SMITHFIELD-LIBERTY HELIX RAMP REHABILITATION

LONGEVITY ENTRY

SMITHFIELD-LIBERTY HELIX RAMP REHABILITATION

LONGEVITY FEATURES

The rehabilitation of the Smithfield-Liberty Parking Garage was undertaken in 1997 and, over 20 years later, the structure exhibits no additional deterioration. Exposed to several hundred cars each day, this critical structure was rehabilitated using materials and methods designed and installed to provide a long-term service life. The success of the project is best evidenced by the fact that no additional structural repairs or rehabilitation have been required since the work was completed. The design and construction processes used to complete this project in the late 1990s is a testament to the longevity that the project has enjoyed. Based on its current state of performance, it is expected that the ramp will likely experience another 20 year extension of its service life without the need for any significant attention.

HISTORY

Originally constructed in 1964, the helix ramp of the Smithfield-Liberty parking garage in downtown Pittsburgh, Pennsylvania, is six levels of post-tensioned concrete slab with perimeter knee wall cantilevered from a conventionally reinforced concrete cylinder. The post-tensioning system for the structure is composed of solid bar reinforcing encased in a grouted conduit. The solid bars have plates at each end to provide compressive force transfer into the slab. The primary visible distress of the structure was exposed, corroding post-tensioned bar anchor plates at the perimeter of the ramp. This circular ramp provides the only means of exit from the top six levels of the attached seven-story parking structure, so it was decided that conventional rehabilitation project delivery methods would not work for this rehabilitation.

EVALUATION

In late 1996, an evaluation of the helix ramp was undertaken to establish the cause of the observed distress in the structure. The evaluation included a condition assessment of the structure, concrete material and corrosion testing, a review of existing structural drawings, and a thorough structural analysis.

The condition assessment included a visual survey to record visible surface defects, including cracks, spalling, and exposed corroding steel elements. Material and corrosion testing included the following:

- Petrographic Analysis
- Concrete compressive strength testing
- Acid-soluble chloride ion testing
- Carbonation testing
- Electrical continuity testing
- Half-cell potential testing
- Corrosion rate testing
- Reinforcing steel location and cover measurements

The results obtained from the condition assessment, structural analysis, and various testing methods were necessary to fully evaluate the distress mechanisms occurring within the structure.

DIAGNOSIS

After evaluating all of the results, the cause of the distress in the structure, consisting of delamination and spalling with exposed reinforcing steel, was determined. Based on the evaluation, three primary causes for the observed distress were identified:

1. The cause of the distress recorded on the top of the ramp slabs was determined to be high chloride ion levels in the lower five levels of the six-level ramp. On these levels, chloride contents exceeding the threshold amount necessary to induce corrosion of the reinforcing steel were found in the top 2.5 inches of the slab.
2. The cause of the distress observed on the underside of the ramp slabs was cracking at old patches in the top slab.
3. For the deterioration occurring on and below the concrete knee walls, insufficient concrete cover on the steel reinforcing and plates was identified as the cause of the distress.

Once the causes of the distress were identified, solutions were developed to address them in consideration of alternative service life expectations.

SOLUTION ANALYSIS

Chloride Ion Content

To address the chloride ion content problem with the ramp slabs, removal and replacement of the top 2.5 to 3 inches of the concrete floor slab was ultimately selected to offer a long-term service life expectation. This solution represented a potential structural problem, however, given that the slab was post-tensioned. Prior to being able to recommend that the top portion of the slab be removed, a structural analysis had to be performed. The analysis was necessary to determine the post-tensioned reinforcing forces on the original slab section, the reduced slab section (once the top portion of the slab was removed), and the final slab section (with the original slab and new topping slab). Upon completion of the analysis, it was determined that the top slab section could be removed if the perimeter of the ramp was shored and supplemental post-tensioned cables were added to the final cross section.

Supplemental Post-Tensioned Cables

The requirement for the supplemental post-tensioned cables influenced the decision to recommend a high quality conventional concrete material with a compressive strength of 6,000psi to closely match the existing concrete strength. In addition, the use of a shrinkage-compensating admixture was recommended to minimize cracking in the new topping slab.

Underside Slab Condition & Water Infiltration Problems

To address the underside slab condition and water infiltration problems, conventional partial-area patch repairs were recommended in conjunction with the application of a hybrid polyurethane fluid-applied membrane with epoxy wear course with specialized aggregate on the top ramp surface. The patch material recommended for the underside slab repairs was a polymer-modified cementitious repair material to facilitate use of the form-and- pump repair technique. The repair material was selected to have compressive stiffness characteristics that closely matched that of the existing concrete. This was necessary to provide uniform compressive stress distribution throughout the concrete slab when stressing supplemental post-tensioned reinforcement.

Concrete Cover Issues

To address the concrete cover problem on the post-tensioned reinforcing anchor plates on the perimeter of the ramp, a new concrete cap was recommended to provide suitable cover for the plates. In addition, a drip edge was recommended to prevent water from running down the underside of the ramps. Although this repair detail reduced the depth of the reveal at the slab perimeter, the architectural appearance of the ramp was not significantly changed. To address the concrete cover problem on the existing reinforcing steel in the knee walls, it was recommended that patch repairs be slightly over-built to obtain suitable concrete cover on the reinforcing steel. The visual effect of the patch overbuild was reduced by enlarging the patch area to the extent where existing reinforcing steel had sufficient concrete cover.

REHABILITATION

The repair solutions described above were incorporated into the contract documents and issued for bidding by experienced repair contractors. The successful bidder was awarded the contract in the summer of 1997 and the work was immediately scheduled to be completed in under 10 weeks during the summer to coincide with the garage's off-peak season.

Garage Ergonomics

Prior to beginning repairs, the traffic in the garage required re-routing. This was necessary since the helix was the only means of exit for the upper levels of the garage and closing the garage was not an option. After considering alternate scenarios to solve this dilemma, a solution was developed to convert the one-way traffic flow into two-way traffic. To accommodate the two-way traffic on the upper six levels, turn-around areas were established on alternating levels to facilitate cars changing direction. Although the turnaround areas resulted in a reduction in parking spaces, the traffic flow was not significantly hampered and the disruption to patrons was minimized.

Fast-Tracked Construction

Once parking traffic was re-routed, the helix ramp was closed, and construction commenced. Given the aggressive construction schedule and limited work area, methods to expedite the repair process had to be implemented. The primary time saving measure utilized during the rehabilitation was hydro demolition, which is a process utilizing water under very high pressure (about 10,000psi) to demolish concrete. This method was used in lieu of conventional jackhammers to remove the top section of chloride-contaminated concrete on the ramp slabs and resulted in significant time savings.

Specialized Equipment

Prior to initiating repairs, the contractor requested the substitution of specified specialty repair materials for materials that they had success with on previous projects. This practice is common on concrete rehabilitation projects but is one that must be carefully considered. For this project, different areas, and even different levels, had different design criteria that had to be met. For example, the post-tensioned areas required a material with a compressive stiffness closely matching that of the existing concrete due to the need to evenly distribute new post-tensioning stresses induced in the slab. The cap placed around the helix ramp perimeter required a material easily placed using the form-and-pump method, but one that did not require similar stiffness characteristics to the existing concrete.

Completion

Following industry standard concrete repair practices and incorporating state-of-the-art materials, the rehabilitation of the ramp was completed on schedule. One of the most important reasons for the success of the project was that the correct process was followed. Involving the correct experienced parties and identifying and addressing the causes of the distress in the structure and developing and implementing a repair approach aimed at providing a long-term service life extension.

PAST, PRESENT, & FUTURE

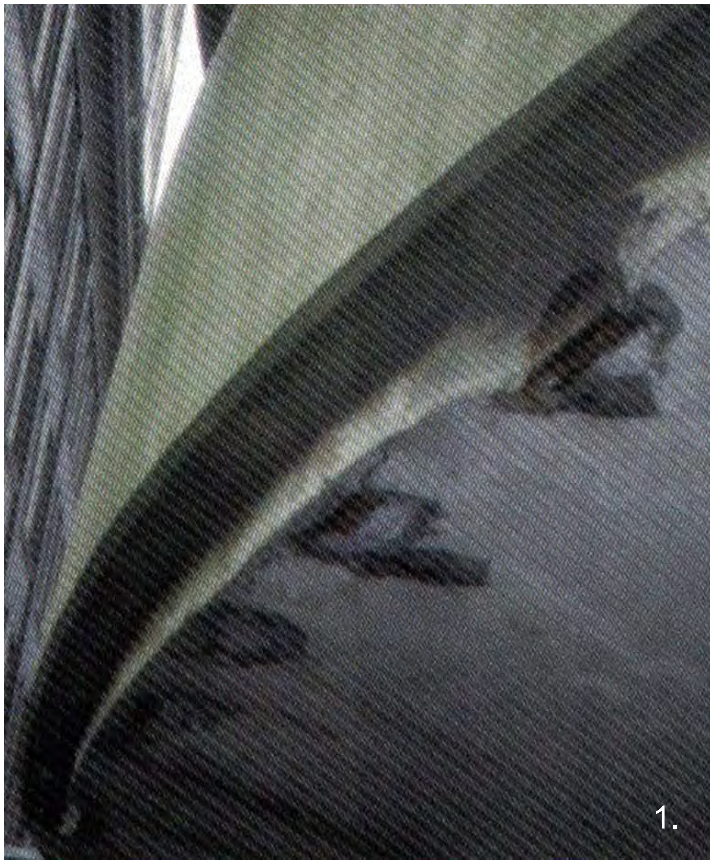
Prior to implementing the rehabilitation described above, another repair of the helix ramp had been undertaken. Partial-area patches completed during that project were found to be deteriorated at the time of the condition assessment performed in 1996. Past repairs are often found to be deteriorating due to the ongoing internal corrosion mechanisms within the structure. Short of implementing cathodic protection or complete replacement, the corrosion process will likely be ongoing, to varying degrees, in most parking structures throughout their service lives.

Given this situation, the concern becomes whether past repair methods and materials addressed the cause(s) of the distress in the structure. Unfortunately, past evaluation and testing techniques fall short of the standards in place today. Rate of corrosion testing, for example, was in its infancy as of 10 years ago. The lack of specialized knowledge about the corrosion process is one of the primary reasons that past repairs are more prone to premature failure than repairs completed today. Another common problem encountered with past repairs was the practice of engaging in an inexperienced contractor to “fix a problem.” In most situations, that contractor didn’t thoroughly evaluate or understand the problem, nor did he properly identify the cause of the problem.

Today, knowledge in the field of concrete structures and corrosion mechanisms is steadily growing through experience and research. Experienced contractors are more prevalent, as are experienced engineers and material specialists. Present day materials and products are being produced to provide a higher quality product. The topping material used on the helix ramp project, for example, incorporated a shrinkage-compensating admixture to control cracking of the material over the existing concrete substrate. Use of this product resulted in a crack-free topping placed in two separate pours on five levels of the ramp. It is expected that these trends toward more specialized experience and product quality will continue.

Although it is difficult to predict the future of concrete rehabilitation, the continued expansion of knowledge and experience in the field is virtually guaranteed. Continued research should expand the understanding of the corrosion process and corrosion control mechanisms. This, in turn, will lead to the development of materials and products that can better control the corrosion process and facilitate longer lasting concrete repairs.

Pictures below, from left to right are as follows - 1) Original slab edge deterioration; 2) Slab edge soffit demolition and formwork; 3) Slab edge formwork and shoring; 4) Completed slab soffit repair with integral drip edge



1.

2.

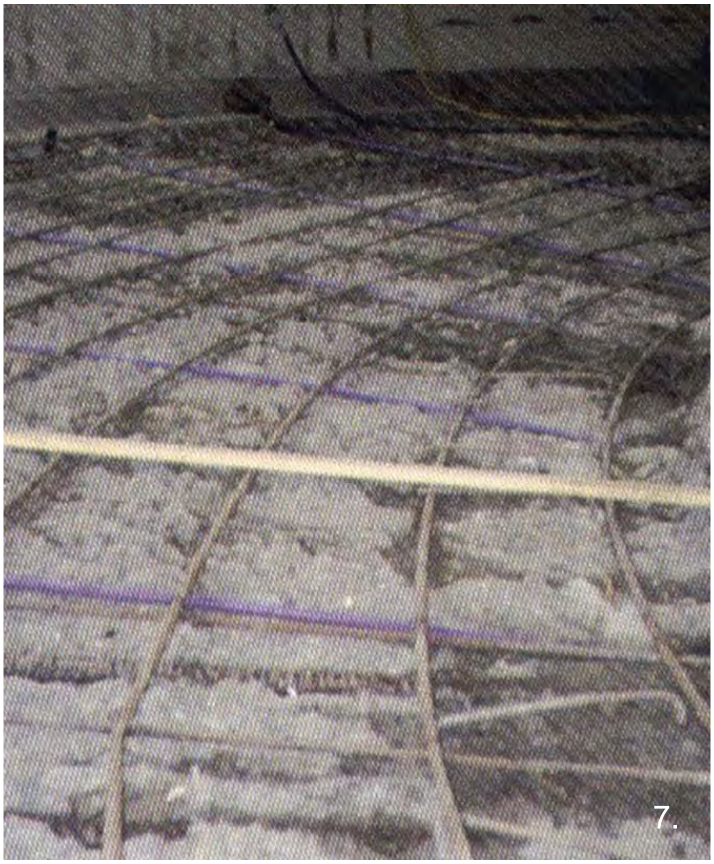
3.

4.

Pictures below, from left to right are as follows - 5) Knee wall vertical repair demolition; 6) Hydrodemolition of ramp slab upper concrete layer; 7) Demolished ramp slab surface with supplemental post-tension reinforcing installed throughout central cylinder; 8) Exposed post-tensioned tendon anchor heads at central cylinder

5.

6.



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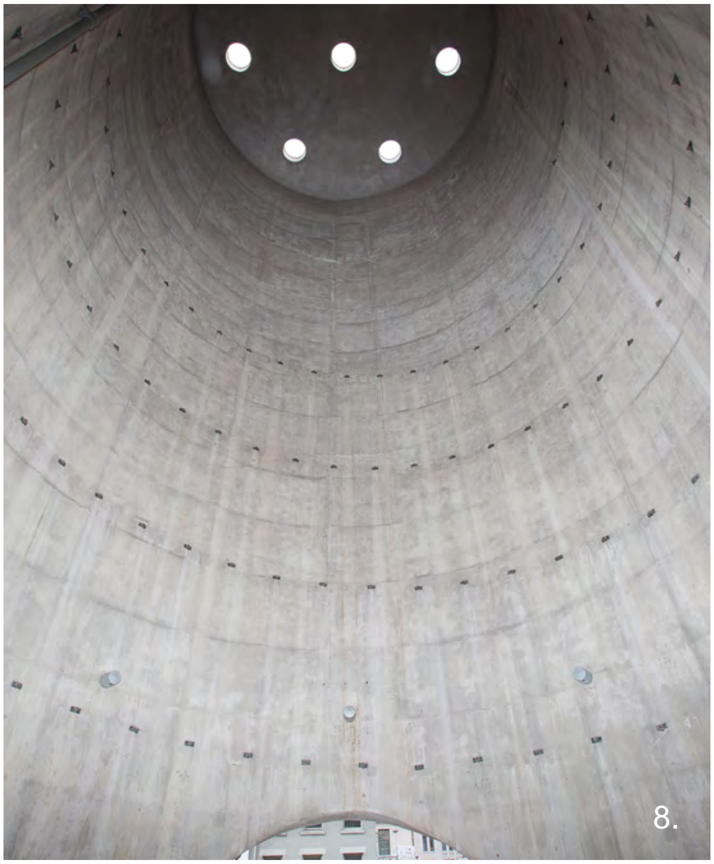

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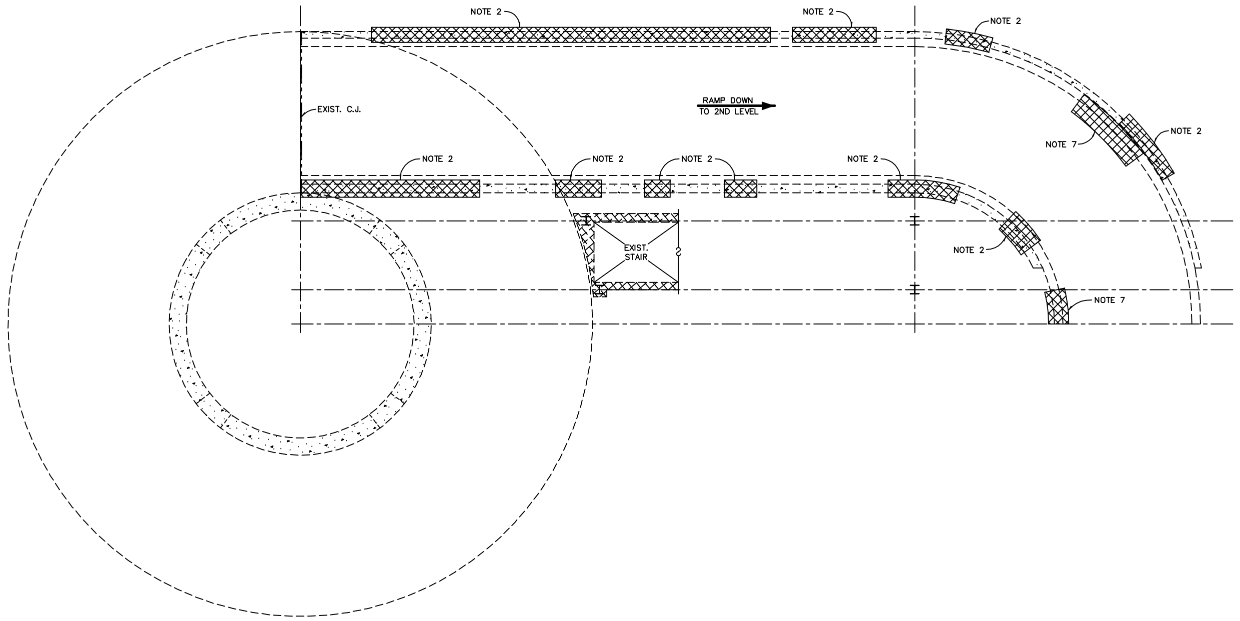
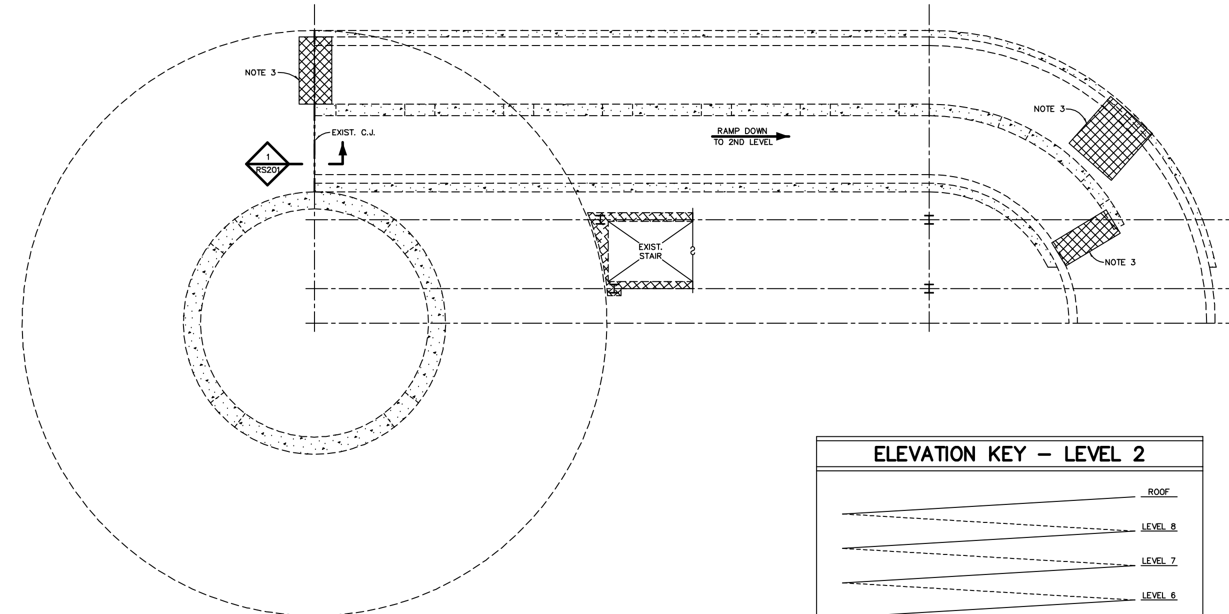
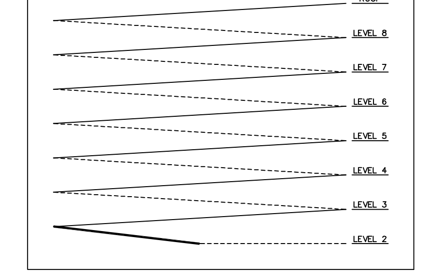


RAMP REHABILITATION PLAN
LEVEL 2
TOP SIDE



RAMP REHABILITATION PLAN
LEVEL 2
UNDERSIDE

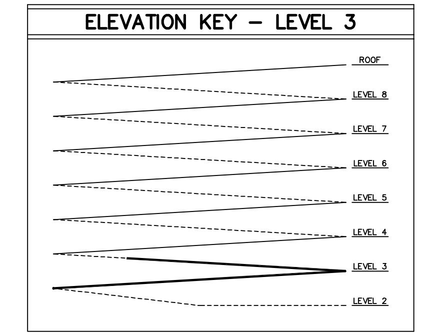
ELEVATION KEY – LEVEL 2

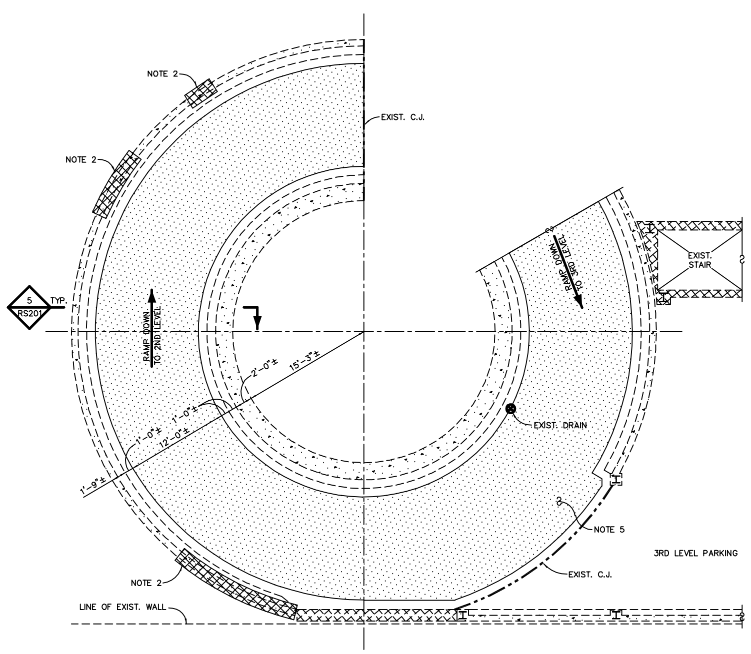


LEGEND

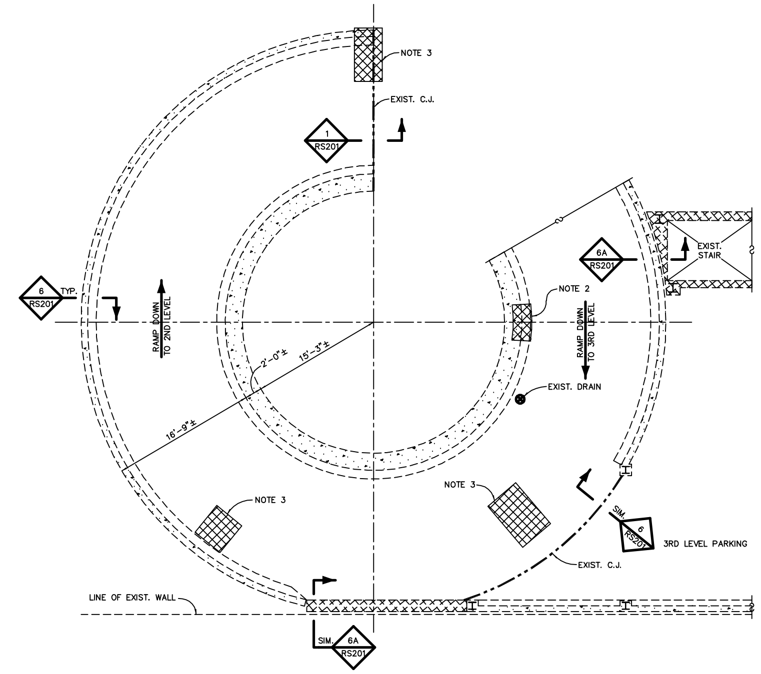
- INDICATES NEW CONCRETE
- INDICATES EXISTING CONCRETE
- INDICATES EXISTING MASONRY
- INDICATES EXISTING BEAM OR EXISTING CONSTRUCTION
- INDICATES NEW BEAM OR NEW CONSTRUCTION
- INDICATES NEW CONSTRUCTION
- INDICATES NEW CONSTRUCTION

ELEVATION KEY – LEVEL 3





RAMP REHABILITATION PLAN
LEVEL 3
TOP SIDE



RAMP REHABILITATION PLAN
LEVEL 3
UNDERSIDE

GENERAL DRAWING NOTES

1. DETERIORATED EXPANSION JOINT REPLACEMENT. SEE SECTION 1/RS201.
2. SPALL OR DELAMINATION REPAIR ON A VERTICAL SURFACE. SEE SECTION 2/RS201.
3. SPALL OR DELAMINATION REPAIR ON AN OVERHEAD SURFACE. SEE SECTION 3/RS201.
4. TOPSIDE PARTIAL RAMP SLAB REPAIR. SEE SECTION 4/RS201.
5. TOPSIDE COMPLETE RAMP SLAB REPAIR AND SUPPLEMENTAL PRESTRESS TENDON PLACEMENT. SEE SECTIONS 5/RS201, 5A/RS201, 5C/RS201 AND PLAN DETAIL 5B/RS201.
6. TYPICAL PERIMITER EDGE REPAIR. SEE SECTIONS 6/RS201 AND 6A/RS201.
7. TYPICAL CURB REPAIR. SEE SECTION 7/RS201.

SHEET NO. RS100

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PAGE #: 1
DATE PLOTTED: 06/02/97
PROJECT NUMBER: 97-068

SMITHFIELD – LIBERTY
GARAGE HELIX RAMP REHABILITATION
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PITTSBURGH, PA 15222

LEVEL 2 & 3 STRUCTURAL REHABILITATION PLANS

DATE: JUNE 2, 1997
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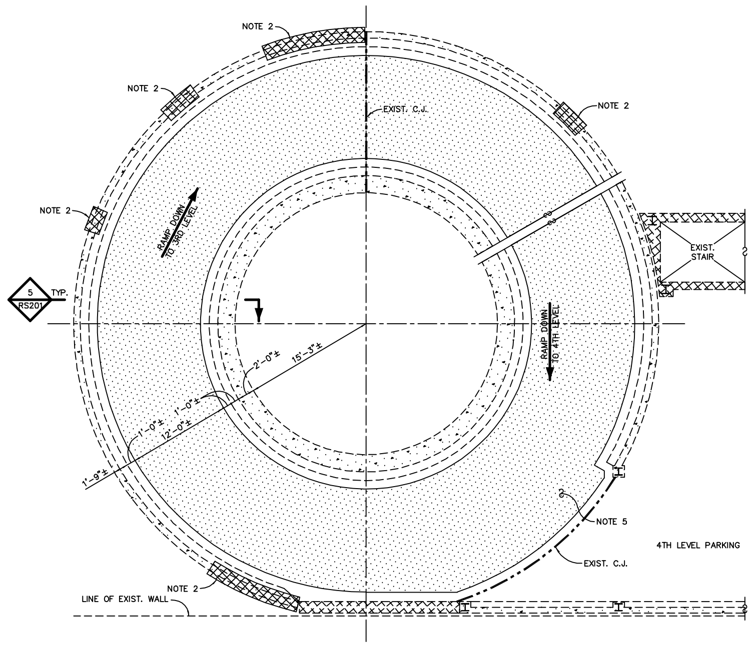
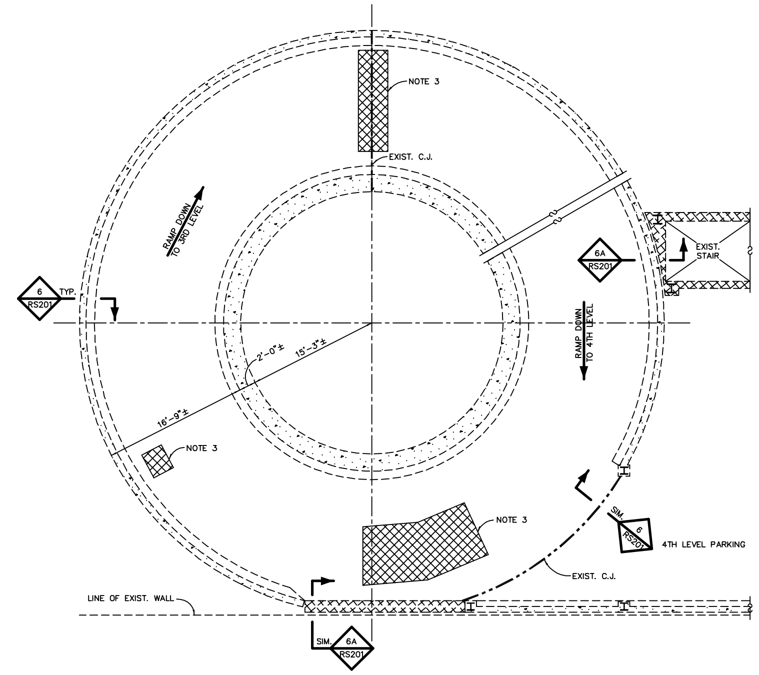
SHEET NO: RS100

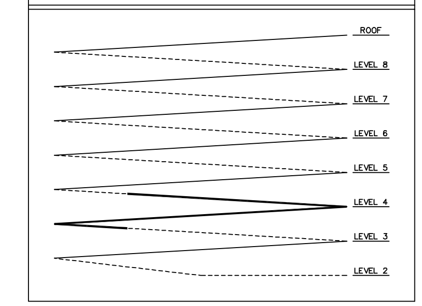


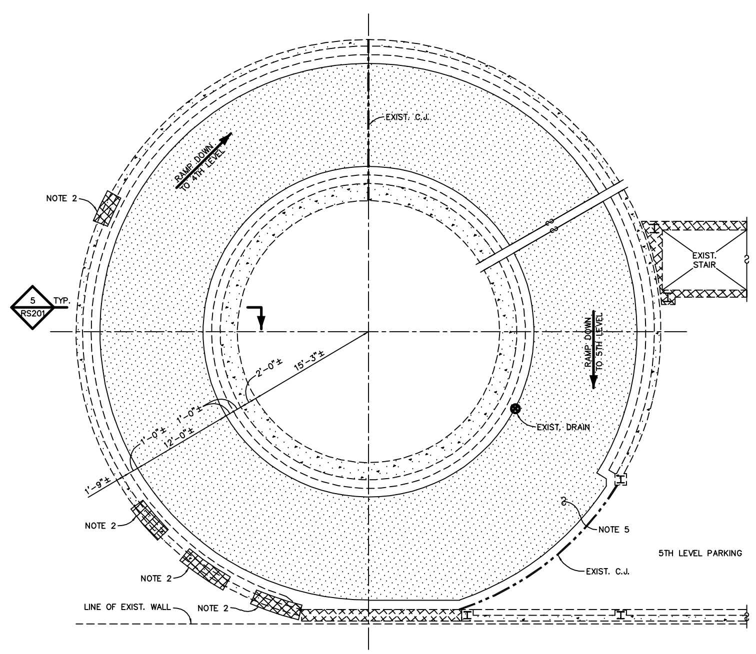
RAMP REHABILITATION PLAN
LEVEL 4
TOP SIDE



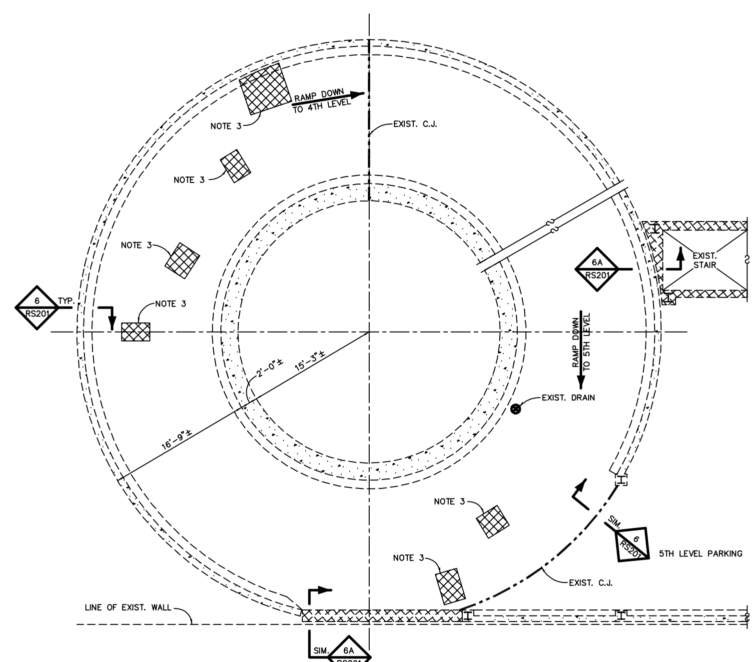
RAMP REHABILITATION PLAN
LEVEL 4
UNDERSIDE

ELEVATION KEY – LEVEL 4



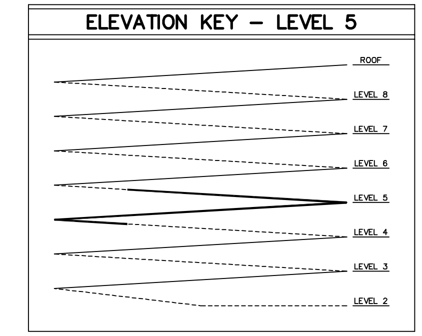


RAMP REHABILITATION PLAN
LEVEL 5
TOP SIDE



RAMP REHABILITATION PLAN
LEVEL 5
UNDERSIDE

ELEVATION KEY – LEVEL 5



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6. TYPICAL PERIMITER EDGE REPAIR.
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7. TYPICAL CURB REPAIR.
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SHEET NO. RS101

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PAGE #: 2
DATE PLOTTED: 06/02/97
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LEVEL 4 & 5 STRUCTURAL REHABILITATION PLANS

DATE: JUNE 2 1997

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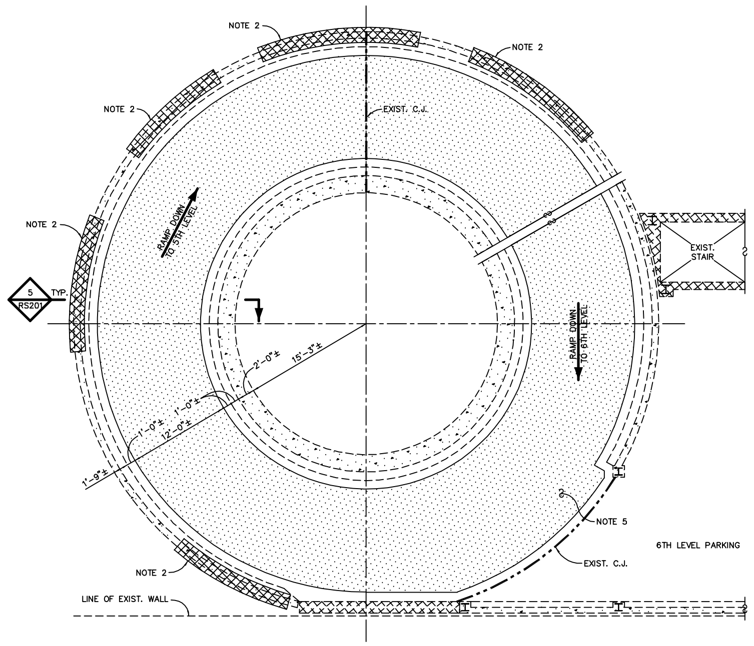
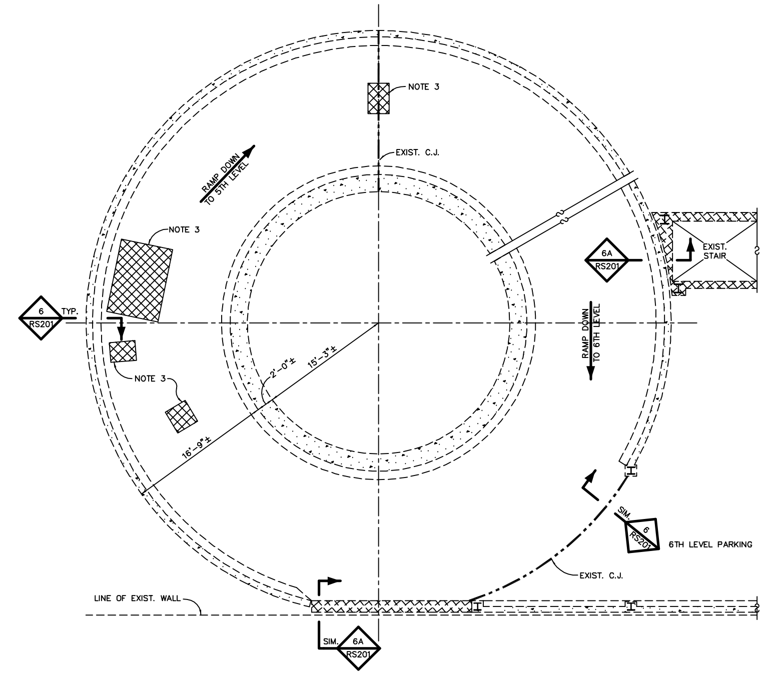
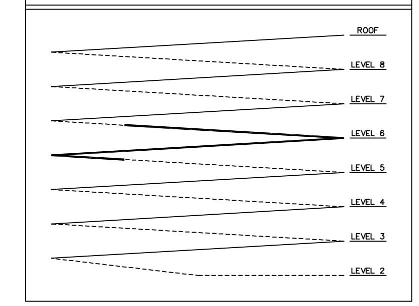


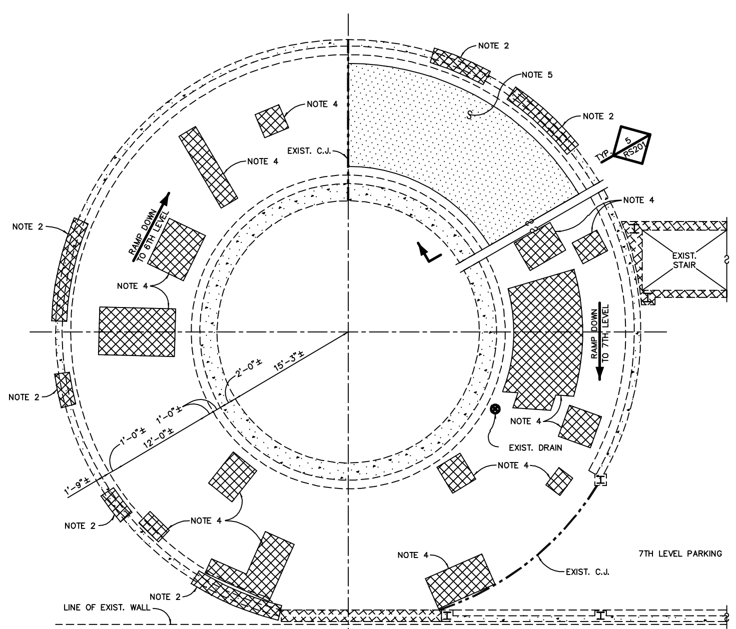
RAMP REHABILITATION PLAN
LEVEL 6
TOP SIDE



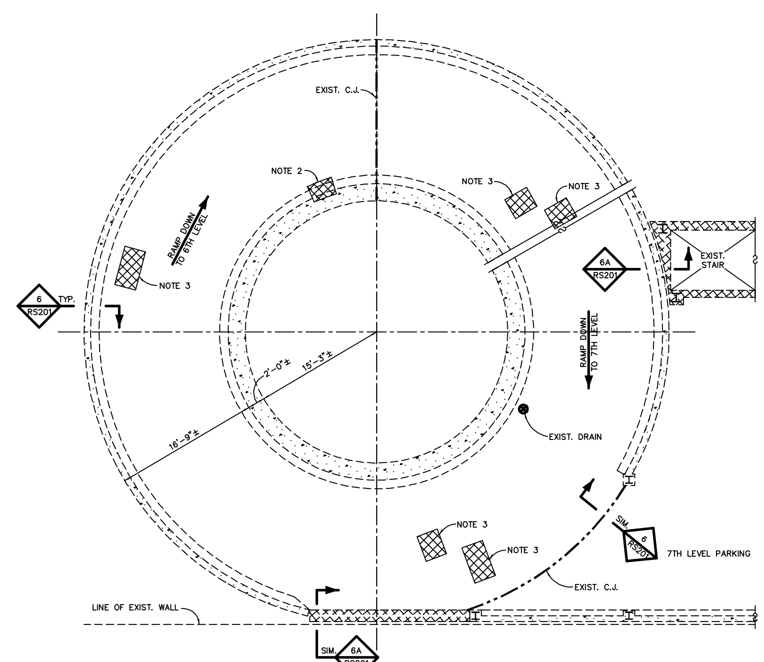
RAMP REHABILITATION PLAN
LEVEL 6
UNDERSIDE

ELEVATION KEY – LEVEL 6



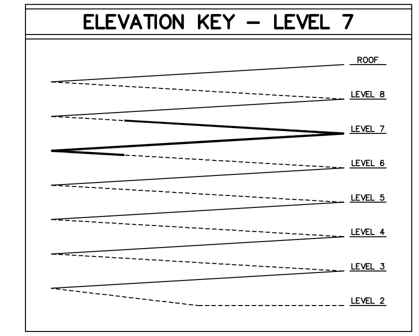


RAMP REHABILITATION PLAN
LEVEL 7
TOP SIDE



RAMP REHABILITATION PLAN
LEVEL 7
UNDERSIDE

ELEVATION KEY – LEVEL 7



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SHEET NO. RS102

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LEVEL 6 & 7 STRUCTURAL REHABILITATION PLANS

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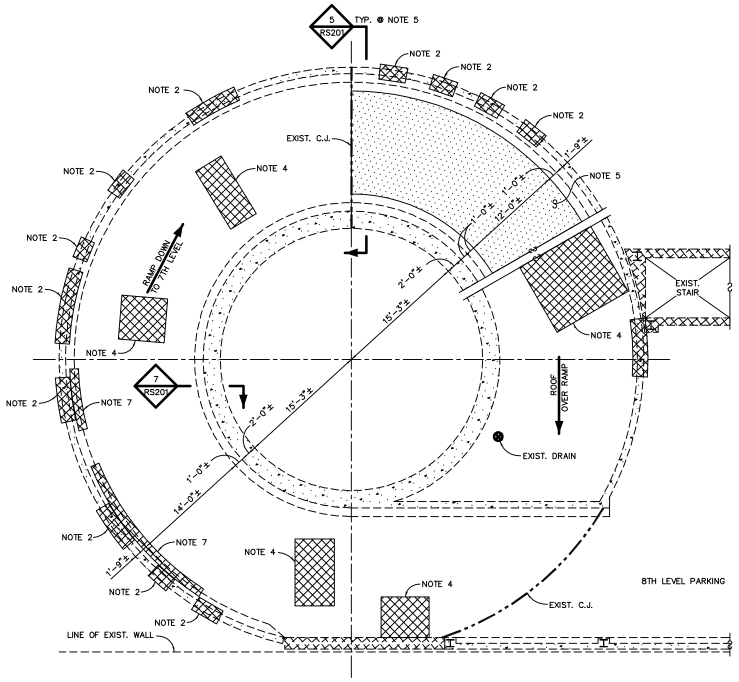
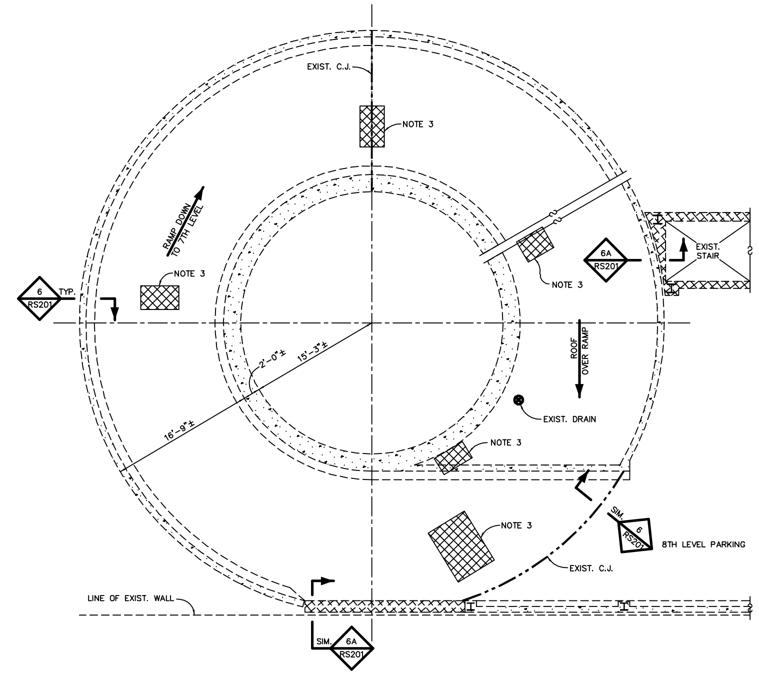
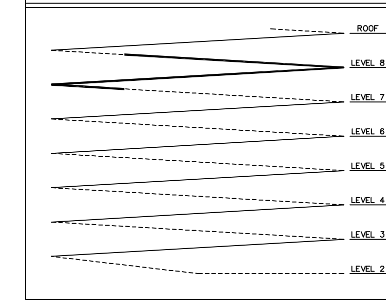


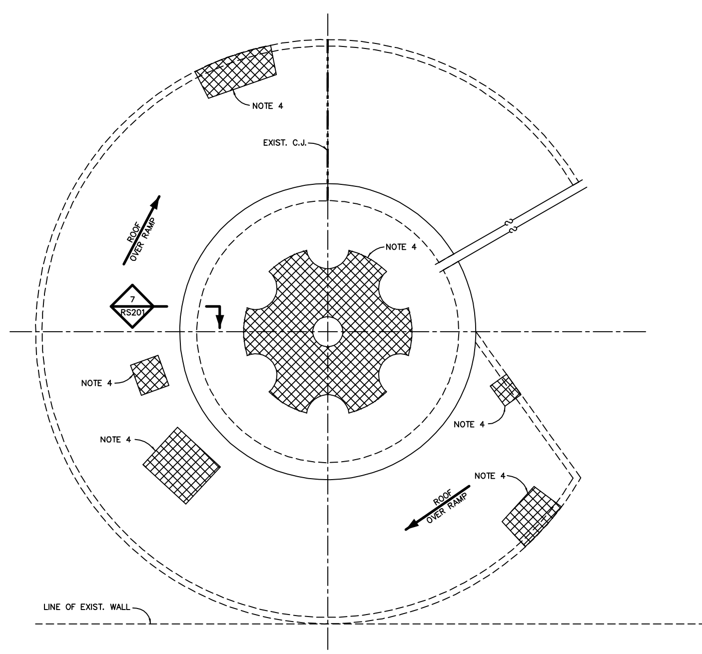
RAMP REHABILITATION PLAN
LEVEL 8
TOP SIDE



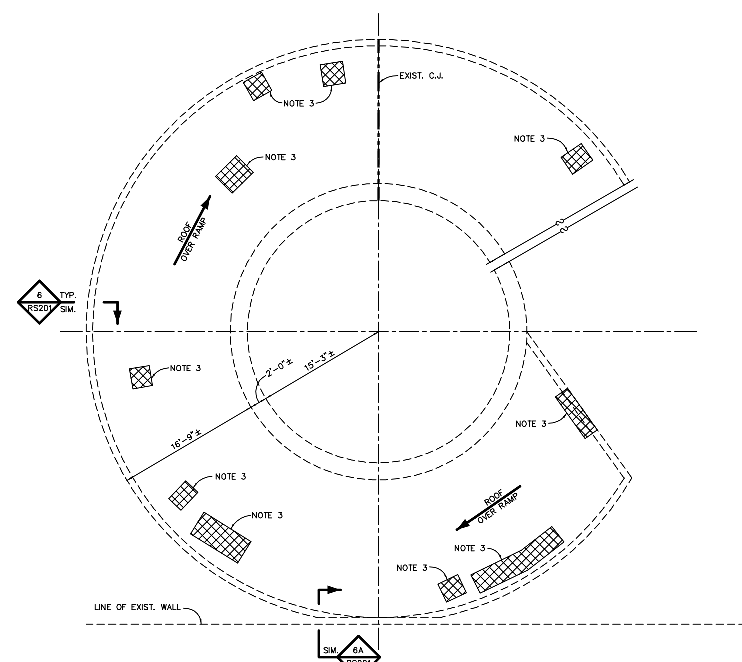
RAMP REHABILITATION PLAN
LEVEL 8
UNDERSIDE

ELEVATION KEY – LEVEL 8



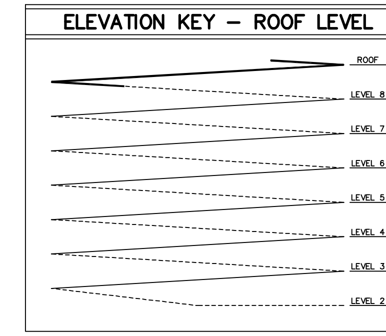


RAMP REHABILITATION PLAN
ROOF
TOP SIDE



RAMP REHABILITATION PLAN
ROOF
UNDERSIDE

ELEVATION KEY – ROOF LEVEL



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SHEET NO. RS103

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PAGE #: 4
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LEVEL 8 & ROOF STRUCTURAL REHABILITATION PLANS

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GENERAL NOTES

STRUCTURAL

CAST-IN-PLACE CONCRETE

C-1. ALL CAST-IN-PLACE CONCRETE WORK SHALL BE IN CONFORMANCE WITH THE "BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE" (ACI 318, LATEST EDITION) AND "SPECIFICATIONS FOR STRUCTURAL CONCRETE" (ACI 301, LATEST EDITION) OF THE AMERICAN CONCRETE INSTITUTE.

C-2. MINIMUM F'c REQUIRED AT 28 DAYS:
- a. PARTIAL RAMP PATCHES . . . . 6,000 PSI.
- b. COMPLETE RAMP RESURFACING. . . . . 6,000 PSI.

C-3. MAXIMUM WATER TO CEMENTITIOUS MATERIALS RATIO:
- a. EXTERIOR SLABS . . . . .0.38.

C-4. ALL CONCRETE SHALL BE NORMAL WEIGHT CONCRETE (144 PCF +/-) WITH CEMENT CONFORMING TO EITHER ASTM C150, TYPE I OR TYPE II, OR ASTM C595, TYPE I(SM) OR TYPE IS WITH THE MAXIMUM PERCENTAGE OF GROUND GRANULATED BLAST FURNACE SLAG CONFORMING TO ASTM C989 LIMITED TO 50% OF THE TOTAL CEMENTITIOUS MATERIALS. MAXIMUM LIMESTONE AGGREGATE SIZE SHALL BE 1", CONFORMING TO ASTM C33.

C-5. CONCRETE TEST CYLINDERS SHALL BE TAKEN IN ACCORDANCE WITH THE REQUIREMENTS OF ACI 318, LATEST EDITION, CHAPTER 5, AND THE CONTRACT SPECIFICATIONS.

C-6. REINFORCEMENT
- a. DEFORMED BARS. . . . . ASTM A615, GRADE 60.
- b. POST TENSIONED REINFORCING . . . . .SEE NOTE C-7 BELOW.

C-7. ALL POST-TENSIONED REINFORCING SHALL BE 1/2" DIAMETER - 7 WIRE LOW RELAXATION STRAND CONFORMING TO ASTM A416 AND HAVING THE FOLLOWING MINIMUM PROPERTIES:
ULTIMATE STRENGTH : 270 KSI
NOMINAL AREA : 0.1531 SQ. IN.
MODULUS OF ELASTICITY (E): 28,500 KSI.

C-8. THE COMPRESSIVE STRENGTH OF POST TENSIONED CONCRETE AT THE TIME OF TENSIONING SHALL BE A MINIMUM OF 4,000 PSI, SEE SPECIFICATIONS. ANCHORAGE BEARING SHALL BE PROVIDED SUCH THAT STRESSES IN EXCESS OF PARAGRAPH 18.13 OF ACI 318R-83(86), "COMMENTARY ON BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE", ARE NOT PRODUCED. MAXIMUM TEMPORARY FORCE TO OVERCOME FRICTION = 33.0 KIPS. ULTIMATE CABLE FORCE = 41.3 KIPS, MAXIMUM ANCHOR FORCE = 29.0 KIPS. LOSSES DUE TO CREEP, SHRINKAGE, ELASTIC SHORTENING, AND STEEL STRESS RELAXATION = 10% OF ULTIMATE STRENGTH. UNIT ELONGATION = 0.079 IN/FT.
FINAL POST TENSION FORCE SHALL BE 30 KIPS AFTER LOSSES.

C-9. GROUT SHALL BE NON-SHRINK, NON-METALLIC TYPE, FACTORY PRE-MIXED GROUT IN ACCORDANCE WITH CE-CRD-C621 OR ASTM C109, WITH F'c OF NOT LESS THAN 6,000 PSI.

C-10. ALL REINFORCEMENT SHALL BE SECURELY HELD IN PLACE WHILE PLACING CONCRETE. IF REQUIRED, ADDITIONAL BARS OR CHAIRS SHALL BE PROVIDED BY THE CONTRACTOR TO FURNISH SUPPORT FOR ALL BARS.

C-11. MINIMUM CONCRETE COVER FOR REINFORCING STEEL SHALL BE 3/4".

C-12. UPON ACCEPTANCE OF THE BID, THE CONTRACTOR SHALL SUBMIT FOR REVIEW BY STRUCTURAL ENGINEER A CONCRETE POUR SCHEDULE SHOWING LOCATION OF ALL PROPOSED CONSTRUCTION JOINTS.

C-13. UPON ACCEPTANCE OF THE BID, THE CONTRACTOR SHALL SUBMIT A CONCRETE MIX DESIGN PREPARED IN ACCORDANCE WITH THE SPECIFICATIONS TO THE STRUCTURAL ENGINEER FOR REVIEW.

C-14. FLUID APPLIED MEMBRANE IS TO BE APPLIED TO ENTIRE RAMP SURFACE. SEE SPECIFICATION SECTION 07120 FOR REQUIREMENTS.

SUPPLEMENTARY

X-1. THIS DRAWING HAS BEEN PRODUCED ENTIRELY ON STRUCTURAL ENGINEERING CORPORATION'S CADD SYSTEM. ANY OTHER LETTERING, LINES OR SYMBOLS, OTHER THAN PROFESSIONAL STAMPS AND SIGNATURES, HAVE BEEN MADE WITHOUT THE AUTHORIZATION OF STRUCTURAL ENGINEERING CORPORATION AND ARE INVALID.

X-2. THE CONTRACTOR SHALL VERIFY ALL EXISTING CONDITIONS, DIMENSIONS, ETC. BEFORE BEGINNING THE WORK.

X-3. ALL STRUCTURAL WORK SHALL BE INSPECTED IN ACCORDANCE WITH THE BUILDING CODE AND ALL LOCAL ORDINANCES. THE OWNER SHALL ENGAGE AN EXPERIENCED, QUALIFIED INSPECTION AGENCY, SUBJECT TO THE REVIEW OF THE ENGINEER, TO PERFORM ALL INSPECTION WORK, AS REQUIRED.

SHOP DRAWINGS

E-1. THE CONTRACTOR SHALL SUBMIT SHOP DRAWINGS FOR THE REVIEW OF THE ENGINEER.

E-2. SHOP DRAWINGS TO BE SUBMITTED SHALL PROVIDE COMPLETE INFORMATION FOR THE PRODUCTS OR COMPONENTS TO BE SUPPLIED. SUBMITTAL INFORMATION SHALL INCLUDE, BUT NOT BE LIMITED TO: REINFORCING BAR, POST-TENSIONED REINFORCING AND ATTACHMENTS.

E-3. THE REVIEW OF SHOP DRAWINGS AND OTHER SUBMITTALS FOR THIS PROJECT IS FOR CONFORMANCE WITH THE DESIGN CONCEPT AND FOR GENERAL COMPLIANCE WITH THE INFORMATION CONTAINED IN THE CONTRACT DOCUMENTS. COMMENTS REGARDING THESE SUBMITTALS DO NOT RELIEVE THE CONTRACTOR FROM COMPLIANCE WITH THE CONTRACT DOCUMENTS. THE CONTRACTOR IS RESPONSIBLE FOR PERFORMING HIS WORK IN A SAFE AND SATISFACTORY MANNER.

TEMPORARY SHORING

TS-1. THE CONTRACTOR SHALL ERECT TEMPORARY SHORING TO PROVIDE SUPPORT AT THE PERIMETER OF THE HELIX RAMP AT LEVELS WHERE TOTAL RAMP SURFACE REPLACEMENT IS TO OCCUR. SHORING CALCULATIONS ARE TO BE PREPARED AND STAMPED BY A PROFESSIONAL ENGINEER REGISTERED IN THE STATE OF PENNSYLVANIA, FOR THE REVIEW OF THE OWNER AND STRUCTURAL ENGINEER. THE SHORING IS TO BE DESIGNED FOR A CONTINUOUS LOAD AT THE PERIMETER OF THE HELIX RAMP OF 1.5 KIPS PER FOOT.

TS-2. THE SHORING SHALL BE CONSTRUCTED IN SUCH A MANNER AS TO ALLOW PEDESTRIAN AND VEHICULAR ACCESS. SEE SPECIFICATIONS FOR ALTERNATE BIDDING OPTIONS.

CONCRETE REPAIR

GENERAL:

1. SEE SPECIFICATIONS FOR DIRECTIONS ON SOUNDING, CONCRETE REMOVAL, SURFACE PREPARATION, PLACEMENT OF REPAIR MATERIALS AND ALL OTHER REPAIR REQUIREMENTS.
2. PROPOSED REPAIR METHODS ARE GENERALLY OUTLINED BELOW AND ARE SHOWN IN DETAILS ON SHEETS RS201.
3. MEASUREMENT AND PAYMENT FOR CONCRETE DEMOLITION AND SPALL REPAIR WILL BE MADE BASED ON THE ACTUAL SURFACE AREA AND VOLUME OF CONCRETE DEMOLISHED AS SHOWN BY EXTENT ON DETAILS, AND AS OUTLINED IN THE PROJECT SPECIFICATIONS.
4. SEE SPECIFICATIONS FOR REQUIREMENTS REGARDING COLOR MATCHING OF NEW PATCHES AND EXISTING CONCRETE.
5. EXTENT OF DAMAGED CONCRETE SHOWN ON PLAN IS APPROXIMATE AND IS PROVIDED FOR GENERAL INFORMATION ONLY.
ACTUAL EXTENT OF DAMAGED CONCRETE IS TO BE DETERMINED IN ACCORDANCE WITH THE REQUIREMENTS OF THE PROJECT SPECIFICATIONS SECTION 03311 "CONCRETE DEMOLITION AND REPAIR".

DEMOLITION:

1. PERFORM SOUNDING OF CONCRETE SURFACES AS REQUIRED BY THE PROJECT SPECIFICATIONS. MARK ALL SPALLED AREAS WITH A PAINT OUTLINE.
2. DEMOLISH CONCRETE TO AT LEAST THE LIMITS MARKED PER NOTE 1 ABOVE IN ACCORDANCE WITH DETAIL 8/RS201 AND TO A MINIMUM DEPTH OF 1-1/2" OR TO SOUND CONCRETE, WHICHEVER IS GREATER. FINAL DEMOLISHED AREA SHALL BE APPROXIMATELY RECTANGULAR WITH STRAIGHT SIDES, LEVEL SURFACE AND SQUARE-CUT CORNERS. THIS MAY NECESSITATE REMOVAL OF SOUND CONCRETE IN SOME AREAS TO CONFORM WITH THE RECOMMENDED REPAIR PROCEDURES. THE SURFACE OF THE SOUND CONCRETE SHALL BE DETERMINED AND APPROVED IN ACCORDANCE WITH THE REQUIREMENTS OF THE PROJECT SPECIFICATIONS.
3. AT THE PERIMETER OF THE DEMOLITION, THE SURFACE NORMAL TO THE FACE OF MEMBERS SHALL BE SAWCUT APPROXIMATELY STRAIGHT FOR A MINIMUM DEPTH OF 1/2" OR TO THE DEPTH OF THE EXISTING REINFORCING STEEL, WHICHEVER IS LESS.
4. THE FINAL DEMOLISHED SURFACE AT ANY LOCATION SHALL BE REASONABLY SMOOTH WITH NO SHARP PROJECTIONS.
5. DO NOT DAMAGE OR CUT EXISTING REINFORCING STEEL DURING DEMOLITION.
6. SAND BLAST CLEAN ALL DEMOLISHED SURFACES AND REINFORCING. REMOVE ALL LOOSE MATERIALS AND RUST AND DISPOSE OF ALL DEBRIS OFF SITE.

RECOMMENDED REPAIR PROCEDURES:

1. FORM AND PUMP METHOD:

- a. SAWCUT EDGE AT PATCH PERIMETER PER DEMOLITION NOTES AND 6" BEYOND EXTENT OF UNSOUND CONCRETE.
- b. REMOVE ALL UNSOUND AND DETERIORATED CONCRETE. DO NOT DAMAGE SURROUNDING SOUND CONCRETE. ALL EXISTING REINFORCEMENT TO REMAIN.
- c. IF EXPOSED REINFORCEMENT IS CORRODED, CONTINUE TO REMOVE CONCRETE UNTIL A MINIMUM OF 6" OF UNCORRODED REINFORCEMENT IS EXPOSED, UNLESS OTHERWISE RECOMMENDED BY THE ENGINEER.
- d. FORMWORK TO BE DESIGNED BY THE CONTRACTOR TO SUPPORT THE DEAD LOAD AND INTERNAL PRESSURE LOAD OF THE PUMPED REPAIR MATERIAL.
- e. PUMP REPAIR MATERIAL PER MANUFACTURER'S REQUIREMENTS.

2. FORM AND CAST METHOD:

- a. SAWCUT EDGE AT PATCH PERIMETER PER DEMOLITION NOTES AND 6" BEYOND EXTENT OF UNSOUND CONCRETE.
- b. REMOVE ALL UNSOUND AND DETERIORATED CONCRETE. DO NOT DAMAGE SURROUNDING SOUND CONCRETE. ALL EXISTING REINFORCEMENT TO REMAIN.
- c. IF EXPOSED REINFORCEMENT IS CORRODED, CONTINUE TO REMOVE CONCRETE UNTIL A MINIMUM OF 6" OF UNCORRODED REINFORCEMENT IS EXPOSED, UNLESS OTHERWISE RECOMMENDED BY THE ENGINEER.
- d. PLACE, FINISH, AND CURE LATEX-MODIFIED CONCRETE REPAIR MATERIAL. TOOL CONTROL JOINTS DURING FINISHING AS REQUIRED.

3. CAST IN PLACE METHOD:

- a. SAWCUT EDGE AT PATCH PERIMETER PER DEMOLITION NOTES AND 6" BEYOND EXTENT OF UNSOUND CONCRETE.
- b. REMOVE ALL UNSOUND AND DETERIORATED CONCRETE. DO NOT DAMAGE SURROUNDING SOUND CONCRETE. ALL EXISTING REINFORCEMENT TO REMAIN.
- c. IF EXPOSED REINFORCEMENT IS CORRODED, CONTINUE TO REMOVE CONCRETE UNTIL A MINIMUM OF 6" OF UNCORRODED REINFORCEMENT IS EXPOSED, UNLESS OTHERWISE RECOMMENDED BY THE ENGINEER.
- d. FORM, PLACE, FINISH, AND CURE CONCRETE REPAIR MATERIAL. TOOL CONTROL JOINTS DURING FINISHING AS REQUIRED.

ABBREVIATIONS:

A.A.	AFTER ALIGNMENT	L.L.	LIVE LOAD/LONG LEG
A.B.	ANCHOR BOLT	LLH	LONG LEG HORIZONTAL
ADD'L	ADDITIONAL	LLV	LONG LEG VERTICAL
ALT.	ALTERNATE	LLBB	LONG LEG BACK TO BACK
APPROX.	APPROXIMATELY	LT.	LIGHT
ARCH.	ARCHITECT	L.W.	LIGHT WEIGHT
B.E.	BOTH ENDS	M.O.	MASONRY OPENING
B.E.W.	BOTTOM EACH WAY	MAX.	MAXIMUM
BOT.	BOTTOM	MECH.	MECHANICAL
B⅊	BASE/BEARING PLATE	MFR.(G)	MANUFACTURER (ING)
BRDG	BRIDGING	MISC.	MISCELLANEOUS
BRG.	BEARING	MIN.	MINIMUM
B.S.	BOTH SIDES	N.F.	NEAR FACE
c/c	CENTER TO CENTER	N.I.C.	NOT IN CONTRACT
C.I.P.	CAST IN PLACE	N.T.S.	NOT TO SCALE
C.J.	CONSTRUCTION JOINT OR CONTROL JOINT	N.W.	NORMAL WEIGHT
		O.D.	OUTSIDE DIAMETER
CA	CAISSON	O.F.	OUTSIDE FACE
CANT.	CANTILEVER	OPNG.	OPENING
CLR.	CLEAR	OPP.	OPPOSITE
COL.	COLUMN	PAR	PARALLEL
COMP.	COMPOSITE	P.C.	PRECAST
CONC.	CONCRETE	PC	PIECE
CONSTR.	CONSTRUCTION	PERP.	PERPENDICULAR
CONT.	CONTINUOUS	⅊	PLATE
CONTR.	CONTRACTOR	PLF	LBS. PER LINEAR FOOT
COORD.	COORDINATE	PSI	LBS. PER SQ. INCH
D.L.	DEAD LOAD	P.T.	PRESSURE TREATED
DIM.	DIMENSIONS	R.E.	RIGHT END
DWG.	DRAWING	REINF.	REINFORCE
EA.	EACH	REM	REMAINDER
E.E.	EACH END	REQ'D	REQUIRED
E.F.	EACH FACE	RET.	RETAINING
E.O.D.	EDGE OF DECK	SCHED.	SCHEDULE
E.O.S.	EDGE OF SLAB	SIM.	SIMILAR
E.W.	EACH WAY	S.L.	SHORT LEG
ELEV.	ELEVATION/ELEVATOR	SLV	SHORT LEG VERTICAL
ELEV. B/	ELEVATION BOTTOM OF	SPAC.	SPACES/SPACING
ELEV. T/	ELEVATION TOP OF	SPEC.	SPECIFICATION
EMBED.	EMBEDMENT/EMBEDDED	SPD.	SPREAD
ENGR.	ENGINEER	SP.L.	SPLICE LENGTH
EQ.	EQUAL/EQUIVALENT	STD	STANDARD
ETC.	ETCETERA	STIFF.	STIFFENER
EXT.	EXTERIOR/EXTENDED	STRUCT.	STRUCTURE
EXIST.	EXISTING	SYM	SYMMETRICAL
EXP.	EXPANSION	T.	TOP
F.F.	FAR FACE	TEMP.	TEMPORARY
FDN.	FOUNDATION	TYP.	TYPICAL
FIN.	FINISH	U/S	UNDERSIDE
FTG.	FOOTING	U.N.O.	UNLESS NOTED OTHERWISE
FT.	FEET	V.I.F.	VERIFY IN FIELD
GB	GRADE BEAM	VERT.	VERTICAL
G.C.	GENERAL CONTRACTOR	W/	WITH
GA.	GAGE	W/O	WITHOUT
GALV.	GALVANIZED	W.P.	WORK POINT
GEN.	GENERAL	WT.	WEIGHT
HORIZ.	HORIZONTAL	W.W.F.	WELDED WIRE FABRIC
I.D.	INSIDE DIAMETER	@	AT
I.F.	INSIDE FACE	℄	CENTER LINE
IN.	INCHES	#	NUMBER
INT.	INTERIOR	ø	DIAMETER
JT.	JOINT	L	ANGLE
KSF	KIP PER SQ. FOOT	JL	DOUBLE ANGLE
L.E.	LEFT END	JLL	TRIPLE ANGLE

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SHEET NO. RS200

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PAGE # 5
DATE PLOTTED: 06/02/97
PROJECT NUMBER: 97-068

SMITHFIELD - LIBERTY
GARAGE HELIX RAMP REHABILITATION
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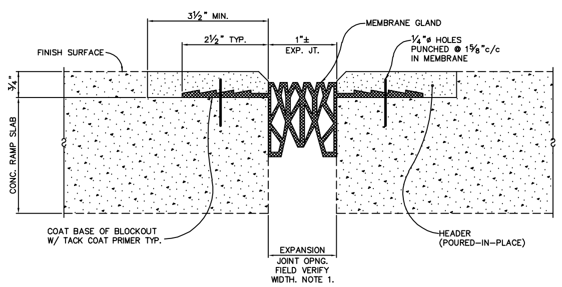
GENERAL NOTES

DATE: JUNE 2, 1997

PROJECT NO: 97-068

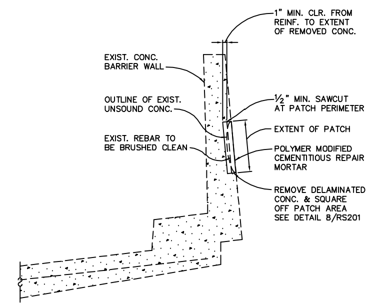
SHEET NO: RS200



SECTION 1 / RS201
TYPICAL EXPANSION JOINT

NOTES:

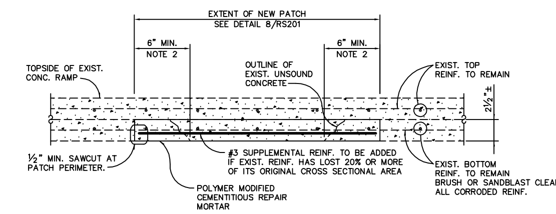
1. REMOVE EXIST. EXPANSION JOINT
2. IF CONCRETE IS DETERIORATED AROUND EXPANSION JOINT, REFERENCE FORM & CAST METHOD RECOMMENDED REPAIR PROCEDURE ON SHEET RS200 FOR ADD'L INFORMATION.
3. REFER TO MFR'S RECOMMENDATIONS FOR TEMP. ADJUSTMENTS AT TIME OF MEASUREMENT. INSTALL IN STRICT COMPLIANCE W/ MFR'S RECOMMENDATIONS. SUBMIT PRODUCT SHEET AND INSTALLATION INFO. FOR ENGINEERS REVIEW.



SECTION 2 / RS201
TYPICAL VERTICAL SURFACE REPAIR

NOTES:

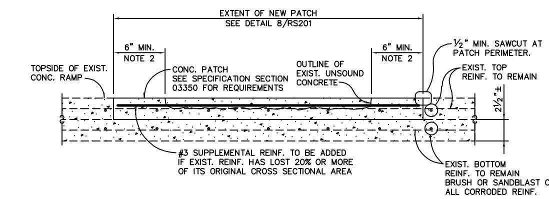
1. SIM. VERT. REPAIR @ INSIDE FACE OF BARRIER WALL OR @ CYLINDER.
2. SEE FORM & CAST METHOD RECOMMENDED REPAIR PROCEDURE ON SHEET RS200.



NOTES:

1. REFERENCE FORM & PUMP METHOD RECOMMENDED REPAIR PROCEDURE ON SHEET RS200 FOR ADD'L INFORMATION.
2. 1'-4" IF SUPPLEMENTAL MILD STEEL REINF. IS TO BE ADDED DUE TO EXIST. DETERIORATION.

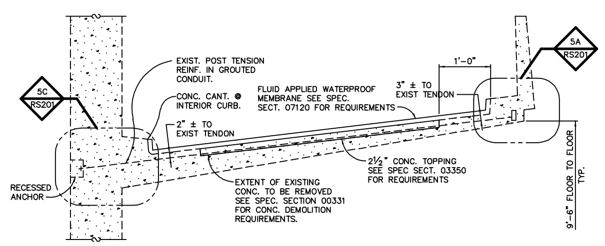
SECTION 3 / RS201
TYPICAL UNDERSIDE PARTIAL DEPTH CONCRETE RAMP SLAB REPAIR



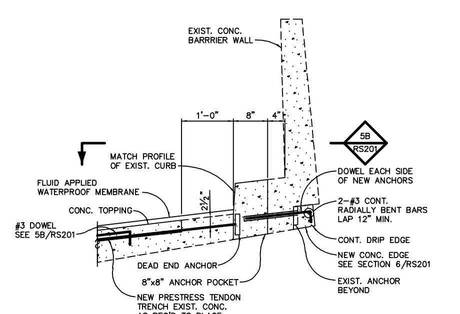
NOTES:

1. REFERENCE CAST IN PLACE METHOD RECOMMENDED REPAIR PROCEDURE ON SHEET RS200 FOR ADD'L INFORMATION.
2. 1'-4" IF SUPPLEMENTAL MILD STEEL REINF. IS TO BE ADDED DUE TO EXIST. DETERIORATION.

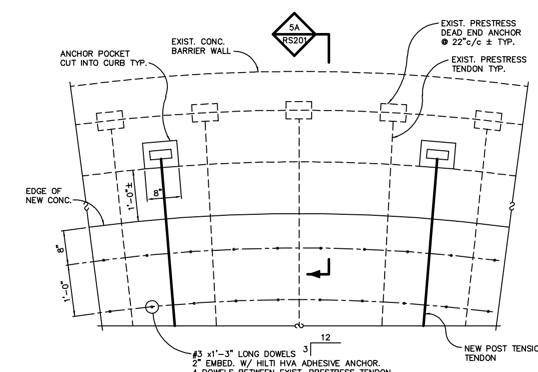
SECTION 4 / RS201
TYPICAL PARTIAL DEPTH CONCRETE RAMP SLAB REPAIR



SECTION 5 / RS201
TYPICAL CONCRETE RAMP SLAB SURFACE REPAIR



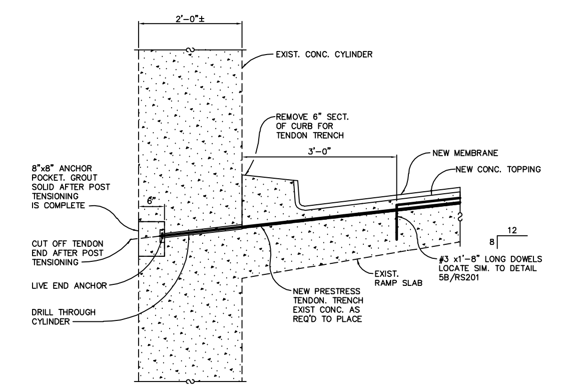
SECTION 5A / RS201
TYPICAL PRESTRESS TENDON INSTALLATION



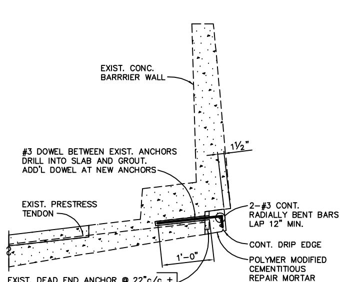
NOTE:

1. SUPPLEMENTAL PRESTRESS TENDONS AT EVERY THIRD SPACE BETWEEN EXIST. TENDONS. ADDITIONAL TENDONS TO BE PLACED AS DETERMINED BY THE ENGINEER AT SEVERLY CORRODED EXIST. TENDONS.

PLAN DETAIL 5B / RS201
TYPICAL PRESTRESS TENDON INSTALLATION



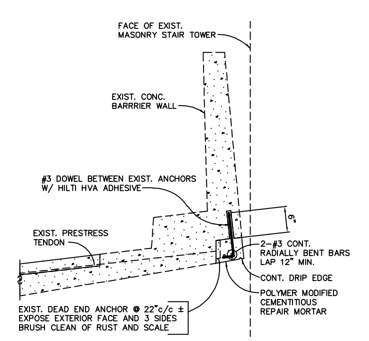
SECTION 5C / RS201
TYPICAL PRESTRESS TENDON INSTALLATION AT INSIDE FACE OF CYLINDER



NOTES:

1. REFERENCE FORM & PUMP METHOD RECOMMENDED REPAIR PROCEDURE ON SHEET RS200 FOR ADD'L INFORMATION.

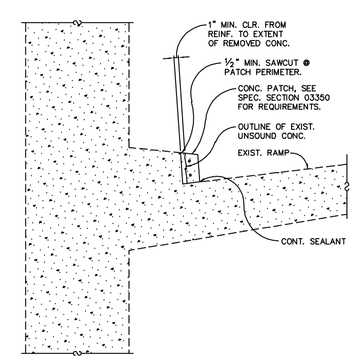
SECTION 6 / RS201
TYPICAL PERIMETER EDGE REPAIR



NOTES:

1. REFERENCE FORM & PUMP METHOD RECOMMENDED REPAIR PROCEDURE ON SHEET RS200 FOR ADD'L INFORMATION.

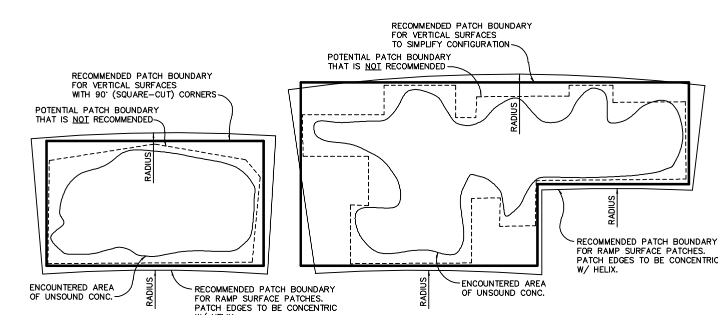
SECTION 6A / RS201
TYPICAL PERIMETER EDGE REPAIR AT STAIR TOWER



SECTION 7 / RS201
TYPICAL CONCRETE CURB REPAIR

NOTES:

1. SEE FORM & CAST METHOD RECOMMENDED REPAIR PROCEDURE ON SHEET RS200.



SAMPLE CASE #1 **SAMPLE CASE #2**

NOTE:

1. IT IS RECOMMENDED THAT INITIAL OUTLINE OF ENCOUNTERED AREA OF UNSOUND CONC. BE MARKED W/ BLUE PAINT. OUTLINE AREA OF REPAIR PER ABOVE RECOMMENDED CASES W/ ORANGE PAINT TO DISTINGUISH FROM THE UNSOUND CONCRETE AREA.

DETAIL 8 / RS201
TYPICAL PATCH AREA CONFIGURATION

SHEET NO. RS201

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SECTIONS AND DETAILS

DATE: JUNE 2, 1997
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SHEET NO: RS201