

Crane safety in construction

Research Summary

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Centre
for WHS

This research summary is based on the *Crane safety in construction* research produced by the Centre for Work Health and Safety and RMIT. Special thanks to Distinguished Professor Helen Lingard and her team for their collaboration on this project.

Between 2003 and 2015, 47 Australian workers were killed in incidents involving cranes (SafeWork Australia, 2016), and on average, 240 serious injury claims arise from crane safety incidents every year (SafeWork Australia, 2019). The construction industry is of most concern, accounting for 22 crane-related fatalities and continuously showing the highest rates of crane-related injuries (SafeWork Australia, 2016).

The cause of crane safety incidents has been unclear. Many factors have the potential to contribute to crane safety incidents, particularly in the construction industry. How those causal and contributing factors interact and the extent to which they contribute to safety incidents is difficult to estimate.

The different types of cranes used in construction adds to the challenge, since research shows that incident type and causal and contributing factors can differ depending on the type of the crane involved (Neitzel, et al, 2001; Beavers, et al, 2006; Shapira, A., & Lyachin, B, 2009).

This research project aimed to better understand the mechanisms underlying crane safety incidents in the Australian construction industry and identify where and how actions can be taken to prevent them. The Centre engaged Prof. Helen Lingard and her research team at RMIT University to design and conduct research focused on meeting two objectives. These were to:

1. identify the causes and contributing factors associated with safety incidents involving cranes in the construction industry; and
2. explore strategies/programs/approaches that could be or have been successfully implemented to prevent crane safety incidents in the construction industry.

The scope of research was restricted to the construction industry in response to the prevalence of

crane safety incidents in this sector. The focus was on two types of crane commonly in use at construction sites (i.e., fixed and mobile cranes).

Method

The research used three different methods:

- A review of the national and international academic and 'grey' literature (industry-based and government documents and reports).
- Consultation with more than 35 informed workers and experts from the construction industry and work health and safety regulatory agencies, either in face to face interviews or in focus groups. Nine interviews and eight focus groups were organised in total.
- An analysis of SafeWork NSW data pertaining to crane safety incidents, work health and safety compliance in the crane industry, and crane workers' licencing and training.

Results

Literature review

The literature review produced a synthesis of available published evidence and provided a frame of reference for the other components of the research. It highlighted that the causes of crane safety incidents are present at different levels within a work system. These causal and contributing factors have been identified relating to:

- The regulatory environment
- Prevailing levels of worker skill and competency
- Industry supply issues
- Site planning and management issues
- Physical worksite conditions
- Human errors and equipment failures

In some instances, latent conditions are also reported as potential causes of serious crane safety incidents, for example in rare but serious cases in which design or manufacturing issues are involved.

The literature review also identified a range of different strategies for preventing crane safety incidents in the construction industry:

- Clarify the roles and responsibilities of workers conducting crane-related activities at the worksite, and the suppliers and sub-contractors when selecting equipment and site planning.

- Improve the training of people responsible for planning, coordinating and supervising lifting operations.
- Improve the licencing systems to record crane operators' competencies in using particular types or models of cranes.
- Promote the adoption of new and emerging technologies to improve crane safety.

Interviews and focus groups

The analysis of the data collected in the consultation activities with the industry experts led to three outputs:

1. An evidence-informed crane safety incident causation model. This model reflects the operation of causal factors at three levels of causation: originating influences, shaping factors and immediate circumstances. The causation model was successfully tested against documented crane safety incidents. This demonstrated that industry subject matter experts were able to extract the causes of one crane safety incident with a high level of consistency using the model. The industry subject matter experts also confirmed the relevance of the crane safety incident causation model both for understanding cause, but also for investigating and preventing crane safety incidents in the construction industry.
2. Five cause-effect diagrams tracing the pathways of causation between factors operating at different levels within the causation model (i.e. originating influences, shaping factors and immediate circumstances). The diagrams show, for instance, how the immediate circumstances of crane safety incidents can be traced back to causal factors in the site, organisational and industrial environments. Each of the five diagrams reflect one core topic identified in the review of literature on crane safety incident causation. These are work environment issues, worksite conditions, human factor issues, equipment issues, and task/activity issues.
3. Twelve strategies for the prevention of crane safety incidents, sorted into seven topic areas:
 - Training and competence
 - Development of a code of practice for crane operations
 - Communications and awareness raising
 - The role of the regulator
 - Design and import issues
 - The use of technology
 - Procurement and the management of commercial relationships.

Each strategy addresses a specific need identified by interview/focus group participants as being

critical for the prevention of crane safety incidents in the construction industry and describes the proposed remedy, as well as the potential benefits, outcomes and performance measures to be considered.

Learnings from SafeWork NSW data

The analysis of SafeWork NSW data revealed that:

- Most crane safety incidents occur in the construction industry.
- Dangerous incidents occur most frequently when mobile and tower cranes are involved.
- Serious injuries occur most frequently for mobile cranes.
- The most common mechanism for all crane safety incidents is a person being hit by the load being lifted. However, the most common mechanism of incident in mobile crane incidents is the collapse (overturning) of the crane.
- A sharp increase of the number of dangerous incidents recorded per tower crane occurred between 2015 and 2018. However, the rate of serious injuries per tower crane remained steady over this period.
- When an immediate cause is identified for a crane safety incident, human error is most frequently cited. Faulty crane equipment is the next most frequent immediate cause identified.
- The experience of the crane crew is a significant risk factor for crane safety incidents. More experienced crane workers are less likely to be involved in crane safety incidents.

Conclusion

Four key areas of work with the potential to prevent crane safety incidents were identified when bringing together the evidence collected using the three research methods (i.e., the literature review, consultation with industry experts and the analysis of SafeWork NSW data).

Workforce competence

Human error, usually from one member of the crane crew, is frequently identified as a cause of crane safety incidents. The analysis of SafeWork NSW data and the consultations with industry subject matter experts both identified competence of the workforce to be a critical issue. However, this was traced back to issues inherent to the training and licencing system, in particular, relating to ease of attaining a licence and difficulty associated with evaluating workers' experience in using a particular make/model of crane.

Industry subject matter experts favoured the implementation of a system to record workers' experience in working with cranes. The introduction of a tiered licensing system, and the provision of specific training for those who make critical decisions with the potential to impact the safety of crane operations at construction sites, were also recommended.

Supply arrangements, communication and planning

Time pressures associated with the delivery of construction projects were found to negatively impact the time available for planning safe lifting activities, and in turn, increase the risk of crane safety incidents. Commercial pressures and specific constraints related to crane hire practices (such as the use of fixed price contracts) were also identified as increasing this risk. While work health and safety management systems can potentially mitigate this risk, industry participants were critical of paper-based systems that did not necessarily address site-specific coordination issues. Participants identified the importance of pre-deployment site visits to inform collaborative lift planning, as well as the need for standard clauses establishing safe operating requirements, and clear roles and responsibilities for safety in commercial agreements between principal contractors and crane hire companies.

Industry and regulatory environment

Features of the industry and regulatory environment, including the internationalisation of construction markets and subcontracting practices, were identified as contributing to crane safety incidents in the construction industry. The analysis of SafeWork NSW data also indicated that a history of non-compliance with WHS regulations was a predictor of subsequent crane safety incidents among construction industry businesses. The consulted experts suggested that one solution would be the adoption, by the WHS regulator, of an increased mentoring role. The provision of more detailed guidance on the prevention of crane safety incidents could improve safe working practices in the use of cranes. The same experts also recommended a more 'aggressive' inspection and enforcement regime as a potential solution to promote the safe use of cranes in the construction industry.

Equipment design, maintenance and use

The operation of substandard cranes and structural/electrical failures were identified as immediate causal factors in crane safety incidents. These were traced back to deficiencies in manufacturers' information, inconsistent maintenance regimes or modifications made to crane installations.

The industry experts consulted in the research identified the importance of third-party crane

assessment programs and suggested testing requirements should be based on functional age relative to a crane's design life (rather than determined by the age of a crane in years). The use of 'back to base' data logging technology to record objective information about crane operation and use was also recommended.

References

Beavers, J. E., Moore, J. R., Rinehart, R., & Schriver, W. R. (2006). Crane-related fatalities in the construction industry. *Journal of Construction Engineering and Management*, 132(9), 901-910.

Neitzel, R. L., Seixas, N. S., & Ren, K. K. (2001). A review of crane safety in the construction industry. *Applied Occupational and Environmental Hygiene*, 16(12), 1106-1117.

SafeWork Australia (2019). *Cranes*. SafeWork Australia: Canberra. Retrieved from: <https://www.safeworkaustralia.gov.au/cranes>

SafeWork Australia, (2016). *Work related traumatic injury fatalities 2015*, SafeWork Australia: Canberra. Retrieved from: <https://www.safeworkaustralia.gov.au/doc/work-related-traumatic-injury-fatalities-australia-2015>

Shapira, A., & Lyachin, B. (2009). Identification and analysis of factors affecting safety on construction sites with tower cranes. *Journal of Construction Engineering and Management*, 135(1), 24-33.