Steel Corrugated Grain Bins

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Rob has been with Haag Engineering since 2009. His primary areas of consulting are structural evaluations, construction-related failure and damage assessments, and wind engineering issues and related storm effects for agricultural and single- and multi-family buildings as well as light-framed commercial buildings. He helps develop and present continuing education seminars as an instructor for Haag.

He graduated from Texas A&M University with a Bachelor of Science in agricultural engineering.

Session Description:
This session will provide an introduction to steel corrugated grain bin terminology, along with the basic operation of these types of bins. Attendees will learn how to identify common problems associated with steel corrugated grain bins, as well as some of the typical failures associated with grain bin operations and storm effects.
Top Three Session Ideas
Tools or tips you learned from this session and can apply back at the office.

1. __________________________

2. __________________________

3. __________________________
Steel Corrugated Grain Bins

Session Outline

Overview

Introduction to Steel Corrugated Grain Bins (Silos)

- Where Found
- Typical Grains
- Protects Commodities
- Moisture Content
- Galvanized-Steel Panels
- Corrugated Profiles
- On-Center Spacing
- Bin Types
  - Stiffener Profiles
  - Stiffener Thickness
  - Unstiffened Grain Bin
  - Internally Stiffened Grain Bin
  - Externally Stiffened Grain Bin
  - Wind Rings
- Regulation
  - Temperature Monitoring Devices
  - Aeration Fans
  - Roof Ventilation – Static and Powered
  - Aeration Vents Flush with Concrete Slab
  - Aerated Floor System Elevated Above the Concrete Slab
- Hooper Bottoms
- Size and Capacity
- Manufacturers

Basic of Grain Bin Operation

- Loaded and Unloaded from Center
- Emptied Through Center Discharge Chute
- Proper Storage
- Regulating the Stored Grain
  - Condensation
  - Grain Spoilage
  - High-Moisture Grain
  - Corroded Grain Bin Walls and Components

Failures of Grain Bins Associated with Operation and Maintenance

- Off-center Unloading or Loading Examples
- Rusted Walls or Components Examples
- Lack of Proper Maintenance Examples
- Improper Aeration Operation Examples

Failure of Grain Bins Associated with Storm Effects

- Wind Damage Examples

Q & A
Steel Corrugated Grain Bins

July 2013

Steel Grain Bin Topics

1. Introduction to Steel Corrugated Grain Bins (silos).
3. Failures of Grain Bins Associated with Operation and Maintenance.
4. Failures of Grain Bins Associated with Storm Effects.
Steel Grain Bin Introduction

• Corrugated steel grain bins can be found on farms, commercial storage/transfer sites, and processing sites.

• Typical grains include corn, soybeans, wheat, rice, etc. that are considered dry and free-flowing.

Steel Grain Bin Introduction

• Storing grain in bins protects commodities from the effects of weather and pests in between harvest and processing time.

• Grains with lower moisture content and grain temperatures within approximately 10° F of the average outside temperature can be stored longer without spoilage.
Steel Grain Bin Introduction

- Grain Bin Shells typically comprise corrugated galvanized-steel panels.

- Corrugated profiles may vary from the typical S-style to a trapezoidal-shape.

- On-center spacing between corrugated ribs are typically 2.66 inches or 4 inches.
Steel Grain Bin Introduction

- Corrugated steel bins can include stiffened and unstiffened type bins.

- Stiffener profiles can vary such as hat-shaped, C-shaped, or Z-shaped.

- Stiffeners can vary in thickness up to approximately 5/16-inch.

Steel Grain Bin Introduction

- On-farm type bins and smaller commercial type bins are generally unstiffened.

- Large commercial bins typically include stiffeners either on the exterior or interior sides.

- Stiffened bins may also include wind rings for added stiffening of the bins near the top.
Steel Grain Bin Introduction

Unstiffened Grain Bin

Internally Stiffened Grain Bin
Steel Grain Bin Introduction

Externally Stiffened Grain Bin

Wind Rings
Grains stored in the bins can be regulated by means of:

- Temperature monitoring devices (e.g., temperature cables hanging from the roof framing)

- Aeration fans that blow air in the bin (pos. pressure) or that pulls air out of the bin (neg. pressure)

- Venting systems (located in the floor and roof)
Steel Grain Bin Introduction

Aeration Fans

Steel Grain Bin Introduction

Roof Ventilation – Static and Powered

Powered

Static
Steel Grain Bin Introduction

Aeration Vents Flush with Concrete Slab

- In-floor aeration vents
- Center floor discharge chute
- Intermediate floor discharge chutes
- Bin sweep

Steel Grain Bin Introduction

Aerated Floor System Elevated Above the Concrete Slab
Steel Grain Bin Introduction

- Bins are also available with hopper bottoms for self-cleaning when frequently filled and emptied.

Grain Bin Sizes and Capacities

- Diameters can vary from about 12 feet to over 150 feet across (about half a football field’s length).

- Heights can vary from about 11 feet to approximately 100 feet tall.

- Grain volumes can range from approximately 750 bushels to over 1.5M bushels.
Manufacturers of Corrugated Steel Grain Bins

- Grain Systems, Inc. (GSI)
- Brock Grain Systems
  - Purchased the grain bin division of Butler Manufacturing in 1997
- Chief Industries, Inc.
- Sukup Manufacturing
- Behlen Grain Systems
- SCAFCO
- Sioux Steel
- Crippen International

Basics of Grain Bin Operation

- Corrugated grain bins are designed to be loaded and unloaded from the center to maintain equal weight distribution around the bin perimeter.

- Grain must be emptied completely through the center discharge chute prior to using the intermediate discharge chutes and bin sweeps.
Basics of Grain Bin Operation

• Proper storage requires monitoring of the grain temperature and moisture.

• Regulating the stored grain can be achieved through temperature readings, aeration (pos. or neg. pressure) fans, drying fans, coring the grain, or by way of stirring and recirculating the grain with augers.

Basics of Grain Bin Operation

• Improper regulation of the grain temperature can lead to condensation.

• Condensation and improper regulating of the grain moisture content can lead to grain spoilage.

• High-moisture grain can also bridge leaving large voids during loading and unloading.

• Long-term exposure to condensation and high-moisture grain can cause corroded grain bin walls and components.
Grain Bins Failures

(Note: Failures can vary from bin deformation to complete collapse)

- **Operation and Maintenance** (Not an exhaustive list)
  - Most Common
    - Off-center unloading, loading, or spoiled/crusted grain due to higher moisture content
    - Corrosion – rusted walls or components
    - Lack of or improper maintenance
  - Less Common
    - Improper aeration operation

- **Storm Effects**
  - Wind

Grain Bin Failures – Off-center unloading or loading

- Off-center unloading or loading can cause compression buckling (plastic deformation) of the grain bin walls.

- Non free-flowing grain (e.g., crusted or spoiled) may also cause plastic deformation of the grain bin walls.

- Eccentric unloading or loading may also cause anchorage failure at the foundation.
Grain Bin Failures – Off-center unloading or loading

Compression buckling due to eccentric discharging.

Eccentric discharging.
Grain Bin Failures – Off-center unloading or loading

Compression buckling due to eccentric discharging.
Grain Bin Failures – Off-center unloading or loading

Compression buckling due to eccentric loading.

Grain Bin Failures – Off-center unloading or loading

Bottom edge of bin shell shifted on foundation due to eccentric unloading.
Grain Bin Failures – Off-center unloading or loading

Eccentric grain flow pattern discernible on the side walls

Bottom edge of bin shell shifted on foundation due to eccentric unloading.

Torn anchor on the north side
Grain Bin Failures – Off-center unloading or loading

Bottom edge of bin shell shifted on foundation due to eccentric unloading.

Attempted prior repair to anchors on the north side

Grain Bin Failures – Off-center unloading or loading

Bottom edge of bin shell shifted on foundation due to eccentric unloading.

Torn anchors on the south side
Grain Bin Failures – Off-center unloading or loading

Bottom edge of bin shell shifted on foundation due to eccentric unloading.

West side wall shifts toward the east

Discharge chute on the west side

Torn anchors on the west side
Grain Bin Failures – Off-center unloading or loading

Bottom edge of bin shell shifted on foundation due to eccentric unloading.

Eccentric grain flow pattern discernible on the side walls.
Grain Bin Failures – Off-center unloading or loading

Bottom edge of bin shell shifted on foundation due to eccentric unloading.

Recent movement of bin side walls

Old torn anchor plate
Newer anchor plate
Grain Bin Failures – Off-center unloading or loading

Bottom edge of bin shell shifted on foundation due to eccentric unloading.

Grain Bin Failures – Rusted Walls or Components

This bin was constructed in the 1970s and was sufficiently full enough to reach the top of the roof cone prior to failure (approximately 90,000 bushels).
Grain Bin Failures –
Rusted Walls or Components

Internally stiffened commercial bin

Corroded stiffeners

Grain Bin Failures –
Rusted Walls or Components

Corroded stiffeners
Grain Bin Failures – Rusted Walls or Components

Corroded wall panels

Grain Bin Failures – Rusted Walls or Components

Corroded fasteners
Grain Bin Failures –
Lack of Proper Maintenance

- Owner was aware that certain panels had rusted.
- Rather than replacing damaged panels, temporary repairs were installed.
Grain Bin Failures – Lack of Proper Maintenance

Fractured panel with corroded edges
Grain Bin Failures – Lack of Proper Maintenance

Repairs prior to the exterior straps included an interior steel plate over the split wall and caulking.

Caulking separated due to continual expansion of the damaged wall.

Grain Bin Failures – Lack of Proper Maintenance

Other fractured panels with corrosion.
Grain Bin Failures – Lack of Proper Maintenance

- Long-term problem with deformed metal wall panels around the fasteners
- Larger washer added prior to the latest exterior painting

Grain Bin Failures – Improper Aeration Operation

- Bin sufficiently full of corn from fall harvest.
- No corn had been removed or added since initial fill and no coring of the corn.
- Bin utilized a negative pressure aeration system.
- Damage occurred in January.
Grain Bin Failures – Improper Aeration Operation

Several aeration fans

Warning label on the fans

(1) Use positive aeration system (push system).
(2) Make sure all roof vents are sized properly, open, and unobstructed.
(3) If using roof exhaust fans, wire roof and supply fans to start simultaneously or make sure roof fans are started when supply fans are started.
(4) Do not operate your aeration system when conditions exist that may cause roof vent icing. Vent icing can occur when ambient air temperature is below 35°F (2°C) and air relative humidity is 90% and above. For any question as to possible icing conditions, shut down the system and contact your local weather bureau.

Neg. pressure aeration system
Grain Bin Failures – Improper Aeration Operation

North side of bin

Upper ring panels buckled inward on north side

Grain Bin Failures – Improper Aeration Operation

Caved in roof on the north side
Grain Bin Failures – Improper Aeration Operation

- Partially collapsed roof vents
- Caved in roof on the north side

- Interior side of the caved in roof
- Impression of metal framing in corn and corn in the Zee-rafters
Grain Bin Failures – Wind Damage

• Bins are stronger against wind forces when full versus empty bins (e.g., a fully sealed coke can versus an empty coke can).

Grain Bin Failures – Wind Damage

• Empty bin with approximately a 128,000 bushel capacity at the time of the incident.

• Approximately 56 feet in diameter and about 58 feet in height to the eave.
Grain Bin Failures – Wind Damage

- Empty bin with approximately a 65,500 bushel capacity at the time of the incident.
- Approximately 40 feet in diameter and about 58 feet in height to the eave.

Grain Bin Failures – Wind Damage

- Empty bin with approximately a 47,000 bushel capacity at the time of the incident.
- Approximately 42 feet in diameter and about 36 feet in height to the eave.
Grain Bin Failures – Wind Damage

View of the empty unstiffened bin from the interior.

Grain Bin Failures – Wind Damage

Anchor bolts partially withdrawn on the windward side. Steel failure in the bolted anchor bracket.
Questions?

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