

The Truth About Parking Structure Maintenance How to Protect Your Investment



Presented By:
Innovative Engineering Inc.

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Learning Objectives

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

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- **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?



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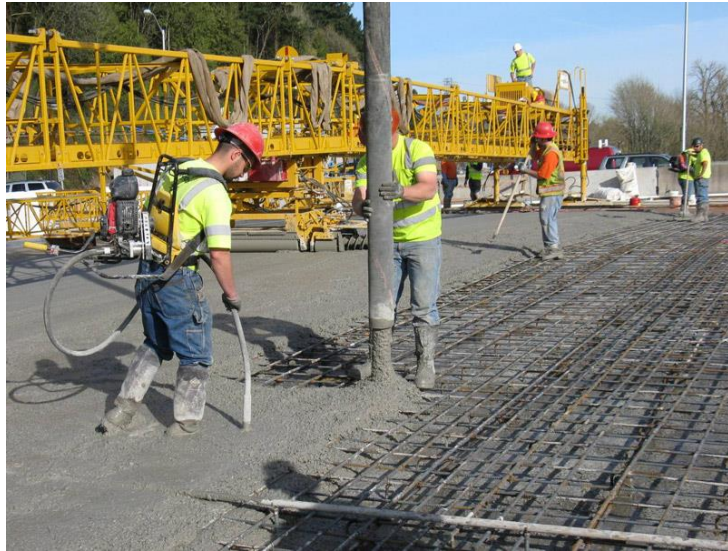


- **Trey Thomas PE**
 - **BSCET, Southern Polytechnic State University**
 - **16 Years in Design and Restoration Engineering**
 - Co-author of Parking Structure & Forensic articles
 - **Certified in Mold, Lead & Asbestos Surveying**
 - **OSHA Competent Person for Boom & Scissor Lifts**
 - **SPRAT Level 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)**



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	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**

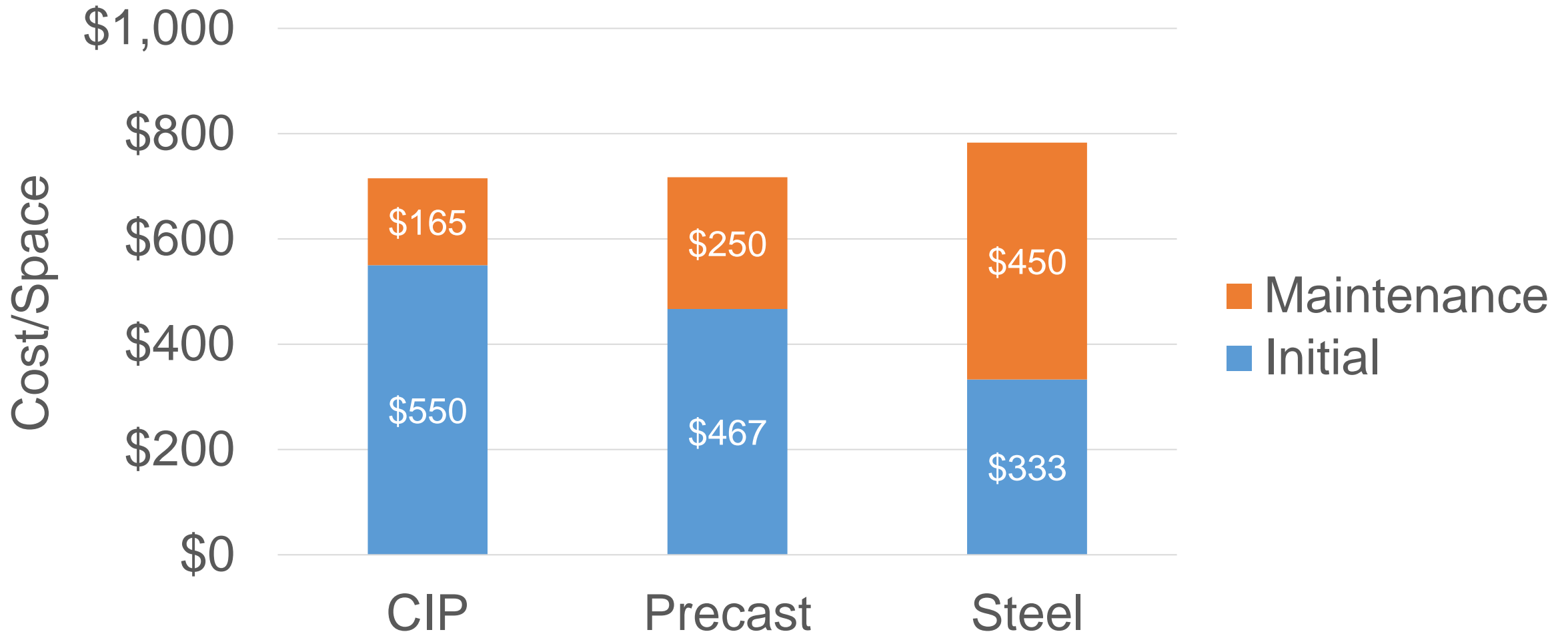
- May be no local plant
- Geometry not Flexible
- Lower Perceived Ceiling heights
- Shearwalls (Closed In)
- More Joints
- Prone to Thermal Expansion & Contraction Damage
- Corrosion of Steel Embedments
- Higher Maintenance Costs

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

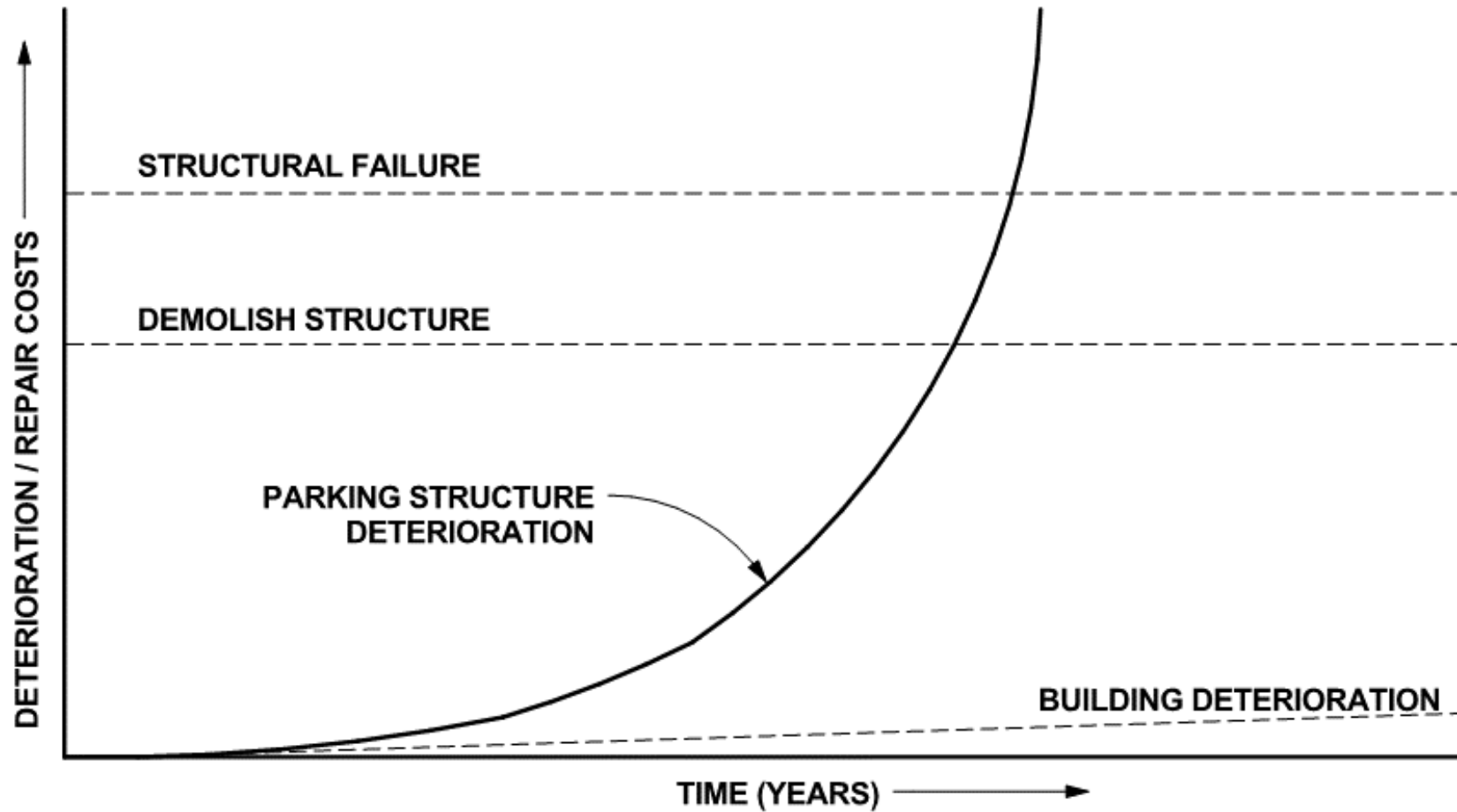


Parking Structures



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

Structure Degradation



Irving Texas, O'Conner Ridge Blvd. Collapse



Parking Structure Maintenance

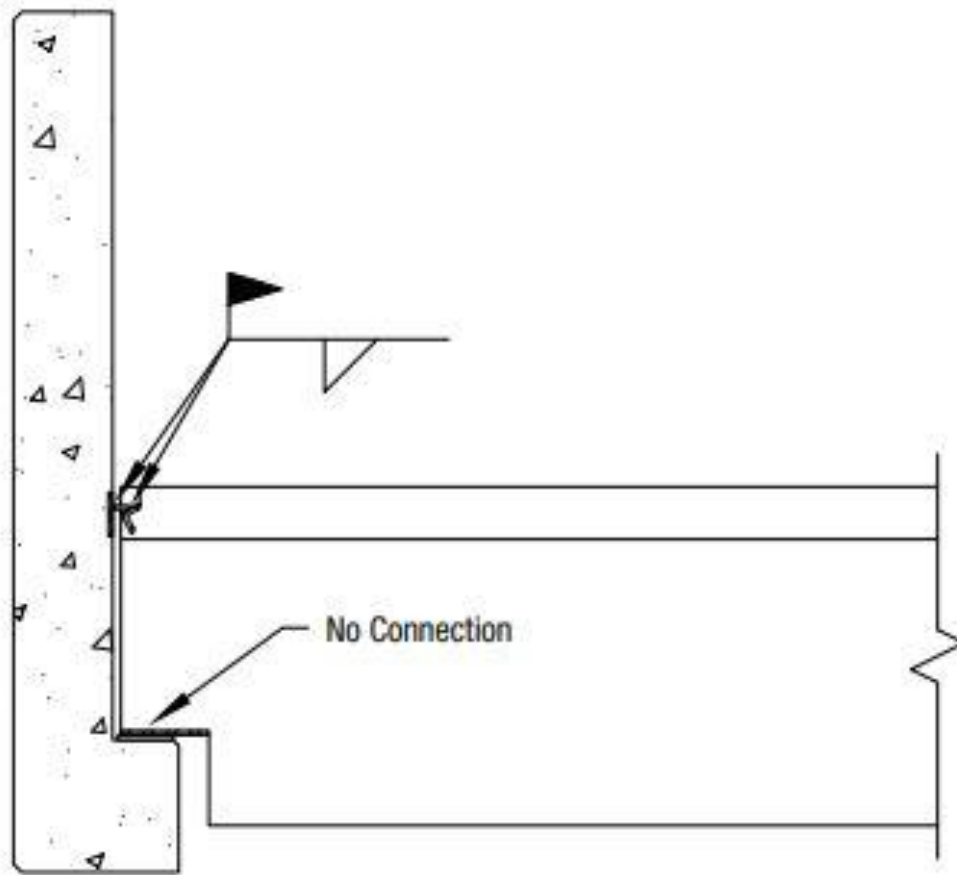
Irving Texas, O'Conner Ridge Blvd. Collapse



• 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

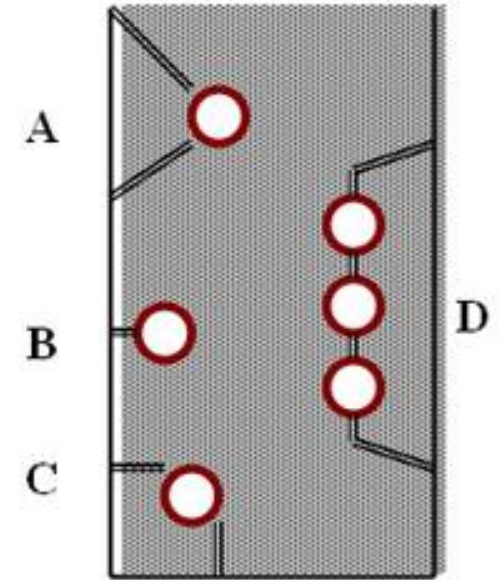
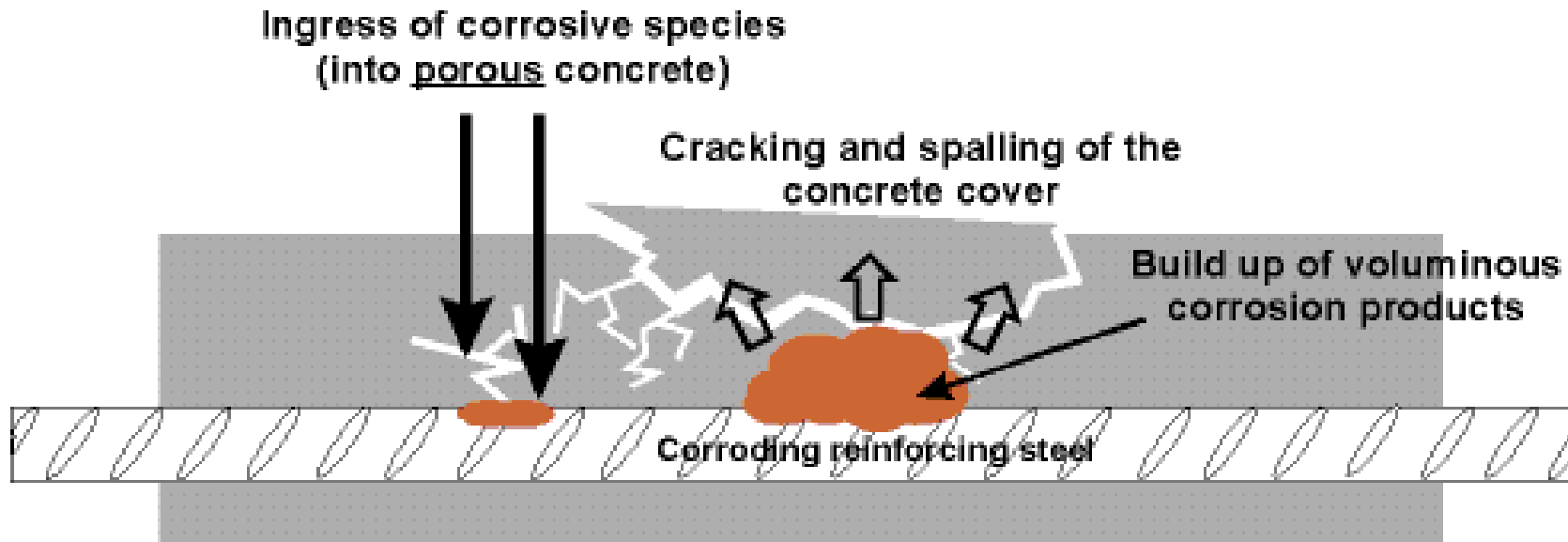
Common Deficiencies

- **Number 1 Enemy**



WATER

Common Deficiency: Corrosion



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

Common Deficiency: Spall & Delamination



Spall



Delamination



Section Loss

Common Deficiency: Exterior Spalls



Spall Over Sidewalk



Spall Size

Common Deficiency: Ponding



Ponding



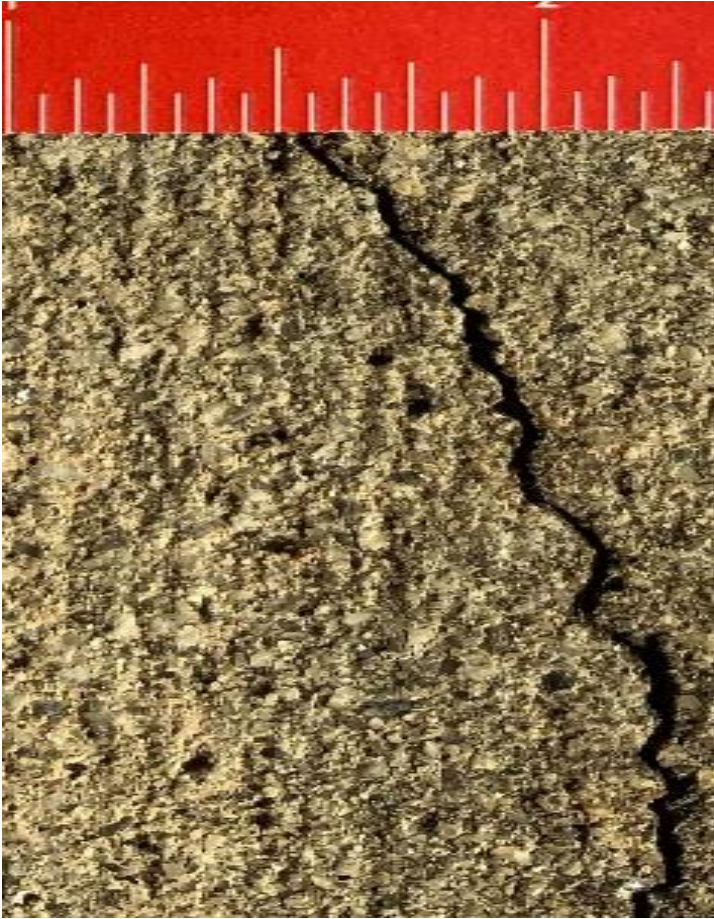
Supplemental Drain

Common Deficiency: Failed Joints



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

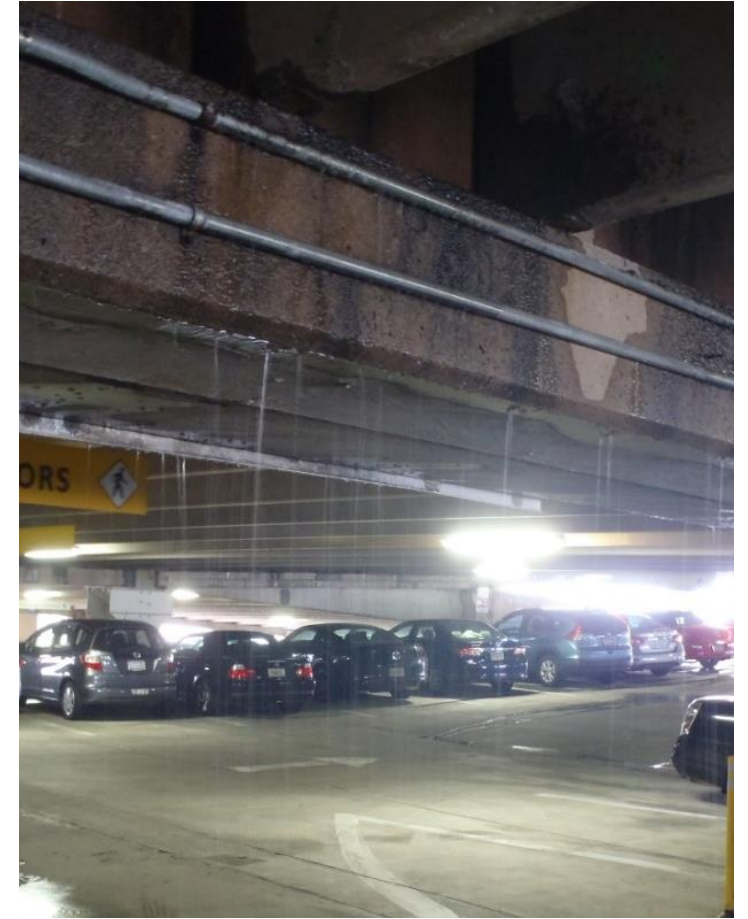
Common Deficiency: This is Why



Sealant Failure

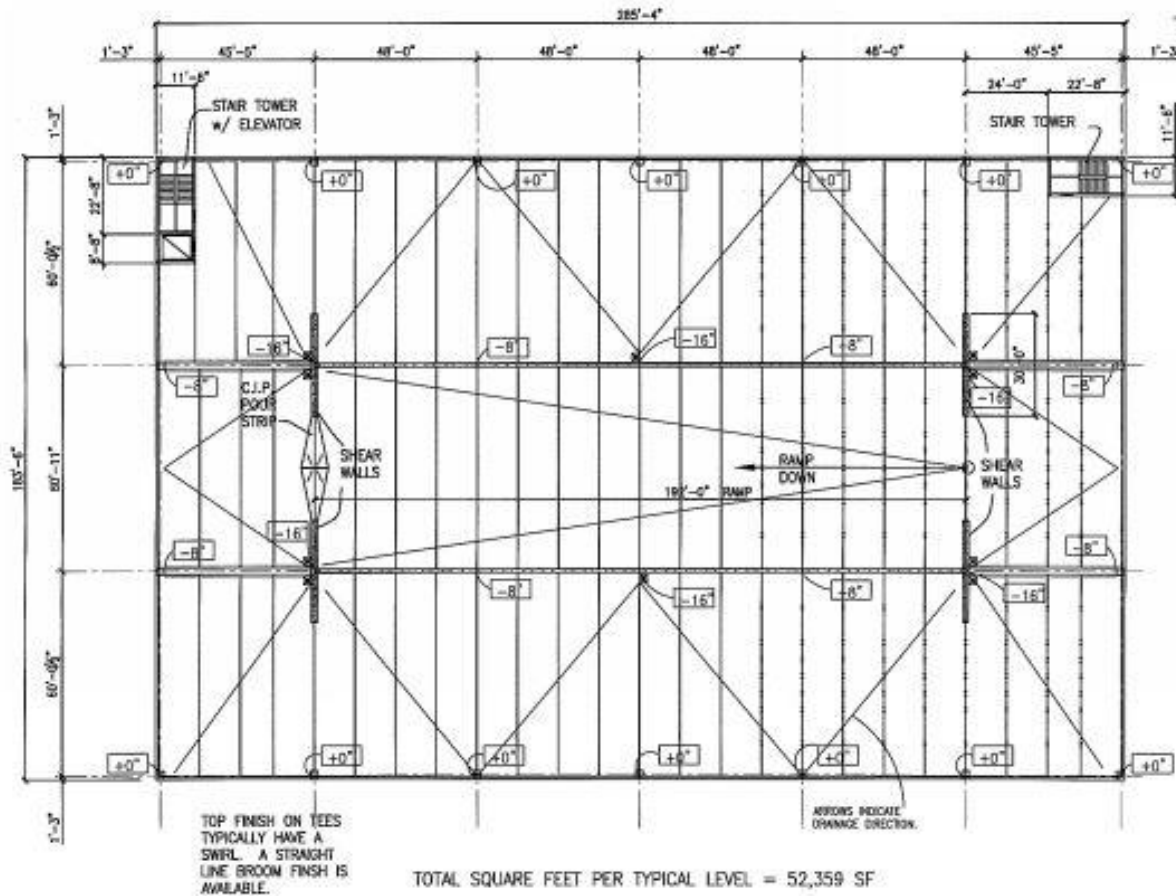


Cracks



Expansion Joint Failure

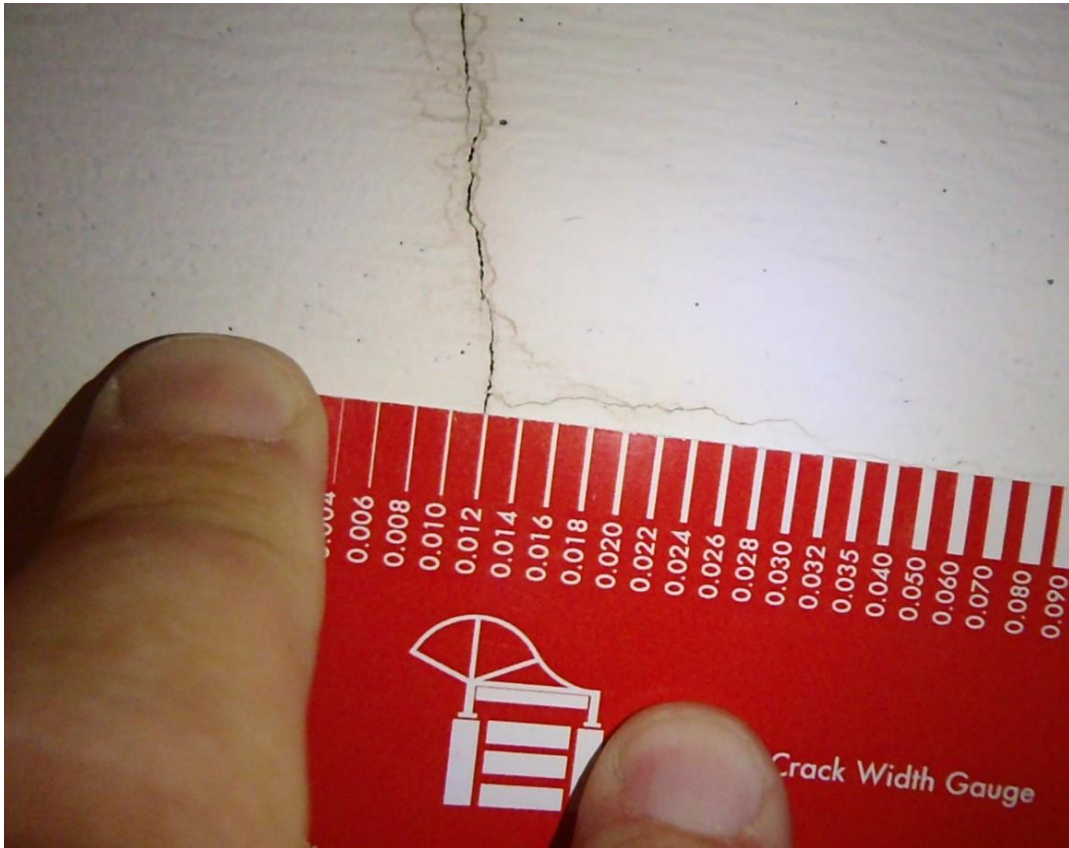
Common Deficiency: Failed Joint Sealant



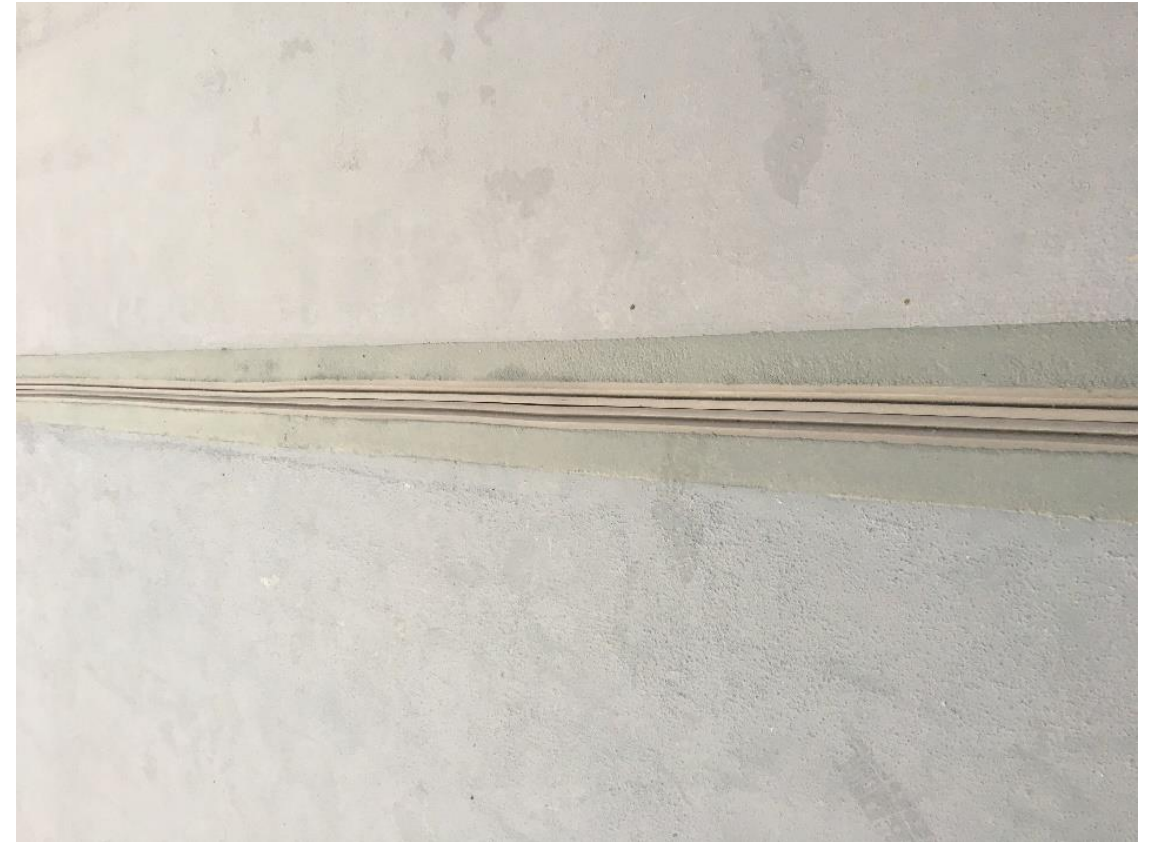
Drainage & Joint Plan

- **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: Cracks to be Sealed



$.013'' \leq \text{Cracks} < .035''$



Cracks that Leak $< .035''$

Common Deficiency: Epoxy Injection



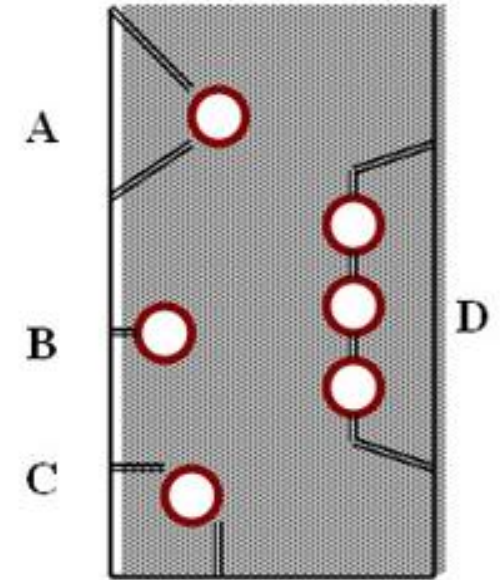
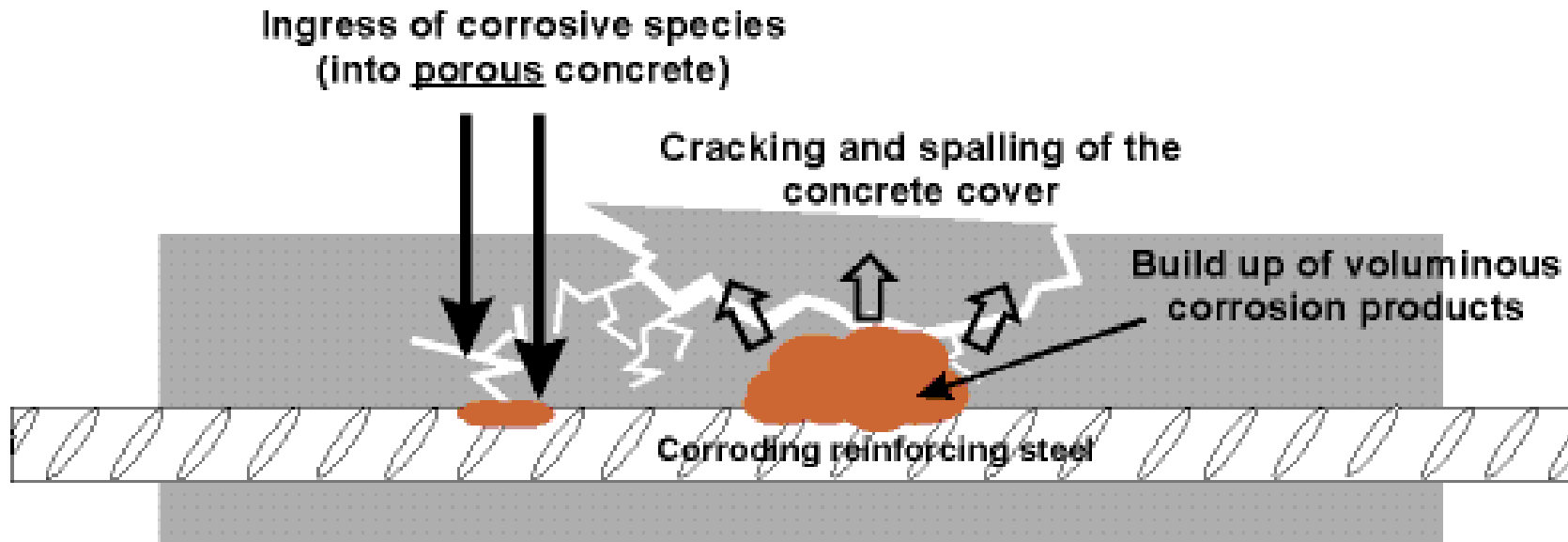
Cracks $\geq .035''$

Photos by Engineered Restorations Inc.



Inflatable Injection Port

Common Deficiency: Corrosion



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

Common Deficiency: Sounding



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: Failed Spall Repair



Improper Surface Preparation

Common Deficiency: Overloaded – Fire Truck

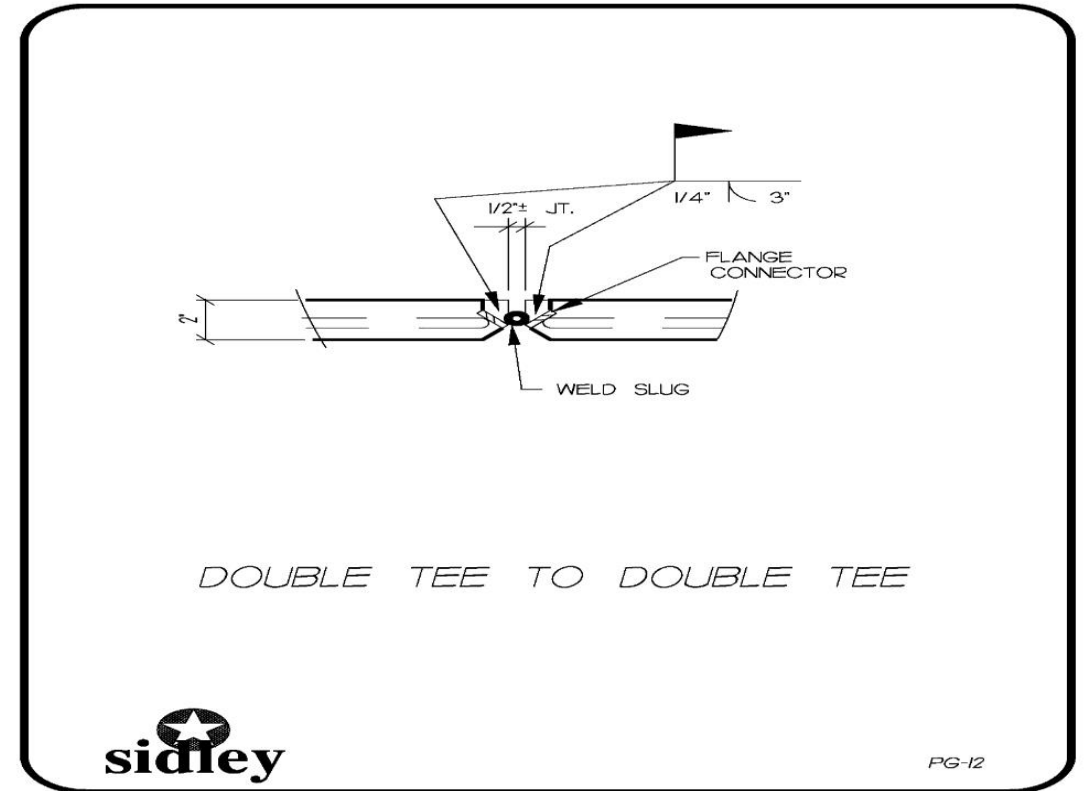


Broken Precast Spandrel Beam

Common Deficiency: Curbs & Wheel Stops



Broken Curb



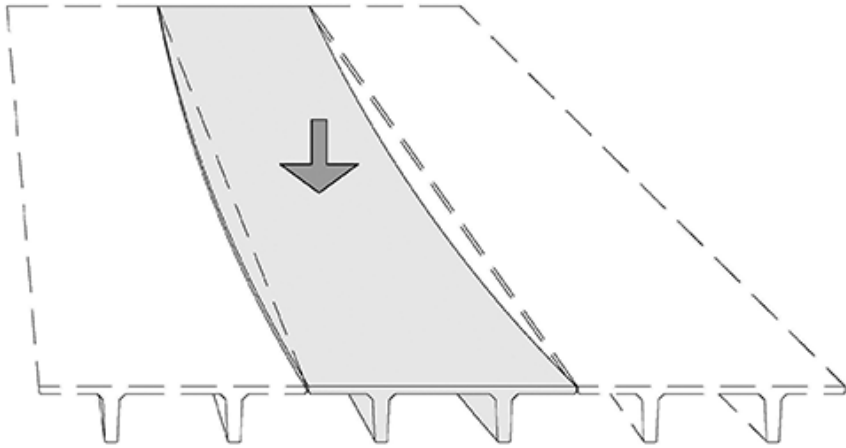
Broken Wheel Stop

Precast Shear Transfer Repair



Parking Structure Maintenance

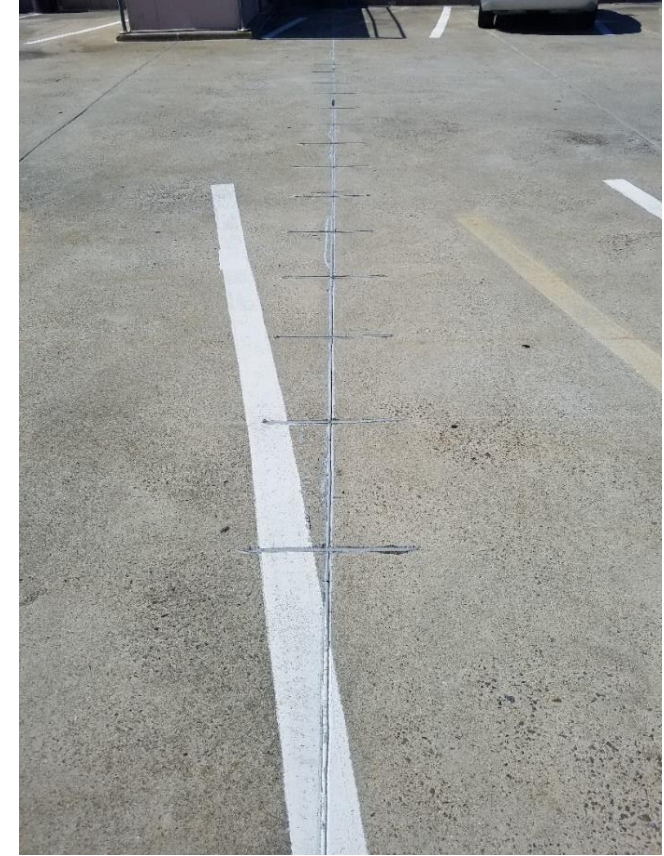
Precast Shear Transfer Repair



Precast Double Tees



Shear Transfer



Repair

Structural Steel Corrosion



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

Precast Haunch Connection Failure

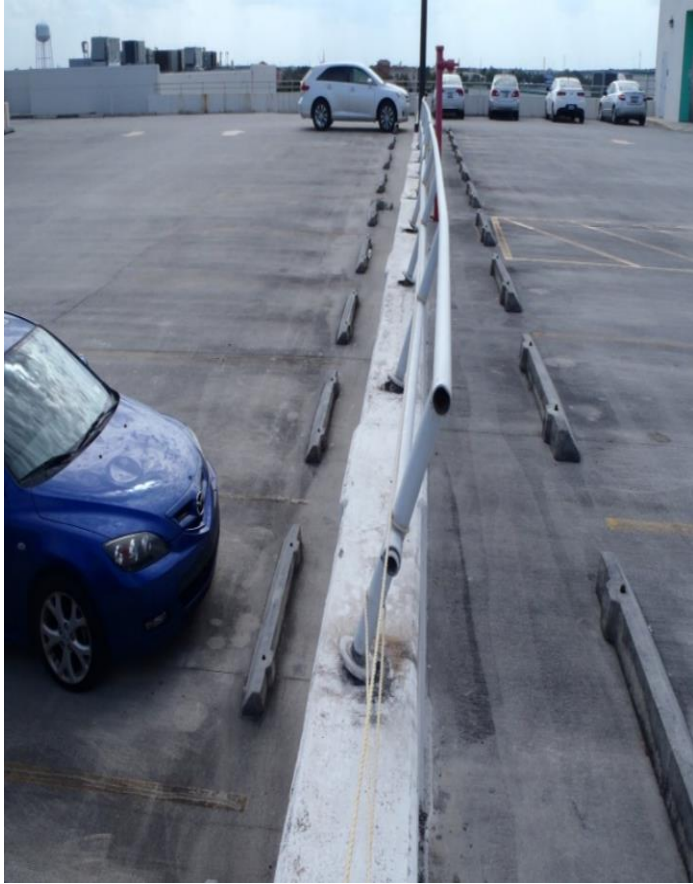


Precast Beam Haunch



4 Months Later

Precast Haunch Connection Repair



Shoring to Remove Load



Applying Epoxy Bonding Agent

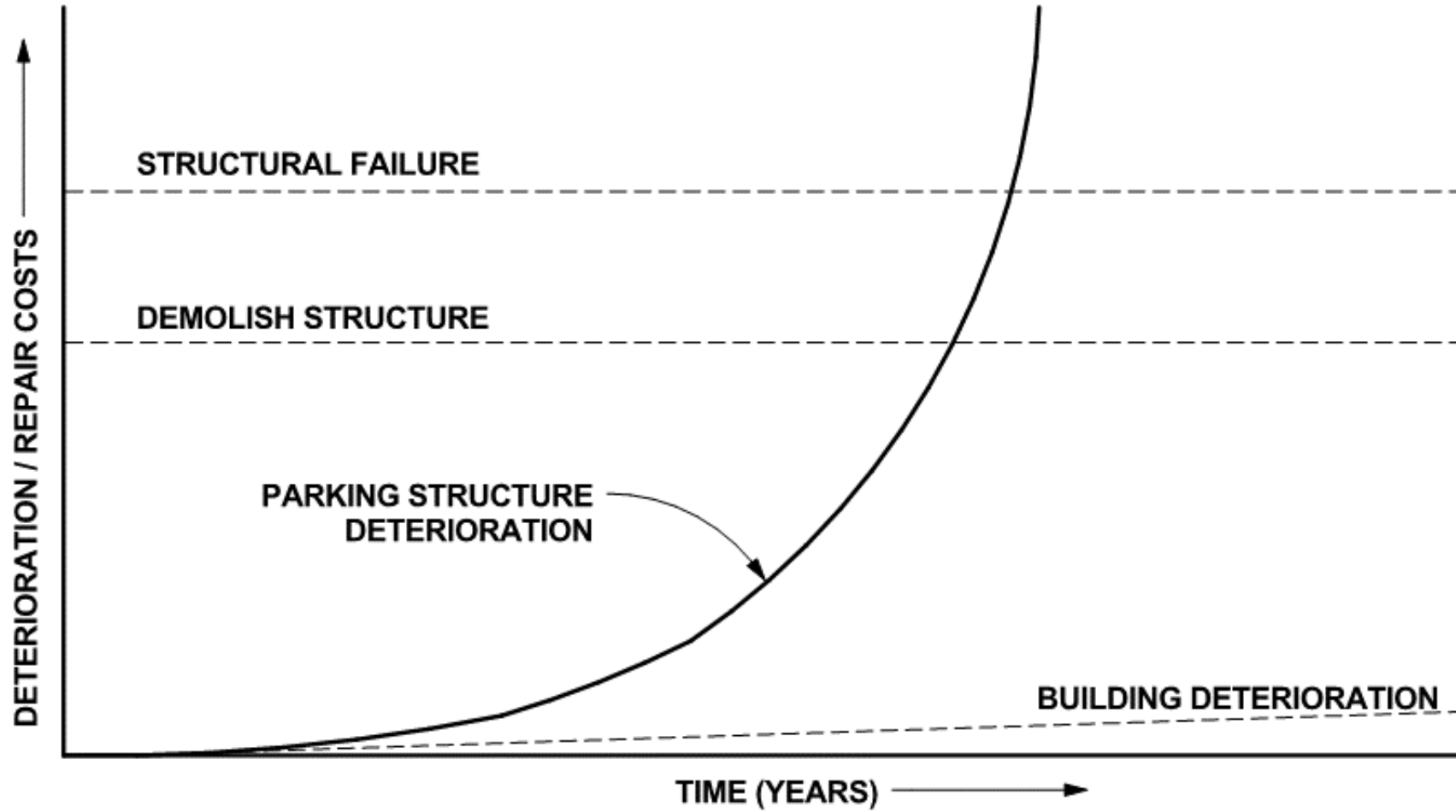
Photo by Engineered Restorations Inc.

Precast Haunch Connection Finished Repair

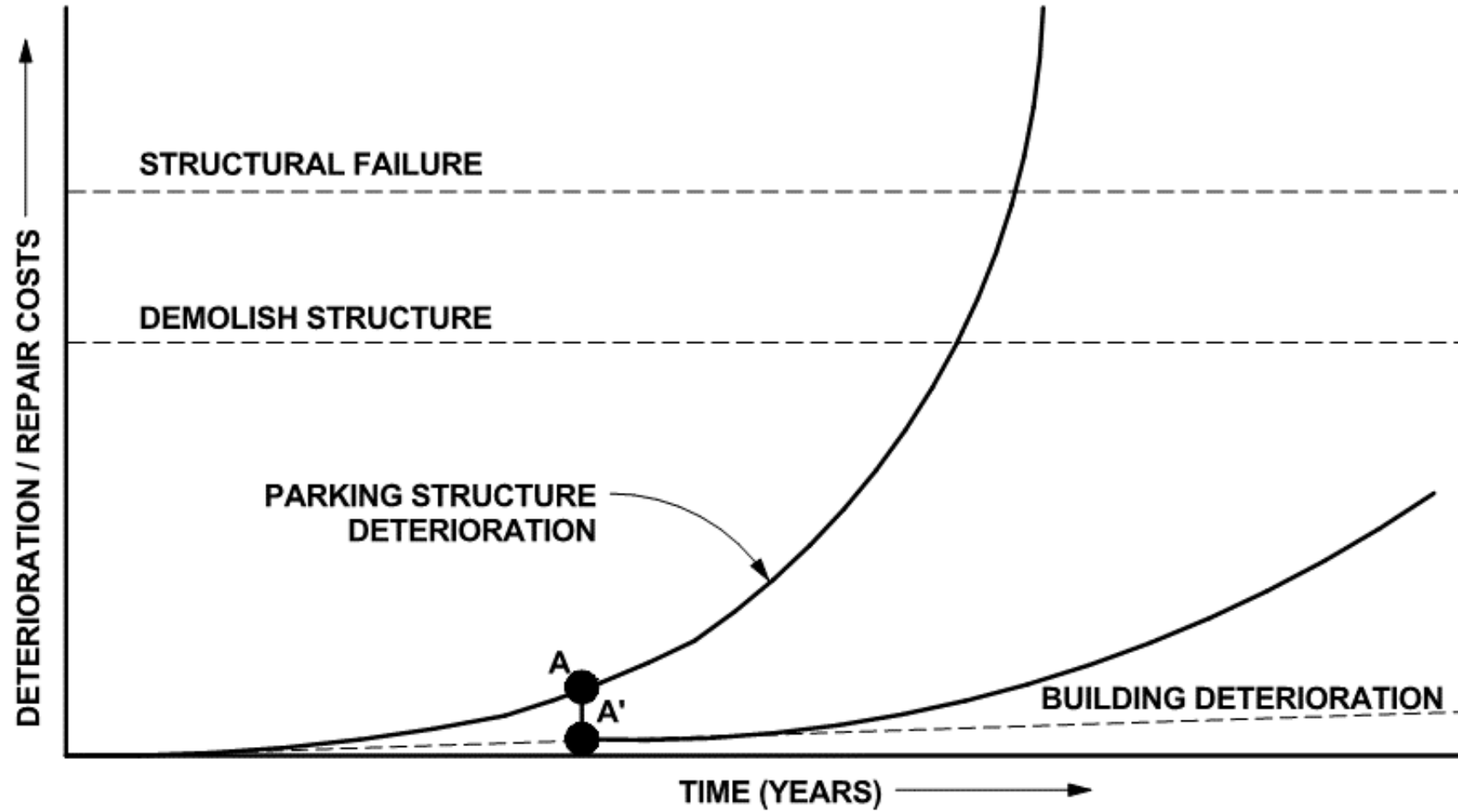


Good as New

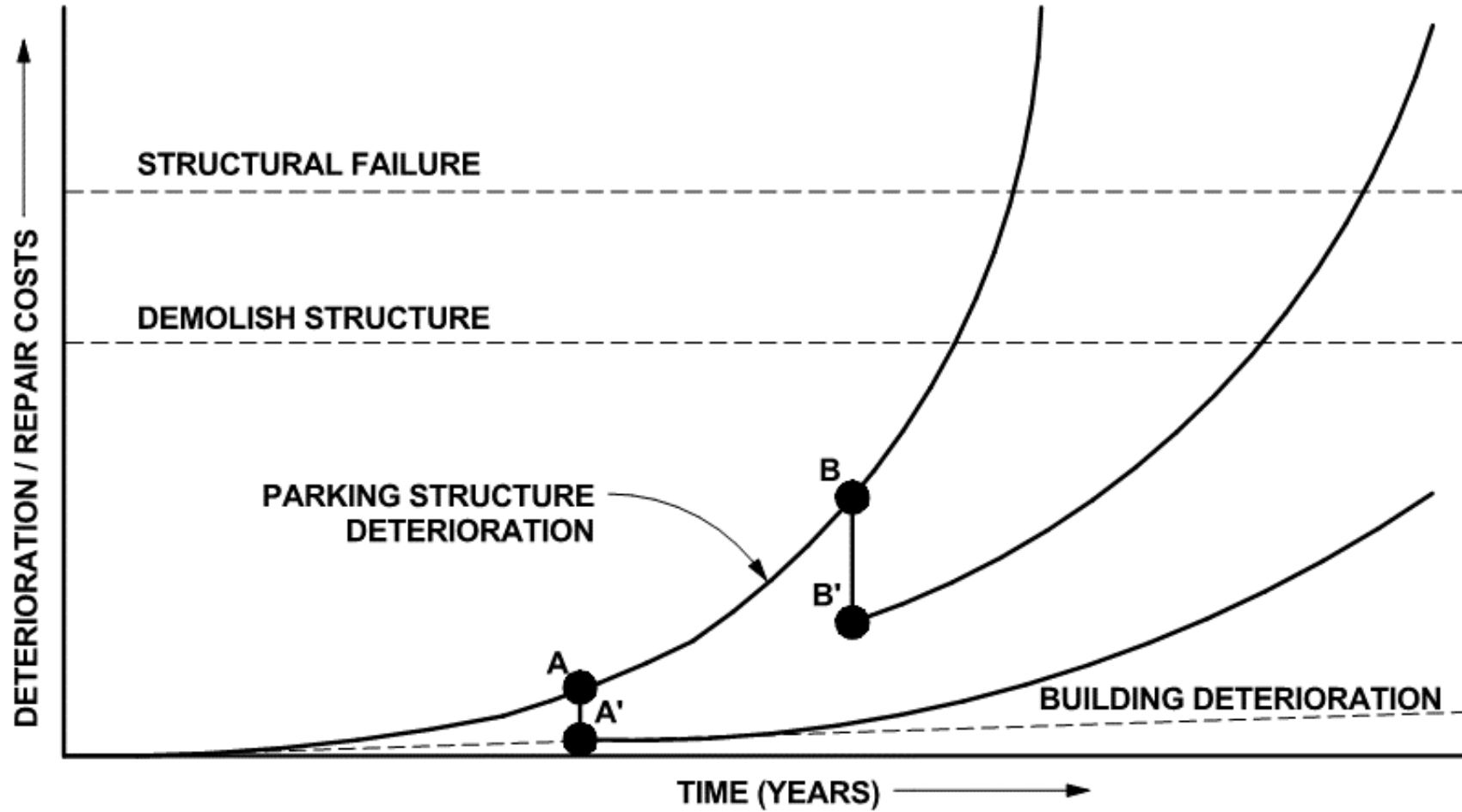
Maintenance Cost Curve



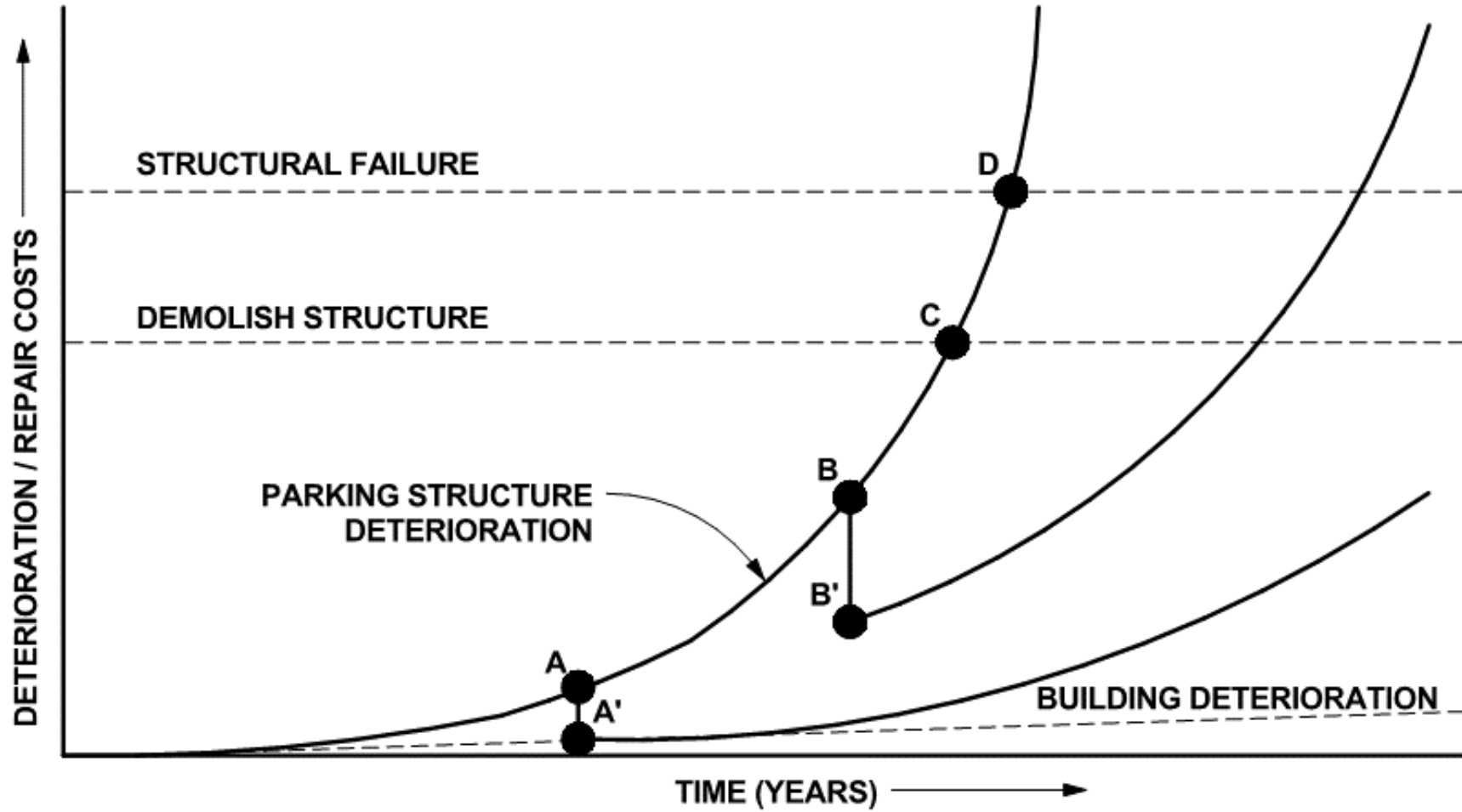
Maintenance Cost Curve



Maintenance Cost Curve



Maintenance Cost Curve



Reactive Maintenance



Now Demolished

Parking Structure Maintenance

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Questions?

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