“Inspection & Maintenance of Concrete Facilities”
By Cheyenne Wohlford
Introduction

- Most Grain Elevators were built between 1950 and 1960 with a life expectancy of 30 years.
- **Operational changes since 1960** include:
  - Increase in turn rate
  - Decrease in unloading and loading time
- **Deterioration** occurs with:
  - Normal wear & tear
  - Exposure to weather
  - Structural deficiencies/failures
- **Construction Flaws, New Builds?**
  - Rebar laps, spacing
  - Concrete PSI Strength
How can you better assess the repair needs of your facility?

Understand the following:

1. Importance of Preventative Maintenance
2. Site Inspection Expectations
3. Reporting - What does this include?
4. Types of Repairs
1. Importance of Maintaining a Facility

Concrete Deterioration Rates:
- Slow in the beginning
- Increase RAPIDLY over time

Factors to Consider:
- Cost
  - Structural Repairs may cost 10 times more than preventative maintenance per silo.
- Downtime
  - Preventative Maintenance = None
  - Structural Repairs = Multiple weeks
- Safety Concerns
  - Falling concrete hazards
  - Potential increases in recordable injuries and workers’ compensation costs.
2. Site Inspection Expectations

What is the purpose of a site inspection?

Gather information:
- Structural History
- Client Expectations
- Areas of Concern
Benefits of obtaining original blue prints:

• Prompt the inspection of an otherwise overlooked area

• Offer explanations of suspect areas or failures
Client Visit

Clients may possess undocumented info:
• Years of operation
• Utilization of specific components
• Turn rates

Client Expectations:
• What information does a client expect to gain from an inspection?
• Should all areas of concern be addressed?
Exterior Inspection Areas

- Silo Walls
- Apex Walls
- Roofs
- Beam Pockets
- Cornices
- Bulging Areas
- Wall Penetrating Equipment
- Noticeable Changes
Exterior Inspection Areas

- Silo Walls
- **Apex Walls**
- Roofs
- Beam Pockets
- Cornices
- Bulging Areas
- Wall Penetrating Equipment
- Noticeable Changes
Exterior Inspection Areas

- Silo Walls
- Apex Walls
- Roofs
- Beam Pockets
- Cornices
- Bulging Areas
- Wall Penetrating Equipment
- Noticeable Changes
Exterior Inspection Areas

- Silo Walls
- Apex Walls
- Roofs
- **Beam Pockets**
- Cornices
- Bulging Areas
- Wall Penetrating Equipment
- Noticeable Changes
Exterior Inspection Areas

• Silo Walls
• Apex Walls
• Roofs
• Beam Pockets
• Cornices
• Bulging Areas
• Wall Penetrating Equipment
• Noticeable Changes
Exterior Inspection Areas

• Silo Walls
• Apex Walls
• Roofs
• Beam Pockets
• Cornices
• Bulging Areas
• Wall Penetrating Equipment
• Noticeable Changes
Interior Inspection Areas

Connection Walls  Hopper Slopes  Aeration Hoppers
Discharge Spouts and Holes  Roof Beams and Connections
Grain Bridging or Caulking  Moisture Marking
Exterior Inspection Areas

- Silo Walls
- Apex Walls
- Roofs
- Beam Pockets
- Cornices
- Bulging Areas
- **Wall Penetrating Equipment**
- Noticeable Changes
Inspection of Concrete Cracks

Necessary Observations:
- Direction
- Width
- Depths
Concrete Crack Activity

**Active Cracks** – grow in depth, width, or direction

**Dormant Cracks** – No growth

All cracks allow moisture to penetrate concrete pores.

Deterioration is dependent upon weather
- Warm weather = allows concrete to hydrate
- Cold weather = water in concrete pores freezes and may cause damage and spalling
Why is moisture migration a problem?

Water expands 9% by volume during freezing process
Rebar can expand 600% of its original volume
• Exerts a force on concrete
• Causes tiny cracks
• When ice thaws, water fills new cracks
• Process is repeated throughout cold weather months
Types of Concrete Cracks

Offset Cracks – cracks with different elevations
Types of Concrete Cracks

Capital “H” Cracks
Types of Concrete Cracks

Horizontal

Vertical
Site Inspection Testing

Nondestructive Testing:

• GPR Scans
• PSI Concrete Tests
• Concrete Moisture Tests
• Surface Profiling
Ground Penetrating RADAR

RADAR = Radio Detection and Ranging
- 2 & 3 Dimensional Scans
- Determines:
  - Spacing
  - Concrete Coverage
  - Wall Thickness
<table>
<thead>
<tr>
<th>Elevation (feet)</th>
<th>Steel Orientation</th>
<th>Average Spacing (inches)</th>
<th>Average Coverage (inches)</th>
<th>Average PSI Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>110'</td>
<td>Vertical</td>
<td>14.4</td>
<td>2.09</td>
<td>3920</td>
</tr>
<tr>
<td></td>
<td>Horizontal</td>
<td>15.7</td>
<td>1.27</td>
<td></td>
</tr>
<tr>
<td>95'</td>
<td>Vertical</td>
<td>16.65</td>
<td>2.85</td>
<td>3920</td>
</tr>
<tr>
<td></td>
<td>Horizontal</td>
<td>11.53</td>
<td>1.58</td>
<td></td>
</tr>
<tr>
<td>80'</td>
<td>Vertical</td>
<td>15.2</td>
<td>1.97</td>
<td>3710</td>
</tr>
<tr>
<td></td>
<td>Horizontal</td>
<td>13.32</td>
<td>1.64</td>
<td></td>
</tr>
<tr>
<td>65'</td>
<td>Vertical</td>
<td>16.15</td>
<td>2.50</td>
<td>3920</td>
</tr>
<tr>
<td></td>
<td>Horizontal</td>
<td>12.18</td>
<td>1.56</td>
<td></td>
</tr>
<tr>
<td>50'</td>
<td>Vertical</td>
<td>14.75</td>
<td>2.14</td>
<td>3815</td>
</tr>
<tr>
<td></td>
<td>Horizontal</td>
<td>14.45</td>
<td>3.23</td>
<td></td>
</tr>
<tr>
<td>35'</td>
<td>Vertical</td>
<td>13.45</td>
<td>1.88</td>
<td>3815</td>
</tr>
<tr>
<td></td>
<td>Horizontal</td>
<td>11.5</td>
<td>1.36</td>
<td></td>
</tr>
<tr>
<td>22' (Roof Level)</td>
<td>Vertical</td>
<td>11.86</td>
<td>2.15</td>
<td>3710</td>
</tr>
<tr>
<td></td>
<td>Horizontal</td>
<td>22.87</td>
<td>3.30</td>
<td></td>
</tr>
</tbody>
</table>
Non-destructive Tests

**Concrete PSI tests** = measures concrete strength in a given area
- Must follow ASTM C805 Guidelines.

**Concrete Moisture Tests** = measures concrete moisture content
used to interpret Moisture Migration
Surface Profiling

Scale of 1 to 12 - Roughness of concrete increases with scale number
*Determines if concrete is suitable for Carbon Fiber repairs*
Destructive Testing

Performed at the request of the customer or third party engineer if non-destructive tests are inconclusive.

Types:

• Concrete Core Sampling - Used to finalize data when concrete PSI tests are inconclusive

• Exposure of Reinforcement Steel - Determines corrosion and cross-section loss. Caliper tool measures remaining rebar width.

• Concrete Carbonation Testing
  - Concrete naturally protects Reinforcement Steel
    - Over time a reaction occurs with atmospheric carbon dioxide & sulfur dioxide reducing the pH level of concrete
  - Carbonation Testing measures if concrete is above or below a pH of 9.2
3. Reporting

Essential way of compiling all findings from a site inspection

Two Sections

• Findings:
  • Testing data
  • Areas of Concern
  • Requests for further testing

• Recommendations
  • Immediate Action
  • Future Needs
  • Monitoring Schedule

*Sharing of report with Third Party Engineer*

• Allows for engineer verification
• Prevents unnecessary repairs
4. Types of Repairs

- Concrete Crack Injection
- Concrete Spalling Repair
- Carbon Fiber Applications
  - Beam Pockets
  - Roof Caps
  - Entry Points
  - Cold Joints
- Shotcrete/Gunite Liners
Concrete Crack Injection

Crack Injection prevents growth

3 Step Process for cracks larger than .06 inches or 1/16\textsuperscript{th} of an inch
1. Grind out crack $\frac{1}{4}$” x $\frac{1}{4}$”
2. Remove debris with air or water
3. Injection with a high-yield, non-shrink, elastomeric caulk
Concrete Spalling Repair

5 Step Process based upon ICRI No. 310.1R-2008

1. Removal of all delaminated concrete including ¼” around exposed rebar
2. Clean rebar to white metal
3. Right angle cut spalled area
4. Treat rebar with Rust Inhibitor
5. Patch with high strength, vertical-overhead concrete patch
Carbon Fiber Applications

• Beam Pocket Repairs

• Roof Caps

• Wall Penetrating Equipment Entry Points

• Cold Joints
Carbon Fiber Applications

Beam Pocket Repairs
Carbon Fiber Applications

Cold Joint Repairs
Steel Reinforced Shotcrete/Gunite Liners

- Add new, structurally sound silo wall
- Uses existing wall as concrete form
- Minimal storage capacity loss (4-5” of Liner Thickness)
Questions & Answers
1-855-752-5047