




KANSAS CITY'S RESILIENT SPIRAL RAMP

Structure

- Built in 1965
- Separate entry & exit single helix ramps
- Two way slab supported by beams and columns

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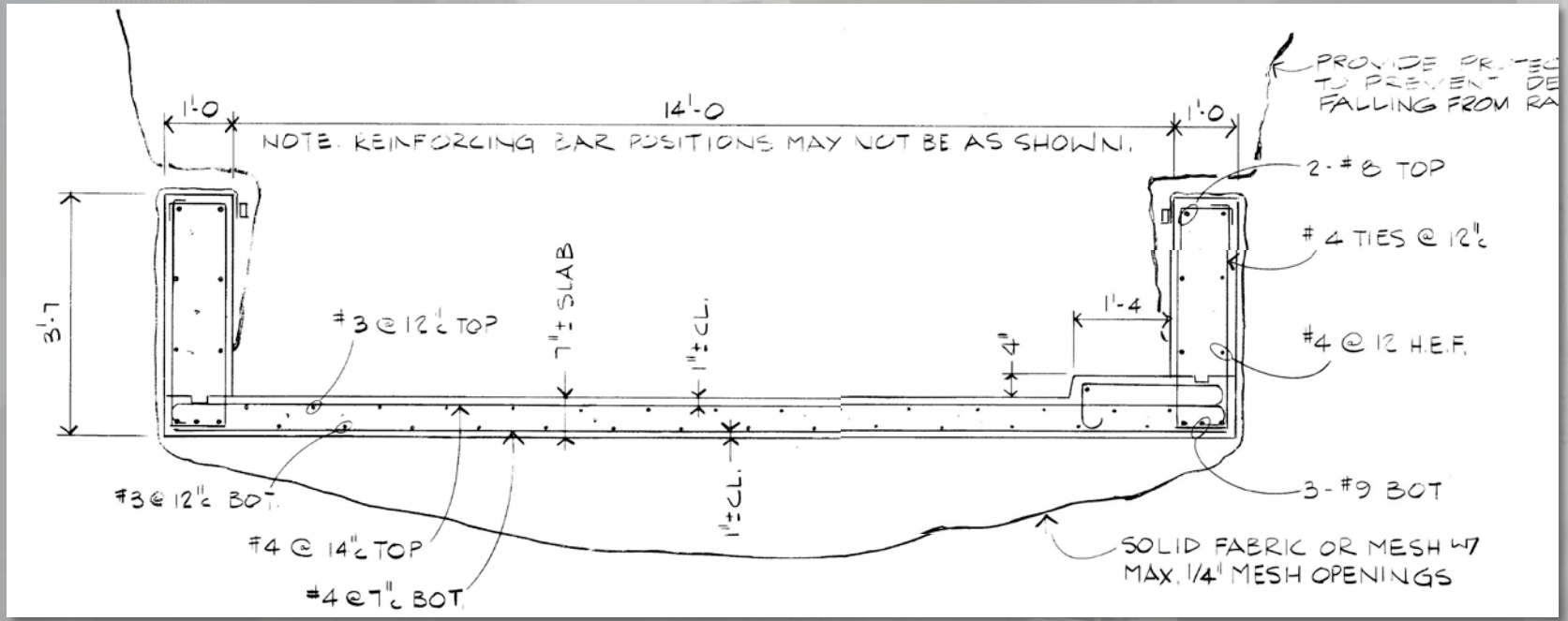
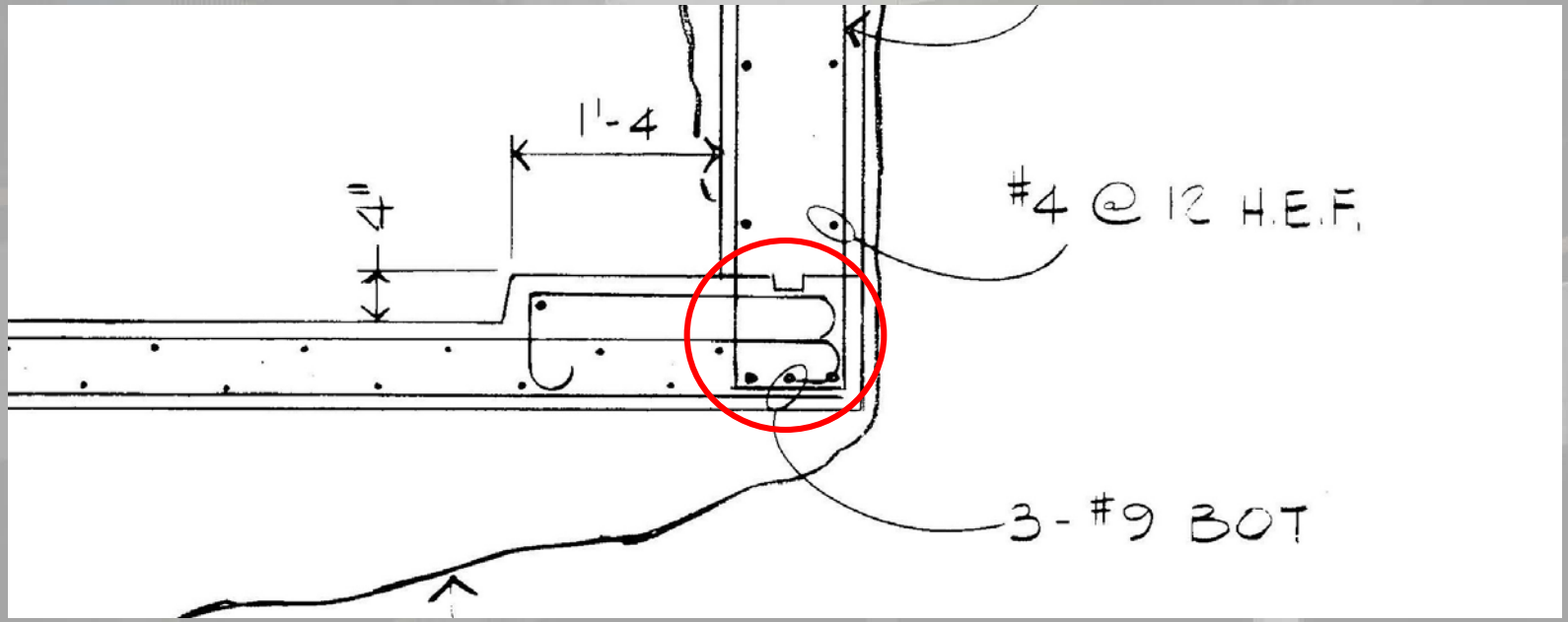
Design


1'-0
14'-0
1'-0
NOTE. REINFORCING BAR POSITIONS MAY NOT BE AS SHOWN.
PROVIDE PROTEC
TO PREVENT DE
FALLING FROM RA
2-#8 TOP
#4 TIES @ 12"c
3'-7
#3 @ 12"c TOP
7" ± SLAB
1" ± CL.
4"
1'-4
#4 @ 12 H.E.F.
#3 @ 12"c BOT.
#4 @ 14"c TOP
#4 @ 7"c BOT.
1" ± CL.
3-#9 BOT
SOLID FABRIC OR MESH W7
MAX. 1/4" MESH OPENINGS

Design



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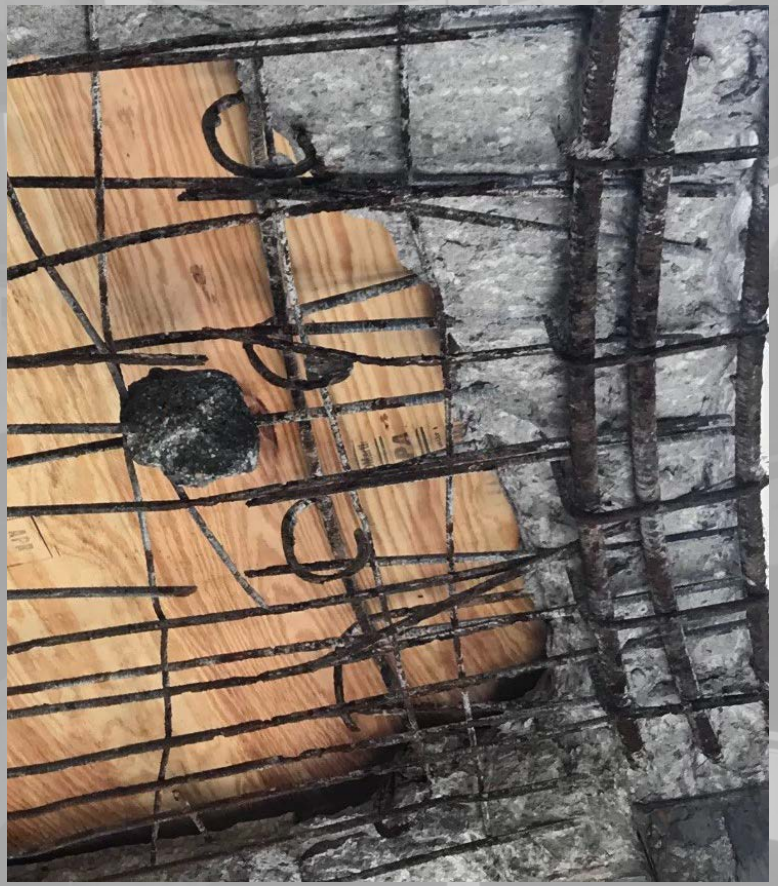
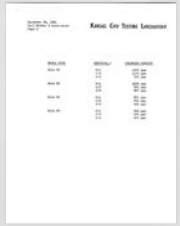


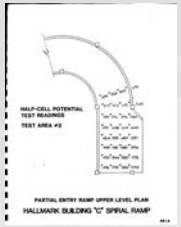
KANSAS CITY'S RESILENT SPIRAL RAMP

Past Studies and Repair

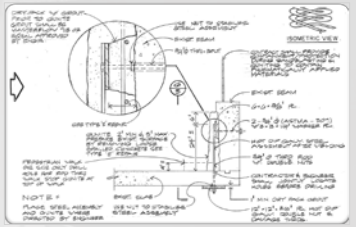
- Study performed in 1981 including chloride testing
  - results indicated high chloride content
  - approximately 20% delaminated deck surface
  - deck repairs performed for an extended 5 year service life



- Further study performed in 1986 including half cell potential
  - deck repaired with silica fume patches performed for an extended 5 year service life



- 1991 all ramp deck surfaces coated



- Further deck patches performed in 2004

- Deemed too expensive to maintain and closed in 2007

Past Studies and Repair

DRILL SITE	DEPTH(in.)	CHLORIDE CONTENT
Hole #1	0-1	1322 ppm
	1-2	1176 ppm
	2-3	523 ppm
Hole #2	0-1	1026 ppm
	1-2	952 ppm
	2-3	967 ppm
Hole #4	0-1	837 ppm
	1-2	554 ppm
	2-3	463 ppm
Hole #5	0-1	565 ppm
	1-2	424 ppm
	2-3	443 ppm

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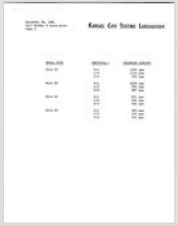

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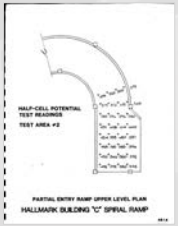

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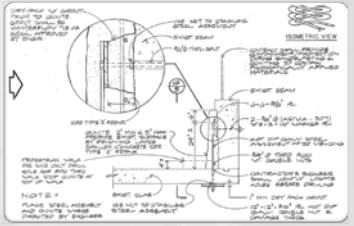
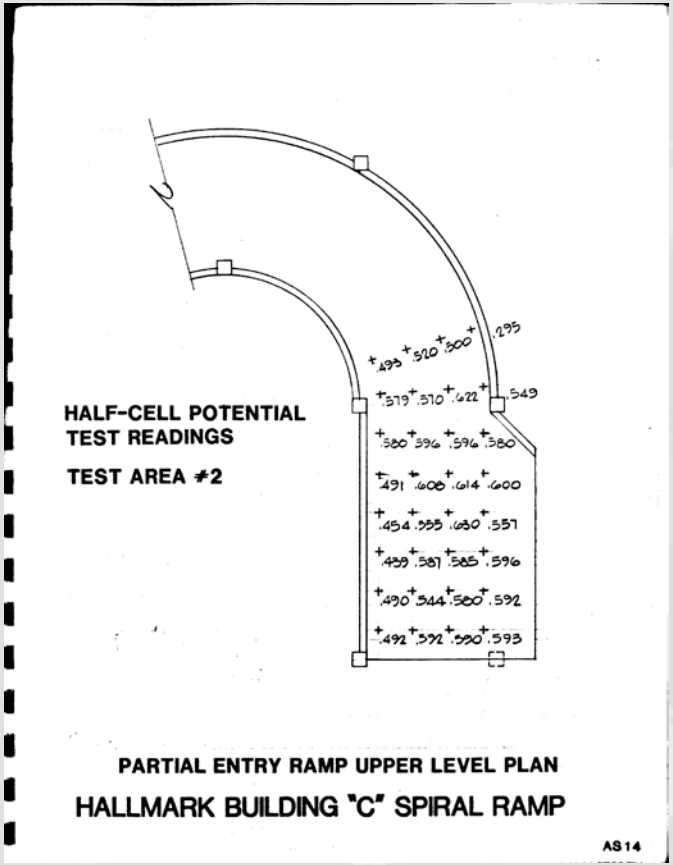


- Further deck patches performed in 2004
- Evaluated and closed in 2007

Past Studies and Repair



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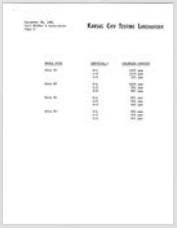

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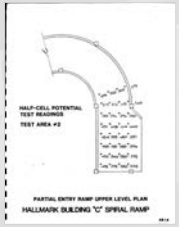

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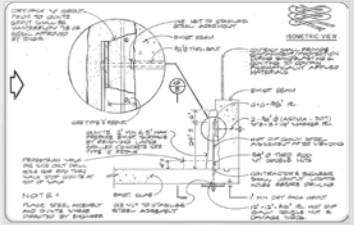

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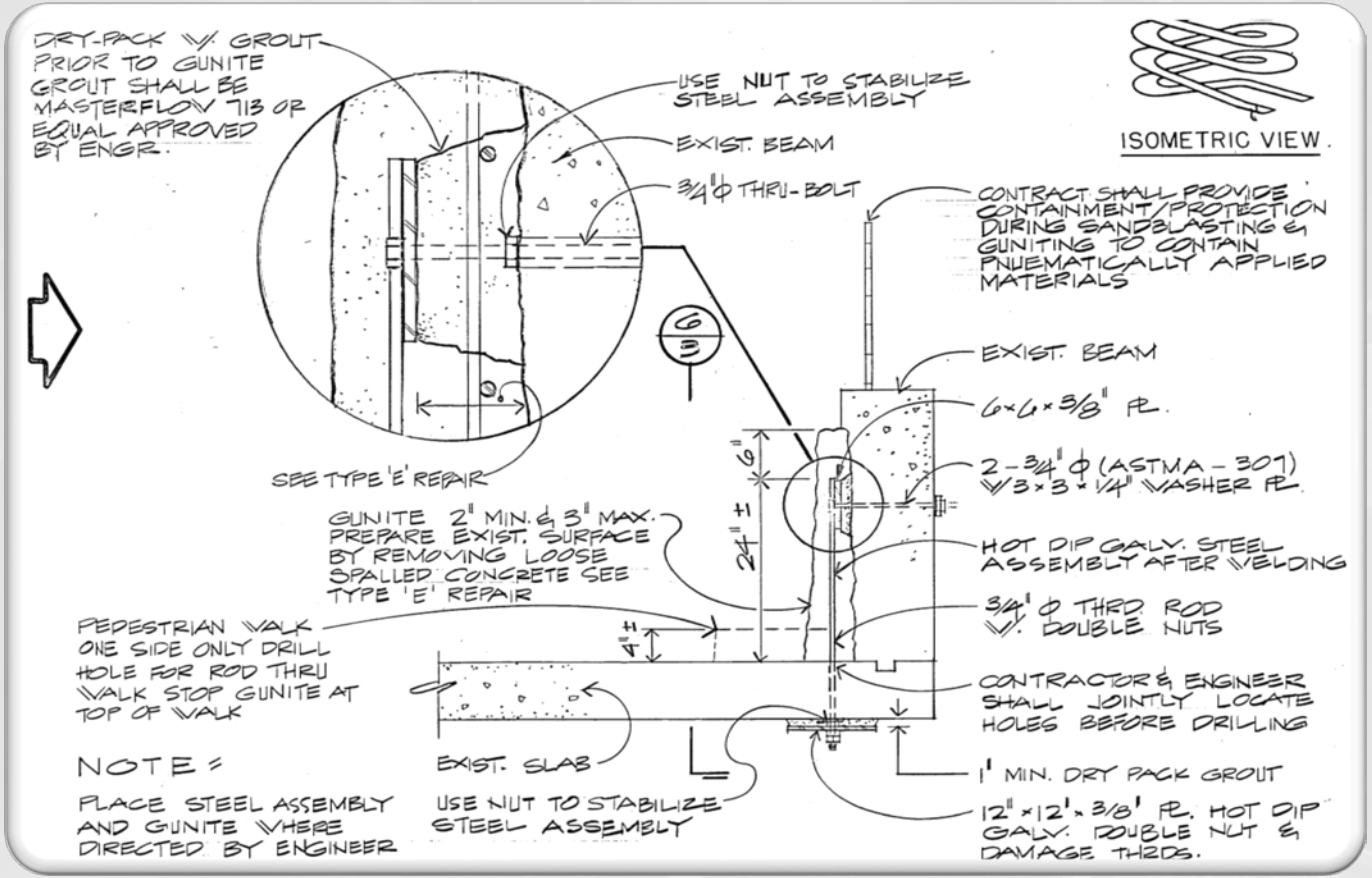

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Present Condition & Repair

- 2016 Study - REPAIR OR DEMOLISH?
- Approximately 35% of deck surfaces delaminated
- Conventional repair and cathodic protection evaluated for increased life span and minimized yearly maintenance costs
- Demolition costs budgeted to be twice that of repair and cathodic protection
- Decision made to proceed with repairs and cathodic protection

Present Condition & Repair

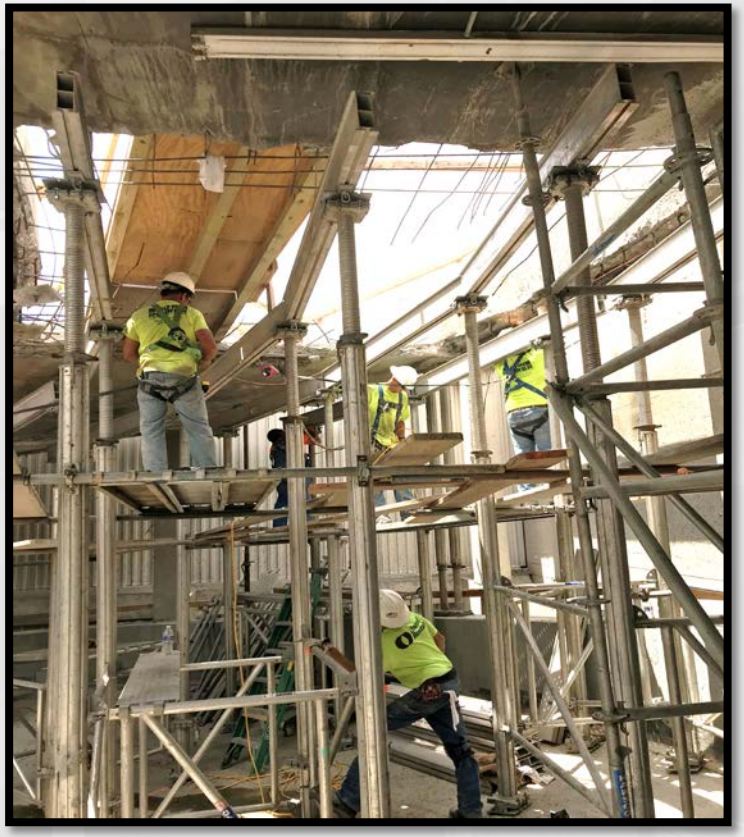
- Temporary handrail required for construction
- New steel handrail designed to meet code for reopening

Present Condition & Repair

- Repairs could only be performed on one ramp at a time

Present Condition & Repair

- Height and large full depth patches required extensive shoring and forming design



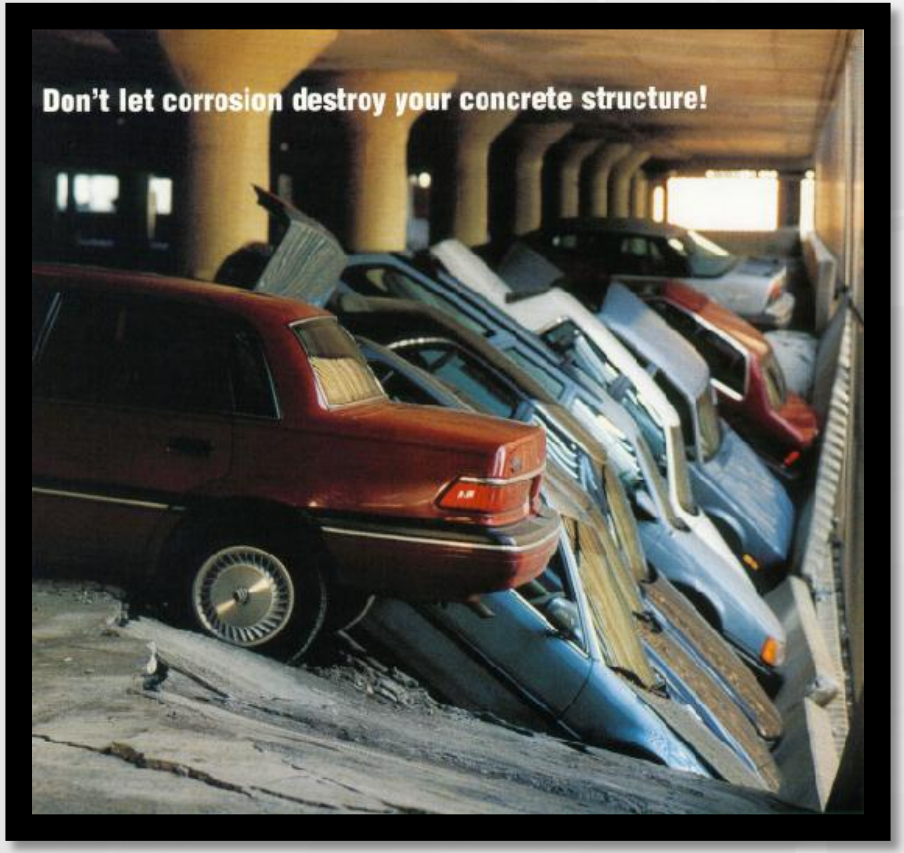
KANSAS CITY'S RESILENT SPIRAL RAMP

Corrosion of Steel in Concrete

- **INITIALLY, STEEL IN CONCRETE IS PROTECTED FROM CORROSION:**
  - **pH > 11 FORMS PROTECTIVE FILM ON SURFACE**
  - **CONCRETE COVER ACTS AS SEMI-BARRIER**
  - **STEEL IS SAID TO BE PASSIVATED**

- **BUT OVER TIME THE PROTECTION OF STEEL IS DESTOYED BY**
  - **MOISTURE**
  - **OXYGEN**
  - **CHLORIDES FROM DE-ICING SALTS**

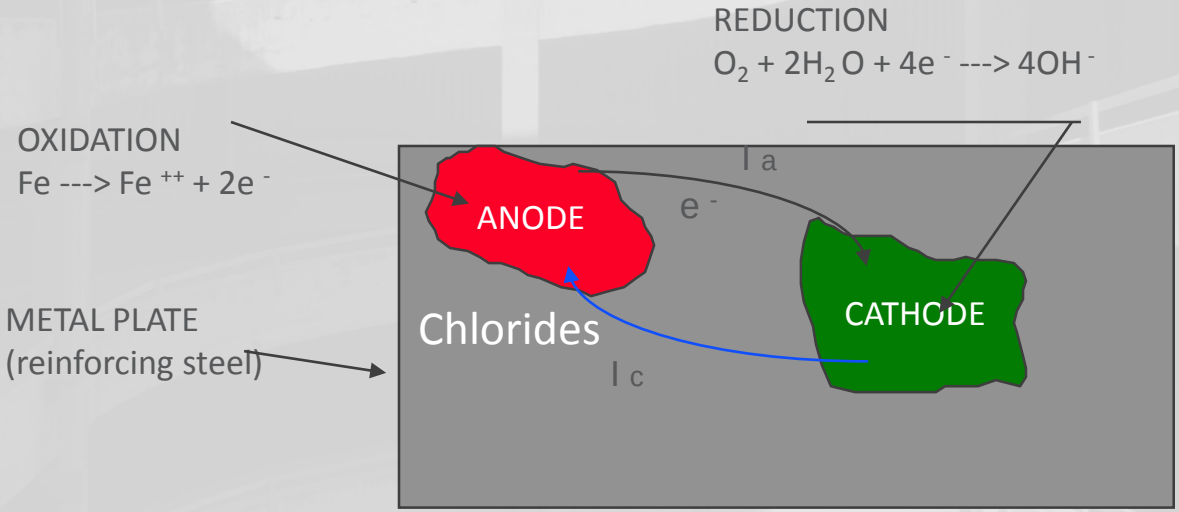
Corrosion of Steel in Concrete



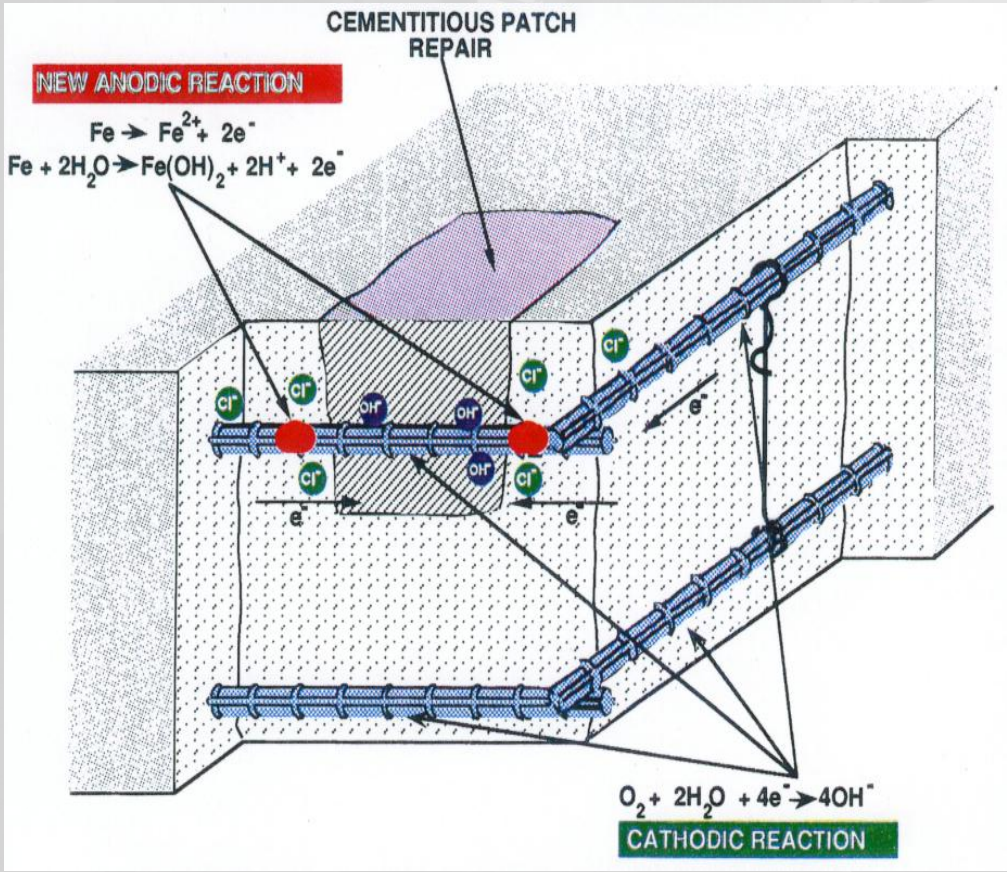
- **RESULTS OF CORROSION:**
  - **DELAMINATION OF CONCRETE**
  - **EASY PATH FOR NEW CHLORIDES**
  - **SECTION LOSS OF REBAR**
  - **STRUCTURAL WEAKENING**
  - **STRUCTURAL FAILURE**

Corrosion of Steel in Concrete

- **ANODE (corrosion occurs, chlorides)**
- **CATHODE (protected area)**
- **ELECTROLYTE (concrete)**
- **METALLIC PATH (rebar)**



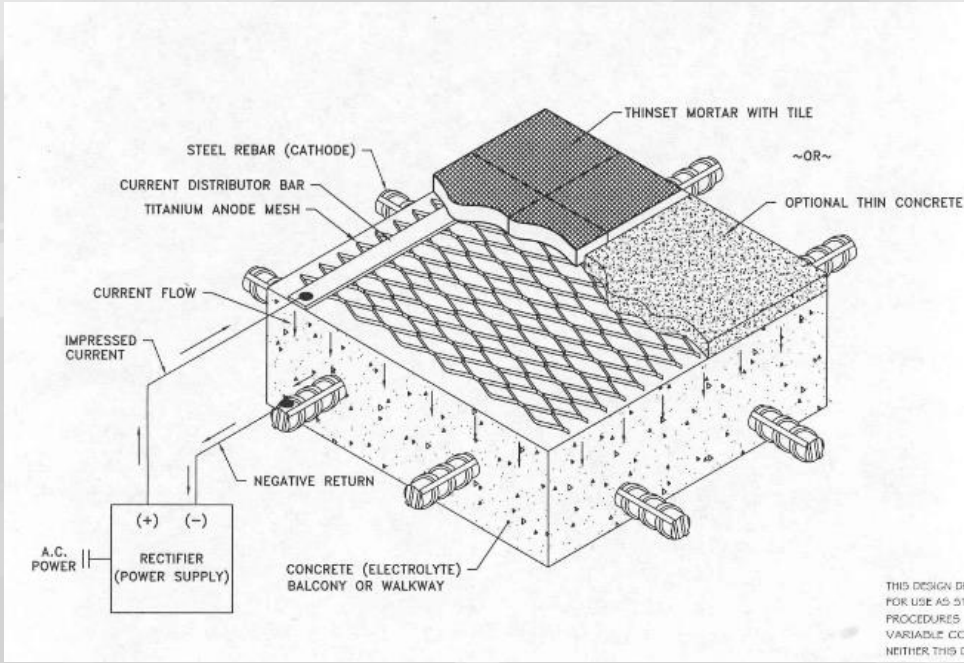
Problems with Traditional Repairs



Anodic Ring Effect

Cathodic Protection (CP)

- Corrosion control solution for chloride contaminated concrete
- A small DC current flows from an anode material, installed in the structure, to the rebar
- Rebar becomes the cathode and is protected
- Impressed current cathodic protection (ICCP) uses a power supply – rectifier
- Sacrificial cathodic protection uses galvanic anodes

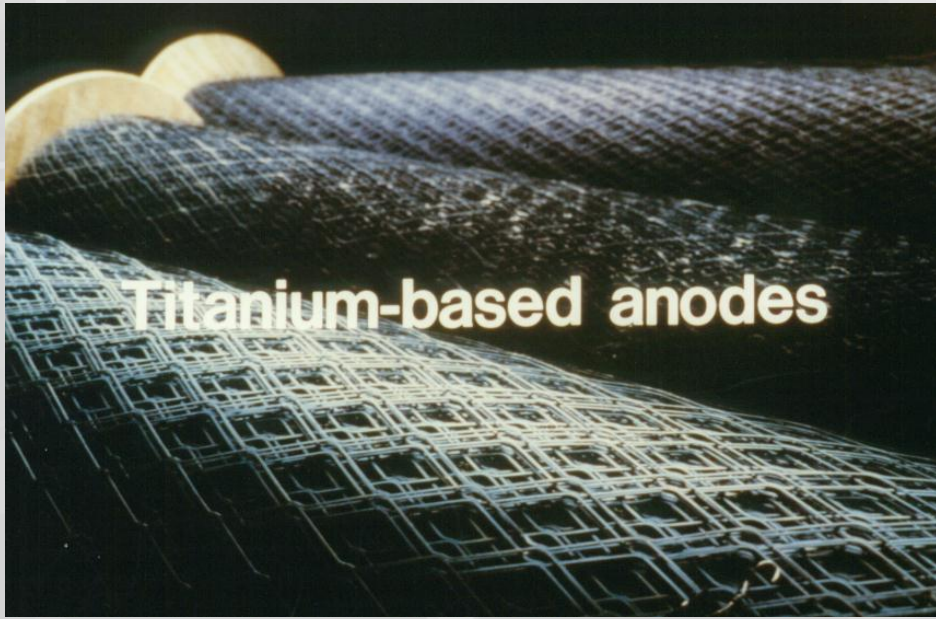


What's a Good Candidate for CP?

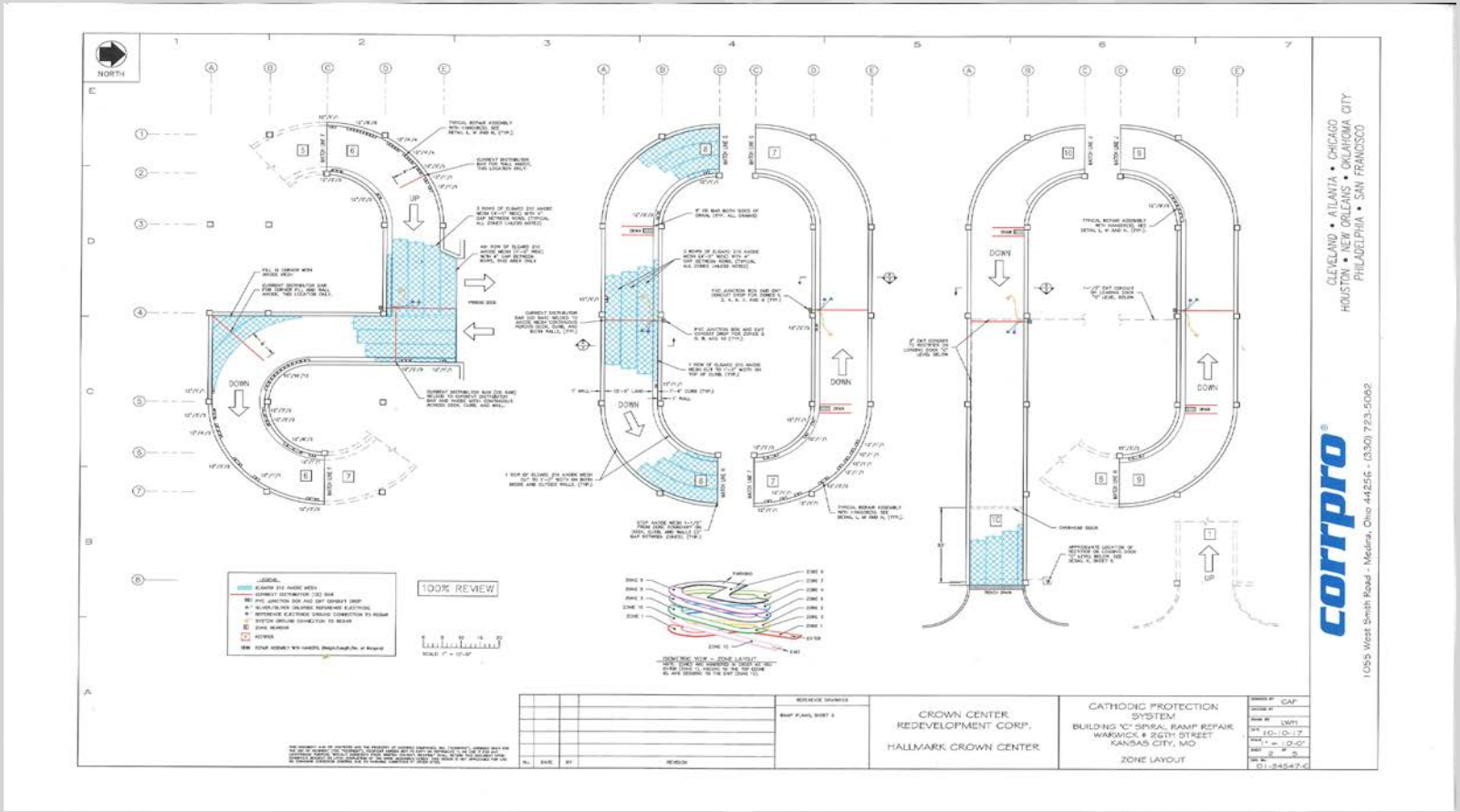
- ✓ Existing, salt contaminated concrete, or corrosive environment
- ✓ Bare reinforcing steel
- ✓ Structurally sound and resilient
- ✓ History of concrete repairs (but not too many)
- ✓ High volume structure or critical use structure
- ✓ Hollow slabs where the deck is integral
- ✓ Parking garages below a building (lateral bracing)
- ✓ Long-term owner
- ✓ Owner with history of using Cathodic Protection

Titanium Based Anodes (ICCP)

- Extensive track record (> 10,000 concrete structures protected worldwide)
- Minimum 40-year anode life expectancy
- Grade 1 titanium substrate
- Mixed-metal oxide (MMO) sintered coating
- Available in mesh and ribbon form
- Popular choice for horizontal decks (bridges, parking garages, etc.)



Design and Layout



Installation

- Ground wire connection to the rebar (cathode)

- Reference electrode installed in each zone.
  Used to monitor system performance

Installation

- Titanium MMO anode mesh placed on scarified and repaired concrete deck

- Spot weld current distributor strip across rows of anode mesh

Installation

- LMC concrete overlay placed over anode mesh.
- Conduit and wiring from spiral ramp are run to electrical room that houses the rectifier and remote monitor units for the complex.
- System energized and adjusted for optimum performance and corrosion protection