

## Construction safety culture: A revised framework

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# CONSTRUCTION SAFETY CULTURE: A REVISED FRAMEWORK

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**Abstract:** Safety culture has been widely accepted as a crucial aspect in construction organisations. Despite its popularity, there is confusion on the actual meaning of safety culture. Another concept called safety climate has been used interchangeably with safety culture and has fuelled more perplexity. This paper aims to clarify the meaning of both concepts and discuss the differences between the two through a literature review. It is argued that safety climate is part of safety culture, that is, it is the psychological dimension of safety culture. Furthermore, this paper has developed a framework to show the overall concept and contents of construction safety culture, which includes the cause, contents, and consequence of safety culture. Measurements are also proposed for construction organisations to measure their safety culture and improve their safety performance continuously.

**Keywords:** Construction safety culture; Safety climate; Culture measurement dimensions; Safety performance; Construction projects.

## 1. Introduction

Many organisations agree that developing safety culture is crucial to prevent accidents and improve safety performance. However, despite its popularity, the detail of definition and management of safety culture has not been clarified thoroughly and *the validity of the safety culture concept remains largely unproven* (Cox and Flin, 1998, p. 189). Furthermore, safety culture has become a generic solution for all psychological and human factor issues, which may be exceeded the evidence for its utility. Pidgeon (1998) supported this notion by stating that studies on safety culture have remained unsystematic, fragmented, and underspecified in theoretical terms. Even recently, there is still confusion on what safety culture actually means (Antonsen, 2009; Choudhry et al., 2007; Haukelid, 2008).

To make the situation more perplexing, there is another concept called safety climate, which at the first glance seems to have the same nature and functions as safety culture. In fact, it has been indicated that the meaning of the term safety culture appears to be very similar to that of safety climate (HSC, 1993). Consequently, the terms safety culture and safety climate are commonly used interchangeably and the border between the two is blurry at best. A good example is that some studies on safety climate are included in the publication of special issue on safety culture while another book treats studies on safety climate and safety culture as one field of research (Antonsen, 2009).

Guldenmund (2000) did an in-depth review on safety climate and safety culture. His work has been cited by numerous authors showing the deep insight that he has provided on this topic. He suggested five fundamental issues that need to be clarified on safety climate and safety culture:

1. Safety climate and safety culture are two concepts that have not been defined properly, an issue that has also been raised by HSE (2005), Choudhry et al. (2007), Haukelid (2008), and Antonsen (2009).
2. There is no clear argument demonstrating the relationship between safety climate and safety culture. Cox and Flin (1998), Wiegmann et al. (2002), and Antonsen (2009) also mentioned this issue.
3. The cause, content, and consequence of safety climate and safety culture are unclear. The cause of the concepts has not been addressed sufficiently, there is no consensus on the content of both concepts, and not many studies have discussed their consequences, particularly safety culture. Recent studies by Choudhry et al. (2007) and Muñoz et al. (2007) have indicated their urgency to resolve this issue.
4. A satisfying model of safety climate and safety culture has not been developed, a notion that was also supported by HSE (2005) and Choudhry et al. (2007).
5. There is lack of studies that consider the issue of the level of aggregation. For example, collecting data on a certain aspect from different levels in an organisation may yield different results. Zohar and Luria (2005) and Zhou et al. (2009) addressed the same issue although it is directed to the concept of safety climate.

The aim of this paper is to review existing literatures on safety climate and safety culture and propose answers to the issues stated above. The concepts will be clarified and the differences between the two will be discussed. Thereafter, this paper will focus on safety culture in the construction industry. Accident rates in construction have decreased due to safety management efforts, comprehensive safety legislation, and public intolerance on risks, environmental damage, and work-related injuries. However, these negative outcome data (e.g. accident rates) have

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gradually bottom out to some asymptotic value. This situation indicates that when it comes to safety, getting from bad to average is relatively easy. However, improving safety performance from average to excellent would be difficult. Reason (2000) argued that safety culture is the secret to improve safety performance and reach this point of excellence. The problem, however, like in other industries, the concept and meaning of safety culture in the construction industry is still unclear.

Therefore, this paper develops a framework which shows the cause, contents, and consequence of construction safety culture. In addition, safety culture measurement strategies are proposed for construction organisations to monitor their safety implementation, find their weak areas, and continuously improve their safety performance.

## 2. Safety Climate

### 2.1.1. Definitions of safety climate

There are many studies that investigate the concept of safety climate and there are similarities that can be derived from it (Cooper and Phillips, 2004; Coyle et al., 1995; Hahn and Murphy, 2008; Loughborough University, n.d.; Mohamed, 2002; Williamson et al., 1997; Zohar, 1980). First, various authors agree that safety climate is concerned about employees' perceptions and attitudes towards safety in the organisation or in their workplace. Second, safety climate only measures perceptions and attitudes towards safety at a certain point in time i.e. during the time when the survey is conducted. This characteristic indicates that safety climate can change over time, thus it is important to measure safety climate regularly to identify trends and areas that need to be addressed. Third, it is important to recognise the level of aggregation of safety climate concept, that is, organisational safety climate and workplace-level safety climate. A study on a multilevel model of safety climate has been conducted by Zohar and Luria (2005). They used two questionnaires administered to production workers of manufacturing plants. The first questionnaire measures organisation-level safety climate, while the second one measures group-level safety climate. The results indicate that at both levels, the climates are globally aligned. In this case, organisational climate predicts group climate level, which predicts individual behaviour.

### 2.1.2. The contents of safety climate

Safety climate studies have been conducted across different industries and countries indicating the wide popularity of the concept. However, despite the richness of safety climate studies, an obvious problem exists. There is lack of standardisation and agreement on which survey should be used to measure safety climate. Guldenmund (2000) suggested that when many of the existing dimensions are relabelled, their number can be reduced significantly and may also indicate their importance to be included in a safety climate survey. Therefore, this paper evaluates previous safety climate dimensions (Cooper and Phillips, 2004; Coyle et al., 1995; Hahn and Murphy, 2008; Loughborough University, n.d.; Mohamed, 2002; Williamson et al., 1997; Zohar, 1980; Zohar and Luria, 2005) and argues that safety climate can be classified into the following six dimensions:

1. **Top management's commitment.** This dimension implies that top management considers safety as equally important as other aspects in the organisation, such as production and profit. Further, top management should respond decisively when a safety issue is raised. It is also crucial for top management to request everyone in the organisation to adhere to safety procedures and improve their safety performance. Top management needs to provide necessary resources for employees to work safely and to monitor safety. Safety personnel must have sufficient power and authority to enforce safety regulations and procedures. Lastly, to keep people motivated to implement safety measures, top management should evaluate employees' safety performance.
2. **Supervisor's involvement.** Supervisors and line managers must support safety implementation by following safety procedures at all time. They need to show commitment towards safety by promoting a safe place to work and creating supportive working relationships to tackle safety issues. It is also important for them to consider safety performance when giving evaluation to their employees.
3. **Trainings.** Necessary induction and trainings must be provided to every employee before they start working. It is crucial for these trainings to be effective in providing sufficient knowledge for every employee to identify safety risks and perform their works in a safely manner.
4. **Communication.** The organisation must have a clear safety policy, regulations, and procedures which are available to every employee. A communication system must be in place for every employee to provide feedback on safety issues and for management to provide responds in a timely manner. It is also important for the organisation to hold safety campaign or awareness program periodically to stress the importance of safety.
5. **Employee's involvement.** Safety must become an equal priority for every employee at work. Employees should also be involved proactively to create a safe work place and improve safety performance because they are the ones who perform the works directly.

6. **Safety policy, rules and guidelines.** Safety policy, rules, and guidelines must be practical, realistic, and suitable for every type of works. They must be accessible and more importantly, they have to be enforced throughout the organisation.

### 2.1.3. Discussion and implication of safety climate studies

Many studies have revealed the importance of safety climate to measure safety-related outcomes, such as accidents and injuries. Consequently, safety climate has become a common method to predict safety performance for more than two decades (Glendon and Litherland, 2001). Seo et al. (2004) and Davies et al. (2001) explained the reason behind the popularity of safety climate survey by summarising its advantages:

1. Traditional safety measures, such as accident rate and incident rate, are not sensitive enough to provide useful information about safety problems. On the other hand, safety climate can identify safety problems before they develop into accidents and injuries (leading indicator instead of lagging indicator).
2. Measuring safety climate can focus on safety efforts to improve problematic areas, which can lead to improvement of other functions in the company. It provides a mechanism to optimise investment on safety-related improvements.
3. Safety climate measurement serves as a valuable tool to identify trends in the organisation's safety performance and to establish benchmarks both internally and externally.
4. Although safety climate measurement cannot replace other diagnostic tools and safety activities, a safety climate survey costs less money and time to be conducted.
5. Research has shown increasing evidence that safety climate is significantly related to safety practices, accidents, unsafe behaviour, productivity, and business performance.
6. It involves employees in the process, which can help identify key issues that need to be addressed. There is also an assurance that employees will not be identifiable, thus encouraging them to express their true feeling without any fear of reprisal.

Based on the above discussion, the following can be concluded about safety climate:

1. Safety climate is employees' perceptions and attitudes towards safety in the organisation or in their workplace. Following a recommendation by Coyle et al. (1995), a safety climate survey should include both attitudinal and perceptual questions. The attitudinal questions are used to uncover employees' safety beliefs that presumably have developed through experiences within and outside the workplace. The perceptual questions, on the other hand, uncover employees' perception of reality in their workplace. Furthermore, there are six dimensions that should be measured namely top management's commitment, supervisor's involvement, trainings, communication, employee's involvement, and safety policy, rules, and guidelines.
2. A safety climate survey should consider different organisational levels (Guldenmund, 2000; Zhou et al., 2009; Zohar and Luria, 2005). Consequently, a certain safety climate survey developed to measure workers' perceptions may not be suitable to measure other positions in the organisation. A generic safety climate survey may be feasible to be developed, but it will require a lot of case studies and analyses.
3. Safety climate only measures perceptions and attitudes towards safety at a certain point in time i.e. during the time when the survey is conducted (Cooper and Phillips, 2004; Mohamed, 2002). This characteristic indicates that safety climate will change over time, thus it is important to measure safety climate regularly to identify trends and areas that need to be addressed.
4. Safety climate is a practical and economical tool to measure safety performance across different industries (Glendon and Litherland, 2001; Guldenmund, 2000; Hahn and Murphy, 2008; Mohamed, 2002).
5. Previous studies on safety climate have focused on four areas: (1) developing safety climate measurement tools and determining safety climate dimensions, (2) developing and testing safety climate theoretical model to discover factors that affect safety behaviour and accidents, (3) finding the relationship between safety climate and safety performance, and (4) investigating the relationship between safety climate and organisational climate (Cooper and Phillips, 2004). These studies, which have been conducted across different industries and countries, have validated safety climate as a strong leading indicator or predictor of safety outcome. It was proposed that future studies should focus on testing the relationships of safety climate with antecedents, moderators, mediators, and other established constructs (Zohar, 2010).

## 3. Safety Culture

### 3.1.1. Definitions of safety culture

The inception of the term safety culture can be traced back to the Chernobyl nuclear accident in 1986. At that time, a poor safety culture was identified as a contributing factor to the disaster (IAEA, 1986). Since then, safety culture has increased in popularity and its poor implementation has been pushed forward as the key source of major accidents (Cox and Flin, 1998; HSE, 2005). Safety culture has been defined in a variety of ways. One definition that has been reused frequently throughout many safety culture publications was the one produced by the Advisory Committee on Safety in Nuclear Installations (ACSNI) who defined safety culture as the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management (cited in HSC, 1993).

Another study by Muñiz et al. (2007) defined safety culture as *a set of values, perceptions, attitudes and patterns of behaviour with regard to safety shared by members of the organisation; as well as a set of policies, practices and procedures relating to the reduction of employees' exposure to occupational risks, implemented at every level of the organisation, and reflecting a high level of concern and commitment to the prevention of accidents and illnesses* (p. 628). This definition is clear and straightforward as well as showcases the multiple dimensions of safety culture plainly, thus we adopt this definition in this paper.

### 3.1.2. The contents of safety culture

Safety culture is multidimensional, a characteristic that has been supported by many studies (Clarke, 2000; Glendon and Stanton, 2000; HSE, 2005; Lee and Harrison, 2000, Muñiz et al., 2007; Wiegmann et al., 2002). Health and Safety Executive (HSE, 2005), based on the work by Cooper (2000), proposed three distinct but interrelated dimensions of safety culture: *psychological, behavioural, and corporate* (HSE, 2005). This three-dimension model aligns with the definition of safety culture proposed by ACSNI (HSC, 1993) and Muñiz et al. (2007) as well as the theoretical frameworks developed by Clarke (2000) and Wiegmann et al. (2002). This paper also considers that the three-dimension model is straightforward and concise, but also comprehensive enough to cover the multidimensionality characteristic of safety culture. Therefore, this paper uses this approach as a foundation to develop its framework. Guldemund (2000) suggested that a theoretical model should be the start of any scientific enterprise on safety culture, thus this paper is in the same line of thinking as this reasoning.

The *psychological* dimension of safety culture refers to how people feel about safety and safety management systems. This can be described as the safety climate of the organisation, which encompasses the attitudes and perceptions of individuals and groups at all levels in the organisation (HSE, 2005). This reasoning indicates that safety climate is part of safety culture, a conceptualisation that has been widely accepted (Cooper, 2000; Cox and Flin, 1998; Glendon and Stanton, 2000; Guldemund, 2000; Loughborough University, n.d.; Wiegmann et al., 2002; Williamson et al., 1997). The *behavioural* dimension is concerned with what people do within the organisation, which includes the safety-related activities, actions, and behaviours exhibited by employees. Lastly, the *corporate* dimension can be simply described as what the organisation has, which is reflected in the organisation's policies, operating procedures, management systems, control systems, communication flows, and workflow systems. The three aspects are interrelated and not mutually exclusive (HSE, 2005).

### 3.1.3. A safety culture causal model

When an organisation aims to improve its average safety culture, it needs to recognise five interdependent subcultures that precede the safety culture. It is argued that each of these subcultures can be socially engineered (Reason, 2000). The five subcultures are (Reason, 1997 cited in Hopkins, 2005; Reason, 2000):

1. An informed culture. This is a cognitive element in an organisation which *relates to being alert to the possibility of unpleasant surprises and having the collective mindset necessary to detect, understand, and recover them before they bring about bad consequences* (Reason, 2000, p. 10). It is argued that in high reliability organisations, there is stability in the cognitive processes that make sense the variation in activity. These organisations strive for system reforms instead of applying local repairs. They aware that failures can be caused by a wide variety of unknown factors, thus they are always alert for novel ways where failures and latent conditions can combine to breach the system defences. Basically they are always preoccupied with the possibility of failure. This informed culture allows an organisation to optimally cope with the unanticipated, which is a critical component of organisational resilience. Further detail on an informed culture or, also called, collective mindfulness, can be derived from Weick et al. (1999).
2. A reporting culture. A reporting culture is the foundation of an informed culture and this can be considered as the most important aspect in safety culture. People must be prepared to report mistakes, near misses, unsafe conditions, wrong procedures, and other safety concerns. To create this reporting culture, people should firstly

be proactive towards safety by always on the lookout for things that need to be reported and secondly have necessary skills and resources which keep them alert to things that can go wrong.

3. A just culture. A just culture determines the effectiveness of a reporting culture. If the organisation always handles errors with blame and punishment, then reports will cease. Blame should only be reserved for behaviour involving defiance, recklessness, and malice. What is required in this case is not a blame culture, but establishing trust through a just culture. The subsequent subcultures, a learning and a flexible culture, largely depend on a reporting and just culture.
4. A learning culture. Reports are a waste of time if an organisation does not learn from them. Therefore, when it comes to safety culture, organisations have to process these reports or any other information conscientiously and make changes as necessary to remedy or improve the situation.
5. A flexible culture. Lastly, safety culture must also be flexible, which means that decision-making processes are varied depending on the urgency and the expertise of people involved. In this case, people who are best equipped must be the ones who make decisions. For example, if an engineer is the one who has expertise, the director should consult with the engineer first before any decision is made.

#### **4. A Proposed Construction Safety Culture Framework and Measurements**

##### **4.1.1. Construction safety**

Safety has been considered as one of key objectives in construction projects. Lack of safety increases the probability of accidents and fatalities, conditions that cannot be justified by any means because they negatively impact the wellbeing and lives of people. Safety also has become a social and moral responsibility for every construction organisation. The society and the norm impose that it is the right of every employee to go home safely every day and it is erroneous to treat employees as mere objects to achieve corporate goals (Lingard and Rowlinson, 2005). It also has to be considered that when accidents happen, they can incur extra costs and cause delays, which will potentially ruin the budget and delay the target completion date of the project. Accidents also can lead to prosecution and civil claim that will jeopardise the future of the project, cause adverse publicity, and even threaten the financial health of a company (Holt, 2005). As the result of this new paradigm, safety performance has become one of key success factors in construction projects. Accordingly, all these reasons signify that safety is such an important factor in the construction industry, thus this paper focuses on the development of a construction safety culture framework and measurement strategies to help construction organisations improve their safety performance. From this point forward, any mention of organisation is referring to construction organisation.

Based on the discussion in the previous sections, this paper has developed a construction safety culture framework consisting of *the cause, the contents, the measurement, and the consequence* of safety culture as shown in Figure 1.

##### **4.1.2. The cause**

As discussed previously, safety culture is preceded by five subcultures: informed culture, reporting culture, just culture, learning culture, and flexible culture (Reason, 1997 cited in Hopkins, 2005; Reason, 2000). A just culture is the start in which an organisation must not handle every mistake with blame or disciplinary action. If employees believe that every report will lead to punishment, then they will stop reporting errors, incidents, and near misses, which could have caused serious accidents. Establishing trust is the key for organisations to develop a just culture. A just culture is the prerequisite of a reporting culture, a crucial aspect of safety culture. It is true that organisations must have a reporting system where employees can report mistakes, near misses, unsafe conditions, wrong procedures, and other safety issues. However, the key of a reporting culture is that employees need to use and be encouraged to use the system. Furthermore, employees need to have necessary skills and resources to identify those safety issues.

A reporting culture is the precondition of an informed culture in which everyone in the organisation is always alert on things that could go wrong. An informed culture is the secret of organisational resilience because it allows organisations to manage unanticipated events. A just and reporting culture are essential to create a learning and flexible culture. A learning culture means organisations should learn from any safety reports submitted and find solutions or provide feedback in a timely manner to improve the situation or respond to the submission. A flexible culture implies that every decision on safety issues must be made after it has been consulted with the best possible person regardless the position of that person.

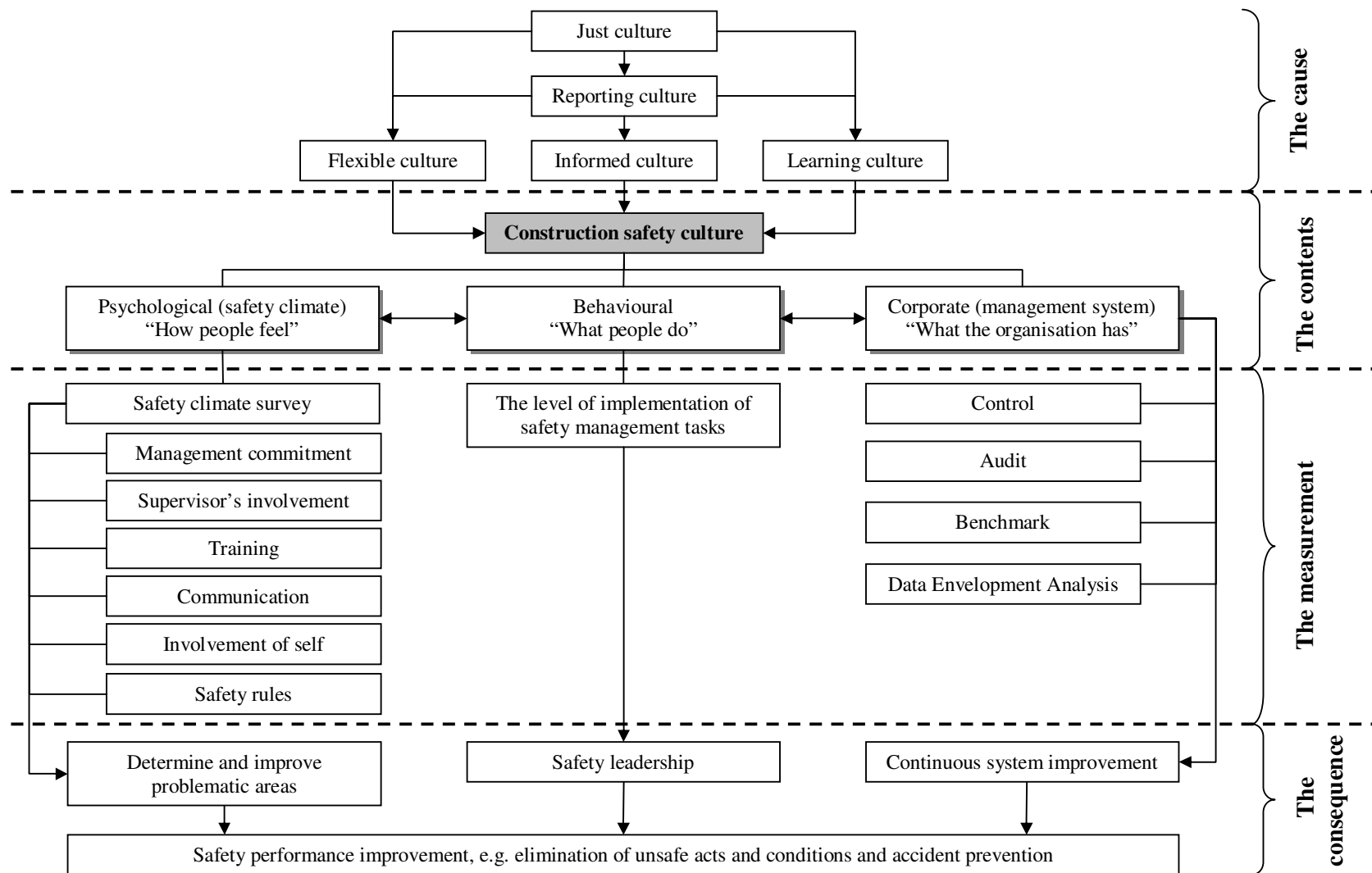


Figure 1 A Framework of Construction Safety Culture

#### 4.1.3. The contents

The contents of safety culture has been discussed in the previous section, thus it will not be discussed further. This paper adapted the definition proposed by Muñiz et al. (2007) as it seemed the best one to describe what safety culture is. Further, the concept has three dimensions, namely psychological, behaviour, and corporate.

#### 4.1.4. The measurement

Lee and Harrison (2000) explained that safety culture has many manifestations, complex, and even intangible. Consequently, they argued that measuring safety culture is beyond the scope of any single method. Glendon and Stanton (2000) agreed that safety culture has many features, thus it is crucial to use a triangulated methodology to measure safety culture. When construction organisations intend to measure their safety culture, this paper argues that the best approach is to measure each dimension separately. The following sections propose strategies to measure each dimension of safety culture.

##### *Psychological dimension*

The psychological dimension of safety culture is the attitudes and perceptions of people in the organisations towards safety. This dimension basically is the same as the safety climate concept discussed earlier. Therefore, safety climate survey is the best approach to measure this dimension. Many studies have been done to develop safety climate survey and determine dimensions of safety climate. It has been discussed that safety climate survey should include both attitudinal and perceptual questions. Furthermore, there are six dimensions that need to be measured namely top management's commitment, supervisor's involvement, trainings, communication, employee's involvement, and safety policy, rules, and guidelines.

##### *Behavioural dimension*

Management should be the first one who initiates safety culture in the organisation, but management is not the only one responsible for safety. Everyone must participate and be accountable. The commitment of top management is obviously critical to create and promote safety culture. However, commitment alone is insufficient for this purpose. There must be some definable processes or activities or practices to make this safety culture become a reality.

From the previous section, it has been explained that there are five subcultures that precede safety culture. These subcultures are collective practices that need to be done by everyone for safety culture to flourish. However, it should be considered that there are various positions in an organisation. Although each position has to do the five collective practices, there are also unique tasks that each position needs to perform. A study by Dingsdag et al. (2006) identified 39 safety management tasks that need to be done to create safety culture throughout an organisation. The so called safety critical positions must perform these tasks to provide safety leadership and promote safety culture. This paper argues that the behavioural dimension of safety culture can be measured by determining the level of implementation of the safety management tasks performed by safety critical positions in the organisation. Observation, self-administered questionnaire, and peer evaluation are strategies that can be used to measure this level of implementation of safety management tasks. Table 1 presents part of the safety management tasks identified by Dingsdag et al. (2006).

##### *Corporate dimension*

The corporate dimension is concerned about safety management system in the organisation. The basic stages in safety management system are planning, developing, organising, implementing, controlling, and auditing. The two important stages to measure the effectiveness of safety management system are controlling and auditing. Controlling involves checking the performance against agreed standards and finding the need for improvement in other stages. Auditing is an additional assessment that observes the whole system from a big picture perspective. Auditing aims to evaluate whether the system is still relevant and whether there is a better system that can be implemented to improve safety performance. Consequently, the result of the auditing is used to give feedback to a planning stage for the organisation to move towards the future (Poon et al., 2008).



Table 1 Safety management tasks (Source: Dingsdag et al., 2006)

Task category	Safety management tasks	Safety critical positions (1 = full understanding required, 2 = working knowledge and awareness required)										
		MD/CEO/GM	Senior manager	Operations/construction manager	Project manager	Engineer	Site manager/superintendent	Foreman/supervisor	Site safety advisor	Regional safety manager	Site safety manager	National safety manager
Proactively identify, assess and determine appropriate controls for safety risks	Carry out project risk assessments	2	2	1	1	1	1	1	1	1	1	1
	Undertake and design safety reviews for constructability, operability and maintenance				1						2	
Effectively communicate and consult with stakeholders regarding safety risks	Provide general safety information and provide basic safety instruction	2	2	1	1	1	1	1	1	1	1	1
	Deliver site/workplace-specific induction	2	2	2	2	2	1	2	1	1	2	2
Monitor, report, review, and evaluate safety program effectiveness	Carry out formal incident investigations				1		1	1	1	1	1	1
	Carry out basic project safety system element audits				2		2		2	1	2	1
Engage with subcontractors in safety performance management	Monitor subcontractor safety activities	2	2	1	1	1	1	1	1	1	1	2
	Identify and include suitable safety requirements into subcontractor packages	2	1	1	1	1	1	1	1	1	1	2
Identify and implement relevant components of the safety and workers' compensation management system	Understand and apply general legislative safety requirements	2	1	1	1	1	1	1	1	1	1	1
	Understand and apply detailed legislative safety requirements			2			2		1		1	2
Provide leadership and manage staff and subcontractor safety performance	Mentor staffs and follow their progress in relation to safety	1	1	1	2		2			2	1	2
	Conduct employee performance appraisals	1	1	1	1							

Benchmarking, a comparison of practices by looking outside one's own sphere to achieve superiority, is another approach to measure the effectiveness of safety management system. The foundation of benchmarking is to find a performance gap and then set goals to close this gap. Benchmarking can be done in three stages. First, an organisation examines its own system to make necessary improvements. For example, safety performance between various types of development (retail, residential, commercial, etc.) or work packages (foundation, structural works, architectural works, interior, electrical, mechanical, etc.) can be compared. Differences in performance then can be analysed and strategies to improve can be formulated. Second, an organisation examines the best practices from others within the construction industry to learn and achieve those best practices. In this case, an organisation can examine and learn from its counterpart that is well known for its exceptional safety performance. Third, an organisation also needs to learn best practices from other industries and achieve those best practices to gain superiority. For example, a construction organisation can learn from other companies in the mining or nuclear power plant industry (McGeorge and Palmer, 2002).

Another popular and objective safety management assessment tool is Data Envelopment Analysis (DEA), which has been recognised as a robust tool for evaluating the performance of organisations, such as business firms, construction companies, hospitals, government agencies, and educational institutions. A study conducted by El-Mashaleh et al. (2010) analysed safety management system performance of construction contractors by using DEA to measure their efficiency of converting inputs into outputs. The inputs refer to contractor's expenses on safety as a percentage of total revenues, while the outputs are measured by the numbers of accidents. The DEA model yields efficiency scores that range between 0 and 1.0. A contractor is considered efficient if it has an efficiency score of 1.0, which means its inputs into safety management system can be completely converted into outputs. Among the 45 contractors investigated in the study, the average of the efficiency scores is 0.32, which means that the inputs into safety are reduced by 68%. Its objectivity and ability to benchmark performance in

organisation and project level are the key benefits of DEA. Further details on DEA are beyond the scope of this paper and can be referred from El-Mashaleh et al. (2010).

#### 4.1.5. The consequence and implication

By conducting a safety climate survey periodically, organisations can identify safety trends and find weak areas that need to be improved. The level of implementation of safety management tasks determines the effectiveness of safety leadership in the organisation. Finally, controlling, auditing, and benchmarking of safety management system as well as DEA will initiate continuous improvement of the safety system. This paper argues that these strategies will help organisations to measure their safety culture and develop strategies to break the safety trend plateau in the construction industry, which will lead to further improvement of safety performance.

### 5. Conclusion

The terms safety culture and safety climate have been used interchangeably and have caused a lot of confusion on what they actually refer to. This paper aims to clarify this issue based on various studies that have been done in the field. First, safety culture is a set of values, perceptions, attitudes and patterns of behaviour with regard to safety shared by members of the organisation; as well as a set of policies, practices and procedures relating to the reduction of employees' exposure to occupational health and safety risks, implemented at every level of the organisation, and reflecting a high level of concern and commitment to the prevention of accidents and illnesses (Muñiz et al., 2007). Based on this definition as well as indication from previous studies, it can be concluded that safety culture is a complex and multidimensional concept. This paper has proposed three dimensions of safety culture, namely psychological, behavioural, and corporate. Safety climate, on the other hand, refers to employees' perceptions and attitudes towards safety in the organisation or in their workplace at a certain point in time.

Second, concerning the relationship between safety culture and safety climate, it can be concluded that safety climate is part of safety culture, that is, safety climate is the psychological dimension of safety culture.

Third, this paper focused on the construction industry where there is lack of consensus on the cause, content, and consequence of construction safety culture. This paper argued that five subcultures, namely just culture, reporting culture, informed culture, learning culture, and flexible culture, are the preconditions of the cause factors of safety culture. The contents of safety culture are its dimensions, which are psychological, behavioural, and corporate. The consequences of safety culture are safety trend identification to improve problematic areas, safety leadership, and continuous improvement of safety system. These three consequences will lead to safety improvement beyond what has been achieved by the construction industry (to break the plateau trend).

Fourth, a framework has been developed to show the overall concept and contents of construction safety culture. Further, measurement strategies have been proposed to measure each dimension of safety culture. The psychological dimension is measured by safety climate surveys that should include six dimensions of safety climate: top management's commitment, supervisor's involvement, trainings, communication, employee's involvement, and safety rules. The behavioural dimension is measured by the level of implementation of safety management tasks. Corporate dimension is measured using controlling and auditing system, benchmarking, and Data Envelopment Analysis. These methods offer a practical way for construction organisations to measure their safety culture, an organisational aspect that has been considered as abstract and intangible.

Fifth, there is lack of studies that consider the issue of the level of aggregation. This paper does not discuss much on this issue, but it is indicated that when measuring safety culture, particularly the psychological dimension, it is important to consider whether the survey can be applied to all levels in the organisation or only to a certain level. Future studies should focus on testing the framework for evaluation, validation, and modification. Detail instruments, such as questionnaires and interviews as well as other data collection methods, must be developed beforehand for this purpose.

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