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## **Characteristics of the safety climate in teams with world-class safety performance on construction projects in South Africa**

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### **Abstract**

Accidents and incidents in the construction environment are not reduced or eliminated effectively, despite numerous efforts made to improve health and safety in the industry. An extensive field of research has been conducted on how teams in the construction environment interact to deliver a project successfully in terms of cost, quality and time. Previous research exists on how team dynamics interface with safety, but is found to be of different focus or markets than this study. This study aims to determine the characteristics of the safety climate that exists in construction teams in South Africa in terms of world-class safety performance, when compared to teams with poor safety performance. An adaptation of the modified safety pyramid (Zohar, 2010) provides a useful conceptual model to investigate the link between safety performance and safety climate related to construction teams. By combining observations from literature and predominantly adapting the Safety Climate Questionnaire (SCQ), a number of directly measurable factors are identified that can be correlated with safety performance and utilised in this investigation to identify the unique characteristics of safety climate in construction teams with world-class safety performance. The characteristics of the safety climate in construction teams were divided into eight groups, namely work pressure, incident investigation, adequacy of procedures, communication and training, relationships, personal protective equipment, spares, and safety. The framework developed in previous studies is used for assessing the responses of safety users to that of safety performance observations. It is found that relationships within an organisation are a major contributory factor

in safety performance, but also the way in which the safety climate is enforced in an inclusive management style through proper procedure, training and communication. This also supports the results of Cohen (1977).

**Keywords:** Construction teams, safety climate

## Abstrak

Ongelukke en voorvalle in die konstruksie-omgewing word nie verminder of effektief uitgeskakel nie, ten spyte van talle pogings wat reeds aangewend is om die gesondheid en veiligheid in die bedryf te verbeter. 'n Wye spektrum van navorsing is gedoen oor hoe die spandinamika in die konstruksie-omgewing werk om 'n projek suksesvol te voltooi ten opsigte van koste, kwaliteit en tyd. Vorige navorsing is ook gedoen oor die invloed van spandinamika op gesondheid, maar daar is gevind dat die fokus of mark op die studies verskillend was. Die doel van hierdie studie is om die eienskappe van die bestaande veiligheidsklimaat in konstruksiespanne in Suid-Afrika te bepaal in terme van wêreldklas veiligheidsprestasie, in vergelyking met spanne wat swak veiligheidsprestasie het. 'n Voorstelling van die gewysigde veiligheidspiramide (Zohar, 2010) verskaf 'n nuttige konsepmodel om sodoende die verband tussen veiligheidsprestasie en veiligheidsklimaat wat verwant kan wees aan konstruksiespanne, te ondersoek. Deur gewaarwordings van literatuur te kombineer met die hoofsaaklik aanpassende Veiligheidsklimaat Vraelys (VV) kan 'n aantal direkte meetbare faktore geïdentifiseer word wat met veiligheidsprestasie gekorreleer word en in hierdie ondersoek gebruik word om unieke karaktereieenskappe van veiligheidsklimaat in konstruksiespanne met wêreldklas veiligheidsprestasie te identifiseer. Die eienskappe van die veiligheidsklimaat in konstruksiespanne is in agt groepe verdeel, naamlik werkslading, voorvalondersoek, geskiktheid van prosedures, kommunikasie en opleiding, verhoudings, persoonlike beskermende toerusting, onderdele, en veiligheid. Die raamwerk wat ontwikkel was in vorige studies is gebruik vir assessering deur die terugvoer van veiligheidsgebruikers te vergelyk met fisiese veiligheidsprestasie-waarnemings. Die bevindings dui daarop dat verhoudings 'n groot bydraende faktor is tot veiligheidsprestasie, maar die manier waarop dit afgedwing word in 'n inklusiewe bestuurstyl deur middel van behoorlike prosedures, opleiding en kommunikasie speel ook 'n belangrike rol. Hierdie bevestig dan ook die resultate soos bevind deur Cohen (1977).

**Slutelwoorde:** Konstruksiespanne, veiligheidsklimaat

## 1. Introduction

The construction industry started as early as 40 000 B.C. and is one of the oldest industries dating back to the start of civilisation. The first evidence of safety regulations was found to date back to 2 200 B.C., when king Hammurabi of Babylon passed a law stipulating penalties for houses collapsing and causing death and injury to the inhabitants (Pérezgonzález, 2005: 7).

Although the global trend of accidents has steadily decreased in recent years, due to the constant effort of industry (Hallowell, 2011: 203), the construction industry remains one of the most hazardous industries at present (Pinto, Nunes & Ribeiro, 2011: 216).

The construction industry contributes to a sizeable portion of the majority of countries' Gross Domestic Product (GDP). Zou & Sunindijo (2013: 605) state that the construction sector employs 7% of the world's workforce, but contributes 30% to 40% of the global fatalities. According to the Global Construction Perspective and Oxford Economics (2011), the construction industry worldwide accounts for over 11% of the global GDP. Vilnius (2008) also states that more accidents occur on construction sites than in any other European economic sector. The construction industry has a unique characteristic when compared to other high-risk industries with small-scale accidents occurring at high frequency and from diverse hazard sources in construction (Hallowell, 2011).

When the South African construction industry is scrutinised, it is found that, since 2008, the industry contributed approximately 9% of the GDP and employed roughly 884 000 workers in the formal sector and a further 450 000 workers in the informal sector (CIDB, 2015). From this it is apparent that the construction industry significantly contributes to the local economy and provides the necessary infrastructure to sustain growth and social upliftment. Drever & Doyle (2012) estimated the overall United Kingdom construction workforce at roughly 1 994 746 and accounting approximately 10% of the GDP (Vilnius, 2008).

The South African construction industry is the third most hazardous and only exceeded by the agricultural and manufacturing sector with R287 million paid during 2013 alone (PWC, 2013). Construction injuries and fatalities are unacceptably high and seem to be on the increase, with 50 fatalities reported in 2011 and 80 fatalities reported in 2013 (Marx, 2014). A similar trend was observed in the Hong Kong construction industry, with an increase of 26.3% in fatalities for 2012 compared to the previous five-year average (HKSAR, Labour Department, 2013). This also seems to be the case with other leading countries, as indicated in Table 1.

Table 1: The status of construction safety management in leading countries

Country	Description of the status of construction safety
United States	The census data from the U.S. Bureau of Labour Statistics (BLS) showed that a total of 774 workers died from injuries they suffered on construction sites in 2010, accounting for 16.5% of all industries. The fatality rate (9.8 per 100 000 full-time equivalent workers) ranked the fourth highest among all industries (BLS, 2010).
United Kingdom	One third of all workplace fatalities occurred on construction sites. It was a fatal injury rate over four times the average level of all industries and was the cause of the largest number of worker fatalities (Health and Safety Executive (HSE), 2009).

Country	Description of the status of construction safety
China	The number of fatalities was 2 538 in the construction industry in 2007 (Zhou <i>et al.</i> , 2008).
Australia	There were 30 fatalities recorded in 2012. This number of fatalities equated to three deaths per 100 000 workers, which was the fourth highest fatality rate of all the industries.
Singapore	There were 24 fatalities in the construction sector in 2006, which occupied 39% of the total 62 workplace fatalities (Ministry of Manpower, 2007).
Korea	The construction sector occupied the highest percentage of fatalities among all sectors (Yi <i>et al.</i> , 2012).

Source: Zou & Sunindijo, 2013

To ensure that the construction industry is sustained and expanded, it is crucial that safety be improved. In spite of safety statistics that seem bleak, the private sector, government and unions have shown their commitment in addressing the matter with the Construction Health and Safety Accord signed in August 2012 that aims to improve the status of health and safety in the construction industry (PWC, 2013).

Previously, the success of a construction project was measured by its performance in terms of cost, safety and quality, and safety should be added as a measure of performance (Smallwood & Haupt, 2005: 2). Identifying the characteristics of teams with world-class safety performance will be of tremendous assistance in this process.

Preliminary investigation suggests that, in some incidents in construction, accidents are not reduced or eliminated effectively, despite numerous efforts made to improve health and safety in the industry. Previous research has been conducted on understanding the team dynamics of role players in a construction project and their influence on health and safety that can potentially reduce the incidents of a construction project. However, this is different from this research in that the current study investigates the perception and performance of workers, rather than the perception of clients (Smallwood, Haupt & Musonda, 2009), clients and consultants (Kikwasi & Smallwood, 2016), as well as architects' perceptions (Smallwood & Haupt, 2007). This research focuses on workers, in general, while previous research was gender based (English, Haupt & Smallwood, 2006). This research also focuses on South African workers as opposed to previous research that focused on other countries (English *et al.*, 2006; Chiocha, Smallwood & Emuze, 2011).

It is important to determine the characteristics of the safety climate of a construction project team with world-class safety records, in

order to assess what contributions these characteristics make to health and safety and how this could benefit the industry as a whole.

## **2. Safety climate and culture characteristics in project teams**

Safety climate is defined as referring to a set of attributes that can be perceived about particular work organisations and that may be induced by the policies and practices imposed by those organisations upon their workers and supervisors (Niskanen, 1994; Sinclair, Martin & Sears, 2010: 1478). Safety climate is regarded as a manifestation of safety culture in the behaviour and expressed attitude of employees (Cox & Flin, 1998).

Safety culture is important, because it forms the context within which individual safety attitudes develop and persist, and safety behaviours are promoted (Zohar, 1980). In the literature, there seems to be confusion regarding the distinction between the concepts of safety culture and safety climate (Schneider, 1975; Schein, 1984; Cooke & Rousseau, 1988). In their study, Schneider & Gunnarson (1991) found that climate reflects the attitudes and behaviour of organisational members, which are directly observable to outsiders, whereas culture is about assumptions, expectations, and outlooks that are taken for granted by organisational members and, therefore, not immediately interpretable by outsiders' notions in their analysis of the psychology of the workplace through organisational climate and culture. Schneider & Gunnarson (1991: 542-551) argue that climate tells us "what" happens in an organisation, whereas culture helps explain "why" things happen in a particular way.

Hinze, Hollowell & Baud's (2013: 139) study aimed to determine the best practices to be implemented in order to improve health and safety. The study found that not a single initiative was responsible for the firms having world-class safety, but rather a combination of different initiatives. The authors listed the 22 most important practices for safety management improvement, of which a significant portion is dependent on the safety climate, such as safe behaviour reward and recognition, and workers' involvement in job hazard identification, to highlight but a few. Regardless of these best practices, there is no consensus on a common set of underlying factors for this conceptualisation of the safety climate, due mainly to the complexity of the safety climate not being fully understood nowadays (Guldenmund, 2000: 216). The Safety Climate Questionnaire (SCQ) developed by Glendon, Stanton & Harrison (1994) lists safety climate questionnaire items that tend to be behaviour anchored or that

deal primarily with respondents' perceptions, making it a distinct conceptual instrument to identify possible factors to measure the safety climate of a construction team with world-class safety records.

To assess the impact of safety culture and safety climate on a construction team, the two concepts will be differentiated and an attempt made to find links to safety performance that may exist and if measures on these concepts can be used to predict safety performance.

## **2.1 Linking safety climate and safety performance**

The purpose of measuring safety climate is to identify areas for inquiry or change where improvements in safety performance can be realised. Industrial organisations will be the major beneficiaries of safety climate improvements. It is thus critical that the safety climate factors should reflect the needs for improvement in these industrial organisations.

Reason (1997) developed the first conceptual model that linked safety climate and safety performance. Zohar (2010) elaborated on this model by linking organisational culture and climate (Zohar, 2010: 1520) (see Figure 1). Although the pyramid represents the original model developed by Reason (1997: 54), it does so by progressing from individual to group and organisational level of analysis, by focusing on the targets of climate perception at each level (Zohar, 2010: 1521). The conceptual method developed by Zohar (2010) as a modified safety pyramid to measure the impact of the safety climate on safety performance of construction teams was used to investigate the linkage between safety climate and safety performance in construction teams in South Africa.

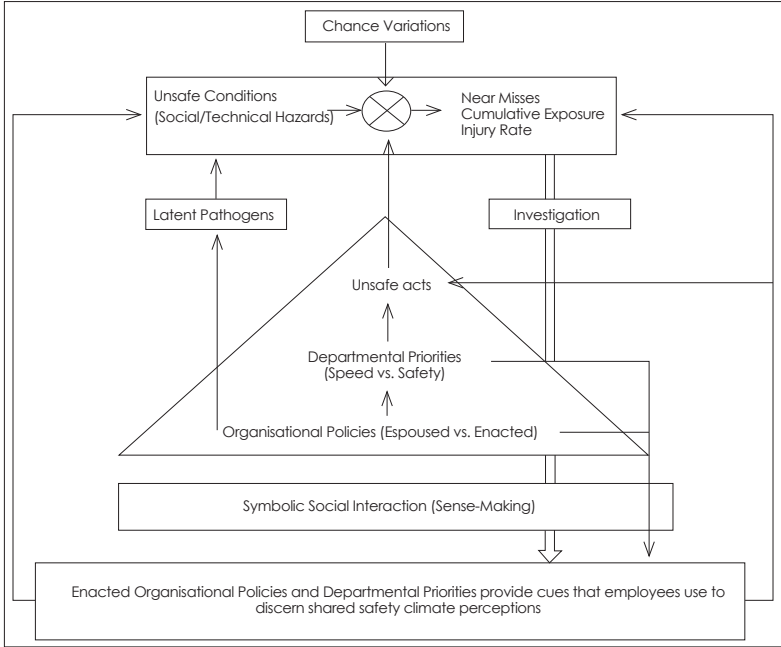


Figure 1: Conceptual model for safety climate

Source: Zohar, 2010

The upper section of the safety pyramid explains the established theory that the likelihood of occupational injuries is a joint outcome of unsafe conditions at the workplace, unsafe acts, and chance variations (Heinrich, 1959). This part of the modified pyramid refers to immediate causes of injuries, while the bottom section labours with the more distal layers of injury causation. The bottom section of the pyramid represents the organisational level policy, focusing on the distinction between espoused and enacted policies. The middle layer represents team priorities for competing operational demands, focusing on safety versus speed/productivity. The upper or surface layer refers to workers' practices while performing high-risk operations, focusing on the prevalence or likelihood of unsafe acts among relevant employees (Zohar, 2010: 1521).

The original model aimed to uncover latent factors that increased the likelihood of an injury through the promotion of unsafe working conditions. However, incorporating the safety climate domain in the lower section of the pyramid adds an important dimension: incorporating employee shared perceptions of their organisation

with the objective targets of such perceptions. With the fact that the safety climate perceptions predict safety behaviours and subsequent safety outcomes (Christian, Bradley, Wallace & Burke, 2009: 1104), the modified model has an additional set of arrows suggesting the effect of the safety climate on the immediate injury factors.

### 3. Methodology

The conceptual method introduced earlier provides a framework to investigate the linkage between safety performance and safety climate of construction teams in South Africa. Glendon *et al.*'s (1994) Safety Climate Questionnaire (SCQ) was used to measure the eight safety climate factors identified as work pressure, incident investigation, adequacy of procedures, communication and training, relationships, personal protective equipment, spares, and safety. Specifically the linkages between these factors and safety performance were investigated in a structured manner. A behaviour sampling technique was used to measure the safety performance of each team member. This method is a reliable and sensitive method for evaluating safety performance (Fitch, Hermann & Hopkins, 1976; Tarrants, 1980: 285). This method involves observing behaviour at random intervals in order to determine safe performance.

#### 3.1 Data collection

As this study explores the safety climate dimension and not the safety culture, it was important that a qualitative approach be followed (Guldenmund, 2000: 220). Data-gathering was performed using a survey consisting of behavioural observation, followed by a questionnaire completed by personally interviewing respondents. This was done, employing the SCQ and following a discreet nominal data set, in which the respondents answered either "yes" or "no" to the 46 questions in the SCQ. The questionnaire comprises eight factors and the question numbers correspond with the questionnaire used in this research:

1. Work pressure (questions 27, 28, 29, 30, 31, 32, 33) = 7.
2. Incident investigation and development of procedures (questions 9, 10, 11, 12, 13,) = 5.
3. Adequacy of procedures (questions 39, 40, 41, 42, 43, 44) = 6.
4. Communication and training (questions 7, 8, 14, 15, 16, 17, 18, 19, 20, 21) = 10.
5. Relationships (questions 22, 23, 24, 25, 26) = 5.



6. Personal protective equipment (questions 34, 35, 36, 37, 38) = 5.
7. Spares (questions 45, 46) = 2.
8. Safety (questions 1, 2, 3, 4, 5, 6) = .

The questionnaire was distributed to, and collected from the respondents by the researcher. Respondents were told that the questionnaire results would be used to improve safety.

The safety behavioural observation was divided into two separate categories, use of Personal Protective Equipment (PPE) and Safety Behaviour. Compulsory PPE included for Group A & C were: hard hat, safety shoes, hearing protection, gloves, glasses; for Group B: hard hat, safety shoes, hearing protection, gloves, glasses, reflective vest; for Group D: hard hat, safety shoes, gloves, glasses. The key behaviours observed were: using the correct tools for a specific task, *i.e.* chisel to break a brick, not other piece of steel; ensuring that protective plastic caps are installed on exposed ends of reinforcing steel; using safety harness when working on scaffolding; abuse of scaffolding, *i.e.* standing on rails; carrying metal sheeting without protective gloves; working underneath an operating crane; whether support is provided underneath both ends of steel being cut, and whether electrical extension cords are fixed to avoid tripping.

Workers' behaviour was only observed when work was performed. No audit was performed on aspects such as evaluating the housekeeping, transport to and from site, preparation before work (such as toolbox talks) or other non-operational task of the construction site.

### 3.2 Sampling method

The study was conducted at Secunda, which falls under the Goven Mbeki Local Municipality, Gert Sibande District in the Mpumalanga province (South Africa).

Of the 39 possible construction companies on SASOL Secunda's vendor list, the four largest locally based companies were sampled. The sample size can be calculated as per equation 1 (Krejcie & Morgan, 1970):

$$S = \frac{X^2NP(1-P)}{d^2(N-1) + X^2P(1-P)} \dots\dots\dots 1$$

where:

S = Required sample size

$X = Z$  value

$N$  = Population size

$P$  = Population proportion

$d$  = Degree of accuracy.

A convenient sample of four construction teams from the sample companies was used, consisting of between eight and 17 members; in total, 53 respondents could be included. The total population of construction workers in Secunda is unknown. However, Statistics SA (2017) provided the working age population of Secunda as approximately 40 000, as per the 2011 census. If it is thus accepted that the population of construction workers should be between the sample size and the total population of Secunda, that population should be between 53 and 40 000. For a population size of 53, the sample size indicates a degree of significance (significance) at 99%, whereas a population of 40 000 indicates a degree of accuracy (significance) of 89%. It could thus be said with all probability that there is between a 89% and 99% likelihood that the outcome of this research predicts the true situation of all construction workers in Secunda. Although the 89% level of significance is slightly low, it still indicates that the outcome would probably be true, rather than not be true.

The four teams, each with a different number of members involved, *i.e.* Team A (8), Team B (11), Team C (17) and Team D (17), respectively, all operated in the Goven Mbeki Local Municipality. Participants and members of the construction teams had to meet the following criteria in order to be included in the sample. They should:

- Work in teams.
- Work in the construction environment.
- Work in a specific team on a regular basis.
- Be 18 years or older.
- Preferably be multiracial of either gender.

### 3.3 Response rate

All of the 53 respondents that formed part of the sample participated and completed the questionnaires, ensuring external validity and a response rate of 100%.

### **3.4 Data analysis and interpretation of findings**

Unsafe behaviours by members in each team were observed in order to obtain safety performance levels. The researcher then identified the compulsory PPE for each site and noted the number of respondents. By multiplying the number of compulsory PPE items required by the number of respondents in the team, a maximum score was determined for each team. From this, a percentage of PPE adherences could be determined for each team.

The measure for safety behaviour was more challenging. The total time spent observing the team was multiplied by the number of respondents in the team to give the total amount of man-hours observed. Due to the limited observation, the man-hours were reverted to minutes. This was then divided by the number of unsafe behaviours or activities observed on site in order to provide a frequency for the unsafe behaviour of each team.

Having collected and processed the data from the questionnaire by means of SPSS software, the feedback from respondents was measured by applying Cronbach's *alpha* to test the reliability of all responses. This is also compared to the feedback from individual groups and individual criteria for safety performance, in order to identify the unique characteristics of safety climate in construction teams with world-class safety performance.

### **3.5 Limitations**

External validity may be limited, due to all construction teams studied being located in the Goven Mbeki local Municipality, and more specifically in the Secunda area. The results might, therefore, only be relevant to construction companies in the Secunda area and are not tested for validity beyond this area.

## **4. Results**

### **4.1 Safety performance**

The safety performance was measured by observing the construction teams for 20 minutes before they answered the questionnaire. From this observation, the safety performance was rated and the teams ranked accordingly.

The safety performance observation was not a safety audit, but merely served as a measure to rank the safety performance between different teams. The safety performance was divided into

two separate categories, use of Personal Protective Equipment (PPE) and Safety Behaviour.

#### 4.1.1 Personal protective equipment

The researcher identified the compulsory PPE for each site and noted the number of respondents. By multiplying the number of compulsory PPE items required by the number of respondents in the team, a maximum score was determined for each team. From this, a percentage of PPE adherences could be allocated to each team, using equation 2. In terms of this, the percentage of PPE adherence is calculated by multiplying the number of respondents by the number of compulsory PPE items. The total number of violations was then subtracted from this and the result divided by the original number. For example, if two members of a team both did not wear safety hats and shoes, the violations would be the two members multiplied by the two PPE items that they did not wear, thus four violations.

$$\% \text{ PPE adherence} = \frac{(\text{Number of Team Members} \times \text{Compulsory PPE Items}) - \text{Violations}}{\text{Number of Team Members} \times \text{Compulsory PPE Items}} \dots 2$$

The findings are summarised in Table 2.

Table 2: Group adherence to PPE requirements

Groups	No. of respondents	Compulsory PPE items	Total observations	Total violations	Percentage adherence	Percentage violations
Group A	11	5	55	5	91%	9.1%
Group B	17	6	102	0	100%	0.0%
Group C	8	5	40	17	58%	42.5%
Group D	17	4	68	26	62%	38.2%
<b>Total</b>	<b>53</b>		<b>265</b>	<b>48</b>	<b>82%</b>	<b>18.1%</b>

Source: Author calculations

According to Table 1, Group B had 100% PPE adherence; Group A was ranked second with 91% adherence; Group D third with 62% adherence, and Group C last with only 58% adherence. It is also necessary to compare the results of PPE adherence to the results of safety behaviour and then to feedback from questionnaires in order to draw conclusions regarding the safety climate in these teams.

#### 4.1.2 Safety behaviour

The measure for safety behaviour was determined using equation 3. The total time spent observing the team was multiplied by the number of respondents in the team to give the total amount of man-hours (converted to minutes) that was observed. This was then divided by the number of unsafe behaviours or activities observed on-site within this time frame to provide a frequency for the unsafe behaviour of each team. For example, Group A had 11 members and was observed for 20 minutes, resulting in a total of 220 minutes of observation, during which five unsafe behaviours were observed. By dividing 220 by 5, the frequency of unsafe behaviour was rated as one unsafe behaviour every 44 minutes for Group A.

$$\text{Unsafe behaviour frequency} = \frac{\text{Observation Time} \times \text{Number of Team Members}}{\text{Number of Unsafe Behaviours Observed}} \dots\dots\dots 3$$

These findings are listed in Table 3.

Table 3: Group safety behaviour frequency

Groups	No. of respondents (N)	Time observed (mins)	Total	Number of unsafe actions	Frequency of unsafe behaviour (mins)	Unsafe actions per hour
Group A	11	20	220	5	44	1.36
Group B	17	20	340	0	Indefinite	-
Group C	8	20	160	11	15	4.13
Group D	17	20	340	10	34	1.76
<b>Total</b>	<b>53</b>		<b>1060</b>	<b>26</b>	<b>41</b>	<b>1.47</b>

Source: Author calculations

According to Table 3, Group B is ranked first with no unsafe behaviour observed; Group A is second with one unsafe behaviour observed on average every 44 minutes (1.36 unsafe actions per hour); Group D third with one unsafe behaviour every 34 minutes (1.76 unsafe actions per hour), and Group C last with the most frequent unsafe actions observed at an unsafe behaviour on average every 15 minutes (4.13 unsafe actions per hour).

#### 4.1.3 Safety performance ranking

When comparing the results of Table 2 and Table 3, it is evident that the ranking of the different groups is in the same order within the two tables' results. Team B had an outstanding safety performance, with

Team C being identified as having the worst safety performance, followed by Team D and then Team A (see Table 4).

Table 4: Group safety ranking

Groups	Safety ranking (1 best and 4 worst)	Questionnaire ranking (1 best and 4 worst)
Group A	2	4
Group B	1	1
Group C	4	3
Group D	3	2

Source: Author calculations

If the percentage PPE violations is compared to the unsafe behaviour violations per hour, as displayed in Figure 2, a trend line comparing the increase in behaviour violations to PPE violations reveals that Groups A and C's behaviour violations are comparatively higher than PPE violations, whereas Group D has a relatively higher level of PPE violations than behaviour violations. In order to investigate this, it is necessary to refer to the feedback from the survey answers in order to draw conclusions.

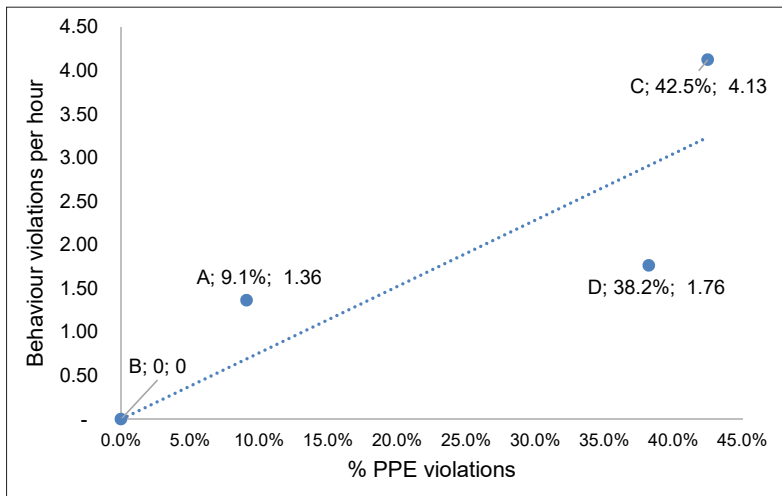


Figure 2: PPE violations compared to safety behaviour violations

Source: Author

## 4.2 Results: Survey answer

The total number of respondents was 53, with 46 questions posed to each, resulting in a total number of 2 438 observations.

Table 5: Safety climate survey answer

Safety climate factor	All				Group A				Group B				Group C				Group D			
	N	Mean	Yes	No	N	Mean	Yes	No	N	Mean	Yes	No	N	Mean	Yes	No	N	Mean	Yes	No
Adequacy of procedures	318	0.8648	275	43	66	0.7121	46	20	102	0.9510	97	5	48	0.9583	46	2	102	0.8333	85	17
Communication and training	530	0.8151	432	98	110	0.4636	50	60	170	0.9000	153	17	80	0.8000	64	16	170	0.9647	164	6
Incident investigation	265	0.8906	236	29	55	0.7636	41	14	85	0.9059	77	8	40	0.9250	37	3	85	0.9412	80	5
PPE	265	0.8264	219	46	55	0.7273	40	15	85	0.9294	79	6	40	0.7750	31	9	85	0.8118	69	16
Relationships	265	0.7887	209	56	55	0.4545	24	31	85	0.8235	70	15	40	0.7750	31	9	85	0.9765	83	2
Safety	318	0.8239	262	56	66	0.8182	54	12	102	0.9020	92	10	48	0.8125	39	9	102	0.7549	78	24
Spares	106	0.8679	92	14	22	0.5909	12	10	34	0.9412	32	2	16	0.8750	14	2	34	0.9706	33	1
Work pressure	371	0.7035	261	110	77	0.3506	26	51	119	0.8824	105	14	56	0.7500	42	14	119	0.7311	87	32
Total	2438		1986	452	506		293	213	782		705	77	368		304	64	782		679	103

Source: Author primary data collection

Table 6: Reliability test results

Group	All		Group A		Group B		Group C		Group D						
	Value	Cronbach's alpha	N	Value	Cronbach's alpha	N	Value	Cronbach's alpha	N	Value	Cronbach's alpha	N			
All	0.815	0.902	45	0.712	0.750	36	0.951	0.924	36	0.958	0.282	26	0.833	0.850	33
Adequacy of procedure	0.865	0.777	6	0.712	0.913	5	0.951	0.521	4	0.958	-0.600	3	0.833	0.773	6
Communication and training	0.815	0.830	9	0.464	0.541	7	0.900	0.815	8	0.800	-0.859	5	0.965	0.075	5
Incident investigation	0.891	0.069	5	0.764	-0.222	2	0.906	0.736	3	0.925	-0.533	2	0.941	-0.400	3
PPE	0.826	0.698	5	0.727	0.858	4	0.929	0.863	5	0.775	0.751	4	0.812	0.419	5
Relationships	0.789	0.715	5	0.455	0.131	5	0.824	0.878	4	0.775	-1.043	3	0.976	-0.133	2
Safety	0.824	0.285	6	0.818	0.245	4	0.902		5	0.813	-0.348	2	0.755	0.737	4
Spares	0.868	0.301	2	0.591	-0.700	2	0.941			0.875	1.000	2	0.971		
Work pressure	0.704	0.731	7	0.351	0.215	7	0.882	0.667	6	0.750	0.585	5	0.731	0.640	7

$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

Source: Author calculations



The respondents were requested to respond to all questions as either affirmative or negative (1 = Yes, 0 = No). The analysis was then compared within the different groups interviewed and for each separate safety climate factor. The results are summarised in Table 5, where N shows the number of observations per category.

In order to determine whether the answers on the survey are reliable, the Cronbach's *alpha* is used to validate the results. The Cronbach's *alpha* is calculated for all questions on the whole sample of respondents, within each safety climate group of questions, for all questions, but distinguished between the different groups of respondents, and within each safety climate group of questions for each group separately. This is displayed in Table 6, where N shows the number of questions per factor and Value shows the mean between "yes" and "no" questions posed.

The overall analysis revealed a Cronbach's *alpha* of 0.902, which is considered an excellent result for the whole survey. The average feedback is an affirmative value of 0.815 for all questions posed. The number of questions is displayed in Table 6 as 45, as opposed to the actual 46 questions asked, due to question 20 being affirmative by all respondents and having a zero variance in the variable, and thus excluded in the calculation of the Cronbach's *alpha*.

Comparing this to the Cronbach's *alpha* for the individual groups, Group B has the highest level of reliability, with an excellent score of 0.924. Although Group C has the highest affirmative score of 0.958, it has the lowest reliability on the survey answers at 0.282, with only 26 questions contributing to the Cronbach's *alpha* and the balance being excluded based on zero variance. Due to this low level of reliability in the questions, it might seem that Group C did not quite make an effort to answer the questions correctly, or did not quite understand the questions. This is also evident in the results of all the individual safety climate factors, with most of them having an unacceptable level of reliability, except three of the factors. This will be discussed later. This is further evident from the unacceptable reliability of answers to communication and training questions posed to Group C, although this is indicated as having a good reliability for all respondents together. Therefore, it seems that there is questionable quality of communication and training, due to the unreliable feedback on this for Group C. It is interesting to note that Group C has the lowest level of reliability in the survey results, and scored the worst on the safety behaviour and PPE observations, whereas Group B has the highest reliability test on the very close to highest affirmative results for all questions.

On the Cronbach's *alpha* for each safety climate factor as calculated for the whole group of respondents, three sets of questions were indicated to have unacceptable feedback, namely Incident investigation, Safety, and Spares. On Incident investigation, Group B is the only group that had an acceptable level of reliability in the survey answers. The questions relate to more complex principles of safety behaviour and incidents, as they also relate to general work activities. This might explain why Group B, being the best on safety compliance, is the only group to provide reliable feedback pertaining to Incident investigation.

On Safety questions, Group D was the only group to provide reliable feedback, albeit being the group with the lowest average affirmative value on the set of questions. Group D confirmed that safety rules do not conflict with established work practice and are practical to implement in all situations. However, they had the lowest affirmative result on the question as to whether safety policy can be implemented under high production pressure. It therefore seems that Group D is safety conscious, which is also evident from their better score on safety behaviour compliance, relative to PPE compliance. Group D is undisciplined, as is evident from their higher relative level of PPE compliance and confirming the tendency to neglect safety policy under production pressure. Group D also indicated that there is a high level of opportunity to express their views on operation problems, but there is a lower level of consultation pertaining to policy development and change in work practice. This top-down management style, one of open communication, is also reflected in Group D's score on relationships. Three of the five questions under relationships are excluded, due to all respondents in Group D having a positive response. On the remaining two questions, only one negative response each was obtained. With this in mind, the zero variance on three of the questions resulted in them being excluded from the calculation of the Cronbach's *alpha*, with the remaining two resulting in a very low score. The high score on the relationship questions might also explain the positive attitude towards safety behaviour and consciousness.

The last safety climate factor with an unreliable Cronbach's *alpha* as measured for all respondents is Spares. This consisted of only two questions and resulted in all but Group C having unacceptable reliability. Group C had a Cronbach's *alpha* of 1.00, due to only one respondent's negative answer to both questions, and being the same respondent, resulted in a perfect correlation between the two questions, hence a perfect Cronbach's *alpha*. The fact that there are only two questions and that they produce unreliable results from all

other Groups, and within Group C it is one of only two results to have an acceptable level of reliability (also refer previous discussion on Group C's overall survey results), would be an indication to discard the question as overall unreliable.

One of the safety climate factors as measured for all respondents had questionable reliability, although it is below an acceptable Cronbach's *alpha* value of only 0.002. This is for PPE questions. Group A and Group B had a reliability score considered to be good, while Group C is in the mid-acceptable range (the only acceptable reliability score, given previous discussions), and Group D having an unreliable score, resulting in the overall Cronbach's *alpha* score to be reduced well below that of Group A's and Group B's individual results. Within Group A and Group B, all respondents but one indicated that PPE use is enforced, and all but three respondents indicated that personnel are trained in the use of emergency PPE. Questions relating to the consulting of PPE users, monitoring of PPE use and acting upon findings, were largely affirmative in Group B, with a large component of negative responses in Group A. This results in the average affirmative response value to be 0.727 for Group A and 0.929 for Group B, although their reliability score is similar. It could be deduced from this that Group A has a larger component of top-down management with hardly any communication at lower levels, whereas Group B is experiencing more of an inclusive management style with visible actions and feedback on PPE use. Group C had a lower affirmative value on PPE use enforcement, but confirmed that personnel are trained in the use of emergency PPE. There is a lower result on consultation of PPE users, although there is a high level of affirmation in monitoring and action upon findings. This confirms the top-down style of management in Group C, as discussed previously, but also points out that PPE use is not heavily enforced, explaining the relatively higher PPE violations of Group C, as discussed earlier. The confirmation of top-down management in Group C might also explain the overall unreliable feedback, which could point to a negative attitude towards cooperation. Group D had a fairly high affirmative value for the questions, but had an unacceptable reliability score. This is based on some uncertainty in the individual questions that seems to be slightly contradictory. There is, however, a bias towards enforcement of PPE use, with some evidence of top-down management style.

Three of the safety climate factors had acceptable Cronbach's *alpha* values, being Adequacy of procedure, Relationships, and Work pressure. The questions relating to Adequacy of procedures

posed to Group A had the highest Cronbach's *alpha* value of all questions posed to all groups, save for the disregarded questions on Spares to Group C. This confirms that there is, in fact, substantial evidence of procedure in place. The affirmative value for these questions is, however, the lowest from all the groups, with questions relating to identification of procedure, *i.e.* own effort to be very high (100% affirmation), while other procedures and communication, *i.e.* view of management and the group's feeling of inclusivity, are lower, again confirming the top-down management style, with possible negative consequences to staff's attitude to management.

This is especially evident in the questions relating to Relationships, where Group A has the lowest score in confirming positive relationships, but also evidenced in uncertainty on this, due to unreliable results. It, therefore, seems that there is some contradictory feedback; uncertainty among staff on their belonging in the company appears evident. This is based on the fact that the question specifically asking if good working relationships exist, has a high level of affirmation, but staff do not trust management; there is a fairly low feeling of trust from management to staff; there is a very low level of confidence about staff's future in the company, resulting in a low level of morale among staff. This could be interpreted as that staff have good relationships among each other, but that there is not a good relationship with management. The result is that Group A had the lowest response towards work pressure questions and the lowest reliability on these questions. The unreliability of the feedback is cause for concern, with contradicting statements within the questions. This might point to an aspect of staff feeling that there is a problematic work pressure, but cannot really confirm this by concrete fact. The low feedback might be due to real unacceptable work pressure, but might also stem from an attitude towards the level of work, due to relationship issues. Group B indicated that there is an adequate level of procedures, with an average affirmative value of 0.951. The Cronbach's *alpha* is, however, indicated to be poor. This might be due to the fact that the majority of the respondents were in agreement of the questions, with two of the six questions a 100% affirmation. However, in three cases, one person had a negative response, of which two of these questions were the same respondent. The last question had two negative responses, of which the one was the same respondent as in the previous two stated questions and the other respondent is different from the previous questions. It could thus be said that the feedback is overall positive, but the 0-1 scale of the research feedback might provide some uncertainty on the reliability; however, it appears to be acceptable.

The feedback on questions relating to relationships also provided a very high level of feedback, with 82.4% confirmation of positive relationships at a Cronbach's *alpha* of 0.878. This is the highest Cronbach's *alpha* for all safety factor questions posed to Group B and second after the questions on procedures posed to Group A, i.e. second highest of all questions to all groups. The reasonably high affirmation value of this, in combination with the high correlation among respondents, as indicated by the Cronbach's *alpha*, might explain Group B's high performance on both safety behaviour and safety performance. It is evident that Group B respondents are satisfied with job security, relationships with management, as well as among each other; this satisfaction seemingly has a positive influence on safety behaviour.

Questions relating to Work pressure to Group B have the highest affirmation value, with a questionable Cronbach's *alpha*. This is interpreted, similar to that of Group A, as there being some uncertainty. In contrast to Group A, it is a positive uncertainty, rather than a negative one. Respondents are mostly of the opinion that work pressure is acceptable, but it is uncertain whether this feedback stems from the positive relationships and, hence, a positive attitude towards work obligations, or whether Group B's work pressure is indeed lower than the others. Group C had fair to high response values, but the Cronbach's *alpha* coefficients range from very high negative to poor. It is, therefore, again questionable whether these results have any interpretation value and are disregarded. Group D had a high level of positive response towards Adequacy of procedures, with an acceptable level Cronbach's *alpha*. The group also had the highest level of positive relationships response of all groups, but the Cronbach's *alpha* is unacceptable for reasons discussed earlier. The Work pressure questions also revealed a fairly positive attitude, albeit with a questionable Cronbach's *alpha* value.

## 5. Conclusions and recommendations

### 5.1 Research conclusion

This research proposed a conceptual framework that identified the characteristics of construction teams with world-class safety records by linking the safety performance with the safety climate.

The importance of safety in the construction industry and what factors contribute to the safety performance of construction teams were extracted from the existing literature. From this, a framework was developed to determine the characteristics of the safety climate

in construction teams and their influence on the safety performance of the teams.

The safety climate questionnaire was used to evaluate the safety climate in construction teams and observations on-site done to evaluate the safety performance of the teams on-site.

From the results obtained, the framework developed during the literature review was used for assessment, using correlations between the research questionnaire and safety performance observations.

The findings revealed that one of the highest reasons for good safety behaviour and performance is good relationships. A positive relationship between staff and employer influences staff to react better to safety requirements. A high level of procedure also revealed good safety performance, but if this is not communicated well, it could result in poor relationships, causing a poorer response in safety behaviour. The enforcement of PPE equipment is necessary in order to ensure that employees adhere to requirements, but if this is performed within a top-down management style, it might hamper relationships and cause poor behavioural response. On the other hand, an inclusive management style without proper enforcement can improve behavioural responses; however, without the necessary enforcement, employees might take shortcuts on safety compliance when work pressure increases.

## **5.2 Areas of concern**

The questions that received the lowest confirmation from the respondents were the trust between management and work teams as well as the question as to whether the employees had a future within the company. These questions formed part of the relationship factors. It is evident that management needs to set clear guidelines on what behaviour is deemed satisfactory and how this will be rewarded, within an inclusive management style with open communication opposed to a top-down prescriptive management style.

The management needs to be consistent in how behaviour is rewarded from one project to the next in order to develop trust in the organisation. Construction teams work almost independently from the organisation, due to their working off-site. This requires greater effort from management to ensure that the values of the organisation support an excellent safety climate, since it is clear that the team members' perception of management is a major contributing factor to the safety climate and, ultimately, to the safety performance.

From the research, it was found that the safety climate factors that contribute predominantly to safety performance are relationships and how it is communicated through Adequacy of procedure, Training and Positive communication. This also confirms Cohen's (1977) findings, whereby the six factors influencing the success of an occupational safety programme were identified as:

- Management commitment;
- Management-Supervisor-Worker interaction (team dynamics);
- Workforce stability and industrial relations;
- Housekeeping and environmental control;
- Training, and
- Conventional safety practices.

## 5.2 Further research recommendations

From the surveys, it was found that the construction teams' perception of safety performance did not reflect the actual performance, more specifically the area of adherence to the use of PPE. This is an important aspect that could contribute to the improvement of safety performance, since some teams were under the impression that they were adhering to the safety requirements, but were only complying by 58%, whereas other teams perceived that they were not complying, although they had a 91% adherence.

Eliminating such inaccurate perceptions could improve the safety performance within a team, since the safe behaviour of the team relies heavily on the perception of what is safe behaviour among the team members.

It is suggested that further research be conducted on the perception of safe behaviour related to the actual safety performance in a team could be aligned, as well as the perception of work pressure related to industry norms. In the latter case, this study did not test specifically to what extent work pressure directly influences safety performance, *i.e.* comparing actual "time-on-the-task" results within different groups. This could provide further insight into the question as to whether work pressure responses, as identified in this study, are based on actual higher levels of work pressure or whether it is only a perception by employees, due to relationship concerns within the organisation.

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## Appendix A

### **Stanton & Harrison (1994) safety climate questionnaire items were modified for this study and are listed below.**

1. Safety rules are adhered to, even under production pressures.
2. Safety rules can be implemented without conflicting with established work practices.
3. Safety rules are practical to apply in all situations.
4. There are adequate opportunities for staff to express their views about operational problems.
5. There are adequate opportunities to discuss important policy issues.
6. Consultation is adequate when changes in working practices are proposed.
7. Meetings take place where causes of operational problems are openly discussed between engineers and management.
8. An effective system exists for communicating plant changes and their implications for safety to operating personnel.
9. Users are involved in developing the incident investigation systems.
10. Members of investigation teams are trained to identify factors that influence the causes of error.
11. There are clear and well-documented procedures for developing specific remedial actions on the basis of identified causes of incidents.
12. The procedure development system used job and task analysis to ensure that the contents of procedures reflect actual working practices.
13. Explicit guidance is provided on human factor aspects of procedure layout (language, format, etc.).
14. Effective training is provided on skills specific to individual tasks and equipment.
15. Potential errors, consequences and recovery points are identified in training.
16. Training includes effective skills practice for normal operations.
17. Training includes skills practice for emergency (e.g., fault conditions).

18. Individuals with relevant operational experience carry out training.
19. Provisions are made to minimise the isolation of one employee from others.
20. Employees are encouraged to support and care for each other's wellbeing.
21. Aspects of company policy are effectively communicated to individuals.
22. Staff trust the management in this organisation.
23. Management trust the staff in this organisation.
24. Staff are confident about their future with the company.
25. Good working relationships exist in this company.
26. Morale is good.
27. Staff has adequate time to carry out individual and concurrent tasks.
28. There is sufficient staff to carry out the required work.
29. There is sufficient "thinking time" to enable staff to plan and carry out their work to an adequate standard.
30. Frustrations that arise from factors beyond staff control can be accommodated without adversely affecting work.
31. Time schedules for completing work projects are realistic.
32. Workload is reasonably well balanced.
33. Workload adjustments that have to be made on short notice can be accommodated without adversely affecting work.
34. PPE use is systematically enforced.
35. Relevant personnel are specifically trained in the use of emergency PPE.
36. PPE users are consulted for suggested design improvements.
37. PPE use is monitored to identify problem areas.
38. Findings from PPE monitoring are acted upon.
39. Operators can easily identify the relevant procedure for a job.
40. An effective documentation management system ensures the availability of procedures.
41. Procedures are technically accurate.
42. Procedures are complete and comprehensive.
43. Procedures are written in clear, unambiguous language appropriate to users' needs.

44. Written procedures match the way in which tasks are done in practice.
45. Critical spare parts are available from stock.
46. Good availability of spares ensures that staff fit correct rather than substitute parts.

The questionnaire comprises eight factors and these question numbers correspond with the questionnaire used in this research:

1. Work pressure (questions 27, 28, 29, 30, 31, 32, 33).
2. Incident investigation and Development of procedures (questions 9, 10, 11, 12, 13,).
3. Adequacy of procedures (questions 39, 40, 41, 42, 43, 44).
4. Communication and training (questions 7, 8, 14, 15, 16, 17, 18, 19, 20, 21).
5. Relationships (questions 22, 23, 24, 25, 26).
6. Personal Protective Equipment (questions 34, 35, 36, 37, 38).
7. Spares (questions 45, 46).
8. Safety (questions 1, 2, 3, 4, 5, 6).

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