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ARTICLE

Case Studies on Risk and Opportunity at Design Stage of Building Projects in Australia: Focus on Safety

Patrick X. W. Zou, Sonya Redman and Steve Windon

Abstract

The aim of this paper is to gain a better understanding of the context, practice, benefits and critical success factors in assessing safety risks and opportunities at the design stage of building projects in Australia. Through case studies and interviews, it is found that the assessment and management of risks and opportunities at the design stage of building projects in relation to safety issues could be effectively implemented with a number of benefits including safety performance improvement through the 'think tank' processes (safety knowledge sharing and application), buildability check, value management and quality improvement. It is suggested that this method could be promoted to the construction industry.

■ *Keywords* – Safety; risk assessment; design stage; building project; construction management

INTRODUCTION AND RESEARCH AIMS

The construction industries around the world offer substantial employment opportunities and contribute significantly to national economic growth, but at the same time they have unacceptably high rates of injuries and fatalities. For example, the Australian construction industry employed 773,000 people accounting for approximately 8% of the country's workforce in the year from 1 July 2003 to 30 June 2004 (ASCC, 2005) and 6.3% of the GDP in that period (ABS, 2005). However, the workers' compensation statistics indicated that the Australian construction industry's incidence rate was 28.6 per 1000 employees in that year which was almost twice the overall industry average of 16.4 per 1000 employees (ASCC, 2006a). It also experienced a high fatality rate of 6.5 fatalities per 100,000 employees in that year, which was almost three times higher than the national average for all industries of 2.3 fatalities per 100,000 employees (ASCC, 2005). The US experienced a similar situation – its construction industry had an injury rate 50% higher than the average of all industries between 1991 and 2001 (Huang and Hinze, 2006); and the situation in China was even worse (*Zou et al*, 2007). This recent empirical evidence suggests that construction industries are more unsafe than other industries and that it is an area needing significant reform if injuries and fatalities are to be mitigated.

Traditional approaches to safety risk management have been focused on techniques and management tools related to the identification of on-site work hazards; developing safety management systems, safety procedures and standards; improving physical working conditions such as the selection of plant and machinery and site access; training site workers; developing better work methods; and providing personal protective equipment (Hinze and Harrison, 1981; Holmes *et al*, 1998; Reese, 2003; Biggs *et al*, 2005). Research has also been conducted to study attributes and behaviour issues in relation to safety.

The design phase is an important stage in building project procurement. It has an important influence on how the building is constructed. Research

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(Hadikusumo and Rowlinson, 2002; NOHSC, 2003, 2005; BLL, 2004; HSE, 2004; Weinstein *et al*, 2005; ASCC, 2006b) has shown that in construction project management, many safety risks may be eliminated or mitigated and opportunities seized at the design stage if proper analysis and assessment is carried out. For example, the report by the UK's Health and Safety Executive (HSE, 2004) shows that 47% of construction injuries/accidents in the UK could have been prevented if proper checks were provided during the design stage. Likewise, Australia's National Occupational Health and Safety Commission's report highlighted the importance of minimizing safety risks and maximizing opportunities at design stage (NOSHC, 2005); Weinstein *et al* (2005) suggests that consideration of construction workers' safety and practice should be salient at the design stage. Some construction companies have developed guidelines for systematic identification, assessment and response to safety risks and opportunities at the design stage. For example, Bovis Lend Lease (BLL) has developed and implemented a programme called ROAD (risk and opportunity at design) to perform risk and opportunity analyses at the design stage of building projects (BLL's ROAD programme will be discussed in detail below).

The main aims of this research are to:

- justify the needs for ROAD implementation
- understand the current practice and critical success factors for the implementation of ROAD in building projects procurement
- understand the implication of ROAD to the construction industry.

The methodologies used in this research include a review of literature and two case studies coupled with three interviews with personnel in Bovis Lend Lease.

LITERATURE REVIEW

WHAT IS ROAD?

ROAD (also called design for safety or safe design) is a process defined as the integration of hazard identification and risk assessment methods early in the design process to eliminate or minimize the risks of injury throughout the life of the product being designed (ASCC, 2006b). It encompasses all design including facilities, hardware, systems, equipment, products, tooling, materials, energy controls, layout and configuration (ASCC, 2006b). It aims at eliminating health and safety hazards and minimizing potential health and safety risks (and also maximizing safety opportunities) by involving all decision makers that will be involved in the lifecycle of the designed product. In particular, ROAD considers design implications in the full lifecycle of the designed product and begins at the conceptual and planning phases with an emphasis on making choices about the design, methods of construction and materials to be used which enhance the safety of the designed product.

WHY USE ROAD?

There are many reasons why ROAD should be implemented. First, it is a requirement established by Acts and Regulations in many countries. The UK's *Construction (Design and Management) Regulations* (HMSO, 1994) place a duty on designers to ensure that any design prepared avoids foreseeable risks to construction workers (MacKenzie *et al*, 2000). Under Section 13 of the Regulations, there is a requirement for designers in the UK construction industry to eliminate hazards in their design in order to make buildings safer to construct, clean, maintain and demolish. Construction industry clients are also required to ensure that any designers they employ are competent in this regard (Huang and Hinze, 2006). Legislation implemented in the UK in 1995 explicitly requires designers to design for worker safety (HMSO, 1994).

Similarly, the American Society of Civil Engineers (ASCE) recognized the importance of eliminating safety risks in a design as a key consideration for safe construction. In its *Policy Statement Number 350* (ASCE, 2001), ASCE states that engineers will have responsibility for recognizing that safety and constructability are important considerations when preparing construction plans and specifications.

In South Africa, designers must ensure that their designs are safe and free of health risks (Republic of South Africa, 1993). The South African *Construction Regulations* (Republic of South Africa, 2003) state that designers shall modify the design or make use of substitute materials where the design necessitates

the use of dangerous structural or other procedures or materials hazardous to health and safety, and that designers shall inform principal contractors of any known or anticipated dangers or hazards or special measures required for safe execution of the work.

In Australia, Queensland, South Australia and Western Australia place similar responsibilities on designers (Bluff, 2003) and the New South Wales State Government requires that a management strategy must exist for the design process to include consideration, evaluation and control of occupational health and safety for the construction stage (NSW Construction Policy Steering Committee, 2000). Furthermore, the Australian health and safety statutes and regulations establish general duties of care as well as specific obligations in relation to particular safety risks, as described below:

- The *Building Code of Australia* (ABCB, 2006) covers matters such as structural safety for fire resistance, access and egress, mechanical ventilation and other health and safety matters relating to building design, which may affect end users, occupants or those maintaining, cleaning or servicing the building.
- The *Australian National Workplace Health and Safety Risk Management Advisory Standard* (2000) supports Section 22 of the *Workplace Health & Safety Act* 1995 which deals with 'ensuring workplace health and safety' and describes a five-step risk management process (NOHSC, 2003).
- In Queensland State, the *Workplace Health and Safety Act* 1995 under section 34B(1) states: 'A person who designs a building or other structure, or a part of a building or other structure, as a workplace has an obligation to ensure that, relevant persons for the building or other structure or part will not be exposed to risk to their health or safety arising out of the design of the building or other structure or part.' This Act details designers' obligations which became effective on 1 June 2003.
- In New South Wales State, the *Occupational Health and Safety Act* 2000 states: 'A person who has control of premises used by people as a place of work must ensure that the premises are safe and without risks to health. The employer must consult with the employees of the employer to enable those employees to contribute to the making of decisions affecting their health, safety and welfare.'
- In South Australia State, the *Occupational Health and Safety and Welfare Act* 1986 'requires designers and owners of [a] building to ensure that the building complies with any applicable prescribed requirement and that those working on or about the building are safe from injury and risks to health'. The *Occupational Health Safety and Welfare Regulations 1995* (South Australia Government, 1995) comprehensively identify a range of health and safety matters to be addressed by duty holders from designers and owners of buildings to designers of structures, manufacturers, importers and suppliers of structural materials and those who erect structures.

The second reason why ROAD should be implemented is the fact that, in construction project management, many risks may be eliminated (and opportunities created) if proper analysis is carried out at the design stage (ASCC, 2006b). The design phase is an important stage in construction project procurement as it has an important influence on how the building/structure will be built and managed. The New South Wales State Government's WorkCover Authority in Australia indicated that, in 2000 in NSW State, 63% of all construction fatalities and injuries could be attributed to design decisions or lack of planning (NSW WorkCover, 2001). (NSW WorkCover is the New South Wales State Government's work safety authority in Australia.) Hinze (2006) and Huang and Hinze (2006) suggest that the owners, architects and engineers need to consider construction worker safety in their design. Also, clients should ensure that they award projects to contractors who have good safety records. Furthermore, clients should also actively participate in the safety process during construction (Huang and Hinze, 2006). Chapman (2001) claimed that the design team's in-depth knowledge of the sources of risk can greatly influence the identification of risks in the design phase of a project. Similarly, Zou *et al* (2006, 2007) stated that designers play important roles and bear heavy responsibilities in minimizing risks and maximizing

opportunities during the design stage of construction projects. They asserted that, to accommodate the risks appropriately, concerted efforts are needed at different phases of a project lifecycle, particularly at the project feasibility, design and construction phases. They further claimed that designers should carry out comprehensive investigations of site conditions, articulate the clients' needs in a technically competent way and, within the limitation of the clients' resources, work collaboratively to develop sound programme schedule and cost planning and minimize defective designs. Furthermore, Loosemore and Zou's (2005) research showed that maximizing opportunities is important in construction project management while the NOHSC's report highlighted the importance in minimizing safety risks and maximizing opportunities at the design stage (NOHSC, 2005).

Third, identifying and eliminating risks at the design stage is key to effective cost and managerial control (Andres, 2002) and many benefits may be achieved, such as improved productivity, avoidance of expensive retrofitting to correct design shortcomings, and significant reduction in environmental damage and its attendant costs.

In short, as claimed by ASCC (2006b), the ROAD programme provides a number of benefits including:

- prevention of injury and disease
- improved usability of products, systems and facilities
- improved productivity
- reduced costs
- better prediction and management of production and operational costs over the lifecycle of a product
- compliance with legislation
- innovation, in that it demands new thinking.

BARRIERS TO IMPLEMENTING ROAD

Despite the beneficial appeal of ROAD, owners, designers and constructors await to see the tangible evidence that this process leads to reduced risks on construction sites before implementing it in their work (Gambatese *et al*, 2005). According to Hinze and Wiegand (1992), Gambatese (1998), Hecker *et al* (2004) and Toole (2004), barriers to implementing ROAD in the US include:

- weak or absent regulatory requirements for architects and engineers to design for the safety of construction workers
- US Occupational Safety and Health Administration's placement of safety responsibility on the employer (typically the constructor)
- liability concerns among architects and engineers
- narrow specialization of construction and design
- limited availability of safety-in-design tools, guidelines and procedures
- limited pre-construction collaboration between the designer and constructor due to the traditional contracting structure of construction industry
- limited education architects and engineers receive on issues of construction worker safety and on how to design for safety.

METHODS FOR ROAD

There were a number of different methods and tools identified in the literature review that allow for safety risks to be identified either during the designing process or through a design review process as listed in Table 1. These processes include design reviews and checklists used to identify safety risks in a design.

It was also discovered that people in control of design decisions can have great influence in addressing safety in design. Designers and engineers in charge of designing should include safety as one of the key tasks during design along with aesthetics and functionality (Hinze and Wiegand, 1992). Clients also impact on construction safety through their involvement. Hinze (1997) identified that owners can favourably affect construction safety by selecting safe contractors, encouraging designers to address safety issues in the designs and by participating in safety management during construction. Huang and Hinze (2006) focused on identifying the owner's role in construction safety through analysis of the project interview data and Gambatese (2000) found various ways in which owners can actively address safety and positively influence project safety performances through:

- ensuring that safety is addressed in project planning and design
- assigning safety responsibility during construction
- addressing project characteristics
- selecting safe contractors

TABLE 1 Methods of ROAD

METHODS	REFERENCES	DESCRIPTION
Design review	Michael and Toole (2005)	One way in which designers could increase safety would be to have a peer review of the completed design, ensuring the design provides an acceptable level of worker safety. That is, the review could ensure the design is not inherently more dangerous to build than necessary
Checklist method	Kim *et al* (2006)	Their method of developing the checklist was first to introduce the concept of design for safety (DFS) and safety management methods from the UK and US, after which a new safety design checklist model was proposed to address the practical problems of using the current checklist which was lacking DFS assessment. The safety design checklist proposed consists of the following items: ● design space and element ● work trade ● types and cause of hazards and risks ● degree of disaster risks ● DFS assessment guidelines ● laws/regulations/codes/notices
	Gambatese *et al* (1997)	A list developed by the authors, which cross-references US Occupational Safety and Health Administration provisions with suggested design modifications that can be used to address safety risks during the design stage
Key principles of safe design	ASCC (2006b)	Key principles of safe design and the importance of safe design and how it can be achieved. The key principle elements for safe design include: ● person with control – people who make decisions affecting the design of products, facilities or processes are able to promote health and safety at the source ● product lifecycle – safe design applies to every stage in the lifecycle from conception through to disposal. It involves eliminating hazards or minimizing risks as early in the lifecycle as possible ● systematic risk management – the application of hazard identification, risk assessment and risk control processes to achieve safe design ● safe design knowledge and capability – should be either demonstrated or acquired by persons with control over design ● information transfer – effective communication and documentation of design and risk control information between all persons involved in all phases of the lifecycle is essential for the safe design approach

- inclusion of safety requirements in the contract, and
- the owner's active participation in safety during project execution.

Gambatese (2000) also suggests, to the extent possible, that owners through their project representatives should participate with the contractors in all project safety activities, including but not limited to new employee orientation; safety meetings; jobsite safety audits and accident investigations; training; incentive programmes and other safety related programmes.

RESEARCH METHOD

The methodology adopted in this research included a review of literature and a study of two cases through desktop information analysis and three face-to-face interviews with senior construction/project/safety managers. The case studies investigated the contents, processes and challenges of the implementation of the

ROAD process. The two ROAD cases included a 5-star green rating office building and a modern university educational building. The senior management members interviewed are:

- Interviewee A – a construction manager (CM), with more than 10 years' experience in the field of construction management, who was the construction manager of Case 1 in this paper.
- Interviewee B – a project manager (PM), with about 20 years' experience in the construction industry, who was the project manager of Case 2 in this paper.
- Interview C – a site manager, with more than 25 years' experience in the field of construction safety management.

BLL'S GUIDES FOR RISK AND OPPORTUNITY AT DESIGN (ROAD)

THE COMPANY'S SAFETY VISION AND MISSION

BLL is a large company operating in many countries including the UK, the US, Australia and China. The company has endeavoured to instil the importance of safety through cultural change. Its cultural movement endeavours to permeate safety practices throughout all levels of the company. BLL's environment, health and safety (EHS) policy is 'the personal responsibility of everyone who is to get things changed, fixed, redesigned or enhanced so as to ensure the health and safety of all who work with us, visit us or do business with us and minimize our environment impact'. To achieve this mission, BLL has developed minimum EHS standards, procedures, policies and guidelines which must be addressed at design stage. Designers engaged on BLL projects must make themselves fully aware of these documents, their meanings and the issues to be managed at all stages of works to ensure compliance.

BLL has focused on ensuring wide health and safety practices by implementing risk and opportunity at design (ROAD) throughout project lifecycles from concept design in order to 'design out unsafe materials, work sequences, temporary works, in use and maintenance practices' (BLL, 2004).

The development of ROAD is a response to the high number of injuries attributed to foreseeable risks, such as poor design decisions or lack of planning. The increasing prevalence of responsible workplace practice and accident mitigation provided the impetus for the fine-tuning and compulsory implementation of the ROAD process in all BLL construction projects.

The company has made a concerted effort towards the implementation of safer work practices not only for the tangible ramifications of cost and time efficiency, but also for intangible advantages, such as an improved reputation for prioritizing safe practices during construction, reduced costs of management and supervision as a result of the identification of design opportunities.

THE CONTEXT OF ROAD

The ROAD programme in BLL is a risk and opportunity identification, assessment, mitigation and management process (BLL, 2004), including:

- identification of safety risk or opportunity
- recording of the proposed solution
- identification of a consultant or trade package whose area has a safety risk or opportunity
- identification and recording of a construction delivery member to be responsible for the action and its closure.

The overall ROAD processes are set out in the following nine steps:

- Building element assessment at pre-construction using ROAD hazard/opportunities checklists.
- Trade package assessment at construction stage using the ROAD hazard/opportunities checklists.
- Recording ROAD document and uploading into the project management plan.
- ROAD agenda item on design programme meetings.
- Establish action and status list.
- Update and report status at each design review.
- Actions from ROAD issues to be considered prior to approval for construction.
- Environment, health, safety and quality monthly management meetings review the reporting of projects including the ROAD status.
- Monthly update of the ROAD document as part of the project review.

The ROAD programme creates a forum for continuous evaluation, review and critique of particular construction methodologies that may pose a risk to safety, or may create an opportunity for informing design decisions and buildability. ROAD is manifest through the 'ROAD document' which is a proforma document introduced to every project at the earliest stage of design meetings between the project manager and other members of the construction delivery team. The document is updated and reviewed on a monthly basis and those amended documents are filed on the database.

In order to make the ROAD document more applicable to individual projects, the project manager develops the ROAD document for that project by using a 'think tank' process. This means the project manager convenes a team of project delivery members (including the construction manager, consultants, client, facilities manager, environment, health and safety manager, site manager, cost planners and nominated other company/subcontractor personnel or experts) to discuss the specific risks applicable to that project in the standard form. It is important to have all members of the construction and design team present in order to cover all aspects of concern and maximize identification of potential problem areas. At the design meetings, the proforma document is completed with details of identified risks and dedicated actions. It becomes the checklist and record of risks and opportunities and is then resolved for that project. The risks are categorized into different levels – high, medium and low levels of harm – as represented in Figure 1.

This process results in a ROAD register, as shown in Figure 2. Monthly review and amendment ensure its currency and value as a mechanism for preventing risk and optimizing opportunities before and during construction.

THE FEATURES OF BLL'S ROAD

There are a number of features the ROAD document provides, including total project supply chain (team/participant) involvement, ownership, responsibility and clear accountability of risks and opportunity, clear assessment methods and regular monthly review meetings. The following sections discuss these features in details.

A compulsory document

At BLL, a ROAD document is a compulsory measure for every project. Under BLL policy, no new project can begin without the review and acknowledgement of the document pre-construction.

Compiling the ROAD document and team involvement

ROAD brings risks and opportunities for improvement at the design stage (or at the latest, before construction) to the attention of all those concerned in the project. It does this by first identifying already known possible hazards or construction techniques, and tabling them in the ROAD document. Initial identifications of risks in the downloadable proforma document may be standard risks with respect to employee health and safety, the local environment or the future user and maintainer.

BLL's method of review and amendment to the ROAD document in the think tank provides a forum for all key participants to be involved in the process of identification and awareness. It also promotes a sense of ownership of the process by giving all stakeholders a voice in the process and forum to participate as a team. The think tank opens lines of communication between different trades and hierarchies, and encourages enthusiastic participation in the successful implementation of their own suggestions. Think tanks or similar meetings are held every month. As design or construction methods change, so too does the ROAD checklist. The ability for all team members to contribute to the compilation of the checklist and its monthly amendments makes ROAD a live, unique and relevant document for every BLL project.

Responsibility and facilitation

At design stage, the creation and detail of the ROAD document is the responsibility of the project manager. At construction, the responsibility shifts to the construction manager. Responsibility may be delegated from the construction manager to other personnel of the delivery team for the overseeing of specific actions. However, ultimately, the construction manager is responsible for the implementation and upkeep of the ROAD process and the project manager oversees it regularly.

Risk and Opportunity at Design (ROAD) and Guide

EH&S Impacts and Hazards Risk Evaluation Tables

Qualitative Measures of Consequence or Impact

Level	*Description of Consequence or Impact*
H (High level of harm)	Potential Death, Permanent Disability or Major Structural Damage. Off-site release not contained, major remediation required with outside assistance, significant detrimental environmental impacts.
M (Medium level of harm)	Potential Temporary Disability or Minor Structural Damage. On site release contained, minor remediation required with outside assistance, short-term detrimental environmental impacts. Any potential for exceeding a Statutory Licence Permit condition.
L (Low level of harm)	Potential incident that has the potential to cause persons to require first aid. On-site release immediately contained, minor level clean up with no short-term environmental impacts.

Qualitative Measures of Likelihood / Probability

Level	*Likelihood / probability*
Likely	Could happen frequently
Moderate	Could happen occasionally
Unlikely	May occur only in exceptional circumstances.

Qualitative Risk Analysis Matrix – Level of Risk

Consequence	*Likelihood / Probability*		
	Likely	Moderate	Unlikely
H (High)	P1	P1	P2
M (Medium)	P1	P2	P3
L (Low)	P2	P3	P3

Key

P1	1st rank actions
P2	2nd rank actions
P3	3rd rank actions
No injury	Acceptable Risk

Ranking a method of deciding priorities can be made.

Items from the 1st rank would be prioritized first followed by those from the 2nd rank and then those from the 3rd rank. Bringing together a risk of injury and likelihood such that an unshaded area is reached means that the risk is acceptable, further assessment of this hazard is needed, but no action need be taken to control the risk arising form it. Such an outcome would arise when considering a hazard, which at worst, would produce a minor injury, which 'could occur sometime'.

If you have now concluded that there are unacceptable hazards for your trade activity, group or area, then you now need to consider what are the existing controls for those hazards.

FIGURE 1 Environment, health and safety impacts and hazards risk evaluation tables

RISK AND OPPORTUNITY AT DESIGN (R.O.A.D.)

Management Discipline		Reviewed by:	Meeting Chaired by :	Updated	9/03/2006
Enviro	E	Craig Scannell, Warren Henson, David Payne michael.kurtz, Andrew Hoskings, graham harbor, robert.hitchcock, Paul Langhorne, Nick Storey, Chris Learmonth, Andrew Quade	Vass Anastasiou	Project Name	Quad 4
OH&S	S			Project Number	113154
Quality	Q			Date	15/11/2005

Item No.	Risk/Opportunity	Proposed Solution	Consultant/Trade Package	Responsibility	Action	Status
	External /Internal Design Scope					
	Existing Site Services	Ensure Authority approval for all works in proximity to Sydney Water (SW) Sewer	Hyder	VA	Issue SW design documentation and ensure written approval of design.	Closed. Sydney Water signed drawings.
	Sewer Vent works	Syd Water to sign-off surrounding construction works re heights & location	Hydraulics	VA	Issue SW design documentation and ensure written approval of design.	Closed. Sydney Water signed drawings.
	Manhole heights at Bennelong Road	Syd Water to review and approve design - review pipework loading and encasement requirements	Hydraulics	VA	To be confirmed once levels established.	
	Services effected by lanCLcape batter to northern boundary	Large rocks included at base of sewer vent.	Civil Works	VA	Christie Civil to complete during stage 2 works.	
	WRAMs relocation to South West corner	expose valves prior to piling in SW cnr of site	Hydraulics	VA	Coordination between Christie and B&M.	Complete
	Make good works to Bennelong Road	Ensure that waterways and culverts are not effected	Hydraulics	VA	Drawings updated. Christies to complete during stage 2 works.	
	Sewer Line parallel to Bennelong Road	SW to confirm concrete encasement is not required.	Hydraulics	VA	Issue SW design documentation and ensure written approval of design.	Complete
	In ground Services coordination	Ensure services are identified and coordinated with construction works	Civil	VA	Services drawings to be coordinated.	In ground services complete.
	HV conduit positioning	Conduits / Cables to be designed for bend capabilities for cabling.	Electrical	VA	Alltech to liase with EA.	
	Main signage conduits	Conduits / Cables to be designed for bend capabilities for cabling.	Electrical	VA	Alltech to install.	
	Telstra / Comms conduits	Conduits / Cables to be designed for bend capabilities for cabling.	Electrical	VA	Alltech to liase with Telstra.	Complete
	Disused pipe material	Determine the pipe material.	Hydraulic	Nick Storey	Confirm ok before removing.	Complete
	Alarm for fire hydrant pump	Ensure correct alarming is in place	HydraulicBMCS	Nick Storey		

ROAD Page 1

FIGURE 2 A sample ROAD document and register

Accountability

In having some members of the delivery team responsible for elements of the ROAD document, accountability ensures implementation. Accountability to superiors could be seen as the key element to ROAD's successful functioning. For example, if discussed and agreed upon actions have not been carried out during the desired time frame, or simply have not been updated in the 'Updated status' column of the ROAD document as 'closed' or 'complete' by those allocated to do so, then the project manager may be reprimanded by higher management.

Accountability is raised each month during the monthly ROAD meetings. BLL policy is for the ROAD checklist to be reported, reviewed and updated monthly at design meetings. By including the ROAD checklist updating into the meetings and monthly reviews, its operational value and importance increases to one of priority.

CASE STUDY 1: THE QUAD 4 OFFICE BUILDING PROJECT

PROJECT BRIEF

Quad 4 is a 5000 m^2 commercial building and is the last stage of a four-part development of 20,000 m^2 of commercial office space within the Homebush Bay precinct in Western Sydney, Australia. The client General Property Group engaged BLL as its principal contractor implementing a design and construct delivery method under a negotiated lump sum contract. The office building attempts a 5-star green rating by employing a number of environmental sustainability strategies such as the use of chilled cooling beams and automated external sunshade louvres. The building also incorporates modern construction techniques such as post-tensioned band beams to increase the column-free space (Figure 3) and permanent formwork systems.

FIGURE 3 Site photo of the Quad 4 office building

THE IMPLEMENTATION PROCESS OF ROAD AND RESULTS

An interview was held with the construction manager of this project in relation to the application of the ROAD process and his perception of its effectiveness and whether it had improved operations, as well as the implication of applying ROAD to the entire construction industry. Below is the summary of the interview findings.

Finding 1 – Compilation and involvement

The ROAD document for the Quad 4 project was first discussed in the presence of all relevant participants in the construction of the building at pre-construction meetings. Key drawings were displayed on the table for ease of reference and analysis of potential risks and opportunities. In addition to site-specific identifications, the ROAD document was reviewed in the light of the safety plan and work methodology statements. This simultaneous process provided the foundation for a sound and broad ROAD document.

Finding 2 – Think tank attendance and knowledge sharing

The construction manager emphasized the importance of professionals (who have knowledge and experience from working on similar projects to that being undertaken), attending the monthly think tank meetings, most notably, experienced project managers and consultants. Their attendance can be enormously beneficial to the breadth of detail in the ROAD checklist. Their experiences can quickly bring to light unforeseen risks and opportunities resulting in a safer construction methodology for that project and creating an educational exercise beneficial to the whole team.

Finding 3 – Responsibility

On the Quad 4 project, the majority of the responsibility for overseeing that correct measures were carried out was held by the construction manager. Other responsibility holders were consultants or experts in their particular trade. Higher management were responsible for monitoring, auditing and questioning the progress of each element addressed in the ROAD document. This system of checks and balances ensures compliance with BLL policy. If some responsibility holders did not keep as up-to-date with their 'completion' or 'closing' of risks as first intended, there was a sense of marked unprofessionalism. It was gleaned from this case study that risk and safety were of the highest priority in construction undertakings. Responsibility in mitigating

safety risks, and therefore the implementation of the ROAD document, played an important part in manifesting that priority.

Finding 4 – Flexibility

The Quad 4 project highlighted another valuable aspect of the ROAD checklist to be its flexible format. It was accessible via the BLL database and could be added to at any time to address changing conditions and increased knowledge. For example, if a subcontractor was employed, their safety plan could be checked against the ROAD checklist document. They may have had commendable procedures which the ROAD document could adopt or the ROAD document may have highlighted faults in the subcontractor's safety measures and could be used as an informative tool.

The flexibility of ROAD, its ability to embrace or reject practices made it a living document that ensured safety at the highest level throughout the construction delivery.

Finding 5 – Experienced project managers essential

The construction manager stressed the importance of having an experienced project manager who would display motivation and commitment to the ROAD programme. Project managers who understand the broader importance of the ROAD document in the workplace can be an extremely valuable asset in achieving the goal of accident minimization. Project managers are able to draw on their previous experiences and also have a powerful role in highlighting the importance of and encouraging commitment from all members of the team to the ROAD process by exuding an enthusiastic and motivated attitude themselves. What follows is a positive response to implementing ROAD actions.

CASE STUDY 2: THE UNIVERSITY OF NEW SOUTH WALES' LAW BUILDING PROJECT

PROJECT BRIEF

Unlike case study 1, the University of New South Wales (UNSW) site, being on campus, was much more confined and had to accommodate pedestrian conditions. The use of ROAD was essential to identify and mitigate safety risks as well as ensure the safety of students and staff in close proximity.

At five storeys high, the 'bold and innovative' building was designed by Melbourne architects Lyons to promote interactivity between staff and students. The building is for the School of Law, the Australian School of Taxation, Kingsford Legal Centre, a law library and other legal facilities. It features light-filled spaces, open staircases, landscaped courtyards and an atrium running through all floors. The building provides 14,000 m^2 of accommodation for teaching and office space. There are 13 classrooms, a Moot Court, student lounge, two Harvard-style lecture rooms with 90 seats and a 350-seat auditorium equipped with state-of-the-art audiovisual equipment.

The project was contracted for about $45 million and commenced in December 2004. It was completed in July 2006. It focused on being an ecologically sustainable development (ESD) through the minimization of disruption to surrounding trees, sun shading, reducing the use of glass on the facade and sensor air-conditioning systems (see Figure 4).

THE IMPLEMENTATION PROCESS OF ROAD AND THE RESULTS

Two face-to-face interviews were held, one with the project manager and the other with the site manager. The interviews focused on the application of ROAD and the managers' perceptions of ROAD as an effective tool for their project and the overall construction industry. Below is the summary of the interview findings.

Finding 1 – Positive participation

In order for the ROAD process to realize its fullest potential as a risk minimizer or opportunity maximizer, the project manager said that positive participation in the process was essential. This was achievable through a motivated management team who could facilitate a successful rapport with other team members with regard to engaging in the ROAD process.

Besides the successful facilitation of meetings, another reason the project manager used ROAD more contentiously at meetings is because BLL was creating a safe work culture. BLL has placed safety at

FIGURE 4 The University of New South Wales' Law Building

the forefront of project members' and workers' minds by putting it on a personal level. The ramifications of unsafe workplace practice deliver a message at an individual/personal level for all that are affected. By doing so, safe work practice is valued and a safety conscious culture emerges. The ROAD process is a key player in guarding against unsafe work practices. As such, it is seen as a positive mechanism towards workplace safety.

The interviewees conceded that ROAD does take a little time and effort. Good ROAD documents encompass a wide variety of risk identifications. Spending quality time on ROAD documents and ensuring their maintenance at monthly meetings is crucial to their success and an invaluable way of heightening the overall outcome of the project.

Finding 2 – Time and cost saving tool

One problem with introducing a new practice to the construction process is the perception that it is another time-consuming task to fulfil. However, the project manager at the UNSW Law Building site believed that ROAD is a 'time and cost saving' tool. It encourages time and cost saving by remedying mistakes that would have otherwise occurred without the ROAD identifying exercise, creating the opportunity to heighten design quality by altering elements for easier and more successful buildability, and taking precautions with regard to safe construction practice.

Finding 3 – A tool for review of buildability and design quality

ROAD can be used as a quality improvement tool. The project manager believed that the use of ROAD early in the project procurement process allowed time for architects and builders to be consulted about difficult construction areas. These opportunities allowed further consideration as to how a difficult design element could be addressed and resolved.

ROAD allowed all members of the team to discuss these problems. This included the client. The project manager applauded the ROAD process which enabled the identification of problems arising from the design early on. In his experience, spectacular or unusual elements to construct could be compromised in quality due to their difficulty or the lack of experience at hand. The ROAD document could be used as an 'opportunity identifier' and highlight to the client and architect that small alterations to the design would enable easier or familiar construction techniques, without compromising high-quality construction.

DISCUSSION OF CASE STUDY RESULTS

DISCUSSION 1 – ADVANTAGES AND BENEFITS OF ROAD

The interviewees claimed that the use of ROAD in construction delivery has many advantages:

- Constant identification of construction procedures ensures that the mitigation of risks are identified and taken responsibility for.
- ROAD creates a system of accountability and transparency within the construction delivery team.
- Upkeep of the ROAD document is a matter of professional pride for construction and project managers who do not want to be viewed as jeopardizing safety on their sites.
- All decision-makers, stakeholders and construction participants have the opportunity to contribute to ROAD and bring their knowledge from previous projects to inform the present one.
- Participation means that everyone has responsibility and ownership of their safety, the environment and the end users.
- ROAD forces a critical analysis of the construction process and buildability of the project. This can elucidate potential risks and opportunities early on.
- Risks and opportunities are identified early allowing time, expectation and budgetary constraints to be adjusted.
- ROAD is on-going and evolves with the project. This flexibility ensures that safety measures can be accounted for throughout the delivery process.
- Increased design quality and a reduction in construction cost wastage.

The interviewees also highlighted a number of tangible and intangible benefits for BLL from the implementation of ROAD, as listed in Table 2.

BLL does not allocate risk analysis to one dedicated officer. Instead, it has taken the approach that risk is a responsibility for everyone. All members of the project delivery team have a role to play as risk identifiers and responsibility holders. BLL has achieved this by giving all members throughout the construction hierarchy a voice as to how they can impose systems that will ultimately protect them, the environment and the end user.

The above practices increase the value of ROAD as a risk identification and management programme. The purpose and result of ROAD is an all round positive one that has gained support and diligent commitment from the whole BLL community.

TABLE 2 Tangible and intangible benefits of ROAD

TANGIBLE BENEFITS	INTANGIBLE BENEFITS
● Tangible effectiveness of ROAD is manifest through the reduced defects in construction, maintenance of budget and the identification of where safer and smarter construction methods can be applied	● Safety awareness and an increase in safety measures on the construction site is the greatest intangible benefit that has come out of the ROAD process. There are fewer accidents and more awareness of safe practices
● The ROAD document is accessible to everyone through the network and this enables past risk identifications to be easily applied so that past mistakes are not repeated	● Client satisfaction is another great benefit. Clients are more satisfied with the reduction in defects and a greater likelihood of construction on time and on budget
● ROAD ensures that there is a review system for project buildability; this review system is undertaken from the senior management down to the client (if they are involved)	● The reputation of the company is improved or heightened because of the organization and predictability allowed by implementing the ROAD process
● ROAD ensures a double checking of safety issues, especially in relation to subcontractors	● People are personally responsible for increasing safety through implementing 'actions' in the ROAD process. This means everyone has a sense of 'ownership' over safety and there is greater employee morale

DISCUSSION 2 – CRITICAL SUCCESSFUL FACTORS FOR IMPLEMENTING ROAD

The interviewees were asked about the critical success factors for implementing ROAD – the following answers were obtained:

- The first critical success factor is the leadership and participation. ROAD relies on the experience of the project manager chairing the ROAD meeting. The project manager needs to have the right attitude, motivation and commitment. They also need to build commitment from the other members of the team by including as many diverse participants as possible in the meeting. The more people present at the meeting, who can share their input, the more likely the ROAD document will be successful in preventing risks and identifying opportunities.
- Another critical success factor is the revisiting of the document at meetings, keeping up the momentum of changes to the document and making sure actions continue to be closed.
- The third critical success factor is the total involvement of all employees. Everyone must participate in the process. Some people may feel that ROAD is an extra task. They need to be encouraged. BLL frames safety in a 'personal way'. The ROAD programme relates to employees on a personal level. We all need to care about safety to care about our employees.
- Fourth, the ROAD document is also successful because it forces architects to think more about how the building will be built from the outset. That attention to detail by a large involved group is educational and participatory for architect, builder and client. The process forces each construction stage to be critically examined and allows the opportunity for quality improvements.
- Fifth, another critical success factor is ROAD's usefulness as an engineering tool. It is a valuable mechanism in controlling design buildability, allocating responsibility for safety measures and monitoring them.

DISCUSSION 3 – FUTURE IMPROVEMENT FOR ROAD

The interviewees identified a number of possible improvements to ROAD. First, there is a need for strong support for ROAD from the top management down. Project managers need support and continual training to increase the overall effectiveness of ROAD. Second, the way forward would be to put more emphasis on 'opportunities' rather than 'risks'. Third, there needs to be greater ownership of the process by employees. Fourth, the ROAD process could benefit from further on-going training for the project and construction managers. Fifth, training for architects and their involvement in ROAD would also enhance the effectiveness of the tool.

DISCUSSION 4 – IMPLICATION OF APPLYING ROAD TO CONSTRUCTION INDUSTRY-WIDE

All interviewees believed that the ROAD programme in BLL is applicable to other companies in the construction industry. First, 'ROAD is good for all projects in the industry. It effectively brings up safety as an important issue and makes sure that the safety issues identified are taken up. The government are supporting this kind of working methodology by taking it up in their construction projects' (Interviewee B). Second, 'a challenge of ROAD is for it to not be perceived as more paperwork. Once the industry sees that its methodology is simple with far-reaching advantages for safety, then the concept can be easily applied across the construction industry' (Interviewee A). Third, 'there is nothing that would inhibit ROAD being implemented across the construction industry – it has so many positives' (Interviewee C).

CONCLUSIONS

This research has found that although there is a framework of Acts, Regulations, approved Codes of Practice and supporting industry guidance to govern occupational health and safety, there is no governing body facilitating the implementation of safety considerations for construction workers during the design process. Architects and clients can gain from many beneficial qualities that come with implementing ROAD in the earlier phases of the project lifecycle. These benefits range from the improvement of workers' safety and the prevention of

injuries and diseases to compliance with legislation, as well as improvements in productivity, usability, cost savings, management and prediction of costs.

Despite the benefits ROAD can offer, there are factors that prevent architects and clients from embracing the concept. Liability exposure and lack of government enforcement ultimately place the responsibility for construction health and safety solely on the builder. Specialization in either construction or design keeps parties separate in their duties. There is limited training and lack of safety risk assessment information, tools and guidelines to help designers develop ways to address the issues. There is also limited pre-construction collaboration between the designer and constructor due to the traditional contracting structure of construction industry.

Safety is important to all construction sites. From both the literature review and case studies, it is clear that assessment and minimization of safety risks at the design stage is necessary, feasible and beneficial. In particular, the ROAD process in BLL simply made it a key priority, while taking advantage of additional factors such as greater teamwork, communal accountability and responsibility for safety, and stronger control and management of safety risks that could disrupt strict timetables and budgets. For it to be successful, the experience of project/construction managers, involvement of all employees, and commitment and action to close the routes for the risks identified from the ROAD process are all needed. It is suggested that ROAD could be introduced and implemented in the entire Australian construction industry to minimize and eliminate safety risks and maximize safety opportunities.

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