The Truth About Parking Structure Maintenance: How to Protect Your Investment

CPMA Annual Conference & Tradeshow
Harrah's Cherokee Casino
Wednesday October 6, 2021

C·P·M·A
Carolinas Parking & Mobility Association

The Pinnacle of Structural Engineering

Innovative EngineeringInc.

Learning Objectives

- **Types of Parking**
- **Parking Structures**
  - Structure Types
  - Cost Comparison
  - Lifecycle Costs
- **Common Deficiencies**
- **Importance of Routine Maintenance & Timely Restoration**

Learning Objectives

- **Parking Structures**
  - Structure Types
  - Cost Comparison
  - Lifecycle Costs
- **Conditions Facing Parking Structures**
- **Common Deficiencies**
- **Importance of Routine Maintenance & Timely Restoration**

Innovative Engineering, Inc.

- **Scott L. Weiland PE**

  - **BSCE University of Michigan**
  - **Graduate Studies:**
    - San Jose State University
    - Georgia Institute of Technology
  - **PE in 20 States + PR & Guam**
  - **Parking Consultants Council**
  - **39 Years in Design and Construction**
    - BOMA Georgia Insight magazine
      - Parking Structure Maintenance Part 1 & 2
      - Falling Building Façade Closes Atlanta Streets
    - National Parking Association Parking Magazine
      - Parking Structure Maintenance
    - Parking Today
      - Why is it Raining in my Parking Structure?

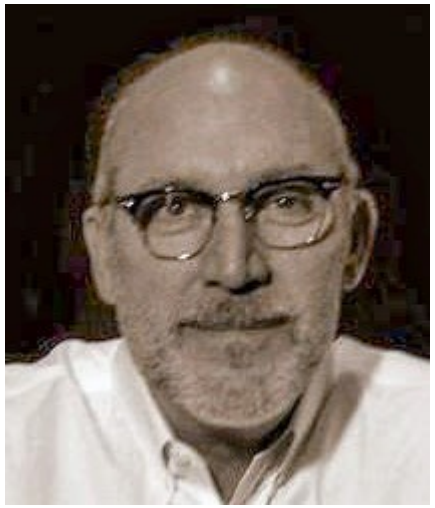
Innovative Engineering, Inc.

- **Trey Thomas PE**
  - **BSCET, Southern Polytechnic State University**
  - **16 Years in Design and Restoration Engineering**
    - Co-author of Parking Structure & Forensic articles
  - **Certified in Mold, Lead & Asbestos Surveying**
  - **OSHA Competent Person for Boom & Scissor Lifts**
  - **SPRAT Level 2 Rope Access Technician**
  - **FAA Part 107 Remote Pilot Certificate**
  - **FAA Part 107 Daylight Waiver**
  - **Level I Certified Thermographer**
  - **Expert estimator (within 5% of actual)**

PARC, LLC

Parking
Access +
Revenue
Consultants

- **Kirk Taylor, AIA, LEED AP**
- **Architecture Graduate, University of Texas, Austin**
- **Managed Texas Office for Walker Parking**
- **Started PARC in 2000**
- **Specialties:**
  - Efficient Parking Facility Design
  - Needs Analysis
  - Access and Revenue Control
  - Market Feasibility
  - Capital Assessment



Engineered Restorations, Inc.

- **Evan A. Moore PE, SE**
- **President ICRI Georgia**
- **Founded by Don Moore 1994**
- **Specialty Contractor**
- **Specialties**
  - Structural Repair
  - Restoration
  - Waterproofing
  - Preservation

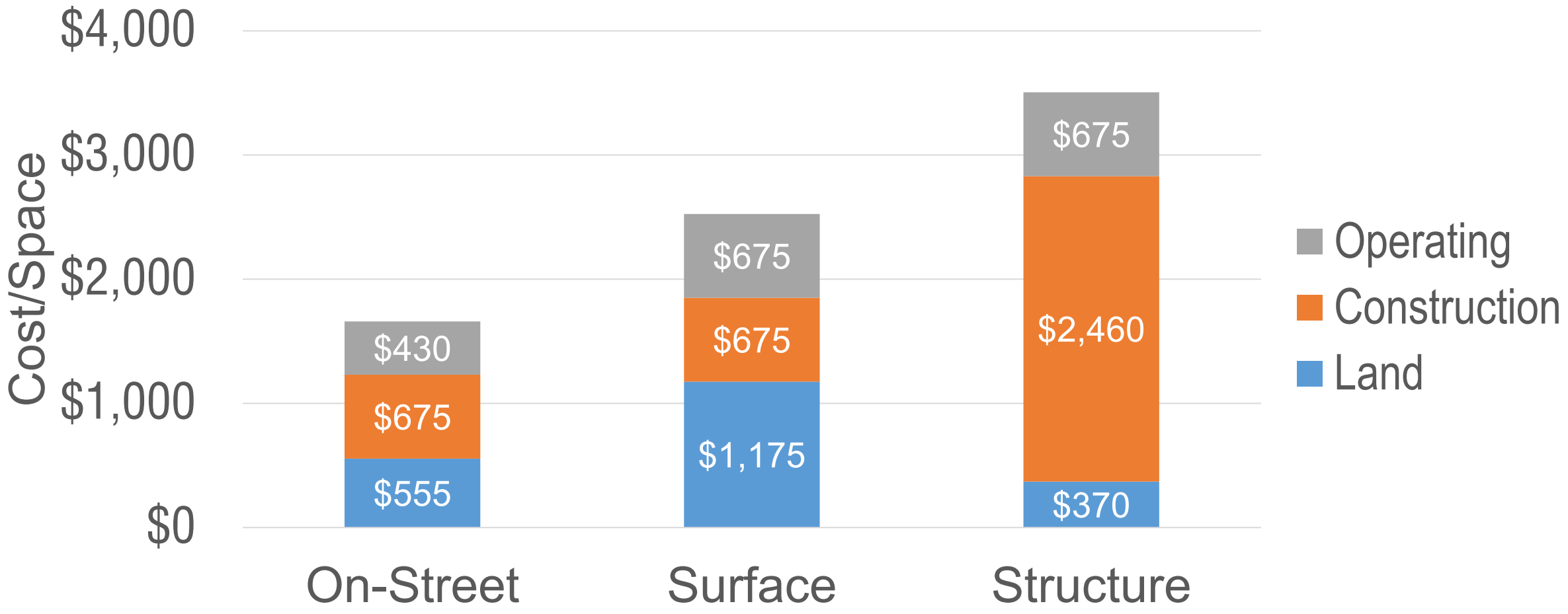
Types of Parking

On-Street

Surface

Structure

Typical Parking Annualized Costs per Space



Structural Systems

Cast-in-Place Concrete

Precast Concrete

Structural Steel

Other Systems (generally not recommended)

Mild Reinforced Concrete	Prone to Cracking
Composite Metal Deck on Steel	Deck Traps Moisture
Bar Joists w/Metal Deck on Steel	Prone to Cracking
Hollow Core Slabs on Steel/Conc.	Prone to Water Intrusion
Filigree Slab Soffits on Steel	Prone to Cracking
Keystone Joist & Beam Soffits	Florida, Steel Connections, Cracks

Cast-in-Place

- **Advantages**
  - Flexible Geometry
  - Monolithic, Fewer Joints
  - Reduced Maintenance Costs
  - Longer Life Expectancy
  - Higher Durability
- **Disadvantages**
  - Higher Initial Investment
  - Longer Schedule
  - More Labor Intensive
  - Difficult Quality Control
  - Weather Dependent

Precast Concrete - Advantages

- **Advantages**
  - Lower Initial Investment than CIP
  - Fabricated in Controlled Plant Environment
  - Not Weather Dependent
  - Accelerated Construction Schedule

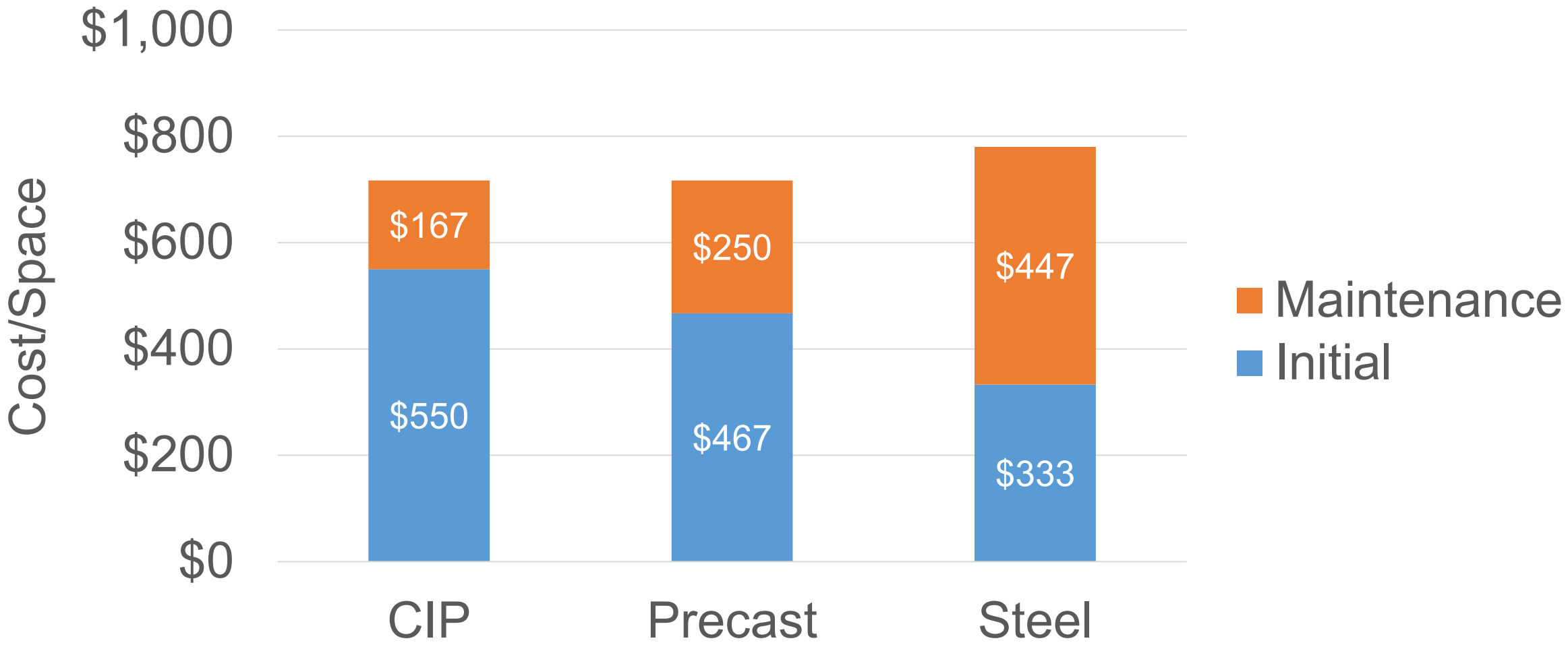
Precast Concrete - Disadvantages

- **Disadvantages**
  - May be no local plant
  - Geometry not Flexible
  - Lower Perceived Ceiling heights
  - Shearwalls (Closed In)
  - More Joints
  - Prone to Thermal Expansion & Contraction Damage
  - Corrosion of Steel Embedments
  - Higher Maintenance Costs

Structural Steel

- **Advantages**
  - Lower Initial Cost than Precast
  - Accelerated Construction Schedule
  - Fabricated in Controlled Environment
  - No Shearwalls (Open)
- **Disadvantages**
  - Corrosion Issues
  - Higher Maintenance Costs
  - Not Suitable for Fire Protection

Typical Annual Life Cycle Costs/Space



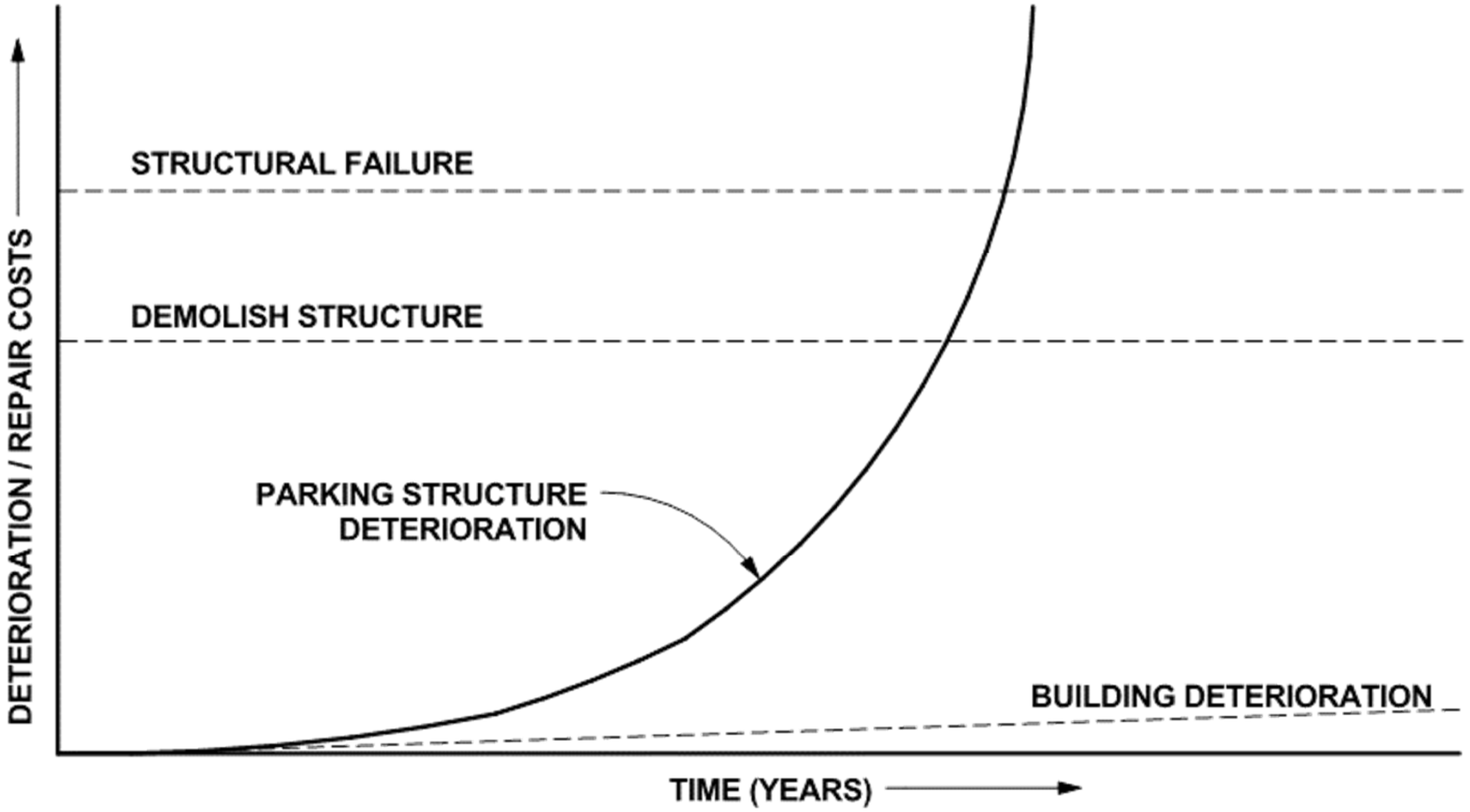
Parking Structures

- **Not Bullet Proof**
- **No Protective Skin**
- **Deterioration Starts Immediately**
- **Subjected To:**
  - Moisture (Rain, Snow, Ice, Deicing Salts)
  - CO_2 Carbonation
  - Extreme Thermal Expansion & Contraction
  - Dynamic Vehicle Loads

Parking Structures – Roman Structures

- Roman Colosseum
- Over 2000 Years Old
- Mild Climate
- No Reinforcing Steel
- Concrete Compression
- Slow Strength Development

Structure Degradation

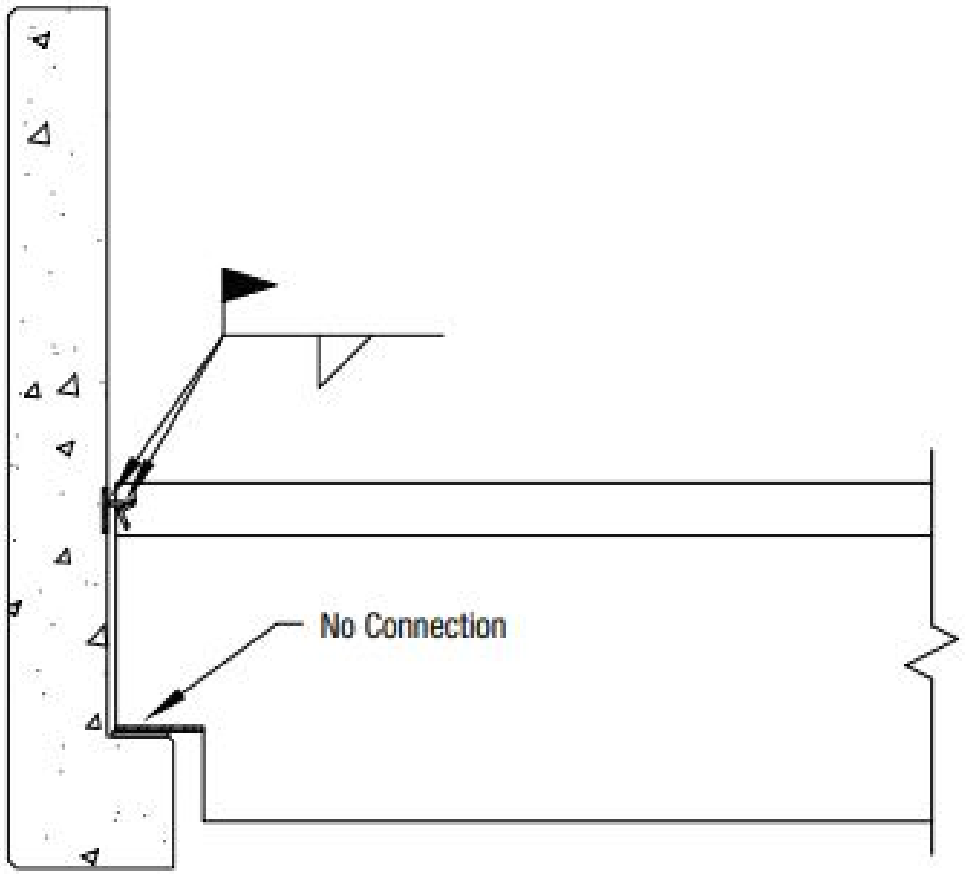


Irving Texas, O'Conner Ridge Blvd. Collapse

Irving Texas, O'Conner Ridge Blvd. Collapse

- **What we know**
  - Old Parking Structure
  - Expansive Soils in TX
  - Exterior Columns Leaning
  - Cracks Sealed with Sealant
  - No OSHA Report
  - Demolished

Irving Texas, O'Conner Ridge Blvd. Collapse



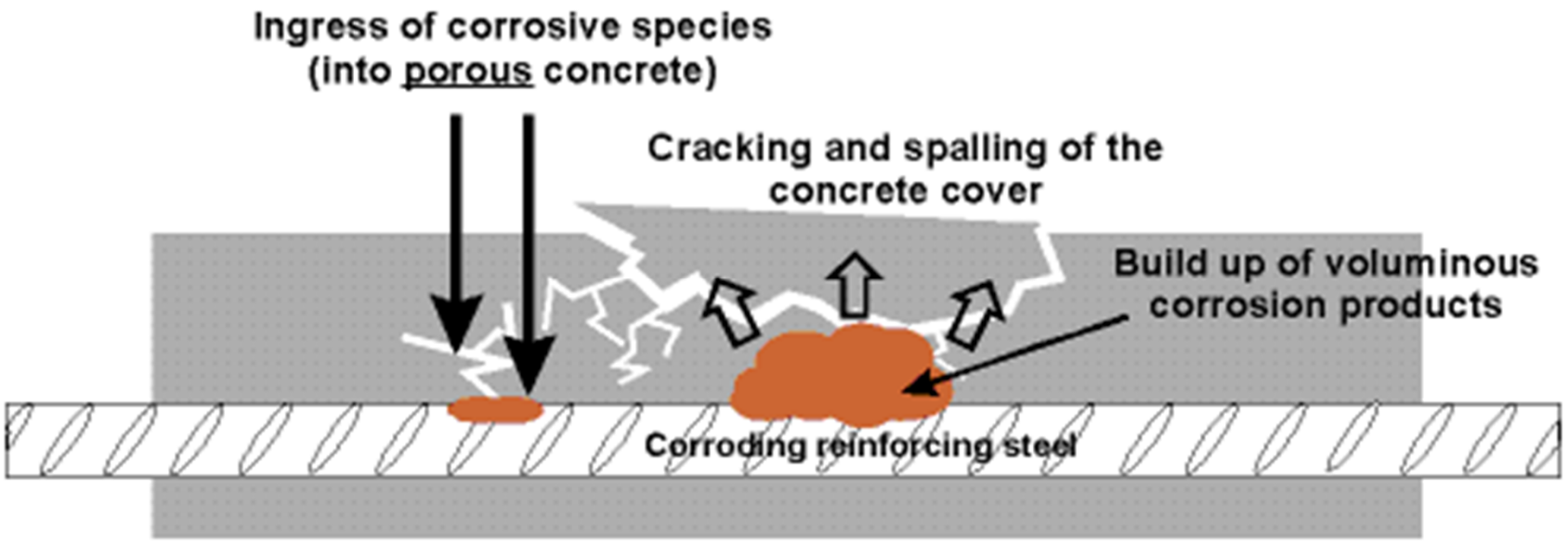
- **Typical Precast Double Tee Joist Seat**

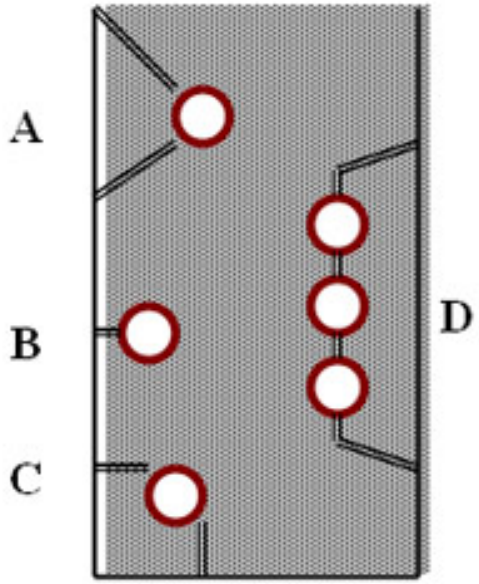
Common Deficiencies

- **Number 1 Enemy**

WATER

Common Deficiency: Corrosion





A: Spall
B: Crack
C: Corner Spall
D:Delamination

Common Deficiency: Spall & Delamination

Rust Expansion & Spalling

Topping Delamination

Common Deficiency: Spall & Delamination

Spall

Delamination

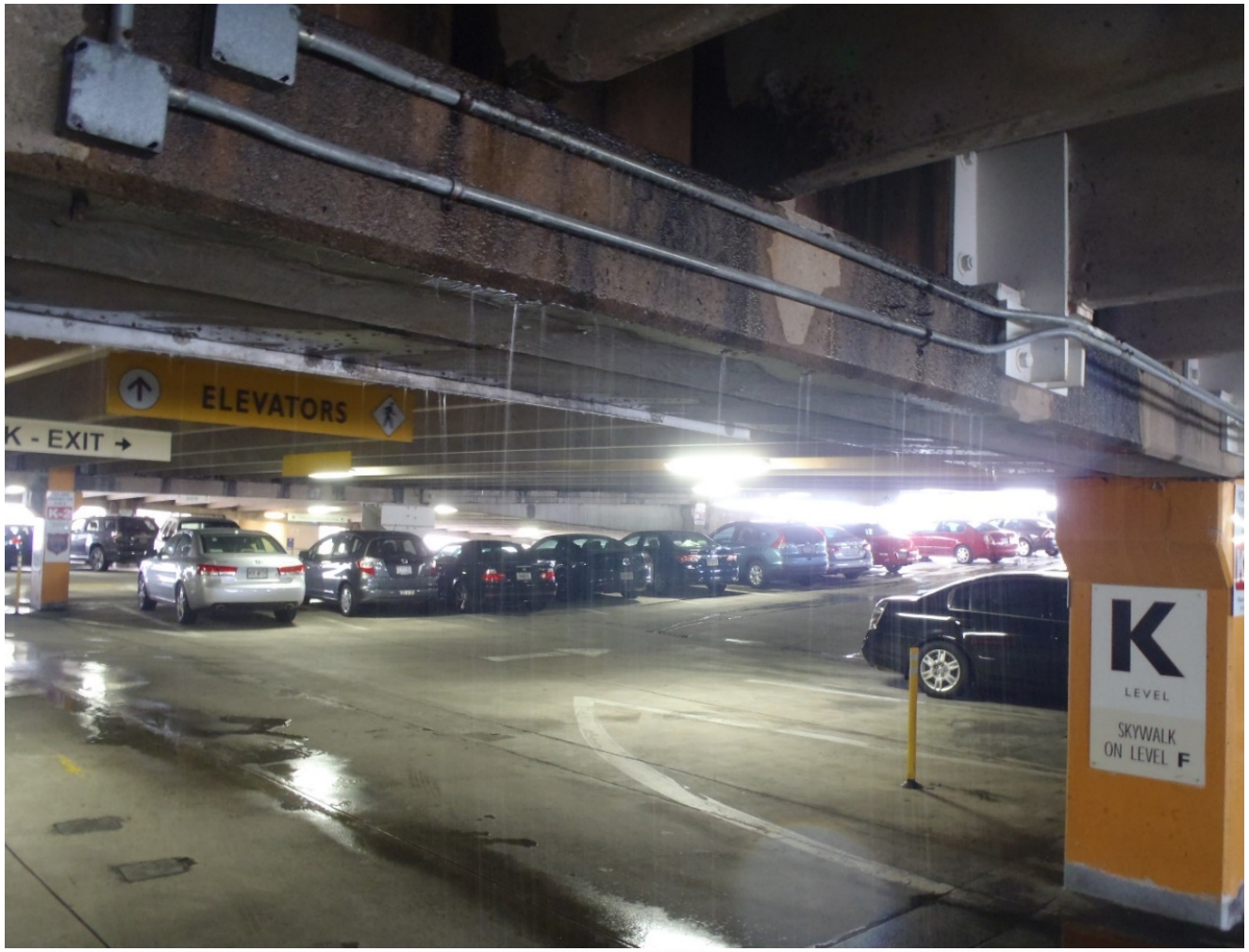
Section Loss

Common Deficiency: Ponding

Ponding

Supplemental Drain

Common Deficiency: Failed Joints



- **Why is it Raining in my Parking Structure?**

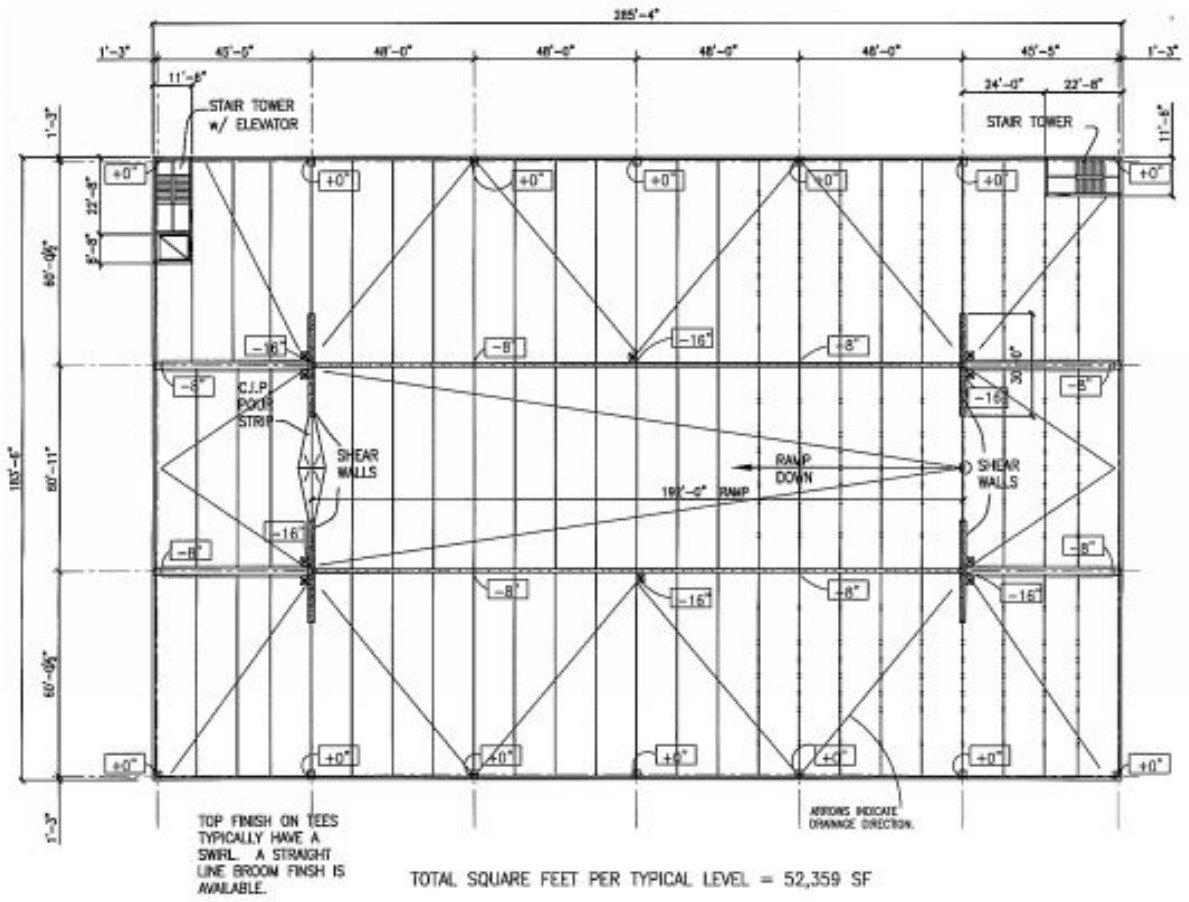
Common Deficiency: This is Why

Sealant Failure

Cracks

Expansion Joint Failure

Common Deficiency: Failed Joint Sealant



Drainage & Joint Plan

- **Precast**
  - All orthogonal lines are sealant Joints
  - Diagonal lines are slope lines
- **Cast-In-Place Slab**
  - Expansion joint in middle
  - Joint sealant at perimeter and at stair towers

Common Deficiency: Failed Joints

Cohesive Failure/Aged & Weathered

Adhesive Failure

Common Deficiency: Failed Joints

Substrate Failure

Heel Damage

Photo by Construction Specifier

Common Deficiency: Failed Joints

Uncured Sealant
Photo by BASF

Bubbles
Photo by BASF

Common Deficiency: Re-Seal Joint Cleaning

Grinding Joint

Photo by US Saw

Wire Brush

Photo by Little Wonder

Common Deficiency: Re-Seal Joint Prep. & Seal

Priming Joint

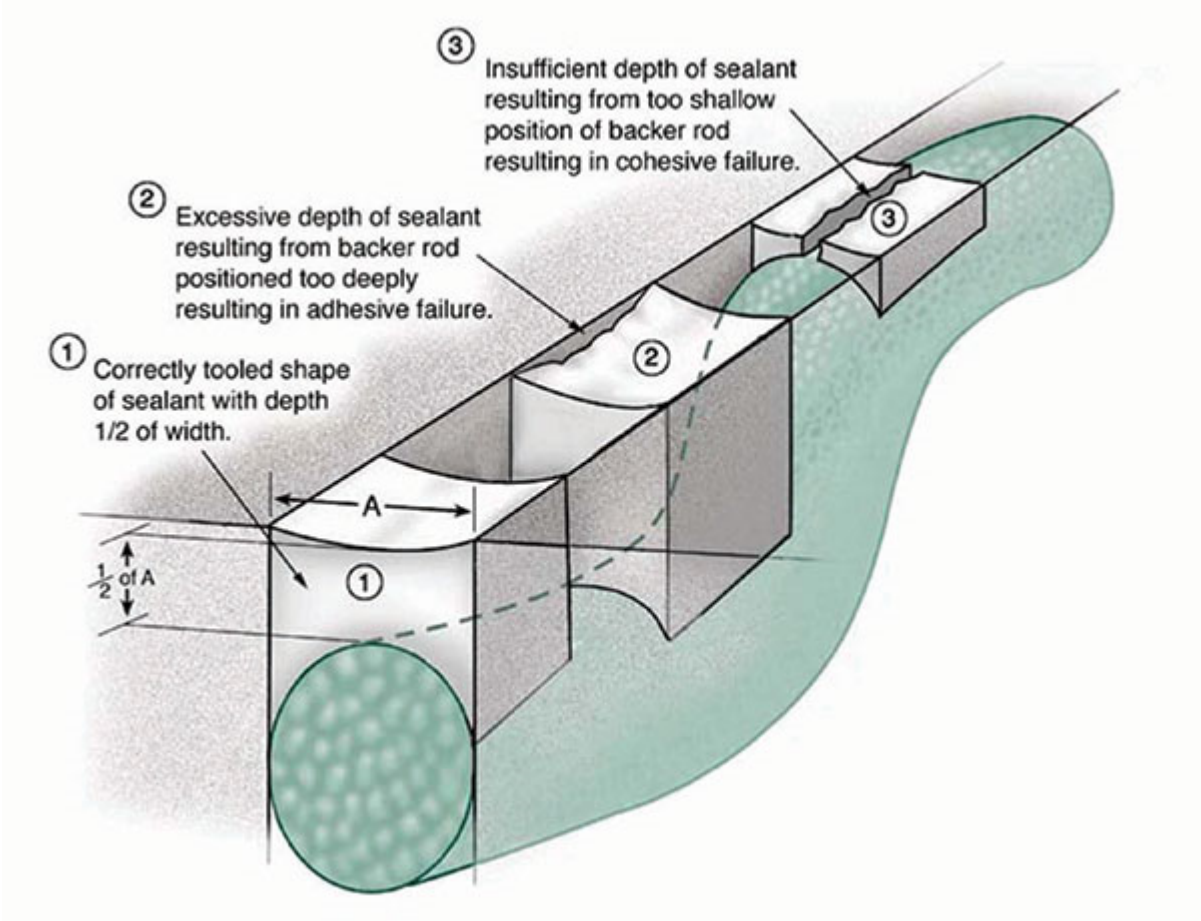
Photo by SIKA

Backer Rod

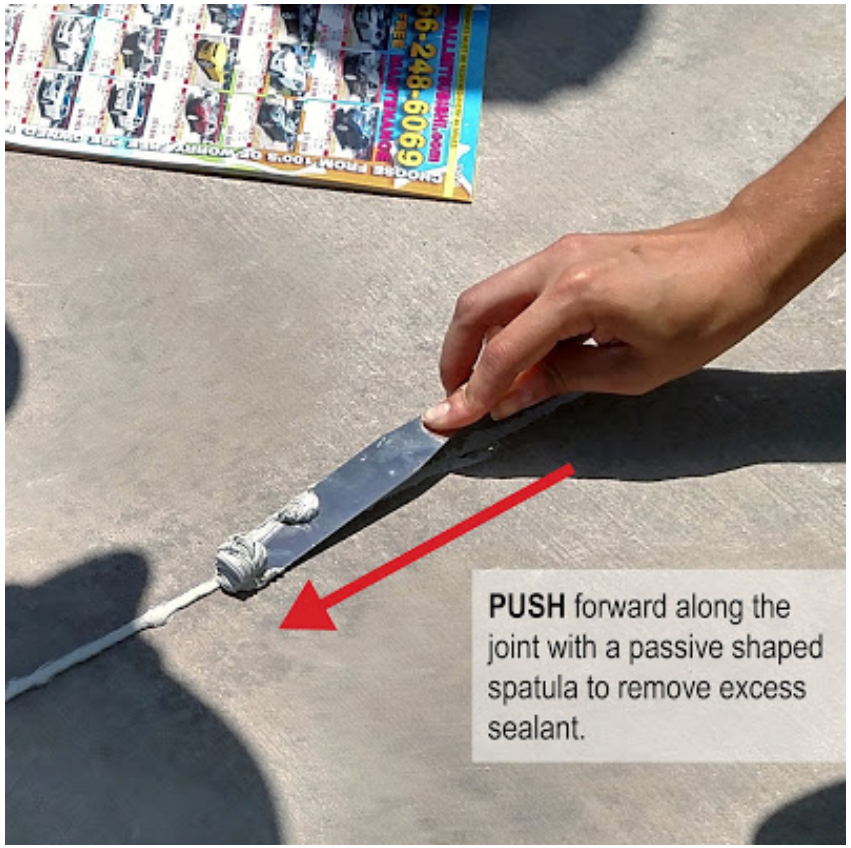
Photo by SIKA

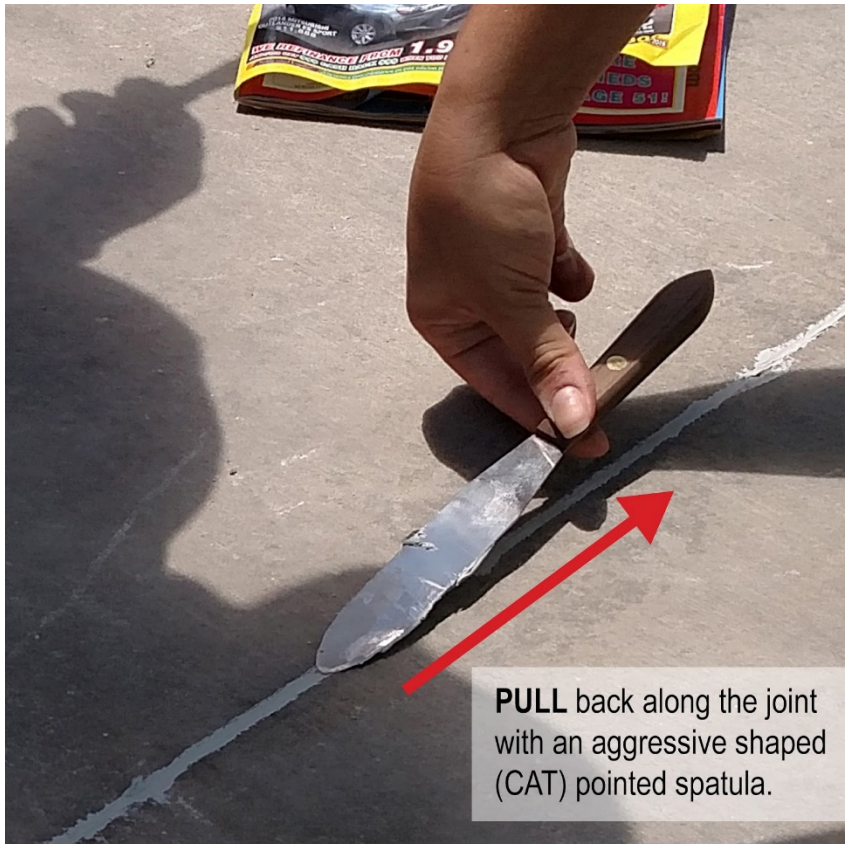
Common Deficiency: Re-Seal Joint Sealant

New Sealant



Common Deficiency: Re-Seal Tooling





Tooling

Photos by Albion Manufacturing

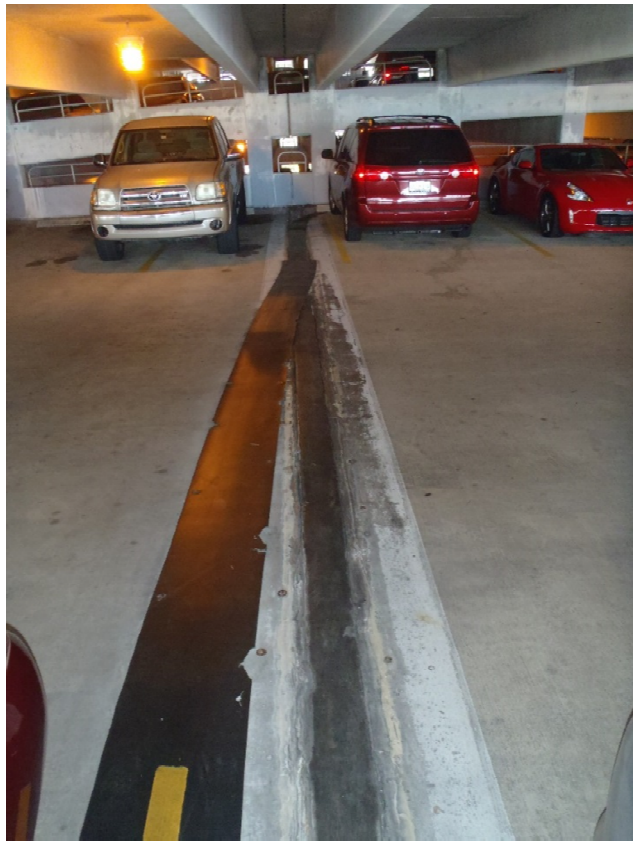
Common Deficiency: Re-Seal Quality Control

Probing NDT

Pull Test

Photo by Construction Specifier

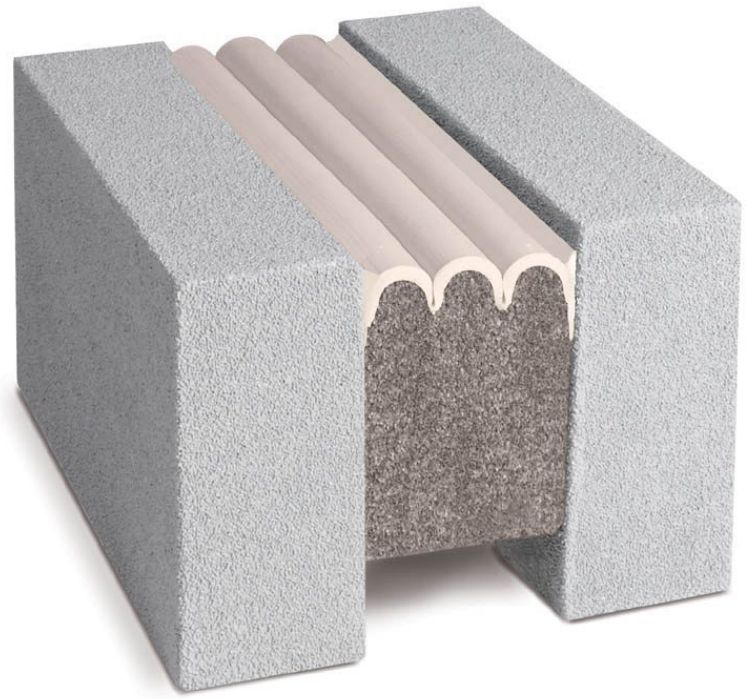
Common Deficiency: Expansion Joints



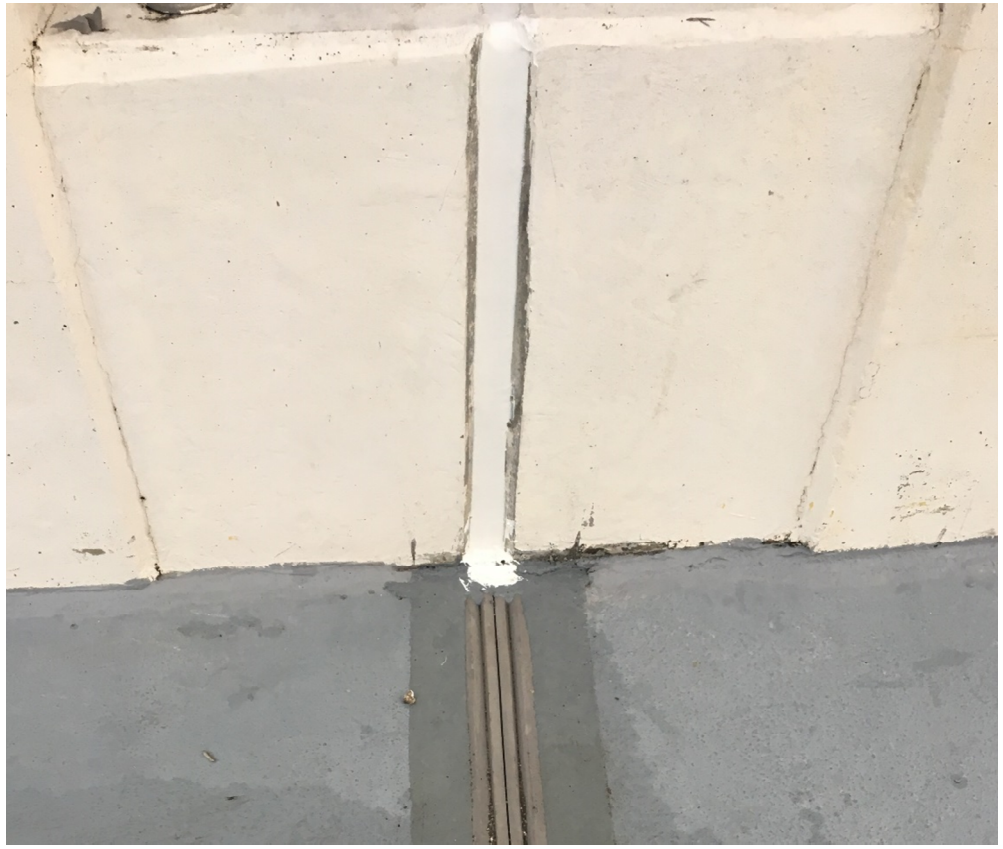
Horizontal Joint

Vertical Joint

Common Deficiency: Expansion Joint Repair

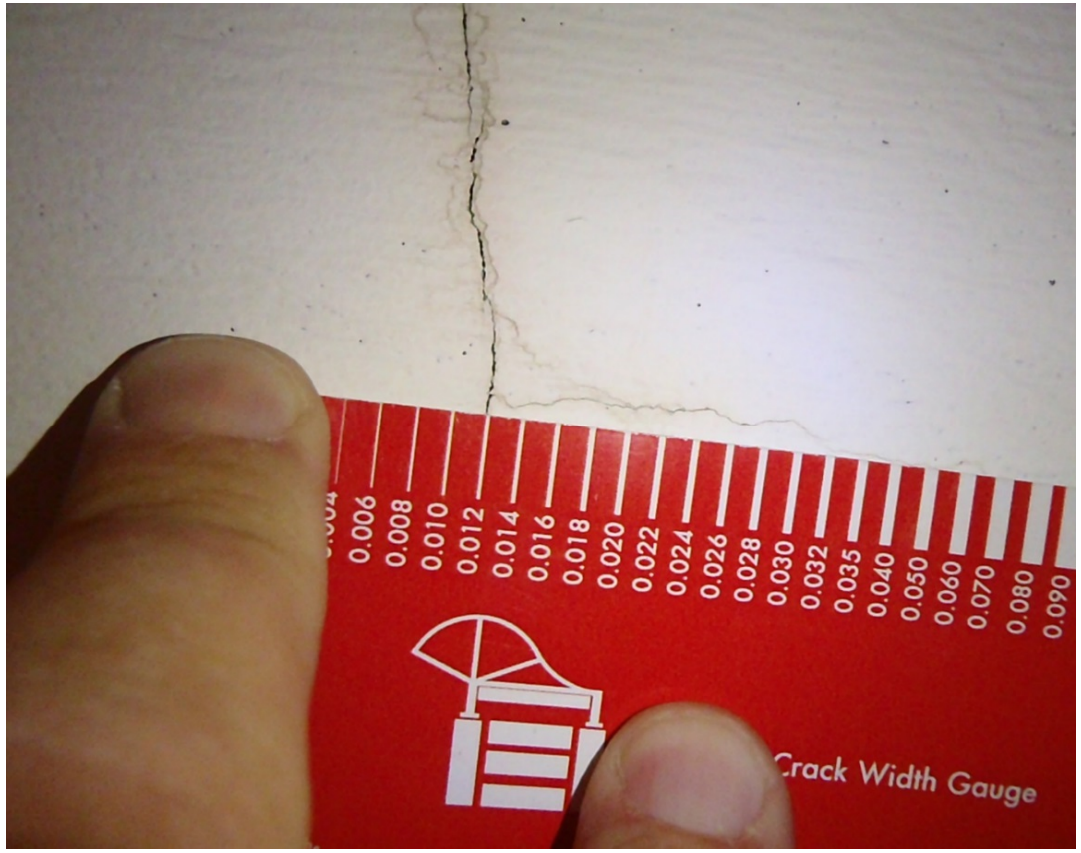


Horizontal Joint - EMSEAL



Vertical Joint

Common Deficiency: Cracks to be Sealed



.013” ≤ Cracks < .035”

Cracks that Leak < .035”

Common Deficiency: Route & Seal

Crack Chasing

Crack Sealant

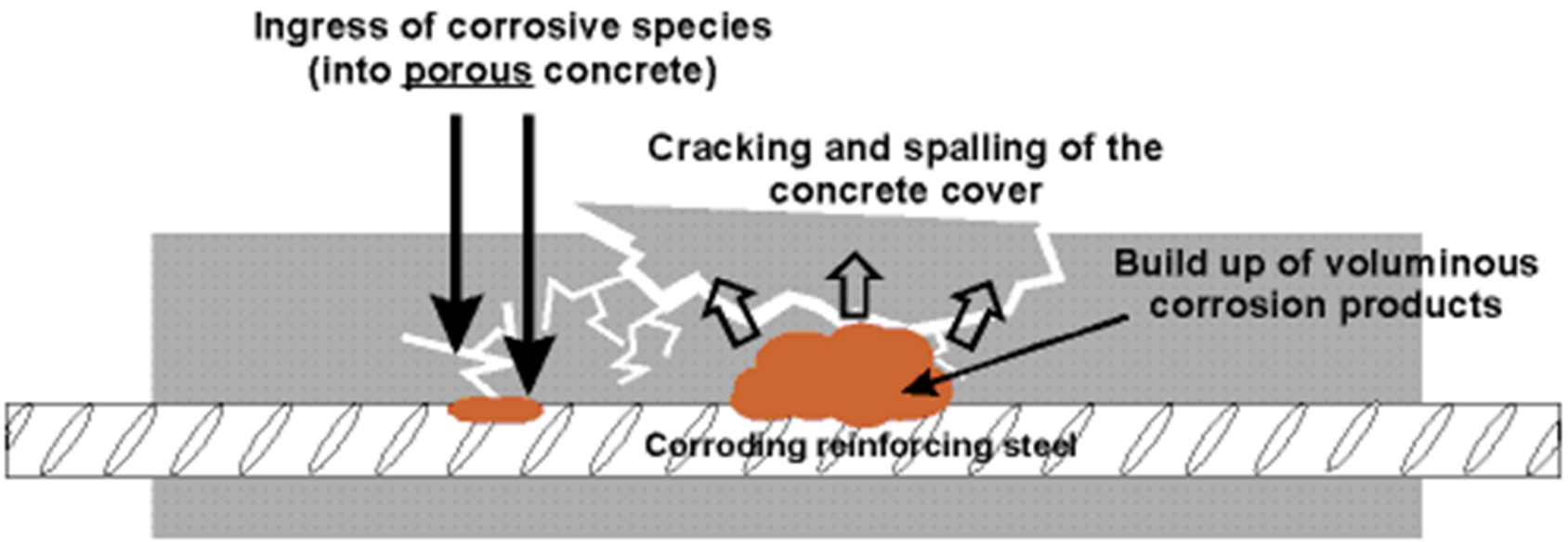
Common Deficiency: Epoxy Injection

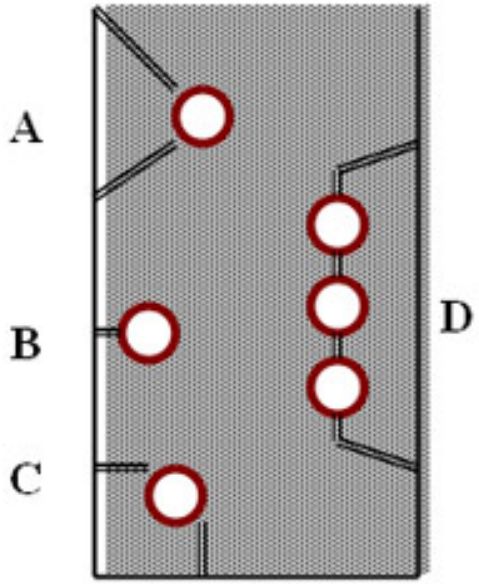
Cracks ≥ .035”

Photos by Engineered Restorations Inc.

Inflatable Injection Port

Common Deficiency: Corrosion





A: Spall
B: Crack
C: Corner Spall
D:Delamination

Common Deficiency: Concrete Spalls

Spall

Delamination

Section Loss

Common Deficiency: Exterior Spalls

Spall Over Sidewalk

Spall Size

Common Deficiency: Sounding

Common Deficiency: Scaling

- Loss of surface mortar
- Freeze-Thaw Damage
- Inadequate air entrainment
- Ponding water

Chloride Ion Testing

Dust at Various Depths

Chloride Ion Concentration

Carbonation Testing

Coring Slab

Depth of Carbonation

Common Deficiency: Last Resort

Traffic Bearing Membrane

Common Deficiency: Better Option

- **Silane Sealer**
  - Water Retardant
  - Breathable
  - Fills Pores of Dense Concrete
  - Minimizes penetration of water and chemicals
  - Reapply 5 to 10 years

Common Deficiency: Crazing

- Shrinkage of the surface layer of paste
- Fine random cracking
- Does not affect structural Integrity
- Rarely affects durability
- Unsightly

Common Deficiency: Failed Spall Repair

Improper Surface Preparation

Common Deficiency: Low Concrete Cover

Exposed Post Tensioning (PT)

PT Strand Splice

Common Deficiency: Low Cover & Repair

Exposed Reinforcing Steel

Patch to Increase Cover

Precast Connection Failures – Spandrel Beam

Shear Crack

Seat Repair

Precast Haunch Connection Failure

Precast Beam Haunch

4 Months Later

Precast Haunch Connection Repair

Shoring to Remove Load

Applying Epoxy Bonding Agent

Precast Haunch Connection Finished Repair

Good as New

Common Deficiency: Overloaded – Fire Truck

Broken Precast Spandrel Beam

Common Deficiency: Guardrail

Failed Guardrail

Broken End Connection

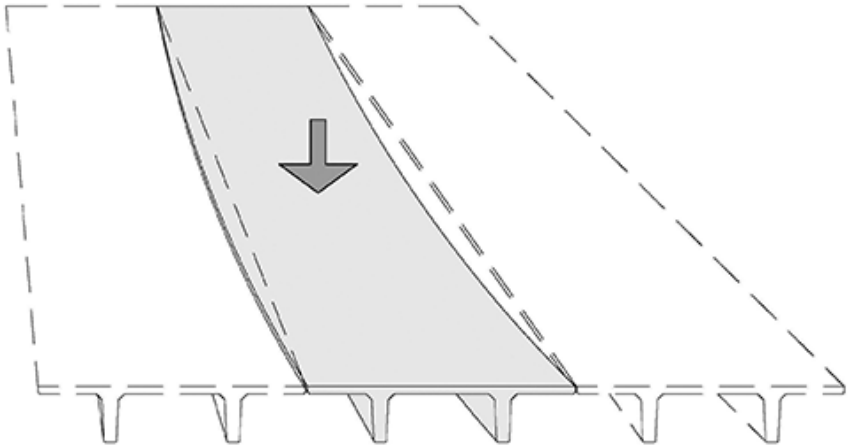
Common Deficiency: Curbs & Wheel Stops

Broken Curb

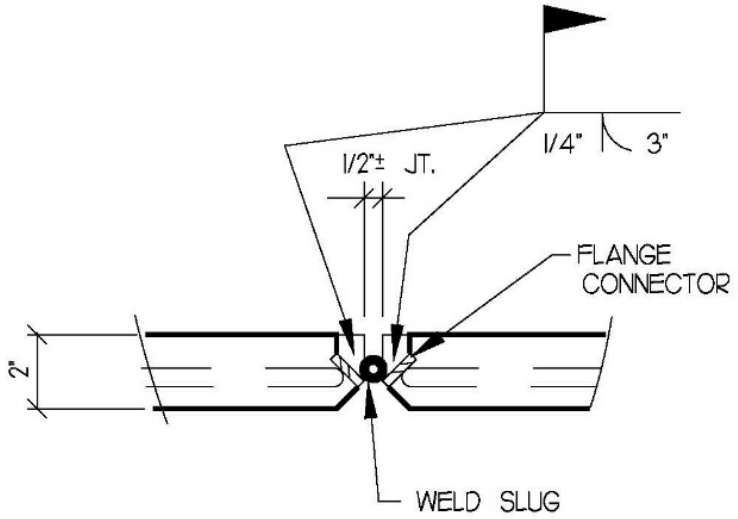
Broken Wheel Stop

Precast Shear Transfer Repair

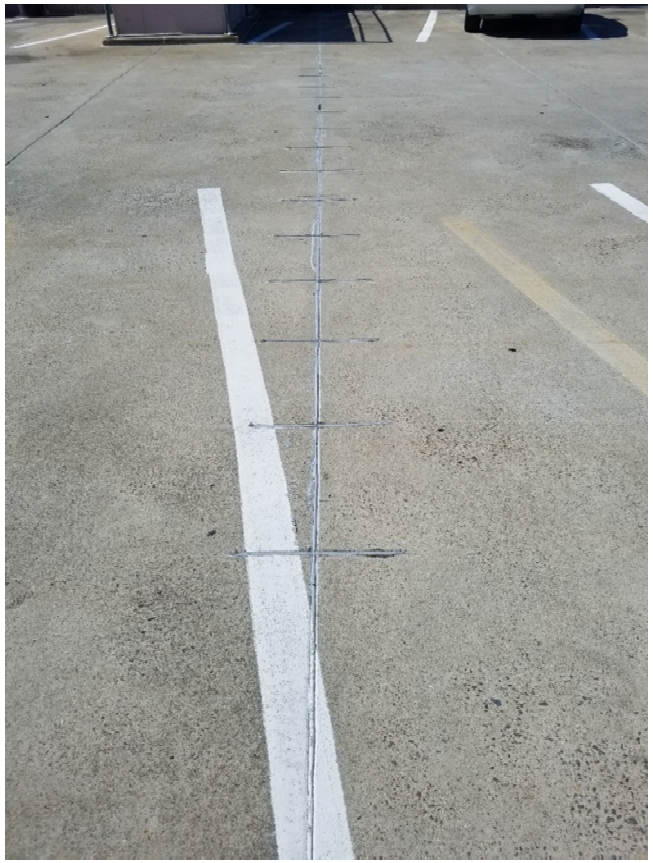
Precast Shear Transfer Repair



Precast Double Tees

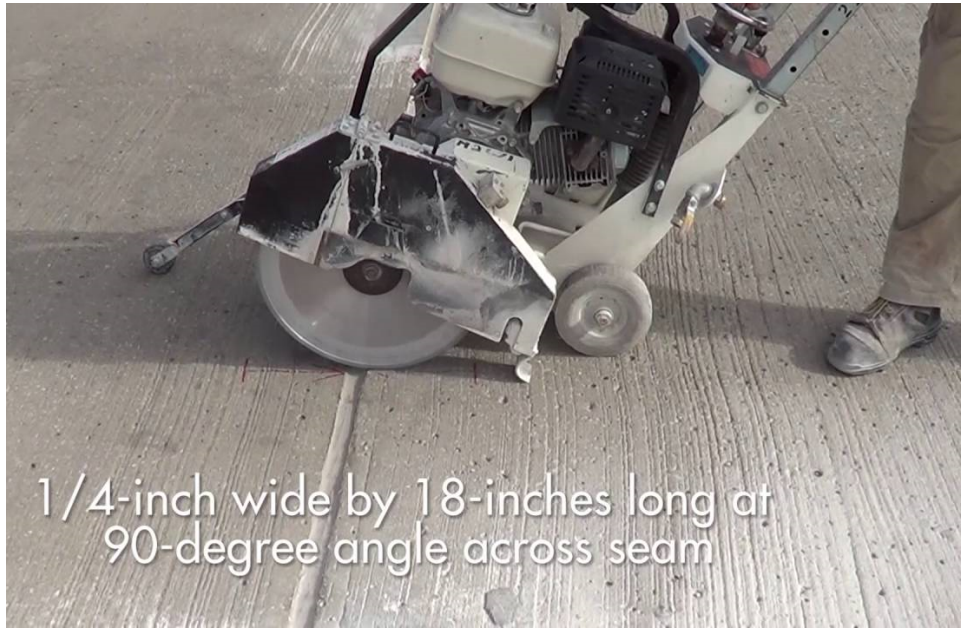


Shear Transfer



Repair

Precast Shear Transfer Repair



Saw Cut Slab

Prepared Joint
& Biscuit

Repair

Images by V2 Composites

Precast Connection Failures – Double Tee Joists

Precast Double Tee Seat

9 Months Later

Precast Connection Failures - Repairs

Steel Seat Repair

CFRP Repair

Image by Structure magazine

Structural Steel Corrosion

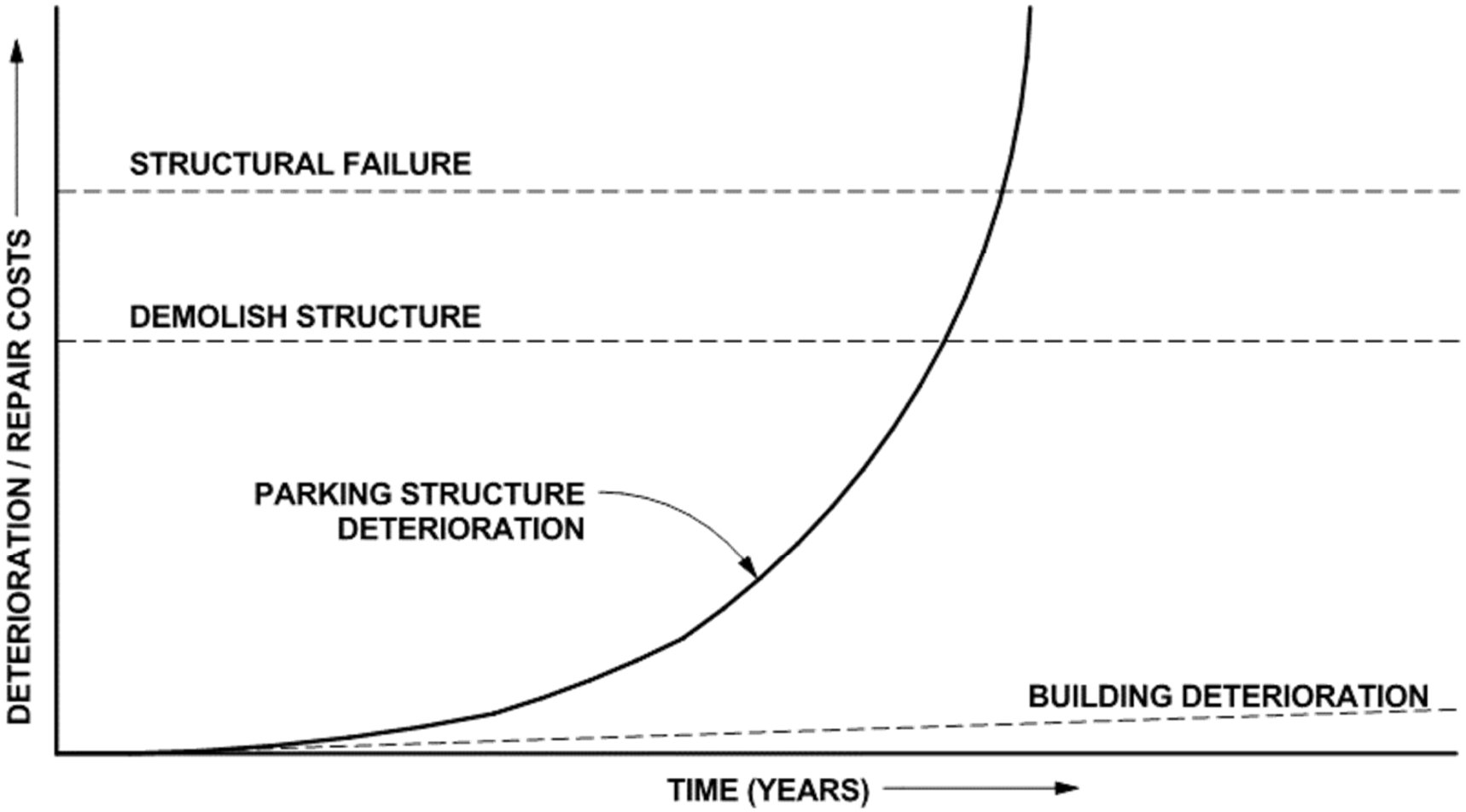
- Steel Protection & Corrosion Issues
- Steel Deck Traps Moisture, Hides Degradation.

Cast-In-Place Concrete: Epoxy Injection

Cast-In-Place Concrete: Carbon Fiber Wrap

Cast-In-Place Concrete: Carbon Fiber Wrap

Maintenance Cost Curve



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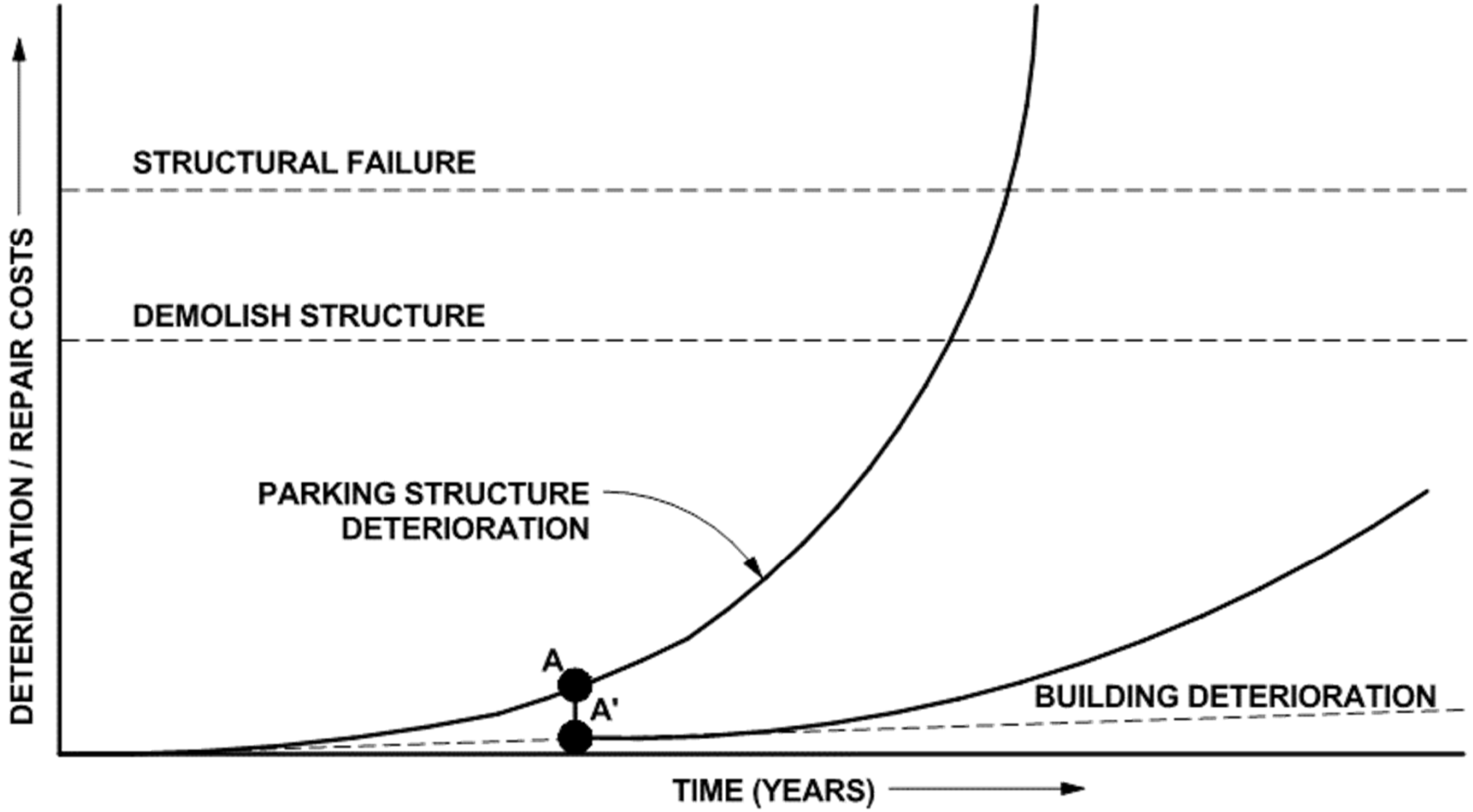

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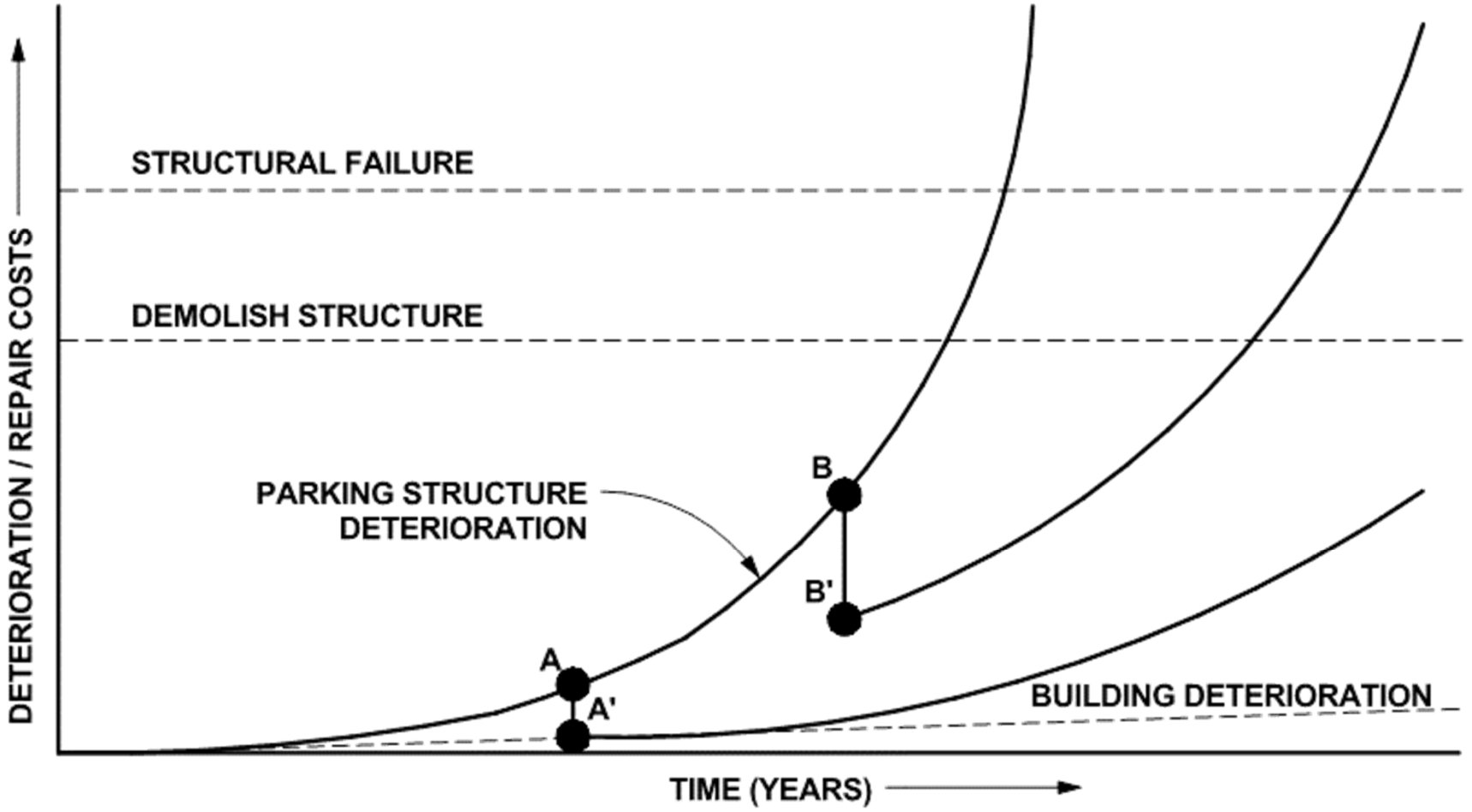

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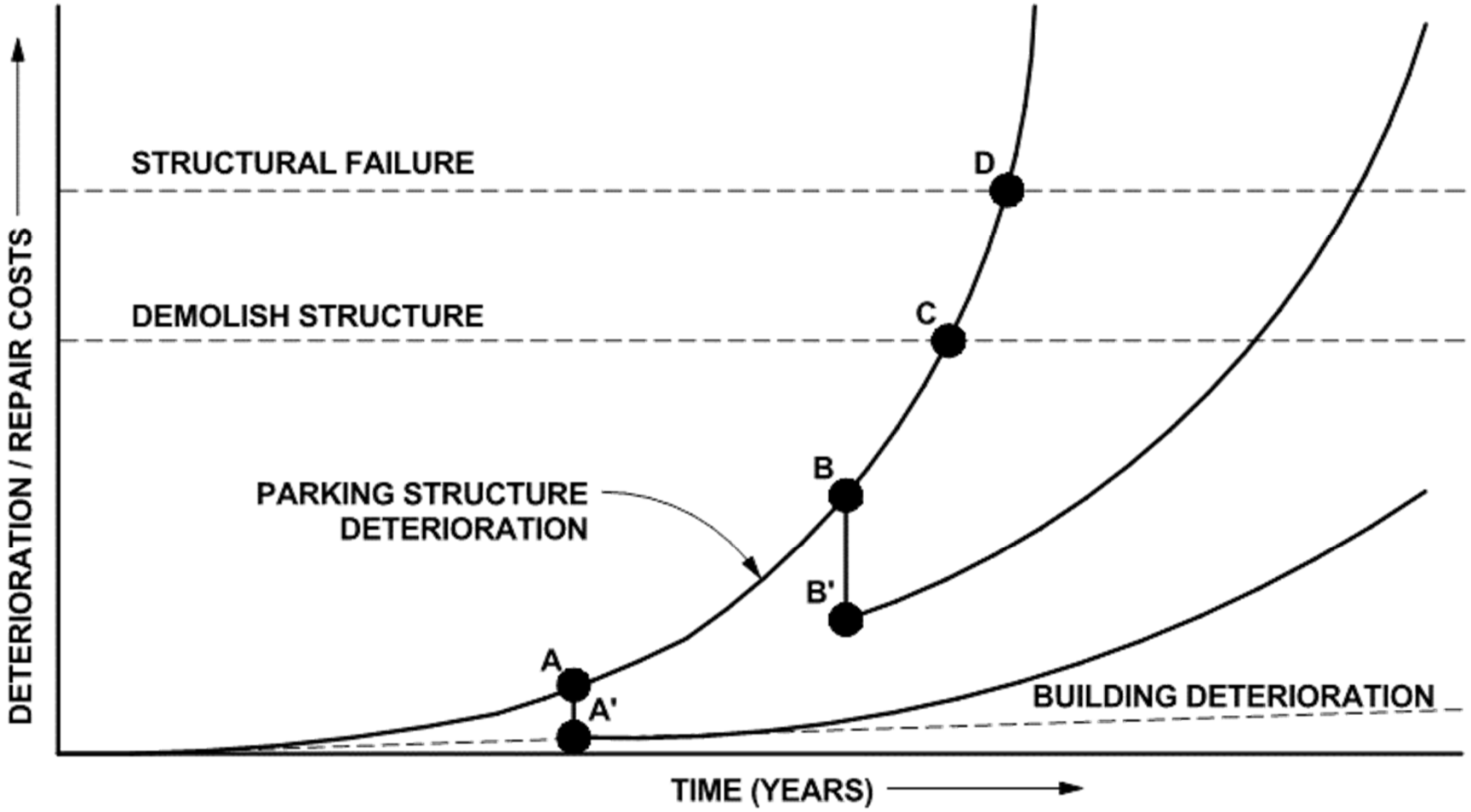
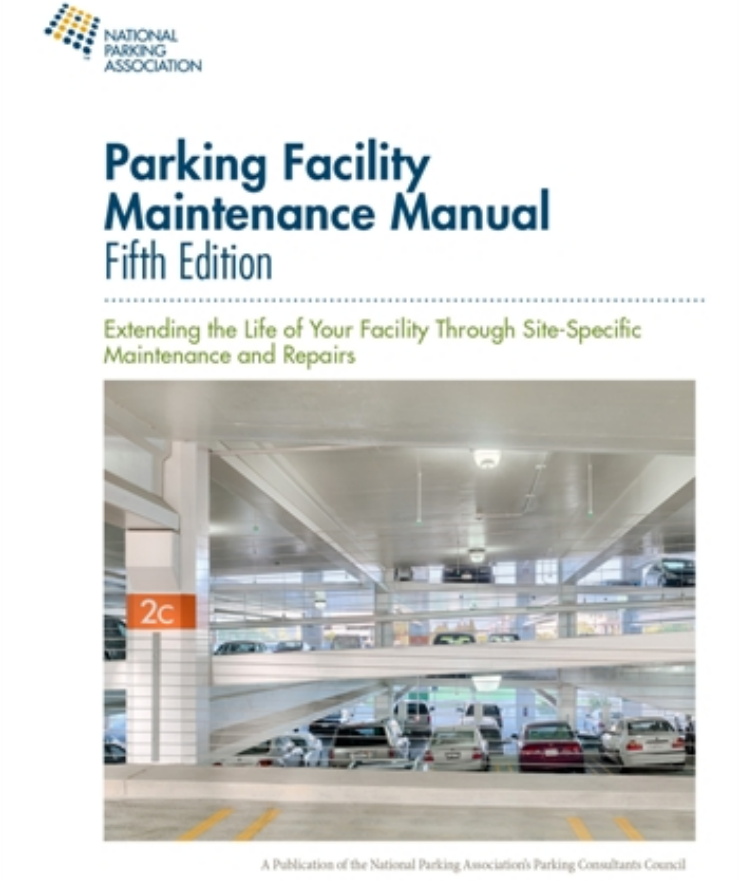


Reactive Maintenance

Now Demolished

Maintenance Program: Planning



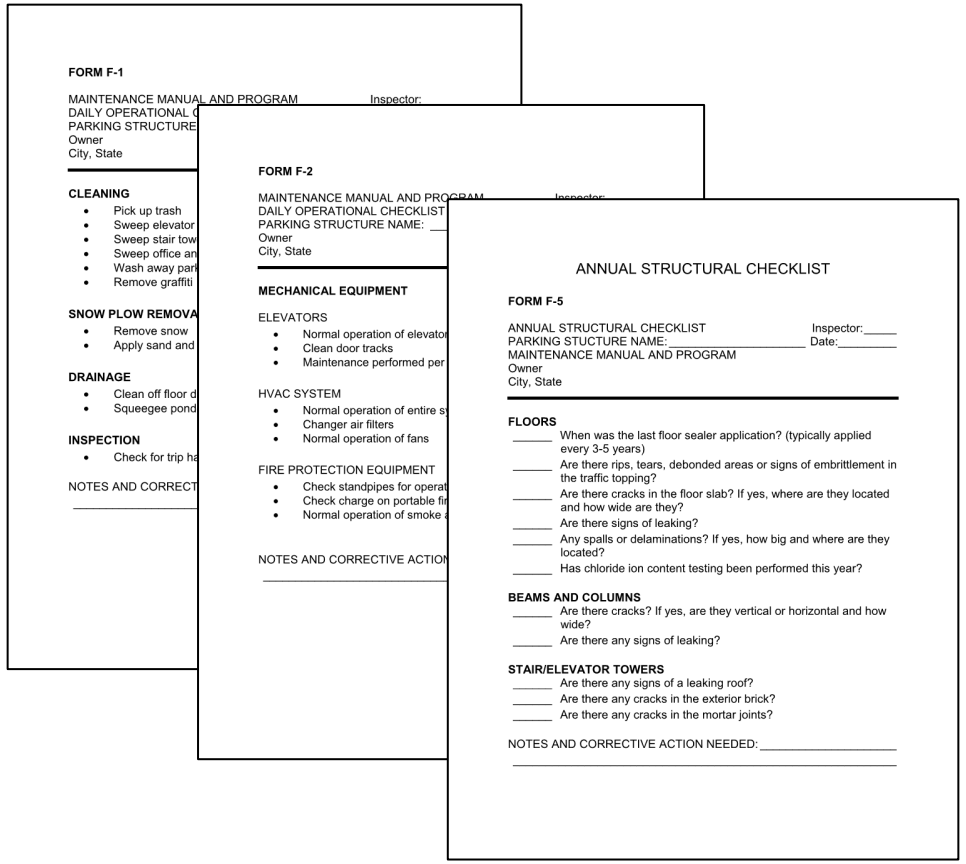
Source: National Parking Association

- Pre-Construction Design
- Condition Assessment
- Maintenance Checklist & Schedule
- Inspection Checklists
- Budget

Maintenance Program

Structural and Waterproofing Systems	Operational Maintenance	Aesthetics
1. Floors	1. Cleaning	1. Landscaping
2. Beams, columns, and bumper walls	2. Snow and ice control	2. Painting
3. Stair and elevator towers	3. Mechanical systems	3. General appearance
4. Joint sealant systems	4. Electrical systems	
5. Architectural sealants	5. Parking control	
6. Exposed steel	6. Security systems	
7. Masonry	7. Signage and striping	
8. Bearing Walls	8. Inspection	
	9. Safety checks	

Maintenance Program: Planning



FORM F-1

MAINTENANCE MANUAL AND PROGRAM Inspector:
DAILY OPERATIONAL C
PARKING STRUCTURE
Owner
City, State

CLEANING
- Pick up trash
- Sweep elevator
- Sweep stair tow
- Sweep office ar
- Wash away par
- Remove graffiti

SNOW PLOW REMOVA
- Remove snow
- Apply sand and

DRAINAGE
- Clean off floor d
- Squeegee pond

INSPECTION
- Check for trip ha

NOTES AND CORRECT

FORM F-2

MAINTENANCE MANUAL AND PROGRAM Inspector:
DAILY OPERATIONAL CHECKLIST
PARKING STRUCTURE NAME:
Owner
City, State

MECHANICAL EQUIPMENT

ELEVATORS
- Normal operation of elevator
- Clean door tracks
- Maintenance performed per

HVAC SYSTEM
- Normal operation of entire s
- Changer air filters
- Normal operation of fans

FIRE PROTECTION EQUIPMENT
- Check standpipes for operat
- Check charge on portable fi
- Normal operation of smoke

NOTES AND CORRECTIVE ACTIO

ANNUAL STRUCTURAL CHECKLIST

FORM F-5

ANNUAL STRUCTURAL CHECKLIST Inspector:_____
PARKING STUCTURE NAME:_____ Date:_____
MAINTENANCE MANUAL AND PROGRAM
Owner
City, State

FLOORS
_____ When was the last floor sealer application? (typically applied every 3-5 years)
_____ Are there rips, tears, debonded areas or signs of embrittlement in the traffic topping?
_____ Are there cracks in the floor slab? If yes, where are they located and how wide are they?
_____ Are there signs of leaking?
_____ Any spalls or delaminations? If yes, how big and where are they located?
_____ Has chloride ion content testing been performed this year?

BEAMS AND COLUMNS
_____ Are there cracks? If yes, are they vertical or horizontal and how wide?
_____ Are there any signs of leaking?

STAIR/ELEVATOR TOWERS
_____ Are there any signs of a leaking roof?
_____ Are there any cracks in the exterior brick?
_____ Are there any cracks in the mortar joints?

NOTES AND CORRECTIVE ACTION NEEDED:_____

- **Priorities:**
  - Structural
  - Operational
  - Aesthetic

Capital Assessment & Management Plan

- Gather Existing Reports
- Review Operator Agreement
- Operations
- Users Types
- Rates: Existing vs. Comp.’s
- Revenue Profile
- Cash Flow
- Performa: Operating Budget w/ Capital Improvements

Buying Services - Scope of Work

Buying Services – The Sequence

- Condition Assessment
  - Level I
  - Level II
  - Level III
- Construction Documents
- Bidding & Award
- Resident Engineering

Learning Objectives

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Questions?

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