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

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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
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

Higher Temperatures

Lower Temperatures

Heat
Measured Temperatures on Octagonal or Circular Penetration Faces

- 308°F (153°C)
- 273°F (134°C)
- 160°F (71°C)
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$_2$
Chloride-Induced Corrosion

oxygen, chlorides

moisture

Crack
Carbonation-Induced Corrosion

Carbon dioxide

moisture

pH 13

pH decreases

pH 10

Corrosion occurs due to the reaction of carbon dioxide with moisture, decreasing the pH and leading to corrosion.

structural
Critical Unit Event Scenarios

- Dynamic & Vibration Process Loading
- Explosion/Fire
- Hurricane/Tornado
- High Winds
- Earthquake
Concrete Repair is a Process!

- **Cause & Effect**
  - Defect, damage or deterioration
    - Leakage
    - Settlemen
    - Deflection
    - Wear
    - Spall
    - Disintegration
    - Crack

- **Repair required?**
  - Safety
  - Structural catastrophe
  - Use disfunction
  - Leakage
  - Effects on environment
  - Aesthetics
  - Preventive maintenance

- **Condition Survey**
  - Evaluate
  - Quantify
  - Document

- **Repair Analysis**
  - Owner Criteria
    - Urgency
    - Cost
    - Expectations
    - Useful life
    - Aesthetics
  - Engineering Criteria
    - Structural req.
    - Effect
    - Constructability
    - Environment
    - Safety

- **Repair Strategy**
  - Methods
    - Surface repair
    - Stabilization
    - Strengthening
    - Waterproofing
    - Protection
  - Techniques
  - Materials
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 discreet anodes
- Mechanical anchorage of substrate and repair material
Thermal Insulating Detail for Octagonal or Circular Slab Opening Repairs

- Install Stainless Steel Banding As Required to Secure Thermal Blanket
- Pressure Impregnated Fire Retardant Lumber and Plywood Formwork
- 1/2" Ceramic Fiber Blanket Lapped a Minimum of 1 ft at Discontinuities
- Existing Coke Drum Cone
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
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
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