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# Interlocked projects in safety competency and safety effectiveness indicators in the construction sector

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ABSTRACT

Safety culture is a concept that has long been accepted in high risk industries such as aviation, nuclear industries and mining, however, considerable research is now also being undertaken within the construction sector. This paper discusses three recent interlocked projects undertaken in the Australian construction industry. The first project examined the development and implementation of a safety competency framework targeted at safety critical positions (SCP's) across first tier construction organisations. Combining qualitative and quantitative methods, the project: developed a matrix of SCP's ($n = 11$) and safety management tasks (SMTs; $n = 39$); mapped the process steps for their acquisition and development; detailed the knowledge, skills and behaviours required for all SMTs; and outlined potential organisational cultural outcomes from a successful implementation of the framework. The second project extended this research to develop behavioural guidelines for leaders to drive safety culture change down to second tier companies and to assist them to customise their own competency framework and implementation guidelines to match their aspirations and resources. The third interlocked project explored the use of safety effectiveness indicators (SEIs) as an industry-relevant assessment tool for reducing risk on construction sites. With direct linkages to safety competencies and SMT's, the SEIs are the next step towards an integrated safety cultural approach to safety and extend the concept of positive performance indicators (PPIs) by providing a valid, reliable, and user friendly measurement platform. Taken together, the results of the interlocked projects suggest that industry engaged collaborative safety culture research has many potential benefits for the construction industry.



## 1. Introduction

Workplace safety incidents are a significant global issue, and in particular, the construction industry is over-represented in workplace injury and death statistics. Despite mechanization, the industry remains labour-intensive and workers are exposed to dynamic, high risk environments on the various projects and construction sites. The International Labour Organisation (2005) reports that at least 60,000 fatal accidents occur each year at construction sites worldwide, equivalent to one death every 10 min. Furthermore, one out of every six fatal workplace accidents takes place at a construction site, and this is increased in industrialised countries, where construction site fatalities account for 25–40% of all workplace fatalities.

In Australia, there were 40 fatalities recorded in the preliminary data for 2008–09, which was the highest number of fatalities of all industries. This corresponds to a fatality rate of 5.9 fatalities per 100,000 employees, which is more than twice the rate of 2.3 for all industries (Safe Work Australia, 2010). In addition, the construction industry accounted for 11% of all serious workers' compensation claims, equating to 40 employees each day requiring one or more weeks off work because of work-related injury or disease.

The economic and social costs of workplace safety incidents are considerable, and in the past governments, industry, and academia have responded to the problem with legislative and compliance-based responses, and a focus on engineering controls and management systems. Following several major disasters in the nuclear, oil, and mining sectors, safety culture has been identified as a critical concept for organisations in reducing workplace safety incidents. Organisations are investing in defining and improving their safety culture, and increasingly being evaluated by employees and clients on how safety is valued and prioritized in the company. Construction industry organisations' have also recognised the importance of cultural influences on safety performance, in particular through the ability of organisational members to effectively implement and continuously improve relevant safety management systems.

Whilst definitional and conceptual variations exist within the safety culture field, it is generally understood that an organisation's safety culture reflects the values, attitudes, competencies and behaviours of individuals and groups in relation safety (ASCNI,

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1993). Safety cultures are typically represented on a continuum, with various levels reflecting cultural maturity (Hudson, 2007). Safety culture is considered a complex, multidimensional construct (Guldenmund, 2000) and this can make it difficult to operationalise at a business level. However, within organisations, some members are suggested to have more influence than others in the development of a positive safety culture (Glendon and Stanton, 2000), and the identification and training of these members is critical to the success of organisational culture improvement strategies. Much of the literature deals with the importance of leadership and management commitment to safety; however it is vital to translate that importance into meaningful frameworks that guide organisations through the practical process of improving safety culture and related safety outcomes.

During 2004–2010, a series of research projects were undertaken in Australia to develop a more comprehensive understanding of the safety issues and challenges in the construction sector. These endeavours enabled the development of a Construction Safety Competency Framework, an implementation process and Practical Guide to Safety Leadership, and an exploratory development of a new type of lead indicator entitled safety effectiveness indicators. All three research foci are briefly described as follows.

## 2. Construction safety competency framework

Developing safety culture and improving safety performance are current challenges for the Australian construction industry. Although there have been improvements in occupational health and safety performance over the past 20 years, the injury and fatality rate in the Australian construction industry as noted previously remains a matter of concern. Current research has identified that positive safety culture is correlated with positive improvements to traditional ‘lag’ indicators such as injury and time off work (Dodsworth et al., 2007; Silva et al., 2004). The problem for industry is how to create and maintain a positive safety culture in different organisations.

Key to the proposed element of research was the establishment of a compendium that lists all roles within a construction site that are in a position to drive the site’s safety culture. By identifying the people who have a primary role in the development and maintenance of the safety culture it is then possible to target training interventions to these people. Toole (2002) has provided a useful guide to identifying safety critical positions within the construction industry. The author has proposed that ‘‘accidents’’ are a result of eight factors: lack of proper training; deficient enforcement of safety rules; lack of safety equipment; unsafe work methods; unsafe site conditions; failure to use proper safety equipment; poor attitudes held towards safety; and isolated unavoidable causes. Therefore, it should be possible to identify safety critical positions by identifying all people who have an influence over those preventable factors. The benefits of this approach include being able to collect information about safety critical roles that are not traditionally seen as primary ‘‘safety roles’’. For example, through focus group consultations using the Toole model as a guide, it may become apparent that a key person influencing site safety culture is the person who ‘‘mans’’/controls access to the site – a role that may not be recognised for its importance. After identifying safety critical roles it is vital to detail the competencies that make a person skilful in that role.

The links between safety critical tasks, the competency with which they are performed and the overall impact on safety culture have been explored by Christian et al. (2009) who in a comprehensive meta-analysis mapped the connections between distal situation – related factors (e.g. management commitment, supervisor support) and distal person-related factors (e.g. personality characteristics, job attitudes), proximal person-related factors (safety motivation, safety knowledge), on safety performance (compliance and participation) and safety outcomes. In addition, Ford and Tetrick (2008) examined task characteristics and their impact on safety motivation safety performance (compliance and participation) and safety outcomes. Competence, as well as attitudinal and motivational factors, appears to have a direct impact on safety culture.

Recent investigations into construction site safety culture (Biggs et al., 2006; Dingsdag et al., 2006), have provided an opportunity through which the industry could focus on this issue. This research, with significant input from industry, developed the Construction Safety Competency Framework which identified 39 Safety Management Tasks and 11 safety critical positions which are crucial to understanding which ‘critical’ safety position holders in an organisation are responsible for what safety task. Specific safety critical positions ($n = 11$) were mapped across the safety management tasks ($n = 39$) and each intersection point ($n = 429$) was ranked with either a 1 or a 2 indicating the level of proficiency and understanding, respectively, the position occupant needed to demonstrate on each of the safety tasks. A score of 1 indicated a requirement of full competency to undertake and/or supervise a particular safety management task while a score of 2 indicated that a working knowledge only was necessary. The determination of either a 1 or a 2 for each intersection point was a majority consensus decision after feedback from all industry participants in the research. The safety critical positions within the industry that have a significant impact on safety culture were mapped, and the behaviours and competencies required to successfully drive a positive site safety culture were identified. Essentially, the Competency Framework identified, in detail, what process should be followed when completing particular tasks; the knowledge, skill and behaviours required to complete the task effectively; and what cultural outcomes should be achieved if the task is completed effectively. The Framework also provided some initial recommendations to industry on training, mentoring and employee motivation. The Competency Framework, given its industry antecedents and validation, was seen as a potential tool in developing safety culture; however feedback from industry indicated that further resources were necessary for industry personnel to be able to adopt the recommendations put forward in the framework. In addition to an easier implementation process requiring fewer resources, there was also an industry articulated need for better options for defining and measuring lead indicators.

## 3. Practical guide to safety leadership

The development of the *Construction Safety Competency Framework* Biggs, Sheahan, & Cipolla, 2006 formulated comprehensive implementation guides for the Safety Management Tasks and safety critical positions identified in the Framework. The outcomes have the potential to enhance current safety skill and practices in first tier construction companies (principal contractors) and greatly assist the strategic development, planning, and implementation of these skills and behaviours in second tier construction companies and associated contractors and sub-contractors.

As useful as the *Construction Safety Competency Framework* is, the immediate implementation of the framework in full, or substantial part, requires extensive resources. In first tier construction companies in Australia, theses resources are typically forthcoming. However, the next level or second tier of construction companies which typically provide contract services to first tier companies or undertake smaller construction projects in their own right, do not usually have access to sufficient resources to implement the framework in substantial form. The Framework was developed conceptually as an iterative scaffold such that an organisation could identify its more immediate needs, develop responses to those with the resources it has at its disposal and then add further safety competencies as resources become available.

Consequently, in order to develop a useful implementation guide for the Framework, it was important to firstly identify the sections of information that would help industry to begin to implement the Framework in a systematic and efficient way. It was also important to highlight the fact that the Framework should be customised to meet the needs and level of safety competency already within the organisation. To this end, preliminary development of the guides commenced, a brief ‘how-to-implement’ document was conceived, and industry participation was sought. Following feedback from industry and corporate partners, several modifications to the original development of the guides were made to the final version.

Of the 11 safety critical positions that were identified in the Framework, four super-ordinate categories or Framework Implementation audiences were created. These categories aimed to collapse the 11 positions into more workable categories for the presentation of the information. It was thought that not all companies would employ staff to fill each of the 11 individual positions identified in the Competency Framework, especially in smaller organisations. For parsimony, the four categories were: (a) Senior Managers (inclusive of CEO’s and Senior Managers); (b) Safety Professionals (inclusive of National Safety Managers, Regional Safety Managers and State Safety Managers); (c) Engineers and Project Managers (inclusive of Engineers, Project Managers and Construction/Operations Supervisors), and (d) Construction Site Managers (inclusive of Site Managers, Foreman and Site OSH Advisors).

Following the initial focus group which indicated that the organisation had been attempting to implement the Framework, it was decided to solicit case studies from organisations who were already working down that pathway. Therefore, several first tier organisations were approached and agreed to provide examples or case studies as to how they initially tackled the task of beginning to map and implement the Competency Framework within their organisations. Five Case Studies were provided by separate first tier construction companies and material from these cases studies highlighted each of three 8 steps outlined in the Practical Guide to Safety Leadership (Biggs et al., 2008). In keeping with the notion of customising the Competency Framework to suit pre-existing safety matrices and internal structure within organisations, each company began the implementation in different ways. It is believed that the ‘tip sheet’ and ‘industry case studies’ will vastly improve the understanding and accessibility of the Framework, particularly for second tier organisations where such information fulfils both an informatics and mentoring function.

The importance of the focus groups with industry professionals cannot be underestimated. Not only do they provide valuable and knowledgeable feedback about the usefulness of the information to industry, but the participants also become stakeholders with ownership of the finished product. Their input helps shape the finished product and therefore the authors can be more confident that their product will be both accepted and valid for industry use.

The final guide in actuality looks quite different to the original guide sent to industry for comment. Although the premise of aiding companies to customise the Framework to suit their individual needs stays intact, the presentation of the guides has changed.

The presentation focus now is on the steps necessary to customise the Framework and therefore draws more heavily on an operational flowchart contained in the original document. This flowchart identified eight steps to implementation, including: Understanding safety culture; Identify safety critical positions; Customise the task and position matrix; Plan, adapt the competency specifications; Use a step wise approach, and; Implement and show continuous improvement. The final guide includes a substantial unpacking of these flowchart steps, defining them, identifying why each step is important, and detailing how the company can implement this step in their organisation. Furthermore, each step contains action ‘tick boxes’ to complete and are illustrated using one or more case study excerpts from industry activity.

The guide contains two workbook style components which can be used to start to implement the Framework in a workshop, pen and paper style manner. First, the action lists from each of the eight Framework flowchart steps are consolidated into one action document to help prompt organisational personnel and identify subsequent steps. Second, several questions and a blank matrix were included that will help organisations perform a current status health check on their company. The questions help identify whether an organisation (1) already has a safety management task in their organisational documentation or not, (2) already has a position holder responsible for a safety management task or not, and, (3) already has a training program providing education (rather than training) in particular safety management tasks or not. Following this exercise, the organisation can begin to complete the ‘blank matrix’, a matrix from the original Competency Framework with the safety critical positions list removed so that companies can identify, in the context of their own organisation, which position is responsible for each task.

## 4. Safety effectiveness indicators

The third interlocked research project reported on here explored the development of an alternative safety performance measure. Having a consistent and reliable measure of safety performance is critical to the overall safety effort, especially when attempting to quantify improvements gained in safety culture development. Currently in the construction industry, traditional performance indicators such as lost time injuries (LTIs) and related lag indicators are the primary measure of OHS performance. The relevance and reliability of these ‘negative’ measures have been questioned; however suitable alternative measures have not yet been presented. Some work on Positive Performance Indicators (PPIs) appeared promising although a recent evaluation in the Australian context revealed a significant gap in ability to follow up and close out on identified actions (Dingsdag et al., 2008). Thus the industry still requires an accurate, reliable and user-friendly mechanism to measure safety performance on sites.

These measurements have the obvious inherent problem in that they can only be compiled after something has gone wrong, thus a

**Table 1**
List of all 13 SMT’s across pilot and field trials (*SMTs used in pilot).

| SMT number | SMT title |
|---|---|
| 1* | Carry out project risk assessment |
| 6* | Carry out workplace and task hazard identification, risk assessments and control (JSAs/SWMSs) |
| 13* | Plan and deliver toolbox talks |
| 16 | Consult on and resolve OHS issues |
| 18* | Challenge unsafe behaviour/attitude at any level when encountered |
| 20 | Recognise and reward people who have positively impacted on OHS |
| 21 | Deliver OHS training in the workplace |
| 22 | Carry out formal incident investigations |
| 24 | Carry out formal inspections of workplace and work tasks |
| 25 | Evaluation research and prepare reports on OHS issues, performance and improvement strategies |
| 26* | Monitor sub-contractors activities |
| 28 | Evaluate OHS performance of subcontractors |
| 36* | Work with staff to solve safety problems |

negative measure – one of failure, rather than performance. Another contributing factor to poor OHS in the construction industry is the various State and Federal laws that govern OHS throughout Australia. These can be confusing and lead to inconsistencies between the safety regimes between states, and between and within construction companies.

Establishing a credible, accurate and timely standard for allowing industry-wide measurement of OHS performance remains the

**Table 2**
Example of SEI worksheet: "Carry out workplace and task hazard identification, risk assessment and control".

| Safety effectiveness indicator for safety management | | |
|---|---|---|
| Task 6 | Carry out workplace and task hazard identification, risk assessments and controls | |
| Job title | | |
| Date of evaluation | | |
| Evaluator status (circle only one) | *Independent observer OR Leader/facilitator OR participant* | |
| Evaluator role | | |
| Workplace name and company | | |
| SEI 6 Description | This SEI evaluates whether or not the three elements of SMT 6 effectively generate workplace and task hazard identification, risk assessments and controls | |
| Why SEI 6 is undertaken | Proactive and robust task risk assessment activities ensure hazard and risk reduction and legal compliance, and increase OH&S risk awareness on site | |
| Element 1 | The scope of task is clearly defined and all team members are involved in the assessment process | |
| Descriptor | The team demonstrates a clear understanding of the tools and systems needed to conduct an accurate task risk assessment | *Yes, No, N/A* |
| Descriptor | Scope of activity is discussed, understood and defined | *Yes, No, N/A* |
| Descriptor | All team members contribute o open and frank discussion which considers all opinions and ideas | *Yes, No, N/A* |
| *Comments* | | |
| Element 2 | Hazard identification, risk assessment and controls are systematically applied | |
| Descriptor | Hazards involved with each task element are identified | *Yes, No, N/A* |
| Descriptor | The level of risk associated with each hazard is identified | *Yes, No, N/A* |
| Descriptor | Controls are allocated in accordance with the hierarchy of control | *Yes, No, N/A* |
| *Comments* | | |
| Element 3 | Processes for monitoring and review of task risk assessment are considered | |
| Descriptor | Monitoring and review activities for task risk assessment application are discussed, planned, specified and allocated | *Yes, No, N/A* |
| *Comments* | | |

**Table 3**
Example of SEI worksheet: "Plan and deliver toolbox talks".

| Safety effectiveness indicator for safety management | | |
|---|---|---|
| Task 13 | Plan and deliver toolbox talks | |
| Job title | | |
| Date of evaluation | | |
| Evaluator status (circle only one) | *Independent observer OR Leader/facilitator OR participant* | |
| Evaluator role | | |
| Workplace name and company | | |
| SEI 13 Description | This SEI measures how to plan and hold a successful, value adding toolbox talk that achieves involvement and awareness | |
| Why SEI 13 is undertaken | Toolbox talks are held as one way of ensuring effective consultation, exchange of ideas and information between work crews and their supervisors leading to increased awareness of safety issues, hazards and safety actions on site | |
| Element 1 | Facilitator/leader encourages and gets participation, listens and provides opportunities for input from all participants | |
| Descriptor | Participants are actively encouraged to participate and to provide input | *Yes, No, N/A* |
| Descriptor | Facilitator is open to feedback, encourages discussion that increases the level of risk awareness relevant to the team and the site | *Yes, No, N/A* |
| *Comments* | | |
| Element 2 | Facilitator/leader organises actions arising from toolbox talk and allocates responsibilities | |
| Descriptor | Action owners are consulted by facilitator/leader before task allocation | *Yes, No, N/A* |
| Descriptor | Facilitator/leader confirms understanding of individual responsibilities milestones and timeframes, and any other action owners involved | *Yes, No, N/A* |
| Descriptor | Action owners recognise and support the need for change and the outcomes wanted from the actions | *Yes, No, N/A* |
| *Comments* | | |
| Element 3 | Facilitator/leader records relevant toolbox meeting discussion, awareness points, actions and action owners | |
| Descriptor | Toolbox talk is accurately documented and distribution process agreed | *Yes, No, N/A* |
| Descriptor | Awareness strategies, opportunities, and any improvements or requests raised or identified are accurately captured | *Yes, No, N/A* |
| Descriptor | Agreed action owners, activities and time frames are recorded and allocated | *Yes, No, N/A* |
| *Comments* | | |

key to moving forward in improving OHS by the Australian Government (Federal Safety Commissioner's, 2006). Referred to as lead indicators, they aim to recognise signals **before** an incident happens. This would give a way to improve safety before an event occurs, thus reducing the lag indicator rates. At present the only tool actively used to measure lead indicators are PPIs. which measure the actions an organisation has taken to manage and improve OHS performance. A major problem with PPIs is they measure how often an event occurs, rather than how effectively it is undertaken. As a consequence there has been a general lack of consistent uptake in the industry as a whole, and lack of convergence and guidance in the literature.

The challenge for a new framework of lead indicators is to develop reliable, comparable and constant indicators that measure safety performance without the drawbacks commonly attributed to PPIs: The indicators must be easily measured, comparable for benchmarking purposes within sections of an organisation and across industries without being subject to random variation. For the construction industry specifically, they must be able to be implemented uniformly from project site to project site notwithstanding the disparate sectors of the industry, the variability of the work undertaken and the diverse risk contexts these generate. Further, they must be simple to implement so that they are not capital and human resource intensive. They must not be so complex that they are time-consuming to administer and collate and they must measure effectiveness instead of simply measuring a number of event s which have no demonstrated effect on safety performance.

As the construction sector in Australia had already identified safety management tasks and safety critical positions, it was a logical step to use this primary source material to develop the new indicators (to be named safety effectiveness indicators) to move beyond the concept of PPI's. Of the original 39 SMT's, 6 were chosen by industry to commence pilot trials with eventually a total of 13 SEI's being developed.

The concept of safety effectiveness indicators (SEIs) assisted the development of 13 of the original 39 Safety Management Tasks (SMTs). Resource constraints restricted both the pilot study ($n = 6$ SEI's) and the follow on field trials to a total of 13 SMT (see Table 1).

A workbook was distributed for the pilot study with project history and information, user instructions, and individual SMT pages. Each SMT page was composed of the SMT title, spaces for name of evaluator, date and which status the evaluator considered him, or herself. This was followed by a description of the SMT and why it should be undertaken. Below this was the measurement scale, which was broken into different elements. The number of elements used ranged from 2 to 5. Each element was constructed of 2 statements on the extremities of a 4 point Likert scale.

Feedback forms were distributed and focus groups were conducted to receive feedback from all participants in the pilot trials. Of the comments received back via the feedback from, the changes requested were: language/wording to be simpler and less complicated; less repetition between elements; and simplification of scales. Of the focus groups held the major changes requested were: language to be made more comprehensible; include additional space for qualitative comments; and clear separation of each SEI commentary and rating process. Respondents opted for a simple binary choice as to whether an action was observed or was not observed, with an immediate opportunity to add qualitative comment to the observation.

**Table 4**
Example of SEI worksheet: "Monitor sub-contractor activities".

| Safety effectiveness indicator for safety management | | |
|---|---|---|
| Task 26 | Monitor sub-contractor activities | |
| Job title | | |
| Date of evaluation | | |
| Evaluator status (circle only one) | *Independent observer OR Leader/facilitator OR participant* | |
| Evaluator role | | |
| Workplace name and company | | |
| SEI 26 Description | This SEI measures the effectiveness of monitoring sub-contractors activities and the effectiveness of safety improvement strategies | |
| Why SEI 26 is undertaken | The monitoring and feedback of sub-contractor activities assists with the development of safety initiatives. The ongoing monitoring and evaluation of sub-contractors' activities ensures that they engage in safe work and take ownership of improving safety | |
| Element 1 | Sub-contractor safety expectations are clearly defined and communicated | |
| Descriptor | Sub-contractor leadership is able to clearly define hazards and controls relevant to the contracted scope of work | *Yes, No, N/A* |
| Descriptor | Sub-contractor has an established capacity to safety undertake the contracted scope of work | *Yes, No, N/A* |
| Descriptor | Sub-contractors and their employees clearly demonstrate that they understand and follow the safety obligations of project defined requirements | *Yes, No, N/A* |
| *Comments* | | |
| Element 2 | Use evaluation tools and mechanisms to determine and monitor the effectiveness of sub-contractor activities | |
| Descriptor | Well defined tools are available and implemented to identify, monitor and evaluate the effectiveness of sub-contractors' safety actions and behaviours | *Yes, No, N/A* |
| *Comments* | | |
| Element 3 | Work with sub-contractors to identify activities that present opportunities for safety improvement | |
| Descriptor | The project shares safety performance information with the sub-contractor for the purpose of communicating and improving safety behaviours | *Yes, No, N/A* |
| Descriptor | The project demonstrates a willingness to provide, receive and consider positive and negative feedback to improve sub-contractor safety understanding, actions and behaviours | *Yes, No, N/A* |
| *Comments* | | |
| Element 4 | Ensure identified improvement strategies are implemented, monitored and effective | |
| Descriptor | The project actively identifies, implements and monitors strategies to continuously improve sub-contractor safety understanding, actions and behaviours | *Yes, No, N/A* |
| Descriptor | There is evidence of people with a safety responsibility taking an active interest in the outcomes of improvement strategies | *Yes, No, N/A* |
| *Comments* | | |

The final worksheet for each SEI incorporated feedback and focus group comments and was structured in a similar fashion for each SEI. Three examples of SEI's for "Carry out workplace and task hazard identification, risk assessment and control", "Plan and Deliver Toolbox Talks", and " Monitors sub-contractor activities" are presented in Tables 2–4.

The initial reaction by participant organisations was favourable to the use of the SEI process. The SEI workbook was considered by all participants as an excellent tool as it "offers consistency across the industry", and they would like to see it "applied across industry" The final SEI measures are seen to be simple to use and robust in their applicability across the sector. In line with National harmonisation of industrial legislation in Australia, the overall aim is to develop a uniform series of measures across Australia and across diverse construction environments.

## 5. Conclusion

The three interlocked projects in safety competency and safety effectiveness indicators briefly described in this paper have been a milestone development in construction safety in Australia. The outcomes of this research have been endorsed by Australia's Federal Safety Commissioner and many organisations have incorporated the outcomes into their organisational practices. For example, Sydney Water, the water supplier for metropolitan Sydney, only accepts contractor tenders from organisations that have a developed and articulated Safety Competency Framework and the Department of Transport and Main Roads in the State of Queensland matches critical roles and required Safety Management Tasks across all of its staff and contractors and trains deficiencies accordingly. More research, however, is recommended, particularly in longitudinal studies on safety effectiveness indicators in a variety of construction environments, to better understand how these may assist in lead indicator predictions and safety planning for the construction industry.

## References


Advisory Committee for Safety in Nuclear Installations (ASCNI), 1993. Third Report: Organizing for Safety. ACSNI Study Group on Human Factors. HMSO, London.

Biggs, H.C., Sheahan, V.L., Dingsdag, D.P., 2006. Improving industry safety culture: the tasks in which safety critical position holders must be competent. In: Proceedings of the CIB W99 International Conference on Global Unity for Safety and Health in Construction. Tsinghua University, Beijing, China, 28–30 June, 2006. Tsinghua University Press, Beijing, pp. 181–187. ISBN: 7 302 13236 4.

Biggs, H.C, Dingsdag, D.P., Roos, C.R., 2008. A Practical Guide to Safety Leadership: Implementing a Construction Safety Competency Framework. Cooperative Research Centre for Construction Innovation, Icon.Net Pty Ltd., Brisbane. ISBN 978-0-9804262-4-3.

Christian, M.S., Bradley, J.C., Wallace, J.C., Burke, M.J., 2009. Workplace safety: a meta-analysis of the roles of person and situation factors. Journal of Applied Psychology 94 (5), 1103–1127.

Dingsdag, D.P., Biggs, H.C., Sheahan, V.L., Cipolla, D.J., 2006. A Construction Safety Competency Framework: Improving OSH Performance by Creating and Maintaining a Safety Culture, Cooperative Research Centre for Construction Innovation, Icon.Net Pty Ltd., Brisbane, pp. 1–66. ISBN 978-0-9775282-9-5. doi: http://dx.doi.org/10.1016/j.ssci.2007.06.008

Dingsdag, D.P., Biggs, H.C., Cipolla, D., 2008. Safety Effectiveness Indicators (SEIs): Measuring Construction Industry Safety Performance, Clients Driving Innovation: Benefiting from Innovation. In: Third International Conference, CRC for Construction Innovation, 12–14 March, 2008. Surfers Paradise Marriott Resort & Spa, Gold Coast, Queensland, Australia.

Dodsworth, M., Connelly, K.E., Ellett, C.J., Sharratt, P., 2007. Organisational climate metrics as safety, health and environment performance indicators and an aid to relative risk ranking within industry. Process Safety and Environmental Protection 85 (1), 59–69.

Federal Safety Commissioner's 2005–2006 Progress Report, 2006. Achieving World-class Safety in the Australian Building and Construction Industry. Office of the Federal Safety Commissioner. Commonwealth of Australia.

Ford, M.T., Tetrick, L.E., 2008. Safety motivation and human resource management in North America. The International Journal of Human Resource Management 19 (8), 1472–1485.

Glendon, A.I., Stanton, N.A., 2000. Perspectives on safety culture. Safety Science 35, 193–214.

Guldenmund, F.W., 2000. The nature of safety culture: a review of theory and research. Safety Science 34, 215–257. http://dx.doi.org/10.1016/S0925-7535(00)00014-X.

Hudson, P., 2007. Implementing a safety culture in a major multi-national. Safety Science 25, 697–722.

International Labour Organisation, 2005. Facts on Safety at Work. <http://www.ilo.org/public/portugue/region/eurpro/lisbon/pdf/wdshw.pdf>.

Safe Work Australia, 2010. Work-related Traumatic Injury Fatalities, Australia 2008–2009. <http://www.safeworkaustralia.gov.au/NR/rdonlyres/30699D00-464C-4168-9C96-C1F30C86B888/0/AnnualNotifiedFatalitiesReport20082009.pdf> (retrieved 12.01.11).

Silva, S., Lima, L.M., Baptista, C.S., 2004. OSCI: an organisational and safety climate inventory. Safety Science 42, 205–220.

Toole, T.M., 2002. Construction site safety roles. Journal of Construction Engineering and Management 128 (3), 203–210.