Government of Western Australia
Department of Mines and Petroleum
Resources Safety

# Mines Safety Bulletin No. 124

**Subject:** Structural safety of buildings, plant and other structures

**Date:** 16 September 2015

## Background

Structural failures, near misses and integrity issues on Western Australian mining operations over the past three years appear to have similar causation factors to the failures reported in Mines Safety Bulletin No. 43 *Structural safety of building and plant*, released on 13 August 1998. The inspectorate is concerned about:

- some recent serious and potentially serious incidents involving loss of structural integrity
- the management of assets through their life cycle
- the suitability and adequacy of structural repairs and/or modifications.

This bulletin updates Mines Safety Bulletin No. 43 with additional recommendations for industry to:

- better manage asset integrity
- address the potential for normalisation of risk for buildings, plant and other structures that typically have a long design life (i.e. people regularly passing damaged structural elements can become desensitised to the increasing risk of structural failure).

*Note: For convenience, the term “structures” refers to any buildings, plant and other structures that are at risk of failure from lack of integrity.*

While no-one was injured in the recent failures, all had the potential to cause multiple fatalities:

- collapse of a 30 tonne gross weight open-top mixing tank — although still under investigation, it appears the support steelwork failed due to corrosion damage and inadequate connection design
- rupture and collapse of a 2 million litre acid leach tank — although still under investigation, it appears the tank shell failed due to corrosion damage
- failure of a 80 tonne jib crane during testing — the strength of the crane was compromised by inadequate design and failure to appropriately communicate the design intent
- concrete supporting plinth for a conveyor take-up sheave tore out of its ground slab — the strength of the plinth was inadequate due to both design and construction defects.
- failure of a back stay on a radial stacker – the stay member was excessively corroded
- failure of a stack – the stack experienced accelerated internal corrosion due a change in the composition of emissions
- failure of a winder sheave supporting shaft – a fatigue crack was not identified until it caused a complete fracture.

As well as the reported failures, mines inspectors have observed structural damage during site visits. Inspectors have required mine management to have the following situations assessed by competent persons:

- corrosion of steelwork members where a large portion of the gross area is missing or webs are corroded through over substantial areas or lengths
- damaged concrete where large areas had spalling (cover damage due to internal corrosion) resulting in compromised bond strength, or there were full-thickness cracks
- impact damage of steelwork members where the permanently deformed shape far exceeds the limits of the design standard
- modified structures where the original design intent is clearly compromised (e.g. removed or improperly modified vertical bracing).

Structural issues identified by inspectors during site visits that needed to be addressed immediately include:

- the potential failure of a run-of-mine (ROM) bin that had one remaining bolt preventing the collapse of the tie wall and the overall collapse of the bin's side walls — the bin had shown signs of distress for some months
- large cracks identified in the support steelwork under a ROM bin — weld repairs and patching were ineffective, and the last remaining structural members were cracked through and displacing
- large cracks in underpans beneath vibrating screens — the original support bracket details were not adequate to accommodate the dynamic loading.

## Summary of hazard

- Structures can fail when their strength is inadequate for the load applied (i.e. not robust or reliable). Failure can involve an entire assembly or parts.
- Catastrophic structural failures are often rapid events with little warning. There is usually insufficient time to escape the vicinity.
- The consequences (including knock-on effects) of structural failure increase when the contained energy or resisted load has secondary harming potential, such as when the failure of one structure (or structural component) causes the failure of others (i.e. a domino effect), or harmful liquids are released.
- Structural failures almost always involve high energies. Even small parts falling from height can result in a fatality or serious injury.

## Contributory factors

### Design

- Original design or design modifications not undertaken by a competent person.
- Inadequate quality control during the design process.
- Change management not adequately implemented.

### Communication

- Lack of confirmation of design intent between the designer and manufacturer (e.g. checking that the manufacturer's interpretation meets the design intent).

- Original designer did not communicate the assumptions and limitations to the manufacturer and end-users (e.g. maintainers, operators).
- Inadequate specification by the user or developer for the design expectations, including those for monitoring and maintenance.

**Competency**

- Those tasked with assessing the structural integrity condition of structures at workplaces did not understand:
  - the limits on the reliability and robustness of those structures
  - the potential consequences of structural failure.
- Original construction did not follow required work practices and standards.

**Monitoring**

- Failure to ensure the condition of the structure remains within the design limits.
- Workplace assessment by a competent person not undertaken.
- Inadequate assessment and reporting of damage, including:
  - assuming that the original design and construction were correct  when determining the plan of action (e.g. some construction has inadequate proof of design or manufacturing data, or insufficient physical build details)
  - not assessing the risk ranking of the structure using consequence of failure and degree of unreliability.
- Following a qualitative assessment (e.g. visual inspection by competent person) where the structural integrity is determined to be inadequate, a quantitative assessment was not undertaken where necessary to determine the most appropriate plan of action.

*Note: Quantitative assessments usually involve accurate calculation of strength and reliability based on measurements and calculated probability.*

**Maintenance**

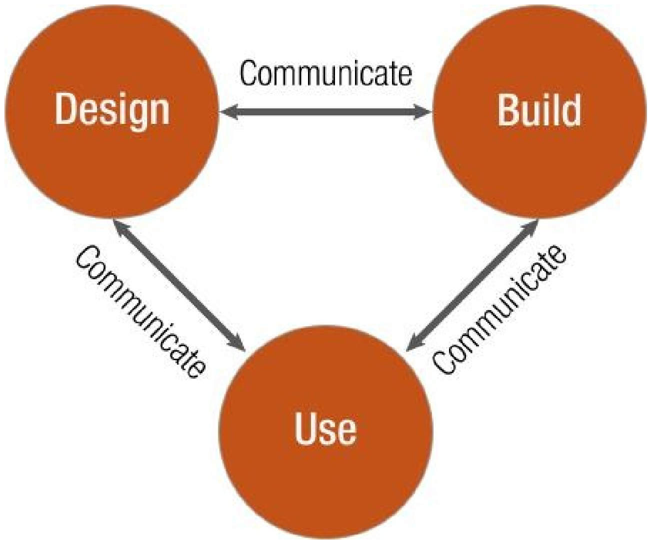
- Repairs were not undertaken by competent persons.
- Failure to identify and remedy the root causes of the failed areas during the original and subsequent repairs.
- Lack of use or utilisation plan to maintain structures in line with the original design intent.
- Inadequate risk ranking, prioritisation and urgency allocated for remedial measures.

**Use**

- Failure to ensure the loading applied was limited to the design value.

## Actions required

Responsible persons are reminded of the importance of managing the structural integrity of structures. Structural integrity and safety rely on good practice throughout a structure’s life cycle (see AS 5104, table A.1). There are three key areas to consider when addressing the causation factors for failure: design, build and use.




The arrows indicate the transfer of design intent. If communication does not happen or is ineffective, structural integrity and safety may be compromised.

The following actions are recommended.

**Design and communication of design intent**

- Designers are reminded of their responsibilities regarding items of plant under section 14 of the *Mines Safety and Inspection Act 1994* and regulations 6.3, 6.4 and 6.5 of the Mines Safety and Inspection Regulations 1995.
- Competent persons should check the adequacy and suitability of designs and modifications.
- Connections known to be at risk of rapid crack failure should not be used in structures supporting dynamic equipment.

**Manufacturing verification**

- The construction of all structures should be verified by a competent engineer (ideally, the original engineer) to ensure it meets the intent of the original design.

**Competency**

- Only persons competent in the structural design of the particular structure should manage the asset, including decisions about its continued use or modification.

*Note: An example of a competent person would be a professional structural engineer with suitable training and experience.*

- The manufacturer or constructor's work practices should be reviewed if their output has defective details — in particular, problems arising from the welding of dynamic equipment are well documented.

**Monitoring**

- During the life cycle of structures at a workplace, a person whose competency covers the specific structures should assess them for structural adequacy. A risk-based approach should be adopted to determine the timing of inspections and monitoring.
- Where a structure has inadequate strength or reliability (robustness), a competent person should advise the immediate measures to be taken to ensure there is no exposure to harm while decisions are made regarding the appropriate course of action in terms of its design life or planned obsolescence.

### Provision, maintenance and repairs

- Employers, including Principal Employers, are reminded of their responsibilities regarding the provision and maintenance of workplaces, plant and systems of work under sections 9 and 13 of the *Mines Safety and Inspection Act 1994* and regulations 6.2, 6.17, 6.18, 6.19, 6.20, 6.21, 6.22 and 6.23 of the Mines Safety and Inspection Regulations 1995.
- Once a defect is identified, take all practicable measures to correct the defect to ensure the safety of personnel.
- For immediate risk mitigation, when structures are discovered to be at risk of failure, risk reduction measures should be applied in accordance with the hierarchy of control (e.g. remediating to the original design and construction state, modifying or strengthening, preventing access).
- For assessment of reliability and robustness where immediate risks are not present, quantitative assessments should be considered to determine the most appropriate plan of action.

### Use

- A use and utilisation plan should be developed and implemented to limit the loading and state of degradation, such that the structural integrity does not decay below an acceptable degree of reliability (robustness).

## Further information

www.dmp.wa.gov.au/ResourcesSafety

- Mines Safety Bulletin No. 43 *Structural safety of buildings and plant*
- *Evaluation of asset integrity management system (AIMS) – guide*

www.standards.org.au

- AS 5104 *General principles on reliability for structures*
- AS/NZS 1170 *Structural design actions* (series)
- AS ISO 13822 *Basis for design structures – Assessment of existing structures*

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