North Parking Structure

Engineering Condition Appraisal

Great Falls, MT

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DRAFT

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I. INTRODUCTION

In accordance with our proposal, ***Carl Walker, Inc***. has completed an Engineering Condition Appraisal of the North Parking Structure in Great Falls, Montana. The primary objectives of this assessment were to assess the general condition of the structure, identify items requiring; repair, maintenance, and/or protection, and provide an estimate of preliminary construction costs for the recommended repairs prioritized into Near-term (within 5 years), Mid-term (6-10 years), and Long-term (11-20 years).

As part of this assessment, ***Carl Walker, Inc.*** completed a visual review of the structure, chain drag survey of the supported floors, light level readings, and conformance of the facility with current ADA standards.

II. STRUCTURE DESCRIPTION

The North Parking Structure was constructed in 1979, and is located at the southeast corner of 1st Avenue North and 4th Street North. The parking structure consists of six supported levels and a slab-on-grade level and provides parking for approximately 498 vehicles.

The overall footprint of the parking structure is approximately 111 feet in the north/south direction and 248 feet in the east/west direction. A typical level is approximately 27,500 square feet and the total supported floor area for the structure is approximately 144,000 square feet. The slab-on-grade floor area is approximately 27,500 square feet.

The structure is a two-bay, double-threaded helix with one-way angled parking. The structural system consists of one-way cast-in-place post-tensioned concrete slabs framing with cast-in-place post-tensioned concrete beams. The supported slabs are 6 to 8 inches in thickness. Based on the original drawings, the slab and beam post-tensioning tendons consist of either unbonded 7-wire strands (ASTM A416) or button headed post-tensioning tendons (ASTM A421).

III. DOCUMENT REVIEW

The documents available for our review are the following:

Original Design Drawings

The "Owner Review" set of the original design drawings dated 1/25/1979 was available for review. The structure was designed by Carl Walker & Associates, Inc. of Minneapolis, Minnesota. The following items were noted on the drawings:

- Sheet S2 – "1st, Typical & Top Tier Plans" was not available for review.
- The parking structure was designed for a uniform live load of 50 psf. The stairs, landings and lobbies were designed for a uniform live load of 100 psf.
- The minimum compressive strength was specified to be 4,000 psi for the slabs.
- The supported slabs were specified to have an air content of 6%.

IV. GENERAL CONDITION REVIEW

On March 9, 10, and 11, 2012, ***Carl Walker, Inc.*** completed a review of the North Parking Structure. The review included a chain drag survey of the supported floors and visual examination of floor and ceiling surfaces, structural elements and their supports, and stairwells to assess the current condition and locate areas of deterioration and/or deficiencies. The following is a summary of our observations.

Floor Slabs

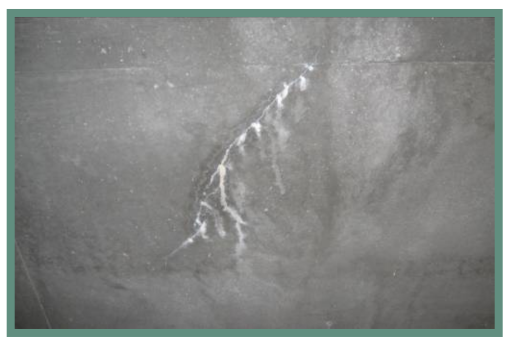
The floor slabs appear to be in good condition with a total of 150 square feet of floor delaminations. Most of the delaminations are relatively small in size ranging from 1 to 6 square feet. This deterioration is located mostly over the beams, where bar reinforcement and tendons are located near the top of the slab. Major contributors towards the deterioration of the concrete slabs are typically high chloride concentrations, shallow concrete cover for the reinforcing steel, and cracks in the slab.

The exact condition of the post-tensioning tendons and anchorages is unknown since these structural elements are embedded in the concrete slabs. Continued monitoring of the post-tensioning system is vital in keeping the structure in a safe and serviceable condition. No grease spots were observed at the underside of the slab which typically indicates deterioration of the post-tensioning tendons.

A narrow concrete overlay has been installed at the exposed roof level near column lines 6 and 9. The concrete overlay has de-bonded from the concrete slab.

Ceilings

To assess the condition of the ceiling (or underside of floor slabs) we performed a visual survey of all areas. The ceilings appear to be in excellent condition with no ceiling delaminations observed. Cracks were observed in the slab typically at the end bays (between column lines 1 & 2) and at the pour strips (between column lines 7 & 8). Staining was observed at some of the cracks which indicates that the cracks may be actively leaking. Some of the cracks have been routed and sealed at the top side of the slab. The condition of the sealant varies from poor to good.



Beams

The cast-in-place post-tensioned concrete beams appear to be in excellent condition. No beam delaminations were observed.

Columns

The concrete columns appear to be in excellent condition. No column delaminations were observed. Deterioration of the grout at the base of the columns was observed at the exposed roof level.

Walls

The concrete walls are in good condition with approximately 10 square feet of small isolated wall delaminations observed. The wall delaminations were observed at the retaining walls.

Sealants

The construction joint sealants appear to be in fair condition at the lower levels and in poor condition at the exposed roof level. Staining was observed at the underside of the slab directly below the construction joints at some locations. Maintenance of the construction joint sealants is critical to prevent water from penetrating the slab down to the post-tensioning anchorages.

Cove sealants are installed at the perimeter of the structure at the curb/precast spandrel interface and at the curb/structural slab interface. The cove sealants appear to be in fair to good condition at the lower levels and in poor condition at the exposed roof level. The sealants at the roof level are in worse condition due to UV exposure.

The exterior façade consists of precast panels with an exposed aggregate finish. The joint sealants between the precast panels at the exterior of the structure are showing signs of wear and are near the end of their useful service life.

Failed sealant was observed at the horizontal isolation joint between the upturned beam and the precast panels at column lines 6 and 9.

Expansion Joints

Deterioration was observed at the expansion joints between the slab-on-grade and the supported slab at Level 1. The expansion joint appears to be silicone sealant which has experienced adhesive failures. The failed expansion joint at the north bay (between column lines A and B) is allowing water to leak into the electrical/maintenance room below.

The expansion joints between the stair towers and the parking structure consist of pre-molded seals and almost all of them have failed. The expansion joints appear to have failed due to their age and the settlement that is occurring at the stair towers.

Surface Treatments

It is unknown if a concrete sealer has been applied to the floor surfaces of this parking structure. There is no deck coating (traffic bearing membrane) installed in this structure. Installing a deck coating at the construction joints and pour strips will help protect the critical areas where the post-tensioning anchorages are located.

Mechanical

The storm drainage system appears to be in good condition. Floor drains are located along the interior column line at the bottom of the sloped bays. There are two floor drains per level. The storm drainage piping consists of galvanized steel piping. The storm drainage piping is in good condition with no deterioration noted.

Based on conversations with the facility manager, there is a ponding issue at the center crossover at level 6. The ponding water creates a slipping hazard during the winter months.

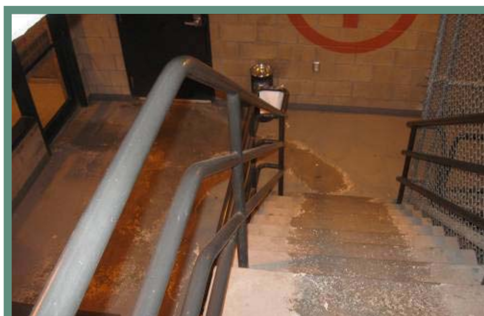
Electrical

The lighting system consists of high pressure sodium light fixtures serviced by conduit that is embedded in the concrete slab. Typically the light fixtures are spaced one per bay with the light fixture centered within the bay. One light fixture at the level 1 ceiling near the exit to 4th Street was not functioning. The light fixture at the level 5 ceiling between column lines B & C and 10 & 11 has been removed, but has not been replaced. For additional information refer to Section V – Lighting Survey.

Stair Towers

Stair towers are located at the northeast and southwest corners of the structure. Both stair towers contain elevators and a stairwell. The stairwell consists of concrete treads, risers, and landings. The stair towers are in relatively good condition.

The stair towers have settled creating an elevation difference between the parking structure and the stair tower of approximately 1 to 2 inches. Based on conversations with the facility manager, the stair towers have been settling for the past 10 years. Further investigation is required to determine the cause of the settlement.



The concrete stairs and landings are painted at both stair towers. The paint is worn down to the concrete at some locations. The locations of the heaviest wear were observed at the lower levels which experience higher volumes of pedestrian traffic.

The metal railings in the stairwells do not meet the height and opening requirements of the current code. The height of the railing is approximately 34 inches and the openings between the horizontal rails are approximately 7 inches. The current code requires that the height shall not be less than 42 inches and the opening shall be less than 4 inches. The railings most likely met the requirements of the code when it was built and likely remain grandfathered in. Deterioration of the paint on the railings was observed at isolated locations throughout the stairwells.

Corrosion was observed at the bottom of the metal door frames at level 4 of the northeast stair tower and at level 5 of the southwest stair tower. The corrosion is limited to the bottom 6 inches of the frame.

Shrinkage of the exterior window gaskets was observed at both of the stair towers. The gaskets are pulling away at the corners of the window frames creating an opening which allows water to easily penetrate the window system.

One of the mullion covers is missing at the east side of the southwest stair tower.

Efflorescence was observed at the masonry walls at both stair towers. The efflorescence was primarily observed at the east end of the north wall in the southwest stair tower, and at the south and west walls of the northeast stair tower. Potential sources of water infiltration could be leaking at the stair tower roof, failed expansion joints, failed mortar joints, failed window gaskets, and failed window perimeter sealants. We did not have access to the stair tower roofs so we were not able to review the roofing system.

Signs were observed in the stair towers warning pedestrians that the stairways may be slippery.

ADA

The following is a summary of the ADA requirements for accessible parking spaces:

- When 401 to 500 parking spaces are provided there must be a minimum of 9 accessible spaces.
- One in every eight accessible spaces must be designated as "van accessible".
- Van accessible spaces must be serviced by an access aisle that is a minimum of 8 feet wide, and a height clearance of 8'-2".
- Accessible spaces must be serviced by an access aisle that is a minimum of 5 feet wide.

There are approximately 18-20 spaces indicated as accessible throughout the structure. Accessible spaces are provided at the southwest quadrant of Level 1 and near the stair towers at the upper levels. Only 2 of the 11 spaces with accessible signage and pavement markings on Level 1 have the required access aisle adjacent to the stall, rendering the remaining 9 spaces non-compliant. One of the accessible spaces at Level 2 near the southwest stair tower has a sign indicating that it is an accessible space, but the pavement markings are yellow in lieu of blue.

The 7'-6" height clearance in the North Parking Structure does not allow for van accessible spaces within the garage.

Miscellaneous Features

Several miscellaneous features of the parking structure were observed including the pavement markings, way finding graphics & signage, vehicle & pedestrian barriers, revenue control equipment, and security/safety.

Pavement Markings: The pavement markings are showing signs of wear and are completely worn down to the concrete at some locations at the exposed roof level. Reapplication of the pavement markings is generally required every 3 to 5 years.

Way finding Graphics & Signage: The way finding graphics and signage throughout the structure provides adequate direction for the users. Each level is clearly marked with color coded signs and there is adequate signage at each level directing users where to go to park or to exit the structure.

The signs are in generally good condition with the following exceptions. One of the signs is missing at Level 6, graffiti was observed on a few of the signs, and the exit signs near the stair towers are not illuminated.

Vehicle/Pedestrian Barriers: The vehicle and pedestrian barrier consists of precast spandrels at the perimeter of the structure. The height of the precast spandrel from the top of the curb to the top of the spandrel is approximately 41 ¾ inches which does not meet the current code requirement of 42 inches.

The vehicle and pedestrian barrier consists of a steel guardrail with barrier strands at the interior column line. The height from the top of the slab to the top barrier strand is approximately 42 inches. There is approximately 10 inches between the top of the slab and the bottom of the steel guardrail and there is an opening of approximately 7 inches between the barrier strands. The current code requires an opening of less than 4 inches.

The barrier near column B-12 at Level 3 was damaged by vehicular impact. The steel guardrail is damaged and one of the barrier strands is sagging.

Revenue Control Equipment: The revenue control equipment consists of Federal APD TD-249 Ticket Spitters and Model G-89 Auto Gates. The equipment is approximately 15 years old. The revenue control equipment appears to be functioning properly. The revenue for this structure is collected by cashier during normal business hours, and by honor system after hours and on weekends.

Security/Safety: The overall security/safety perception of the parking structure is generally good. The stair towers are well lit and the structure has adequate openness. The exits are clearly marked with exit signs, however the exit signs were not illuminated. Security cameras were observed inside the stair towers at Level 1 and near the office at the west end of Level 1. Smoke detectors and emergency egress lighting were observed in the stair towers.

Intercoms are provided at each level within the stair towers, but there is no signage to identify them.

V. LIGHTING SURVEY

Carl Walker, Inc. performed limited light measurements using a Minolta T-1 illuminance meter in areas that we considered to be exhibiting typical light levels for the structure. In the following paragraphs, we have shown the light levels recommended by Illuminating Engineering Society (IES) and the measured light levels for this structure.

The light fixtures are typically spaced at one per column bay (approximately 19 feet on center). The lighting system consists of high pressure sodium light fixtures. The lighting system is serviced by conduit that is embedded in the concrete slab.

The following horizontal light levels, in foot candles (fc), are average light levels recommended by IES for covered parking structures. Horizontal light levels are measured on the floor.

	Min. Horizontal (fc)	Uniformity Ratio
General parking and pedestrian areas	1	10:1
Ramps and corners	2	10:1
Entrance areas and Stairways	2	10:1

We measured horizontal light levels at three locations within the structure. The first location is at Level 4 between column lines '10' and '11' and columns lines 'B' and 'C'. The second location is at Level 5 between column lines '4' and '5' and columns lines 'A' and 'B'. The third location is at Level 6 (roof level) between column lines 'B' and 'C' and '9' and '14'. At the time of our measurements, no spaces were occupied and all surrounding lights were functioning. The results from the light level readings are provided below.

	Average	Minimum	Maximum	Max./Min.
Level 4	3.95	1.10	9.00	8.18:1
Level 5	3.09	1.00	6.20	6.20:1
Level 6	2.23	0.30	8.00	26.67:1

The minimum and average light measurements are in conformance with the Illuminating Energy Society's (IES) recommendation of one foot-candle at Levels 4 and 5. The average light measurements are above the IES minimum, but the minimum light measurement does not meet the IES minimum of 1.0 fc at Level 6. IES recommends a maximum/minimum horizontal uniformity ratio of 10:1 or less. The uniformity ratio at the location of the light survey was 8.18:1 at Level 4 and 6.20:1 at Level 5, which complies with the IES recommendation. The uniformity ratio at Level 6 was 26.67:1, which does not comply with the IES recommendation.

VI. DISCUSSION AND RECOMMENDATIONS

Carl Walker, Inc. performed a condition survey of the City of Great Falls North Parking Structure to identify deterioration and damage. Based on this review, we prepared preliminary recommendations for a repair program that are most appropriate to maintain the structural integrity and prolong the service life of the structure.

We recommend that an engineer perform design services for the recommended repairs, as well as perform construction monitoring services during construction to review their implementation and allow for recommendation and design of any additional repairs resulting from unforeseen conditions that were concealed prior to construction. We have made the following recommendations:

CONCRETE

C1 – Top of Slab Repair: Remove delaminated concrete, clean and coat of the embedded reinforcement, and install a new high quality concrete repair mortar.

C2 – Overlay Repair: Remove the de-bonded concrete and additional concrete as required to maintain a 1 ½" minimum thickness for the new overlay, prepare the surface in accordance with industry standards, and install a new concrete overlay.

C3 – Wall Repair: Remove the delaminated concrete, clean and coat the embedded reinforcement, and install a new high quality concrete repair mortar.

WATERPROOFING

W1 – Rout & Seal Cracks: Routing and seal the cracks in the concrete slab to help prevent the infiltration of moisture and chlorides. This includes resealing cracks where the existing sealant has failed.

W2 – Remove & Replace Sealant at Construction Joints: Remove and replace the sealants at all construction joints to help prevent the infiltration of moisture and chlorides.

W3 – Remove & Replace Cove Sealant: Remove and replace the sealants at all cove joints to help prevent the infiltration of moisture and chlorides. The cove sealants at the exposed roof level should be replaced in the Near-Term (within 5 years), while the cove sealants at the lower levels can be deferred until the Mid-Term (6 to 10 years).

W4 – Remove Grout at Base of Column & Replace with Cove Sealant: Remove the deteriorated grout at the bases of the columns at the exposed roof level and installing cove sealant.

W5 – Remove & Replace P/C Panel Sealants: Remove the existing sealants between the precast panels and replacing them with silicone sealant.

W6 – Remove & Replace Isolation Joint Sealant at Level 7: Remove the existing sealant at the horizontal isolation joint between the upturned beam and the precast panels at column lines 6 and 9 at Level 7 and replace them with silicone sealant.

W7 – Remove & Replace Expansion Joints at Level 1: Remove the existing expansion joints at Level 1 and replace them with new multi-cell winged expansion joints.

W8 – Remove & Replace Pre-Mold Expansion Joints at Stair Tower: Remove and replace the existing pre-Mold expansion joints at the stair towers. We recommend that further investigation, including soil borings and consultation with a geotechnical engineer, be performed to determine the cause of the settlement prior to replacing the expansion joints.

W9 – Install Deck Coating at Pour Strips: Install a 5 foot wide strip of deck coating at all pour strips and a 1 foot wide strip of deck coating at all construction joints to help protect the embedded mild reinforcement and slab post-tensioning system.

When deck coatings are applied to existing slabs, continued corrosion of the embedded reinforcing steel and subsequent spalling of the concrete surface may continue, however, at a much-reduced rate. The application of deck coatings will reduce the infiltration of moisture and chloride, which will subsequently reduce the rate of corrosion of the reinforcing steel as well as increase the life of the concrete repairs and the sealants.

W10 – Install Concrete Sealer: Apply a clear water repellent concrete sealer at all supported slab surfaces. The concrete sealer will help prevent the infiltration of moisture and chlorides. The date of the last concrete sealer application is unknown.

MECHANICAL

ME1 – Install Supplemental Floor Drain: Install a supplemental floor drain at the center crossover at Level 6 to eliminate the ponding water and potential slip hazard. The supplemental floor drain should be connected to the existing storm drainage system.

ELECTRICAL

E1 – Add Light Fixtures to Improve Lighting: Add light fixtures and/or upgrade the existing light fixture at the roof level to meet recommended IES light levels.

E2 – Replace Light Fixture: Replace the light fixture that is missing at Level 6.

E3 – Upgrade Lighting: Consider removing the existing metal halide light fixtures and replacing them with new state of the art light fixtures that are more energy efficient. We have provided an estimated cost for lighting replacement in the 6 to 10 year range.

STAIR TOWERS

S1 – Repaint Stair Tower Railings: Repaint the stair tower railings. This work is scheduled for the Mid-Term (6-10 years) since the paint is currently in good to fair condition overall.

S2 – Clean & Paint Door Frames: Clean and paint all corroded door frames.

S3 – Install Silicone Wet Sealant at Stair Tower Windows: Install silicone wet sealant at all stair tower windows (glass to metal frame joint) to provide a watertight enclosure.

S4 – Remove & Replace Window Perimeter Sealants: Remove and replace all window perimeter (masonry to metal frame joint) sealants at all stair tower windows to provide a watertight enclosure.

S5 – Replace Mullion Cover: Replace the mullion cover that is missing at the southwest stair.

S6 – Re-point Deteriorated Mortar Joints: Re-point all deteriorated mortar joints at the exterior of the stair towers to minimize water infiltration.

S7 – Install Masonry Sealer: Apply a clear water repellant sealer to all exterior wall surfaces of the stair towers to help reduce water infiltration.

S8 – Install Exposed Aggregate Coating: Install an exposed aggregate epoxy coating in the stair towers to help improve the slip resistance. The epoxy coating will also help protect the concrete and embedded reinforcement.

MISCELLANEOUS

M1 – Repaint Pavement Markings: Repaint the pavement markings at all levels every 3 to 5 years. Access aisles should be provided at all accessible spaces when the pavement markings are repainted. While this will reduce the total number accessible spaces, a minimum of 9 accessible spaces can still be provided to meet ADA requirements.

M2 – Replace Missing or Damaged Signs: Replace all signs that are damaged or missing.

M3 – Replace Exit Signs: Replace all of the exit sign with new illuminated exit signs.

M4 – Guardrail Repair: Replace the barrier strand and section of steel guardrail that has been damaged due to vehicular impact at Level 3.

M5 – Revenue Control Equipment: Typically the useful life of Parking Access and Revenue Control System (PARCS) equipment is seven to ten years. The relatively mild “indoor environment” has helped extend the life of the existing PARCS equipment. However, PARCS equipment that is fifteen years old is usually considered technologically obsolete. Technology is advancing at a rapid pace throughout society and advanced technology is now commonplace in the parking industry.

The operating scenarios used to mange parking facilities are likewise changing in North America. More facilities are now operated without staffed cashier booths. In some instances the cashiers are being replaced by parking attendants who help customers having problems with automated equipment, perform light housekeeping, provide a roving security presence, etc. Pay-on-foot operations where customers pay their parking fee before returning to their vehicle are now commonplace. Pay-in-Lane machines are also used in some instances to automate the collection of fees in the exit lane. In some markets a credit card in – credit card out operating scenario has been successfully implemented. Other parking managers have retained the traditional exit lane cashiering mode of operations. Each approach obviously has a list of advantages and disadvantages and the operating scenario for a specific parking facility should be carefully chosen.

The installation costs of PARCS equipment for the operating scenarios in a particular parking facility will vary considerably. For example the costs for a pay-on-foot pay station can vary from $20,000 to $65,000 depending on the features included on the machines. Some PARCS systems require a sophisticated computer network for efficient management capabilities. The operating and maintenance costs associated with different operating scenarios should also be considered. The compatibility of equipment with equipment in other nearby facilities is also an important consideration.

For these reasons, the City of Great Falls should first determine the best operating scenario for the North and South Parking Structures before setting a budget for replacing the existing equipment. The equipment costs could vary widely. However, the costs to operate and maintain the system, and the customer service provided will also vary.

FUTURE EVALUATIONS AND TESTING

Periodic Evaluation: A periodic updated evaluation is recommended every 3 to 5 years.

Chloride Ion Analysis: During the next evaluation, remove concrete dust samples for chloride ion analysis to develop a slab depth/chloride-ion profile in the parking structure. This information will be useful in providing insight as to the long-term durability and expected service life of the parking structure and repairs, as well as determining the appropriate concrete protection system to be installed (e.g. silane sealer vs. traffic-bearing deck membrane). Follow-up testing is recommended every 3 to 5 years to monitor the progression of chloride contamination in the concrete.

Stair Tower Settlement Evaluation: The original design drawings indicate that the parking structure is supported on a steel pile foundation system, while the stair towers are supported separately on a concrete mat foundation system. Changes in soil conditions would have a greater affect on the mat foundation that the steel pile foundation could result in the differential settlement between the stair towers and garage structure. We recommend further investigation, including soil borings and consultation with a geotechnical engineer, be performed to determine the cause of the settlement.

VII. COST ESTIMATE

We have prepared an opinion of cost for the recommended repairs for the City of Great Falls North Parking Structure to assist you with developing a budget for implementing the repairs. The repairs have been prioritized into three categories; Near-Term (within 5 years), Mid-Term (6 to 10 years), and Long-Term (11 to 20 years). Costs are in 2012 dollars and are not factored for inflation.

Cost Estimate

					Cost		
Work Item		Unit	Estimated Quantity	Unit Cost	Near-Term (0-5 years)	Mid-Term (6-10 years)	Long-Term (11-20 years)
CONCRETE							
C1	Top of Slab Repair	S.F.	150	$40.00	$6,000.00	$9,000.00	$20,000.00
C2	Overlay Repair	S.F.	100	$30.00		$3,000.00	
C3	Wall Repair	S.F.	10	$100.00	$1,000.00		$1,000.00
WATERPROOFING							
W1	Rout & Seal Cracks	L.F.	2,100	$5.00	$10,500.00		$10,500.00
W2	Replace Sealant at Construction Joints	L.F.	2,500	$4.00	$10,000.00		$10,000.00
W3	Replace Cove Sealant	L.F.	8,300	$4.00	$8,000.00	$24,000.00	$8,000.00
W4	Replace Grout at Base of Column with Cove Seala	L.F.	60	$7.50		$500.00	
W5	Replace P/C Panel Sealants	L.F.	3,600	$10.00	$36,000.00		$36,000.00
W6	Replace Isolation Joint Sealant at Level 7	L.F.	110	$7.00	$800.00		$800.00
W7	Replace Expansion Joints at Level 1	L.F.	116	$125.00	$14,500.00		$14,500.00
W8	Replace Premold Expansion Joints at Stair Towers	L.F.	100	$80.00	$8,000.00		$8,000.00
W9	Install Deck Coating at Const. Joints & Pour Strips	S.F.	4,500	$4.00	$18,000.00		$18,000.00
W10	Install Concrete Sealer	S.F.	144,000	$0.50	$72,000.00		$144,000.00
MECHANICAL							
ME1a	Install Supplemental Floor Drain	L.S.	1	$15,000.00	$15,000.00		
ME1b	Install Supplemental Floor Drain Piping	L.F.	110	$50.00	$5,500.00		
ELECTRICAL							
E1	Additional Lighitng at Roof Level	EA.	1	$1,000.00	$1,000.00		
E2	Replace Light Fixture	EA.	1	$1,000.00	$1,000.00		
E3	Upgrade Lighting	L.S.	1	$175,000.00		$175,000.00	
STAIR TOWERS							
S1	Repaint Stair Tower Railings	L.S.	1	$5,000.00		$5,000.00	$5,000.00
S2	Clean & Paint Door Frames	EA.	2	$500.00	$1,000.00	$1,000.00	$2,000.00
S3	Install Silicone Wet Sealant at Stair Tower Windows	L.F.	2,100	$7.00	$14,700.00		
S4	Replace Window Perimeter Sealants	L.F.	1,000	$7.00	$7,000.00		
S5	Replace Mullion Cover at SE Stair	EA.	1	$500.00	$500.00		
S6	Re-point Deteriorated Mortar Joints	S.F.	1,000	$15.00	$15,000.00		$15,000.00
S7	Install Masonry Sealer	S.F.	10,000	$1.50	$15,000.00		$15,000.00
S8	Install Exposed Aggregate Coating	S.F.	4,300	$5.00	$21,500.00		$21,500.00
MISCELLANEOUS							
M1	Repaint Pavement Markings	L.S.	1	$5,000.00	$5,000.00	$5,000.00	$5,000.00
M2	Replace Missing or Damaged Signs	EA.	5	$100.00	$500.00		
M3	Replace Exit Signs	EA.	12	$250.00	$3,000.00		
M4	Guardrail Repair	L.S.	1	$3,000.00	$3,000.00		
Total					$293,500.00	$222,500.00	$334,300.00
Construction Mobilization & General Conditions (15%)					$44,000.00	$33,400.00	$50,200.00
Construction Contingency (10%)					$34,000.00	$25,600.00	$38,500.00
Total Construction Budget					**$371,500.00**	**$281,500.00**	**$423,000.00**
Engineering and Testing (Design, Const. Observation, Evaluations, etc.)					$43,500.00	$38,500.00	$52,000.00
Stair Tower Settlement Investigaion					$15,000.00		
Total Project Budget					**$415,000.00**	**$320,000.00**	**$475,000.00**

VIII. LIMITATIONS

The recommended restoration and protection of the parking structure can be performed and the rate of further deterioration reduced. However, we cannot guarantee that further deterioration will not take place with continued service-related exposure. Effective ongoing maintenance can significantly reduce long-term maintenance costs. Monitoring of the parking structure can assist in scheduling future maintenance.

Specific repair procedures are not part of this evaluation. This report defines items in need of repair and presents conceptual procedures. Construction Documents are required to address all aspects of materials selection and methods for repair of the parking structure. Repair cost projections are based on deterioration quantities identified during our review. Quantities and costs are not intended to define a guaranteed maximum cost, and variations in final quantities should be anticipated.

The evaluation and restoration of existing structures require that certain assumptions be made regarding existing conditions. Since some of these assumptions may not be confirmed without expending additional sums of money and/or destroying otherwise adequate or serviceable portions of the building, ***Carl Walker, Inc.*** cannot be held responsible for latent deficiencies which may exist in the structure, but which have not been discovered within the scope of this evaluation.

APPENDIX A
GLOSSARY OF RESTORATION CONCEPTS

APPENDIX A - GLOSSARY OF RESTORATION CONCEPTS

Introduction

Concrete deterioration is generally evident by cracking, delamination, spalling, scaling, and leaching. These signs of distress and the associated corrosion of embedded steel are the most common deterioration problems of concrete parking structures. The figures provided in this Appendix are from the "Parking Garage Maintenance Manual" by the National Parking Association.

Corrosion of Reinforcing Steel

Concrete provides a very alkaline environment (pH from 12 to 13.5) which normally protects embedded steel from corrosion. The intrusion of chlorides into the concrete around embedded steel upsets this alkaline condition and corrosion is likely to proceed if moisture and oxygen are available to support the process.

The chlorides normally enter the concrete from deicing salt solutions permeating through the hardened concrete from the top surface. The chloride concentrations therefore are highest at the surface and reduce with the depth below the surface, as shown in Figure A1. Figure A1 also shows the effect of concrete quality on chloride penetration.

There are two methods of testing for chloride content of concrete. One method is to test for water soluble chlorides per FHWA-RD-77-85, and is the test method recommended for the future evaluations of the North Parking Structure. Another method is for acid soluble chlorides (ASTM C114). The acid soluble method was not used because it will indicate not only free chloride ions which contribute to corrosion, but also those which have formed chemical compounds during cement hydration and do not contribute. It is estimated that about half of chlorides which are added at the time of mixing will be so combined.

Calcium chloride and other chlorides containing admixtures are frequently added to concrete during batching, especially during cold weather. As more has become known about the effect on corrosion, this practice of adding chlorides has been greatly curtailed, and is now usually prohibited in parking structures.

The chloride content above which corrosion is likely to occur is called the "threshold level." While there is some difference in opinion, we have established a range of 0.03 to 0.04 percent by weight of concrete as the threshold level for parking structures. This corresponds to approximately 1 to 1.5 pounds per cubic yard or 300 to 400 parts per million as shown in Figure A1.

Metallic corrosion is a dynamic electro-chemical process and induces progressive deterioration. Corrosion by-products (rust) occupy a volume several times that of the parent metal. This expansion causes high tensile stresses which crack and separate ("delaminate") the surrounding concrete. Initial cracking can occur when section loss of the parent metal is five percent or less. Cracks first appear vertically over the reinforcement nearest the exposed surface. These cracks allow direct access of moisture and additional chloride to the reinforcement, causing accelerated corrosion and subsequent delamination.

The impact that corrosion has on a structural member is variable. Three things happen, all of which are detrimental to the structural integrity:

- Surface spalling occurs, causing maintenance and serviceability problems.
- The reinforcement loses significant cross section and strength which causes increase in stress redistribution throughout the remaining reinforcement.
- The reinforcement debonds from the concrete, causing loss of monolithic interaction thus, inability of the reinforcement to carry any forces.

The progressive movement of concrete is a result of corrosion-induced jacking. It is also typical that concrete cross section loss, in addition to reduction in reinforcement area, impairs the load-carrying capacity of individual floor slab, beam and column systems.

The top and bottom reinforcement corrode similarly. Surface spalling near mid-span reduces the concrete section as a function of spall depth. Concrete section reduction at mid-span can significantly reduce the structural capacity of the concrete member. At the same time, severe corrosion of bottom reinforcement can result in its overstressing and possible yielding or failure.

Cracking

Concrete cracking is caused by tensile stresses. These stresses may be due to load, as a flexural member, or other causes such as shrinkage or temperature drop. Some cracking is usually anticipated and the effects can be minimized by reinforcement or joints. Properly positioned reinforcement arrests crack development by keeping cracks short and tightly closed. Control joints are positioned to keep cracking only where it is planned. It is common practice to provide sealed crack control joints in concrete members when exposure to water is expected. Cracking can be detrimental when it occurs to an extent and frequency not expected. If abnormal or uncontrolled cracking develops, then steps are necessary to minimize the effect of cracking on long-term structure durability.

Uncontrolled construction cracking is usually caused by improper control joint detailing or concrete placement, insufficient consolidation, inadequate curing of the concrete, premature removal of form supports, or by plastic shrinkage of the concrete. Service-related cracking is usually due to temperature changes, load, settlement, or internal stress. Corrosion of reinforcing bars and aggregate chemical reaction are common causes of internal stress.

Delamination

Concrete delamination usually results from the corrosion of reinforcing steel as shown in Figures A2 and A3. Delaminations often cannot be seen from the surface, and are located by sounding or with ultrasonic testing. The most common method is sounding with a hammer or steel chain. When a steel chain is dragged on a delamination a definite pitch change can be heard and the delamination sounds hollow. Delaminations will usually continue to crack and eventually become a spall.

Spalling

Most concrete spalling associated with parking structures is the end result of corrosion-induced stress. Figures A2, A3, and A4 demonstrate this process. It is preceded by internal horizontal fractures (delamination) which eventually migrate from the steel to the nearest surface. When fractures reach the surface, the concrete breaks away leaving an open spall or pothole.

Scaling

Concrete scaling deterioration attacks the mortar portion (paste) of the concrete mix. It first appears as minor flaking and disintegration of the concrete surface. Scaling eventually progresses deeper into the concrete, exposing aggregate which breaks away. This aggravates the process by exposing more paste to the elements. In extreme cases, apparently sound concrete can be reduced to a gravel-like condition in a short period of time. Figure A5 shows surface scaling deterioration.

Concrete scaling is usually caused by freeze-thaw action. If concrete is frozen in a saturated state, excess water freezing in the concrete causes high stress and weakens the mortar. Cyclic exposure to freeze-thaw action is very destructive to concrete in a saturated state. Deicing salt solutions accelerate the deterioration by increasing the number of freeze-thaw cycles and increasing the pore pressure.

Air entrained concrete is must more resistant to scaling than non-air entrained types. Air entrainment consists of microscopic air bubbles in the concrete. These bubbles, created by the addition of an admixture at the time of mixing, when properly sized and distributed, can act as small shock absorbers to cushion internal stresses caused by freezing and thawing.

Joint Deterioration

The two most common methods for providing crack control or relief of restraint in concrete slabs are control joints and expansion joints. Joints on supported floor slabs in parking structures must be sealed against water leakage and intrusion of incompressible debris, both of which are damaging to the joint system.

Control joints deteriorate for reasons usually associated with failure of the sealant or failure of the adjacent concrete. Joint sealants which fail prematurely may not have the required degree of flexibility, bond strength, or durability for a particular application. If concrete adjacent to the joint is not sufficiently durable, then local scaling will cause joint sealant failure.

Expansion joint deterioration usually refers to the failure of the joint sealant system. The failure may be in the sealant materials or the adjacent concrete. Premature failures are most commonly associated with improper joint design, improper sealant material, incorrect installation, or in-service damage from traffic or snow plows.

Leaching

Leaching is caused by frequent water migration through the floor slab or cracks. As water migrates through, it takes along part of the cementing constituents, depositing them as a white film, stain, or in extreme cases, stalactite on the ceiling below. This process eventually weakens the concrete and is accelerated by porous or perpetually moist concrete. Leaching frequently occurs along cracks, construction and control joints, beneath gutter lines, and around floor drains.

Surface Popouts

Popouts in the concrete surface result from freezing of the coarse aggregate. Certain aggregates are porous and become saturated with water. Upon freezing, the water expands, fracturing the aggregate. A pit or spall up to several inches in diameter results on the concrete surface.

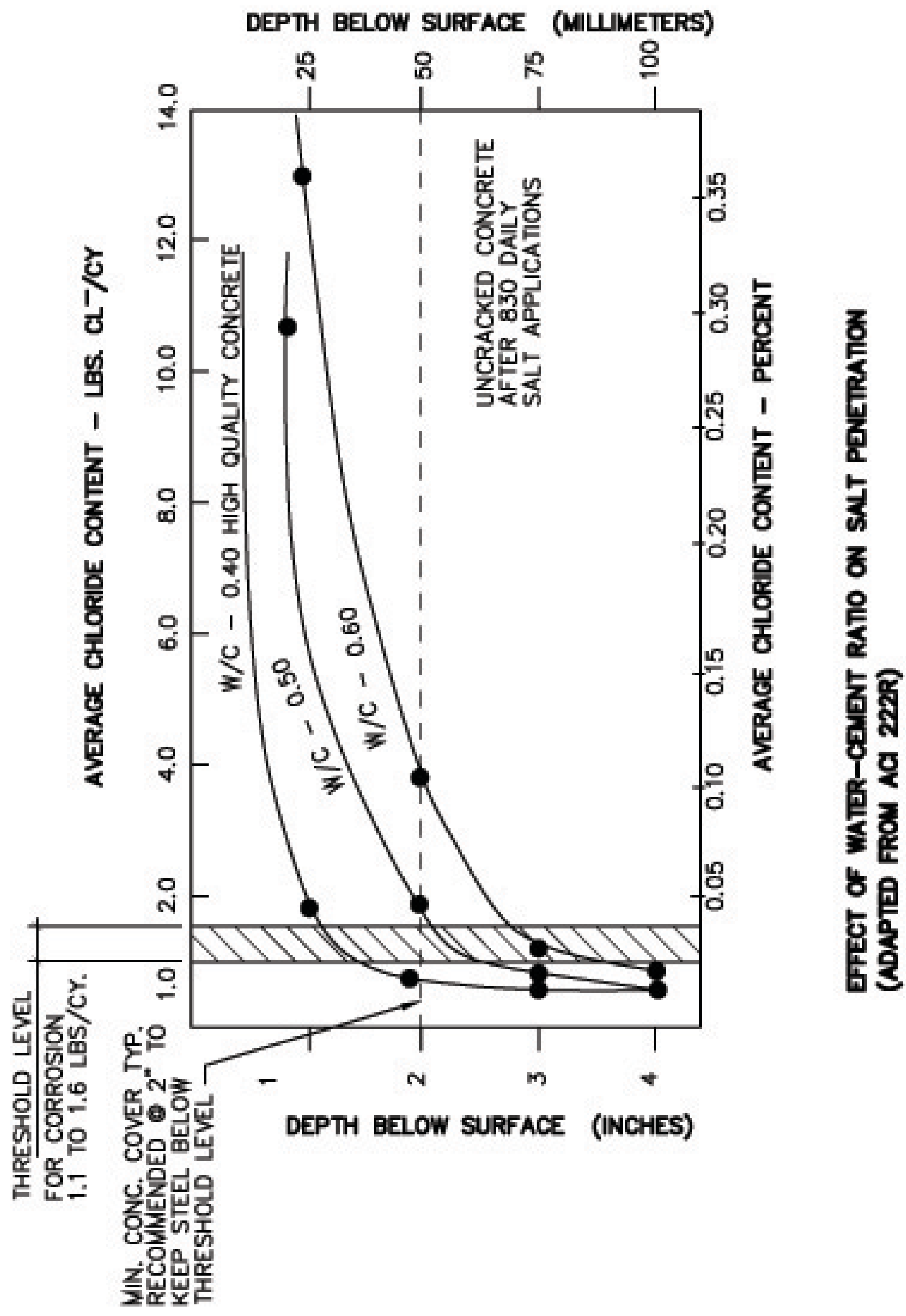


FIGURE A-1
CHLORIDE ION CONCENTRATION VS DEPTH BELOW SURFACE

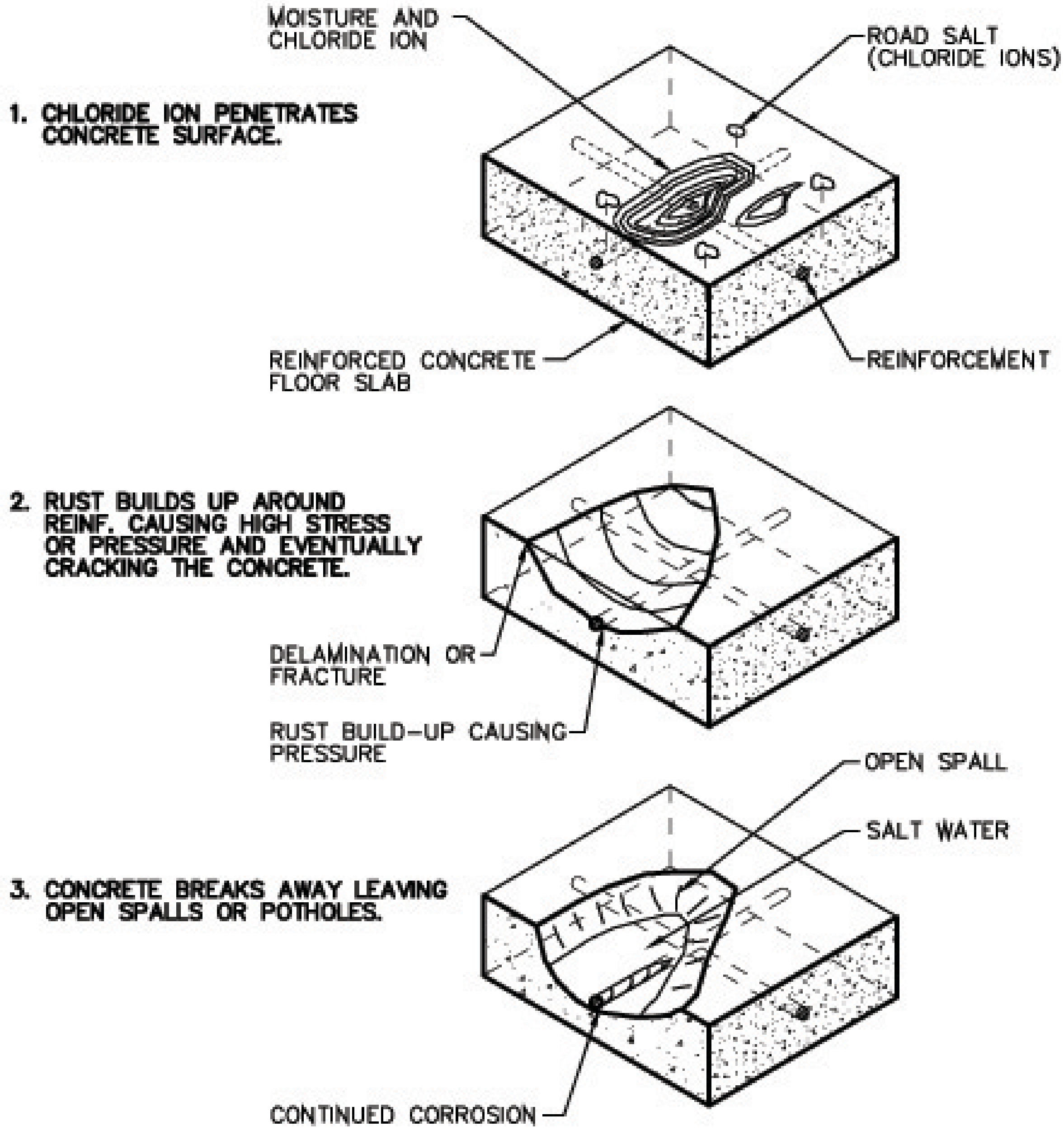
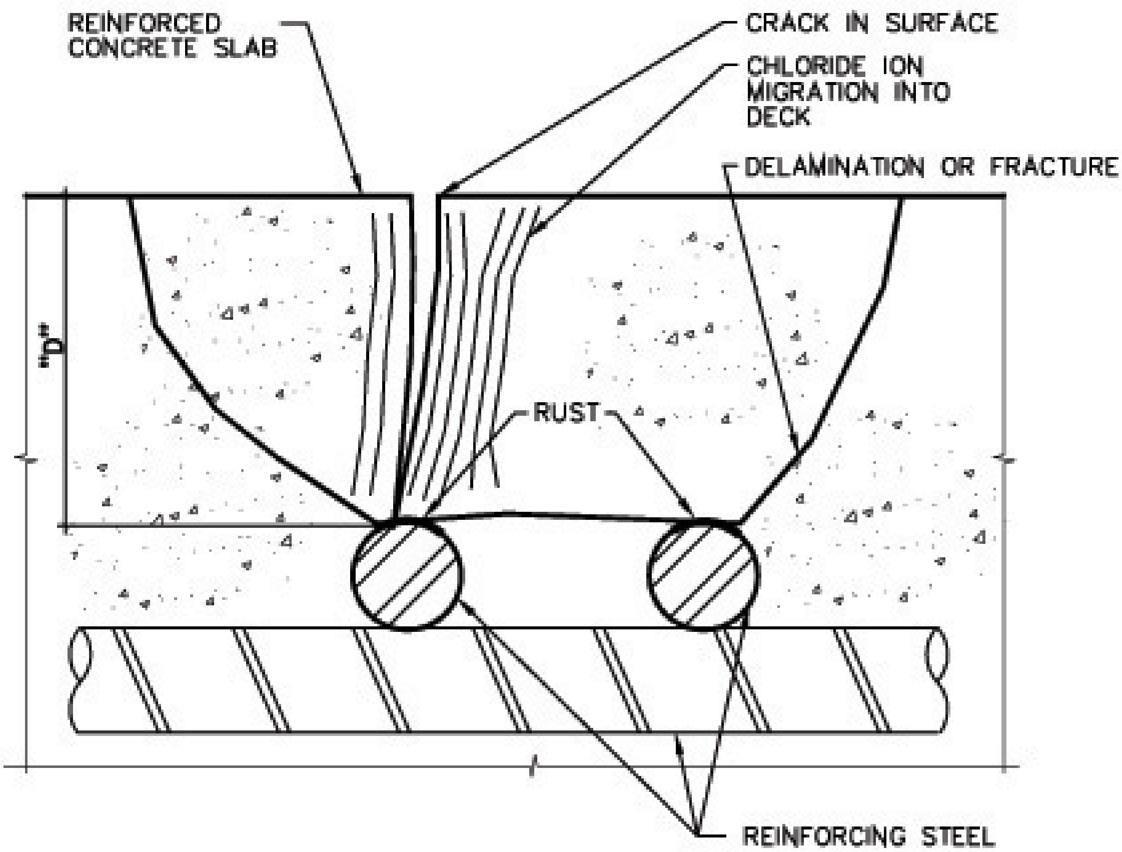
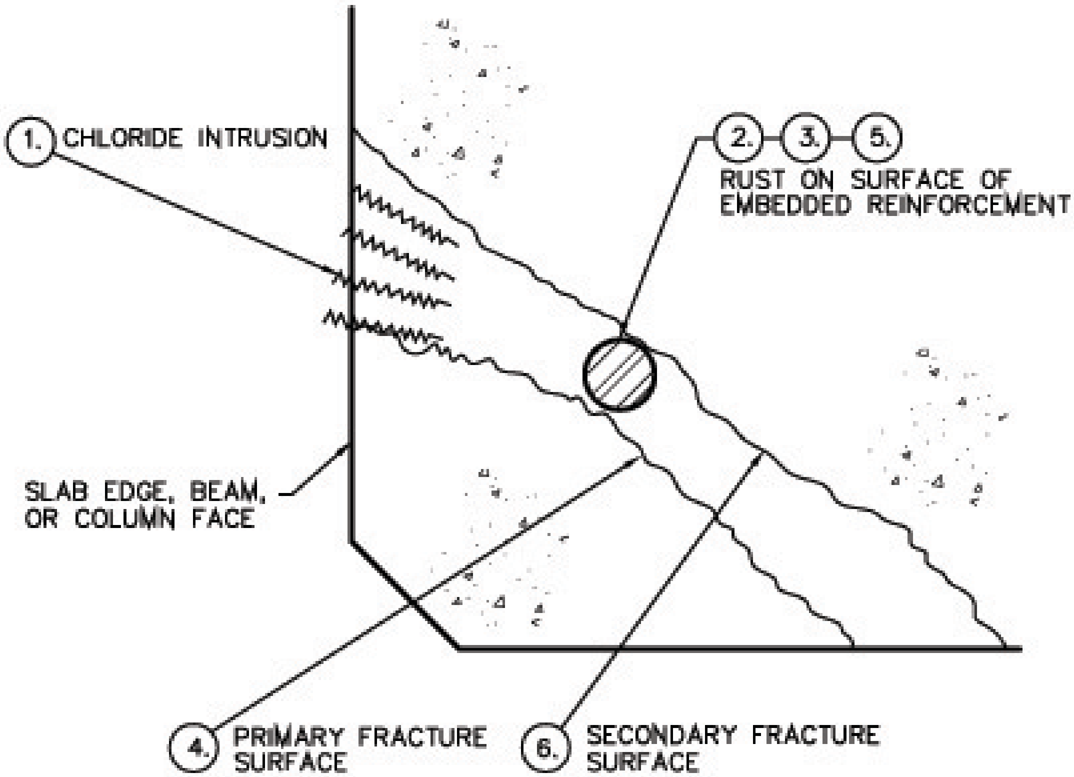


FIGURE A-2
CORROSION INDUCED DELAMINATION AND SPALLING PROCESS



"D" = DEPTH OF CLEAR COVER OVER REINFORCING STEEL

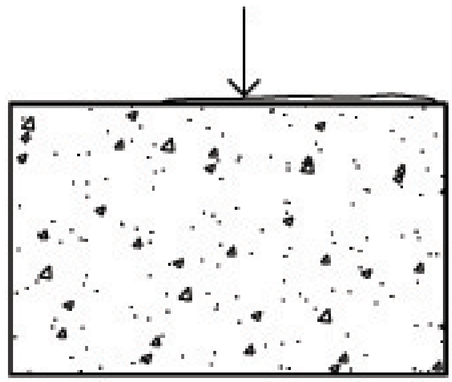
FIGURE A-3
REBAR CORROSION, DELAMINATION AND SPALLING MECHANISM



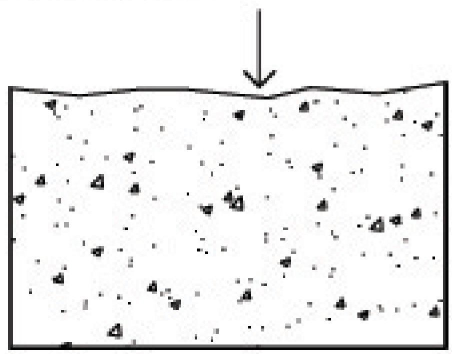
PROCESS DESCRIPTION

1. CHLORIDE ION INTRUSION CONTAMINATES CONCRETE LOWERS PH AND INDUCES CORROSION OF EMBEDDED REINFORCEMENT.
2. CORROSION BY-PRODUCTS "RUST" DEVELOP AT BAR SURFACE.
3. RUSTED BAR HAS INCREASE IN VOLUME WHICH CAUSES HIGH STRESSES IN CONCRETE SURROUNDING BAR.
4. HIGH STRESSES CRACK THE CONCRETE AT THE PRIMARY FRACTURE SURFACE.
5. ADDITIONAL SALT WATER AND AIR CAUSE FURTHER RUSTING OF BAR.
6. CRACK FORMS AT SECONDARY FRACTURE SURFACE.

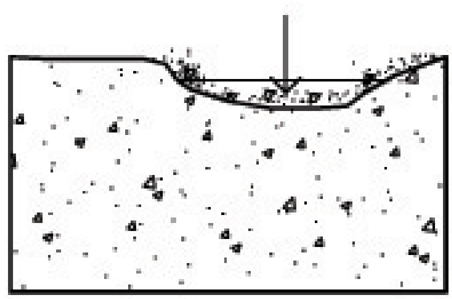
FIGURE A-4
SPALL DEVELOPMENT



1. CONCRETE BECOMES SATURATED BY WATER PENETRATION THROUGH PORES AND CAPILLARIES



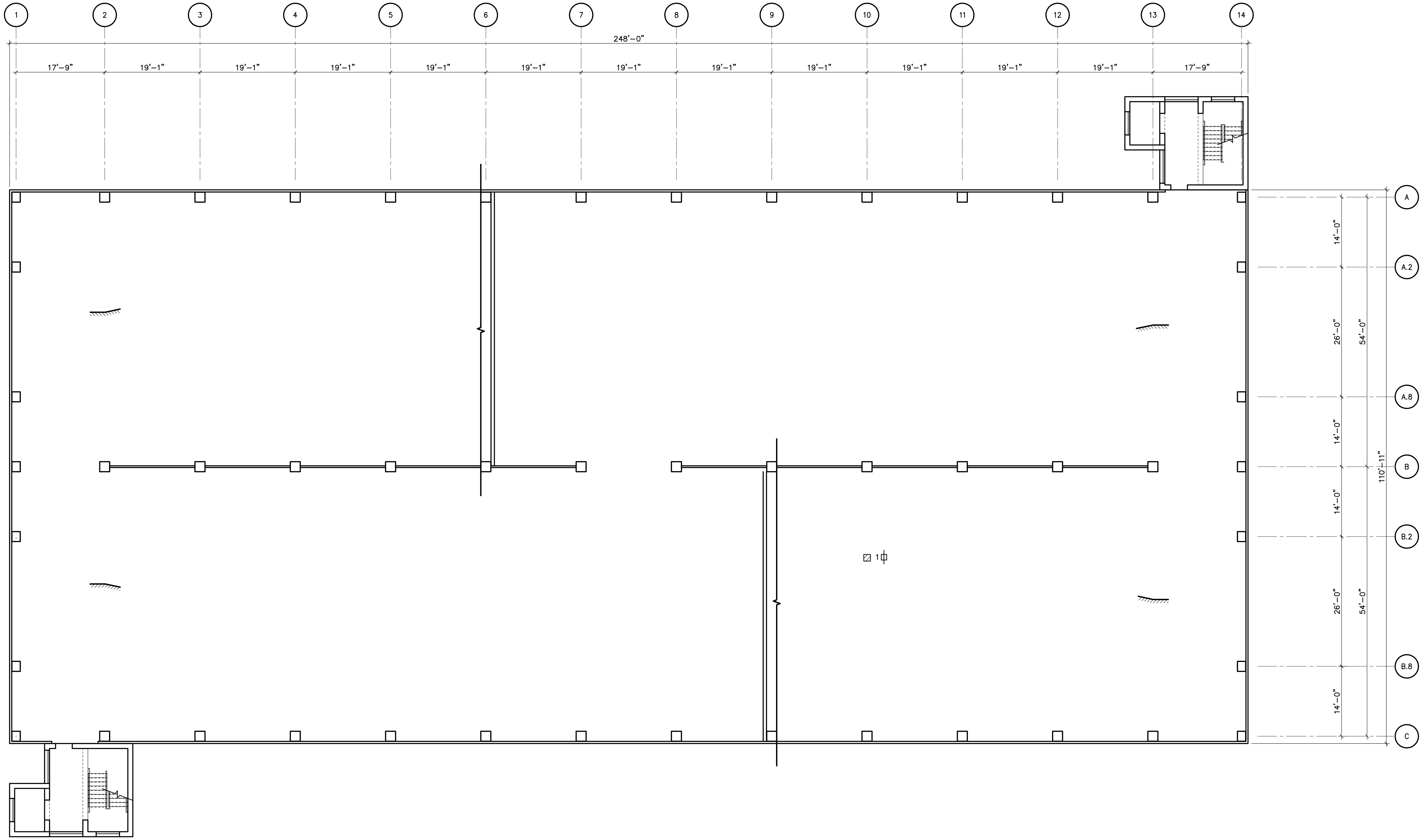
2. CONCRETE IS FROZEN IN A SATURATED STATE CAUSING HIGH STREESSES. LOOSE FLAKES APPEAR ON SURFACES AS THE MORTAR BREAKS AWAY.



3. AS FLAKING PROGRESSES, AGGREGATE IS EXPOSED AND EVENTUALLY BREAKS AWAY, THEREBY EXPOSING MORE PASTE TO FREEZE-THAW DAMAGE IN EXTREME CASES. APPARENTLY SOUND CONCRETE CAN BE REDUCED TO A GRAVEL-LIKE STATE IN A SHORT PERIOD OF TIME.

FIGURE A-5
CONCRETE SURFACE SCALING

APPENDIX B
CONCRETE DELAMINATION SURVEY



LEVEL 1 PLAN

3/32"=1'-0"

xR1-2011-547-P101

North

LEGEND

▨ = TOP OF SLAB DELAMINATION

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NORTH PARKING STRUCTURE

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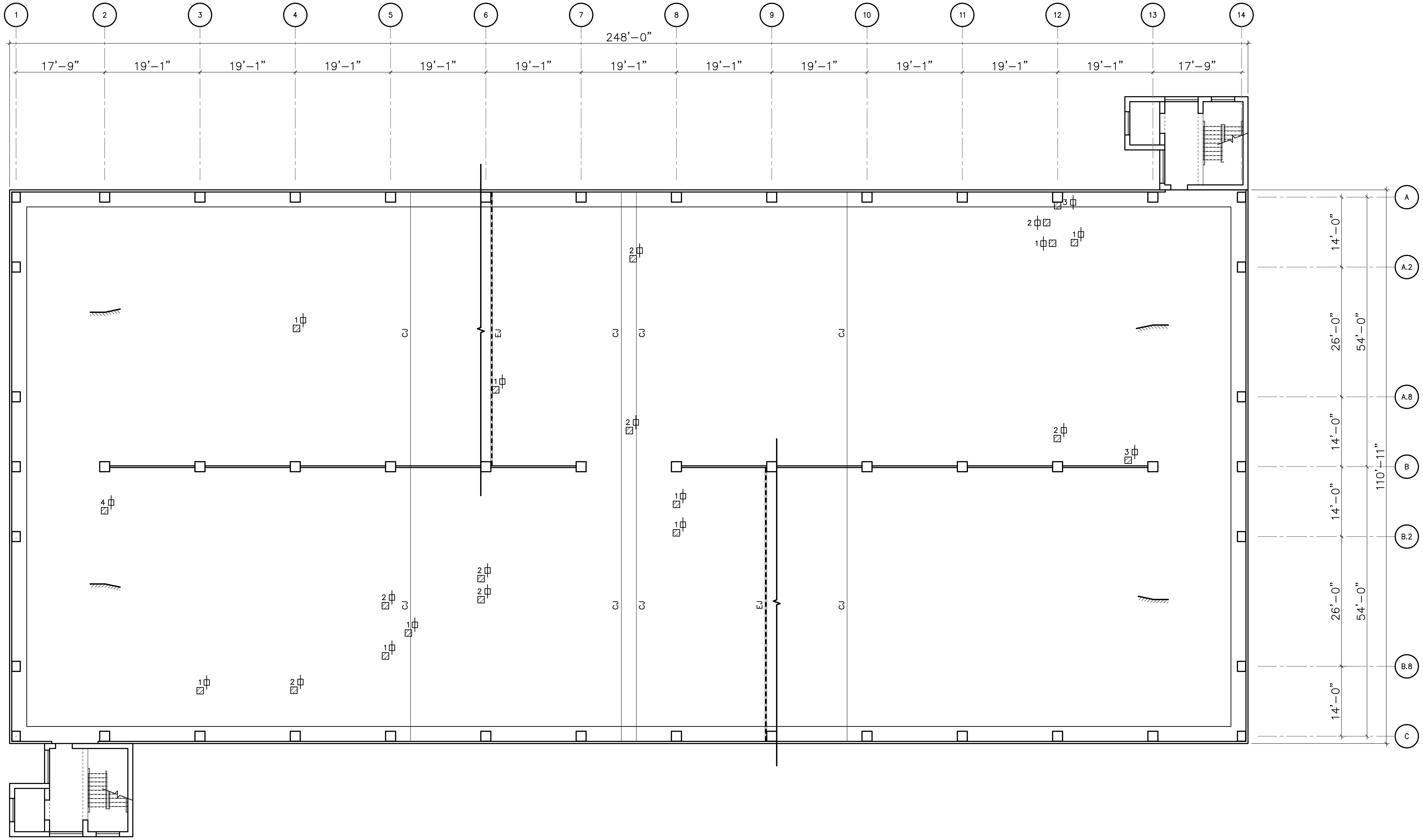
SHEET TITLE
APPENDIX B
LEVEL 1 PLAN



LEVEL 2 PLAN
3/32"=1'–0"
xR1–2011–547–P102
North

LEGEND

▨ = TOP OF SLAB DELAMINATION

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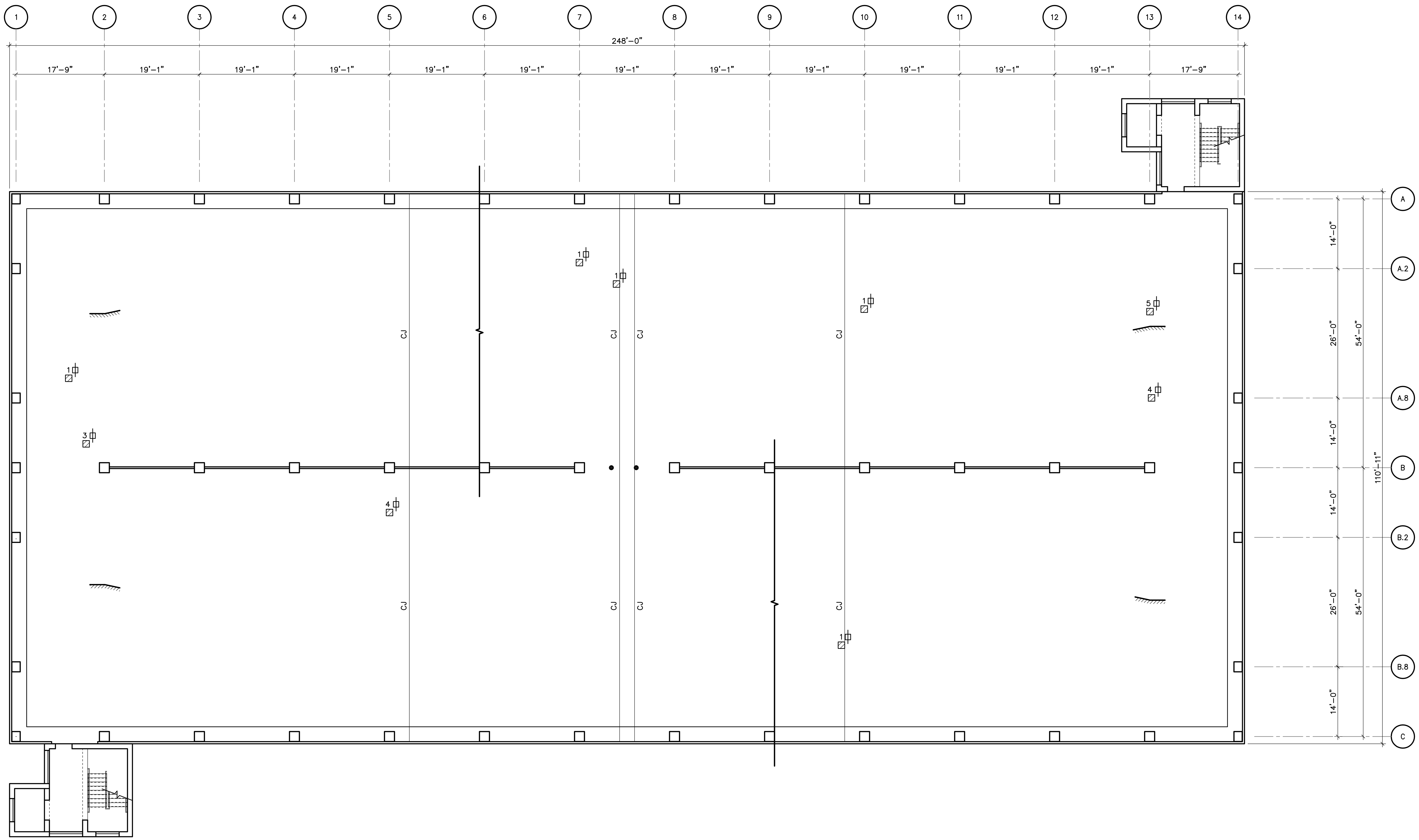
APPENDIX B
LEVEL 2 PLAN



LEVEL 3 PLAN

3/32"=1'-0"

xR1-2011-547-P103

North

LEGEND

▨ = TOP OF SLAB DELAMINATION

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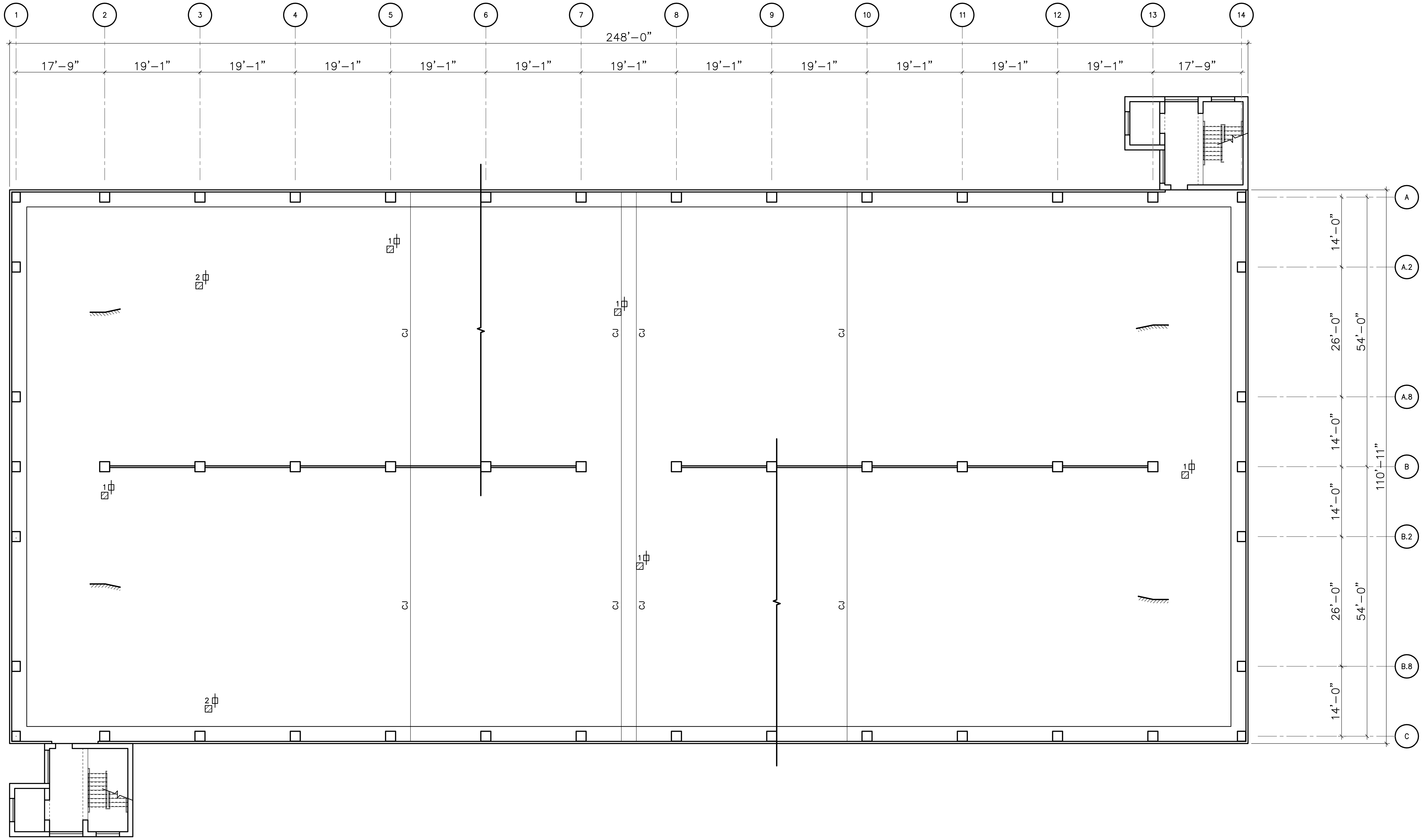
APPENDIX B
LEVEL 3 PLAN

B3



LEVEL 4 PLAN

3/32"=1'-0"

xR1-2011-547-P104

North

LEGEND

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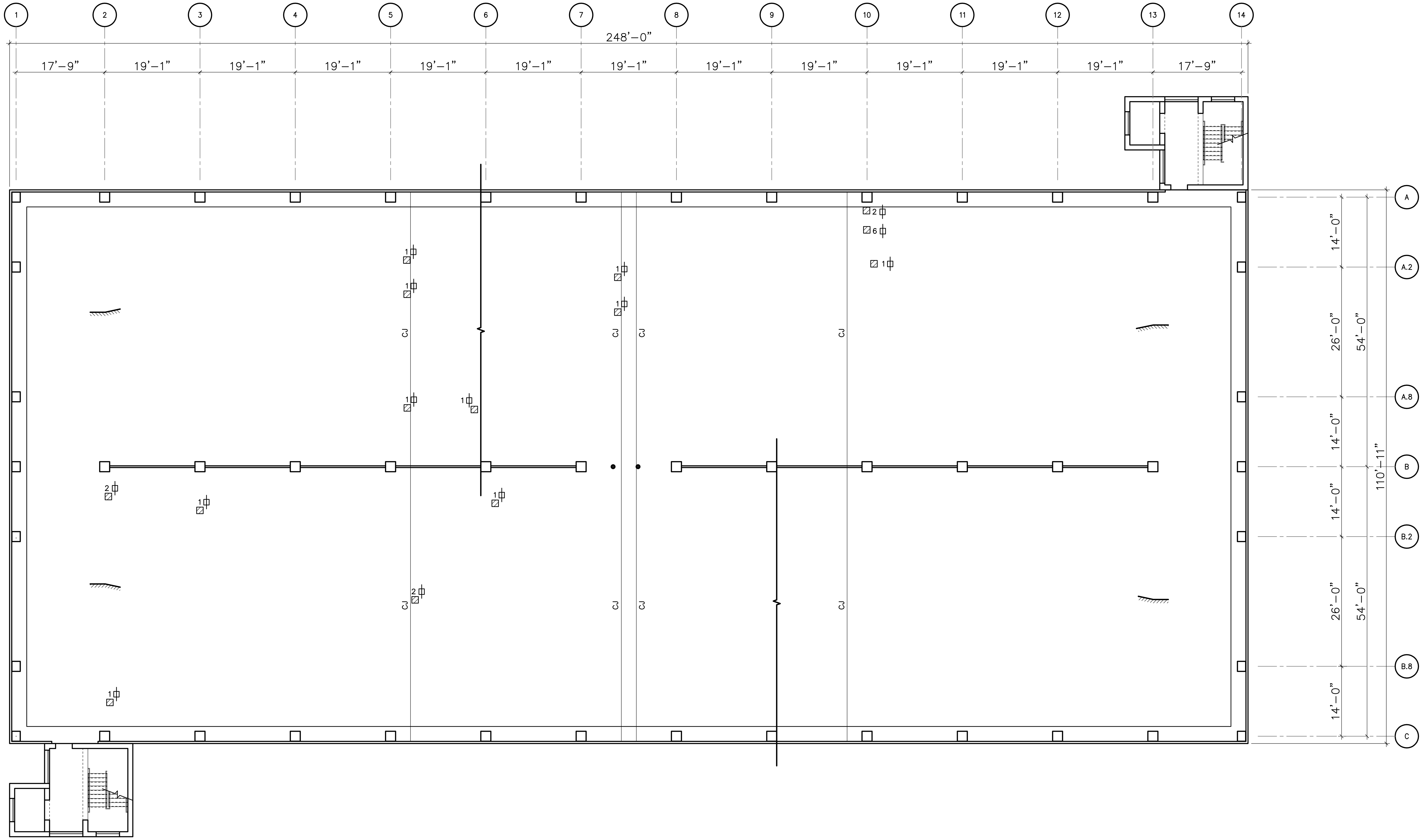
APPENDIX B
LEVEL 4 PLAN



LEVEL 5 PLAN
3/32"=1'–0"
xR1–2011–547–P105
North

LEGEND

▨ = TOP OF SLAB DELAMINATION

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LEVEL 5 PLAN

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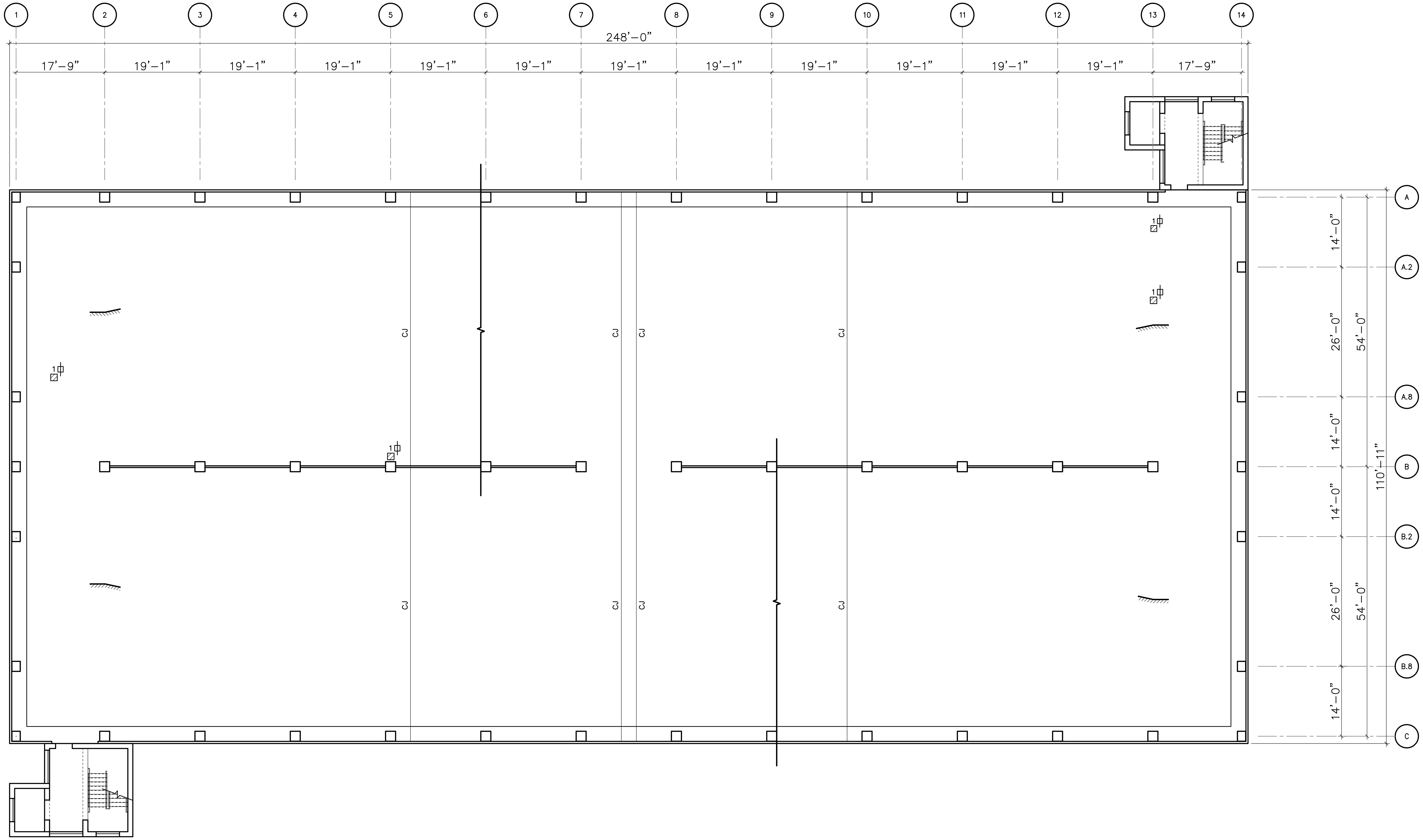

LEVEL 6 PLAN

3/32"=1'–0"

xR1–2011–547–P106

LEGEND

▨ = TOP OF SLAB DELAMINATION

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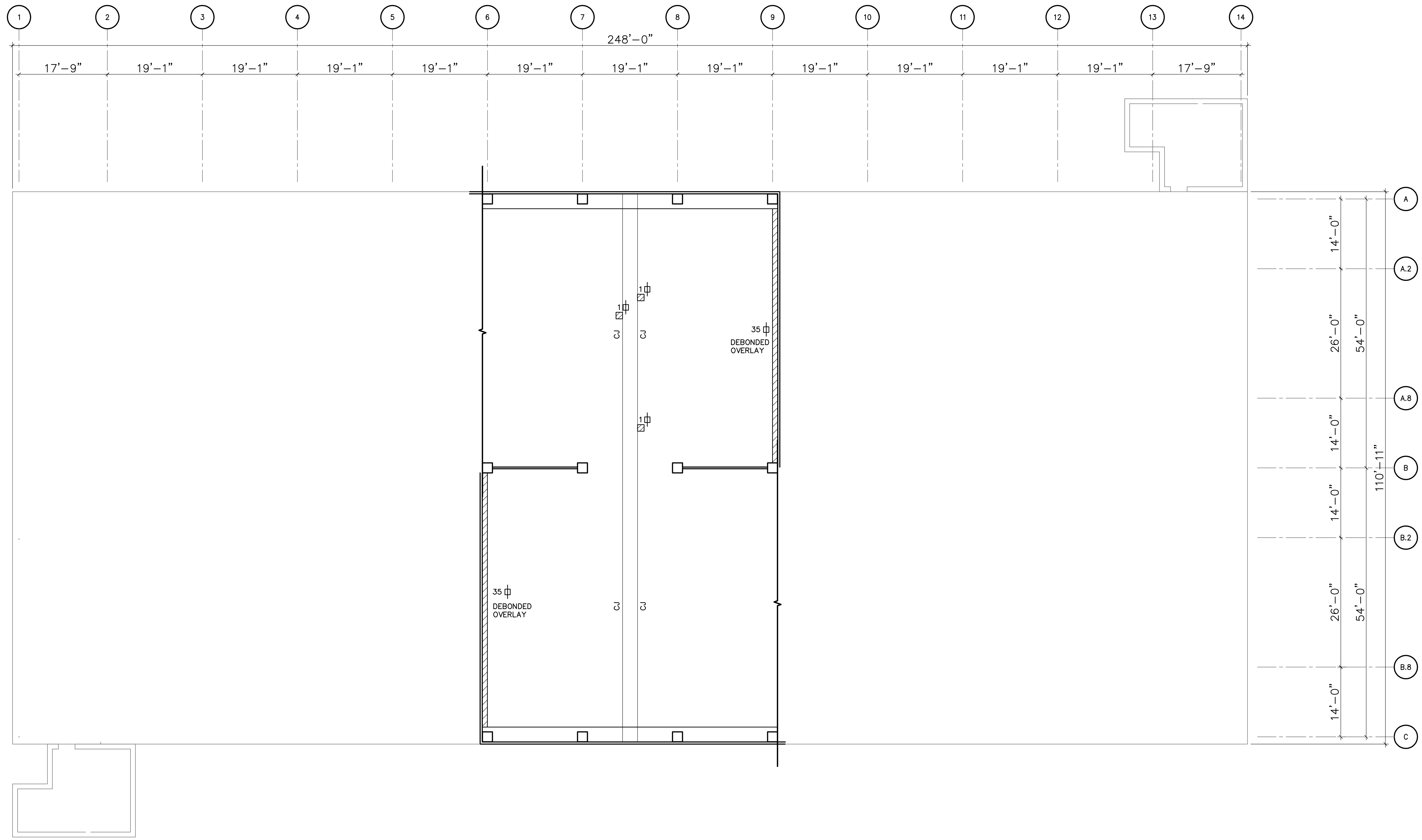
APPENDIX B
LEVEL 6 PLAN

B6



LEVEL 7 PLAN
3/32"=1'–0"

xR1–2011–547–P107

North

LEGEND

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APPENDIX B
LEVEL 7 PLAN

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