Structural stability criteria in grain handling

By Pieter Fourie, Eko Design

Grain handling poses challenges in various disciplines and cost-effective operations involving capacity optimisation, minimum product damages, safe storage and compliance with market demand. There are also legislative requirements ensuring that health and safety standards are met.

Regulation Gazette 10113, Vol 584 of February 2014 states:

- Inspections of structures are carried out periodically by competent persons in order to render the structures safe for continued use.
- The inspections contemplated in the sentence above are carried out at least once every six months for the first two years and then yearly.
- The structure is maintained in such a manner that it remains safe for continued use.
- The records of inspection and maintenance are kept and made available on request to an inspector.

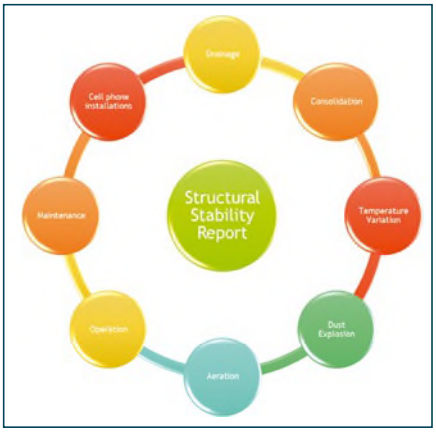
This presents the industry with challenges regarding what a structured inspection entails and what form records should take. The best way to approach the problem would be to establish the cause of structural failure. Experienced silo designers will take the relevant variables into consideration in the analysis process (*Figure 1*).

Variables to consider

Drainage: Proper drainage ensures that reinforcement is not compromised by the ingress of water. Base plates and steel structure bolts subjected to ponding will corrode and weaken. Grain quality could be affected by water penetrating bins.

Consolidation: Understanding site geology is critical to identify potential problems that may occur, such as the presence of dolomite or collapsible sand and clay. During the investigation special attention must be paid to possible movement, which will manifest itself in cladding and cracking of structural elements.

Figure 1: Variables to consider when establishing cause of structural failure.

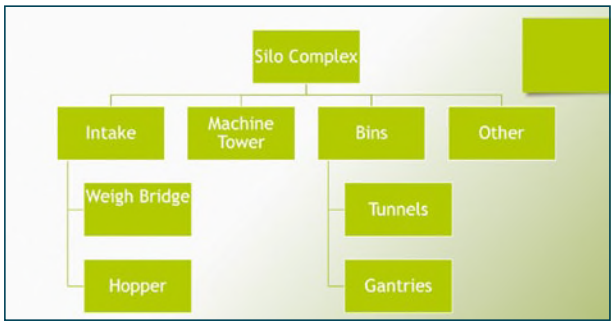


Temperature variation: Higher temperatures will expand steel silo walls, allowing grain to settle in the newly created space. When the temperature drops the silo wall will try to compress the grain, causing additional circumferential stresses in the thin shell. The common term for this action is ratcheting.

Dust explosion: It is important to zone areas properly to ensure that the right equipment is used for specific zones. Insurance companies will demand management of this risk.

Aeration: Incorrect aeration design can lead to roof failure, which will cause gantry collapse. The balance between airflow in and out should be understood, together with the resistance that the grain mass will give.

Figure 2: Sequence of a typical storage facility.



Operation: The safe storage of grain at the right moisture content and temperature will ensure the free flow of product without the risk of bridging and subsequent collapse causing additional stresses. The new trend is to refrigerate grain to temperatures below 15°C, which eliminates the necessity for expensive fumigation. Spontaneous combustion in oilseeds is a risk that can be managed by proper aeration and seed conditioning via the combination of temperature and relative humidity.

Maintenance: This is always the area where costs are cut first if the bottom line is under pressure. This is to the detriment of assets and safety standards. The answer lies in a structured approach that prioritises action. This approach should clarify non-negotiable corrective actions and items that can be postponed to the following year's budget.

The first distinction to be made will be the identification of primary and secondary structural elements. Primary elements include the main frame that keeps the installation stable and safe, such as gantry supports, foundations, bins, etc. Cladding and paving are typical of secondary elements.

Typical inspection procedure

The first step will be to group the complex into operational areas to analyse stability specifics applicable to that entity. *Figure 2* illustrates the sequence of a typical storage facility. Taking the hopper as an example, the criteria in *Figure 3* will apply.

Operations will typically look at aspects such as the effect of increased loads on supporting beams and grids. On the maintenance side, the steel members will be checked for level of corrosion that will impact on thickness of webs and flanges, affecting the allowable safety factor. Other areas will be the integrity of the beam connections, cracks and wear and tear. This will be documented in an orderly manner. A good method of presentation is to classify it as green, yellow and red with an index classification as indicated in *Table 1*.

Figure 3: Criteria for structural stability report.

Table 1: Index classification for silo maintenance.

Category	Description	% Original strength	Action needed
1	New construction or excellent condition.	100%	None
2	Slight service deterioration. Strength of members not affected.	100%	None
3	Slight reduction in strength due to rust or minor spalling.	95% to 100%	Repaint, patch or tighten bolts.
4	Some reduction in strength. Repair should be included in maintenance schedule.	75% to 95%	
5	Severe deterioration with major reduction in strength.	50% to 75%	Repair or replace members.
6	Member strength compromised. Not safe for operation.	< 50%	Replacement

The red category requires immediate attention, while green can be placed on the three- to five-year budget. Each industry will have specific criteria. An example of this would be an edible oil refinery with specific classifications for a high-risk installation such as the hexane unit.

The improper mounting of dishes and other devices poses a safety hazard due to possible accidental falls from a height onto people or assets. Common areas of non-compliance are anchoring on safety rails, drilling of holes in the roof for cable entry, and not sealing the area properly, which causes corrosion of beams and reinforcement. Another area of concern is proper earthing. If a spark is transferred into the machine tower it may lead to a dust explosion.

One can conclude from all this that a standard operation procedure should be in place for each silo complex to ensure that regular inspections are carried out. This will assist in optimising the budget process for maintenance and ensure that the complex complies with legislation. The structured process set out here will simplify the investigation and will lead to good recordkeeping, which can be compared on an annual basis. It will result in a history of records for the complex.

For enquiries, send an email to pieter.fourie@ekodesign.co.za or visit *www.ekodesign.co.za*.