
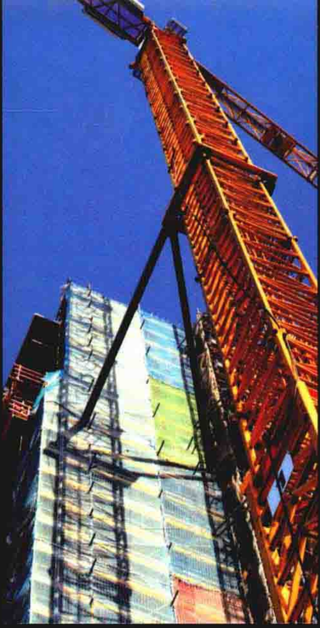
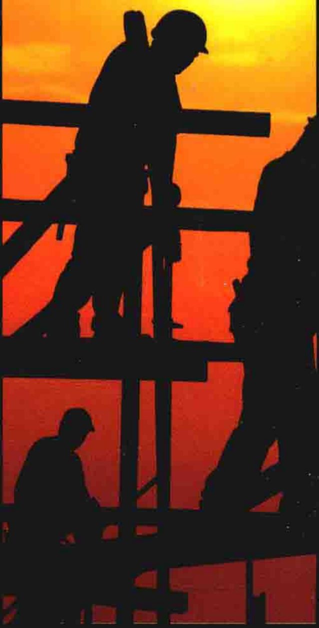

STRATEGIC SAFETY MANAGEMENT

in Construction and Engineering

Patrick X.W. Zou • Riza Yosia Sunindijo

WILEY Blackwell

Strategic Safety Management in Construction and Engineering

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This edition first published 2015

Registered office
John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom

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Library of Congress Cataloging-in-Publication Data applied for

A catalogue record for this book is available from the British Library.

ISBN: 9781118839379

Set in 10/12pt, MinionPro by Laserwords Private Limited, Chennai, India
Printed and bound in Malaysia by Vivar Printing Sdn Bhd

1 2015

Foreword

Two thousand years ago, the Roman Statesman Marcus Tullius Cicero argued that "the safety of the people shall be the highest law." An emphasis on health and safety and the protection of all human beings should be the mark of any advanced society. However, somehow, health and safety (or "elf 'n safety") seems to have acquired a negative, restricting reputation. Most of my new undergraduate students admit that they have had good, exciting activities in their schools and colleges cancelled because of "elf 'n safety". And yet, in a review of the exemplary success on all fronts of the construction of the London 2012 Olympic Park, General the Lord Dannatt (*British Army Chief of the General Staff 2006–2009)* found that "health and safety was not just an annoying millstone hung around middle management's neck, but it was the enabling theme on which the project senior leadership team could found the bedrock of operational efficiency leading to completion under budget and ahead of schedule."

This book presents a strategic perspective on construction safety management providing both a historical and contemporary commentary. It deals with economics, climate and culture, skills, training and learning as well as the important contemporary topic of safety in design. The book also explores research methods in the domain and the research to practice challenge.

I have known the author for many years and been privileged to learn more about his work in this important area.

I commend this book to you.

Alistair Gibb, PhD, BSc, CEng, MICE, MCIOB
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Acknowledgements

Writing a book such as this means we have drawn data from a large number of sources, and we are indebted to many experts and commentators for their help. Especially we would like to thank Emeritus Professor Denny McGeorge of the University of Newcastle for proofreading the chapters; Adam Sun, a former MPhil student at UNSW Australia, for relevant data collection and analysis efforts for Chapter 2; Professor Andrew Dainty of Loughborough University for his invaluable contributions to Chapter 7; and Professor Alistair Gibb of Loughborough University for writing the Foreword.

We are grateful for the information obtained through various sources from the organisations included in this book: Lend Lease, Fluor, Gammon, John Holland, the Master Builders Association of the Australia Capital Territory, Leighton Holdings and so on.

The authors would like to thank UNSW Australia, University of Canberra and Swinburne University of Technology, where they have worked for many years, including undertaking part of the safety research that has been incorporated in this book.

We are also thankful to the editor(s) at Wiley–Blackwell for their contributions, especially Dr Paul Sayer and Harriet Konishi.

Finally, we would like to dedicate this book to our parents and family who have supported us continuously.

Contents

1 Safety Management in Construction and Engineering: An Introduction

This book addresses *Safety Management in Construction and Engineering* by taking a broad view of safety from a strategic decision-making and management perspective. It focuses on strategic decisions made by the boardroom and senior management, including safety strategy design, development, implementation and evaluation. The book also addresses the importance of balancing and integrating the 'science' and 'art' of safety management, together with an exploration of how safety is perceived and enacted by top management and on-site operatives. The localised on-project-site context for safety strategy implementation, monitoring and evaluation is emphasised, while case studies are provided to demonstrate the implementation of safety concepts, principles and techniques in practice.

The importance of the industry

Construction and engineering is an US $8.7 trillion market, accounting for 12.2% of the world's economic output (Global Construction Perspectives & Oxford Economics, 2013) and providing employment for about 200 million people worldwide (Murie, 2007). It is supported by a complex supply chain encompassing numerous industries ranging from steel, timber and concrete producers to furniture and carpet manufacturers. The supply chain extends further to other industries, such as trucking, shipping, manufacturing and mining, which may not have an obvious direct relationship to the construction and engineering industry (Hampson & Brandon, 2004; Jackson, 2010). The industry is important because of its size and output, which underpins various

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economic activities and contributes to the delivery of social and environmental objectives of a nation (Health and Safety Executive, 2009).

By way of demonstrating the importance of the construction and engineering sector, Australia and the UK are cited as examples. In Australia, the construction and engineering industry engages in three broad areas of activity: residential building (houses, apartments, flats, and so on), non-residential building (offices, shops, hotels, schools, and so on), and engineering construction (roads, bridges, rails, water and sewerage, and so on). Both the private and public sectors undertake construction and engineering activities. The private sector is engaged in all three categories, while the public sector plays a key role in initiating and undertaking engineering construction activities and those related to health and education (ABS, 2010). The construction and engineering industry is the third largest contributor to Gross Domestic Product (GDP) in the Australian economy and has a major role in determining economic growth. In 2010–11, the industry accounted for 7.7% of GDP and had significantly increased its share of GDP from 6.2% in 2002–03. It also employed 9.1% of the Australian workforce in 2010–11, making it Australia's third largest industry after health care and social assistance, and retail trade (ABS, 2012).

In the UK, the construction and engineering industry contributes about 6.7% to the nation's economy and 10% of all jobs. The UK also has the sixth largest green construction sector in the world. Due to the importance of the sector, the UK government published the Construction 2025 report, which summarises the industrial strategy for the construction sector in the coming decade. The Construction 2025 report outlines the steps that the government and the industry will take in the short and medium terms to achieve four ambitious goals: (1) a 33% reduction in both the initial cost of construction and the whole life cost of assets, based on 2009–10 levels, (2) a 50% reduction in the overall time from inception to completion for new buildings and refurbished assets, based on the industry's performance in 2013, (3) a 50% reduction in greenhouse gas emissions in the built environment as compared to the 1990 baseline, and (4) a 50% reduction in the trade gap between total exports and total imports for construction products and materials based on data in February 2013. The UK government also stresses the importance of investment in infrastructure projects and house building for the economy (HM Government, 2013).

Characteristics of the construction and engineering sector

The construction and engineering sector has unique characteristics which influence the ways construction and engineering organisations operate within the sector, including how they manage safety. These characteristics can be classified into two levels: industry-related and project-related, as discussed in the following sections.

Industry-related characteristics

There are several characteristics at this level, which influence an organisation as a whole. They typically reflect the conditions and nature of the industry. The first characteristic is that the industry is complex in nature. In 1996, Gidado (1996) explained (and it is still valid today) that this complexity originates from (1) uncertainty due to the various components needed in each activity within the production process, which come from various sources including the resources employed and the environment, and (2) interdependence among activities, which is concerned with bringing different parts together to form a work flow. Gidado (1996) further elaborated that the uncertainty has four causes: (1) the unfamiliarity of management with local resources and the local environment, (2) lack of complete specification for the activities on site, (3) the uniqueness of every construction and engineering project (with regard to materials used, type of work, project teams, location and time) and (4) the unpredictability of the environment. This uncertainty characteristic compels construction and engineering organisations to apply a decentralised approach to decision making. The interdependence is influenced by three factors: (1) the number of technologies and their interdependence, (2) the rigidity of sequence between various main operations and (3) the overlaps of stages or elements in construction and engineering processes. The organisation of the workforce into trades and the subcontracting practice intensify this interdependence, which calls for more local rather than centralised coordination (Dubois & Gadde, 2002).

The second characteristic is the low levels of entry to and exit from the construction industry and the large number of small-size enterprises. Although considered a service industry, the entry to the construction industry is different from other service industries, such as finance, insurance, real estate, professional services and business services. The level of education is the most important factor in identifying entrants into self-employment in the other service sectors, but it is less so for construction. In fact, high school dropouts are much more likely to enter self-employment in construction than college graduates (Bates, 1995). In Australia, about 90% of construction organisations employ less than five people or are identified themselves as sole proprietorships. In 2013, the construction industry had the highest number of businesses operating in Australia. Within the same period, however, there were also more than 50,000 exits, representing a 16.5% exit rate, which is higher than the average for all industries at 14.1% (ABS, 2013). All this indicates that there are low requirements to enter the industry, while at the same time the exit rate is also relatively high, thus demonstrating the dynamic nature of the industry.

The third characteristic is the intense and fierce competition and low profit margins due to the sheer number of construction and engineering businesses, especially the small-sized ones (Arditi et al., 2000).

The fourth characteristic is economic pressures, which are typically worsened by late progress payments, and unfair allocations of risk (Arditi et al., 2000;

Duffy & Duffy, 2014), which lead to confrontational relationships between parties, making the industry well known for its reputation for fragmentation, conflicts, mistrust, claims and litigation (Duffy & Duffy, 2014; Kanji & Wong, 1998).

The fifth characteristic is related to the workforce, which is labour intensive. Despite the effort to automate and the general advancement of technology, the industry remains traditional and is slow in adopting new technology. Many construction sites still use relatively high rates of unskilled workers, especially those in developing countries (Giang & Pheng, 2011). Furthermore, recent trends show an increase in the proportion of older workers. Together with the physically demanding nature of the construction and engineering work and the exposure to the external environment when working on sites, they intensify the already challenging job and increase the risk of injury and chronic health conditions among older workers (Brenner & Ahern, 2000; Schwatka et al., 2012).

The sixth characteristic is gender imbalance. The industry is one of the most gender-segregated sectors where men dominate the employment in the building trades. The sector is considered as 'tough' due to this masculine identity. The culture of taking safety risks and working physically for long hours in primitive working conditions are considered as the norms. This 'man's job' is associated with physical labour, dirt, discomfort and danger, which, interestingly, creates a hierarchy within the building trades. The rougher, dirtier trades are perceived to be more masculine than the more 'refined' and intellectual trades. Labourers, steel-fixers, bricklayers and ground workers are at the bottom of the status hierarchy, but at the top of the masculinity hierarchy. In contrast, electricians have a high status, but they are not real men (Ness, 2012). This kind of mindset spawns resistance to change, making it extremely difficult to persuade the construction workforce to embrace safety, which is considered as an intrusion into their 'normal' ways of operating (Lingard & Rowlinson, 2005).

Project-related characteristics

The construction and engineering industry is also inherently a site-specific project-based activity. According to Project Management Institute (2013), a project has two characteristics: temporary and unique. First, temporary indicates that a project has a definite beginning and end in nature. The end is reached when project objectives have been achieved or when the project is terminated because its objectives cannot be met, or when the need for the project no longer exists. A project may also be terminated if the client wishes to do so.

Second, every project creates a unique result. Buildings can be constructed with the same or similar materials, by the same or different teams and by the same or different methods of construction. There are many factors that cause each construction project to be unique, such as the site location, design, specific circumstances, stakeholders and so on. These characteristics provide added challenges in construction organisations and the industry at large. While many other industries have standardised their elements and activities, the construction sector has been slow in adopting standardisation. The uniqueness of each project and project constraints may also make standardisation difficult (Dubois & Gadde, 2002; Kanji & Wong, 1998). Furthermore, the lack of standardisation, the unique nature of each project and the temporary nature of a project limit the impact of learning because project teams need to re-learn and contextualise their learning every time they move to a new project.

The third characteristic is related to the uncertain and interdependent environment of the construction and engineering industry, as discussed in the previous section, which causes more problems when it comes to achieving project objectives. In this kind of environment, failure of any of the parties may seriously affect project duration and the quality of the final product. The traditional project delivery system, which separates the design and construction stages, may result in the lack of constructability and excessive design changes during construction, which escalate costs and delay the project (Arditi et al., 2000; Kanji & Wong, 1998).

Fourth, the strong emphasis on individual projects favours a narrow perspective, both in time and scope (Dubois & Gadde, 2002). As a result, competitive tendering is seen as a strategy to promote efficiency and to assure that a job is carried out at the lowest possible cost. Instead of generating efficiency, this practice can lead to poor performance. Contractors may cut corners to reduce their tender prices only to use variations due to incomplete design or project changes to inflate the prices in the later stage of construction. Awarding contracts based on price alone may also lead to reduced quality, conflicts, and poor safety implementation. Mayhew and Quinlan (1997) indicated that competitive tendering worsens project safety risks because economic pressures and intense competition penalise those organisations who try to do the right thing due to their higher tender prices. Although the industry may have slowly shifted to the value-for-money basis in assessing project tenders, generally price is still the main factor that decides the winning bid.

Fifth, mega projects typically have significant impacts on the surrounding community and environment. McDonald-Wilmsen (2009) estimated that 90 million people might have been displaced in the past decade due to such projects. For example, the development of the Three Gorges Dam project required the Chinese government to resettle more than one million people, which led to many socio-cultural issues, such as ineffective compensation distribution, loss of employment and inadequate new housing (McDonald-Wilmsen, 2009). This project also has significant on-going impacts on the environment. The increased water levels in the Three Gorges Dam (up to 175 metres) may destabilise the soil and cause landslides as well as other environmental impacts, which could be hazardous to aquatic flora and fauna. Eventually, species that cannot adapt to the new environment will disappear (Stone, 2008).

There are also other features affecting safety in construction projects, such as design complexity, tight project duration, multiple level subcontracting and construction, site restriction and complicated procurement and contracting systems.

Why a book on strategic safety management?

Today's major construction organisations recognise the need to integrate safety into all decision making. We believe that strategic safety management is a way of achieving the level of integration which is indicative of a mature organisation. Many developed economies have made significant improvement in safety management through the use of systems, structures and modern technology, but have found it difficult to achieve exponential improvements in safety performance. More of the same will not produce the next big leap in safety performance (Wagner, 2010). This is because no matter how automated a production process or complex a management system is, people cannot be separated from the process or the system. People still control production and sometimes must intervene when unplanned events occur. It is often concluded that human error is the cause of 50–90% of all accidents. Simply put, people make mistakes and while human error may be undesirable, it is an inevitable aspect of everyday life (Lingard & Rowlinson, 2005; Peters & Peters, 2006). Reason (1990) argued that safety improvement can only be achieved through an attention to human error mechanisms. This human factor is particularly important in the construction and engineering industry due to its labour-intensive characteristic (Lingard & Rowlinson, 2005). Consequently, construction and engineering organisations should recognise the need to balance and integrate 'science' and 'art' when implementing safety management.

The premise of this book is that viewing safety management from the strategic perspective serves as a unique view point that has not been covered in the current body of safety knowledge. The following topics, portraying different components of the 'science' and 'art' of safety management, will be discussed in the subsequent chapters, demonstrating how these key components can be integrated into construction and engineering businesses and projects. Case studies and examples are also given in each chapter to show how each topic can be applied in practice. Figure 1.1 is a conceptual model which illustrates the relationship of strategic safety management to the other themes contained in this book.

Historical development and current trends in construction safety management

Construction safety has undergone a substantial evolution in the past century as illustrated in Figure 1.2. In the early 1900s, safety was virtually non-existent. There were no workers' compensation laws, thus typically construction organisations did not need to pay anything when accidents happened. Without any compelling financial incentive, there was no encouragement for the industry to implement or consider safety. It is difficult to forget the iconic black and white photograph, taken in 1932, showing workers sitting on a steel beam without any personal protective equipment (PPE) 69 floors up in the Rockefeller

Figure 1.1 Key themes in this book

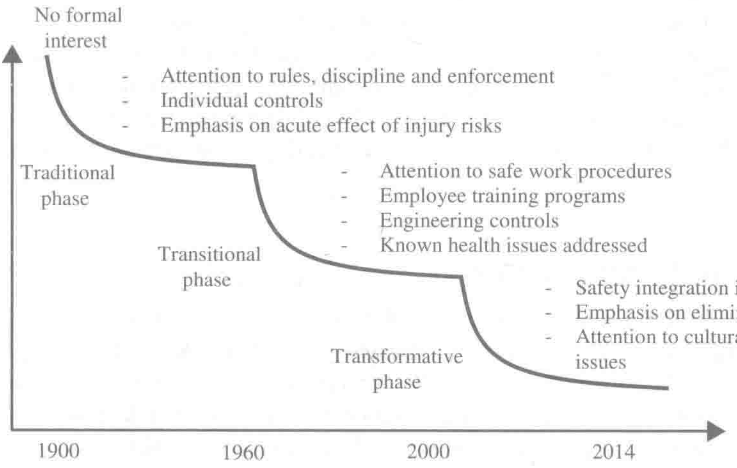

Figure 1.2 The evolution of safety management (Source: adapted from Pybus, 1996, p.18 in Finneran and Gibb, 2013.)

Center project (Rockefeller Center, 2013). About the same time, workers scaled the structure of the Sydney Harbour Bridge without any fall protection (NSW Government, 2010). An infamous tragic accident showing the lack of interest towards safety happened in 1911 in New York when a fire broke out in the Triangle Waist Company building killing 146 employees, mostly women. It is believed that the exit doors were deliberately locked, the fire escape was dysfunctional, and the fire-fighting equipment was insufficient, further demonstrating the lack of safety concerns during this period (Cornell University, 2004).

Protesting voices arose, bewildered and angry at the lack of concern and the greed that caused these catastrophes. Responding to this demand, workers' compensation law was passed, thus compelling many industrial sectors to improve their safety performance. This became the beginning of the traditional phase in safety management. In the early years of the safety movement, the management focused on improving physical conditions and reducing unsafe behaviours. Workers were required to follow a set of rules and to use personal protective equipment at work (Petersen, 1988).

After this initial step, safety professionals started thinking in management terms, marking the dawn of the transitional phase. Initially, setting policies, defining responsibilities and clarifying authorities became a trend. In the 1960s and 1970s, professionalism was the focus and it was achieved by defining the scope and functions of safety professionals, developing curriculums for formal safety education and establishing a professional certification program. Some governments also passed more stringent occupational health and safety acts, further compelling the industry to take safety measures seriously. Many organisations became more proactive in implementing safety by establishing safety plans, safe work procedures and identifying safety risks before any activity began (Lingard & Rowlinson, 2005; Petersen, 1988).

The current trend is at the transformative phase, which places emphasis on the integration of safety into decision making, the elimination of safety risks, the development of workforce skills and the fostering of safety culture as we described in the previous section, demonstrating the importance of strategic safety management.

Alarming incident and injury problems

This evolution of safety has significantly improved safety performance in the construction industry. However, in recent years, it appears that this improvement has plateaued and the industry is facing difficulties in achieving further improvements, while injuries and fatalities still occur on a regular basis. Despite having an important role in the global and national economies, the construction industry has a notorious reputation as being one of the most dangerous industrial sectors (Health and Safety Executive, 2013; Lingard & Rowlinson, 2005; Murie, 2007; Safe Work Australia, 2013). It provides employment for about 7% of the world's workforce, but is responsible for 30–40% of work-based fatal injuries (Murie, 2007). The International Labour Organisation (2003) estimated that there are at least 60,000 fatalities on building sites every year. This estimate is conservative because many countries underreport their construction injuries and fatalities. Murie (2007) estimated that 100,000 people are killed on construction sites annually.

In the UK, the statistics for 2012–13 showed that the construction industry accounts for only about 5% of employment, but is responsible for 27% of fatal injuries and 10% of reported major injuries. The rate of fatal injury per 100,000 workers was 1.9 and the industry still accounts for the greatest number of fatal injuries among the industrial sectors (Health and Safety Executive, 2013). In Australia, there were 211 fatalities in the construction industry from 2007 to 12, corresponding to 4.34 fatalities per 100,000 workers, which is nearly twice the average national fatalities rate of 2.29 (Safe Work Australia, 2013). In Singapore, the fatality rate in 2013 was 2.1 per 100,000 workers, while the rate in the construction industry was more than three times higher at 7.0 (Ministry of Manpower, 2013). These statistics are worse in the USA where, in 2012, the rate of fatal injury per 100,000 workers in the construction industry was 9.9, significantly higher than the average rate for all industries at 3.4 and the rate in other developed nations (Bureau of Labor Statistics, 2014).

The above-mentioned statistics and the six reasons listed below (Holt, 2005; Reese & Eidson, 2006), highlight the need to continue improving safety performance in construction.

1. Governments around the world have laws that require construction organisations to provide safe work conditions and adequate supervision. Lack of safety, therefore, may lead to prosecution or claims, which will become the source of extra costs and adverse publicity.
2. Lack of safety increases the probability of accidents, which may lead to human suffering, disabilities and deaths.
3. When an accident happens, the morale of workers is weakened. On the contrary, accident prevention programs strengthen morale and improve on-site productivity.
4. A safe operation in the workplace is considered a moral obligation by the current society; thus good safety practices are essential to improve and maintain reputation.
5. A good safety record and proven safety management system are valuable marketing tools to attract new clients and support business expansion.
6. A safety management program contributes to the financial health of construction organisations by helping them avoid costs associated with accidents. An accident incurs both direct and indirect costs as well as insured and uninsured costs.

Current safety management body of knowledge

Due to the high rates of accidents and injuries in the construction industry, much effort has been taken through research and better work practices to improve safety performance. Figure 1.3 shows the domains of research and practice aimed at promoting safety performance improvement in the industry. The overlaps between the circles and the ellipse illustrate the level of interface between each of these domains and the effort required to improve safety

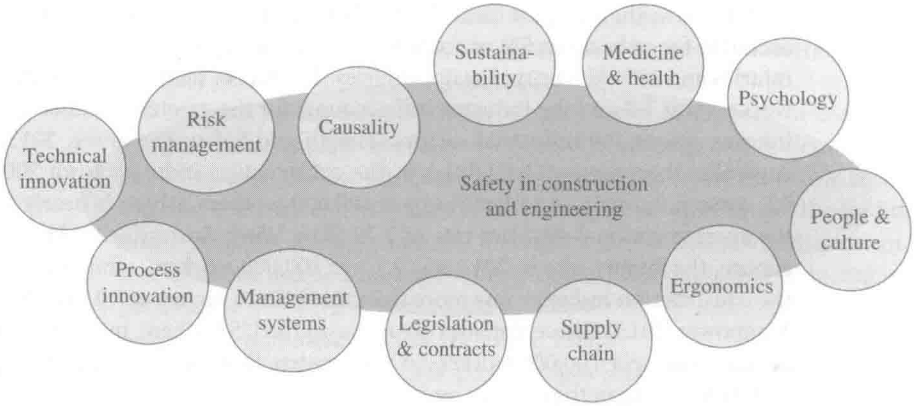

Figure 1.3 Indicative interfaces between safety and other domains of research and practice (Source: adapted from Finneran and Gibb, 2013.)

(Finneran & Gibb, 2013). For example, there is a significant overlap between the domains of risk and safety because the principles of risk management are commonly used to identify, assess and mitigate safety risks. On the other hand, there is a much less overlap between technical innovation and safety because of the traditional and labour-intensive characteristics of the industry. Recently, research on building information modelling (BIM) and its application in practice has grown in popularity.

There are many books on safety management, further demonstrating the importance of this topic. Some of these books, particularly the ones related to the construction and engineering industry, totalling more than 10 titles, are listed in Bibliography.

The book's contents

Chapter 2: economics of safety

This chapter discusses the economic aspects of safety management in construction, including benefits, costs and investment optimisation. This topic is significant because efforts to improve safety are hindered by many barriers and those influenced by economic considerations are particularly dominant. As stated earlier, the subcontracting practice in the industry, coupled with intense competition and the uncertainty of demand, force construction organisations to focus on reducing costs at the expense of other factors, including safety. Stakeholders in construction and engineering should realise that lack of safety increases the probability of accident occurrences and an accident could have an adverse impact on economic performance due to fine and compensation costs, loss of productivity, production delay, weakened morale and bad reputation.