Braun Intertec Corporation
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November 17, 2020 Project B2008772

Mr. Michael Henry
Sage Apartment Communities, Inc
18006 Sky Park Circle
Irvine, CA 92614

Re: Structural Evaluation and Testing for Parking Garage
Knollwood West Apartments
1010 Lake Street East
Hopkins, Minnesota

Dear Mr. Henry:

Braun Intertec Corporation is pleased to provide this letter to report the findings of the Structural Evaluation and Testing for the Parking Garage at the Knollwood West Apartments located in Hopkins, Minnesota.

Background

Mr. Wilson, of Kaas Wilson Architects, contacted Braun Intertec on September 11, 2020 to request a structural evaluation of the precast concrete deck in the parking garage. The parking structure is a split-level building with concrete masonry unit (CMU) walls and the lower level is partially below grade. The sole flooring system is an 8'-0" wide by 2'-0" deep web structural double-T precast plank. Most of the outside flanges of these "T's" (approximately 3 1/2 inches thick) appear to have delaminated from the welded wire mesh and shear plates. Distress can be viewed from the top and underside of the precast planks.

Observations and Comments

The following information was obtained through a site visit on October 28 and 30, 2020 by Kimberly Deibel, of Braun Intertec:

General Observations (Photograph 1):

- The building was separated into two sections; east and west, with an expansion joint along the middle running north/south.
- Precast planks make up both the upper level floor and the roof which span east/west. The planks were 8 feet wide by 2 feet deep by approximately 60 feet long with 10, 1/2-inch diameter tendons spaced 2 inches on center in each stem and wire mesh reinforcing located

in the flange section. The double-T stem was 4 inches wide at the bottom and tapers out to 6 1/2 inches wide at the top. The flange was 3 1/2 inches thick. Weld shear plates were spaced at 4 feet on center along the length of the plank (Photograph 19).

- The planks were bearing on a CMU wall and on steel beams at the south drive lane.
- According to the structural plans dated August 4, 1969, the planks were designed for a live load of 50 pounds per square foot or 2000 pound-force point load and deadload of 15 pounds per square foot. The steel beam lintels are W16 x 50 shape with a 5/16 inch thick bottom plate. No topping slab is called out in the drawings.

Planks: (Reference delamination/distress plan for additional information)

- Delamination on the top side of the planks was found throughout the garage usually near a joint and in the drive lane (Photographs 2, 5, 9).
- Over half of the planks had spalling along the entire underside of the planks directly adjacent to the joints. The remainder of joints had underside spalling localized at the shear plates of varying locations along the length and varying degree of severity (Photographs 3-4,6-8).
- The topside delamination and the underside spalling correlated to each other at many of the locations.
- There were two holes in the plank deck (flange) on the west section of the building with multiple other locations with plywood on the underside of the flange likely to prevent falling concrete. These holes were at a shear connector where corrosion of the connector and wire mesh were observed (Photographs 10-12).
- Plank P-20 had visible corrosion on the underside at the middle of the plank (Photographs 13-14).

Steel Lintels drive lane below the upper level floor:

- A steel beam spanned between the CMU walls at the drive lane between east and west sections of the south end of the building (Photograph 15).
- The CMU wall at the steel beam bearing area was cracking (Photograph 16).
- The steel beam had pack rust between the bottom of the beam flange and the additional bottom plate. This pack rust pushed on the bottom plate making it bow (Photograph 17).
- The precast planks had localized cracking at the bearing point on the steel beam (Photograph 18).

CMU Lintel over north doorway on lower level:

- The bottom web of the CMU had separated at what appears to be the location of the reinforcement. There were rust stains visible inside the crack.
- Scaling was observed on the face shell above the bond beam and on the bond beam (Photographs 20-21).

Other Observations:

- A spall was observed on a roof precast plank at a bearing location (Photograph 22).
- The exterior east wall had damage near the down spout (Photograph 23).
- Efflorescence observed on the CMU wall throughout the building.

Test Results

Six cores were extracted (reference plan view for locations) from the topside of the precast plank to test the chloride-ion concentration in the concrete. Each core was cut into three horizontal section and pulverized into powder. This powder was tested in general accordance with ASTM C1152 "Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete". The results can be compared to a threshold based on the guidance described in ACI 222R-01, "Protection of Metals in Concrete Against Corrosion". Utilizing an assumed concrete density of 150 pounds per cubic foot, the chloride ion content that corresponds to 1 and 1.5 pounds per cubic yard are 0.02 percent and 0.04 percent respectively. Reference the attached laboratory test report for additional information.

In summary, all locations were at or above the threshold percentage within the top 1/2 inch of the precast planks. Five of the six locations were at or above the threshold percentage within the 1 inch to 2-inch range where the wire mesh reinforcement and shear connectors would be located. Corrosion of reinforcing steel in concrete will depend on many different environmental conditions and material properties. The high alkali environment of concrete creates a pacification layer on the steel however when the chloride ion content reaches a threshold level, it will de-pacify the steel and allow corrosion to commence. These test results support our opinion that years of water and salt from the cars has permeated the concrete due to lack of waterproofing.

Conclusion

Since there is no topping slab and no waterproofing on the planks, water and salt from the cars have permeated the top of the slab causing the reinforcement to corrode and therefore spall the concrete. The worst area of distress is at the joints between each plank and in the middle of the span which is the drive lane. The shear connectors create a space with more steel inside the concrete and therefore higher corrosion expansion. There are other locations of delamination/corrosion away from the joints but are observed as less severe. With the high chloride content currently in the slab, the concrete will need to be protected from any further permeation of water and salt from cars in the further. A waterproofing system should be installed and maintained on an annual basis.

It is our opinion that the planks can be repaired and do not require full replacement. While specifics of the repair are still to be designed, we suggest four possible options. All options would require some degree of concrete removal at the joints and installing new shear connectors between the planks.

1. Complete the repair using Fiber-Reinforced Cementitious Matrix (FRCM). This material can be applied (in similar fashion to shotcrete) to the roughened surface from below with minimal added thickness of the cement and therefore less weight added to the planks.

2. Reinforce the stem portion of the double tees with Fiber Reinforced Polymer (FRP). This will increase the strength of the planks from the loss over the flanges. This would be paired with a concrete infill at the damaged flange sections.

3. Pour a secondary slab on the top of the planks with a mechanical connection between the Double-tee planks and slab for a composite system. This would add the most weight to the structure.

4. Decrease the span of the precast plank by adding steel columns below. The location of these columns would depend on how much the decreased double-T section could support and would also require a concrete infill at the damaged flange sections.

The top side delamination areas shown in the reference plan that are outside the repair area described above should be chipped out and patched as needed.

At the south end of the building, water has been leaking past the precast planks ends which is causing the steel beam lintels to corrode and the pack rust is causing the bottom plate to bow. We recommend the replacement of these steel beams along with repairing the cracks to the CMU bearing area wall. Also, the bond beam in the CMU over the doorway on the north end should be fully replaced.

Braun Intertec, along with Kaas-Wilson, will be preparing construction repair documents to address the conditions noted in this report. We will be working with team to identify the preferred repair option based on the 4 options presented above and develop the details accordingly.

(continued on next page)

General

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

If you have any questions, please contact Kim Deibel, at 651.245.3876 or kdeibel@braunintertec.com.
Sincerely,

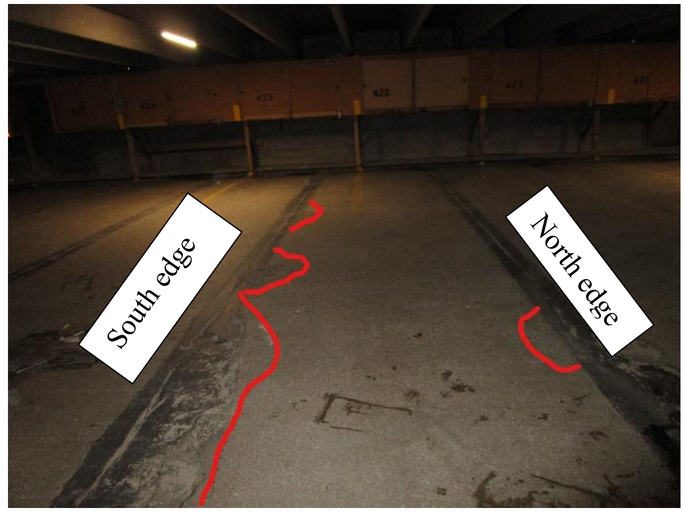
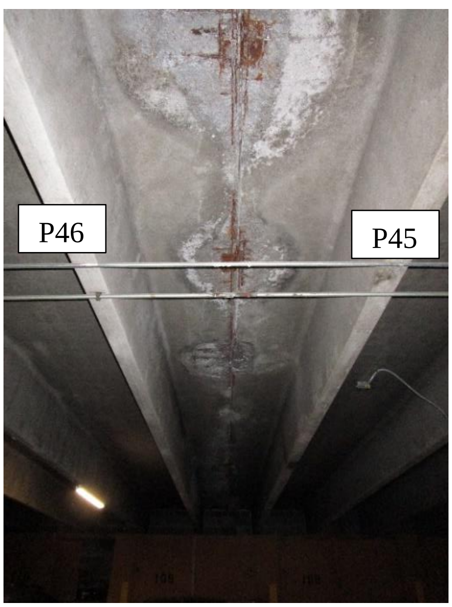
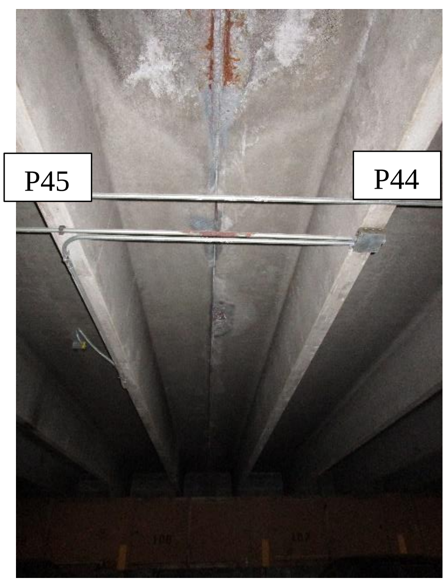
BRAUN INTERTEC CORPORATION

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly licensed professional engineer under the laws of the State of Minnesota.

Kimberly A. Deibel, PE
Technical Manager, Senior Engineer
Minnesota Registration No. 48736
November 17, 2020

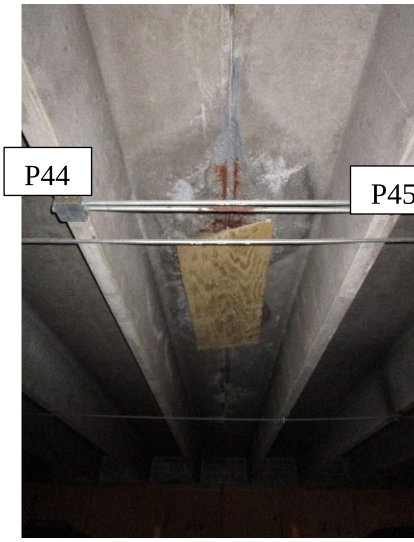
Jason S. Hanlon, PE, MLSE
Business Unit Manager, Principal Engineer

Attachments:
Photo Exhibit (6 pages, 23 photos)
Knollwood Garage Delamination/Distress Plan
Chloride-Ion Test Results

Photograph 1	Photograph 2
	
Photograph 1	**Photograph 2**
Overall photo from upper level entrance ramp looking north.	Example of top side delamination: P45 looking west. (Delamination circled in Red)
	
Photograph 3	**Photograph 4**
Example of underside distress: P45 looking west-south edge.	Example of underside distress: P45 looking west-north edge.

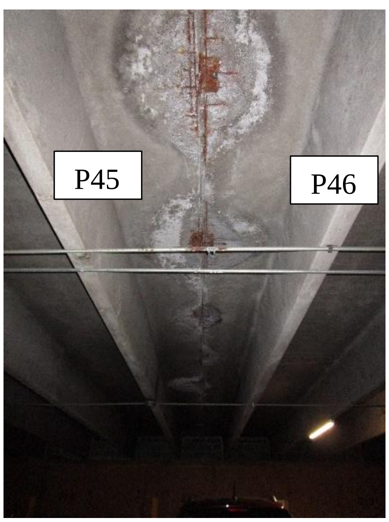
Photograph 5

Example of top side delamination: P45 looking east. (Delamination circled in Red)



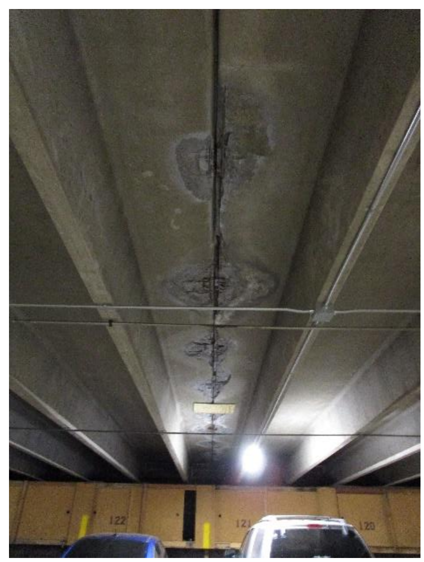
Photograph 6

Example of underside distress: P45 looking east-north edge.



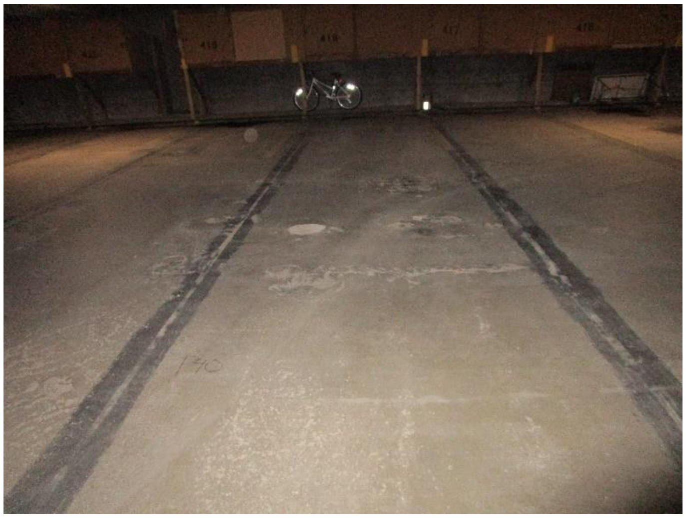
Photograph 7

Example of underside distress: P45 looking east-south edge.



Photograph 8

Typical underside distress: Between P58 and P59 looking west.



Photograph 9	Photograph 10
Panel 40- Looking West, top side delamination across the entire precast panel.	Hole between P43 and P44.

Photograph 11	Photograph 12
Close up view of hole, multiple layers of delamination at wire mesh reinforcement.	Corrosion of shear connectors and wire mesh.

Photograph 13

Distress in P20 at midpanel.

Photograph 14

Close up of Photograph 13.

Photograph 15

Overall view of steel lintels at the south drive lane opening.

Photograph 16

Cracking in the CMU wall below the steel beam.

	
Photograph 17	**Photograph 18**
Close up of Photograph 15, pack rust observed.	Cracking at bearing of precast planks over the steel beam.
	
Photograph 19	**Photograph 20**
End view of reinforcement in the precast plank web above steel lintel.	Lintel at lower level doorway, bottom portion of CMU has separated.

Photograph 21

Close up of photograph 17, rust stains visible.

Photograph 22

Spall on a Roof precast plank.

Photograph 23

East exterior wall, damage to the CMU wall at downspout

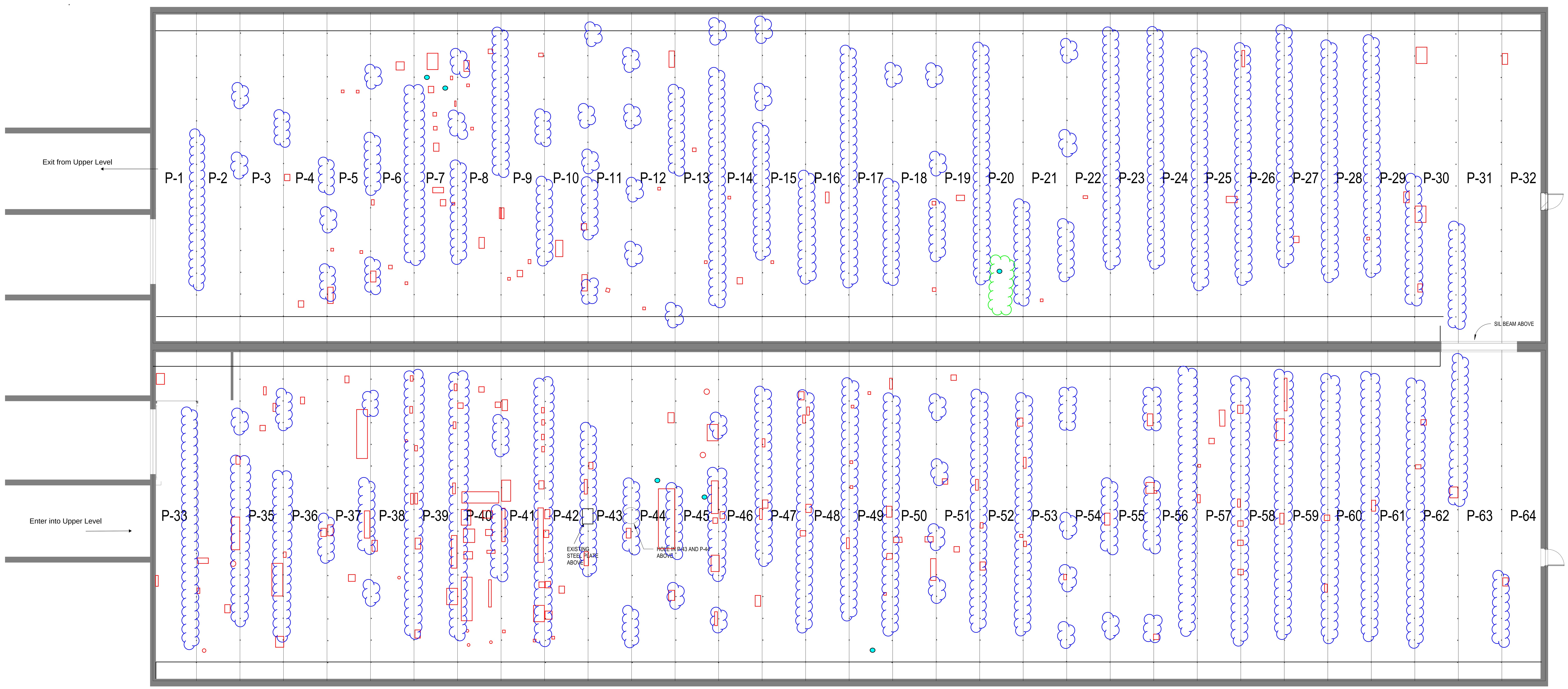
No Photo

Photograph 24

BRAUN INTERTEC
The Science You Build On.

KNOLLWOOD APARTMENTS- DELAMINATION/DISTRESS PLAN
PROJECT NUMBER: B2008772
SITE VISIT DATE: OCTOBER 28 AND 30, 2020
BY: KIMBERLY DEIBEL, PE AND JESSE HOLLEN

NOTES:
1. LOCATIONS AND SIZE ARE APPROXIMATE
2. MARKS IN RED ARE TOP SIDE DELAMINATIONS
3. MARKS IN BLUE ARE UNDERSIDE VISIBLE DISTRESS
3. MARKS IN GREEN ARE UNDERSIDE DISTRESS AT MIDDLE OF PLANK
4. MARKS IN TEAL CORE LOCATIONS FOR CHLORIDE TESTING



1 Level 1 R.C.P.
1/8" = 1'-0"

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9/14/2020 9:55:50 AM

kaas wilson architects
1301 American Blvd E.
Suite 100
Bloomington, MN 55425
tel: (612) 879-6000
fax: (612) 879-6666
www.kaaswilson.com

Project:
Knollwood Apts Parking Garage Repairs
1010 Lake Street Northeast, Hopkins, MN 55343

Owner:
Sage Apartment Communities
18006 Sky Park Cir Suite 200, Irvine, CA 92614

Project Number	20049
Date	09.03.2020

Rev. No. | Revision | Date

Level 1 RCP

1/8" = 1'-0"

A301

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Minneapolis, MN 55438

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Acid Soluble Chloride in Mortar and Concrete
ASTM C 1152

Date: **November 13, 2020**

Project Number: **B2008772**

Client:
Michael Henry
Sage Apartment Communities, Inc.
18006 Sky Park Circle, Suite 200
Irvine, CA 92614

Project Description:
Knollwood Apartments

Batch Data:

Mix Description:	Not Provided
Date Cored:	October 28, 2020
Sample Location:	Knollwood Apartments Parking Garage
Samples Procured By:	Braun Intertec
Type of Sample:	3” Concrete Cores

Laboratory Data:

Core Location	Depth from top surface	Chloride Ion Content as a Percent of Concrete
Core 1 - P-7, 14’-0” from east wall and 1’-3” from north edge of panel	¼ - ½”	1.557%
	1 ¾ - 2”	0.024%
	3 ½ - 3 ¾”	0.011%

Core Location	Depth from top surface	Chloride Ion Content as a Percent of Concrete
Core 2 –P-7, 18’-6” from east wall and 4’-5” from north edge of panel	¼ - ½”	1.079%
	1 ½ - 1 ¾”	0.011%
	2 ½ - 2 ¾”	0.015%

Core Location	Depth from top surface	Chloride Ion Content as a Percent of Concrete
Core 3 – P-20, 9’1” from middle wall and 3’-10” from south edge of panel.	¼ - ½”	2.207%
	1 ½ - 1 ¾”	0.513%
	2 ½ - 2 ¾”	0.010%

Core Location	Depth from top surface	Chloride Ion Content as a Percent of Concrete
Core 4 –P-46, 28’-0” from middle wall and 4’-0” from south edge of panel.	¼ - ½”	1.117%
	1 ¾ - 2”	0.024%
	3 – 3 ¼”	0.011%

Core Location	Depth from top surface	Chloride Ion Content as a Percent of Concrete
Core 5 – P-44, 22’-0” from middle wall and 6” from south edge of panel.	¼ - ½”	1.674%
	2 – 2 1/4”	0.624%
	3 ½ - 3 ¼”	0.010%

Core Location	Depth from top surface	Chloride Ion Content as a Percent of Concrete
Core 6 –P-49, 5’-8” from west wall and 3’-5” from north edge of panel.	¼ - ½”	0.896%
	1 – 1 ¼”	0.360%
	1 ¾ - 2”	0.008%

Discussion

Corrosion of reinforcing steel in concrete will depend on many different environmental conditions and material properties. The high alkali environment of concrete creates a pacification layer on the steel. The chloride ion content reaching a threshold level will de-pacify the steel and allow corrosion to commence. ACI 222R-01, "Protection of Metals in Concrete Against Corrosion" provides guidance on the corrosion of reinforcing steel and chloride thresholds as described. Typically, the range of 1.0 to 1.5 pounds per cubic yard of concrete is assumed to be the threshold. There are many other factors affecting the rate of corrosion in concrete structures and corrosion may not be active even if the chloride threshold is reached.

Utilizing an assumed concrete density of 150 pounds per cubic foot, the chloride ion content that corresponds to 1 and 1.5 pounds per cubic yard are 0.02 percent and 0.04 percent, respectively.

General

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

Sincerely,

BRAUN INTERTEC CORPORATION

Katrina Sargent
Staff Scientist II