Recent failures of storage bins, silos and other structures highlight the need to increase awareness of hazards associated with these structures. Since 2010, one miner was killed when a storage bin collapsed; another miner was killed when the concrete silo he was standing on collapsed. These deaths and several near misses are alarming. Careful examination and prompt correction of hazards are essential to maintaining these structures. These occurrences can be greatly reduced by utilizing the following best practices.

- Examine structures for indications of damaged, weakened or displaced structural elements, bulging or deformed bin sides or tops, gapped joints, cracked or broken concrete, corroded or fatigue-cracked metal, bent or buckling columns, beams or braces, loose or missing connectors, cracked, broken or inadequate welds, etc.
- Inspect structural elements for reduced load-carrying capacity, thinned or missing sections of beam and column webs or flanges, corroded rusted or flaked metal surfaces, delaminated plywood or water-weakened wooden structures.
- Clean accumulations of material from around the base of structures and flanges of horizontal beams. Carefully inspect for damaged support columns, braces, anchor bolts and eroded foundations.
- Report all areas where indications of structural weakness are found.
- Protect lower level structural elements from collision damage by mobile equipment.
- Minimize spillage and eliminate the source promptly.
- New structures should be designed and certified as appropriate by a registered professional engineer in accordance with local building codes and in conformance with accepted engineering practices. Significant modifications to existing structures should be undertaken only after consultation with an engineer. Structures should be constructed according to plans and specifications by trained workers using good materials and employing generally accepted construction methods.

Report Structural Damage or Deterioration To Your Supervisor
Structural Inspection of Processing Plants

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Structural Condition Assessments
Structural Materials

- Steel
- Concrete (plain, reinforced, pre-stressed)
- Timber
- Other - Masonry, Aluminum, Fiber-Reinforced Polymer (FRP), etc.
Inspecting Structural Steel

- Corrosion (holes, delamination & loss of cross section)
- Cracking (overload & fatigue)
- Overloads (buckling & deflection)
- Member Impact Damage
Corrosion holes & delamination
Reinforced Concrete

Concrete is strong in compression but weak in tension. Rebar is introduced so that steel, which is strong in tension, can carry the tensile load while concrete carries the compressive load.
Inspecting Concrete Structures

- Cracking
- Delamination (Internal Splitting - Silos)
- Spalling
- Rebar Corrosion
- Crushing
- Impact Damage
Spalling & Corrosion from Exposure to Chemicals
Inspecting Timber Structures

- Cracking
- Deflection / Sag
- Crushing
- Fungi - molds, rot, dry rot
- Wood Boring Insect Damage
Inspection Tools

☐ Cleaning
  - chipping hammer, wire brush

☐ Inspection
  - chipping hammer, screw driver or ice-pick, plumb bob, flashlight, binoculars

☐ Measuring – tape, calipers, ultrasound, level

☐ Safety & Misc. - safety harness, dust mask, compass
Safe means of access shall be provided and maintained to all working places.
b) Defects on any equipment, machinery, and tools that affect safety shall be corrected in a timely manner to prevent the creation of a hazard to persons.
Machinery, equipment, and tools shall not be used beyond the design capacity intended by the manufacturer where such use may create a hazard to persons.
Inspection of Processing Plants
Beams - Bending & Shear Resistance

- Beams and girders are common members used to resist bending moments and shearing forces. Bending is resisted by flanges; shear is resisted by web.
Bending Moment

Positive Moment

Negative Moment

Compression

Tension

Neutral Axis

Tension

Compression

Neutral Axis
Shear Force

- Equal (magnitude) but opposite (direction) forces which tend to slide one section of a member past an adjacent section.
Corroded web of wide flange beam
Long corrosion hole at web to flange interface
This beam was still standing (?)
Corrosion hole in web of beam (hidden by piping)
Corrosion holes in web of beam
Corroded web @ end of beam
Corrosion hole in web & buckled top flange
Heavy delamination of bottom flange
Buckled web
Buckled webs of corroded channels
Beam modifications need engineered!
Columns

Buckled column flanges @ web corrosion hole
Corrosion hole in web of column
Buckled flanges at bottom of column @ corrosion hole
Repaired column base (appears good)
Bad Repair At Column Base
Another Bad Column Repair (base)
... a few feet up from base
Rotted timber column
An equipment mishap – these types of repairs can be evaluated by an engineer.
Crooked Column (creation of moment)
Severe equipment damage
Replacement time!
Inspect the column foundations
Don’t take the bracings out!
Corroded diagonal brace
Corroded diagonal and gusset plate
Corroded diagonal
Corroded channels/girts supporting the siding
Check equipment supports! Corrosion hole in channel post for a magnetic separator
Corroded channel post support for a magnetic separator
Crack in a support beam for a shaker screen
Fractured spring support for vibrating equipment
Deteriorated concrete flooring
Floor slab cracks - a potential source of rebar corrosion
Look at floor grating - corrosion @ supports
Corrosion at support edge of grating
Corroded stair channels
Corroded angle supporting stair tread
Don’t forget to check the handrails!
Corrosion holes in handrail support post
Heavy Roof Loading
Roof Collapse Due to Clinker Buildup and Snow Load
Inside of Failed Structure
Corrosion of bottom flange of roof support channel
Buckled Vertical Roof Truss Member
Bolted Connections

☐ Check tightness

☐ Look for
  ■ missing bolts
  ■ sheared bolts
  ■ elongated bolts
  ■ excessive corrosion
Inspect connections! Corroded bolt heads
Welded Connections

- cracked welds
- poor quality - irregular surface
- corrosion in connected parts
- Always use qualified welders
Fractured weld @ connection
Vibrating equipment - fracture & poor quality weld
Irregular weld surface w/ porosity
Exposed rebar on the side of a concrete settling tank
Collapsed floor – Avoid this!
Plant collapses can be costly.
Recap - Inspection of Processing Plants

- Check the beams, columns, diagonal braces
- Examine members for buckling, corrosion, damage, excessive sag, holes, local buckling, and cracking.
- Examine connections for corrosion, missing or cracked elements
- Examine floors, roofs, walls, & foundation
- Examine equipment supports, stairways, & handrails