

A multi-level safety culture maturity model for (new) building projects in Hong Kong

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ABSTRACT

Ninety-two per cent of industrial fatal accidents in Hong Kong in 2021 were attributed to the construction industry. Previous construction safety culture studies focused on projects as a singular organisation. Studies in building projects from a multi-tier perspective merit further examination. This study develops a safety culture maturity (SCM) framework to assess (new) building projects in Hong Kong at three levels: Client Safety Culture (CSC), Main Contractor Safety Culture (MSC) and Subcontractor Safety Culture (SSC). A closed question survey (N=31) incorporating subculture constructs (Informed, Just, Reporting, Learning and Flexible Cultures) with Hudson's safety culture ladder (Pathogenic, Reactive, Calculative, Proactive and Generative Cultures) is conducted. The findings reveal: CSC (Mean: 3.55, SD: 0.512), MSC (Mean: 3.71, SD: 0.311) and SSC (Mean: 1.90, SD: 0.605). Kruskal-Wallis One-Way-ANOVA shows that the mean maturity value of three organisations are unequal ($\chi^2 = 53.8$, $df: 2$, $p: < 0.001$). A SCM framework is designed for (new) building projects related to near misses and accidents. It would not be applicable to health-related, workplace violence, burglary and accidents outside construction-related activities. This is the first study to examine the safety culture maturity at three organisational levels. The study recommends improving project-based SCM by intervening and aligning individual levels between CSC, MSC and SSC.

KEYWORDS Building engineering; safety culture; maturity model; multi-level; Hong Kong; safety sub-cultures; building construction; (New) building projects

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1. Introduction

Accidents in the construction industry are a perpetual issue, and 23 out of 25 industrial fatalities (92%) in Hong Kong are attributed to the construction industry (Labour Department, 2022).

2. Research background

Empirical studies reported that 80% of construction accidents were caused by workers' unsafe behaviours due to human error (Meng et al., 2021; Al-Bayati, 2021; Wamuziri, 2013). An investigative study in nuclear plant accidents analysed the causation of incidents and attributed them to human errors and human tendencies to resolve problems through pattern recognition based on their knowledge, workspace and work memory (Reason, 1988). Reason's work represented the cognitive psychological school of thought associated with accidents and human error, whereby systems fail due to a human error from a slip, a lapse, a mistake or a violation (Reason, 2000). The human error approach has a strong body of knowledge such as the semantic network analysis of 60,000 Korean case studies illustrating that accidents' highest contributions were from human error and skill-based error (Kang et al., 2021).

A separate school of thought in the joint cognitive system sees human error as a symptom of a deeper problem

in the system (Rasmussen, 1995; Dekker, 2014). Accident investigation in the aviation industry had developed the idea of hindsight bias. Hindsight bias is the reporting of what the victim could have done with the information available at the time of the incident in contrast to the information available at the time of the accident investigation (Dekker, 2001). The phenomenon was observed in a study of safety climates regarding inquiries into major accidents as counterfactual comparisons in formal logic (Hudson, 2007). Modern scholars hold the view that joint cognitive systems in the case of human errors are not the causation of accidents, but starting points for finding the root cause of deeper problems in the system (Dekker, 2001; Abdelhamid and Everett, 2000; Hopkins, 2006; Hudson, 2007; Rasmussen, 1995).

3. Safety climate

Safety climate was devised by Professor Zohar in a study of the characteristics of factories that are high risk with recorded low levels of accidents. Safety climate is a concept that implies a unified set of cognitions regarding safety aspects in an organisation (Zohar, 1980). Safety climate is defined as a perception of the work environment and the study found that improvements to work environments could motivate workers to actively participate in safety activities (Neal and Griffin, 2006).

4. Safety culture

Accident investigation by the International Atomic Energy Agency on the Chernobyl nuclear accident in 1986 introduced the term safety culture (Fleming and Meakin, 2004). The report stated that the lack of a safety culture at all managerial and operation levels resulted in errors and violations that caused the disaster (Fleming and Meakin, 2004). Safety culture is a loosely defined term referring to general matters: the personal dedication and accountability of all individuals engaged in any activity (Choudhry et al., 2007). The concept is similar to safety climate as defined by Professor Zohar in 1980.

The term safety culture has been interpreted differently by researchers (Choudhry et al., 2007). Safety climate and safety culture likewise have ambiguous definitions, and sometimes the terms are even used synonymously. Nonetheless it is proven that the concept exists in an organisation in which a positive safety climate/culture will reduce the number of accidents (Han et al., 2021; Mosly and Makiki 2020; Choudhry et al., 2007).

One study provided a definition of safety climate where policies are centralised and safety culture where policies are decentralised in work environments such as location and project basis in the construction industry (Al-Bayati, 2021). Other studies opted for the concept of using organisational culture to influence safety to avoid the misnomer associated with the definition of the terms (Hopkins, 2006).

The concept has proven that a positive safety climate can impact safety behaviour and reduce accidents (Neal and Griffin, 2006; Guo et al., 2015; Yu et al., 2020; Chen et al., 2021). A further study by Zohar in the manufacturing industry using a double blind test confirmed a relationship between safety climate and micro accidents, where micro accidents were defined as injuries without resulting in lost time, utilising Heinrich's pyramid as a measurement tool to forecast potential safety incidents (Zohar, 2000).

In a healthcare safety culture study, safety motivation and safety behaviour were found to have a 2-year lagged effect (Neal and Griffin, 2006). Interventions to progress a safety culture inevitably take time; however a way to start would be to break down the elements of a safety culture into subcultures (Reason, 2000). A safety culture is the product of a number of inter-dependent sub-cultures: Informed Culture, Just Culture, Reporting Culture, Flexible Culture and Learning Culture (Reason, 2010).

5. Safety culture maturity models

In the medical industry three typologies of organisational cultures have been observed in empirical studies. The three typologies are pathological, bureaucratic and generative and define an organisation's responses to encountered problems (Westrum, 2005).

These typologies can be contrasted in their method of dealing with anomalies such as pathological ones which are preoccupied with personal power, needs, and glory, and will find a scapegoat to blame. The bureaucratic type is focused on rules and department turf, and will seek justice while generative cultures are concentrated on the mission and when things go wrong will discover the basic problems within the system (Westrum, 2005). Information can be received at the right time and at the right place in generative cultures, but information will get stuck in pathological cultures while in bureaucratic cultures it will flow but it will take time (Westrum, 2005).

Two additional levels of reactive and proactive were extended into the culture typology resulting in five levels of safety cultures, adding depth to the framework and allowing more subtle classification to increase the accessibility of the framework to the industry to allow the idea of progressing through the levels of safety culture (Parker et al., 2006), though the additional levels have been criticised for deviating from the ideas of the original author regarding typology and being too lenient particularly in its definition of pathological culture (Westrum, 2014).

Interviews were conducted with senior oil and gas company executives to characterise 11 tangible and seven less tangible aspects of safety culture to provide descriptive terms for the five levels of organisation cultures (Parker et al., 2006). Safety cultures can change over time and the five different levels (pathological, reactive, calculative, proactive and generative) are organisation cultures on a ladder that was developed (Hudson, 2007).

Previous studies commented that changing a typology from one culture to another is to change the leadership to facilitate the change (Westrum, 2005).

Other industries have separately developed similar maturity models, such as the Cultural Maturity Model in the petroleum industry (Fleming and Meakin, 2004) and UK Coal Journey Maturity Model in the mining industry (Foster and Hault, 2013). These models are tailored for their industry and share the characteristic five progression levels. While these models are developed for the purpose of progression, they have been designed for sequential progression but do not allowing jumping to the next level.

In these industries the relationship between workers and management is within the same organisation, whereas construction work is characterised by sub-contracting workforces specialised in specific tasks and the interaction between management and workers is more complicated. A study in manufacturing proved that subunits within the same organisation have been shown to have varying perceptions of Safety Culture, illustrating subunits having different safety cultures (Zohar, 2000). A multi-level safety culture identifies five levels of Safety Agents, namely Client, Principal Contractor, Supervisor, Coworkers, and Individual Worker Perception (Zhang et al., 2015).

6. Safety climate/culture studies in construction

Studies have been conducted to understand the major factors that influence safety culture with various backgrounds and localities and all them have used a survey method (Guo et al., 2015; Chen et al., 2021; Gao et al., 2019; Yu et al., 2020; Loosemore et al., 2020; Mosly and Makiki, 2020; Wamuziri 2013). A study in Hong Kong found that older staff, highly educated staff and staff with greater knowledge have a correlation with a better safety climate (Fang et al., 2006). In contrast to the comparable regulatory background of Australia, Indonesia and China found that despite the different levels of education, the critical factor in all three countries was management commitment (Loosemore et al., 2020). Further studies also confirmed this view with a study in Saudi Arabia which found its most significant factor to be supervision, guidance and inspection followed by education and training (Mosly and Makiki, 2020). However in Iran the most influential factor in their study was dealing with workers' attitude and perceptions and the provision of safety training and knowledge rather than commitment from management (Chen et al., 2021).

Indeed these studies were not conducted in the context of the five levels of typologies as no framework exists in the construction industry, and most studies have indicated top management and commitment from management (Mosly and Makiki, 2020; Chen et al., 2021; Al-Bayati, 2021), and actions from management or management practices (Zhang et al., 2015; Mosly and Makiki, 2020) to be key factors in safety cultures. Existing safety culture studies in construction focused on projects as a singular organisation including a study on multi-level safety agents (Zhang et al., 2015), while the impact of sub-units within the same organisation have proven to have significant impact (Zohar, 2000). In building construction, work tasks are sub-contracted to workforces akin to subunits each with its own management and hierarchy of command. The sub-contracts of building projects in construction merit further examination from a multi-tier organisation perspective.

7. Aim and objectives

The aim of this research is to understand Safety Culture Maturity Levels in the building construction industry for (new) building projects in Hong Kong at three levels. The objectives of this research are to:

- Develop a framework to assess the safety culture maturity for construction incorporating Reason's Inter-dependent Sub-Cultures (Reason, 2000) and Hudson's Safety Culture Maturity Model (Hudson, 2007)
- Identify if different organisational levels in building construction in Hong Kong have the same safety culture maturity levels, i.e. Null

hypothesis is the mean safety culture maturity levels of client ($\mu1$), main contractor ($\mu2$) and subcontractor organisations ($\mu3$) being the same:

$$H_0: \mu1 = \mu2 = \mu3$$

H_A : The means are not all equal

- Identify the lower and upper limits of safety culture in the three levels of organisations

A literature review is conducted in regard to safety culture in terms of the five sub-cultures of Informed Culture, Just Culture, Reporting Culture, Flexible Culture and Learning Culture (Reason, 2010) as well as a survey as shown in Figure 1 below.

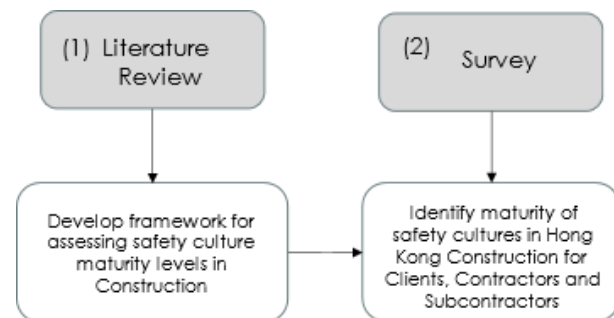


Figure 1. Research method.

The survey comprised two parts, the first being to collect personal information such as work experience, level of education and the second part to collect their perception of safety culture in the Hong Kong construction industry.

8. Maturity model and sub-cultures

The survey was developed in combination with the inter-dependent sub-cultures that define safety culture and Hudson's safety culture maturity model. Questions were related to the characteristics of the safety culture maturity model in a closed question survey representing one of the five maturity levels in the Hudson model (Hudson, 2007) and five sub-culture constructs of the safety model (Reason, 2010). Using the sub-culture constructs can provide insights into the construction industry's safety culture.

Fifteen questions comprising three of each sub-culture were developed utilising the knowledge gained from the literature review of the safety culture sub-culture (Figure 2).

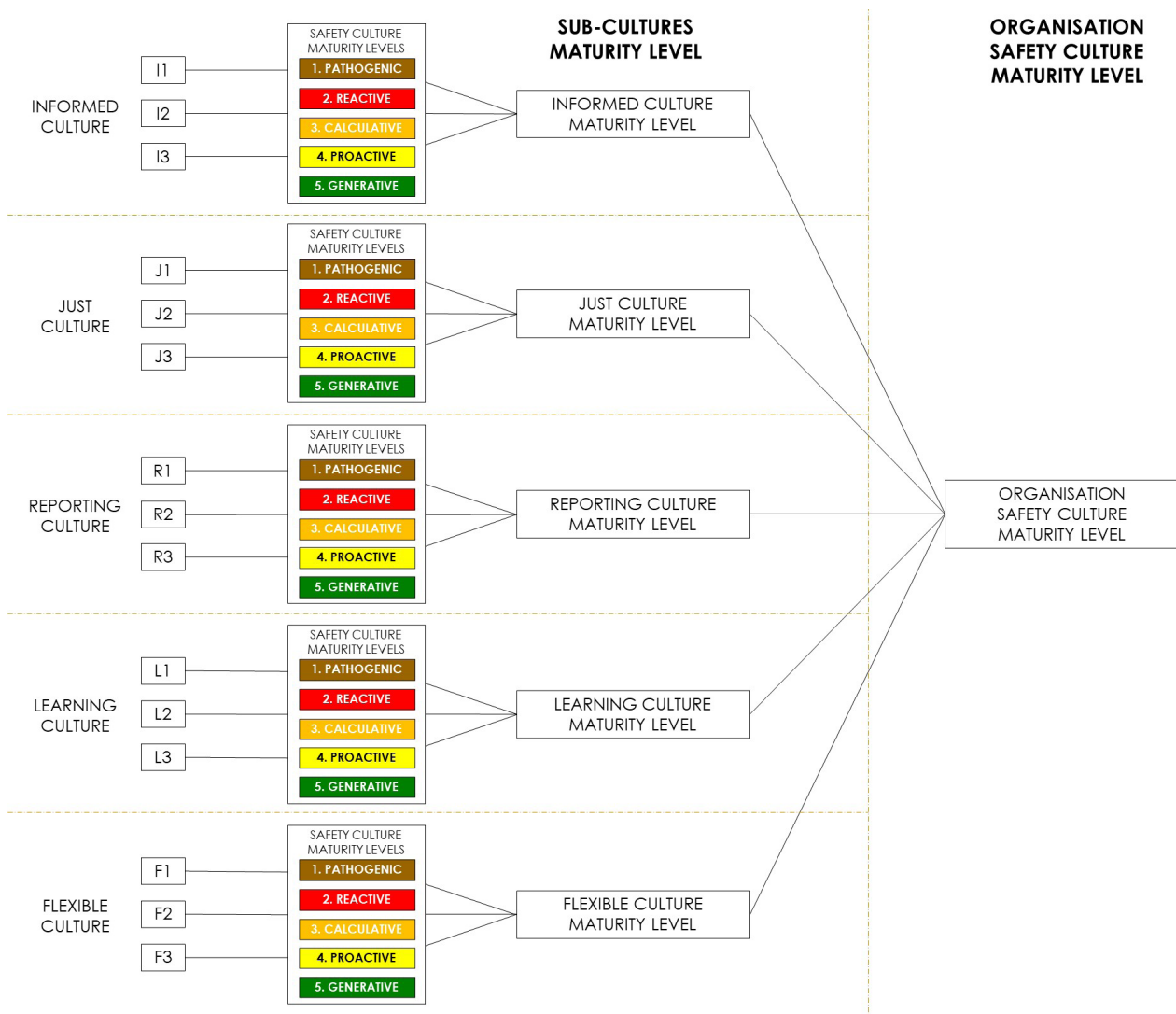


Figure 2. Safety culture maturity model assessment framework (organisation).

9. Multi-level (clients, main contractors and sub-contractors)

The safety culture framework is illustrated showing the development of safety cultures at a subunit level parallel to the organisational level (Zohar, 2000). In the construction context this is particularly relevant and contrasting to the other industries as separate legal entities in a hierarchy that coexists in construction projects.

Studies in safety cultures in construction have focused on identifying influencing safety culture factors without consideration of the multi-level effects of organisations. While five safety agents were identified (Zhang et al., 2015), the analysis was from an organisation tier perspective. The five safety agents were consolidated into three organisational levels that are prevalent in all of Hong Kong's building construction projects: Client Safety Culture (CSC), Main Contractor Safety Culture (MSC) and Subcontractors Safety Culture (SSC). CSC, MSC and SSC

form the constructs of the Safety Culture Maturity Level (SCM) of the building construction industry in Hong Kong (Figure 3). By examining these three organisational levels, an understanding representative of Hong Kong's building construction can be developed for future intervention studies.

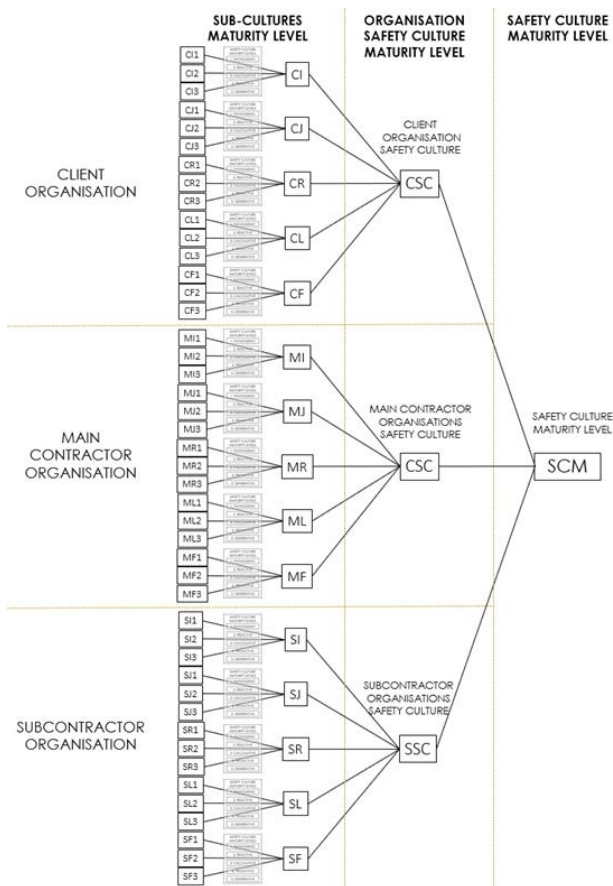


Figure 3. Framework for assessing the safety culture maturity level in building construction.

10. Safety culture sub-cultures

10.1. Informed culture

Informed culture relates to organisations being alert and the possibility of dealing with unpleasant surprises, recognising failure and how the unanticipated is coped with (Weick, 1987). An organisation responds to deal with anomalous information, from pathogenic where anomalous information is prevented, to local fix, global fix and inquiry to discover the root cause of a problem (Westrum, 2005).

Another aspect relates to information flow. When information flow can be delivered to the right people at the right time or information is used as a political commodity, there is a continuum between trust, cooperation and no trust (Westrum, 2014). Almost as an analogy to life blood, information flow in generative cultures becomes mission oriented and less personal (Westrum, 2014).

In the construction industry this is related to the reporting of safety statistics back to the organisation. The extent of safety statistics can range from not gathering information at all to only gathering lag measurements such as accident rates to regularly reporting lead indicators such as recording staff training rates, compliance rates and

finally in generative cultures statistics are used as indicators for staff to actively work together to improve (Reiman and Pietikäinen, 2012).

The constructs that are used in the survey are:

- How safety information is communicated to members in an organisation:
- How an organisation will react when a bad situation occurs, e.g. poor site planning which results in workers being exposed to critical safety hazards, is reported to the organisation
- How an organisation approaches safety statistics

10.2. Just culture

Just culture describes an organisation's response to accountability and situations of non-compliance and how it deals with examining its own weaknesses and improving upon them (Frankel et al., 2006). In pathogenic organisations the response would be to investigate the non-compliant situation and locally terminate the staff (Pepe, 2011). In a Just Culture organisation the investigation will examine at a deeper level to investigate the mindset of the perpetrator as to whether the actions were intentional, reckless or honest mistakes and depending on the intention a procedure will be conducted to educate or punish the member of staff (Pepe, 2011).

At a more advanced level this has been articulated as Restorative Just Culture where mistakes are responded to with restorative care, rather than punishment – it looks at what pain is caused, and who caused the pain (Kaur et al., 2019). Restorative Just Culture represents a generative culture as it promotes trust with qualitative improvements for staff including the willingness to report adverse events, and increase in the number of staff who feel encouraged to seek support (Kaur et al., 2019).

Inquiries and understanding will allow a learning culture to develop if an organisation does not blame but pursues a process of continual improvement through identifying the weaknesses of its own system (Frankel et al., 2006).

The constructs that are used in the survey are:

- How an organisation reacts after an accident has occurred which results in damage to property or personal injury due to an action later discovered that was caused intentionally by a member of staff (sabotage)
- How an organisation reacts after an accident has occurred which results in damage to property or personal injury due to an action later discovered that was caused unknowingly by a member of staff (honest mistake)
- How an organisation reacts after an accident has occurred which results in damage to property or personal injury due to an action later discovered that was caused recklessly by a member of staff (reckless violation)

10.3. Reporting culture

Reporting culture is the willingness to report without being ignored, the information reported would not be taken seriously and would not be regarded as worthy of analysis or further action (Hudson, 2003). Incident reporting in the aviation industry is exemplary so much so that events that are not regarded as serious are nevertheless reported (Hudson, 2003). Previously in the medical sector, nurses would feel reluctant to speak up about faults for fear of repercussions and that generally, harmed patients would be compensated by insurance and there would be little benefit of doing so (Frankel et al., 2006). The two extremes form the basis of reporting cultures.

In the construction industry in Hong Kong accident reporting is regulated by Cap 59 Factories and Industrial Undertakings Ordinance, Cap 509 Occupational Safety and Health Ordinance and Cap282 Employees Compensation Ordinance. All work accidents which occur at a workplace resulting in death, serious bodily injury or accidents with injury leave not exceeding 3 days must be reported to the Labour Department.

The mandatory accident reporting mechanism is legally required no matter whether the role is as client, contractor or consultant with their own reporting mechanism and only for the government's record only. An incident with potential more serious consequences such as an object falling from height with sufficient force to cause serious injury had a person been there is not required to be reported. In a generative culture these Near Miss incidents would be willingly reported and inquiries would be conducted to understand the root causes to prevent such actions (Phimister et al., 2003).

Turning a blind eye to an unsafe situation would be pathogenic for fear of retribution, intervention in regard to unsafe conditions being fixed upon being discovered would be reactive, reporting the incident would be calculative, reporting the incident by free will would be proactive and conducting an inquiry for continuous learning would be a generative culture.

The constructs that are used in the survey are:

- How a member of staff in an organisation will react when he/she witnesses a near miss in a working area that is not their designated working area
- How a member of staff in an organisation will react when he/she discovers an unsafe situation in their area of works that are critical to a project
- How a member of staff in an organisation will react when he/she observes that a fellow staff member does not follow the prescribed procedures

10.4. Learning culture

Learning culture is the social engagements in the context of making improvements by learning from

mistakes, but it is not related to staff training and qualifications.

Knowledge becomes a resource that becomes shared within a group, whether that social group provides intellect by injecting new knowledge into the group or by having an individual in the group with access to someone else with that knowledge (Nahapiet and Ghoshal, 1998). The generative level of learning culture will review the shortcomings of an organisation through inquiries, identify the root causes (Abdelhamid and Everett, 2000) and then share the knowledge with the organisation (Hudson, 2003).

In a generative culture, acknowledging the mistakes that people make is a free lesson to prevent a more serious incident, while a pathogenic culture will not acknowledge incidents and it is likely that similar incidents will repeatedly occur.

The constructs that are used in the survey are:

- What an organisation will do when a minor incident occurs
- What an organisation will do when a serious accident has occurred, and an investigation has been conducted
- What an organisation will do when a near miss happens

10.5. Flexible culture

Flexible culture is related to an organisation's adaptability between consistency against variability and the adaption to changes in readiness to respond to circumstances to deal with the unexpected (Reason, 2010). Generative flexible cultures will have the cognitive ability of being alert to the possibility of unpleasantness (Reason, 2010).

An organisation with stable activity patterns but not adaptable to changes in the market conditions and the environment and sticks to a fixed approach would be a pathogenic organisation, while generative cultures would show signs of high reliability as they can efficiently adapt to changes to cope with crises (Weick, 1987).

Training and preparedness for the unexpected using hazard management are common in construction (Kassem et al., 2017). Pathogenic organisations may not have such a system in place but relegate the hazards to organisations at other levels, calculative organisations will have hazard management systems in place but the efficiency of the system is localised to the work activity, while proactive organisations will extend the fix globally to the project and generative cultures will extend to sharing with the entire organisation for the purpose of learning.

The constructs that are used in the survey are:

- How an organisation manages hazards
- How prepared an organisation is for a crisis
- How an organisation approaches innovation

11. Survey design

A quantitative survey was prepared based on safety culture studies in other industries (healthcare, aviation) and aligned to practices within the building construction in Hong Kong. Fifteen survey questions were prepared with three questions relating to one of the five sub-cultures. Each response was recorded on a 5-point scale ranging from 1 (Pathogenic) to 5 (Generative) corresponding to a maturity level and responses for all three organisations were collected. The questions were vetted by two safety construction professionals with over 10 years of experience.

12. Qualitative sampling

Studies in construction safety culture emphasise the importance of top-down influence. Their findings show attitudes of senior and middle management being crucial to the success in developing advanced cultures, and later studies have echoed this view with management-related factors being identified as the significant influence (Hudson, 2007; Mosly and Makiki, 2020; Mosly, 2019; Wamuziri, 2013).

There are only three methods to assess study safety cultures, which are survey, ethnographic studies and case studies (Han et al., 2021). Therefore, the survey was sent to managers with over 10 years of experience in the industry with roles within the construction industry who represent industry leaders in the Hong Kong construction industry. They have experience working in different organisations, projects and are able to provide an accurate assessment of the industry's maturity level based on their ethnographic experience (Han et al., 2021; Hopkins, 2006).

Qualitative sampling was used to collect data, and an introduction to the research was provided prior to handling the surveys in using Google Form to ensure clarity and to minimise misinterpretations.

13. Results and discussion

Thirty-one completed surveys were returned (N=31) which is considered a small number for this type of test; however, the personnel approached to complete the survey were recruited through selective sampling to ensure the quality of responses, and all the respondents had at least a bachelor's degree in construction and had worked for at least 10 years in building construction. The number of samples and quality were sufficient for this pilot study, whereas future intervention studies will require larger sample sizes to achieve data saturation. The breakdown of the highest level of education is: BSc (22), MSc (8) and Ph.D. (1). Years of working experience was: 10-14 years (27), 20-24 years (1) and above 25 years (3).

The current roles of the respondents are corporate management (3%), senior management (6%), safety (19%), site management (16%), technical/project managers (23%), commercial discipline (10%) and consultants (23%). The respondents' personal experience in working in different ranges of organisations include public clients (10), private clients (4), international contractors (22), local contractors (18), subcontractors (6) and consultants (8) providing a variety of personnel from different disciplines and organisations.

Jamovi software version 2.25 was used to analyse the data and the findings reveal that for the three organisations as follows: Client (Mean: 3.55, SD: 0.512), Main Contractor (Mean: 3.71, SD: 0.311) and Subcontractor (Mean: 1.90, SD: 0.605).

The Shapiro-Wilk test for normality revealed: Client (p -value: 0.003), Main contractors (p -value: 0.022) and Subcontractors (p -value: <0.001) where p -values of less than 0.05 indicate strong evidence against normal distribution (Table 1).

Table 1. Shapiro-wilk normality test results.

Descriptive & Shapiro-Wilk Normality Tests			
	C AVG	MAVG	SAVG
N	31	31	31
Mean	3.55	3.71	1.90
Standard deviation	0.512	0.311	0.605
Skewness	-0.901	-0.187	1.92
Std. error skewness	0.421	0.421	0.421
Kurtosis	2.65	1.34	3.86
Std. error kurtosis	0.821	0.821	0.821
Shapiro-Wilk W	0.886	0.919	0.773
Shapiro-Wilk p	0.003	0.022	<0.001

14. Cronbach's alpha on internal reliability

Cronbach's alpha on internal reliability test gave the results: for Client (α : 0.867), Main Contractor (α : 0.771) and Subcontractor (α : 0.912) so the developed framework for safety culture maturity model assessment are acceptable, good and excellent as the values are above 0.7 Table 2(a), 2(b) and 2(c).

Table 2(a). Scale reliability (cronbach's α) on client organisation construct CI, CJ, CR, CL, CF.

Client (CSC)		
Scale Reliability Statistics		
	mean	Cronbach's α
scale	3.55	0.867

Table 2(b). Scale reliability (Cronbach's α) on main contractor organisation construct MI, MJ, MR, ML, MF.

Main Contractor (MSC)		
Scale Reliability Statistics		
	mean	Cronbach's α
scale	3.71	0.771

Table 2(c). Scale reliability (Cronbach's α) on subcontractor organisation construct SI, SJ, SR, SL, SF.

Subcontractor (SSC)		
Scale Reliability Statistics		
	mean	Cronbach's α
scale	1.90	0.912

The internal reliability test showed that the framework for assessing the safety culture maturity level of Hong Kong's (new) building projects is good (α : 0.867) as shown in Table 3.

Table 3. Hong Kong building construction safety maturity level.

Scale Reliability Statistics – Hong Kong Building Construction Safety Culture Maturity Level (SCM)			
	mean	sd	Cronbach's α
scale	3.06	0.322	0.878

Objective 1 of developing a framework to determine the safety culture maturity model for (new) building projects in Hong Kong at an individual level for the different organisations and together as a multi-level assessment was shown to be acceptable as the Cronbach's alpha is over 0.7.

14.1. Mean safety culture value of organisations

A Kruskal-Wallis One Way Anova Test was performed as there are three categories of data (Client, Main Contractors, Subcontractors), and the results are ordinal and non-parametric. The findings reveal that the null hypothesis that is the mean score of the safety maturities of the three organisations (Client, Main Contractors and Sub-

Contractors) can be rejected ($\chi^2 = 53.8$, $df: 2$, $p: < 0.001$) and the alternative hypothesis that the three organisations do not have a similar mean score is accepted (Table 4(a)).

A Dwass-Steel-Critchlow-Fligner Pairwise comparison shows that the safety culture maturity level between Clients and Main Contractors (p -value: 0.503) is statistically highly significant while the safety culture score with Subcontractors (p -value: < 0.01) is not (Table 4(b)).

Subcontractor organisations were found to be less mature in regard to safety culture compared to contractors and client organisations which are quite closely aligned.

Table 4(a). Kruskal-wallis one way anova test between the three organisations' safety culture maturity score.

Kruskal-Wallis One Way Anova Test			
	χ^2	df	p
Safety Culture Maturity Level	53.8	2	< 0.001

Table 4(b). Dwass-steel-critchlow-fligner pairwise comparison of the three organisations' safety culture maturity score.

Pairwise comparisons			
		W	p
CSC	MSC	1.58	0.503
CSC	SCS	-8.77	< 0.001
MSC	SCS	-9.04	< 0.001

The results show that under objective 2, the mean scores of the three organisations are not the same.

14.2. Lower and upper limits of safety culture maturity levels

At a 95% confidence interval, the lower and upper limits indicate that Safety Culture Maturity Level of the Building Construction in Hong Kong is Reactive to Calculative (LL: 2.94, UL: 3.17), Client Organisations (LL: 3.37, UL: 3.73) and Main Contractor Organisations (LL: 3.60, UL: 3.82) are at a calculative level, while Subcontractor Organisations (LL: 1.65, UL: 2.09) are in a range of pathogenic to reactive level (Table 5).

Table 5. Confidence interval lower and upper limits.

		95% Confidence Interval					
	N	Mean	Lower	Upper	SD	Minimum	Maximum
SCM AVG	31	3.06	2.94	3.17	0.322	2.53	4.27
C AVG	31	3.55	3.37	3.73	0.512	2.13	4.73
M AVG	31	3.71	3.60	3.82	0.311	2.93	4.40
S AVG	31	1.90	1.69	2.12	0.605	1.27	4.00

15. Discussion

15.1. (New) Building Project

The research provides a framework to evaluate the safety culture maturity levels in the building construction industry in Hong Kong. In contrast to oil & gas, aviation and medical industries that have adopted safety culture maturity models, construction is unique due to decentralised project localities, finite project durations, subcontracting of different trades and multi-level organisations. In the construction industry, clients, main contractors and subcontractors work with varying combinations of organisations in every project. Moreover a subcontractor's involvement may be short in contrast to the project's entire contract duration; thus, safety culture commitment levels could correlate to the amount of time and complexity of their works on the project.

15.2. Organisation safety culture maturity level alignment

The findings reveal that the safety culture maturity levels of clients, main contractors and subcontractors are not equal. It is important to align the maturity levels between the organisations on a site.

It is recommended that the client procures contractors and subcontractors with proven similar levels of safety culture to establish site safety culture expectations and behaviours in all organisations that will be involved in the project.

The findings show that clients and main contractors are calculative while subcontractors have a cognitive dissonance with a lower safety culture maturity level in the range of pathogenic to reactive that will need to be addressed. Intervention studies aim to align the maturity levels of all organisations which would be required prior to alignment of the culture maturity levels.

15.3. Organisation safety culture maturity level improvements vs. project-based improvements

Contrarily, medical industries where personnel are located in the same healthcare facility indefinitely, allow progression plans to be developed, enacted and studied longitudinally (Neal and Griffin, 2006). It is common in construction projects to have a variety of subcontractors where their involvement is not throughout the entire project duration.

Organisations in the construction industry should adopt their own unique approach. Rather than project-based enhancements, individual organisations should nurture safety culture maturity levels themselves, though the resultant efforts will only be realised at a project level with actual works on site combined with the external influences and interactions of separate organisations.

For organisations to improve their safety culture, they

must first become aware of safety culture. This study has provided a framework to enable organisations to assess their safety culture maturity levels. Albeit that the framework in this study was used to assess multi-level organisations, the same constructs can be used to assess organisations with a single level.

After assessing safety subculture maturity levels, the organisation can develop a roadmap to enhance its safety culture maturity level, conduct plans and actions to enhance the subcultures, and then maintain and test the effectiveness of the plans and actions.

15.4. Limitations

Although the sample size is small, the respondents of the survey were recruited through selective sampling (10+ years of working in the industry) to ensure the representation and quality of responses as a pilot study and proved with a 95% confidence level the alternative hypothesis that the mean culture values of the three organisations are not equal. Some respondents such as commercial discipline staff would have limited involvement in accidents such as insurance claims and were briefed on near-miss and unsafe condition terminology. The survey focused on (new) building projects in Hong Kong and may not be applicable to other construction works (repair and maintenance/RMAA works, and civil engineering works) and those in other countries which may be different in nature. Due to the time limitation of the study being undertaken only on organisations with three levels, future studies can consider further including organisations with five and up to 7 levels.

The framework in this study covers construction work-related near misses and accidents; however, for cases related to health, workplace violence, theft and burglary and outside the site boundary, subculture questions would be required to be re-examined in order to be relevant.

16. Conclusion

Studies in safety culture in the construction industry have focused predominately on identifying the major contributing factors to a positive safety culture. Many studies have found that there is a correlation between safety culture and safety behaviour in the construction industry (Guo et al., 2015; Chen et al., 2021; Gao et al., 2019; Yu et al., 2020; Loosemore et al., 2020; Mosly and Makiki, 2020; Wamuziri, 2013).

Previous studies have not addressed the uniqueness of the construction industry being comprised of decentralised projects with multi-level organisations. This study found that organisations at different levels do not have the same safety culture maturity levels. The findings provide a new perspective on safety management in the construction industry.

Organisations individually should become aware of their safety culture and actively strive to cultivate their maturity levels to establish their intrinsic safety culture maturity level. Clients should engage parties with safety culture maturity levels equivalent or greater than their target levels to reduce the cognitive dissonance resulting from unequal organisational safety maturity levels such that a homogeneous project safety culture can be developed.

Three areas of future study are suggested, the first of which is to identify the extent of extraneous influence upon main contractors and subcontractors' safety culture such as client influence, type of work, and complexity work. CSC, MSC and SSC will have separate intrinsic framework safety culture maturity levels at the project level and the aggregate of the three organisational levels will work together to form a homogenous project safety culture. In understanding the extraneous forces acting upon each individual safety culture, interventions should be applied at each organisational level to benefit the project level's safety culture maturity. The second is to study the safety subculture interventions at the subcontractor level such as introduction of regulations in reporting safety statistics, positive reinforcement in reporting near miss incidents and establishment of an anonymous reporting system.

Lastly is the adoption of Industry 4.0 technologies to push past the current established upper limits of safety culture maturity levels such as improving team-based training through VR training and simulations (Chheang et al., 2020), reduction of agency and multi-level organisations by implementation of automated systems and blockchain systems, reduction of on-site subcontractors by the adoption of MiC, DfMA and other off-site prefabrication technology such that complicated works will be conducted in a factory-based environment.

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