



# **Parking Structure Maintenance**

*Presented By:  
Innovative Engineering Inc.*

**SCOTT L. WEILAND PE**

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**Florida Parking and Transportation Association**

# Learning Objectives

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

# Innovative Engineering, Inc.



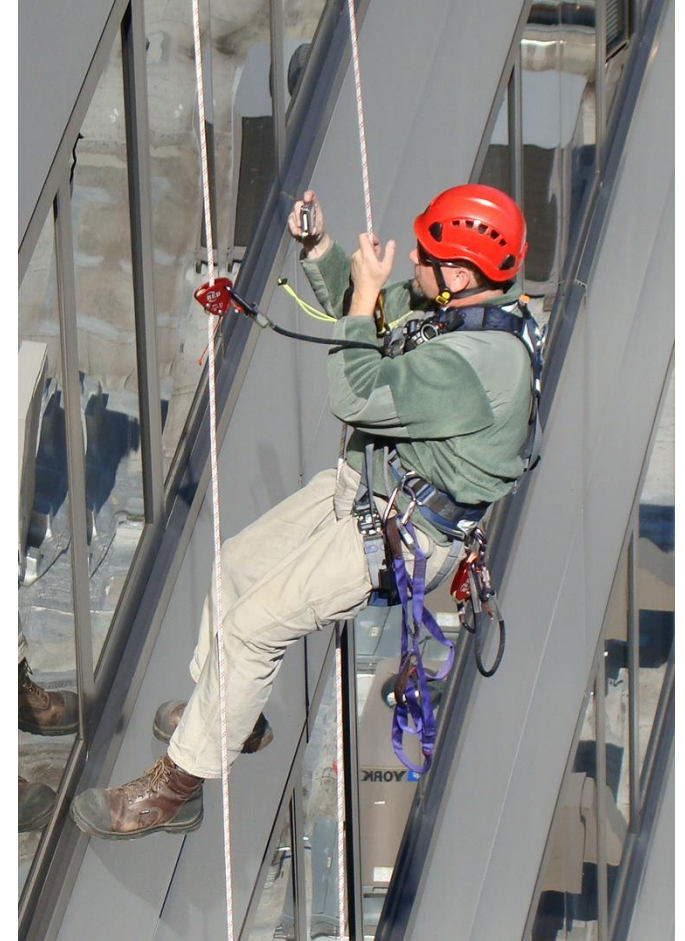
- Scott L. Weiland PE
- BSCE University of Michigan
- Graduate Studies:
  - San Jose State University
  - Georgia Institute of Technology
- PE in 20 States + PR & Guam
- 38 Years in Design and Construction
  - BOMA Georgia Insight magazine
    - Parking Structure maintenance part 1 & 2
    - Falling Building Façade Closes Atlanta Streets
  - National Parking Association Parking magazine
    - Parking Structure Maintenance



# Innovative Engineering, Inc.



- **Trey Thomas PE**
  - **BSCET, Southern Polytechnic State University**
  - **15 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**
  - **Expert estimator (within 5% of actual)**
  - **Facility Condition Assessments (FCA's)**
  - **Façade Inspection**
  - **Parking Structure Restoration**

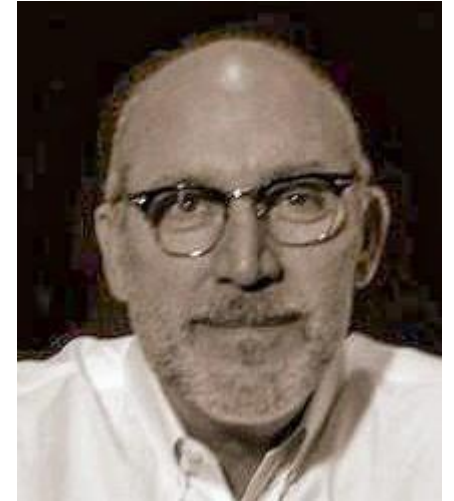




# PARC, LLC



- 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
- Founded by Don Moore 1994
- Specialty Contractor
- Specialties
  - Structural Repair
  - Restoration
  - Waterproofing
  - Preservation



# Structural Systems

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## Cast-in-Place Concrete



## Precast Concrete



## Structural Steel



# **Others Systems (generally not recommended)**

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



# Cast-in-Place

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- **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

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- **Advantages**

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

- **Disadvantages**

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

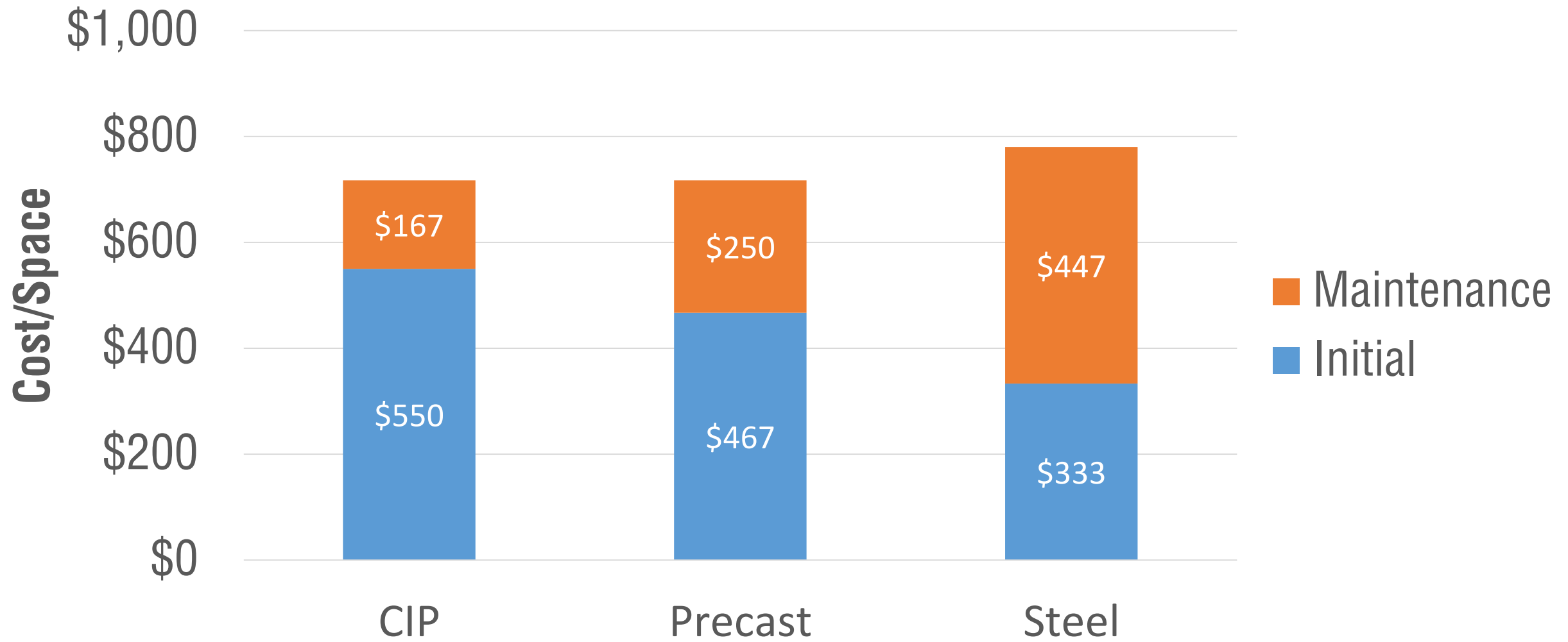


# Structural Steel



- **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



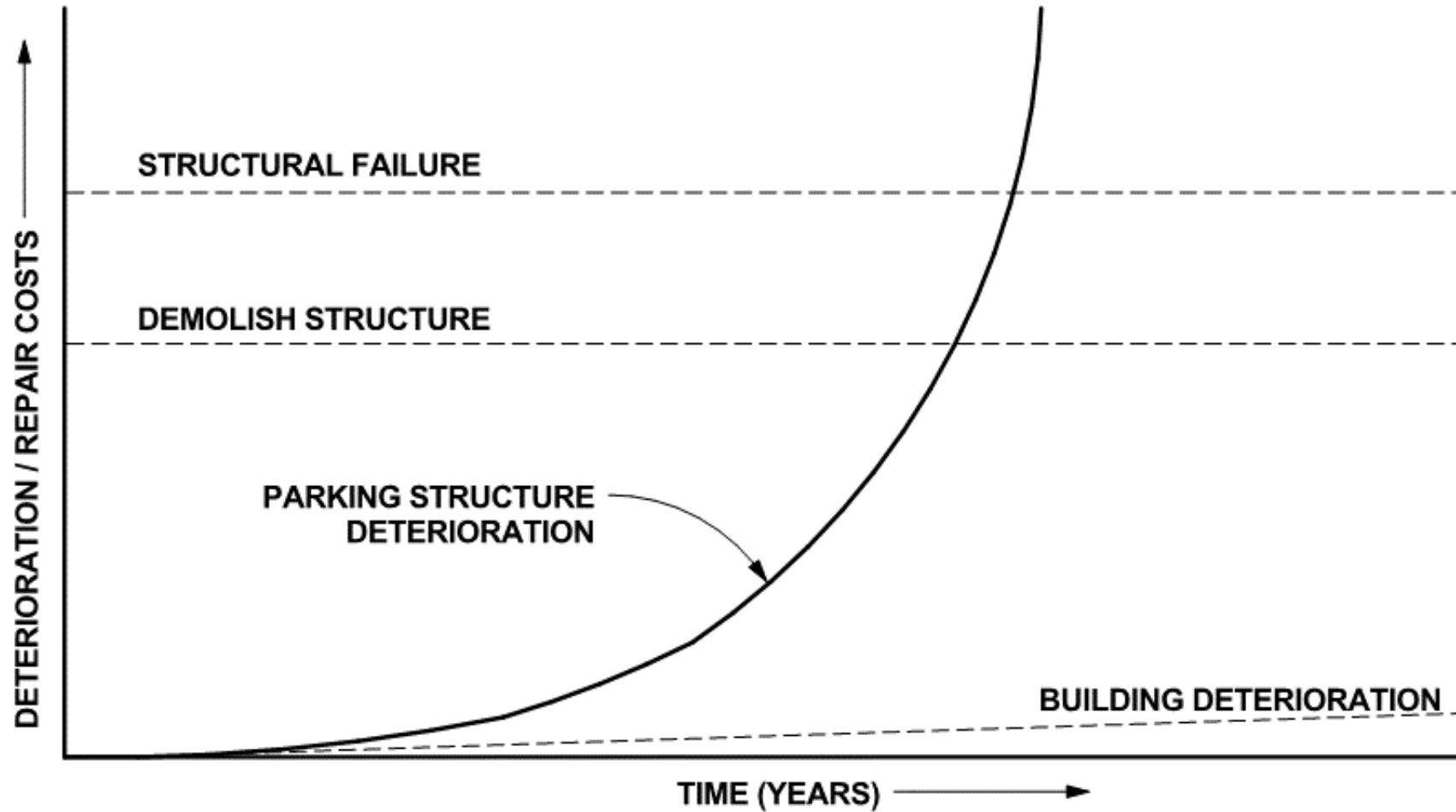


# Parking Structures



- Not Bullet Proof
- No Protective Skin
- Deterioration Starts Immediately
- Subjected To:
  - Moisture (Rain, Snow, Ice, Deicing Salts)
  - CO2 Carbonation
  - Extreme Thermal Expansion & Contraction
  - Dynamic Vehicle Loads

# Structure Degradation



# **Irving Texas, O'Conner Ridge Blvd. Collapse**

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Parking Structure Maintenance

# Common Deficiencies

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- **Number 1 Enemy**



**WATER**

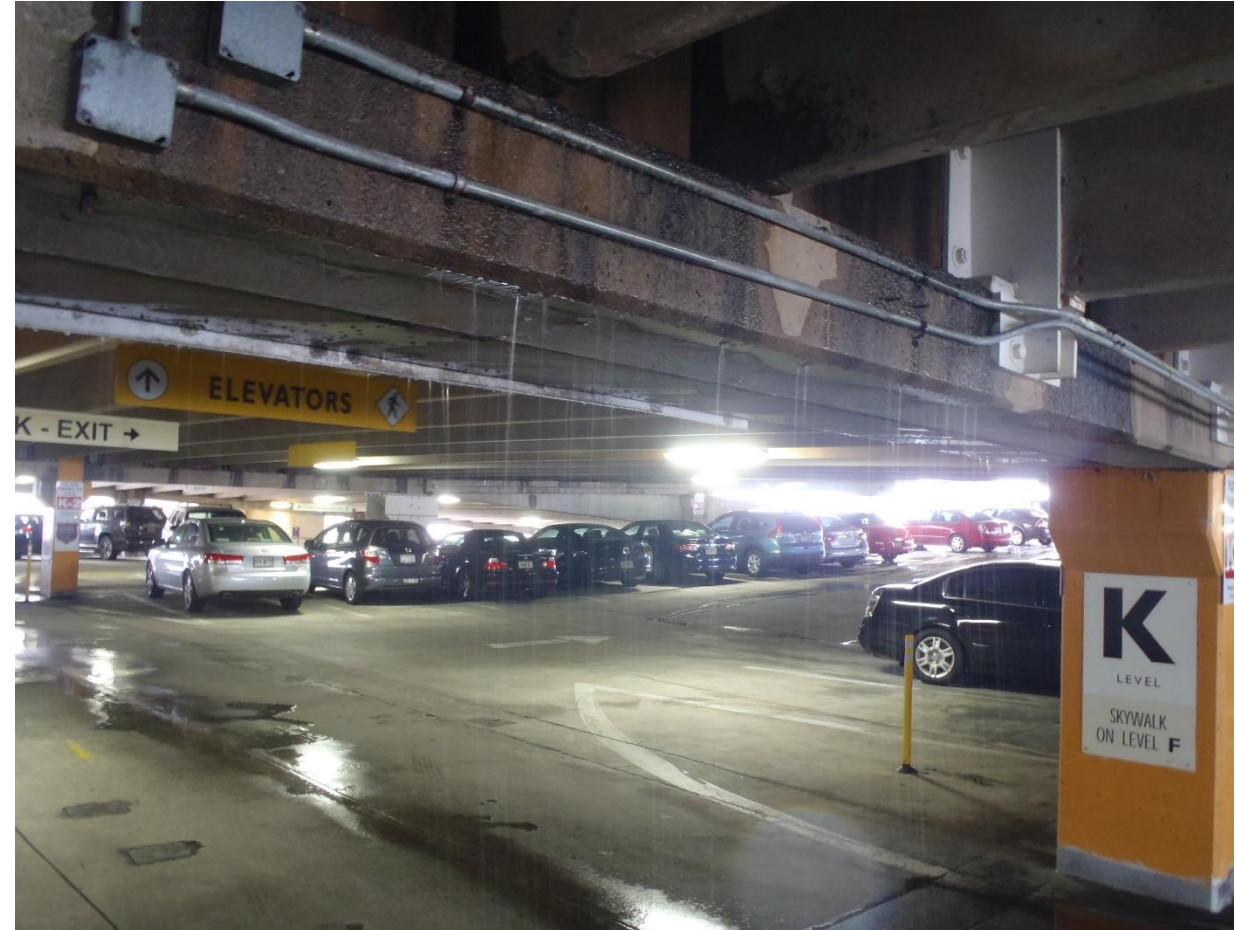


# Common Deficiency: Ponding



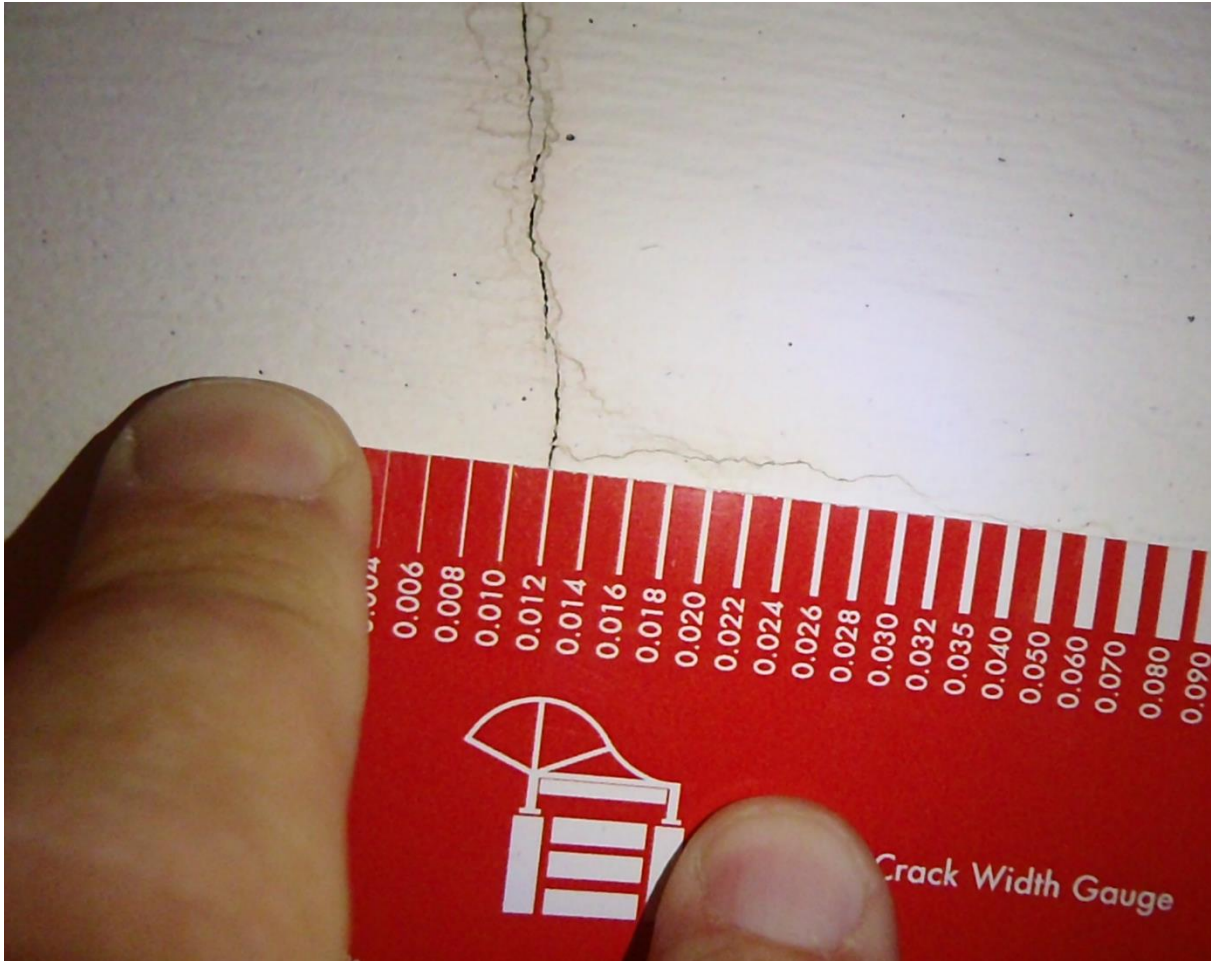


# Common Deficiency: Failed Joints





# Common Deficiency: Cracks & Repair



# Common Deficiency: Route & Seal

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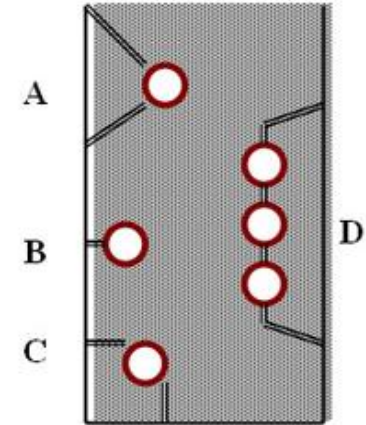
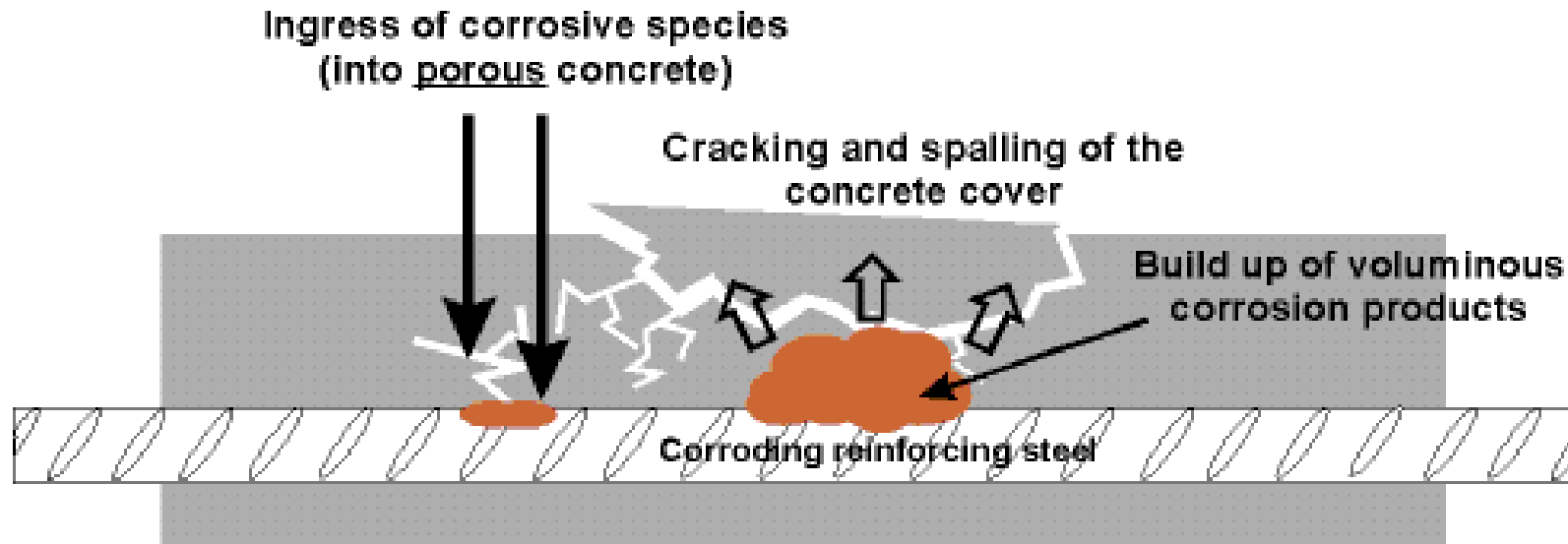
# Common Deficiency: Epoxy Injection

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Parking Structure Maintenance

# Common Deficiency: Corrosion



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



# Chloride Ion Testing



# Carbonation Testing





# Common Deficiency: Last Resort



Parking Structure Maintenance

# Common Deficiency: Sounding





# Common Deficiency: Spall & Delamination





# Common Deficiency: Failing Spall Repair





# Common Deficiency: Exterior Spalls (Over Sidewalk)



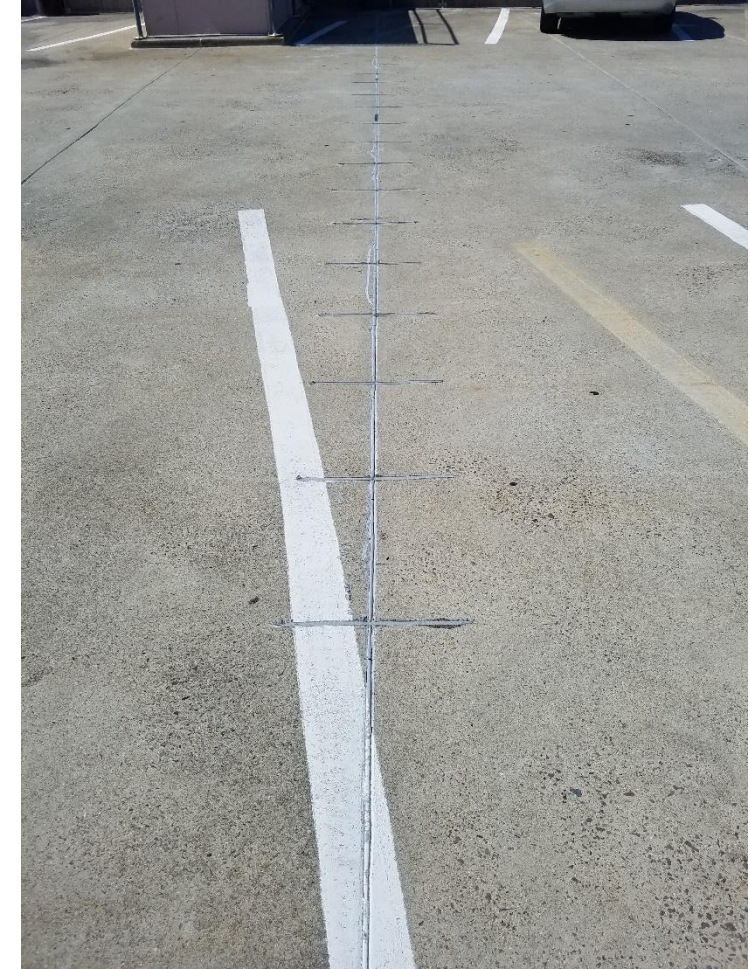
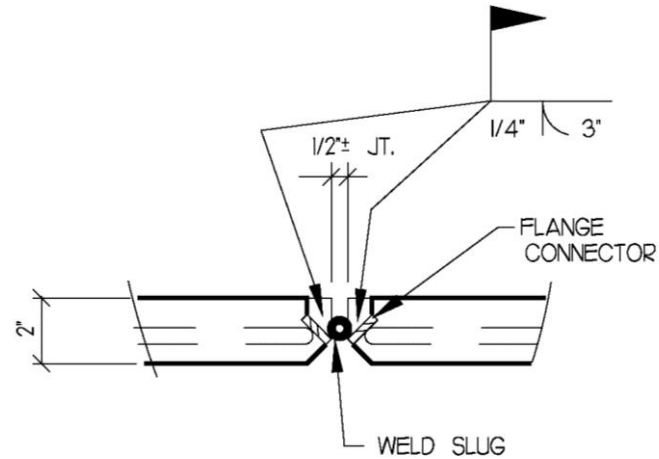
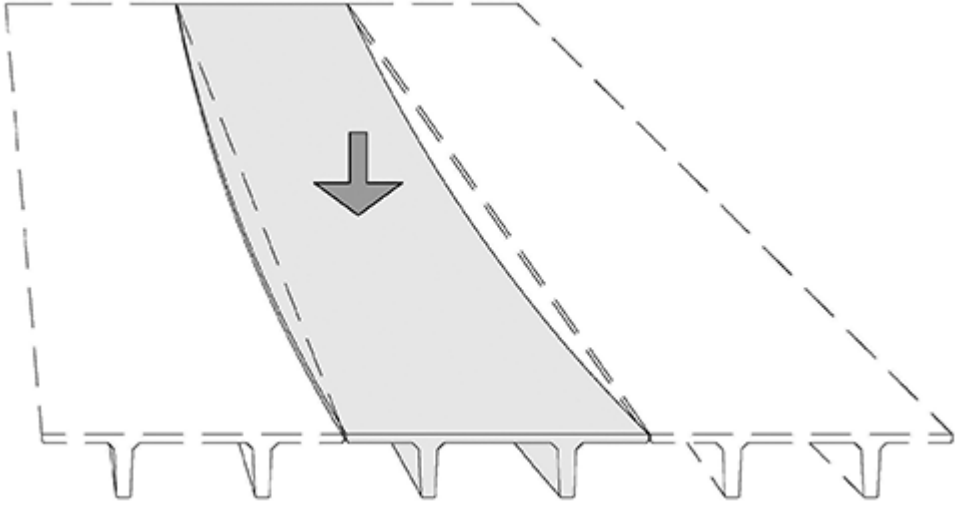
# Precast Shear Transfer Repair



Parking Structure Maintenance

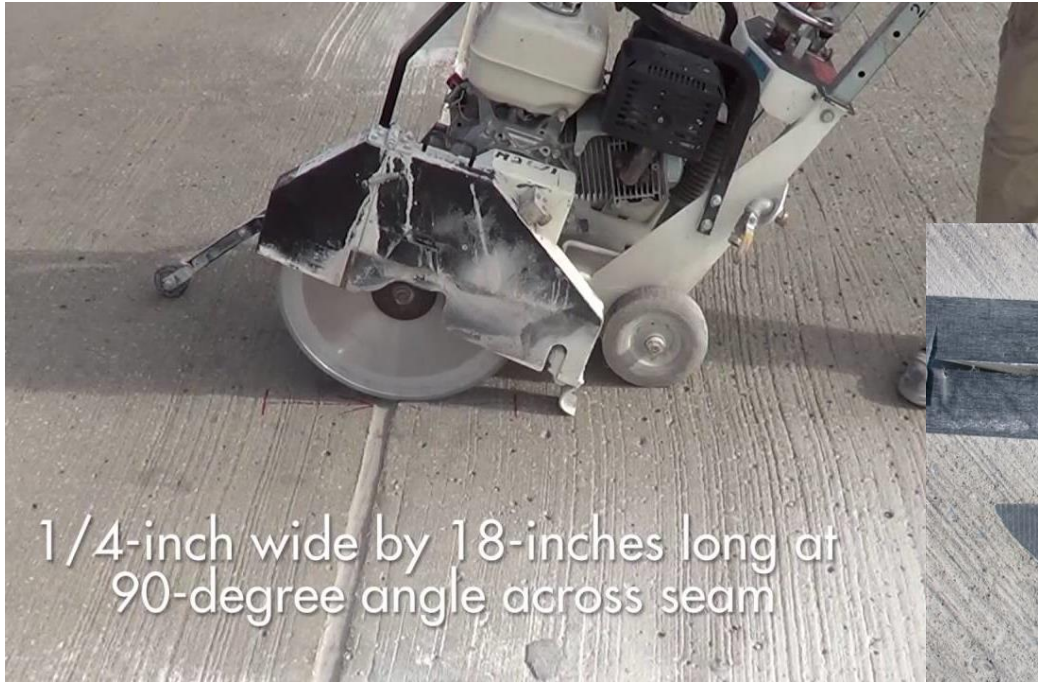


# Precast Shear Transfer Repair



# Precast Shear Transfer Repair

## Saw Cut & Biscuit Repair



Images by V2 Composites



# Structural Steel Corrosion

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

# Precast Connection Failures – Double Tee Joists





# Precast Connection Failures - Joist



Image by Structure magazine



# Precast Haunch Connection Failure & Repair

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# Precast Haunch Connection Failure & Repair





# Precast Haunch Connection Failure & Repair

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- Repaired

# Common Deficiency: Guardrail





# Common Deficiency: Overloaded – Fire Truck





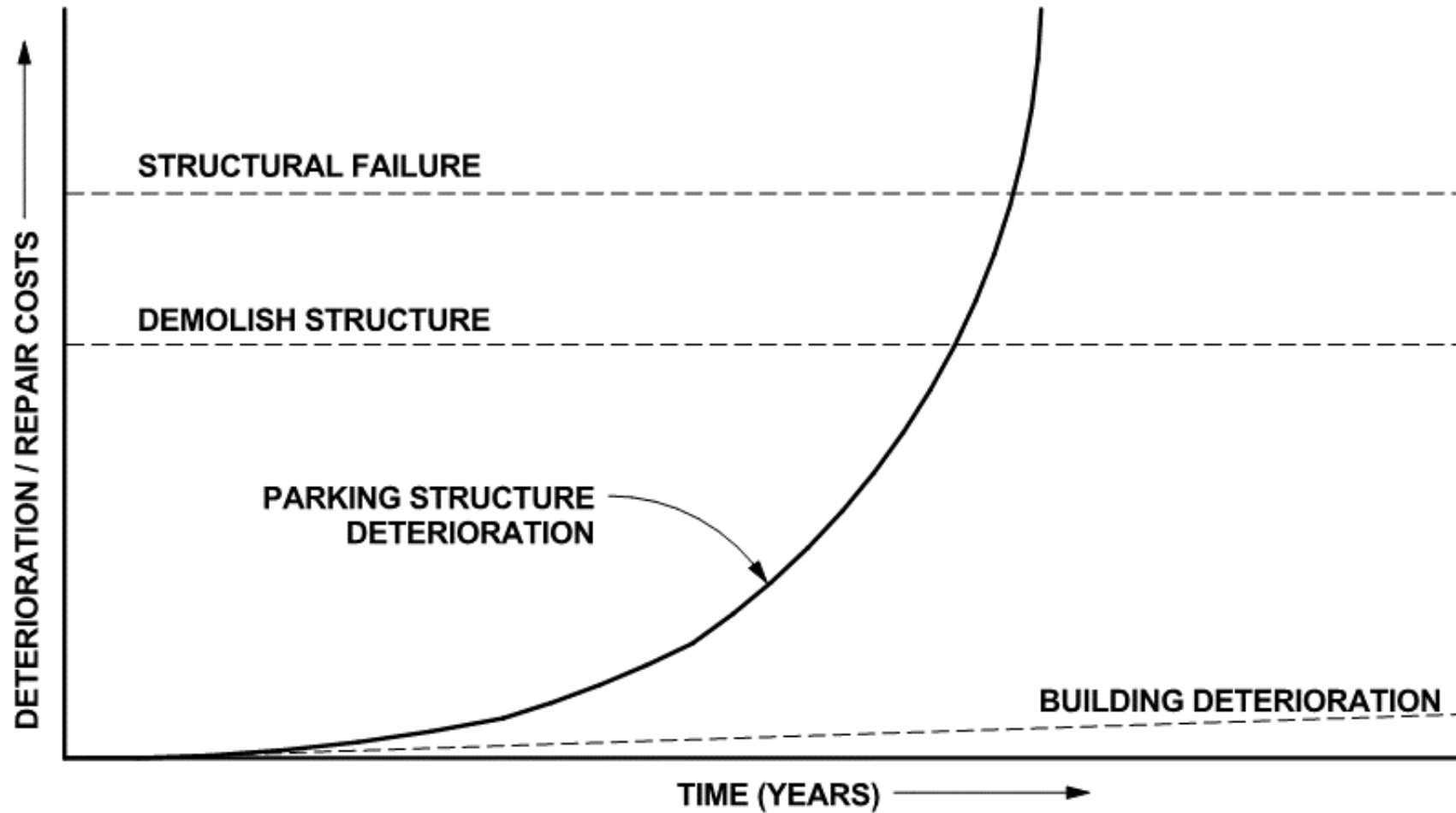
# Common Deficiency: Curbs & Wheel Stops

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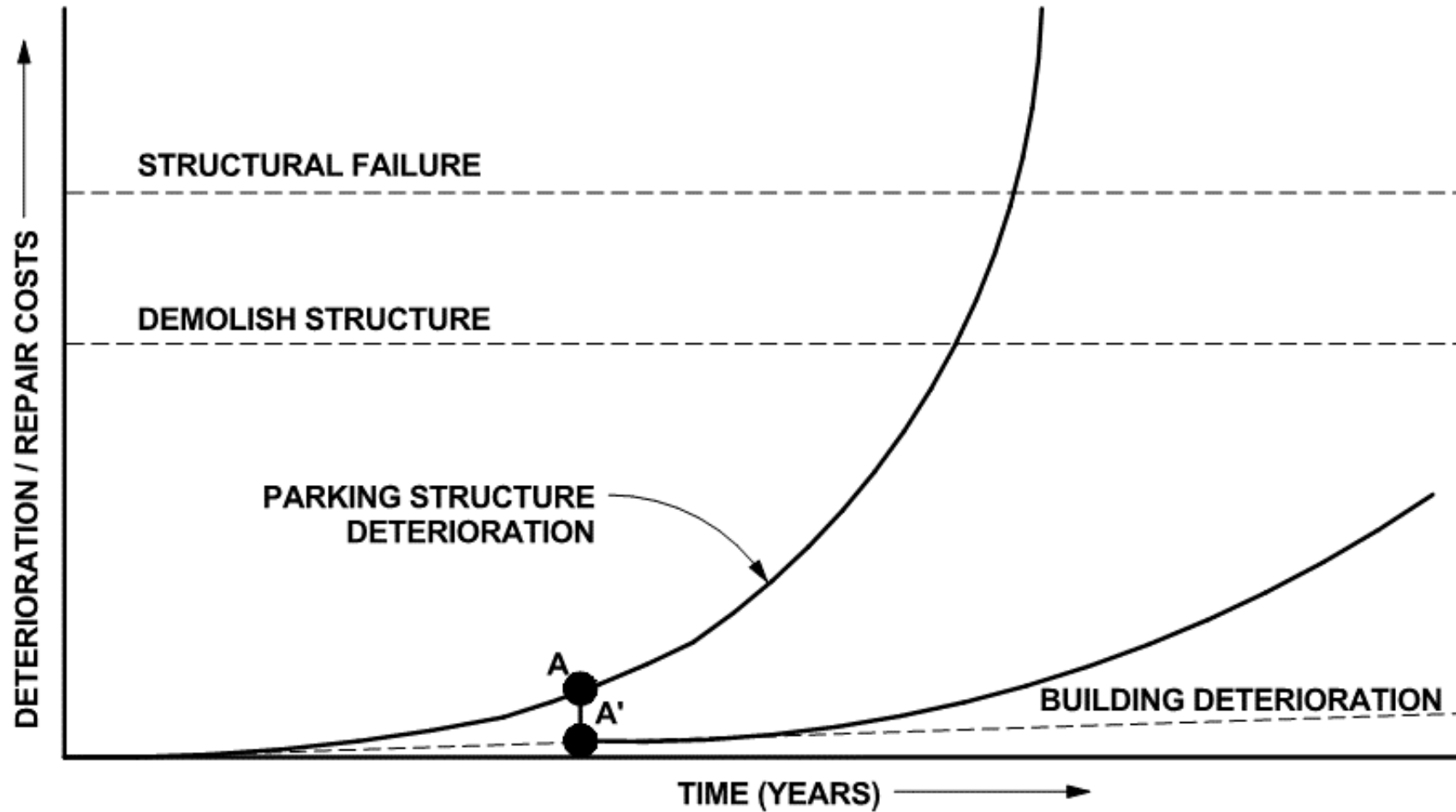




# Maintenance Cost Curve

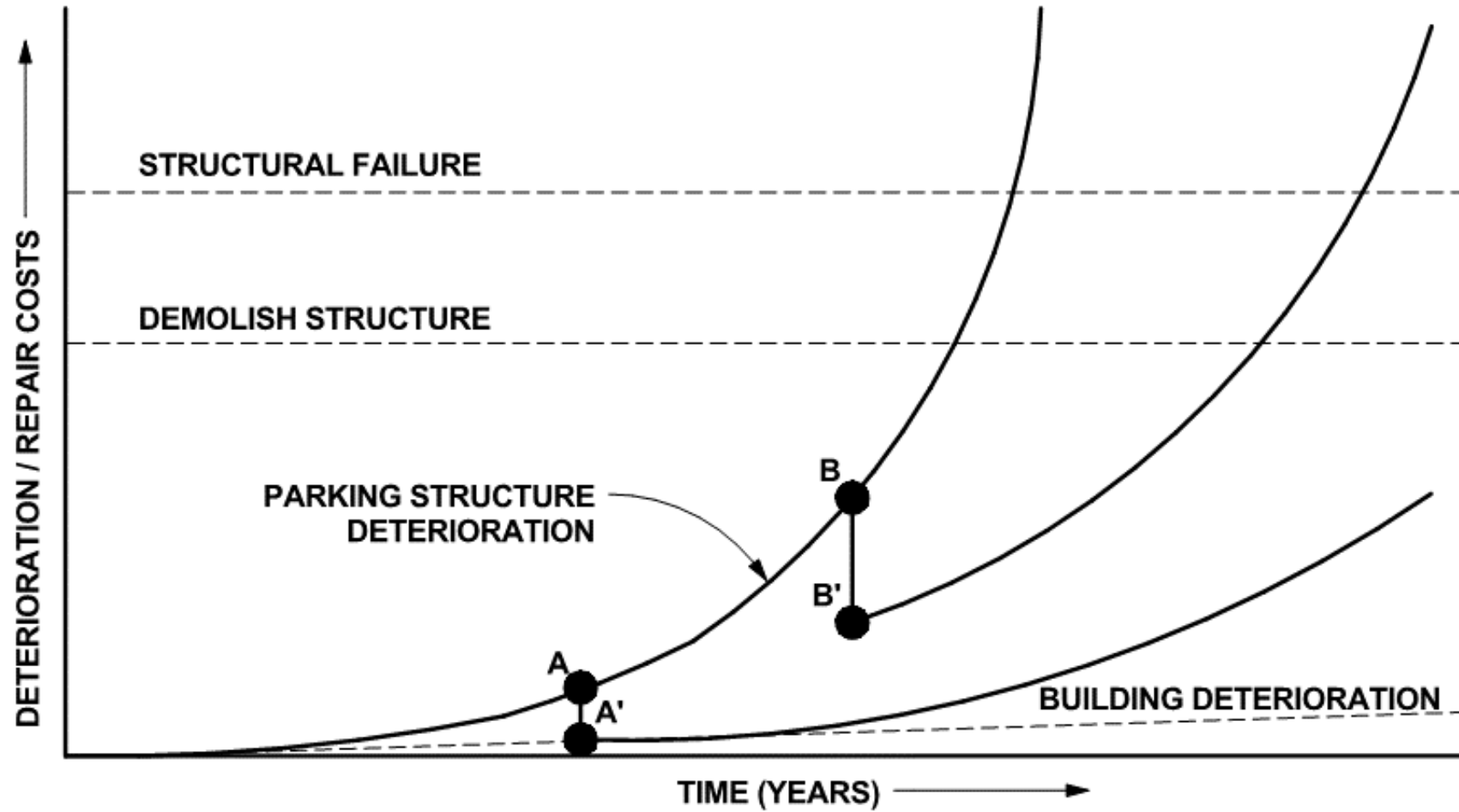


# Maintenance Cost Curve

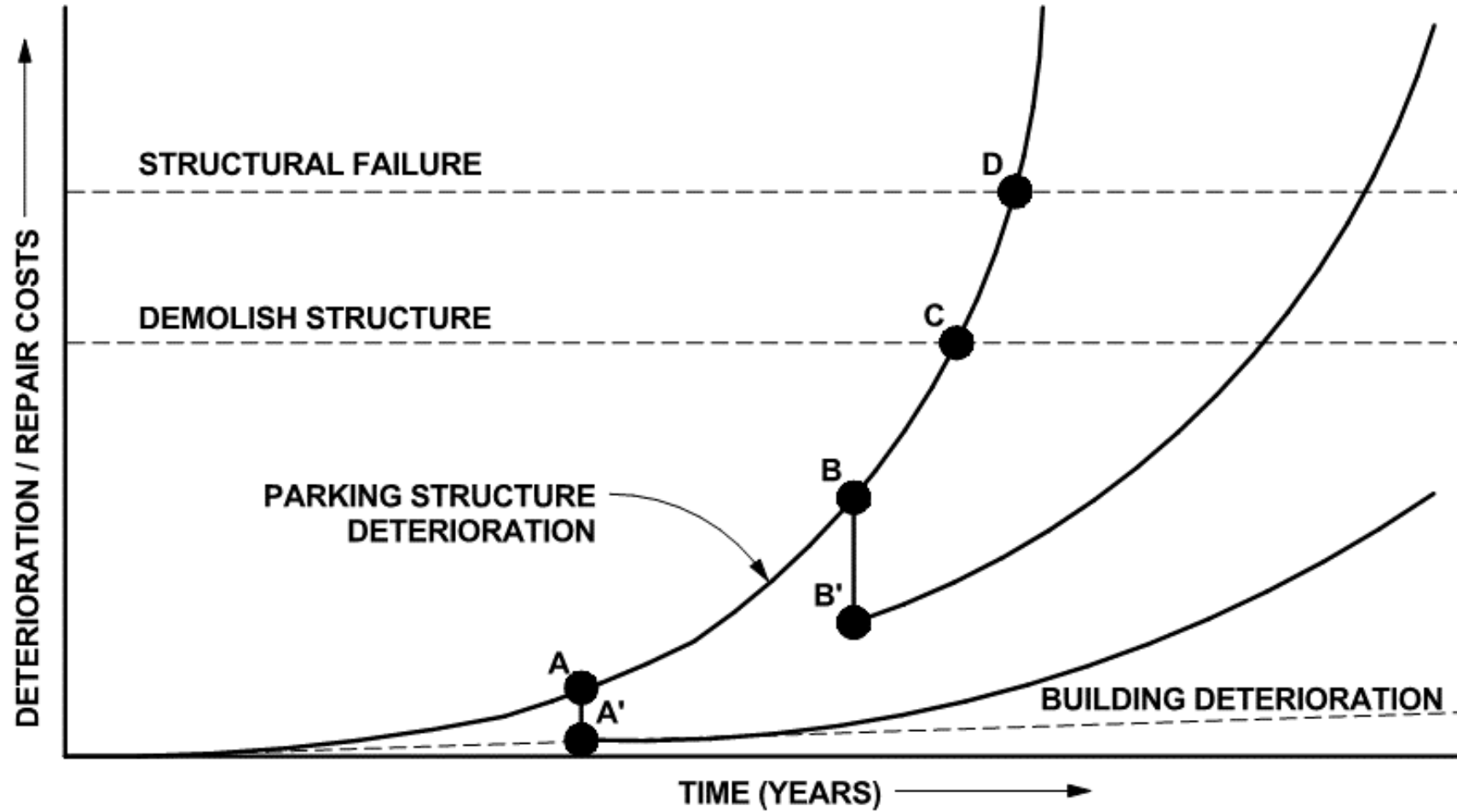




# Maintenance Cost Curve



# Maintenance Cost Curve





# Reactive Maintenance



Parking Structure Maintenance

# Maintenance Program: Planning

The image shows three overlapping forms used for parking structure maintenance planning. FORM F-1 is the topmost form, followed by FORM F-2, and FORM F-5 is the bottommost form.

**FORM F-1**  
MAINTENANCE MANUAL AND PROGRAM  
DAILY OPERATIONAL CHECKLIST  
PARKING STRUCTURE NAME: \_\_\_\_\_  
Owner: \_\_\_\_\_  
City, State: \_\_\_\_\_

**CLEANING**

- Pick up trash
- Sweep elevator
- Sweep stair tower
- Sweep office area
- Wash away parking lot
- Remove graffiti

**SNOW PLOW REMOVAL**

- Remove snow
- Apply sand and salt

**DRAINAGE**

- Clean off floor drains
- Squeegee pond

**INSPECTION**

- Check for trip hazards

NOTES AND CORRECTIVE ACTION: \_\_\_\_\_

**FORM F-2**  
MAINTENANCE MANUAL AND PROGRAM  
DAILY OPERATIONAL CHECKLIST  
PARKING STRUCTURE NAME: \_\_\_\_\_  
Owner: \_\_\_\_\_  
City, State: \_\_\_\_\_

**MECHANICAL EQUIPMENT**

**ELEVATORS**

- Normal operation of elevator
- Clean door tracks
- Maintenance performed per manufacturer's instructions

**HVAC SYSTEM**

- Normal operation of entire system
- Change air filters
- Normal operation of fans

**FIRE PROTECTION EQUIPMENT**

- Check standpipes for operation
- Check charge on portable fire extinguishers
- Normal operation of smoke detectors

NOTES AND CORRECTIVE ACTION: \_\_\_\_\_

**FORM F-5**  
ANNUAL STRUCTURAL CHECKLIST  
PARKING STRUCTURE NAME: \_\_\_\_\_  
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: \_\_\_\_\_

- Elements of a Maintenance Program
  - Condition Assessments
  - Housekeeping
  - Routine Maintenance
  - Preventive Maintenance
  - Replacement
  - Budget



# Learning Objectives

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- **Common Deficiencies**
- **Importance of Routine Maintenance & Timely Restoration**

# Questions?

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