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Concrete Bin Failures and Why
Prepared for: GEAPS Exchange 2016

Arthur D. Moeller, PE
Moeller Engineering, LLC

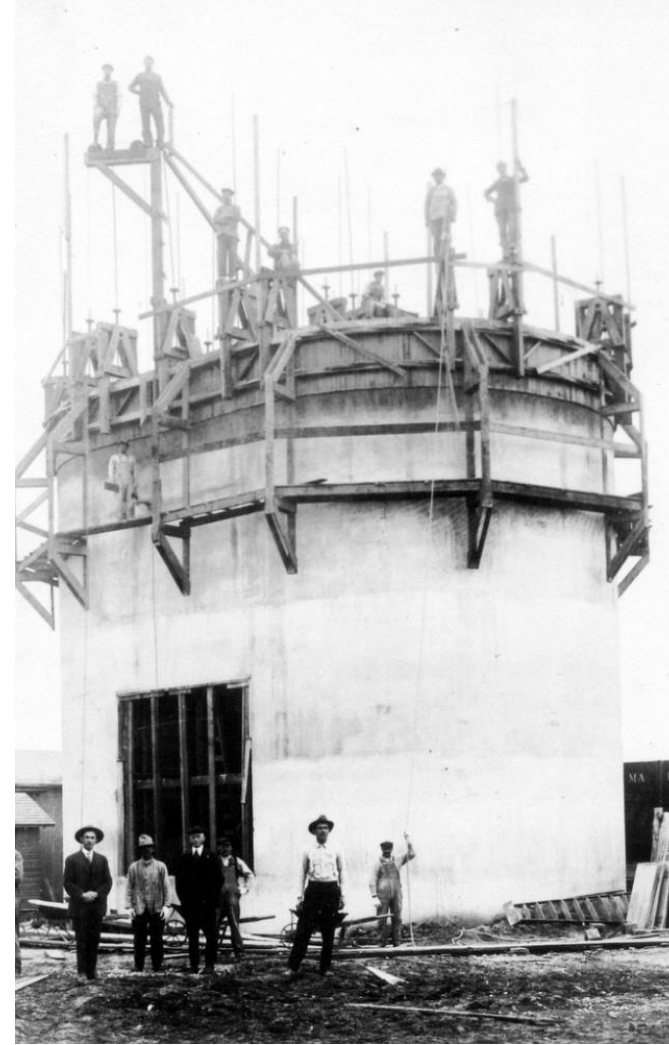
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Topics

- AG INFRASTRUCTURE FACTS
- AG INDUSTRY LOSSES
- CONCRETE SILO ENGINEERING
 - REASONS FOR FAILURE
 - THE INSPECTION
 - RESTORATION PLAN DEVELOPMENT AND EXECUTION
- SILO INSPECTIONS/MAINTENANCE



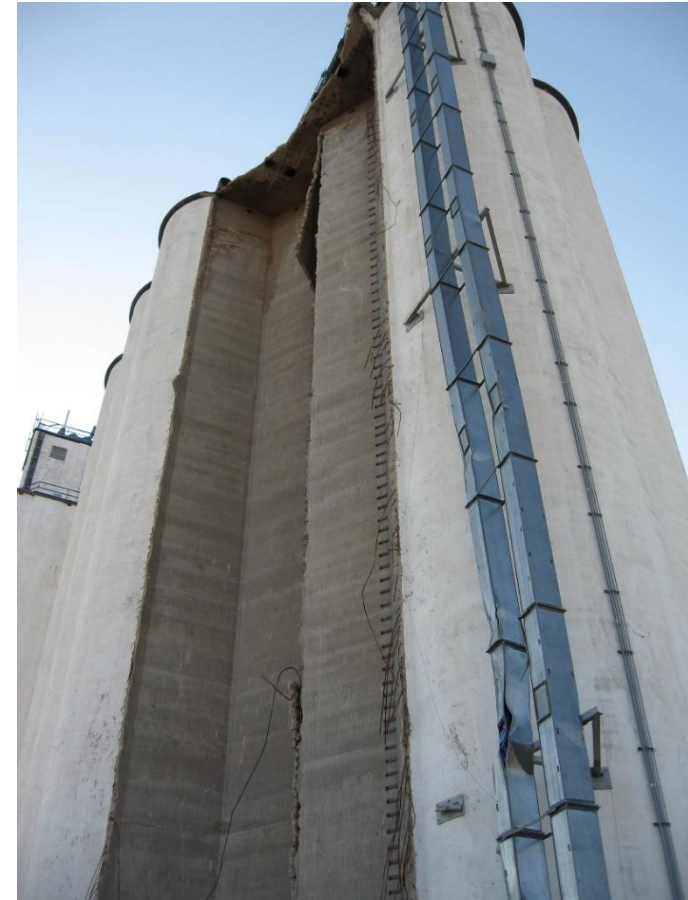
SILO CONSTRUCTION THROUGHOUT THE 1950'S



JUST THE FACTS...

- THROUGH THE 1950'S
 - 3 BILLION BU STORAGE ADDED (5.5 BILLION TOTAL)
 - TODAY'S STORAGE, 10.7 BILLION BU, OFF-FARM COMMERCIAL
- AGING INFRASTRUCTURE
 - MORE THAN HALF GREATER THAN 50 YRS
 - ESTIMATED 75,000 CONCRETE SILOS, JUST DURING THAT DECADE AND EARLIER
 - 20% OF TODAY'S TOTAL STORAGE





RUSSELL, KS, JUNE 25, 2010
STRUCTURAL FAILURE, COLLAPSE
constructed mid 1950's



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OWNER DECIDED TO DEMOLISH

WHY THE DECISION TO DEMO?

NOVEMBER 20, 2012 - SILO COLLAPSE OAKLEY, KS



CONSTRUCTED MID 1950'S



OWNER DECIDED TO REBUILD



APRIL 13, 2010 GRAIN DUST EXPLOSION



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BUILT 2004

1. STRUCTURAL EVALUATION
2. CONSTRUCTION COST EVALUATION
3. OWNER DECIDED TO REPAIR



OHIO SILO EXPLOSION, OCT. 2014



CONSTRUCTED 2007





2014 CONCRETE SILO FAILURE



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FACILITY REBUILT



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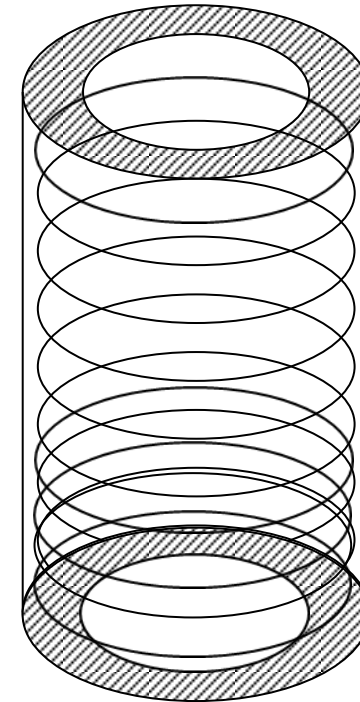


ASSESS YOUR CONCRETE STRUCTURES- *ARE YOU ON THAT GREATER THAN 50 LIST?*

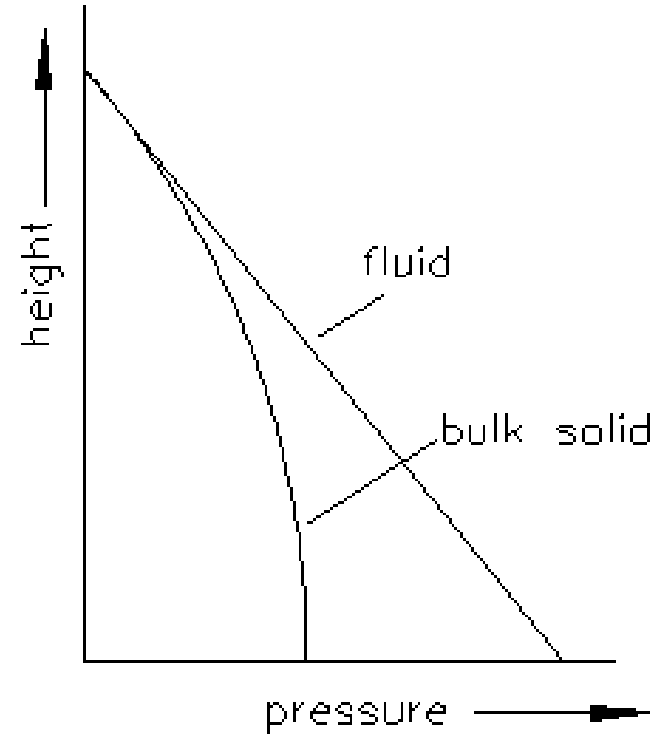
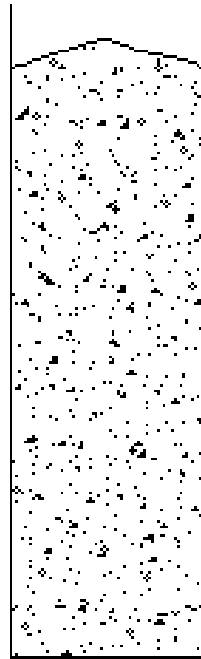


Concrete Silo Construction

- Concrete (Not cement!)-Portland cement, fine aggregate, coarse aggregate and water
- Steel Reinforcing Bar – “Rebar”
- Qualified Contractor
 - Inspection



Gradient Pressure Theory



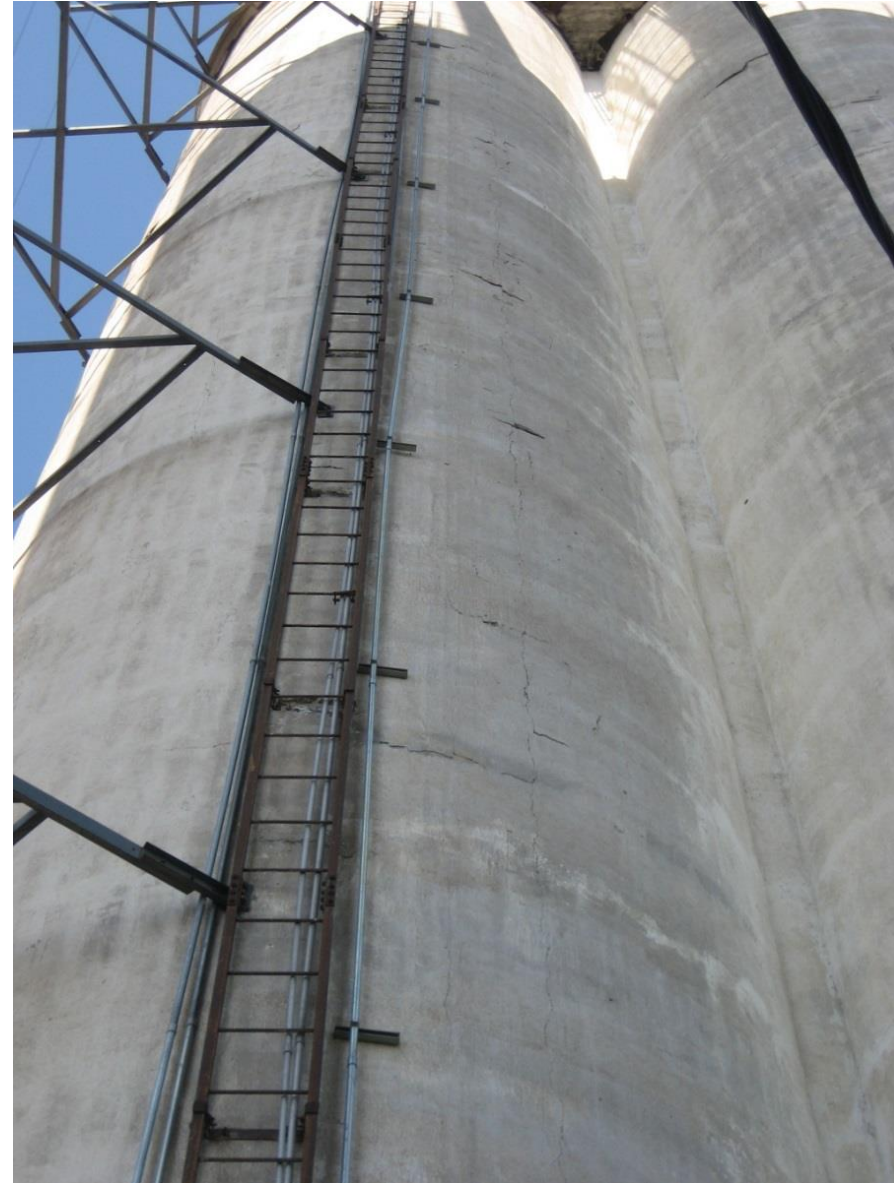


CONCRETE CONSTRUCTION TODAY



While Inspecting, look for cracking

Cracking is an indication of structural deficiencies of the concrete wall



Look for these signs of problems:

- Cracking
 - Spider
 - H-cracking
- Surface distress
 - Spalling
 - Scaling



What is causing the cracks?

1. Lack of rebar
2. Wearing of aging equipment
3. Drying and shrinkage
4. Thermal Stresses
5. Weathering
6. Corrosion of Reinforcement
7. Poor Construction Practices
8. Errors in design and detailing



-How much use (CYCLING)?



SPALLING CONCRETE EXPOSED REBAR, CONCERNED?

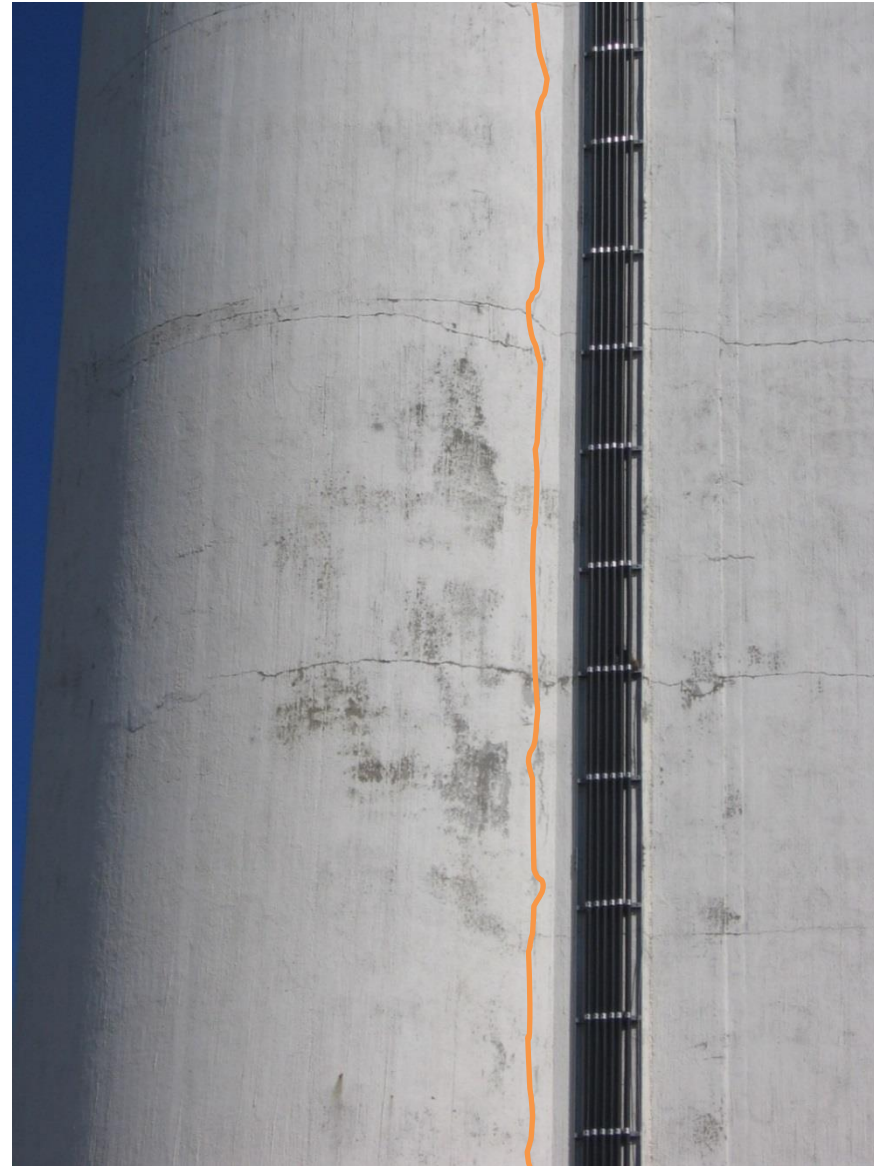


SPALLING AND DETERIORATION

WELL DEFINED CRACKS...



Define these Cracks.



“H” Cracks



Look carefully



Crack concerns?

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Crack concerns?



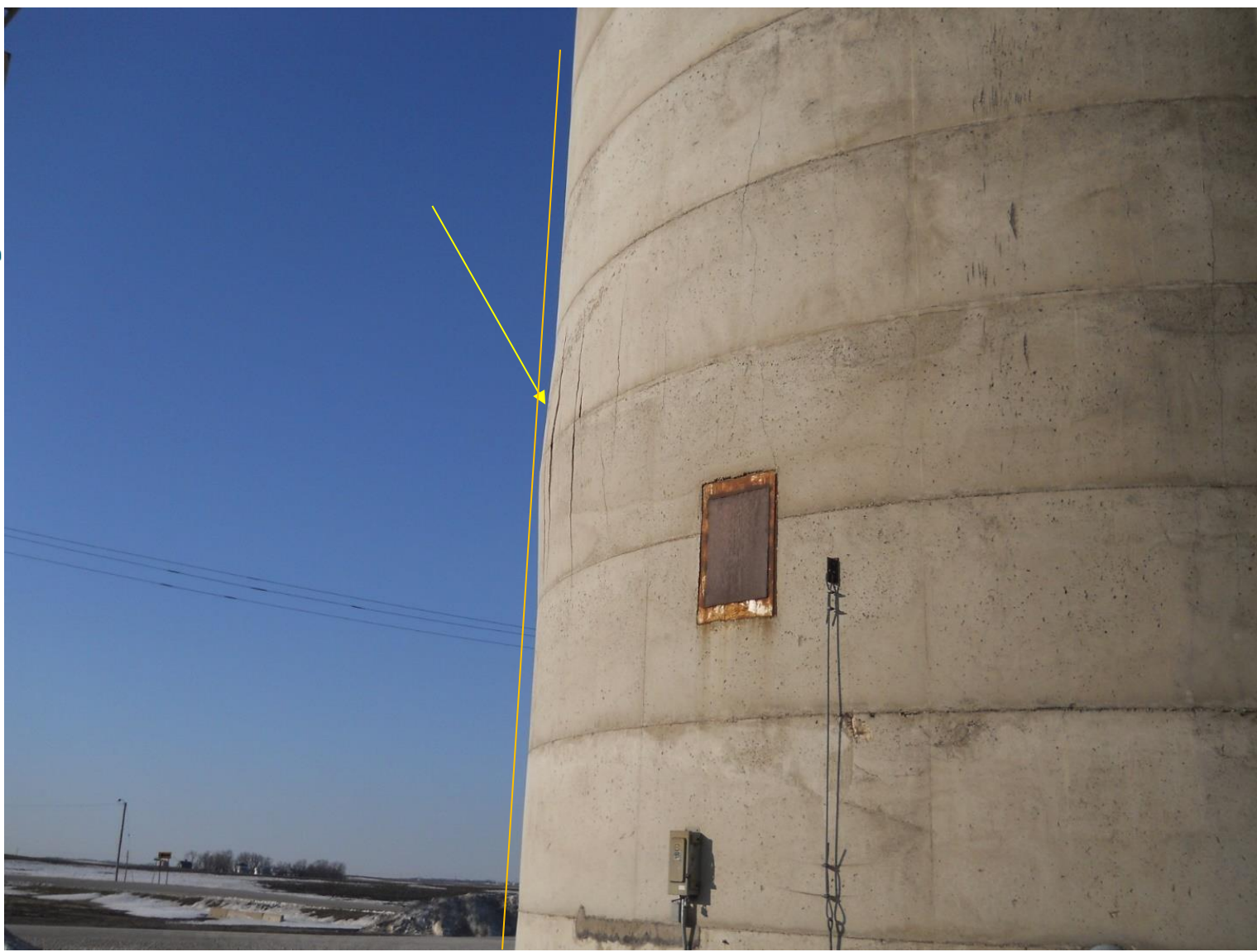
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Look carefully



INSPECT THESE KEY SILO COMPONENTS:

- Foundation
- Roof: look for shifting with respect to the silo walls (walking) and curb cracks
- Interior silo walls
- Silo sidewall openings – interior
- Exterior silo walls
- Silo sidewall openings – exterior
- Tunnels – Top and sides



What can be done? Liner?



THE ENGINEERING BEHIND IT



Grain Bin Load Calculator

Bin and Commodity Specifications

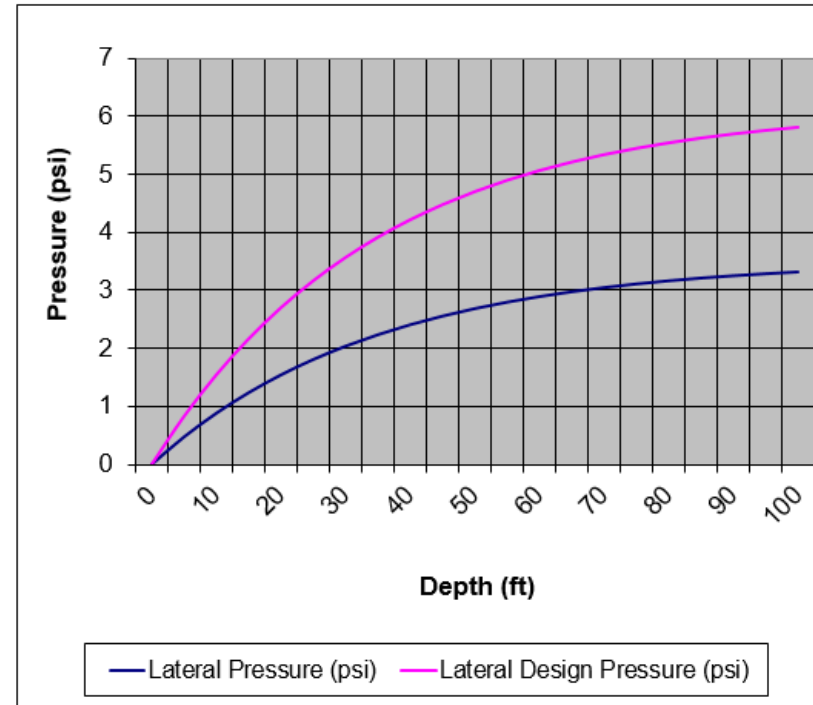
24	ft	Diameter of bin	
110	ft	Height of bin	
4	in	Thickness of Liner	
3500	psi	Strength of Liner	
0.5	in	Size of Bar (Diameter)	
6	in	Vertical Spacing of Bars	
60000	psi	Yield Strength of Rebar	
1.5		Overpressure coefficient (1.35 - 2.00)	
0.58		Coefficient of friction	CHART
38	°	Emptying angle of repose	CHART
23	°	Filling angle of repose	CHART
49	lb/ft ³	Density of commodity	CHART

If eccentric loading and/or unloading is occurring

12	ft	Distance from center of bin to eccentric loading/unloading point
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Calculated Values

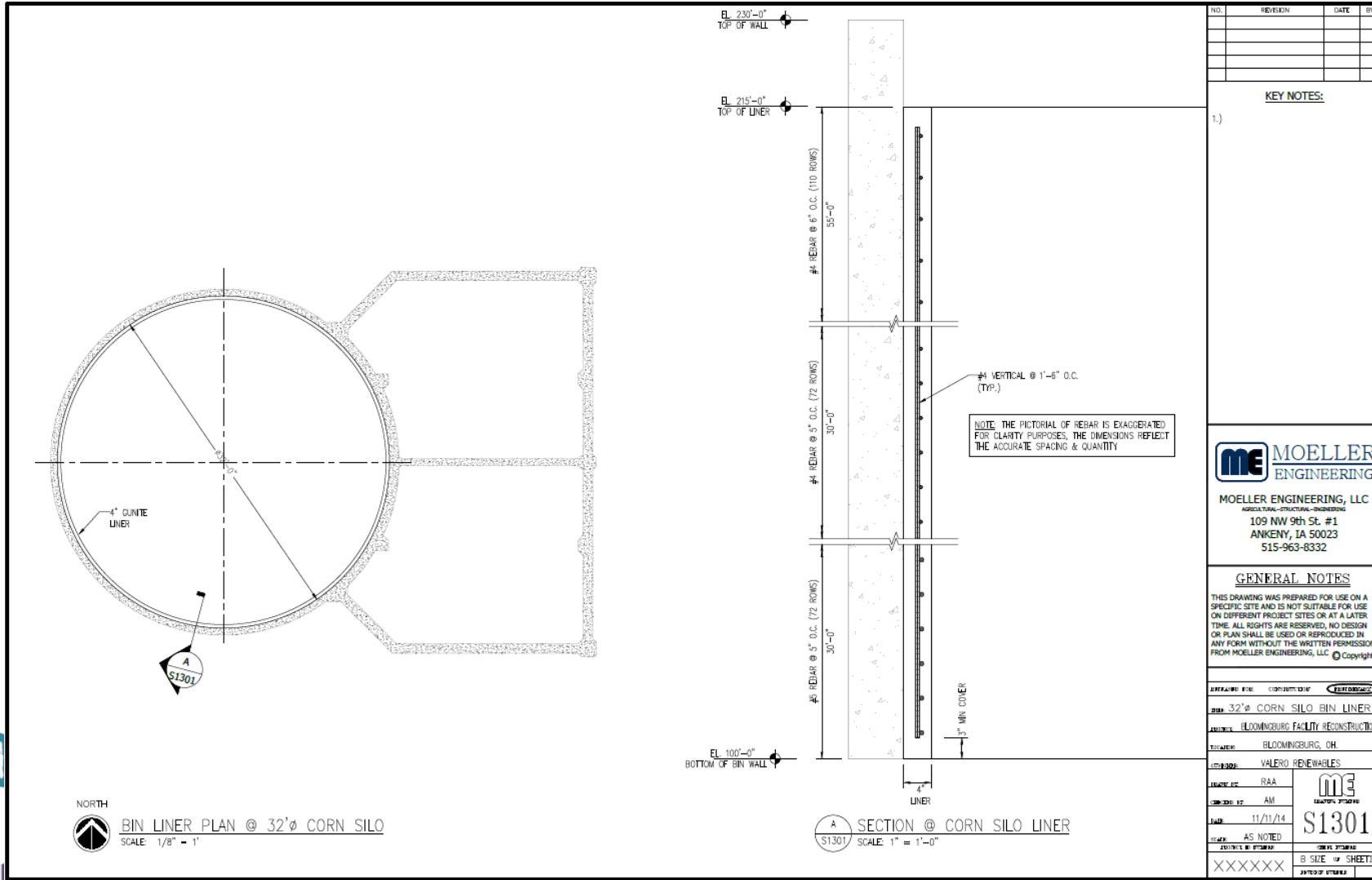
0.033	in ²	Area of steel per inch of height	
0.299		k; Ratio of internal lateral pressure to vertical pressure	
11.280	psi	Vertical pressure	
3.374	psi	Lateral Static pressure	
5.904	psi	Lateral Design Pressure	
25.980	ksi	Hoop Stress	
36.000	ksi	Allowable Stress in Rebar Provided	
		Hoop Stress Check	OK
0.080	As	Min. Area of Steel Check	OK
0.008	As/Ag	Temp. and Shrinkage Check	OK



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LINER DESIGN PLAN AND SECTION



BIN LINER PLAN @ 32'Ø CORN SILO
SCALE: 1/8" = 1'

RECOMMENDATIONS

PREVENTATIVE MAINTENANCE PROGRAM

- REGULARLY SCHEDULED ENGINEERING INSPECTIONS
- SURFACE TREATMENTS
- REGULAR VISUAL EVALUATIONS BY PERSONNEL
- CONDITION SURVEY LOG
 - CRACK MONITORING

SUGGESTED REPAIRS (PROTECT THE REBAR!)

- INTERIOR LINERS
- SPALL REPAIR
- CRACK PATCH

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Be aware of your surroundings

