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CONDITION SURVEY
of
MONTGOMERY COUNTY GARAGE 47/47A
at
7401 WAVERLY STREET, BETHESDA, MARYLAND

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HAA Project No. 15-198

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INTRODUCTION

Holbet Apple Associates, Inc. (HAA) was contracted to perform a condition survey and prepare a structural condition report for existing Parking Garage 47/47A. The main intent of this condition survey was to conduct field observations and determine what portions of the existing facility need to be modified, repaired, or replaced. A summary of the observed deterioration/damage, drafted damage plans for all levels, conceptual recommendations for repairs, and a preliminary budget cost estimate for the recommended repairs are provided in this report.

EXECUTIVE SUMMARY

The slabs of the first phase (Garage 47) of this facility were found to have significant amounts of corrosion-related damage caused by water penetration into the concrete which has high levels of corrosion-inducing chloride contamination derived from deicing salts used in the winter. The protective deck coatings previously applied to the slabs in this phase have deteriorated and are no longer effective. The ideal approach to the repair of this garage would be to replace all of the slabs. Although this would be expensive, it would minimize future repair costs. Less costly, but less effective, repair approaches would be to repair just the damaged slab areas and then try to lessen the occurrence of future damage by the use of some combination of coating, cathodic protection and penetrating corrosion inhibitor. There is only a minimal amount of slab damage at the second phase (Garage 47A) of the garage which can be addressed by spot repairs followed by repairs to the existing deck coatings.

The ledger angles in the stair/elevator tower walls of Garage 47A are corroding and causing the brick and mortar of the wall to crack and spall. These angles need to be exposed and cleaned and then have new flashing and weeps installed when the brick is replaced. An area on the west end wall of the garage is in danger of falling off and needs to be rebuilt. One wall of a stair tower is unbraced and needs to be braced. Miscellaneous cracks and spalled brick at all walls should be repaired.

Guardrails, and their supports, throughout the garage need to be repaired and/or repainted and sealed. Other miscellaneous steel beams and angles need to be cleaned and repainted. Drains should be added to eliminate ponding conditions.

BACKGROUND

This facility is approximately rectangular in plan: 130 feet wide in the north-south direction and 467 feet long in the east-west direction. It was built in two (2) phases with two (2) different types of structural framing. The first phase, referred to as Garage 47, was built in the 1970’s and constitutes the eastern 235’ end of the facility. The second 232’ long phase, Garage 47A, was built in the 1980’s to the west of the older phase with part of this second phase extending over Waverly Street. Garage 47 consists of five (5) levels and Garage 47A consists of seven (7) levels in height. An expansion joint is provided at the connecting line of the two phases. The lowest level of Garage 47 extends slightly below grade due to the slope of the site, whereas the lowest level of Garage 47A is at grade.

The columns of the garage are arranged to divide the width of the garage into two (2), approximately equal bays. The segments of the garage on each side of Waverly Street were constructed with a single helix configuration in which the slabs in the bays on the north and south side of the garage slope in opposite directions between level crossover bays at each end. The sloping slabs have 90° parking on each side of a center two-way drive aisle whereas the crossover bays only have 90° parking on the exterior side of the drive aisle. The segment of the garage spanning over Waverly Street is level and has 90° parking on each side of the center drive aisle in each bay of its width.

The lower two levels of Garage 47A are located on the west side of Waverly Street, while the upper five levels extend over Waverly Street to meet the upper levels of Garage 47, which extends eastwards from Waverly Street. The south sides of both phases of the garage extend along the north side of Montgomery Avenue. There are vehicular entrance/exists on each side of Waverly Street into the garage. Additional entrance/exits are located along Montgomery Avenue at the southwest corner of Garage 47A and the southeast corner of Garage 47. Stair/elevator towers are located at the middle of the north and south sides of the garage and another stair/elevator tower is located at the southwest corner of the garage. Stair towers are also located at the southeast corner and at the middle of the north side of the garage. The stair and elevator towers are typically enclosed by concrete masonry block walls with face brick veneer on some walls. Expansion joints separate the stair/elevator towers from the main structure.

The structural framing of the first phase, Garage 47, consists of approximately 5½" thick cast-in-place mild-reinforced concrete slabs spanning approximately 7'-1" between structural steel beams. The beams in turn frame into structural steel girders spanning approximately 63' between steel columns. The south façade of this phase is clad with architectural precast concrete panels spanning vertically over four (4) levels with mesh guardrails at the opening between the panels. The north and east facades of this phase are open with only pipe guardrails along the edges of each level. There are no vehicular barriers of any type located along the sides of this phase of the garage.

The structural framing of the second phase, Garage 47A, typically consists of approximately 6" thick one-way post-tensioned concrete slabs spanning in the east-west direction to post-tensioned concrete beams which frame into concrete columns spaced at approximately 63'-0" o.c. The west portion of this phase, spanning over Waverly Street, is constructed with post-tensioned concrete slabs spanning about 16' in the north-south direction to post-tensioned concrete beams which span 66'-0" across the street in the east-west direction to concrete columns and then cantilever 13'-9" to the expansion joint between the two phases. The south facade of this phase of the garage, and the middle portion of the north facade spanning over Waverly Street, are enclosed with cast-in-place concrete rail walls. The remaining portions of the north facade consist of steel pipe guardrails embedded into the top of concrete knee walls.

PROCEDURE

The top surfaces of the structured levels were sounded with a chain drag to locate delaminations which are the beginning phase of the concrete spalling process where the concrete has split internally, approximately parallel to the face of the concrete surface. This splitting typically occurs at the face of the concrete's reinforcing steel which is undergoing corrosion (rust). The rusting steel expands to occupy more span than the original steel, thus pushing out the concrete covering it. When these delaminations are sounded with a tool, they produce a noticeably different sound than non-delaminated concrete.

Visual observations were made of the slab soffits and beams, columns, and walls to note obvious cracks, spalls, delaminations, leaks, rusting metal, etc. Suspect areas were sounded with a hammer to locate hidden delaminations. Furthermore, during extended periods of rain, the garage was revisited and observed for signs of leakage and ponding.

Since deterioration of non-structural items, such as joint sealants, drains, railings, masonry walls, etc., frequently affect either the condition of adjacent structural members and/or safety conditions in the garage, the conditions of these items were also observed and noted.

Finally, a hammer-drill was used to collect powdered concrete samples from the slab in order to be tested to determine the general level of chloride-ion contamination in the parking decks. Chloride-ion contamination is one of the major contributors to corrosion-related damage in concrete structures. Determining the extent of chloride-ion contamination in the concrete can affect the selection of materials and procedures necessary to repair any damage found in the survey. A total of twenty-four samples were gathered from 8 locations dispersed throughout parking deck areas of the first phase, as identified in the attached drawings. Three (3) samples were retrieved from the top three (3) inches of each location, one from each inch (i.e., 0”-1”, 1”-2”, 2”-3”). All samples were taken from areas of the original concrete, and not from areas that have been patched. These samples were sent to a lab to be tested for chloride-ion contamination.

OBSERVATIONS

Significant differences in the observed conditions were found between the two phases of the garage. Large areas of concrete slab damage were found in the decks of the older phase (Garage 47), whereas significantly fewer areas of damage were detected in the newer phase (Garage 47A).

The following existing damage and conditions likely to lead to future damage were noted in the older phase (Garage 47) of the facility:

- **Previous Slab Repairs:** Numerous areas of the slabs throughout this phase had previously been repaired. These repairs were full depth in most cases. Based on the coloring of the repairs and surface textures, it was evident that some areas had been patched several times at different dates (Photo No. 1). It is apparent that areas on the perimeter of, and adjacent to, previous patches had delaminated sometime after the original patches were made and then the same areas were revisited years later to repair these new delaminations. This is characteristic of a phenomenon known as the “halo effect” which is caused by the higher alkalinity of new concrete placed in the patches having a higher alkalinity than the existing surrounding original concrete where the alkalinity has been reduced by chloride-ion contamination of the concrete. This difference in alkalinity creates an electro-chemical cell between the new and existing concrete which causes an increased rate of corrosion in the reinforcing steel passing through the interface between the two concretes. This corrosion causes the concrete surrounding the patch to delaminate, thus the term: “halo effect”. In some cases, this accelerated corrosion will extend back into the patches to cause them to also delaminate.

- **Slab Surface Damage:** Besides the failure of previous patches and the halo effect damage, many new delaminated or spalled surface areas were found throughout all levels of this phase of the garage (Photo No. 1). Moderate to severe scaling (i.e., loss of surface mortar and clearly exposed aggregates) were also observed, mainly at the top exposed floor (Photo No. 2). This scaling damage is usually caused by freezing and thawing effects and/or other construction related issues such as over-finishing or finishing while bleed water is on the surface. It is also worth noting that a membrane coating existed over some of the slab surfaces at some levels and, as a result, it is not possible to say for sure whether all of the areas of possible delaminated concrete detected using chain-drag and hammer sounding were actually concrete delaminations or only debonded areas of coating. The only effective way to tell for certain would be to completely remove the coating in suspect areas to evaluate the concrete underneath.

- **Slab Soffit Damage:** Areas of slab soffit spalling and delamination were also observed throughout all levels of this phase of the garage (Photos No. 3 and 4). It was noted that the majority of this damage occurred under the same locations where significant surface damage was observed.

- **Slab Edge Damage:** The vertical sides of some slab edges had spalled or delaminated (Photo No. 5). The majority of this type of damage was observed at the interior sides of the ramp slabs. The top steel beam flanges that were directly below the slab in these areas had corroded at these locations.

- **Deck Coating:** A deck coating had previously been installed on most of the slabs of this phase. Significant areas of this coating had been removed when prior slab repairs were performed and only a few of these repair areas had been re-coated. Many areas of the remaining original coating were worn off and no longer effective.

- **Precast Wall-to-Slab Connection Damage:** The south-side precast façade panels were connected to elevated slabs with bolted angles (Photo No. 6). The concrete slab around some of these angles is cracked and delaminated. Many of these angles also had visible corrosion on them.

- **Corroded Beam Flanges:** Many of the steel beams throughout this phase of the garage had minor corrosion visible along the edges of their top flanges (Photo No. 5).

- **Guardrail Damage:** The base of some of the guardrails was heavily corroded and the posts and railings were also corroding at a few locations (Photo No. 7).

- **Leakage and Ponding:** The garage was revisited during a period of extended rain in order to better examine the location of leakage and ponding. The ponding locations are noted on the drawings for this phase and shown in Photo No. 9.

- **Expansion Joints:** The expansion joints around the perimeter of the north center stair tower were heavily damaged on Levels 3 and 4 (Photo No. 10).

- **North Center Stair:** The west end of the north exterior wall of this stair tower had apparently moved outwards away from the west wall. There was no apparent connection between the walls at the northwest corner of the stair tower (Photos No. 11 and 12).

The following damage and defects were observed for the newer phase (Garage 47A) of the facility:

- **Slab Surface Damage:** Some minor areas of delaminated concrete were detected on all levels of this phase of the garage (Photo No. 13).

- **Slab Soffit Damage:** A few areas of delaminated concrete were found on the soffit of the Level 7 slab.

- **Concrete Beam and Column Damage**: One area of beam soffit damage and a few areas of column face damage (Photo No. 14) were found. Also some cracking on the face of a Level 7 column were observed but this area had not delaminated.

- **Knee-Wall Damage at Railing:** Delaminated and spalling concrete was found at numerous locations where the guardrail posts were embedded into the knee-wall along the north side of this phase of the garage (Photo No. 15). Rust stains at these locations indicated that the embedded ends of the posts and/or embedded metal sleeves at the post bases were corroding.

- **Guardrail Damage:** As noted above, the bottoms of the guardrails at the perimeter knee walls were corroding at many locations. The bottoms of the guardrail posts along the interior edges of the ramps were also corroding (Photo No. 8). There was no sealant around the bases of most of these posts. Some of the posts have split vertically along the seams of the pipe.

- **Deck Coating:** There is a deck coating on most of the slabs in this phase of the garage. The coating is in relatively good condition except that the top coat is wearing off in the drive aisles of Levels 1 through 3.

- **Expansion Joints:** Some of the original expansion joint seals had previously been replaced and the new joint seals were in good condition. Some of the original expansion joint seals had failed to various degrees at the following locations:

  - Deck joint at south bay on Level 4.
  - Deck joint at north and south bay on Level 5.
  - Deck joint at south bay on Level 6.
  - Joint around center stair/elevator tower along south side of garage at Levels 4 and 6.
  - Joint around center stair/elevator tower along north side of garage at Levels 6 and 7.

- **Stair/Elevator Tower Walls:** At all three of the stair/elevator towers in this phase of the garage, the mortar and brick is cracked and spalling to various degrees along the ledger angles in the wall (Photo No. 16). Where the angles have been exposed by the spalls, they are observed to be corroding. No flashing was visible at the exposed angles and there was no soft joint under any of the angles. Widely spaced small diameter weeps were provided just above the horizontal ledger angle leg level. At some ledger locations, the brick has moved outwards (Photo No. 17). Vertical cracks and spalled brick were also found at some corners of these towers above Level 7 (Photo No. 18).

- **West Exterior Wall:** The brick of this wall has bulged outwards up to 2” at the probable location of a ledger angle along the edge of the Level 2 slab (Photo No. 19).

- **Stair Coatings:** A deck coating has been placed on the treads and landings of the stairs in this phase. It is typically in good condition above Level 3, but begins to exhibit worn and/or torn areas at various locations at the lower levels in all stairs (Photo No. 20).

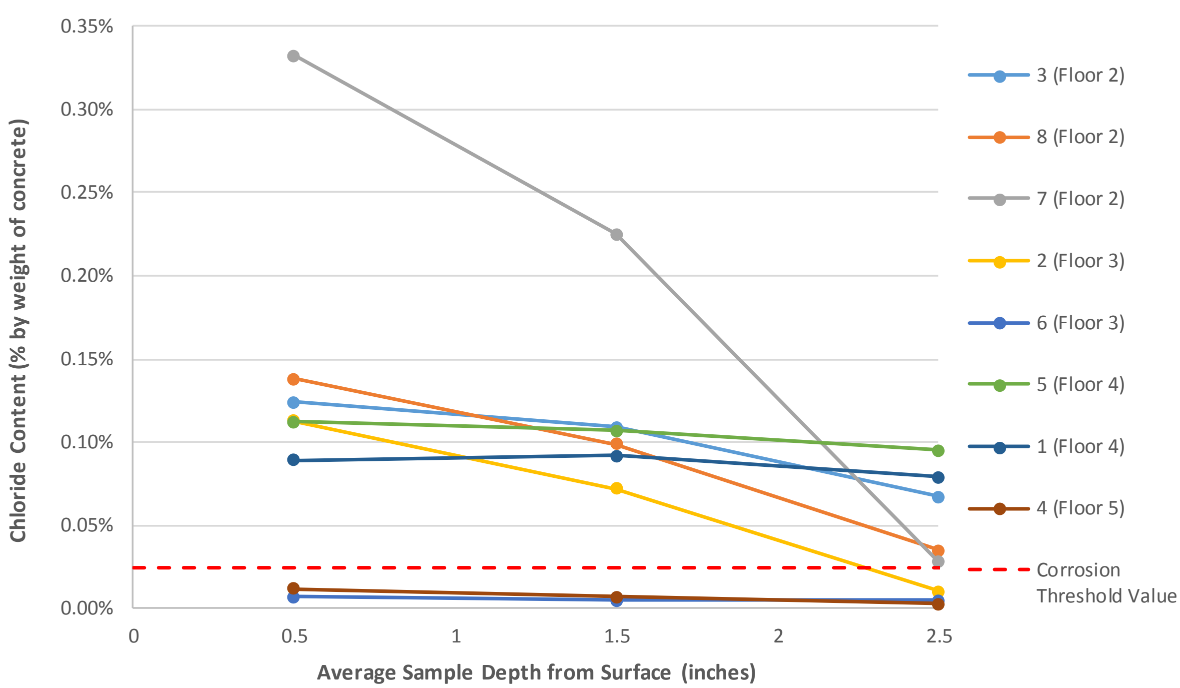
TEST RESULTS AND ANALYSIS

Corrosion of embedded metal in concrete is an electrochemical process in which the high original alkalinity of new concrete surrounding the metal is reduced by various causes, among them contamination by chloride-ions. Chloride-ion contamination typically occurs as a result of snow containing deicing salts falling off of cars during the winter. In older building construction, chloride-ions were sometimes even added to the original concrete by contractors unaware of their drastic effects at the time. An electrical potential is created between this contaminated concrete and adjacent non-contaminated concrete of higher alkalinity which results in corrosion of the metal in the presence of water and air. During the corrosion process, the metal expands to occupy more space than its original volume, thus pushing out the concrete covering the metal and eventually splitting the concrete. Concrete separation due to horizontal plane cracks is referred to as delamination and the splitting of concrete is referred to as spalling.

As previously noted, samples of the concrete were taken from each inch for the top three inches of depth at various locations. All samples were taken from areas within drive aisles and a couple of feet away from parking spaces in the first phase areas of the garage. Each sample was tested for the amount of chloride-ion contamination as a percentage of the concrete sample. The table below shows the test results for the samples taken at each location.

Location			Depth from top of slab (inches)		
Sample ID	Floor	Description	0" to 1"	1" to 2"	2" to 3"
3	2	Middle of south ramp	0.124%	0.109%	0.067%
8	2	West level side	0.138%	0.099%	0.035%
7	2	Middle of north ramp	0.332%	0.225%	0.028%
2	3	East level side	0.113%	0.072%	0.010%
6	3	West level side	0.007%	0.005%	0.005%
5	4	Middle of south ramp	0.112%	0.107%	0.095%
1	4	North ramp, towards bottom of ramp	0.089%	0.092%	0.079%
4	5	East level side	0.012%	0.007%	0.003%

In order to better evaluate these results, the graph below showing chloride content vs depth was developed. An average depth was used for each depth increment (e.g., average of 0.5 inches shown for 0 to 1 inch sample). Also the legend is sorted by elevation that the sample was taken (i.e., sample 3 was taken at highest elevation and sample 4 at lowest elevation).



Based on the graph above, a variation in the amount of chloride-ion contamination can be observed throughout the collected samples. This variation can be attributed to any one of the following: varying amounts of de-icing salts deposited based on location in the garage; effect of existing cracks allowing faster penetration of chloride-ions; localized differences in the concrete quality leading to different rates of penetration; and the effect of ponding, rain, and power-washing in removing chlorides from the surface. These localized variations may be able to explain the high contamination in sample 7 and the much lower contamination in samples 6 and 4. The main conclusions that can be observed from this analysis are as follows:

- **Contamination Above Threshold Limit for Most Samples:** Generally, a chloride-ion content of around 0.025% of concrete weight is considered to be the threshold value above which corrosion of steel in the concrete will begin. This threshold is highlighted in the figure above with a dashed red line. Most of the samples had chloride-ion levels well above this threshold for the 1st and 2nd inch of depth and most were above the threshold even for the 3rd inch of depth down. Considering the code requirements at the year of construction and the estimated thickness of the slab (approximately 4" to 5"), the top rebar level is probably located somewhere within the top 2 inches, on average. Based on these results, the potential for corrosion initiation, as well as ongoing corrosion, for the reinforcement in these areas of the garage slabs are high.

- **Decrease in Chloride Contamination with Depth**: Typically, chloride-ion contents found in garage slabs decreases with the increase in depth from the surface. This reflects the condition where the chlorides contained in de-icing salts (brought into the garage by vehicles) are deposited on the surfaces of the slabs as melted water which soaks into the concrete. Thus, the chloride-contamination is higher near the surface where the salt is deposited by the water, working its way down into the slab. This process is confirmed by these test results which show a drop in chloride-ion content from the 1st inch to the 3rd inch. Interestingly, some samples (5 and 1) have slightly lower chloride-ion content in the 2nd inch compared to the 1st inch. This is likely due to the effect of chloride-ions being washed away from the surface of the concrete (due to rain water as well as possible power washing over time). Large amounts of cracking as well as porous concrete near the surface of the slab, can also possibly lead to deeper penetration of moisture and chloride-ions. Considering the total thickness of the slab (approximately 4"-5"), almost the full-depth of the slabs at these locations can be assumed to be contaminated above the corrosion threshold value; which means that there is a high potential for corrosion for both the top and bottom reinforcement.

A previous study, conducted by Smislova Kehnemui and Associates on June 2, 2014, similarly tested three (3) locations in the first phase (Garage 47). Two of these were located on the Second Floor and one on the Fourth Floor. Their results also indicate chloride content values (0.071%, 0.31%, and 0.094%) much higher than the threshold at a 1" depth for all three samples.

DISCUSSION AND RECOMMENDATIONS

Garage 47:

This first phase of the garage has many extensive deteriorated slab areas which require repairs. Based on the Observations and Test Results, it appears that much of the original concrete of this phase is highly contaminated with chloride-ions which are causing significant corrosion-related slab surface damage as well as soffit damage. This contamination appears to be full-depth in many areas and therefore most of the reinforcement in the slabs is either actively corroding or close to corrosion initiation.

One possible option for reducing the levels of contamination is to use a method known as electrochemical chloride extraction or 'desalination'. Using this method, chloride-ions are extracted by applying an electrical field between the reinforcement and an externally mounted anode mesh, which effectively transports chloride-ions towards the anode and out of the concrete. The implementation of such a method is very costly and may not be as effective on areas with very high amounts of contamination. This method would also prevent use of the area being treated for several months. As such, this is not an economically effective way of reducing the chloride concentration in this phase of the garage.

Another option for eliminating the chloride contamination and preventing future corrosion is to do a partial depth overlay for the whole deck which involves removing the top layers of contaminated concrete and replacing it with sound new concrete. However, this option would probably not be effective for the slabs in this phase of the garage because the lower portion of the deck will still remain relatively highly contaminated after the partial depth overlay repair. Therefore, the most effective option for eliminating the chloride contamination in the concrete, especially for the thin slabs with high contamination in this garage, is complete slab demolition and replacement. Although this repair option would have a high initial cost, it would help to minimize the occurrence of future corrosion-related damage, and the costs required to repair that damage, and would therefore be a long-term cost-effective repair approach for this phase of the garage.

If the complete slab replacement approach is too costly to enact, the next most economical means to address the existing conditions in this phase of the garage would be to only repair damaged portions of the decks. Due to the full depth contamination and the relatively thin slab in this phase of the garage, it is recommended to perform full-depth patch repairs at damaged slab areas, regardless of whether the damage is observed on the surface or the soffit. Unfortunately, considering the previously discussed "halo effect" phenomenon, this option will likely lead to exacerbated deterioration conditions for areas surrounding the patch repairs. In addition, based on the exponential nature of deterioration for highly contaminated decks, the currently sound areas of the original concrete will likely also deteriorate sometime in the near future. Therefore, after the damaged areas have been repaired, one or more of the following items should be incorporated into the scope of repair work for Garage 47 to help minimize the occurrence of future corrosion related damage in the garage:

- **Cathodic Protection:** This involves either imposing a low-voltage electrical current into the slab's reinforcing steel to counteract the corrosion-producing currents produced by the electro-chemical cells in the concrete (active system), or adding sacrificial anodes in the slab which decompose over time due to the electro-chemical activity instead of the steel corroding (passive system). The active system requires periodic monitoring and adjustments of the voltage while the passive system will eventually lose its effectiveness as the anodes decompose. Both of these systems are costly, so that implementing this system may not be as cost-effective as complete deck replacement, especially if the cathodic protection system is not carefully maintained.

- **Penetrating Corrosion Inhibitor:** This material is applied as a liquid to the surface of the slabs where it then penetrates into the concrete and partially inhibits the electro-chemical process causing the corrosion of the steel, thereby slowing, or stopping, the corrosion activity. This method must be applied directly to the concrete surface and will require complete deck coating removal before applying the corrosion inhibiting liquid. The effectiveness of this material in retarding corrosion activity is somewhat controversial in the concrete repair industry, especially in highly chloride-contaminated concrete such as the existing slabs in this phase of the garage.

- **Elastomeric Deck Coating:** The application of an elastomeric deck coating system will help to keep the moisture and air required for corrosion activity out of the concrete, thereby reducing the rate of occurrence of new corrosion-related damage. This flexible coating will also bridge over cracks in the concrete to help prevent water from penetrating into the cracks. The deck coating, used by itself, will not completely stop the occurrence of future corrosion damage since the concrete already contains some moisture and additional water can enter tears in the coating or as water vapor through the soffits of the slabs. Therefore, a periodic maintenance program should be established to locate and repair any concrete damage as it starts to occur. These coatings

should also be inspected periodically to locate, and repair, any tears or worn spots. They typically require the addition of a new topcoat every five to ten years.
As mentioned in the Observations section, the current coating is significantly worn in some areas and missing in others. As a result, the coating work for this phase of the garage would entail repairing damaged areas of existing coating and then adding a new topcoat over the existing coating as well as installation a new coating system on any areas of bare concrete.

In addition to the concrete slab repairs, the following are also recommended for the first phase (Garage 47):

- **Repair Precast Wall-to-Slab Connection Damage:** If the damaged connections fail, the precast panels could fall off of the building. Therefore, all of the damaged connections should be repaired. If the concrete surrounding these connections has spalled, it should be repaired. If the damage is extensive, a new connection should be added in sound concrete near the existing connection.

- **Clean and Repaint Corroded Beam Flanges**: The current conditions of the corroded steel beam flanges do not affect the structural integrity of the garage. However, the rust should be cleaned from their surfaces and repainted for future corrosion prevention purposes.

- **Wall at North Center Stair:** The movement of this wall indicates that it is apparently unbraced along the edge which makes it unstable with the potential for collapse in high winds. This wall should therefore be braced back to the other walls of the stair tower.

<u>Garage 47A:</u>

The following conditions need to be addressed in this phase of the garage:

- **Damaged Slab Areas**: The extent and amount of damage in this phase of the garage is much less compared to Garage 47. As a result, partial-depth spot repairs are recommended for both the soffit and surface damage observed in this phase.

- **Concrete Beam and Column Damage:** The existing beam and column damage should be repaired.

- **Deck Coating:** To insure continued effectiveness of the coating in this phase of the garage, the new damaged areas of coating should be repaired and a new topcoat should be applied over the lower three (3) levels of the garage. Some consideration should be given to applying a coating to the few slab areas which are currently uncoated.

- **Repair Guardrails at Knee-Walls**: The guardrails throughout this phase of the garage are embedded into knee-walls at their base. Moisture has leaked into this embedment and has caused visible signs of corrosion at many locations and delaminated or spalling concrete at some locations. The concrete damage renders the guardrail ineffective in preventing a pedestrian from falling off of the edge. Therefore, the damaged concrete at these locations should be repaired. As part of these repairs a sealant should be added around the base of all posts that are embedded into the concrete to keep water out of the post embedment.

- **Stair/Elevator Tower Walls:** The apparent ineffective flashing and/or weeps placed in the brick walls at the ledger angles have allowed water to corrode the angles. The corrosion of these steel ledger angles causes the steel to expand. The expansion of the vertical legs of the angles pushes the brick outwards while the expansion of the horizontal legs of the angles pushes both upwards on the brick above the angle and downwards on the brick below the angle. Since no soft joint was provided under the ledger angles, this vertical expansion of the horizontal angle legs causes the brick between the angles to be compressed, resulting in the observed spalling of the brick. The horizontal expansion of the horizontal angle legs also pushes out the mortar placed across the ends of the angles, causing it to crack and spall.

The cracking and spalling of the brick created by this corrosion allows more water into the wall where it can cause more corrosion of the ledger angles, resulting in even more cracking and spalling of the wall. During the winter, water gathering between the brick and the ledger angle can freeze and expand, causing the brick to move out more, creating a larger void which can fill with more water which expands when frozen to push the brick out even more. These damage cycles can eventually cause large pieces of brick and/or wall to spall off of the walls. Even the small pieces of brick and mortar currently spalling off of the walls can injure a pedestrian walking past the garage.

These conditions should therefore be repaired by exposing, cleaning and repainting the ledger angles and then installing proper flashing, weeps and a soft joint when the brick is replaced.

- **West Exterior Wall:** The bulged brick on this wall appears to be an advanced example of the corrosion-related ledger angle expansion discussed above. Due to the extent of the outwards movement of the brick, it appears that the brick is in imminent danger of falling off of the ledger angle. This area of the wall should therefore be rebuilt as soon as possible.

- **Stair Coatings:** There were no obvious concrete repairs made to the stairs prior to the application of the coating, so the need for the coating is not clear. However, since the coating is already present, the worn areas should be repaired in case the protection provided by the coating is required.

  Urethane coatings, however, are not typically applied to slabs-on-grade since moisture vapor coming up through the slab from the ground will typically cause the coating to fail as is evident at the ground floor at all three of these stairs. These slabs-on-grade also typically do not have much reinforcing steel in them to corrode, so there is no real need for a coating to prevent corrosion-related damage. For these reasons, we recommend that the remnants of the existing coating on the ground floor slabs just be removed and no new coating applied there.

For damage common to both phases of the garage:

- **Guardrails:** Corrosion of the guardrails could cause the guardrails to fail and allow a person to fall of an elevated deck. All of the corroded guardrail elements should therefore be repaired, replaced and/or cleaned and painted to insure the structural integrity of the rail system. Sealant should be placed around the bottoms of all posts to try to deter future corrosion.

- **Ponding:** As discussed, the corrosion-related damage of the concrete is initiated by water, and the chlorides it can carry, penetrating into the concrete. The observed extensive scaling of the slab surfaces is caused by the freezing of water-saturated concrete. Ponded areas of water pose slipping hazards to both vehicles and pedestrians, especially if they become ice during freezing weather. To help reduce these problems, the ponding conditions in the garage should be eliminated by adding drains to remove the water.

- **Expansion Joints:** The failed expansion joints will allow water to pass along the edge of the slab where it could possibly cause corrosion-related damage. Therefore, the failed expansion joint glands should be replaced.

- **Garage Restriping**: The existing striping and traffic markings of the garage will be damaged while performing the recommended repairs. Therefore, all of the damaged deck striping and markings in the garage should be repainted after repairs are completed.

OPINION OF PROBABLE COSTS

The probable costs provided here are based on providing isolated repairs to slab damage areas. Alternate costs are provided for complete slab replacement, cathodic protection and penetrating corrosion inhibitor use at the Garage 47 slabs.

Estimating the costs of concrete repairs is difficult since the quantities of the repairs typically exceeds the damage quantities found during the survey by a factor of two to three due to one or more of the following reasons:

- Vehicles or other obstructions prevented a complete examination of the entire garage area
- Additional damage occurs between the time of the survey and the beginning of the repairs
- The vibrations from demolition cause additional delaminations to occur over reinforcing steel which is corroding but has not yet caused the concrete to split.
- Removing additional concrete along reinforcing bars to allow required lap splice lengths for the addition of new bars alongside deteriorated bars.
- Combining closely spaced damage areas into one larger repair to allow for more economical and quicker repairs.

To reflect this anticipated increase in repair quantities we have increased the surveyed quantities by a factor of 2.0 to calculate the probable repair costs. The unit costs used below were obtained from bids received for recent concrete repair projects in this area, or from specialty contractors who perform this work. We have determined the probable repair costs for the different repair methods discussed as follows:

Repair Item	Estimated Quantity	Unit Cost	Total
A. Repairs:			
1. Full-Depth Slab Repairs	6,200 sf	$ 35.00	$ 217,000
2. Slab Surface Repairs	720 sf	$ 25.00	18,000
3. Slab Soffit Repairs	22 sf	$ 65.00	1,430
4. Column Repairs	14 sf	$ 85.00	1,190
5. Beam Repairs	4 sf	$ 73.00	292
6. Knee-Wall Repairs	50 sf	$230.00	11,500
7. Repair Brick Wall Ledgers	400 lf	$150.00	60,000
8. Rebuild Bulged Brick Wall	80 sf	$100.00	8,000
9. Repair Corroded/Split Guardrail Posts	150 ea.	$200.00	30,000
		Subtotal: Repairs	$ 347,412
B. Waterproofing Work:			
1. Replace Expansion Joints	350 lf	$ 150.00	$ 52,500
2. Repair Existing/Add New Deck Coating	25,500 sf	$ 2.50	63,750
3. New Coating Topcoat	146,500 sf	$ 1.50	219,750
4. Add Drains and Piping	6 ea.	$ 1,500.00	9,000
5. Rout and Seal Wall Cracks	200 lf	$ 6.00	1,200
6. Repair Stair Coating	2,000 sf	$ 2.00	4,000
		Subtotal: Waterproofing Work	$ 350,200

Repair Item	Estimated Quantity	Unit Cost	Total
C. Miscellaneous Work: 1. Allowance to Clean and Paint Steel Beam Flanges	Lump Sum		$ 10,000
2. Allowance to Clean and Paint Precast Wall Connections	Lump Sum		5,000
3. Repaint Deck Striping	Lump Sum		12,000
4. Allowance to Clean, Paint and Seal Guardrails	Lump Sum		10,000
5. Brace North Stair Wall	Lump Sum		2,500
	Subtotal:	Miscellaneous Work	$ 39,500
Subtotal: Total Repair Costs			$ 737,115
Contractor's Overhead and Profit	30%		$ 221,135
		Total Repairs Cost	**$ 958,250**
Alternate No. 1: Replace Garage 47 Slabs	Lump Sum		$4,600,000
Alternate No. 2: Install Cathodic Protection System on Garage 47 Slabs	Lump Sum		$2,000,000
Alternate No. 3: Apply Penetrating Corrosion Inhibitor to Garage 47 Slabs	Lump Sum		$172,000

Additional costs can be expected for work on architectural finishes, partition walls, temporary traffic controls, temporary parking relocation, construction document preparation, construction inspections, etc. Therefore, the actual total repair project costs will be higher than the costs noted above. We recommend that an additional 20% be added to these costs to provide for this additional work and to provide a construction contingency cost for unexpected work needed. We caution that these probable costs are preliminary in nature and should only be used for in-house budgetary planning

After the garage has been repaired, a maintenance program should be established to help prevent future damage. This program should include, at a minimum:

- Washing down the garage at least once in the spring, and preferably again in the fall, to remove chlorides which can damage the concrete and dirt and debris which could damage the coating system.
- Periodically inspecting and cleaning the drains to avoid clogged drains and ponding problems.
- Inspecting the coating system for damage which should then be repaired.
- Repairing any new concrete damage when it is first observed.

APPENDIX A
Photos

Photo No. 1

Typical Garage 47 Slab Damage

Area within white painted lines is delaminated concrete. Note the rectangular areas of different colors indicating previous slab repairs made at different times, most of which are now delaminated.

Photo No. 2

Typical Concrete Surface Scaling

Moderate to severe scaling was observed in some areas of the garage.
The area marked in white lines is delaminated.

Photo No. 3
Typical Slab Soffit Damage – Garage 47
Detected spalling and deterioration area on the soft is marked in red. Exposed rebar is visible where the concrete has spalled.

Photo No. 4
Slab Soffit Damage at Stair/Elevator Tower Areas – Garage 47
The soffit of the area between the stair/elevator tower edges and the adjacent beam had spalled concrete and exposed rebar.

Photo No. 5

Slab Edge Damage – Garage 47

The sides and corners of inner edges of ramp slabs has delaminated and spalled.
These slabs rest on corroded steel flanges.

Photo No. 6

Wall-to-Slab Connection – Garage 47

Some of the angles in the south-side precast facade panel-to-wall connections have rusted and surrounding concrete has spalled.

Photo No. 7

Typical Guardrail Damage – Garage 47

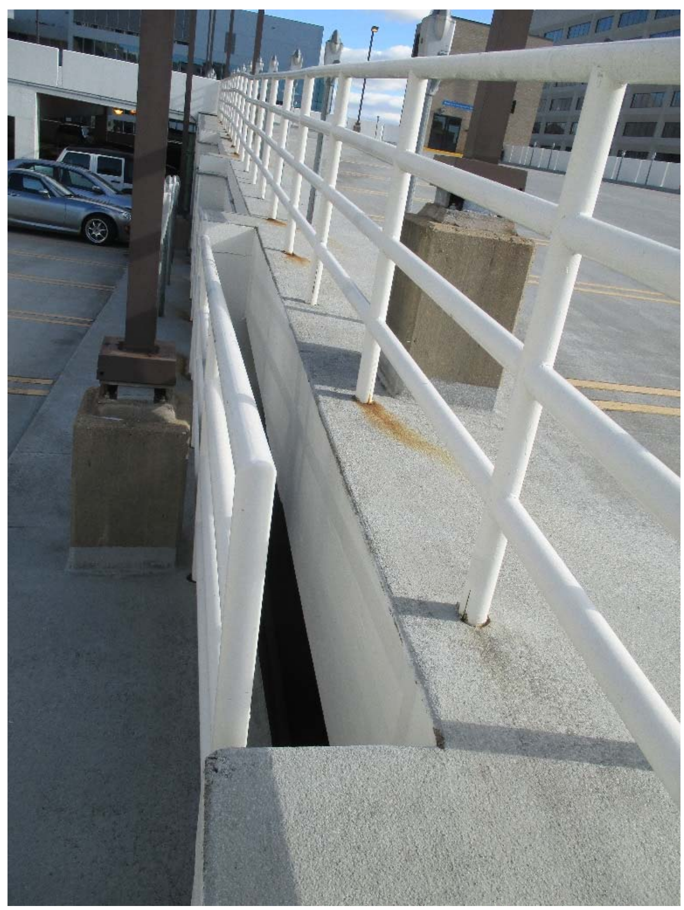
The bases of many guardrail posts are corroding and some corrosion is also occurring at the upper portions of the guardrails.

Photo No. 8

Typical Guartail Damage at Garage 47A Ramp

The bases of the guardrails embedded in the curb are corroding and some have split vertically along their welded seams.

Note that there is no sealant around the bottoms of the posts.



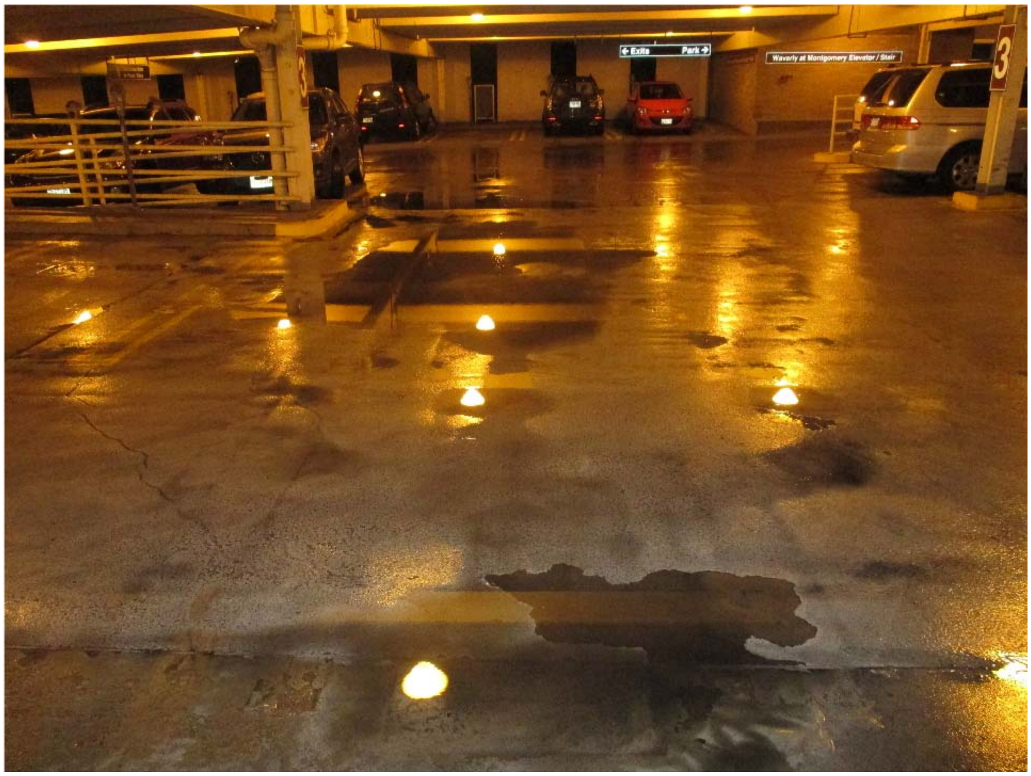


Photo No. 9
Areas of Ponding – Garage 47
Areas of ponding observed during extended periods of rain.

Photo No. 10
Expansion Joint Damage at Stair Tower

Photo No. 11
Exterior Wall Movement at North Center Stair Tower
The exterior wall of the tower has moved outwards from the return wall on the right.

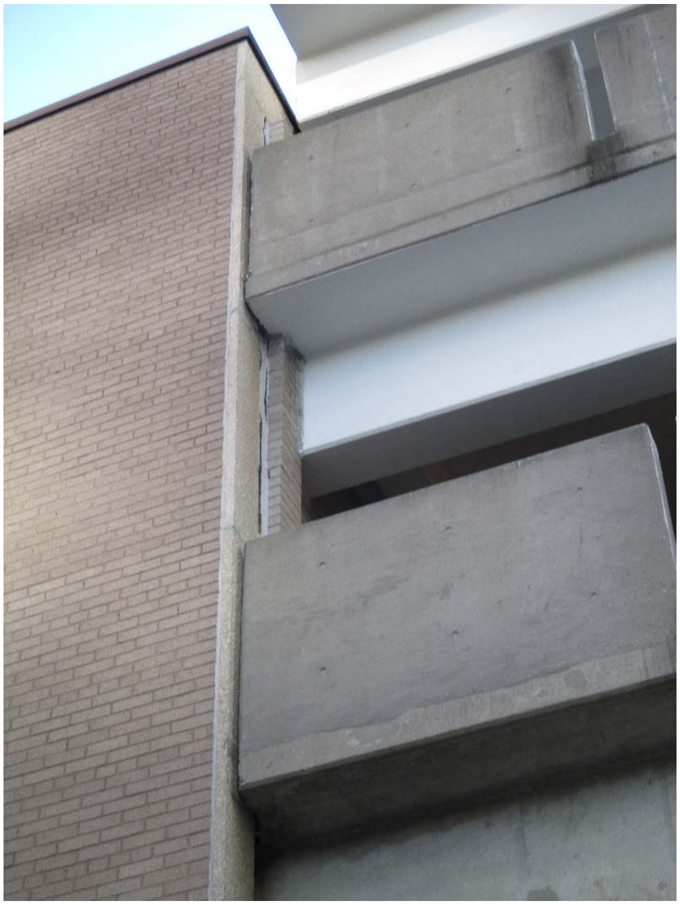


Photo No. 12
Exterior Wall Movement at North Center Stair Tower
Note the sealant in the vertical joint between the walls has torn open due to the outwards movement of the exterior wall.

Photo No. 13
Slab Surface Delamination
Garage #47A: This phase generally had less delamination than the older phase (Garage #47). The white rectangles in the photo show the detected delaminated areas.

Photo No. 14
Concrete Column Face Delamination – Garage 47A
Concrete delamination was detected on the column face and marked with black chalk.

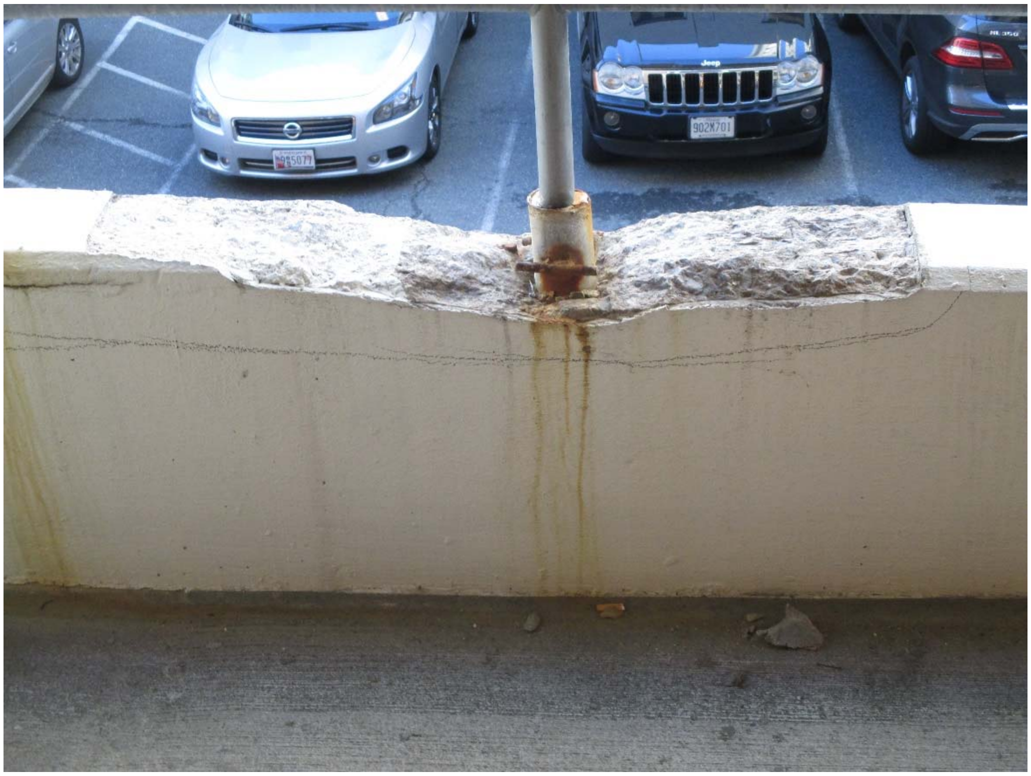


Photo No. 15

Concrete Knee Wall Damage – Garage 47A

The corrosion of the embedded guardrail post sleeve has caused the knee wall concrete to spall.

Photo No. 16

Typical Wall Damage at Ledger Angle

The mortar and brick are spalling along the ledger angle. Note the rust stains from the corroding angle.

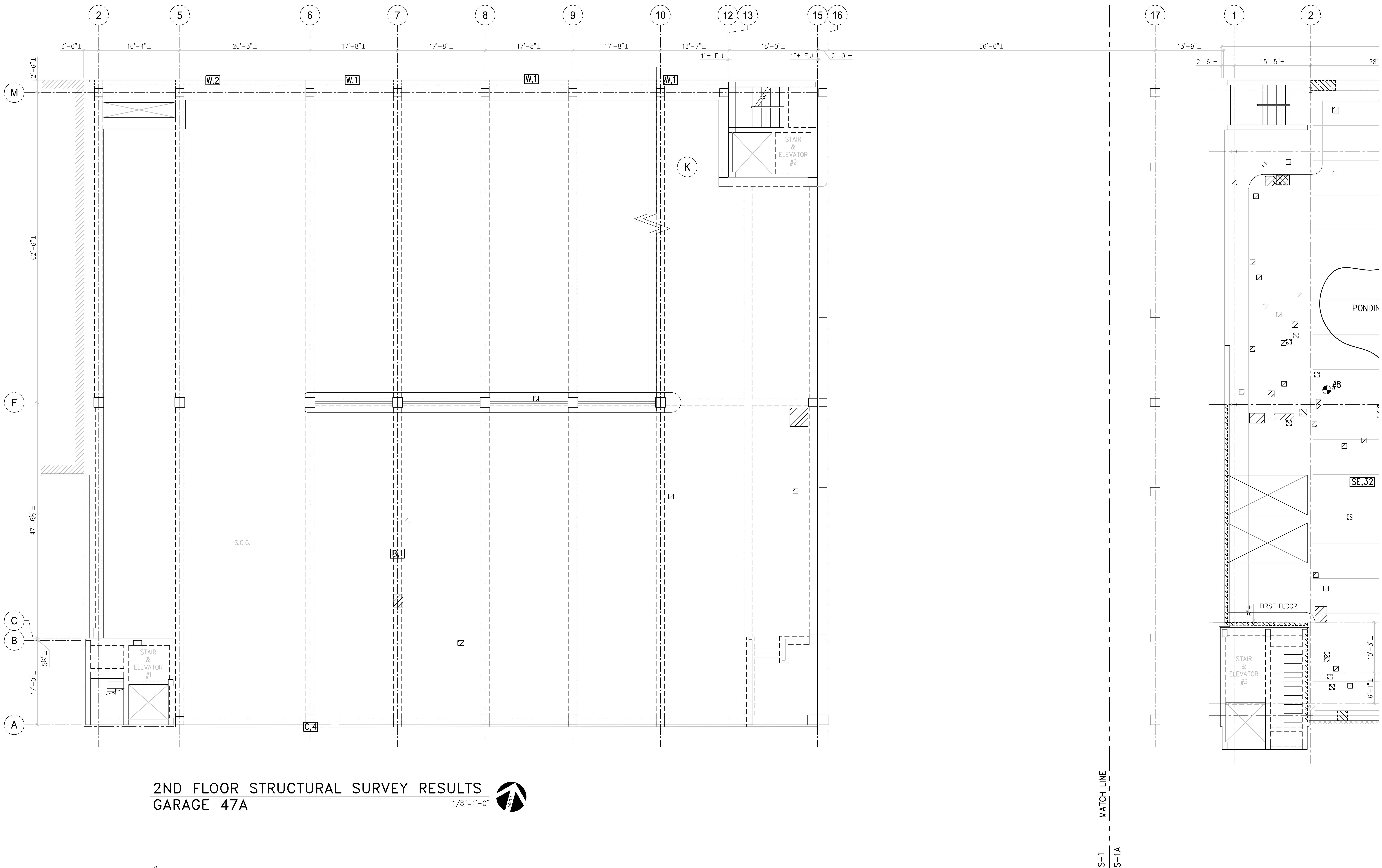
Photo No. 17
Typical Wall Damage at Ledger Angle
The brick is being pushed outwards by the corrosion of the ledger angle.

Photo No. 18
Typical Brick Wall Damage
The corner of the brick wall is spalling and cracked vertically.

Photo No. 19
Bulging Brick at West Wall

Photo No. 20
Typical Deteriorated Stair Coating

APPENDIX B
Structural Damage Drawings



2ND FLOOR STRUCTURAL SURVEY RESULTS
GARAGE 47A

1/8"=1'-0"

DENOTES CHLORIDE TESTING SAMPLE LOCATION AND ID#.

DR DENOTES EXISTING DECK DRAIN.

ER DENOTES EXPOSED REBAR ON SURFACE.

DEJ DENOTES DAMAGED EXPANSION JOINT.

CWC DENOTES CORRODED PRECAST WALL TO SLAB CONNECTION.

X,Y INDICATES CONCRETE DELAMINATION/SPALLING DAMAGE AS FOLLOWS:

	SYMBOL X	SYMBOL Y
B	BEAM SOFFIT DAMAGE	AREA OF DAMAGE (SQ. FT.)
C	COLUMN FACE DAMAGE	AREA OF DAMAGE (SQ. FT.)
W	WALL DAMAGE AT RAILINGS	AREA OF DAMAGE (SQ. FT.)
SE	SIDE OF SLAB EDGE DAMAGE	AREA OF DAMAGE (SQ. FT.)

SE,# BOT. DENOTES CORNER DAMAGE ALONG THE BOTTOM OF SLAB EDGE.

1 DAMAGE SYMBOL KEY

N.T.S.

PLAN NOTES

1) DENOTES APPROXIMATE SIZE AND LOCATION OF SLAB SURFACE CONCRETE DELAMINATIONS OR SPALLS.

2) DENOTES APPROXIMATE SIZE AND AREA OF SLAB SOFFIT CONCRETE DELAMINATIONS OR SPALLS.

3) DENOTES LOCATION OF VEHICLE DURING SURFACE STUDY. EXTENT OF SURFACE DAMAGE BENEATH VEHICLE, IF ANY, IS UNKNOWN.

4) PONDING DENOTES AREAS OF PONDED WATER OBSERVED AFTER PERIOD OF RAIN

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STRUCTURAL CONDITION SURVEY
MONTGOMERY COUNTY PARKING GARAGE NO. 47/47A

7402 WAVERLY STREET
BETHESDA, MD

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PROJECT NO.: 15-198	SHEET NO.: S-1
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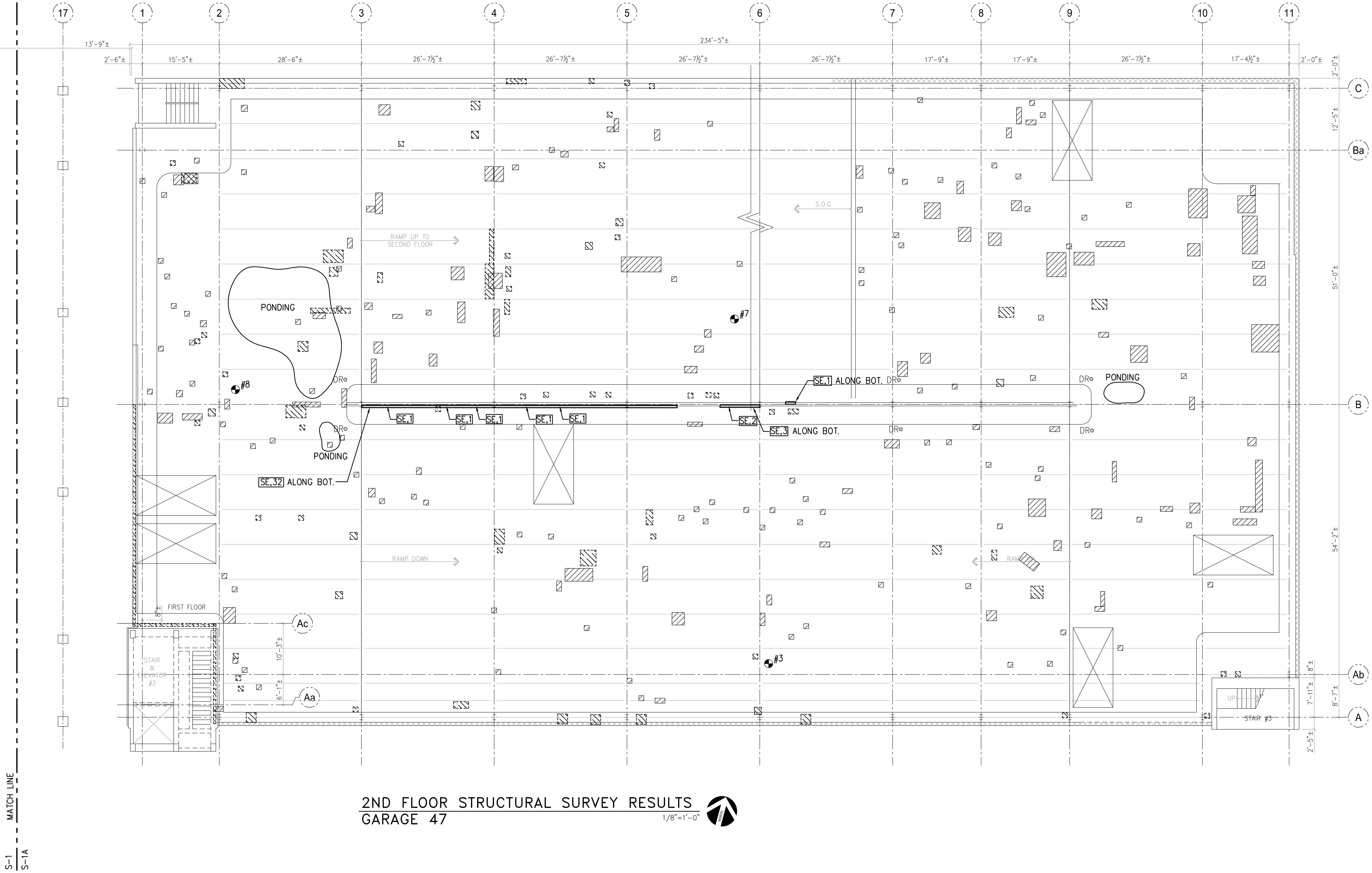
SCALE: AS NOTED	



2ND FLOOR STRUCTURAL SURVEY RESULTS
GARAGE 47

1/8"=1'-0"

DENOTES CHLORIDE TESTING SAMPLE LOCATION AND ID#.

DR DENOTES EXISTING DECK DRAIN.

ER DENOTES EXPOSED REBAR ON SURFACE.

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	SYMBOL X	SYMBOL Y
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C	COLUMN FACE DAMAGE	AREA OF DAMAGE (SQ. FT.)
W	WALL DAMAGE AT RAILINGS	AREA OF DAMAGE (SQ. FT.)
SE	SIDE OF SLAB EDGE DAMAGE	AREA OF DAMAGE (SQ. FT.)

SE,# BOT. DENOTES CORNER DAMAGE ALONG THE BOTTOM OF SLAB EDGE.

1 DAMAGE SYMBOL KEY
N.T.S.

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2ND FLOOR STRUCTURAL SURVEY RESULTS GARAGE 47

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15-198	S-1A
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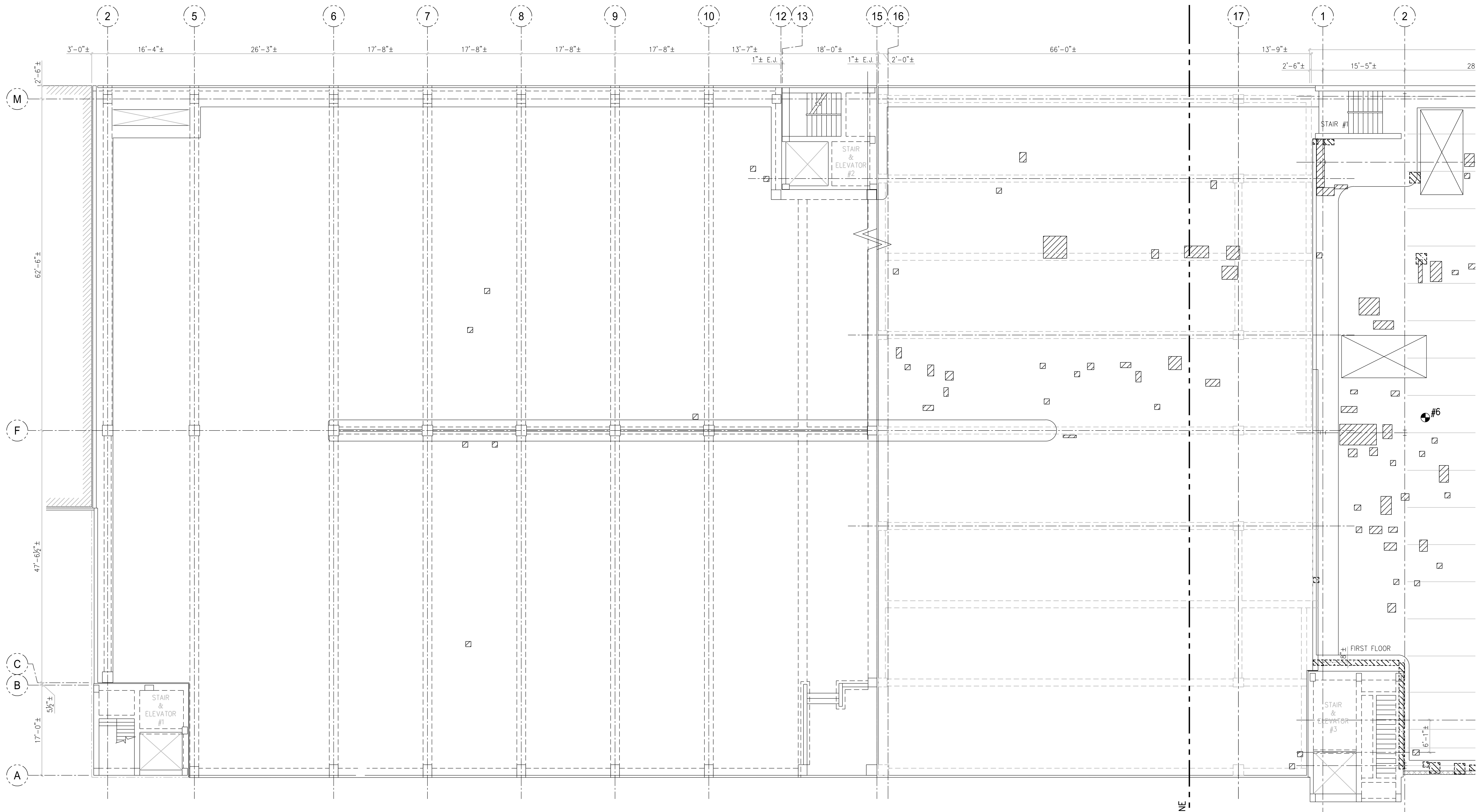

3RD FLOOR STRUCTURAL SURVEY RESULTS
GARAGE 47A

1/8"=1'-0"

S-2 | S-2A

DENOTES CHLORIDE TESTING SAMPLE LOCATION AND ID#.

DR DENOTES EXISTING DECK DRAIN.

ER DENOTES EXPOSED REBAR ON SURFACE.

DEJ DENOTES DAMAGED EXPANSION JOINT.

CWC DENOTES CORRODED PRECAST WALL TO SLAB CONNECTION.

X,Y INDICATES CONCRETE DELAMINATION/SPALLING DAMAGE AS FOLLOWS:

	SYMBOL X	SYMBOL Y
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C	COLUMN FACE DAMAGE	AREA OF DAMAGE (SQ. FT.)
W	WALL DAMAGE AT RAILINGS	AREA OF DAMAGE (SQ. FT.)
SE	SIDE OF SLAB EDGE DAMAGE	AREA OF DAMAGE (SQ. FT.)

SE.# BOT. DENOTES CORNER DAMAGE ALONG THE BOTTOM OF SLAB EDGE.

1 DAMAGE SYMBOL KEY

N.T.S.

PLAN NOTES

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SCALE: AS NOTED

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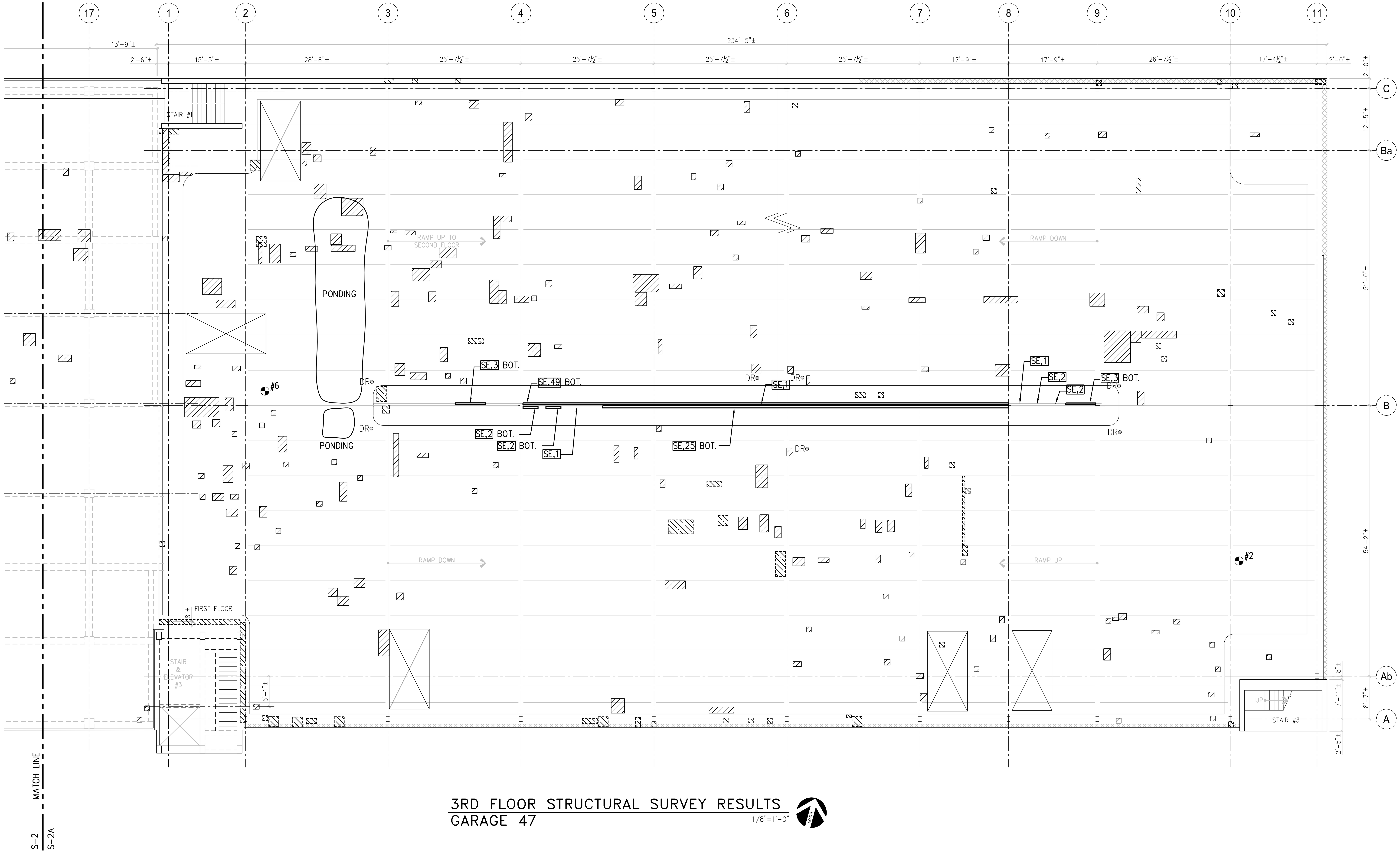

3RD FLOOR STRUCTURAL SURVEY RESULTS
GARAGE 47

1/8"=1'-0"

# DENOTES CHLORIDE TESTING SAMPLE LOCATION AND ID#.

DR DENOTES EXISTING DECK DRAIN.

ER DENOTES EXPOSED REBAR ON SURFACE.

DEJ DENOTES DAMAGED EXPANSION JOINT.

CWC DENOTES CORRODED PRECAST WALL TO SLAB CONNECTION.

X,Y INDICATES CONCRETE DELAMINATION/SPALLING DAMAGE AS FOLLOWS:

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C	COLUMN FACE DAMAGE	AREA OF DAMAGE (SQ. FT.)
W	WALL DAMAGE AT RAILINGS	AREA OF DAMAGE (SQ. FT.)
SE	SIDE OF SLAB EDGE DAMAGE	AREA OF DAMAGE (SQ. FT.)

SE,# BOT. DENOTES CORNER DAMAGE ALONG THE BOTTOM OF SLAB EDGE.

1 DAMAGE SYMBOL KEY

N.T.S.

PLAN NOTES

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2) DENOTES APPROXIMATE SIZE AND AREA OF SLAB SOFFIT CONCRETE DELAMINATIONS OR SPALLS.

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4) PONDING DENOTES AREAS OF PONDED WATER OBSERVED AFTER PERIOD OF RAIN

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STRUCTURAL CONDITION SURVEY
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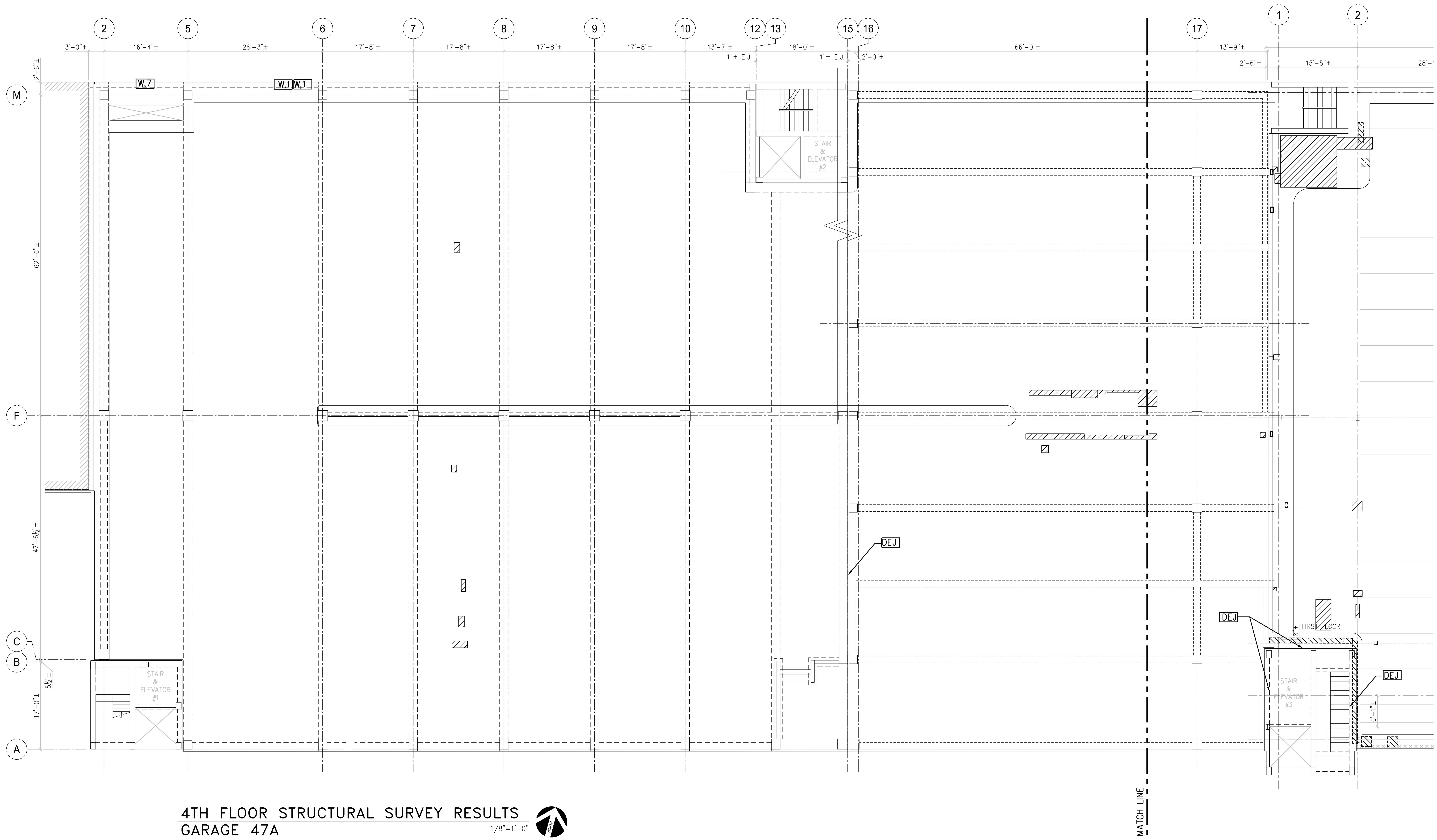

4TH FLOOR STRUCTURAL SURVEY RESULTS
GARAGE 47A

1/8"=1'-0"

DENOTES CHLORIDE TESTING SAMPLE LOCATION AND ID#.

DR⊙ DENOTES EXISTING DECK DRAIN.

ER DENOTES EXPOSED REBAR ON SURFACE.

DEJ DENOTES DAMAGED EXPANSION JOINT.

CWC DENOTES CORRODED PRECAST WALL TO SLAB CONNECTION.

X,Y INDICATES CONCRETE DELAMINATION/SPALLING DAMAGE AS FOLLOWS:

	SYMBOL X	SYMBOL Y
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C	COLUMN FACE DAMAGE	AREA OF DAMAGE (SQ. FT.)
W	WALL DAMAGE AT RAILINGS	AREA OF DAMAGE (SQ. FT.)
SE	SIDE OF SLAB EDGE DAMAGE	AREA OF DAMAGE (SQ. FT.)

SE,# BOT. DENOTES CORNER DAMAGE ALONG THE BOTTOM OF SLAB EDGE.

1 DAMAGE SYMBOL KEY

N.T.S.

PLAN NOTES

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2) DENOTES APPROXIMATE SIZE AND AREA OF SLAB SOFFIT CONCRETE DELAMINATIONS OR SPALLS.

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4) PONDING DENOTES AREAS OF PONDED WATER OBSERVED AFTER PERIOD OF RAIN

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STRUCTURAL CONDITION SURVEY
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SHEET TITLE:

4TH FLOOR STRUCTURAL SURVEY RESULTS GARAGE 47A

PROJECT NO.: 15-198	SHEET NO.: S-3
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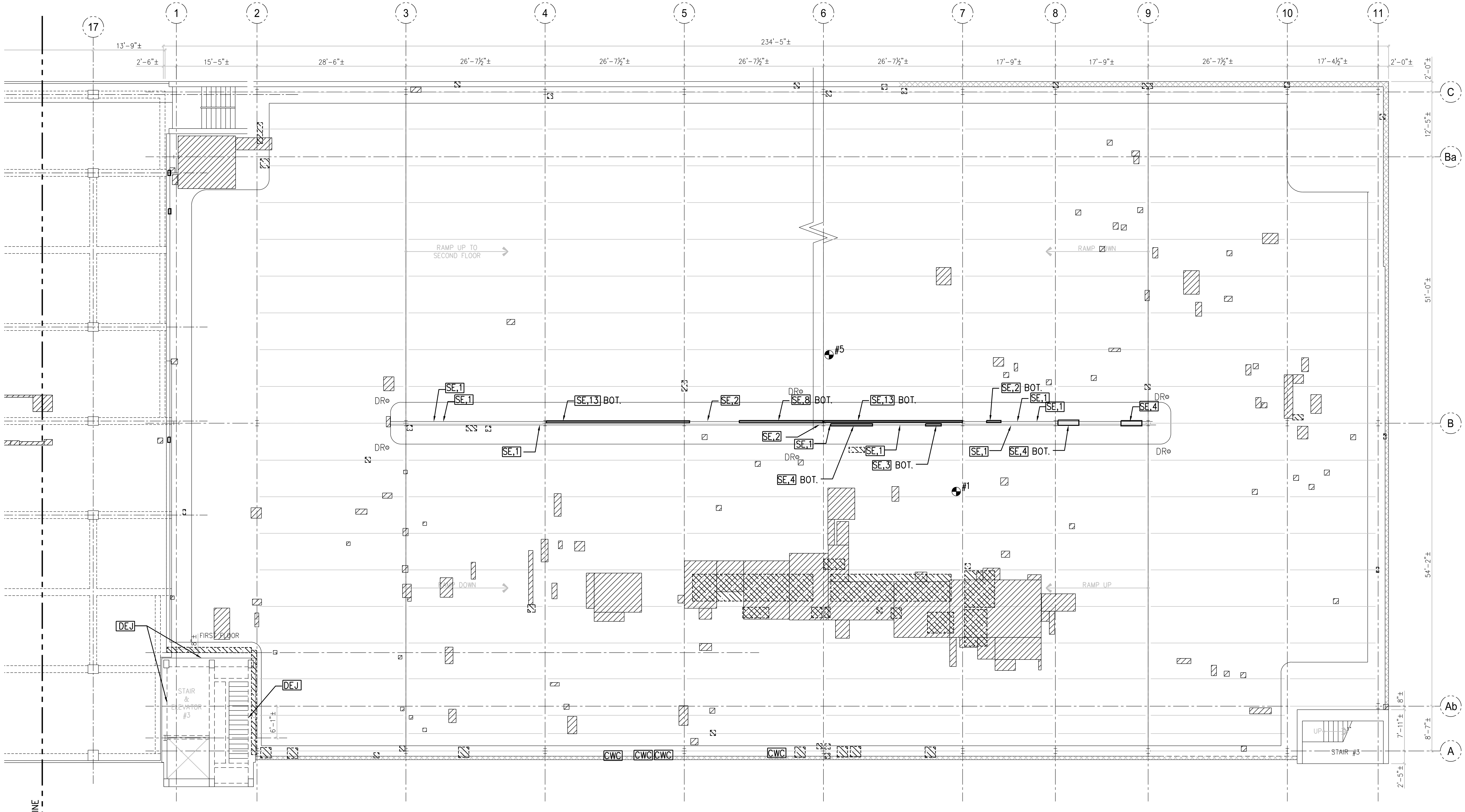
SCALE: AS NOTED	



4TH FLOOR STRUCTURAL SURVEY RESULTS
GARAGE 47

1/8"=1'-0"

- DENOTES CHLORIDE TESTING SAMPLE LOCATION AND ID#.
- DR DENOTES EXISTING DECK DRAIN.
- ER DENOTES EXPOSED REBAR ON SURFACE.
- DEJ DENOTES DAMAGED EXPANSION JOINT.
- CWC DENOTES CORRODED PRECAST WALL TO SLAB CONNECTION.
- X,Y INDICATES CONCRETE DELAMINATION/SPALLING DAMAGE AS FOLLOWS:

	SYMBOL X	SYMBOL Y
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C	COLUMN FACE DAMAGE	AREA OF DAMAGE (SQ. FT.)
W	WALL DAMAGE AT RAILINGS	AREA OF DAMAGE (SQ. FT.)
SE	SIDE OF SLAB EDGE DAMAGE	AREA OF DAMAGE (SQ. FT.)

- SE,# BOT. DENOTES CORNER DAMAGE ALONG THE BOTTOM OF SLAB EDGE.

1 DAMAGE SYMBOL KEY

N.T.S.

PLAN NOTES

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2) DENOTES APPROXIMATE SIZE AND AREA OF SLAB SOFFIT CONCRETE DELAMINATIONS OR SPALLS.

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4) PONDING DENOTES AREAS OF PONDED WATER OBSERVED AFTER PERIOD OF RAIN

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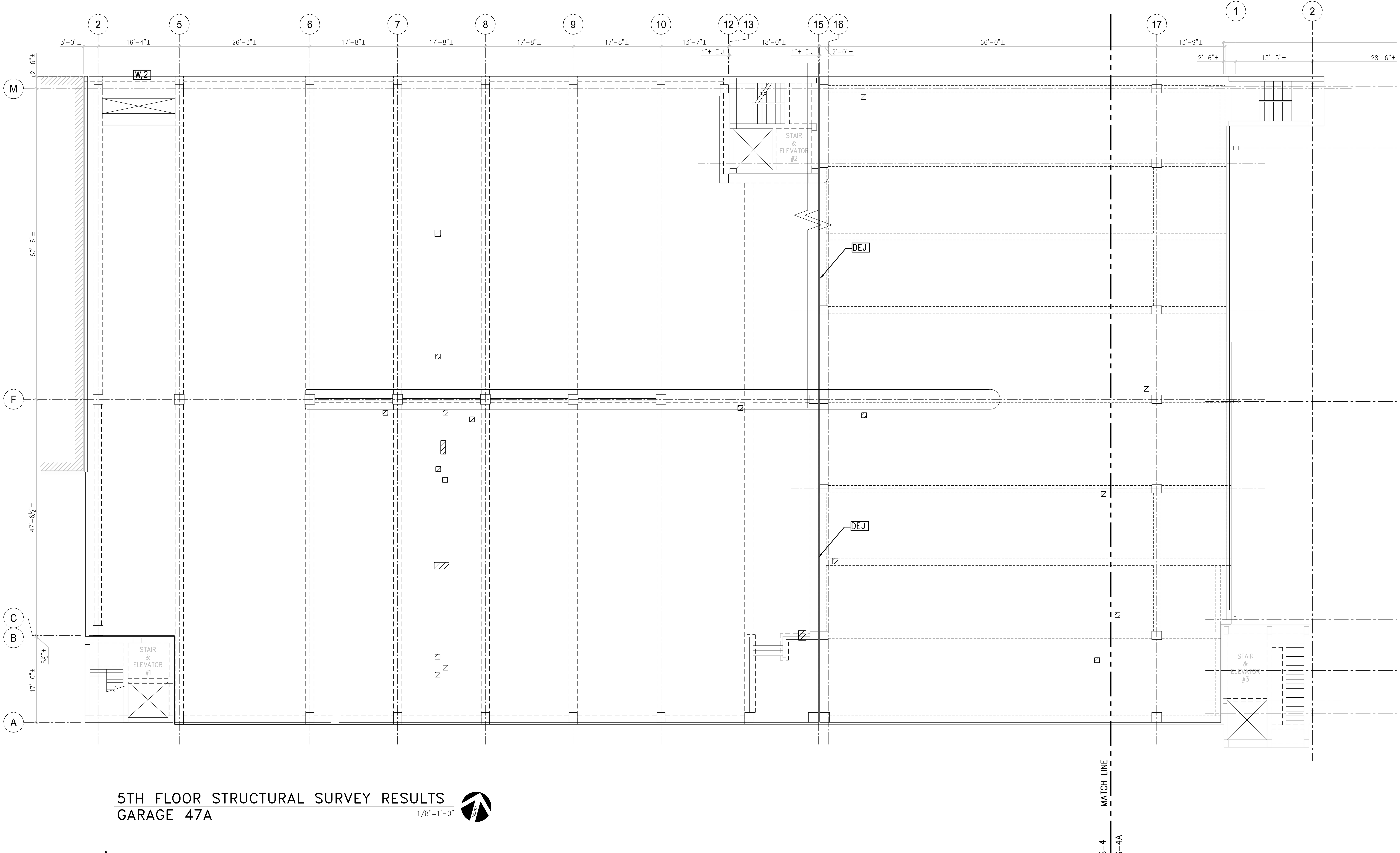
4TH FLOOR STRUCTURAL SURVEY RESULTS GARAGE 47

PROJECT NO.: 15-198	SHEET NO.: S-3A
DATE: 12/18/15	
SCALE: AS NOTED	



5TH FLOOR STRUCTURAL SURVEY RESULTS
GARAGE 47A

1/8"=1'-0"

DENOTES CHLORIDE TESTING SAMPLE LOCATION AND ID#.

DR⊙ DENOTES EXISTING DECK DRAIN.

ER DENOTES EXPOSED REBAR ON SURFACE.

DEJ DENOTES DAMAGED EXPANSION JOINT.

CWC DENOTES CORRODED PRECAST WALL TO SLAB CONNECTION.

X.Y INDICATES CONCRETE DELAMINATION/SPALLING DAMAGE AS FOLLOWS:

	SYMBOL X	SYMBOL Y
B	BEAM SOFFIT DAMAGE	AREA OF DAMAGE (SQ. FT.)
C	COLUMN FACE DAMAGE	AREA OF DAMAGE (SQ. FT.)
W	WALL DAMAGE AT RAILINGS	AREA OF DAMAGE (SQ. FT.)
SE	SIDE OF SLAB EDGE DAMAGE	AREA OF DAMAGE (SQ. FT.)

SE.# BOT. DENOTES CORNER DAMAGE ALONG THE BOTTOM OF SLAB EDGE.

1 DAMAGE SYMBOL KEY

N.T.S.

PLAN NOTES

1) DENOTES APPROXIMATE SIZE AND LOCATION OF SLAB SURFACE CONCRETE DELAMINATIONS OR SPALLS.

2) DENOTES APPROXIMATE SIZE AND AREA OF SLAB SOFFIT CONCRETE DELAMINATIONS OR SPALLS.

3) DENOTES LOCATION OF VEHICLE DURING SURFACE STUDY. EXTENT OF SURFACE DAMAGE BENEATH VEHICLE, IF ANY, IS UNKNOWN.

4) PONDING DENOTES AREAS OF PONDED WATER OBSERVED AFTER PERIOD OF RAIN

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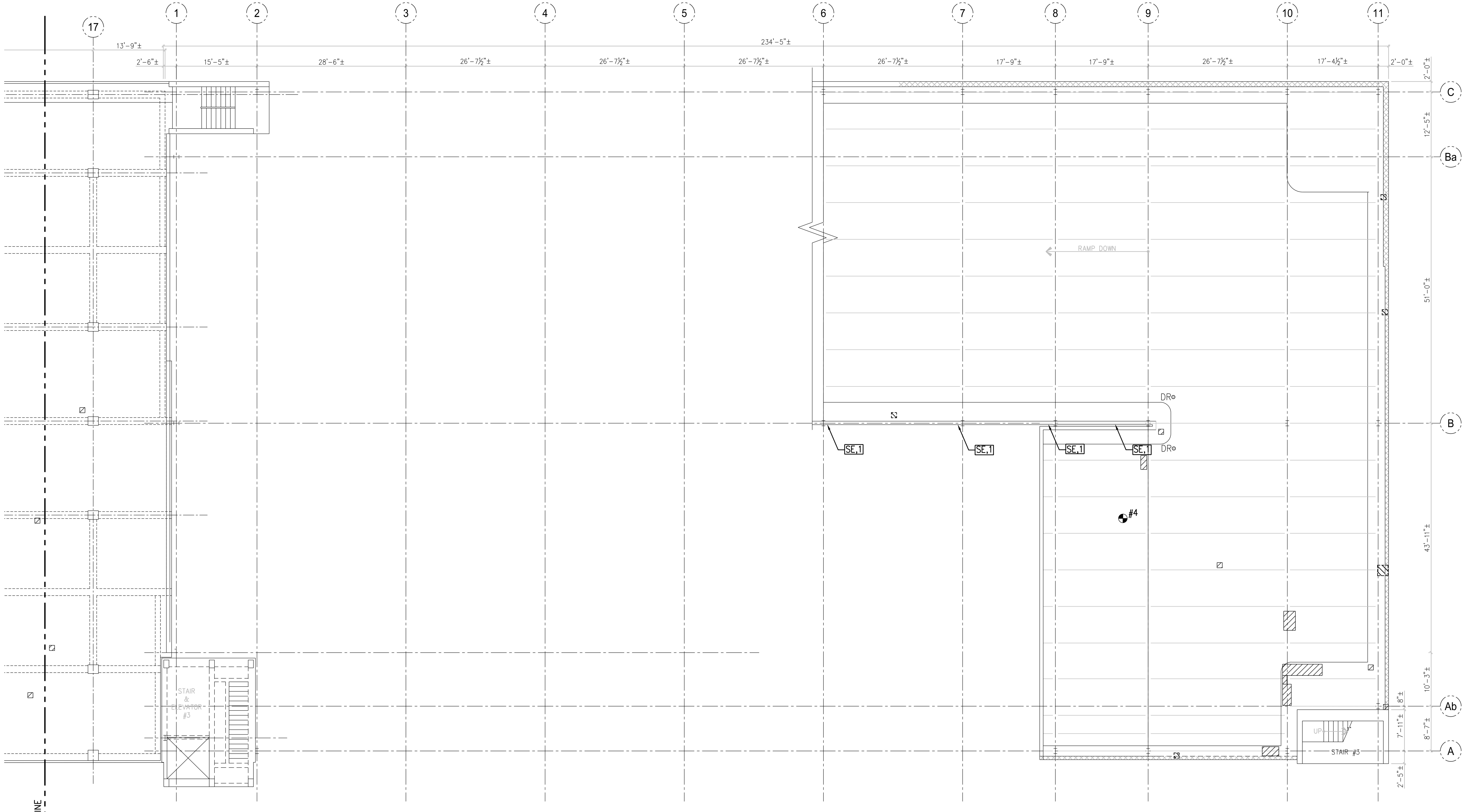
STRUCTURAL CONDITION SURVEY
MONTGOMERY COUNTY PARKING GARAGE NO. 47/47A

7402 WAVERLY STREET
BETHESDA, MD

NO.	REVISION	DATE

SHEET TITLE:
5TH FLOOR STRUCTURAL SURVEY RESULTS GARAGE 47A

PROJECT NO.: 15-198	SHEET NO.: S-4
DATE: 12/18/15	
SCALE: AS NOTED	



MATCH LINE

S-4 | S-4A

5TH FLOOR STRUCTURAL SURVEY RESULTS
GARAGE 47

1/8"=1'-0"

- DENOTES CHLORIDE TESTING SAMPLE LOCATION AND ID#.
- DR DENOTES EXISTING DECK DRAIN.
- ER DENOTES EXPOSED REBAR ON SURFACE.
- DEJ DENOTES DAMAGED EXPANSION JOINT.
- CWC DENOTES CORRODED PRECAST WALL TO SLAB CONNECTION.
- X,Y INDICATES CONCRETE DELAMINATION/SPALLING DAMAGE AS FOLLOWS:

	SYMBOL X	SYMBOL Y
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C	COLUMN FACE DAMAGE	AREA OF DAMAGE (SQ. FT.)
W	WALL DAMAGE AT RAILINGS	AREA OF DAMAGE (SQ. FT.)
SE	SIDE OF SLAB EDGE DAMAGE	AREA OF DAMAGE (SQ. FT.)

- SE,# BOT. DENOTES CORNER DAMAGE ALONG THE BOTTOM OF SLAB EDGE.

1 DAMAGE SYMBOL KEY

N.T.S.

PLAN NOTES

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3) DENOTES LOCATION OF VEHICLE DURING SURFACE STUDY. EXTENT OF SURFACE DAMAGE BENEATH VEHICLE, IF ANY, IS UNKNOWN.

4) (PONDING) DENOTES AREAS OF PONDED WATER OBSERVED AFTER PERIOD OF RAIN

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STRUCTURAL CONDITION SURVEY
MONTGOMERY COUNTY PARKING GARAGE NO. 47/47A

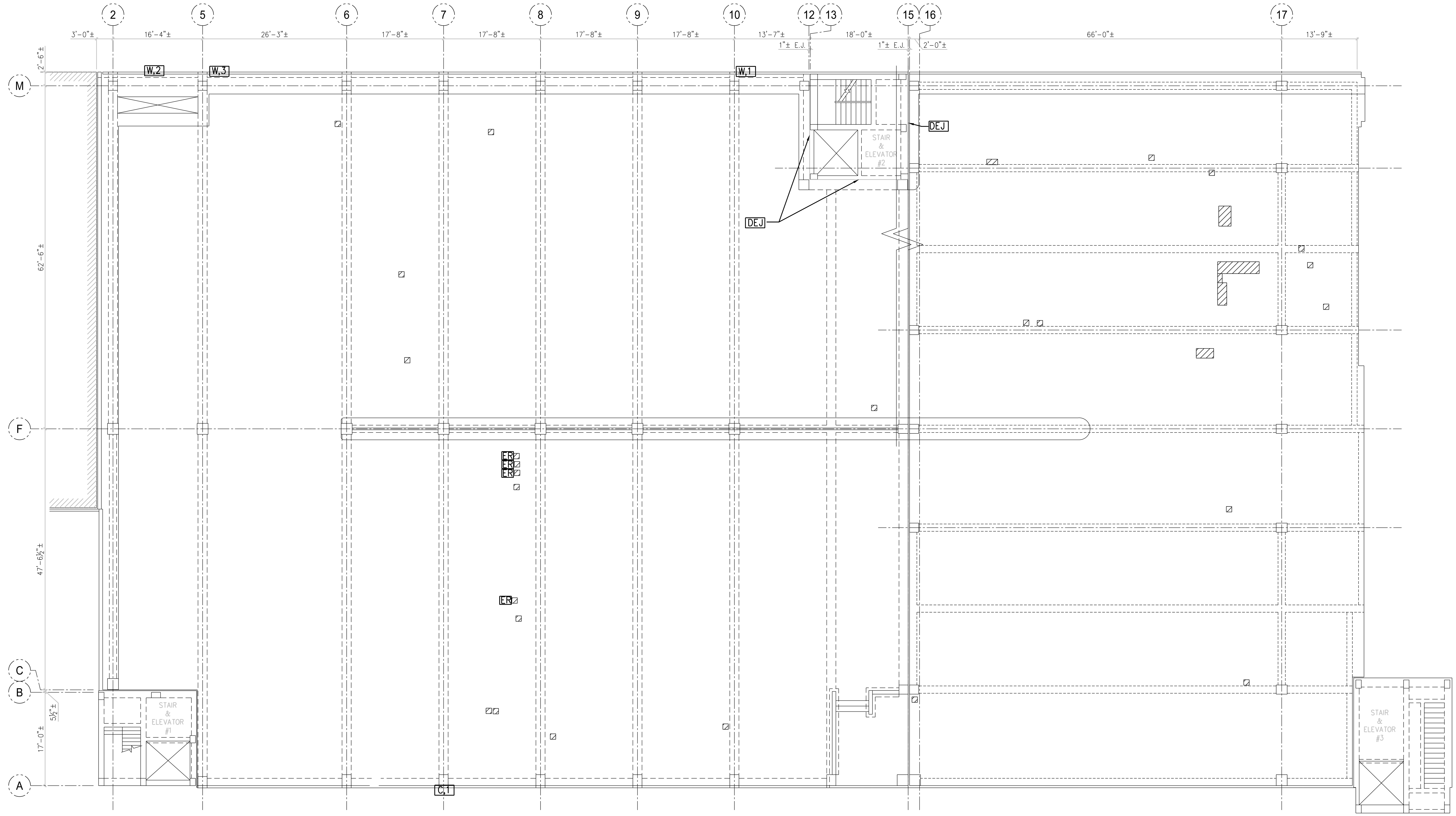
7402 WAVERLY STREET
BETHESDA, MD

NO.	REVISION	DATE

SHEET TITLE:

5TH FLOOR STRUCTURAL SURVEY RESULTS GARAGE 47

PROJECT NO.: 15-198	SHEET NO.: S-4A
DATE: 12/18/15	
SCALE: AS NOTED	



6TH FLOOR STRUCTURAL SURVEY RESULTS
GARAGE 47A

1/8"=1'-0"

NORTH

DENOTES CHLORIDE TESTING SAMPLE LOCATION AND ID#.

DR DENOTES EXISTING DECK DRAIN.

ER DENOTES EXPOSED REBAR ON SURFACE.

DEJ DENOTES DAMAGED EXPANSION JOINT.

CWC DENOTES CORRODED PRECAST WALL TO SLAB CONNECTION.

X,Y INDICATES CONCRETE DELAMINATION/SPALLING DAMAGE AS FOLLOWS:

	SYMBOL X	SYMBOL Y
B	BEAM SOFFIT DAMAGE	AREA OF DAMAGE (SQ. FT.)
C	COLUMN FACE DAMAGE	AREA OF DAMAGE (SQ. FT.)
W	WALL DAMAGE AT RAILINGS	AREA OF DAMAGE (SQ. FT.)
SE	SIDE OF SLAB EDGE DAMAGE	AREA OF DAMAGE (SQ. FT.)

SE,# BOT. DENOTES CORNER DAMAGE ALONG THE BOTTOM OF SLAB EDGE.

1 DAMAGE SYMBOL KEY

N.T.S.

PLAN NOTES

1) DENOTES APPROXIMATE SIZE AND LOCATION OF SLAB SURFACE CONCRETE DELAMINATIONS OR SPALLS.

2) DENOTES APPROXIMATE SIZE AND AREA OF SLAB SOFFIT CONCRETE DELAMINATIONS OR SPALLS.

3) DENOTES LOCATION OF VEHICLE DURING SURFACE STUDY. EXTENT OF SURFACE DAMAGE BENEATH VEHICLE, IF ANY, IS UNKNOWN.

4) PONDING DENOTES AREAS OF PONDED WATER OBSERVED AFTER PERIOD OF RAIN

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HA ASSOCIATES

HOLBERT APPLE ASSOCIATES, INC.
STRUCTURAL ENGINEERS

3423 Olney-Laytonsville Road, Suite 6
Olney, Maryland 20832

Ph (301) 570-1460
Fax (301) 570-1462

STRUCTURAL CONDITION SURVEY
MONTGOMERY COUNTY PARKING GARAGE NO. 47/47A

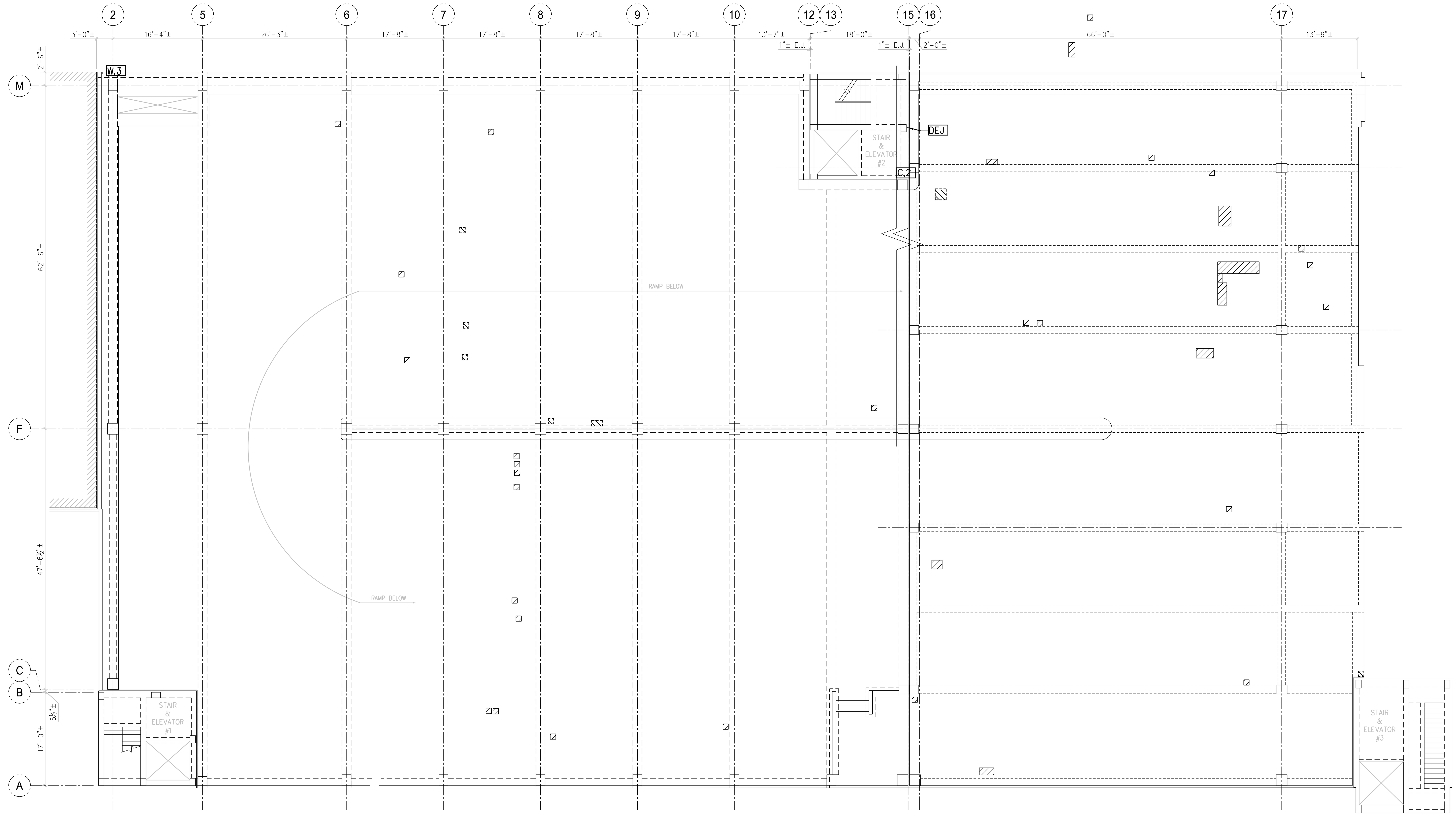
7402 WAVERLY STREET
BETHESDA, MD

NO.	REVISION	DATE

SHEET TITLE:

6TH FLOOR STRUCTURAL SURVEY RESULTS GARAGE 47A

PROJECT NO.: 15-198	SHEET NO.: S-5
DATE: 12/18/15	
SCALE: AS NOTED	



6TH FLOOR STRUCTURAL SURVEY RESULTS
GARAGE 47A

1/8"=1'-0"

- DENOTES CHLORIDE TESTING SAMPLE LOCATION AND ID#.
- DR DENOTES EXISTING DECK DRAIN.
- ER DENOTES EXPOSED REBAR ON SURFACE.
- DEJ DENOTES DAMAGED EXPANSION JOINT.
- CWC DENOTES CORRODED PRECAST WALL TO SLAB CONNECTION.
- X.Y INDICATES CONCRETE DELAMINATION/SPALLING DAMAGE AS FOLLOWS:

	SYMBOL X	SYMBOL Y
B	BEAM SOFFIT DAMAGE	AREA OF DAMAGE (SQ. FT.)
C	COLUMN FACE DAMAGE	AREA OF DAMAGE (SQ. FT.)
W	WALL DAMAGE AT RAILINGS	AREA OF DAMAGE (SQ. FT.)
SE	SIDE OF SLAB EDGE DAMAGE	AREA OF DAMAGE (SQ. FT.)

- SE# BOT. DENOTES CORNER DAMAGE ALONG THE BOTTOM OF SLAB EDGE.

1 DAMAGE SYMBOL KEY

N.T.S.

PLAN NOTES

1) DENOTES APPROXIMATE SIZE AND LOCATION OF SLAB SURFACE CONCRETE DELAMINATIONS OR SPALLS.

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STRUCTURAL CONDITION SURVEY
MONTGOMERY COUNTY PARKING GARAGE NO. 47/47A

7402 WAVERLY STREET
BETHESDA, MD

NO.	REVISION	DATE

SHEET TITLE:

7TH FLOOR STRUCTURAL SURVEY RESULTS GARAGE 47A

PROJECT NO.: 15-198	SHEET NO.: S-6
DATE: 12/18/15	
SCALE: AS NOTED	

APPENDIX C
Lab Results

Tourney Consulting Group LLC
3401 Midlink Drive
Kalamazoo MI 49048

TCG TOURNEY CONSULTING GROUP

Phone (269)-384-9980
Fax (269)-384-9981
www.tourneyconsulting.com

ASTM C 1218 Water-Soluble Chloride Ion Contents (PPM)

Client: Holbert Apple Associates, Inc.
3423 Olney-Laytonsville Rd.
Suite 6
Olney, Maryland 20832

Date Received: 11/11/15
Date Tested: 11/16/15
Date Reported: 11/17/15

Attention: Kurt Wagner

TCG Project No. **15131**
Job Description: Montgomery County Garage No. 47/47A H&A # 15-198

Sample Description: The concrete powder samples were received for testing from our client. The sample bags ere mark with the depth increments listed below. All samples were dried and crushed as needed, to ensure all material passed a #20 Sieve. The Chloride data is reported mass of sample.

TCG Technician: MW

	Depth Increments in Inches					
	0 to1		1 to 2		2 to 3	
Sample ID & Slab Location	Chloride Content ppm	Chloride content (% by mass of sample)	Chloride Content ppm	Chloride content (% by mass of sample)	Chloride Content ppm	Chloride content (% by mass of sample)
1	888	0.089%	924	0.092%	794	0.079%
2	1134	0.113%	717	0.072%	104	0.010%
3	1235	0.124%	1090	0.109%	668	0.067%
4	119	0.012%	74	0.007%	29	0.003%
5	1116	0.112%	1066	0.107%	950	0.095%
6	66	0.007%	45	0.005%	45	0.005%
7	3320	0.332%	2251	0.225%	277	0.028%
8	1381	0.138%	987	0.099%	353	0.035%

Reviewed By;

Larry Wachowski

Larry Wachowski
Laboratory Manager