

# Successful Approach to the Repair of Reinforced Concrete Support Structures in Delayed Coking Units

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November 11, 2015

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# Structure Elements of Interest within Delayed Coking Units

- Octagonal or Circular Penetrations
- Switch Deck
- Head Deck
- Columns
- Beams
- Coke Pits
- Sluiceways & Railroad Tracks
- Anchorages



# Coker Unit – Common Industry Problems

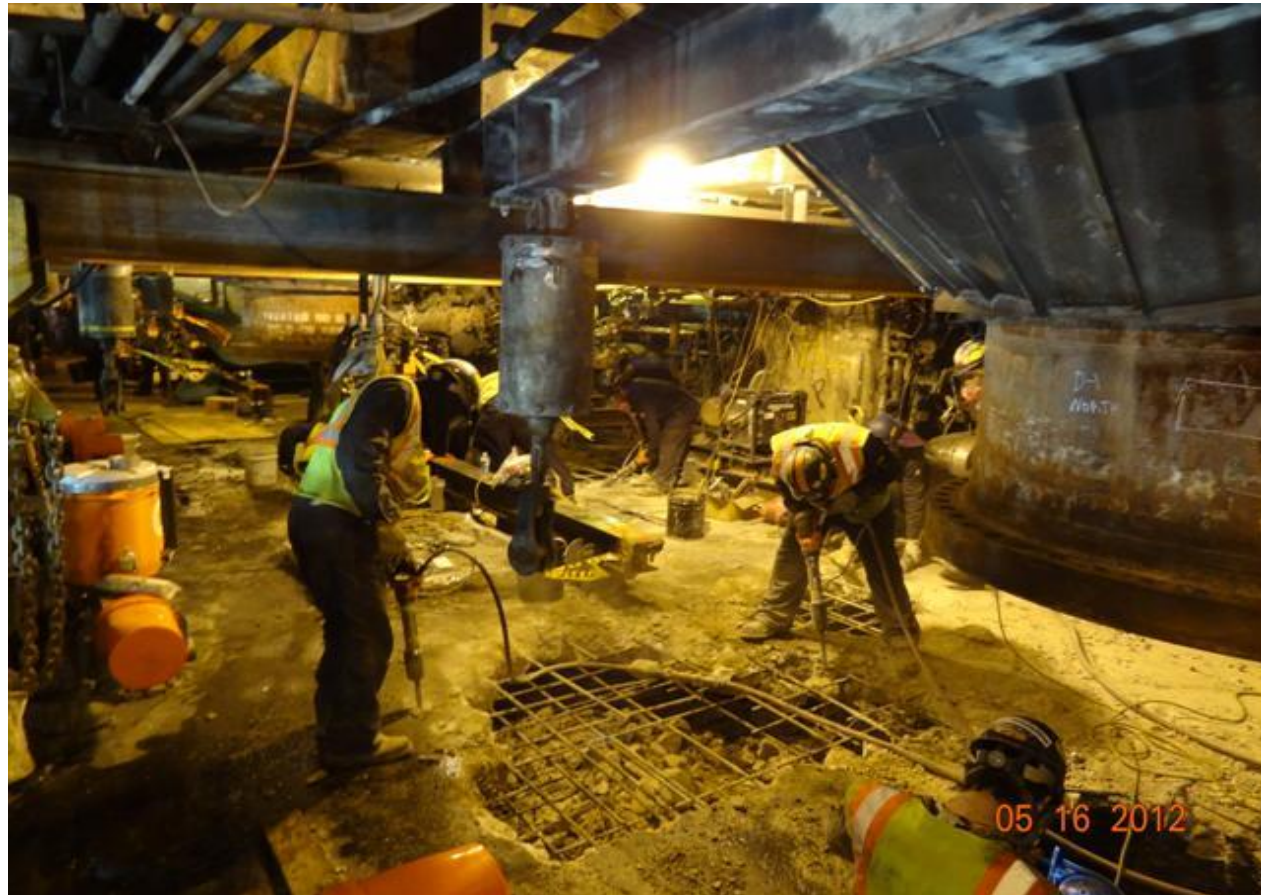
- Coker Octagonal or Circular Slab Penetration





# Coker Unit – Common Industry Problems

- Coker Head Deck



# Coker Unit – Common Industry Problems

- Coker Columns





# Coker Unit – Common Industry Problems

- Anchor Bolts



# Coker Unit – Common Industry Problems

- Grouting





# Coker Unit – Common Industry Problems

- Coke Pits





# Coker Unit – Common Industry Problems

- Coke Chute



# Coker Unit – Common Industry Problems

- Coke Pit Floor



TIMELAPSE CAMERA V.1.0 2011/12/26 14.02.36

# Coker Unit – Common Industry Problems

- Coker Railway & Sluiceway





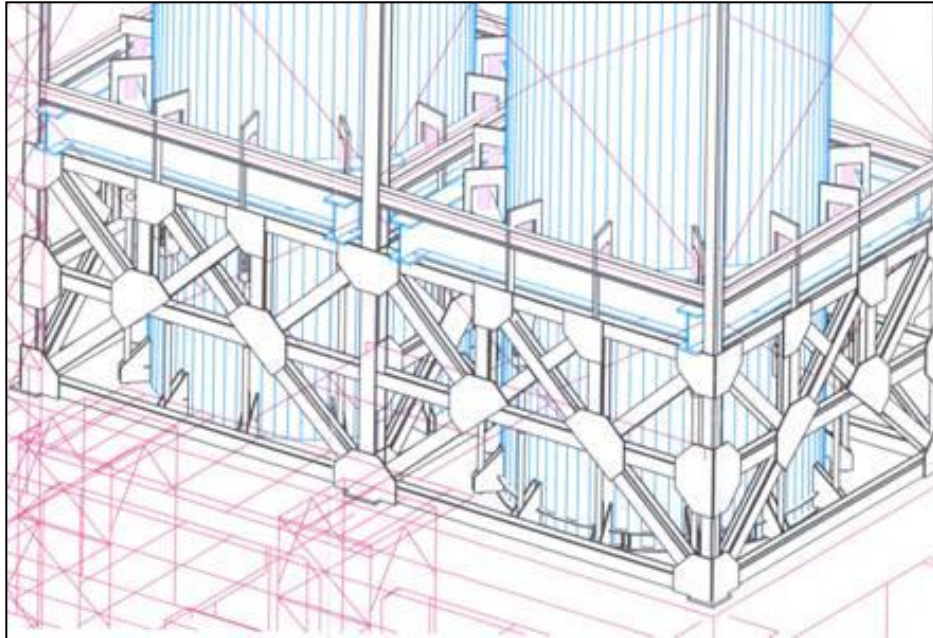
# Coker Unit – Common Industry Problems

- Coker Fireproofing



# Coker Unit – Common Industry Problems

- Supporting Coke Drums





# Coker Unit – Common Industry Problems

- Material Selection

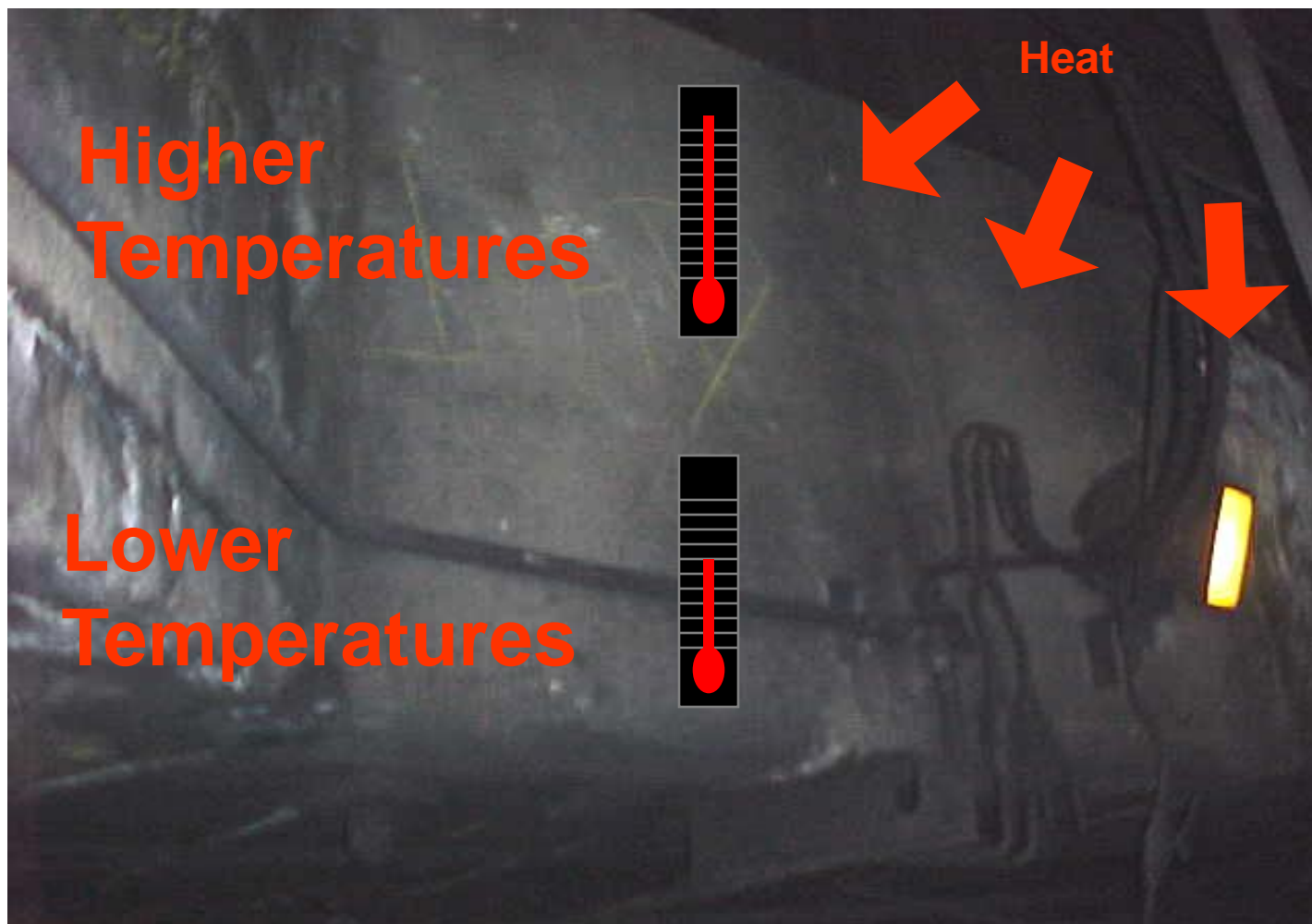




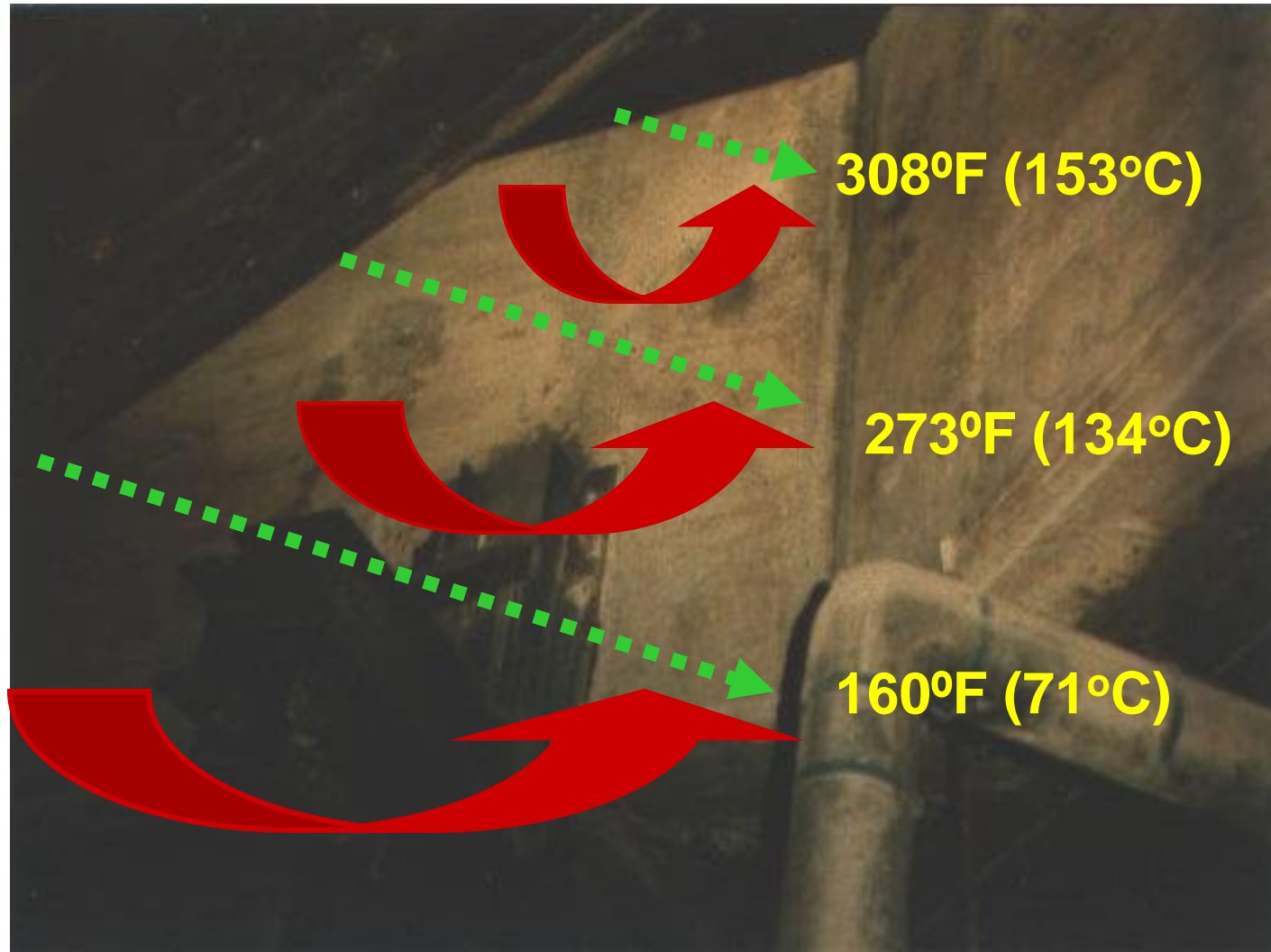
# Deterioration & Damage Mechanisms

- Elevated Temperatures
- Mass Concrete Shrinkage
- Dynamic Loading
- Impact Damage
- Fire Damage
- Corrosion-Induced Deterioration
- Failed Patch Repairs

# Thermocouple/Infrared Thermometer Readings

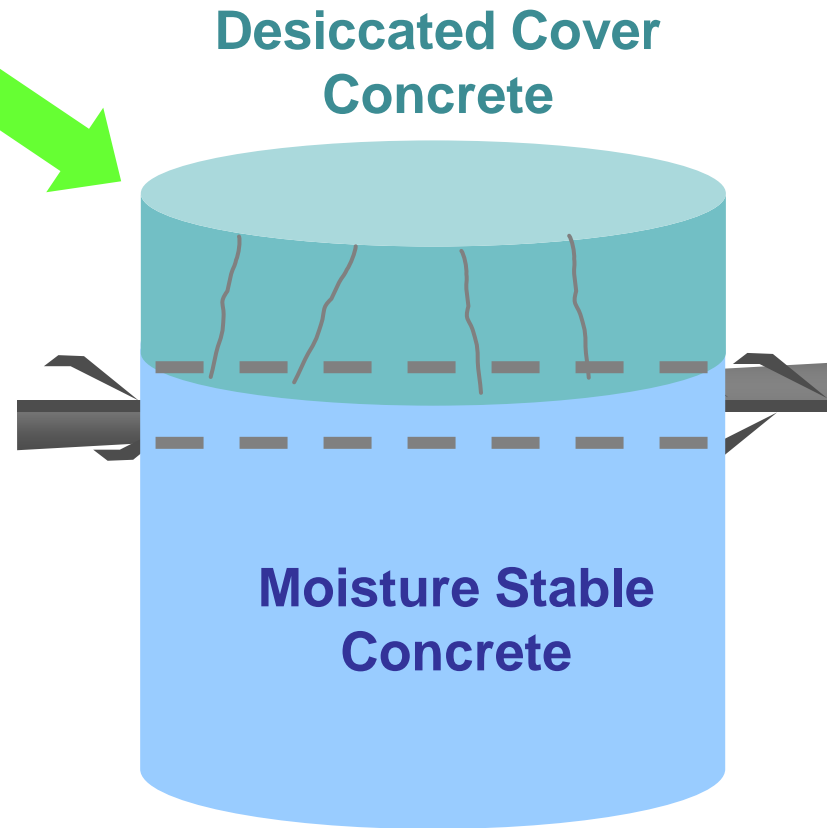
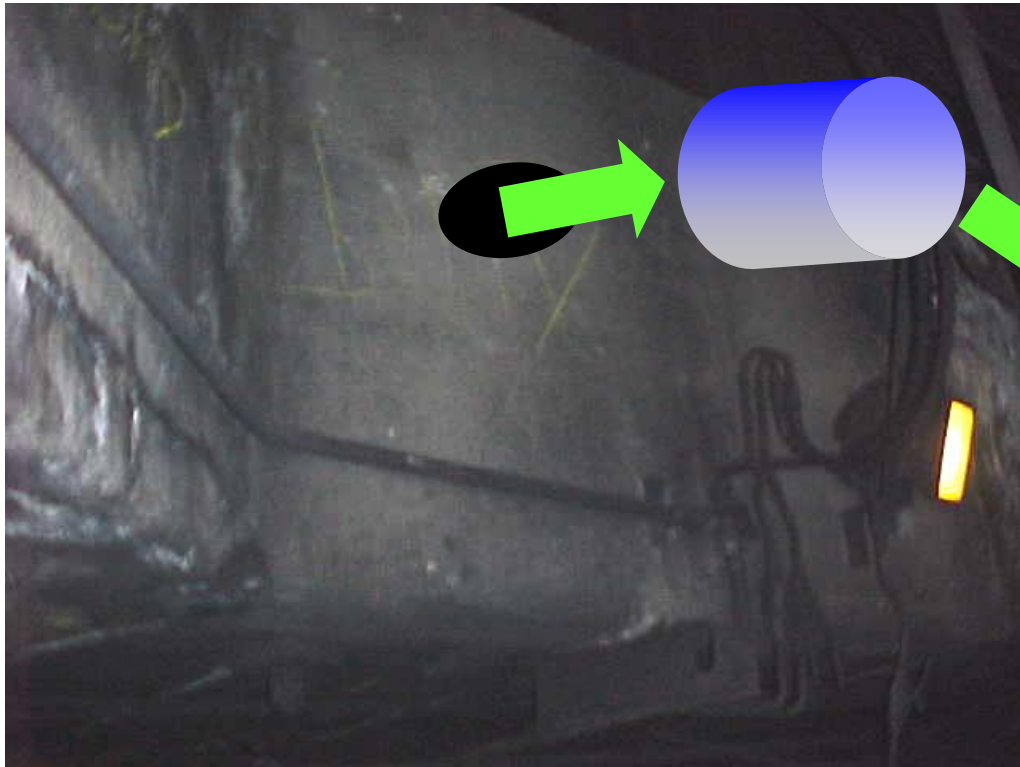


# Measured Temperatures on Octagonal or Circular Penetration Faces



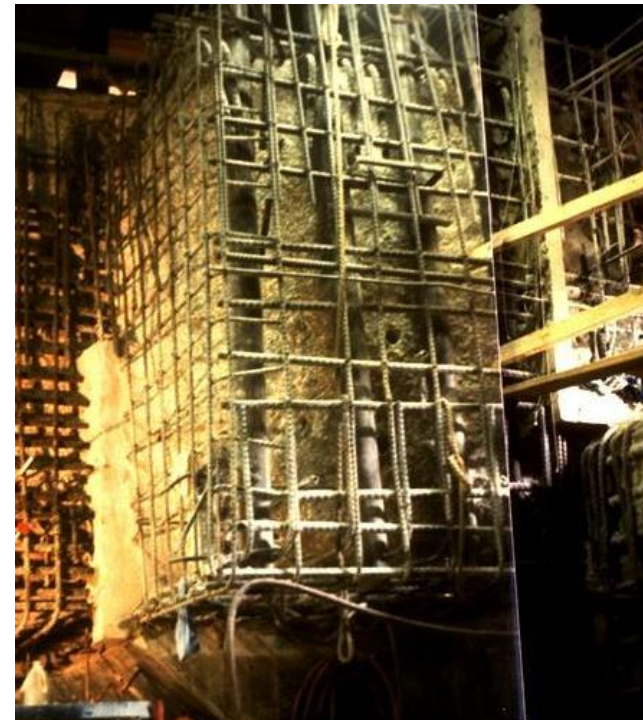


# Microcracking of Cover Concrete



# Fire Damage

- Aggregate swells
- $\text{H}_2\text{O}$  to steam
- Chemical change



# Impact Damage

- Impact of steel bucket edge on Coke Pit Walls and Basin
- Front-end loaders on Basin

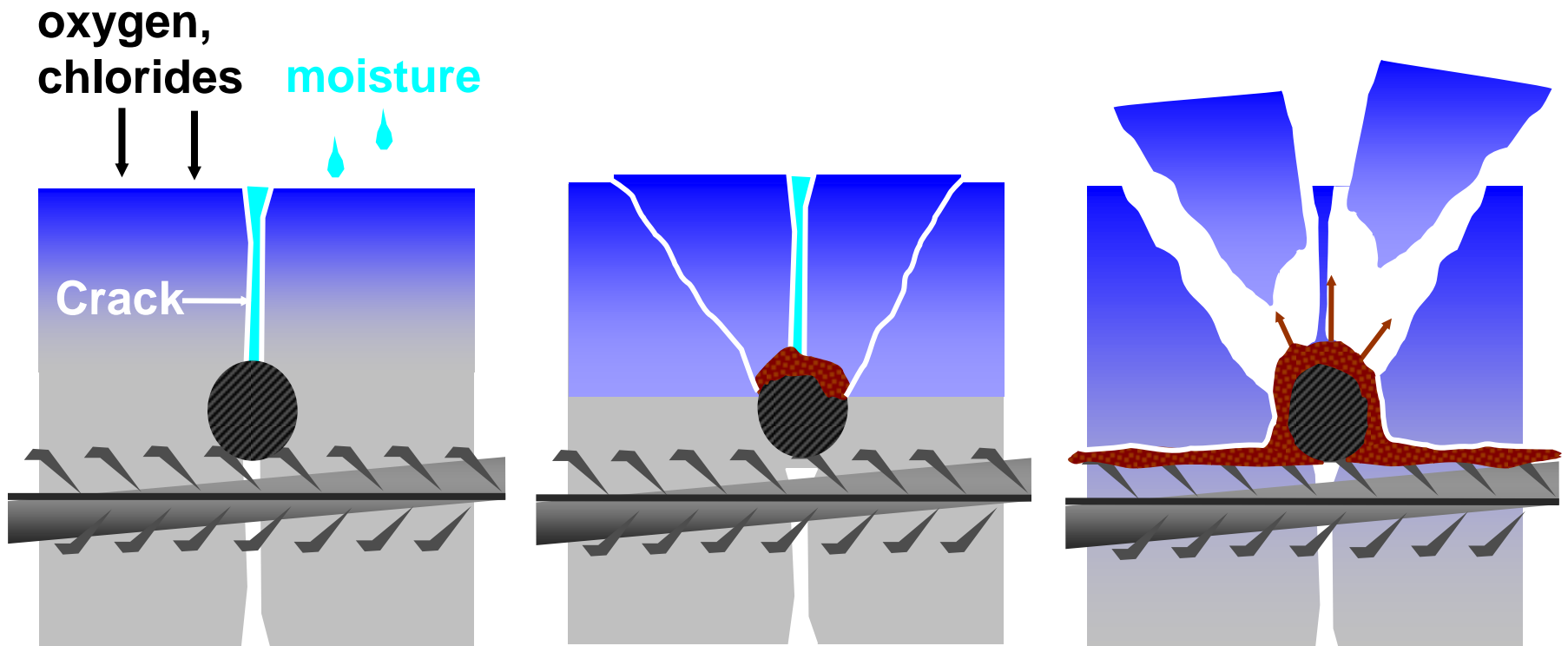




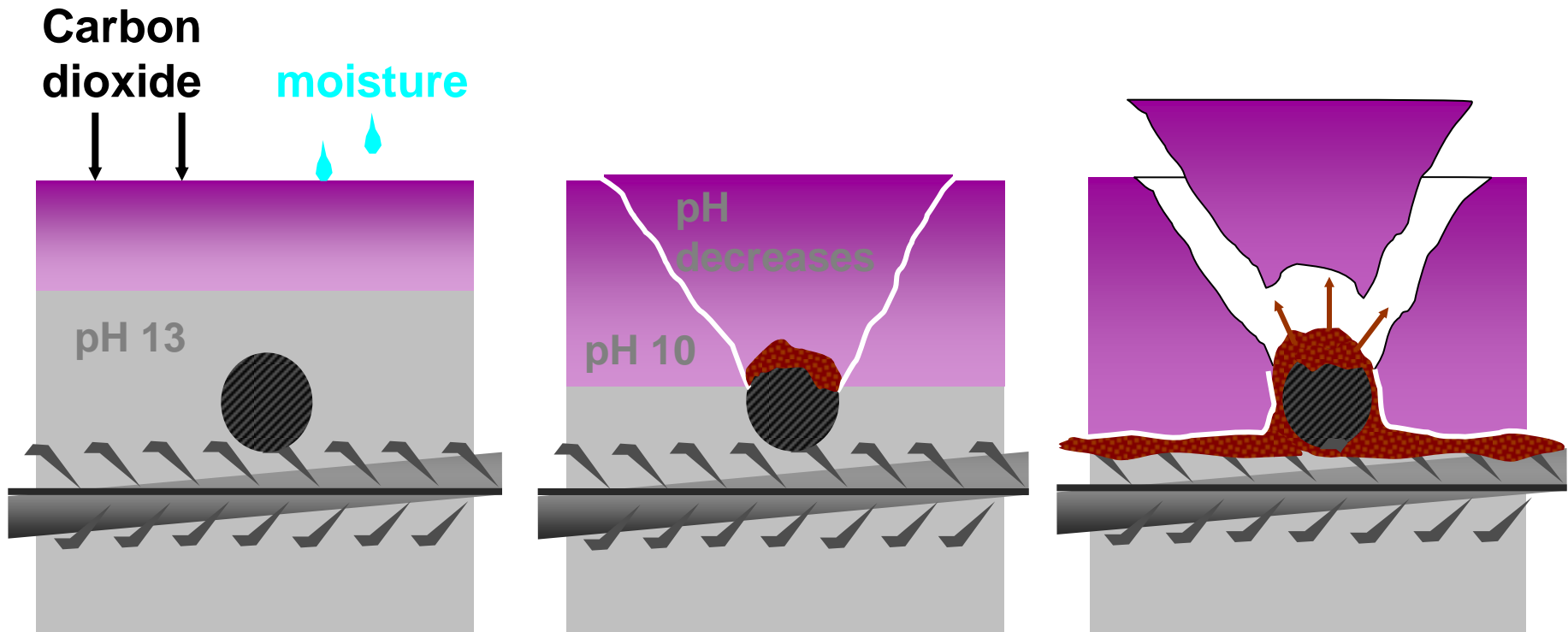
# Factors Leading to Corrosion within Coke Drum Support Structures

- Cast-in-chlorides
- Air-borne chlorides
- High temperature
- Moist/wet conditions inherent to process
- Shortcut access of elements through cracks
- High concentration of CO<sub>2</sub>

# Chloride-Induced Corrosion



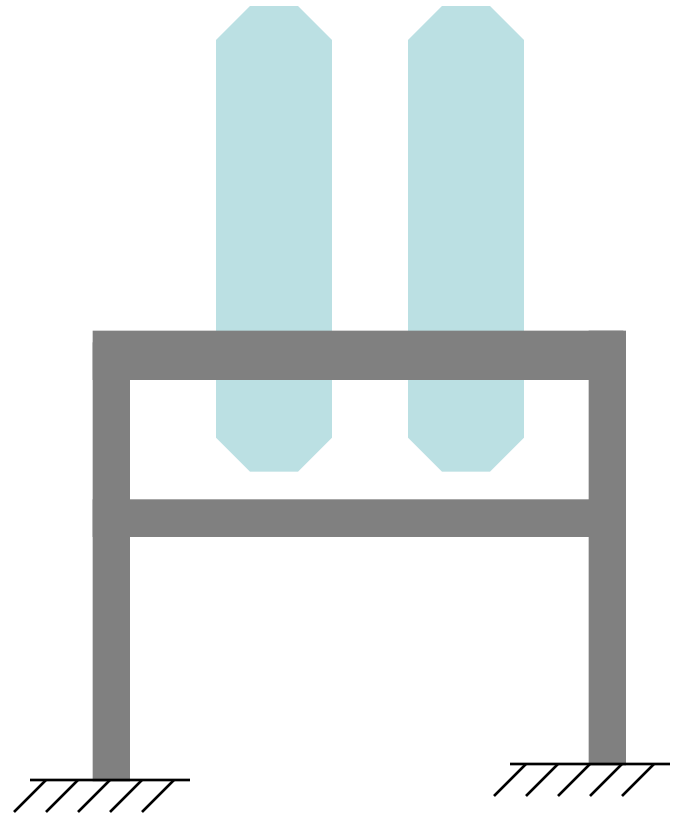
# Carbonation-Induced Corrosion



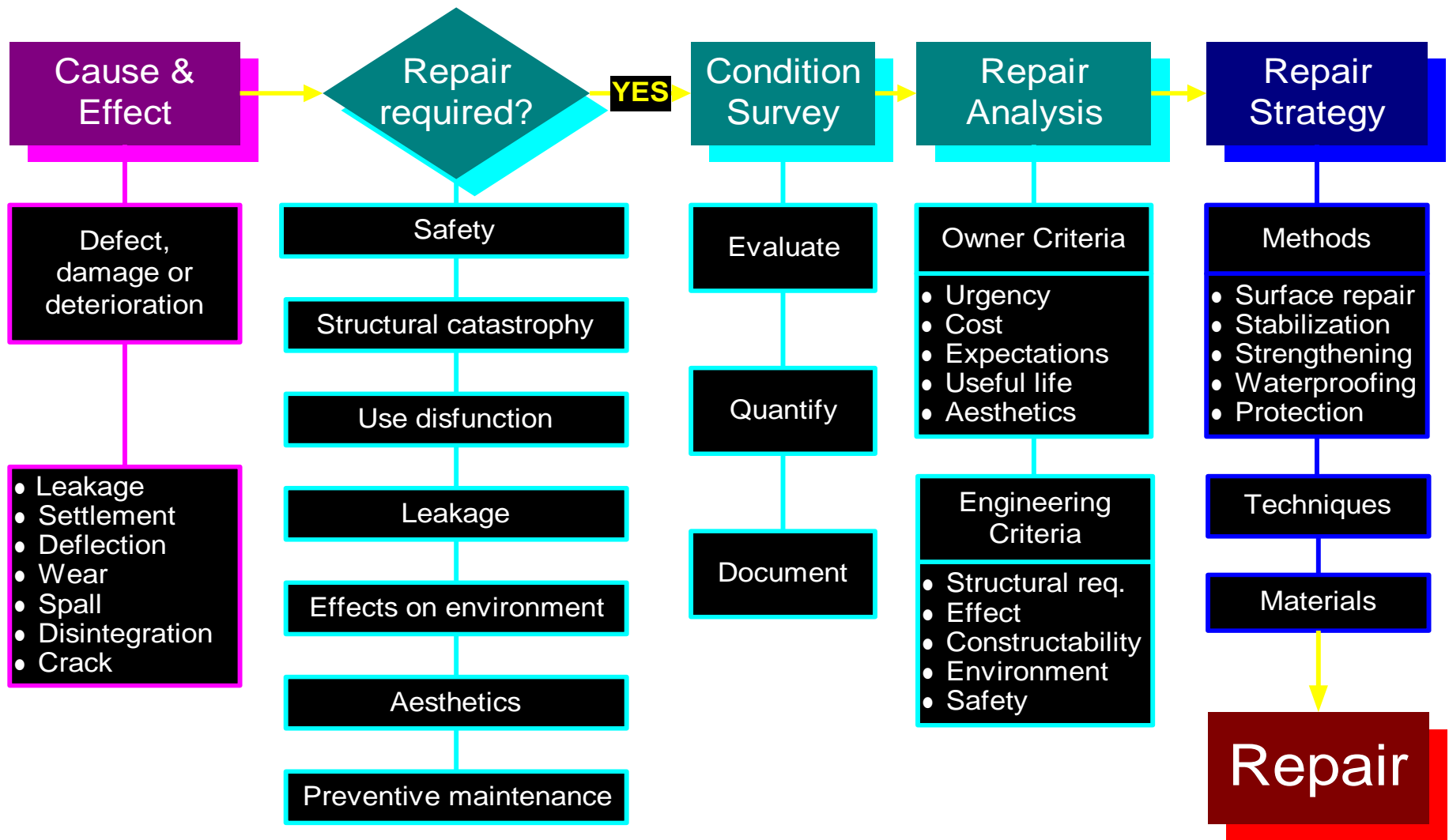


# Critical Unit Event Scenarios

- Dynamic & Vibration Process Loading
- Explosion/Fire
- Hurricane/Tornado
- High Winds
- Earthquake



# Concrete Repair is a Process!



# Fast-Track & Turn-Key Opportunity

- Condition Evaluation, Site Presentation & Order of Magnitude Repair Costs
- Engineering
- Repair & Rehabilitation
- On Line and/or Turnaround Repairs
- Quality Assurance & Quality Control



# Condition Survey

- Field Investigation
  - Visual Inspection - Site Survey
  - Acoustic Impact Testing
  - Rebound Hammer Testing
  - Pachometer/GPR Survey
  - Ultrasonic Testing (UPV and/or IE)
  - Sample Extraction
  - Anchor Bolt Testing
- Laboratory Tests
  - pH Testing and Carbonation Depth Determination
  - Chloride Ion Content
  - Compressive Strength Testing

# Condition Survey (continued)





# Anchor Bolt In-situ Testing

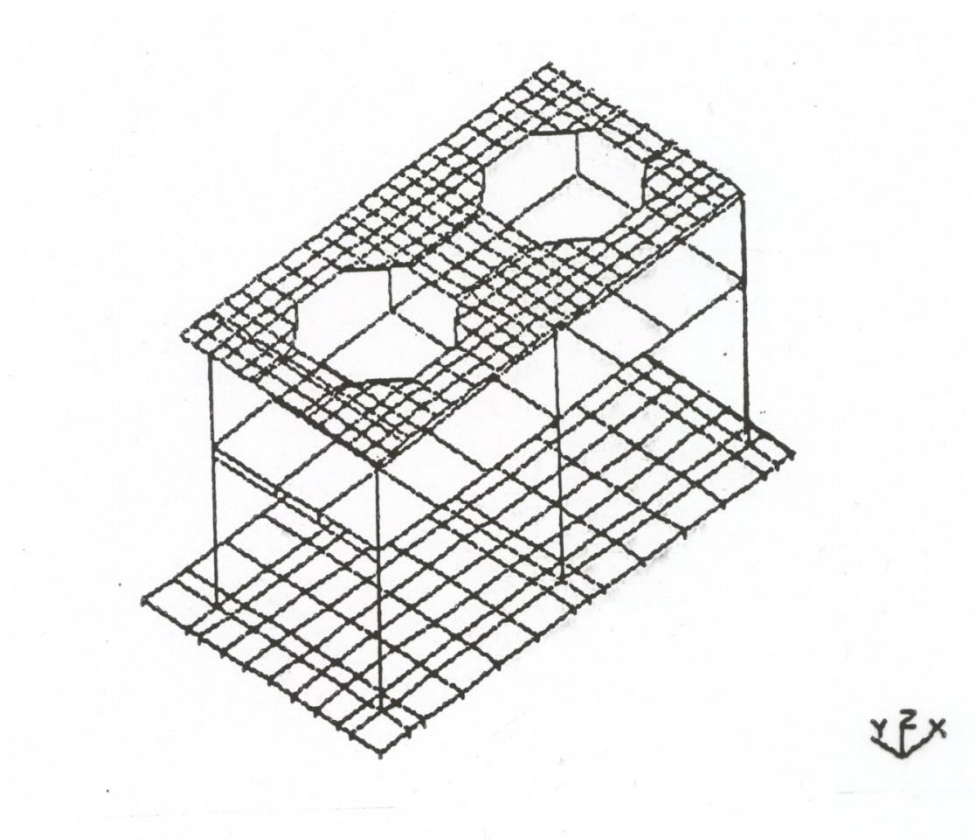


Employing Ultrasonic Technology – Anchor Bolt tops are ground smooth & plane. A Technician then attaches a Transducer to the prepared surface for a “flaw” detection reading.

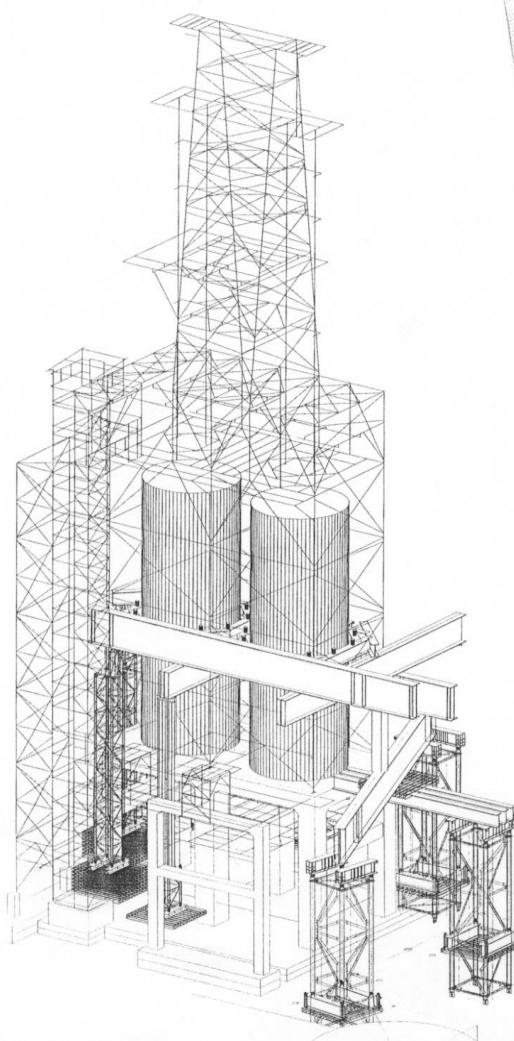




# Finite Element Analysis

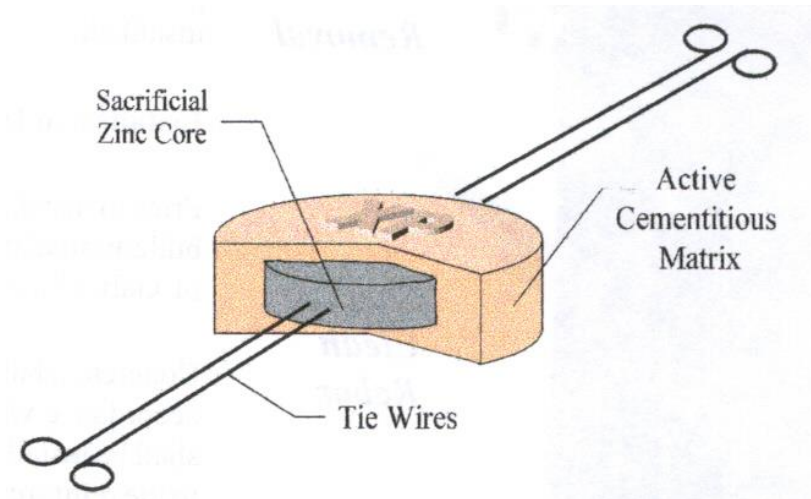


# Engineered Coke Drum Support Structure Shoring Plan



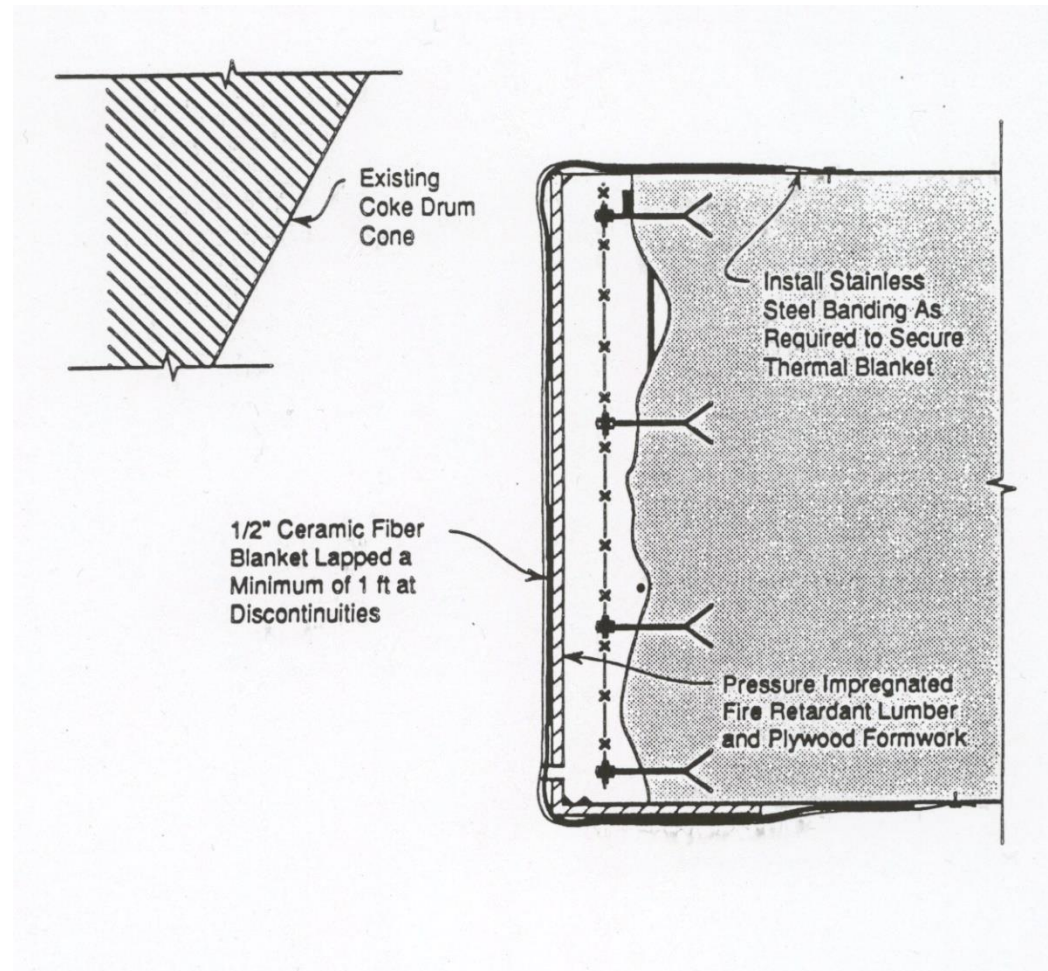
# Special Considerations for Coker Repairs

- Determine need for shoring
- Corrosion protection: use of sacrificial discrete anodes
- Mechanical anchorage of substrate and repair material

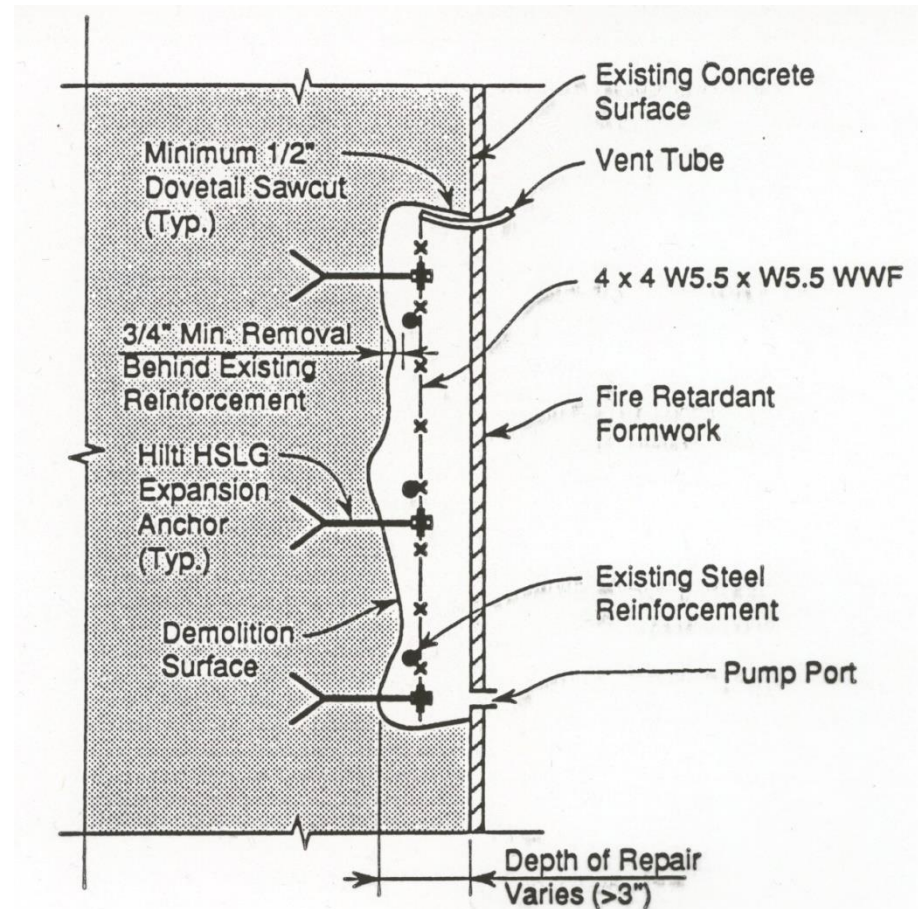




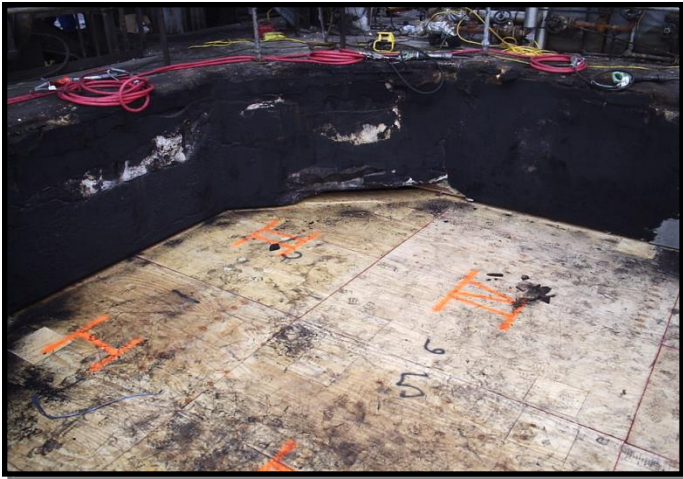
# Thermal Insulating Detail for Octagonal or Circular Slab Opening Repairs



# Formed Deep Repair Detail for Beams and Columns



# Octagon Wall Repair



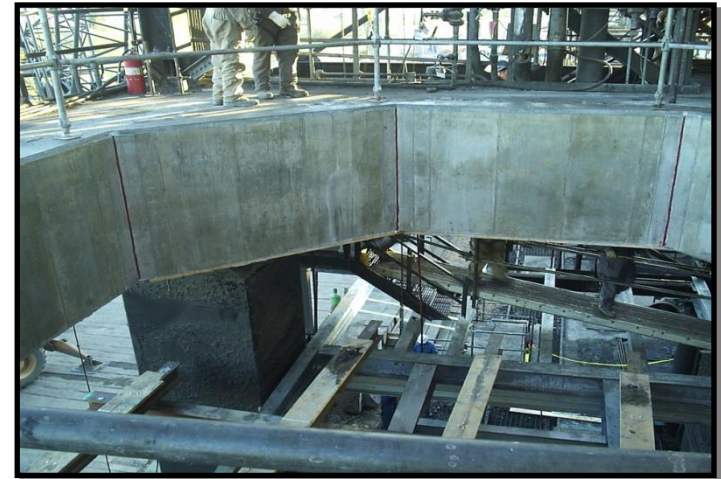
Octagon Wall: Before



Flying Form Work



Octagon Wall: During



Octagon Wall: After



# Coker Column Repairs



Demo



Formed



Repaired

# Anchor Bolt Repair



**Before**



**After**



# Coker Unit – Restoration Alternatives

- Despall Structure



# Coker Unit – Restoration Alternatives

- Pre-cast Panelized Repair of Coke Pit Walls





# Coker Unit – Restoration Alternatives

- Column Strengthening



# Coker Unit – Restoration Alternatives

- Flexural Strengthening – External P-T Encased in Concrete



Before



After

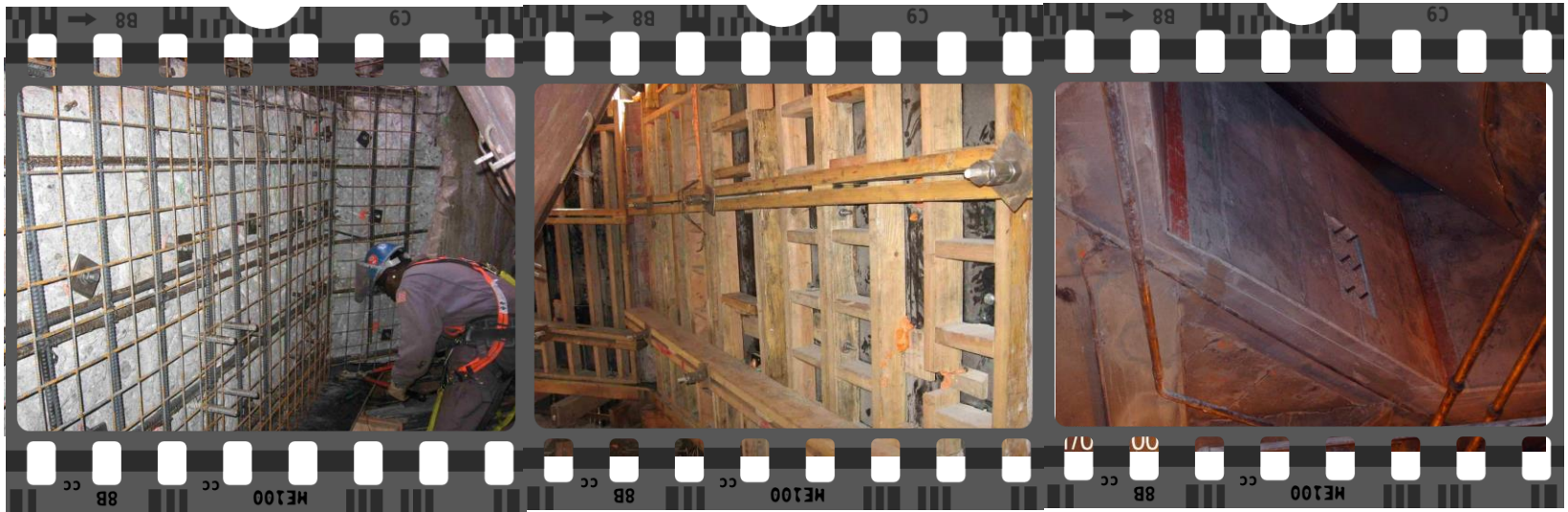


# Coker Unit – Restoration Alternatives

- Repair-In-Kind



# Rehabilitation Project Solutions



Before

During

After



# Rehabilitation Project Solutions

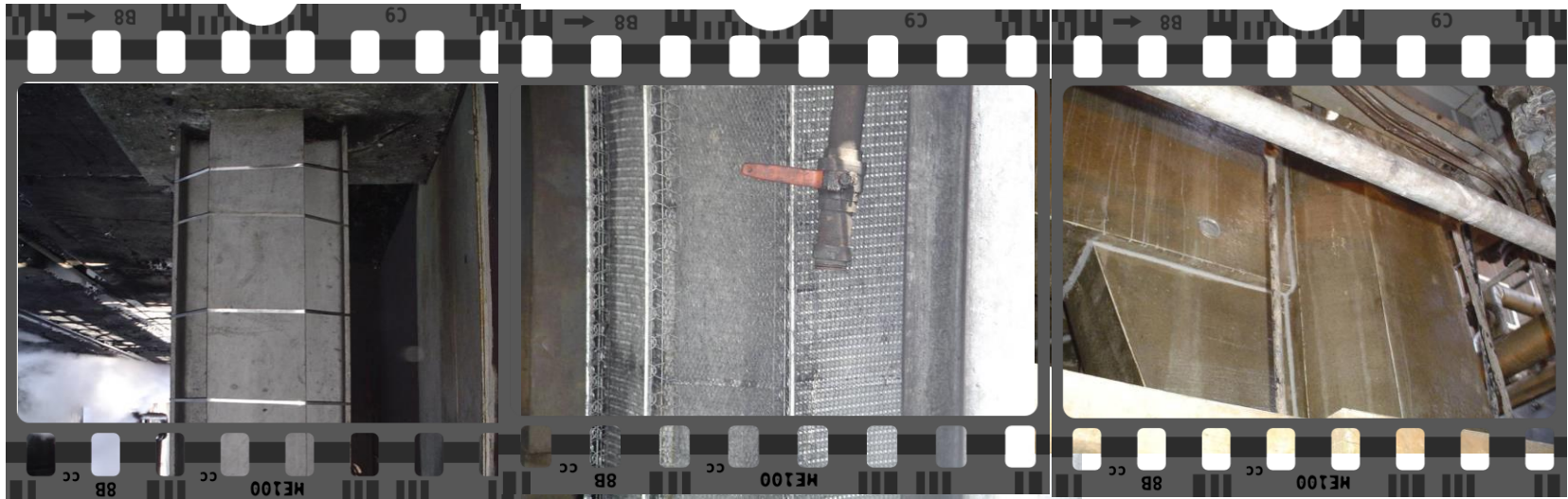


Before

During

After

# Rehabilitation Project Solutions



Before

During

After

# Rehabilitation Project Solutions



Before



After

# Questions ?

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