SCHEDULE

DOOR NO.	SIZE	MATERIAL	DOOR TYPE	GLAZING	FRAME TYPE	THRESHOLD	REMARKS
2-1	3'-8" x 7'-0"	H.M.	V	1/4" WIRED GLASS	I		B LABEL F.P.S.C.
2-2	3'-0" x 7'-0"	H.M.	F	1/4" WIRED GLASS	II		B LABEL F.P.S.C.
2-3	5'-6" x 7'-0"	DURANODIC ALUM.	K			[illegible]	FRAME AS T-1, SEE DWG A-15
2-4	3'-0" x 7'-0"	H.M.	K		I		B LABEL
2-5	3'-0" x 7'-0"	H.M.	K		I		B LABEL
2-6	PR 2'-6" x 7'-0"	H.M.	K		II		
2-7	PR 2'-6" x 7'-0"	H.M.	F		II		
2-8	3'-0" x 7'-0"	H.M.	K		II		
2-9	3'-0" x 7'-0"	H.M.	K		II		
2-10	3'-0" x 7'-0"	H.M.	F		II		B LABEL
2-11	3'-6" x 7'-0"	DURANODIC ALUM.	K			[illegible]	FRAME AS T-1, SEE DWG A-15
2-12	3'-0" x 7'-0"	H.M.	V	1/4" WIRED GLASS	I		B LABEL F.P.S.C.
2-13	3'-0" x 7'-0"	H.M.	V	1/4" WIRED GLASS	I		B LABEL F.P.S.C.
2-14	3'-0" x 7'-0"	H.M.	F		II		
2-15	3'-0" x 7'-0"	H.M.	F		II		
2-16	3'-6" x 7'-0"	H.M.	F		I		
2-17	3'-0" x 7'-5"	H.M.	F		II		B LABEL F.P.S.C.
ROLL UP DOOR D	27'-9" x 7'-4"	STEEL					FIRE DOOR

PAINTED LETTERS CENTERED ON STRIP

MACHINE ROOM

NOTES:

1. ALL DOOR DESIGNATIONS TO BE PAINTED LETTERS
3. CENTER LINE OF ALL SIGNS TO BE 5'-4" ABOVE FIN. FL.
4. LETTERS NOT TO EXTEND CLOSER THAN 3" TO BORE OF DOOR.
5. DOOR TITLES WRITTEN IN FULL ON SIGN SCHEDULE, DWG A-5.

DOOR SIGN DETAIL ½ FULL SIZE.

DO NOT ENTER

LEFT TURN ONLY

TO BE PAINTED ON FLOORS AS LOCATED ON PLANS

DIRECTIONAL ARROWS

DOWN

UP ONLY

OVERHEAD SIGNS

SCALE 1½"=1'-0"

1. SIGNS TO BE ⅜" THICK WHITE OPAQUE ACRYLIC WITH RED ACRYLIC LETTERS & ARROWS.
2. LETTERS TO BE 4" HIGH HELVETICA MEDIUM STYLE
3. HANG SIGNS AS DIRECTED BY ARCHITECT
4. SEE ALSO DWG A-8 FOR GENERAL NOTES
5. REVERSE ARROWS & WORDS AS REQUIRED FOR SIGN ORIENTATION
6. HANG USING TWO ⅜" CHROME PLATED CHAINS & CHROME PLATED "S" HOOKS WITH BRASS BUSHINGS / SIGN 1/4" EXP. BOLTS

2	"AS BUILT" DWGS.
NO.	REVISIONS

SECOND LEVEL (EL. 60'-6")

SCALE 1/16" = 1'-0"

DATE JUNE 1, 1970

COMM. 1343

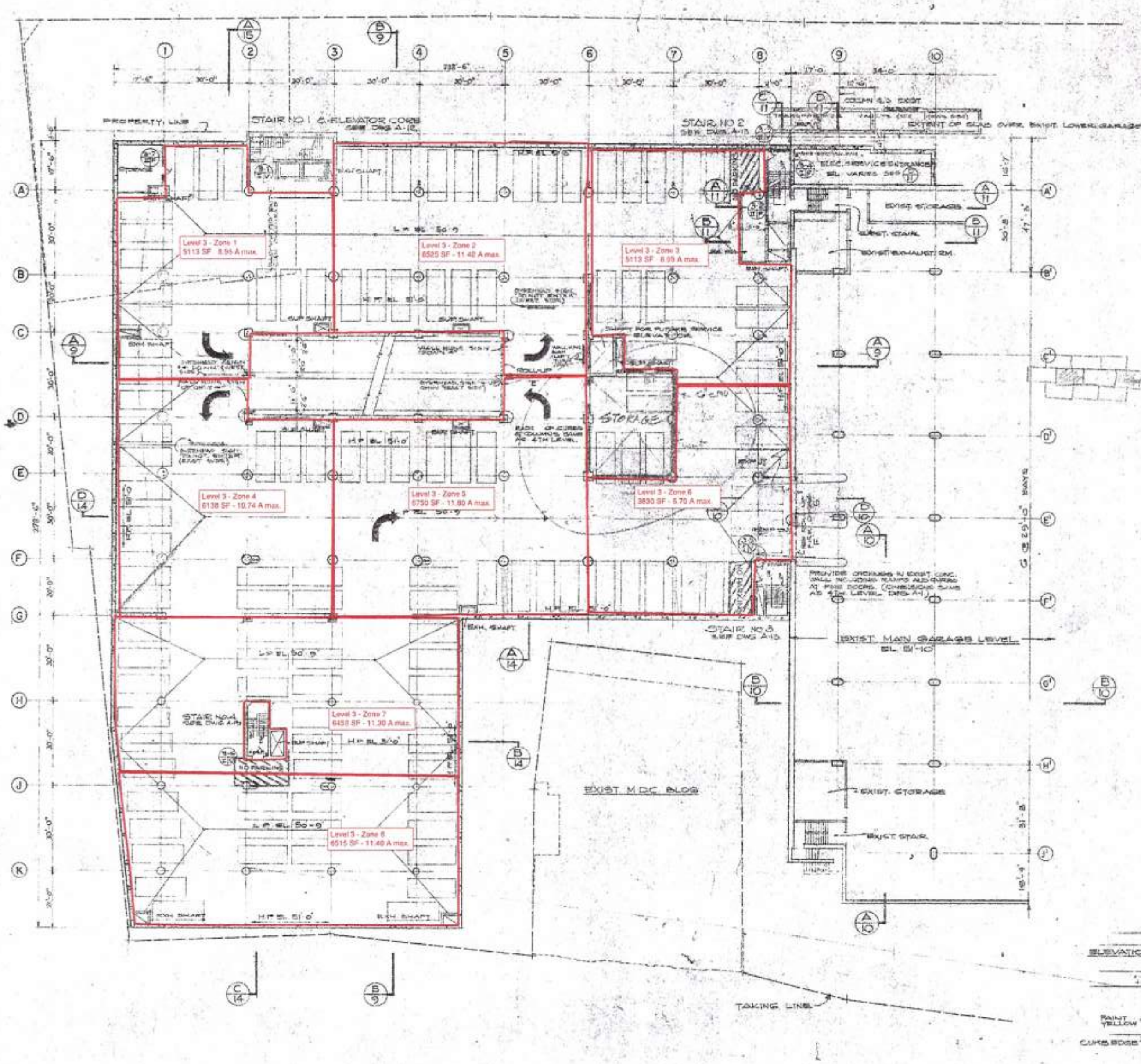
HOYLE, DORAN AND BERRY INC. ARCHITECTS BOSTON, MASSACHUSETTS

UNIVERSAL ENGINEERING CORPORATION CONSULTING ENGINEERS

ASHBURTON PLACE GARAGE

GOVERNMENT CENTER COMMISSION

A-4



DOOR SCHEDULE

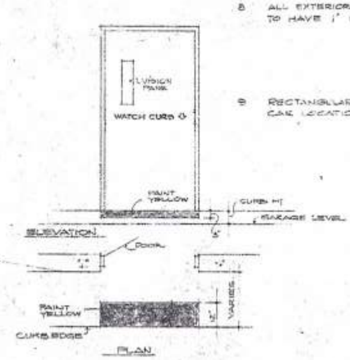
DOOR NO	SIZE	MATERIAL	DOOR TYPE	GLAZING	FRAME TYPE	THRESHOLD	REMARKS
3-1	3'-6" X 7'-0"	H. M.	V	1/4" WIRED GLASS	I		B LABEL F.T.S.C.
3-2	3'-0" X 7'-0"	H. M.	F		II		
3-3	3'-6" X 7'-0"	H. M.	V	1/4" WIRED GLASS	III		B LABEL F.T.S.C.
3-4	3'-0" X 2'-8"	H. M.	F		I		B LABEL CONSTRUCTION FRAME IS 4-SIDED
3-5	3'-6" X 7'-0"	H. M.	V	1/4" WIRED GLASS	I		B LABEL F.T.S.C.
3-6	3'-6" X 7'-0"	H. M.	V	1/4" WIRED GLASS	I		B LABEL F.T.S.C.
3-7	3'-0" X 7'-0"	H. M.	F		II		
"E"	27'-0" X 7'-6"	STEEL					FIRE DOOR
"F"	12'-4" X 7'-0"	STEEL					FIRE DOOR
"G"	12'-4" X 7'-0"	STEEL					FIRE DOOR

DOOR SIGN SCHEDULE

DOOR NO.	WIDTH	DOOR SIGN (SEE DETAIL ON DWG A-4)
4-2	4'-0"	ELEVATORS MACHINE RM
4-5	3'-0"	WELL PUMP RM
4-7	3'-0"	STORAGE
4-8	3'-6"	BILGE PUMP RM
3-2	3'-0"	SPRINKLER RM
3-4	3'-0"	ELECTRIC SERVICE ENTRANCE
3-7	3'-0"	STORAGE
2-2	3'-0"	LOADING ZONE
2-4	3'-0"	MAIN ELECTRIC RM
2-5	3'-0"	MECHANICAL RM
2-6	PR 2'-6"	MAIN ELECTRIC RM
2-7	PR 2'-6"	EMERGENCY GENERATOR RM
2-8	3'-0"	AIR INTAKE CHAMBER
2-9	3'-0"	STORAGE
2-10	3'-0"	MECHANICAL RM
2-14	3'-0"	STORAGE
2-15	3'-0"	TELEPHONE RM
1-2	2'-8"	OFFICE NOTE: PAINT ON GLASS
1-5	PR 2'-6"	MECHANICAL RM - LOADING ONLY
1-8	3'-0"	STORAGE
1-3	3'-0"	STORAGE
T-5	3'-0"	FAN AND SPRINKLER RM

GENERAL NOTES

1. DOOR SIGN DETAIL IS SHOWN ON DWG A-4
2. ALL LEVELS TO HAVE YELLOW PAINTED STALL MARKINGS AS SHOWN ON DWGS A-1 & A-2
3. NO PARKING AREAS TO HAVE 6" WIDE YELLOW LINES 2'-0" O.C. PAINTED ON FLOOR. LETTERS TO BE 10½" H x 2" W PAINTED WHITE
4. FOR DIRECTIONAL ARROWS PAINTED WHITE ON FLOORS SEE DETAILS ON DWG A-4
5. FOR OVERHEAD DIRECTIONAL SIGNS SEE DETAILS ON DWG A-4
6. OVERHEAD ELECTRICAL EXIT SIGNS ARE SHOWN ON ELEC. DWGS
7. EXIT DOORS: 1-6, 2-12, 3-3, 3-5, 4-3, 4-4, SHALL HAVE WARNING SIGN WATCH CURB PAINTED ON BOTH SIDES IN MANNER AS DESCRIBED FOR DOOR SIGN DETAIL ON DWG A-4 AND CURB PAINTED AS SHOWN BELOW
8. ALL EXTERIOR CORNERS INSIDE & OUTSIDE BUILDING TO HAVE 1" CHAMFER
9. RECTANGULAR SPACES ON PLANS INDICATE CAR LOCATIONS.



THIRD LEVEL (EL. 51'-0")

SCALE 1/16" = 1'-0"
DATE JUNE 1, 1970
COMM 1343
APPROVED

HOYLE, DORAN AND BERRY INC. ARCHITECTS BOSTON, MASSACHUSETTS
UNIVERSAL ENGINEERING CORPORATION CONSULTING ENGINEERS

ASHBURTON PLACE GARAGE

GOVERNMENT CENTER COMMISSION

NO	REVISIONS	DATE
2	"AS BUILT" DWG	
1		

A-3

Appendix B – Rectifier Measurements

Rectifier ID LL-1

Date 7/11/2019
Technician MM

Manufacturer Goodall Electric, Fort Collins, CO
Manufacture Date 12/24/1992
Model No. TVAYCA 24-12 (7) FNPSZ
Serial No. 92A1198
No. Channels 6
Description Silicon Diode rectifier

Rectifier Breaker Positions As Found

Main ON
Circuits ON
AC supply, V 117

Rectifier Breaker Positions As Left

Main Off
Circuits Off
AC supply, V 0

AC breaker switched off at distribution panel

Meter Readings

Circuit	Main OFF				Main ON			
	V, volts	I, Ampere	Ref A, mV	Ref B, mV	V, volts	I, Ampere	Ref A, mV	Ref B, mV
1	1.4	0.86	-91	-28	3.1	0.87	-190	-12
2	0.4	0.8	109	112	3.3	0.86	66	63
3	1.4	0.8	-44	110	2.2	1.14	36	210
4	1.4	0.8	31	-8	2.3	1.1	-118	34
5	1.4	0.8	-26	-41	2.5	1.15	110	86
6	1.4	0.8	73	-88	2.7	0.86	69	14

Notes: Meters are jumping, not stable
Wiring polarity is reversed on refernce cells (Red is reference, Blk is test ground)

Wiring continuity check, ohm						
Circuit ->	1	2	3	4	5	6
Str-Test A	0.8	4.9k	0.2	736	0.6	2.2
Str-Test B	1.1	4.8k	0.8	0.3	0.5	2
Test A - B	1.5	2.5	1.3	736	1.3	1.8

	Power OFF		Short?	Power ON				
Circuit	Ref A, mV	Ref B, mV	Resistance	V, volts	Ref A, mV	Ref B, mV	Shift A	Shift B
1	-133	0	No	2.1	163	73	296	73
2	117	113	No	2.1	99	198	-18	85
3	-13	99	No	2.1	37	154	50	55
4	6	19	No	2.1	-76	119	-82	100
5	-64	0	No	2.1	186	250	250	250
6	28	-127	No	2.1	224	257	196	384

Note: External DC power supply applied to wires disconnected from rectifier,
Potential measurements taken on panel binding posts, mV (reverse polarity)

1936 Bruce B. Downs Blvd. #315 Wesley Chapel, FL 33544 Ph: 813-501-0050 Fax: 813 -830-7565

Rectifier ID	L2	**Date**	7/11/2016
		Technician	MM
Manufacturer	Goodall Electric, Fort Collins, CO		
Manufacture Date	12/24/1992		
Model No.	TVAYCA 24-12 (8) FNPSZ		
Serial No.	92A1199		
No. Channels	8		
Description	Silicon Diode rectifier		

Rectifier Breaker Positions As Found		**Rectifier Breaker Positions As Left**	
Main	Off	**Main**	Off
Circuits	ON	**Circuits**	Off
AC supply, V	117	**AC supply, V**	0

Meter Readings

Circuit	Main OFF				Power ON			
	V, volts	I, Ampere	Ref A, mV	Ref B, mV	V, volts	I, Ampere	Ref A, mV	Ref B, mV
1								
2								
3								
4								
5								
6								
7								

Notes: Meters appeared to be working but main breaker was melted.
No tests were conducted using the rectifier panel, power was disconnected for safety

Wiring continuity check, ohm							
Circuit ->	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Str-Test A	0.6	0.8	0.4	43	1	Disconn	0.8
Str-Test B	0.2	0.7	0.4	0.6	1.4	3 Mohm	1.4
Test A - B	0.8	2.2	0.3	23	2.5		1.8

Circuit	Power OFF		Short?	Power ON				
	Ref A, mV	Ref B, mV		V, volts	Ref A, mV	Ref B, mV	Shift A	Shift B
1	82	150	No	2.3	234	340	152	190
2	6	203	No	2.3	239	217	233	14
3	69	16	No	2.3	362	360	293	344
4	25	54	No	2.3	235	209	210	155
5	66	-44	No	2.3	302	111	236	155
6	N/A	86	No	2.3	N/A	176	N/A	90
7	55	148	No	2.3	291	237	236	89

External DC power supply applied to wires disconnected from rectifier, measurements taken on binding posts on panel, mV (reverse polarity)

Rectifier ID	L3	**Date**	7/11/2016
		Technician	MM
Manufacturer	Goodall Electric, Fort Collins, CO		
Manufacture Date	12/23/1992		
Model No.	TVAYCA 24-12 (9) FNPSZ		
Serial No.	92A1200		
No. Channels	9		
Description	Silicon Diode rectifier		

Rectifier Breaker Positions As Found		**Rectifier Breaker Positions As Left**	
Main	Off	**Main**	Off
Circuits	ON	**Circuits**	Off
AC supply, V	117	**AC supply, V**	0

Meter Readings

Circuit	Main OFF				Power ON			
	V, volts	I, Ampere	Ref A, mV	Ref B, mV	V, volts	I, Ampere	Ref A, mV	Ref B, mV
1	0.4	0.01	7	16	0.4	0.01	8	74
2	0.4	0.01	45	125	1.5	0.55	229	406
3	0	0.01	-72	136	0	0.01	-63	144
4	0.3	0.01	10	0	0.3	0.01	10	1
5	0.3	0.01	50	54	0.3	0.01	80	73
6	0.3	0.01	11	22	0.3	0.01	33	36
7	0.3	0.01	22	-8	0.3	0.01	32	-4
8	0.3	0.01	-54	49	0.3	0.01	-48	71

Notes: Meters are correct, match portable
Swapped unused card from Ch9 to Ch1, output was 1.2 V, 0.5A, no adjustment
No adjustment capability on potentiometer dials - Cards and Stack are bad.
Wiring polarity is reversed on refernce cells (Red is reference, Blk is test ground)
Meter values jumpy

Wiring continuity check, ohm								
Circuit ->	1	2	3	4	5	6	7	8
Str-Test A	0.4	1.3	1.2	1.1	0.7	1.4	0.6	1
Str-Test B	0.6	1.1	1.9	0.6	2.2	1	0.7	1.1
Test A - B	1.2	0.2	2.3	1.7	0	1.7	1	2.2

Circuit	Power OFF		Short?	Power ON				
	Ref A, mV	Ref B, mV	Resistance	V, volts	Ref A, mV	Ref B, mV	Shift A	Shift B
1	-6	0	200K	2.1	580	110	586	110
2	64	202	300k	2.1	335	887	271	685
3	-90	146	2	2.1	26	322	116	176
4	10	51	300k	2.1	788	5100	778	5049
5	473	86	300k	2.1	620	428	147	342
6	-244	14	300k	2.1	-115	349	129	335
7	22	-16	300k	2.1	942	783	920	799
8	-34	146	300k	2.1	854	430	888	284

External DC power supply applied to wires disconnected from rectifier,
measurements taken on binding posts on panel, mV (reverse polarity)

25 August 2016

LABORATORY REPORT

BY Brian J. Toney

PROJECT 111409.71 – Structural Conditions Assessment, McCormack Building Garage, One Ashburton Place, Boston, MA

SUBJECT Testing for Acid-Soluble Chloride in Concrete

SAMPLES Four concrete cores designated "1" through "4" were submitted by Greggrey Cohen on 25 August 2016.

PROCEDURE

We tested the above-described cores in accordance with ASTM C1152/C1152M-04(2012)e1 – Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete with one modification. ASTM C1152 designates the use of methyl orange to check the pH. Methyl orange changes color from yellow to red across pH 4 to 3, which we have found difficult to accurately detect. Instead, we use litmus paper with a range of pH 0 – 3, which dramatically changes color from blue to yellow, to check the acidity of each solution.

Sample Preparation

- We sliced 1/2 in. thick wafers at specified depths from the cores using a water-cooled diamond saw.
- We washed each wafer with distilled water immediately after cutting so as to remove any concrete residue from the surfaces.
- We then crushed the wafers until all material passed a No. 20 (0.0331 in.) sieve using a Retsch RS 200 ring and puck mill.
- We mix the crushed material thoroughly by transferring it from one glazed paper to another at least ten times.
- We cleaned the puck, ring, and bowl between each use by using a scouring pad, steel wool pad, and vacuum followed by wiping with isopropanol and lint-free wipes.

Chloride Ion Extraction

- We added 10 g of crushed sample to a 250 mL beaker and weighed to the nearest 0.1 mg.
- We added 75 mL of distilled water to the beaker, stirring the solution into suspension.

- We also added 75 mL of distilled water to a 250 mL beaker with no sample powder for a blank. The blank was processed in the exact same manner as the other samples.
- Slowly, we added 25 mL of dilute nitric acid (1:1, by volume).
- We covered the 250 mL beaker with a watch glass and allowed it to stand for 1 – 2 min.
- We added 3 mL of hydrogen peroxide (30% solution).
- We verified the acidity of the solution using litmus paper.[1] If the pH was not less than 3, we added more nitric acid until the solution was sufficiently acidic.
- We covered the sample with a watch glass and placed it on a preheated hot plate, bringing the solution to a rapid boil. We removed the beaker from the hot plate as soon as the solution boiled.

Filtration

- We filtered the samples as soon as practical, and did not wait until the samples cooled to room temperature.
- We vacuum filtered the sample through coarse filter paper into a clean 500 mL vacuum flask.
- We rinsed any residue left in the beaker onto the filer paper using a distilled water squirt bottle until the beaker was clean.
- We transferred the sample solution into a 250 mL beaker, and rinsed the 500 mL vacuum flask into the beaker until the final volume of collected filtrate was approximately 175 mL.

Titration

All titrations were performed with the sample solutions at room temperature.

- We determined the equivalence point of each sample using a Mettler-Toledo T5 Autotitrator with an Accumet chloride ion selective electrode. We used 0.05 N Silver nitrate as the titrant.
    - We added 2 mL of 0.05 N NaCl.
    - The solution was titrated in 0.2 mL increments, and stopped six readings past the detected equivalence point.

[1] According to ASTM C1152/C1152M-04(2012)e1, methyl orange indicator should be used to verify acidity. Due to the difficulty of observing the color change of the solution, SGH uses litmus paper to check pH.

- The equivalence point was determined as the peak of first derivative data plot. We determined the chloride content according to the following formula:

  Cl, % = 3.545 [(V_1-V_2) N]/W, where:

  V1 = milliliters of 0.05 N $AgNO_3$ solution used for sample titration (equivalence point),

  V2 = milliliters of 0.05 N $AgNO_3$ solution used for blank titration (equivalence point),

  N = exact normality of 0.05 N $AgNO_3$ solution,

  W = mass of sample, g.

RESULTS

Our calculated chloride ion contents for each test sample are as follows:

Table 1 – Acid-Soluble Chloride Test Results.

Sample ID	Depth (in.)	Chloride Content in Sample (% by weight)
L1	1/4 – 3/4	0.1424
L1	1-1/4 – 1-3/4	0.0761
R2	1/4 – 3/4	0.2108
R2	1-1/4 – 1-3/4	0.0655
R3	1/4 – 3/4	0.0473
R3	1-1/4 – 1-3/4	0.0273
R4	1/4 – 3/4	0.1523
R4	1-1/4 – 1-3/4	0.2122

Note 1: ASTM C1152 states that the single-laboratory standard deviation is 0.0015 (% chloride by weight of sample). In other words, two results from the same sample should not differ by more than 2.8 times the standard deviation, or 0.0042%. The multilaboratory standard deviation is 0.0021 (% chloride by weight of sample); i.e. two results from the same sample at two different laboratories should not differ by more than 0.0059%.

Note 2: ACI 201 notes that the chloride corrosion threshold is 0.20% total acid soluble chloride by weight of cement. Results above are reported in percent by weight of sample (or concrete).

To compare this threshold value to the results above for a typical concrete mix with a unit weight of 145 lbs per cubic foot; this threshold is equivalent to 0.029% Cl by weight of concrete for a six cement bag mix (564 lb per cubic yard), and 0.034% Cl by mass of concrete for a seven cement bag mix (658 lb cement per cubic yard).

For non-typical concrete (lightweight, heavyweight, or varying amounts of cement), convert from percent Cl by weight of concrete using the following formula:

(% Cl by Weight of Cement) = [(% Cl by weight of concrete) x (Unit Weight of Concrete, lb/cf) x 27] / [(Weight of Cement per unit weight of concrete, lb/cy)].

SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

CLIENT	Comm. Of MA Office of Planning, Design and Construction	SHEET NO.	
SUBJECT	Structural Condition Assessment	PROJECT NO.	111409.71
	Parking Garage	DATE	9/16/16
	One Ashburton Place, Boston, MA	BY	TMM
		CHECKED BY	PMM

DIVISION	DESCRIPTION	Quantity	Units	Unit Cost	Total	Comment
01 00 00	GENERAL CONDITIONS					
	General Requirements	1	ls	$ 113,600.00	$ 113,600	
	Mobilization	1	ls	$ 10,000.00	$ 10,000	
	Subtotal				**$ 123,600**	
03 00 00	CONCRETE					
	Concrete Repair - Debonded Topping	9,000	sf	$ 45.00	$ 405,000	
	Concrete Repair - Underside Ribs	1,500	lf	$ 150.00	$ 225,000	
	Concrete Repair - Topside Waffle Slab	5,500	sf	$ 75.00	$ 412,500	
	Concrete Repair - Full Depth Loading Dock, Entrance	150	sf	$ 125.00	$ 18,750	
	Concrete Repair - Underside	450	sf	$ 150.00	$ 67,500	
	Concrete Repair - Walls and Columns	1,000	sf	$ 75.00	$ 75,000	
	Subtotal				**$ 1,128,750**	
07 00 00	THERMAL AND MOISTURE PROTECTION					
	Rout and Seal Cracks	3,000	lf	$ 12.50	$ 37,500	
	Vehicular-Traffic-Bearing Waterproofing System (VTBW)	140,000	sf	$ 5.50	$ 770,000	
	Subtotal				**$ 807,500**	
21 00 00	ELECTRICAL					
	ICCP System Upgrades	1	allowance	$ 250,000.00	$ 250,000	
	Subtotal				**$ 250,000**	
	DIRECT CONSTRUCTION COST					
	Subtotal Direct Construction Cost Plus General Cond.				**$ 2,309,850**	
	MARK-UP					
	10% Overhead	1	ls	$ 230,985	$ 230,985	
	5.0% Profit	1	ls	$ 127,042	$ 127,042	
	0.65% General Liability Insurance	1	ls	$ 17,341	$ 17,341	
	0.75% Performance Bond	1	ls	$ 20,139	$ 20,139	
	1.00% Permits	1	ls	$ 27,054	$ 27,054	
	Subtotal Mark-up Cost				**$ 422,600**	
	TOTAL CONSTRUCTION COST					
	Total Construction Cost				**$ 2,732,450**	
	MISCELLANEOUS					
	15% Contingency	1	ls	$ 409,868	**$ 409,868**	
	Subtotal				**$ 409,868**	
	COST ESTIMATE TOTAL				**$ 3,143,000**	Rounded up to next $1000