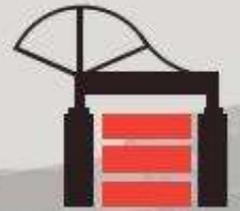


# Parking Structure Maintenance



*Presented By:*

**SCOTT L. WEILAND PE**  
with  
**INNOVATIVE ENGINEERING**  
*Wednesday September 26, 2018*

**Carolina Parking Association**

# Learning Objectives

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- **Types of Parking**
- **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**

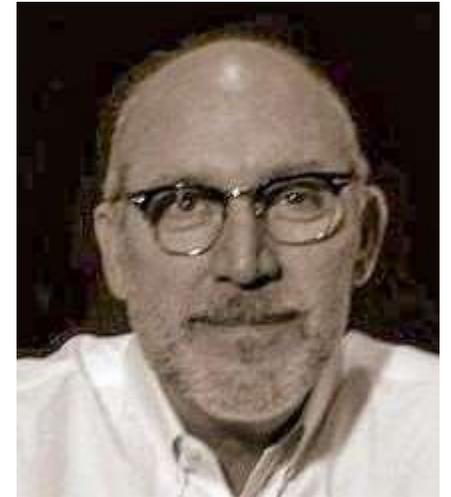


# PARC, LLC

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



# Types of Parking

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## On-Street



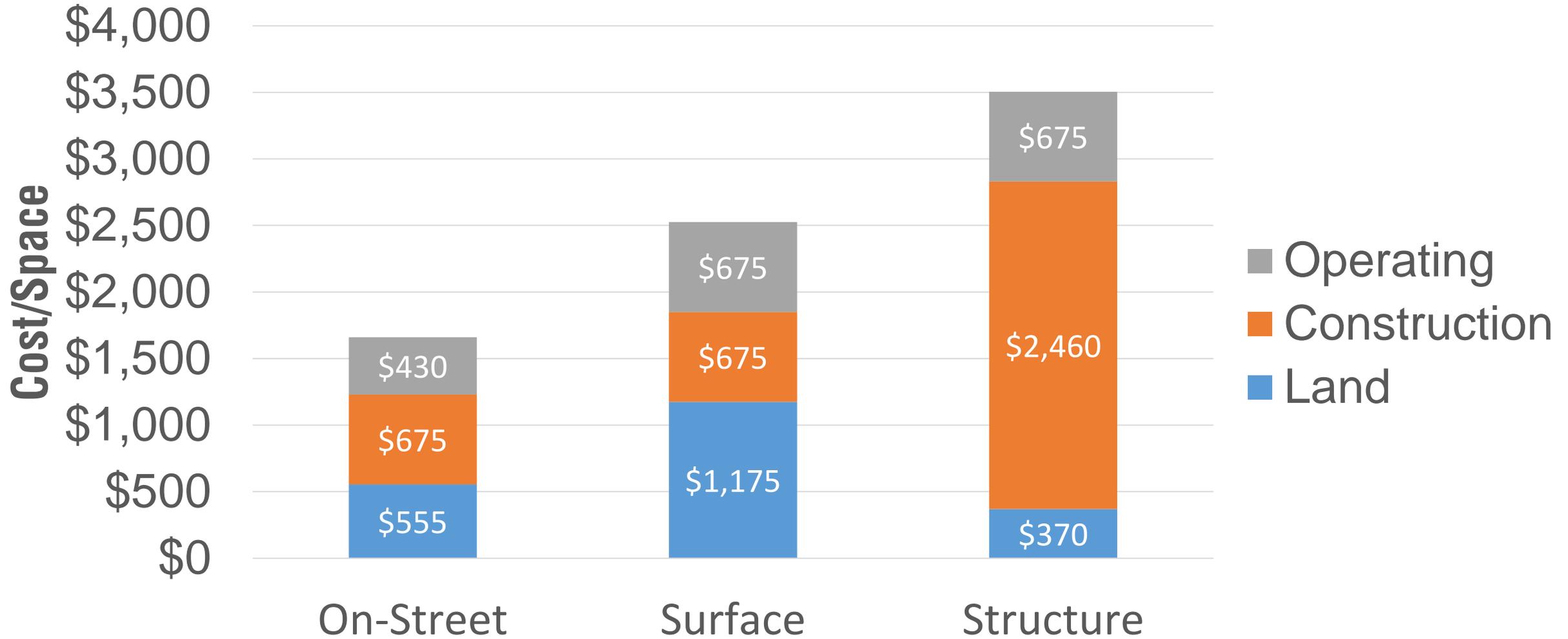
## Surface



## Structure



# Typical Parking Annualized Costs per Space

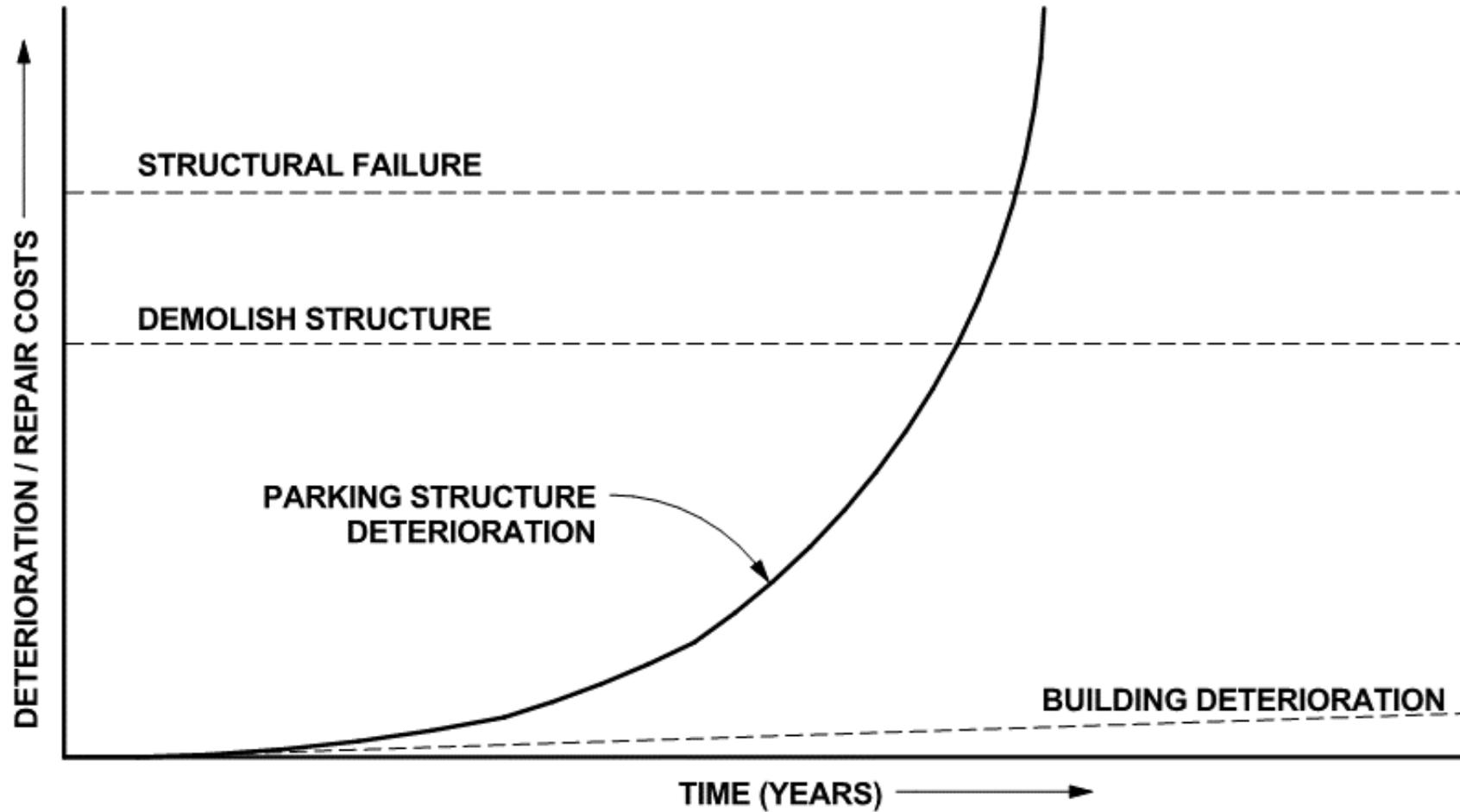


# Parking Structures



- Not Bullet Proof
- No Protective Skin
- Deterioration Starts Immediately
- Subjected To:
  - Moisture (Rain, Snow, Ice, Deicing Salts)
  - CO<sub>2</sub> Carbonation
  - Extreme Thermal Expansion & Contraction
  - Dynamic Vehicle Loads

# Structure Degradation



# Structural Systems

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## Cast-in-Place Concrete



## Precast Concrete



## Structural Steel



# 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

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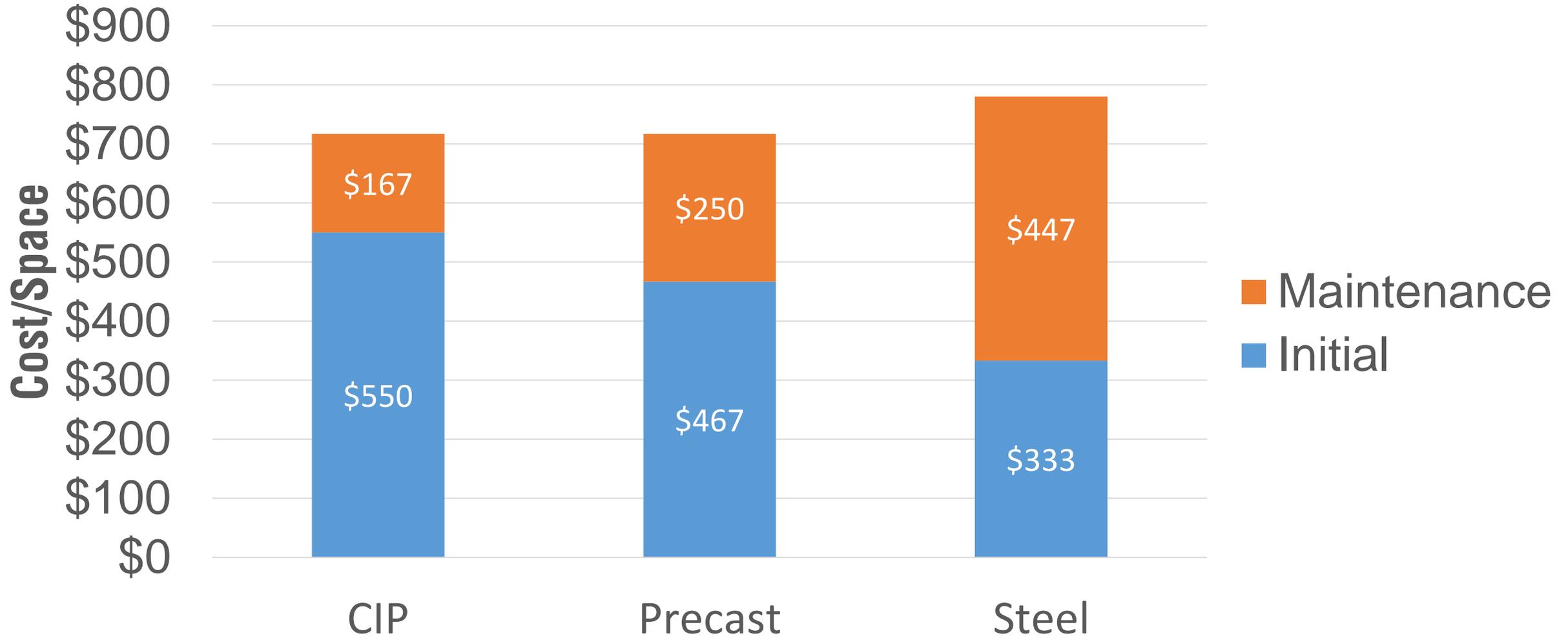
- **Advantages**

- 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



# Common Deficiencies

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- Number 1 Enemy



**WATER**

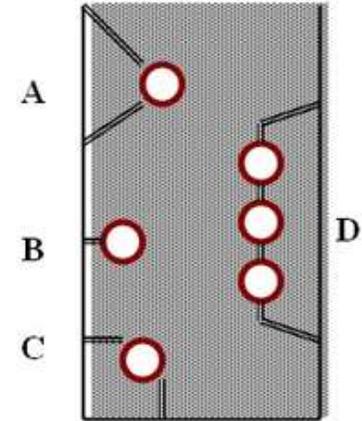
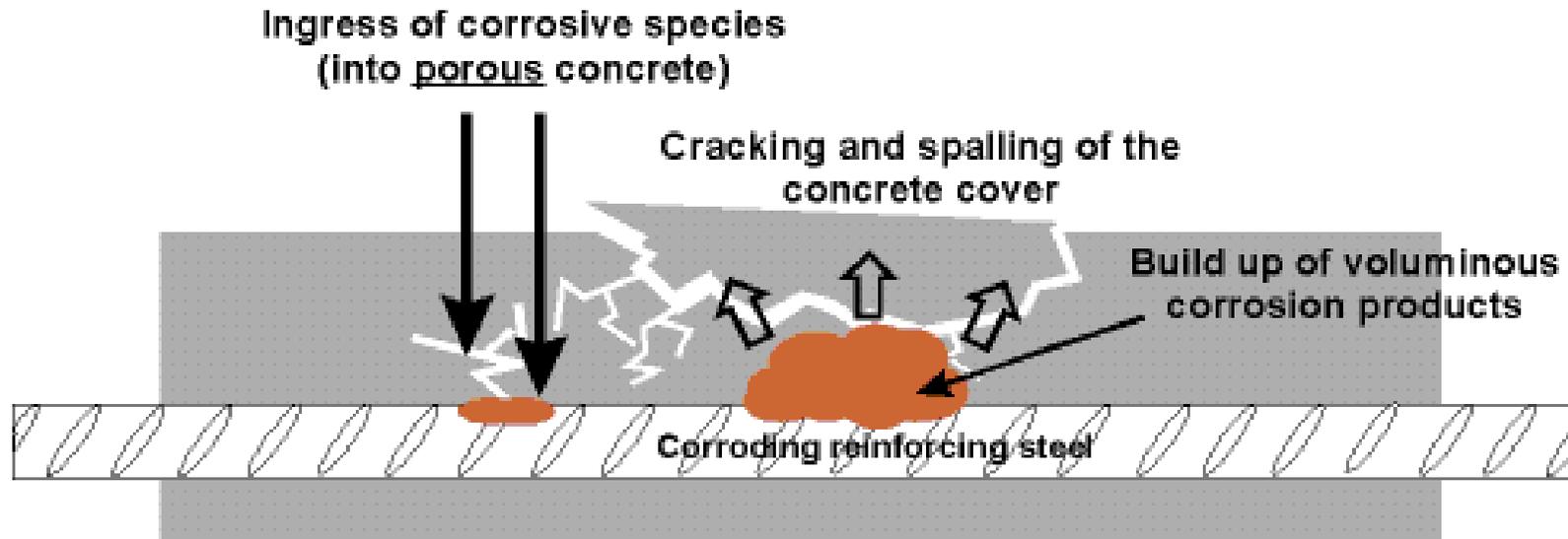
# Common Deficiency: Ponding



# Common Deficiency: Failed Joints



# Common Deficiency: Corrosion



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

# Chloride Ion Testing



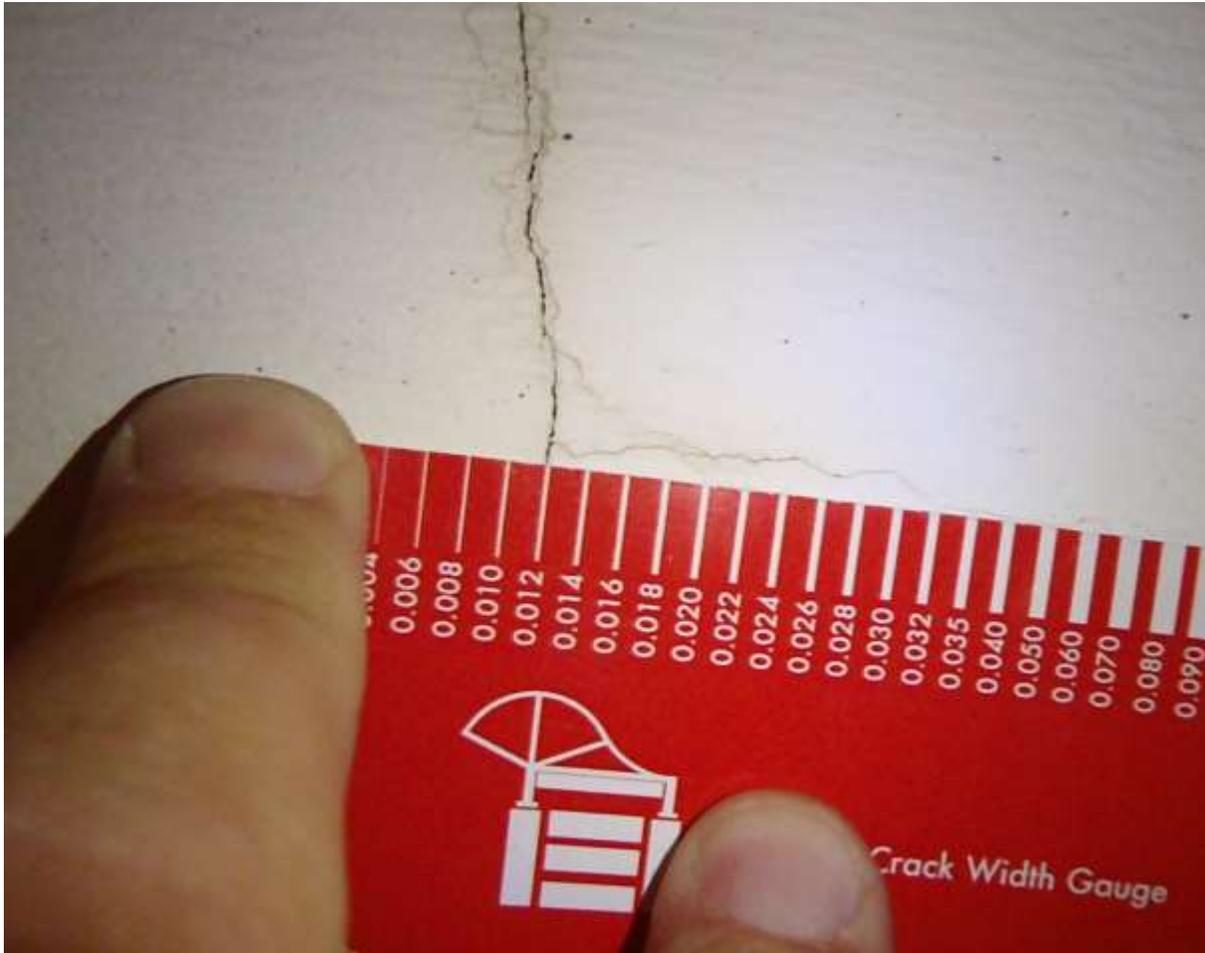
# Carbonation Testing



# Common Deficiency: Last Resort



# Common Deficiency: Cracks & Repair



# Common Deficiency: Epoxy Injection

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# Common Deficiency: Spall & Delamination



# Common Deficiency: Sounding



# Common Deficiency: Failing Spall Repair



# Common Deficiency: Exterior Spalls (Over Sidewalk)



# Common Deficiency: Expansion Joints



# Common Deficiency: Overloaded – Fire Truck



# Common Deficiency: Guardrail



# Common Deficiency: Curbs & Wheel Stops

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# Cast-In-Place Concrete: Post Tensioning

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- Abrasion
- PT Cable Failure

# Precast Connection Failures - Girder



# 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



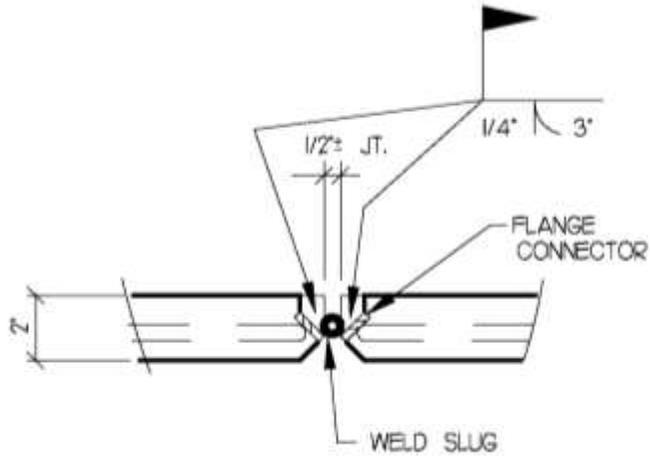
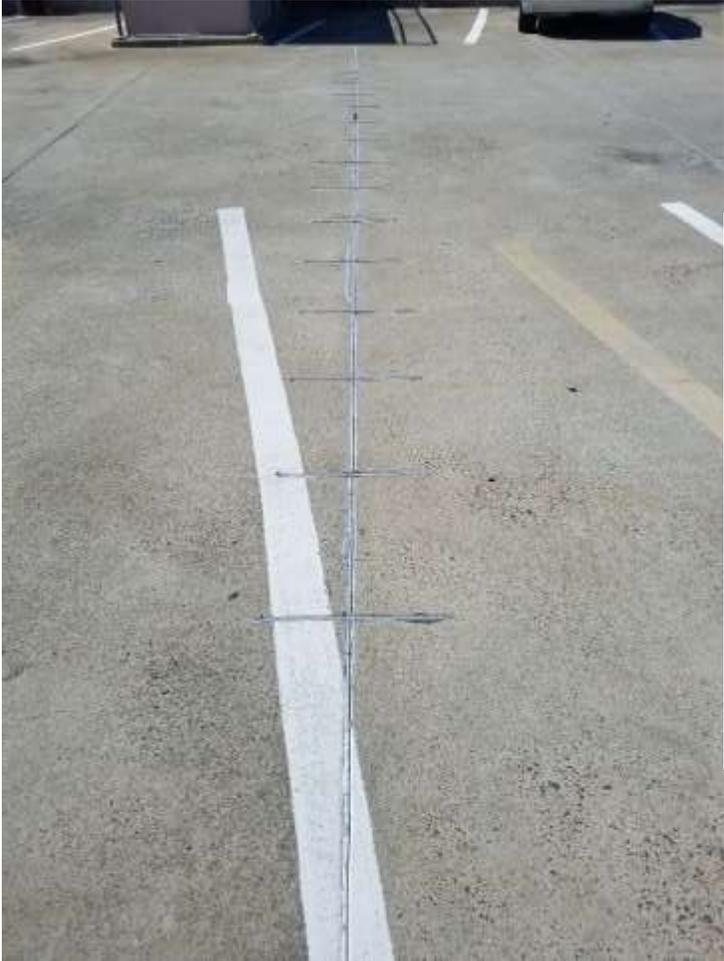
# Precast Haunch Connection Failure & Repair

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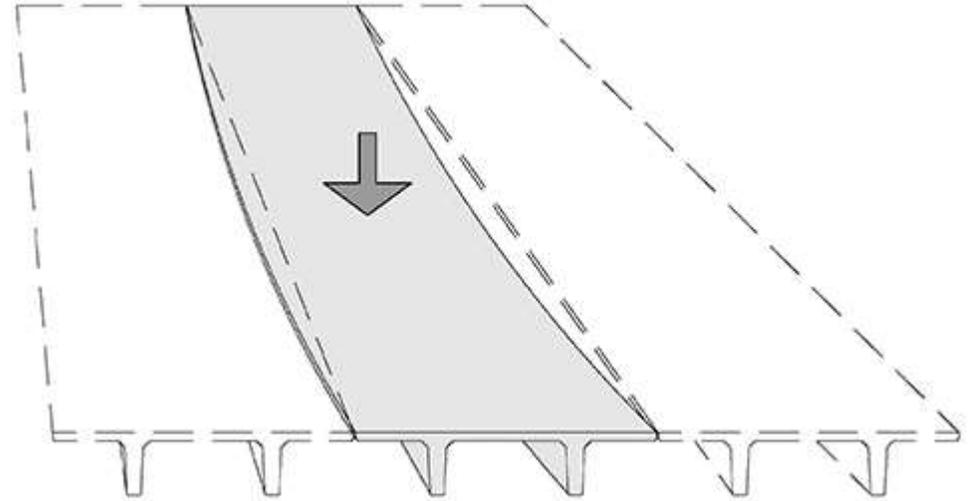


- Repaired

# Precast Shear Transfer Repair



- Saw Cut & Biscuit Repair
- Biscuit Repair



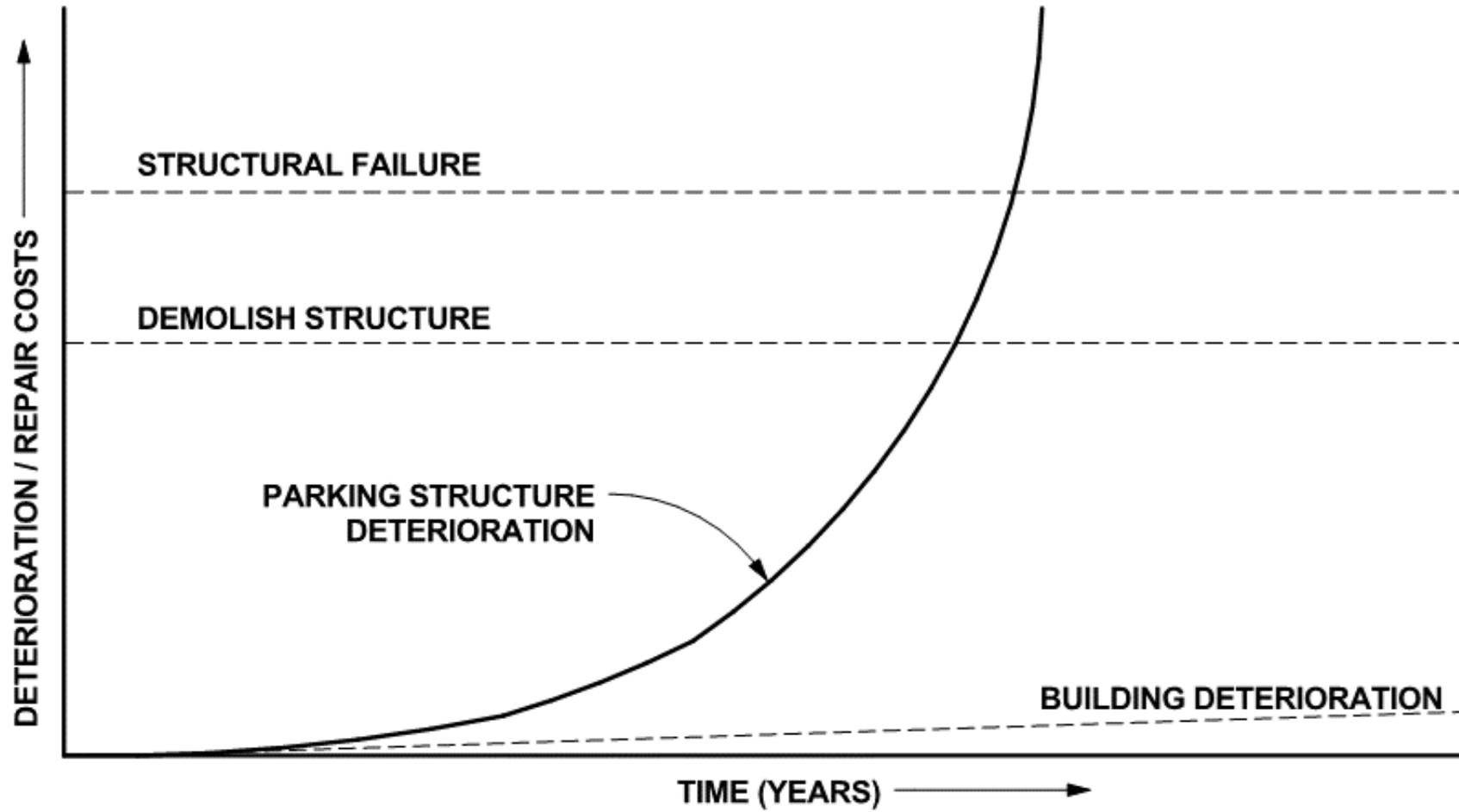
# Structural Steel Corrosion

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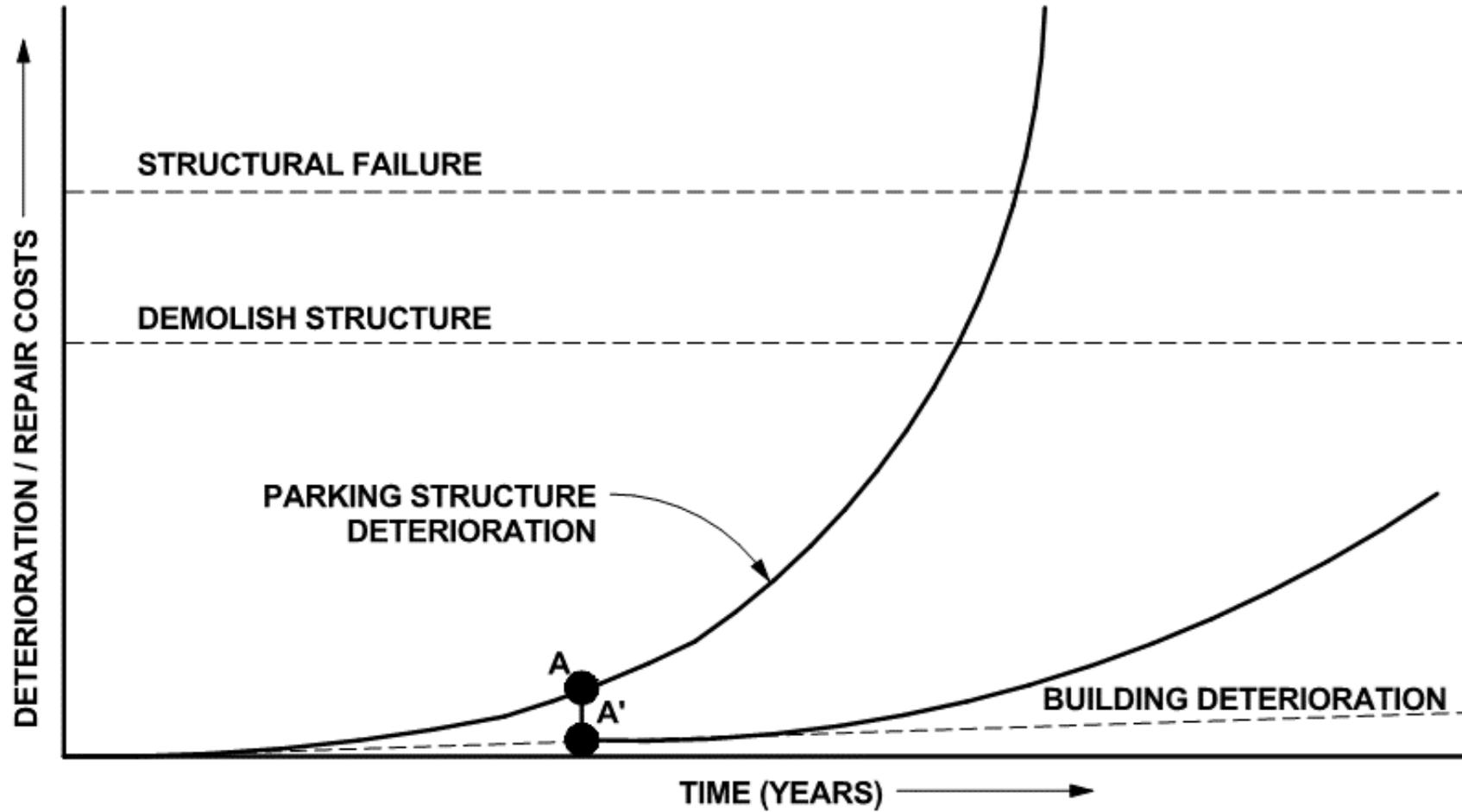


- Steel Protection & Corrosion Issues
- Steel Deck Traps Moisture, Hides Degradation.

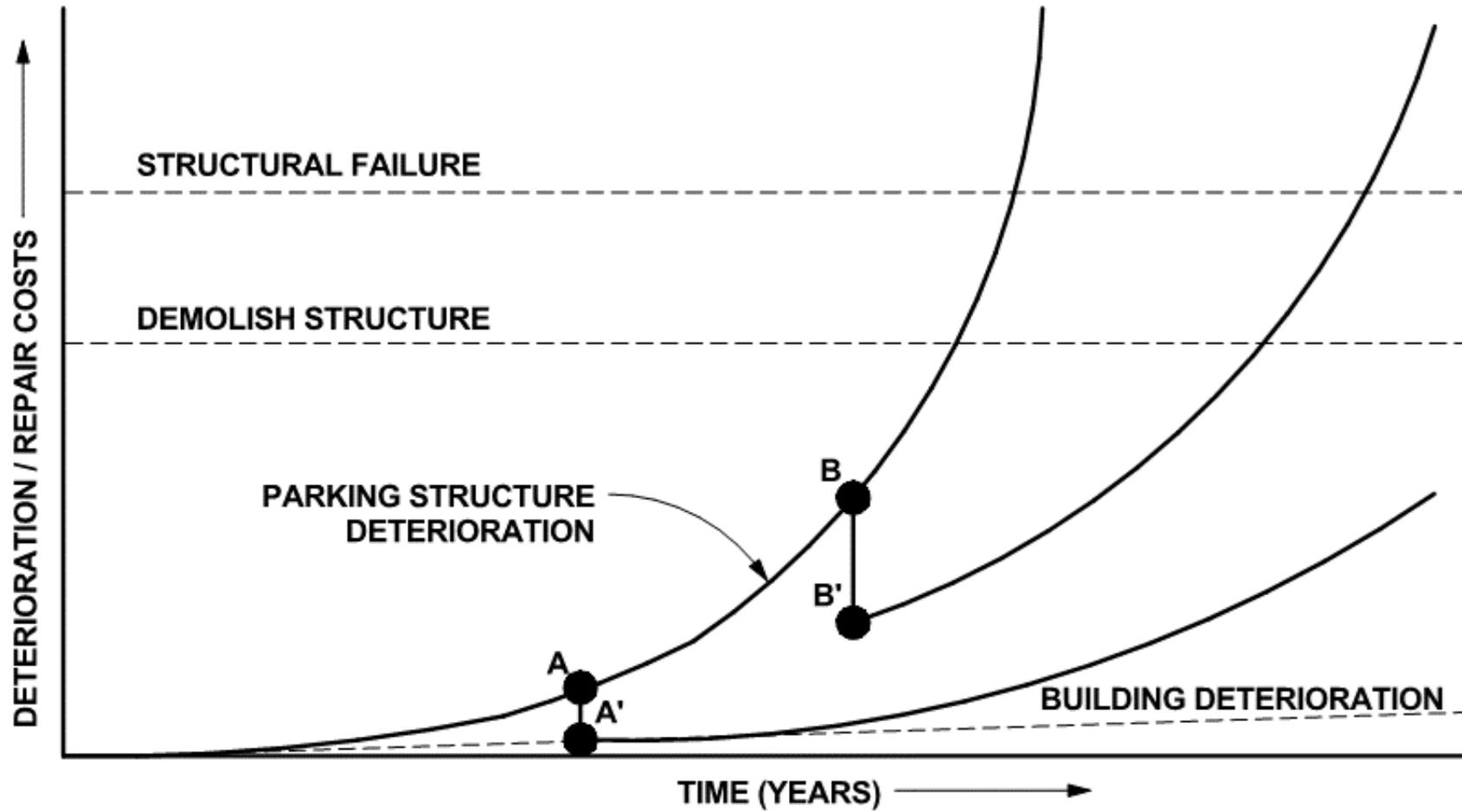
# Maintenance Cost Curve



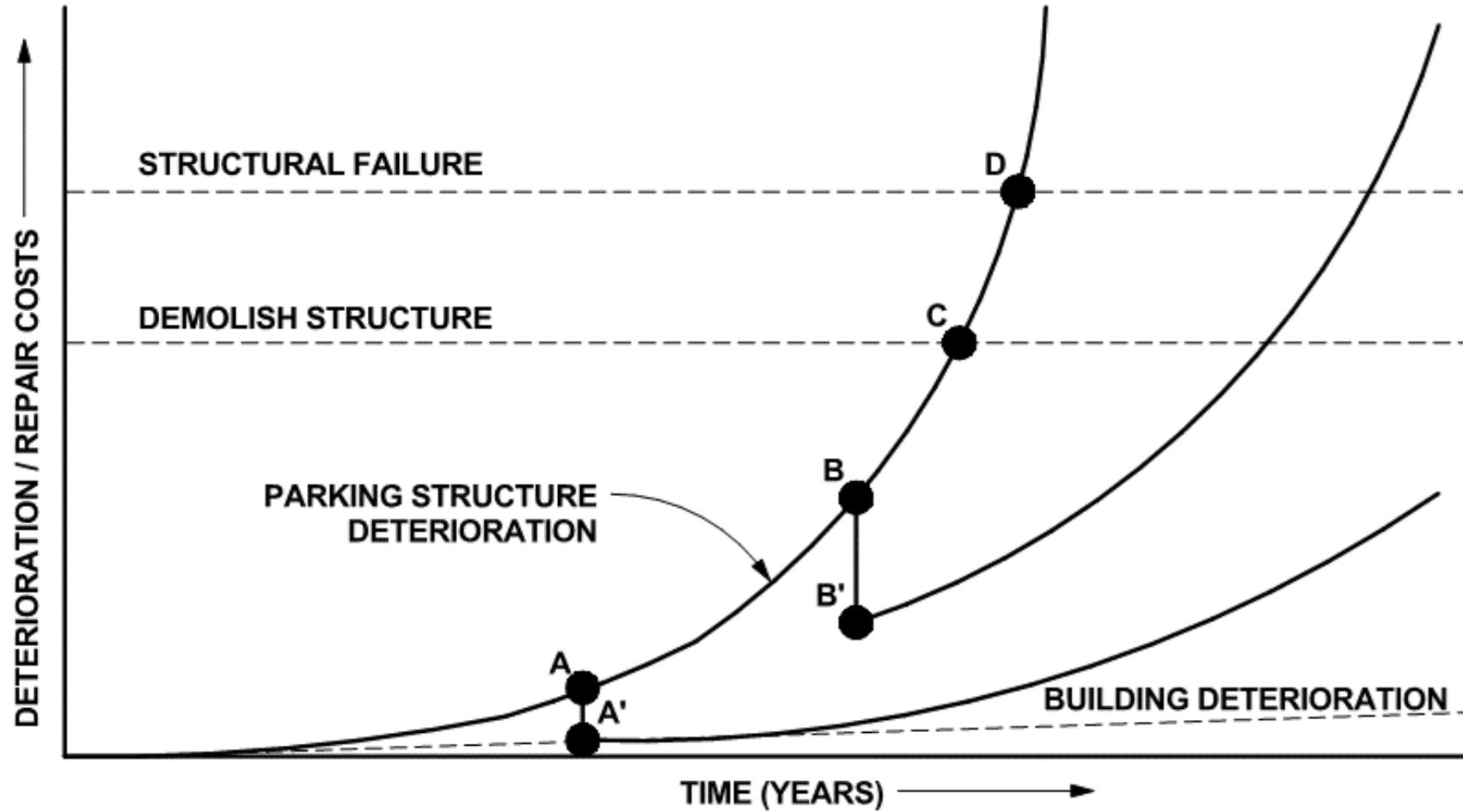
# Maintenance Cost Curve



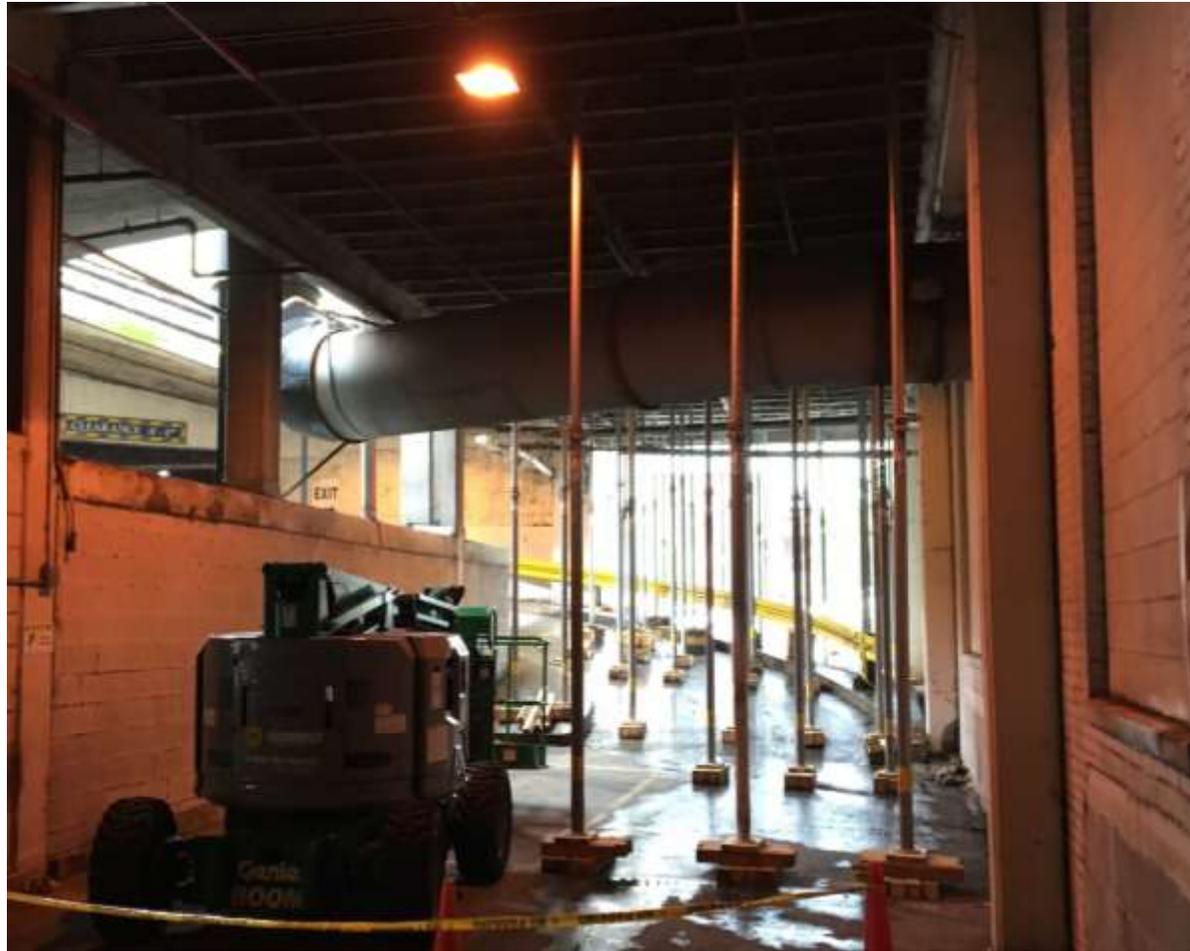
# Maintenance Cost Curve



# Maintenance Cost Curve



# Reactive Maintenance



Parking Structure Maintenance

# Maintenance Program: Planning

The image displays three overlapping forms used for parking structure maintenance planning:

- FORM F-1: MAINTENANCE MANUAL AND PROGRAM DAILY OPERATIONAL CHECKLIST PARKING STRUCTURE**
  - Owner: \_\_\_\_\_
  - City, State: \_\_\_\_\_
  - CLEANING**
    - Pick up trash
    - Sweep elevator
    - Sweep stair treads
    - Sweep office area
    - Wash entry park
    - Remove graffiti
  - SNOW PLOW REMOVAL**
    - Remove snow
    - Apply sand and salt
  - DRAINAGE**
    - Clean off floor drains
    - Squeegee ponds
  - INSPECTION**
    - Check for trip hazards
  - NOTES AND CORRECTIVE ACTION: \_\_\_\_\_
- FORM F-2: MAINTENANCE MANUAL AND PROGRAM DAILY OPERATIONAL CHECKLIST PARKING STRUCTURE**
  - 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**
  - Inspector: \_\_\_\_\_
  - Date: \_\_\_\_\_
  - 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

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# Questions?

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