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Manuscript title: Personal Attributes of Supervisors: Is it the Key to Transforming Construction Safety?

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Abstract

The UK construction industry accounts for a disproportionately high number of major and fatal injuries. The industry has a poor worker safety record and several stakeholders have made efforts to improve its performance. Much of such efforts have however targeted reactive control measures. Research indicates that there is a positive correlation between a proactive alternative - safety behaviours, and safety performance. These behaviours are shaped by the personality of individuals or determined by their social sphere of interaction including supervisors. Thus, the role the supervisor plays in influencing frontline workers' (FLW) behaviours was investigated. Using a survey and statistical tests, the perspectives of FLW were obtained and analysed respectively to establish the vital supervisors' qualities that improve their safety behaviours. The emerging qualities were found to rank from highest to lowest potential as follows: integrity/trust, openness/transparency, genuine care, accountability, flexibility, respect, fairness, consistent high personal standards, ability to empower and beliefs. The findings from this study suggest that organisations can improve their safety performance by focusing on the above qualities in three stages. The findings also highlight the need for organisations to focus on subtle but significant human qualities that are often ignored in safety management.

Notation

SP_{FLW} safety performance of the frontline workers

SSO_{FLW} source safety orientation of the frontline workers

E external factors that produce a safety stimulus

I internal factors that produce a safety stimulus

1. Introduction

The UK construction industry accounts for £90 billion (6.7%) in value-added and about 2.93 million jobs, equating to 10% of the entire employment for the national economy (Department for Business Innovation and skills, 2013). Whilst the economic contribution by the industry is commendable by any measure, its accident statistics are not as impressive and considered by some commentators as rather dire. A glance at the current health and safety (H&S) statistics of the UK construction industry exposes the need to manage occupational safety and health (OSH) risks better. Figure 1 shows that over the last decade, there has been an overall reduction in the rate of fatal injuries to workers (employees and self-employed) in the UK. However, it is also clear that over the last 5 years this rate of reduction of fatal injuries has been plateauing (Health and Safety Executive [HSE], 2017). In comparison to other high-risk industries such as manufacturing and agriculture responsible for 19 and 27 fatal injuries respectively, the construction industry was responsible for 30 fatal injuries in 2016/17. According to HSE (2017), this is the lowest on record for construction.

Investigations conducted by Pybus (1996) and Hudson (2007), have helped to establish three dominant phases in the evolution of safety practice and culture. These are practices driven by a legal requirement and framework, those that are determined by engineering controls, and practices that rely on people-centric solutions. Figure 2 depicts the transition between the three stages as safety practices in an organisation or project evolve over time to bring about improvement in performance. It also shows plateaus in the rate of improvement, which lead to the activation of the next stage. Thus, after a focus on a legal framework, which

includes rules and enforcement, and then engineering controls, which includes designing out OSH risks as early as possible, the innovative phase is subsequently activated where the focus is on people, typically frontline workers (FLW). In general, the three phases build upon each other and should not be treated in isolation (Finneran and Gibb, 2013; Talabi et al., 2015; Borys et al., 2009).

This paper focuses on OSH (particularly safety) improvements that can be realised during this innovative phase, as the unsafe behaviours of FLW are known to be one of the main causes of accidents and unwanted incidents (Hollnagel et al., 2006; Begur and Babu, 2016). Geller (2005) and HSE (2009) have suggested that a focus on behaviours to improve safety performance constitutes what is typically referred to as behaviour-based safety (BBS), while Zin and Ismail (2012) and Sulzer-Azaroff and Austin (2000) provided guidance on the successful implementation of behaviour-based safety programmes (BBSPs). Such programmes should however not be used to replace a comprehensive safety management systems (SMS) but should instead be used as a complementary tool to improve the efficacy of existing SMS.

Fang et al. (2015) argued that BBSPs focus directly on the FLW and their behaviours, and often neglect the impact of management on FLW's behaviours therefore limiting the effectiveness of such programmes. In their study, they contended that there are three layers of management on construction projects namely: strategic, tactical and frontline operational. They concluded that the frontline operational management, also known as supervisors, play a vital role in influencing the safety behaviours of FLW. Talabi et al. (2017) also established that direct supervisors significantly influence the safety behaviours of FLW. In a complex project

delivery network, the supervisor is the direct line manager of the FLW (Gibb et al., 2015) and therefore likely to engage with FLW more frequently than other management team members. As a result of this peculiar position in the management hierarchy, supervisors are suitably placed to bring about improvements in the safety behaviours of FLW, and are therefore the focus of this study.

Although supervisors have been identified as being important to improving FLW's safety behaviours, it has not been established how supervisors can bring about this improvement. This study was therefore conducted to discover how supervisors can achieve this improvement, by building on research by Bolt et al. (2012) and Talabi et al. (2015), in which personal values such as respect, trust and care, were identified as factors that improve the performance of construction organisations. This study focused on these factors to establish the extent as well as which personal values can bring about an enhancement in safe behaviours and performance beyond the *plateau* of current safety performance.

Further, Talabi et al. (2015) concluded that construction contractors utilised BBSPs more than consultants, hence the focus on contractors in this study. In addition, although accidents tend to be multi-causal in nature (Gibb et al., 2014; Hopkins, 2006; Reason, 1990), this study concentrated on FLW, who are at the 'sharp' end of the accident causation network, tend to be the injured party and usually work for contractors. The FLWs' supervisors also usually work for contractors.

This paper will be directly useful to strategic, tactical and frontline contractor management teams. Construction Clients will also benefit from this paper as contractual

arrangements can be revised to account for the findings herein.

2. Factors that influence the safety behaviours of FLW

Early work done by Neisser (1967), Skinner (1974) and Watson and Rayner (2000) have led to important theories that explain how human behaviours can be influenced. Their work identified a myriad of factors with potential influence on the safety behaviours of FLW. These factors can be broadly grouped into two categories based on the classification of Gutierrez (2012) as internal (typically unobservable) and external (typically observable) ones. Ultimately, management teams need to ensure that both internal and external factors support FLW to engage in safe behaviours. Figure 3 presents conceptual alternatives that illustrate how these factors can influence FLWs.

The circle denotes the safety orientation of the FLW, while the arrows denote stimuli (such as personal attributes of supervisor, peer pressure, carrot and stick) that can influence their behaviours. The arrows outside the circle denote external stimuli (for example safety culture) while arrows within the circle denote internal stimuli (such as personal attitudes). Logically, the most favourable option is quadrant 4 where both the external and internal stimuli encourage the FLW to engage in safe behaviours.

The effects of the influences on the safety performance of the FLW can be summarised by the relation in Equation 1.

$$SP_{FLW} \cong SSO_{FLW} \pm E_{Safety\ Stimulus} \pm I_{Safety\ Stimulus} \quad (1)$$

Where:

SP_{FLW} is the Safety Performance of the FLW

SSO_{FLW} is the Source Safety Orientation of the FLW

E is the external factors that produce a safety stimulus

I is the internal factors that produce a safety stimulus

The rationale of Eq. 1 is that each FLW comes on to a project with a foundational safety performance (source safety orientation, SSO), which can be affected by the type and number of behaviour stimuli to establish the safety performance they attain in the discharge of their tasks. The focus of the study that underpins this paper is the external stimuli provided by FLW's supervisors. The study explored which stimuli construction companies should address to further enhance their safety performance through a behaviour-based safety route.

3. Methodology

A quantitative research approach was adopted for this study and the data was collected via a questionnaire survey. The questionnaire had two sections; the first section (A) collected demographic information and the second section (B) collected the respondents' views on the factors that influence safe behaviours. Closed questions with a five point Likert scale ranging from 'strongly disagree' to 'strongly agree' were used throughout the survey with a provision for comments at the end of the questionnaire.

A non-probability large sample, specifically a convenience sample, was used for this study (Bryman, 2012). One major criticism of studies that use non-random sampling is that the outcomes cannot be generalised (Naoum, 2013). However, Yin (2009) explains that there are

different types of non-random sampling cases; one of them is the representative or typical case. Bryman (2012) refers to this as the exemplifying case, where typifying cases are selected because they characterise a wider group of cases or provide an appropriate context for certain research questions to be answered. This is the case for the job positions considered in this study: FLW, supervisor and site manager.

The data were gathered from five different UK construction sites (in London, England), albeit from one organisation that did not have a BBSP. It was a medium-sized organisation and held the role of the Principal Contractor (Construction Design and Management, 2015) on its projects. The unit of analysis is however the individuals.

Over three months, various approaches were used to collect the data and participation was voluntary. For some, managers distributed the questionnaire to workers on their respective sites while one of the researchers attended various sites (with permission) and administered the questionnaire personally in safe areas, such as canteens, site offices and induction rooms. In some instances, workers were approached during their breaks. In other instances, a more organised setting brought a group of workers into a meeting room. Workers who preferred to complete the questionnaire themselves were given the liberty to do so. With others, the researcher progressed through the questionnaire asking the questions and writing down the responses.

A total of 239 people responded to the survey and Tables 1 and 2 show the number of responses pertaining to each site and job category respectively. FLWs were the main focus as they are the ones that tend to get injured. FLWs usually take instructions from their direct

supervisor, who in turn takes instructions from the site manager, hence the consideration of these two hierarchically higher positions for this study. Extrapolating the many-to-one relationship between FLWs and their direct supervisors or FLWs' supervisors and their site managers meant that it was not possible to consider people beyond the site manager in the timeframe for this study. The sample of people above the 'site manager' position would have been too small in comparison to the others.

The difference in the total numbers (233 and 239) arises, as six respondents did not complete the job position section of the survey. The data from the completed questionnaires were entered into IBM SPSS (Statistical Package for the Social Sciences) Statistics (for Mac) version 22.

Table 3 shows the codes used for the agreement variables.

Demographic group data (for example, current job position, which could be 'site manager' or 'supervisor' or 'trade worker' or 'other') in section A were classed as nominal data, while safety behaviour data in section B, which was collected on a Likert scale, were classed as ordinal (Field, 2013).

The following statistical procedures and tests were undertaken: normality test (also known as Shapiro-Wilk test [Shapiro and Wilk, 1965]) to check if the data was normally distributed; Cronbach's Alpha to check the internal validity of the scales; the One-Sample Wilcoxon Signed Rank (OSWSR) test to investigate if there was a statistically significant difference between the hypothetical median of 'three', which is the middle position of the five point Likert scale, and the observed median of supervisors' personal qualities (PQ)

[integrity/trust (1), openness/transparency (2), accountability (3), flexibility (4), fairness (5), beliefs (6), consistent personal standards (7), genuine care (8), respect (9) and ability to empower (10)] that increase safe behaviours of FLW (SBFW); and finally, the Kruskal Wallis test was conducted to make comparisons among ‘job position’ groups – site manager, supervisor and trade worker (also the FLW). A statistically significant level of 0.05 (95% confidence) was used. This is a generally accepted level for behavioural science studies of this nature (Field, 2013).

The survey instrument was used to measure the ten PQ of supervisors that were theoretically hypothesised to increase the safe behaviours of the respondents.

For the OSWSR test (used to establish the importance of each PQ); the null hypothesis, H_0 , was that the median of ‘high levels of supervisors’ PQ (for example respect [PQ9]) increase the SBFW’ is equal to three. The alternate hypothesis, H_a , was that the median of ‘high levels of supervisors’ PQ increase the SBFW’ is not equal to three. Therefore, for the null hypothesis, H_0 : median of PQ9 = 3, and for the alternate hypothesis, H_a : median of PQ9 $\neq$ 3.

For the Kruskal Wallis test (used to investigate how the results differ among job positions); the null hypothesis, H_0 , was that high levels of supervisors’ PQ (for example respect) had the same effect on the safe behaviours of respondents across job positions. The alternate hypothesis, H_a , was that high levels of supervisors’ PQ (for example respect) did not have the same effect on the safe behaviours of respondents across job positions.

4. Results

The FLW were asked to indicate their level of agreement with ten statements for the ten PQ of

their supervisor - one statement per PQ. An example of one of the statements was, “A high level of integrity/trust of your supervisor increases the amount of your safe behaviours”. The other nine statements followed this exact format.

The supervisors’ PQ scale had a high level of internal consistency, as determined by a Cronbach’s alpha value of 0.85 (DeVellis, 2012 and Kline, 1998). Table 4 shows the SPSS output for the Cronbach’s alpha.

The ten PQ scores were not normally distributed for site managers, supervisors and trade workers, as assessed by Shapiro-Wilk’s test ($p < 0.05$) (Shapiro and Wilk, 1965). Table 5 shows an excerpt of the SPSS output for the test for normality for supervisors’ integrity/trust, openness/transparency, accountability and flexibility.

Figure 4 shows a graph that displays how high levels of supervisors’ PQ are perceived to increase the SBFW.

To support the results and as mentioned earlier, the OSWSR test was used to identify any differences between the hypothetical median of ‘three’ and the observed median scores of the responses of the FLW for each PQ of their supervisor. Taking PQ1 (integrity/trust) for example, the null hypothesis, H_0 : median of $PQ_1 = 3$, and for the alternate hypothesis, H_a : median of $PQ_1 \neq 3$, where PQ_1 is “high levels of supervisors’ integrity/trust increases the amount of your safe behaviours”.

Table 6 shows the SPSS output for this test and Table 7 summarises the results. Extrapolating a Likert scale, the following was used to interpret the results of the agree/strongly agree values in this section: 0 to 20 represents ‘unimportant’ outcomes, 21 to 40

represents 'slightly important' outcomes, 41 to 60 represents 'somewhat important' outcomes, 61 to 80 represents 'very important' outcomes and 81 to 100 represents 'extremely important' outcomes.

Integrity/trust, openness/transparency, genuine care and accountability emerged to be 'extremely important', while flexibility, respect, fairness, consistent high personal standards and ability to empower emerged as 'very important'. Finally, beliefs emerged to be 'slightly important'. The results of the OSWSR test showed that there was a statistically significant difference between the hypothetical median of 'three' and the observed median of 'four' for all the PQ but 'beliefs', where the hypothetical and observed medians were equal to 'three' and not statistically significantly different.

The test shows that the null hypothesis should be rejected for all the PQ but beliefs. The null hypothesis for beliefs is retained, therefore it is 'failed to be rejected' and the alternative is rejected. Further investigation of the results show that the hypothetical median of 'three' is lower than the observed median of 'four' for all but 'beliefs', where the hypothetical median of 'three' is equal to the observed median of 'three'. For comparisons, Figures 5 and 6 show a breakdown of the results of this OSWSR test for 'integrity' and 'beliefs' respectively.

A Kruskal-Wallis test was conducted to determine if there were differences in the scores of supervisors' PQ among the three 'job position' groups: site manager, supervisors and FLW. Tables 8 to 18 show the results of this test. The asymptotic significances are displayed for all the figures and the significance level is 0.05.

The distributions of the scores of supervisors' consistent high personal standards increasing the safe behaviours were not similar for all 'job position' groups, as assessed by visual inspection of a boxplot in Figure 7.

The pairwise comparisons in Table 15 however showed that there were no statistically significant differences between each job position pair based on supervisors' consistent high levels of personal standards increasing the safe behaviours of the respondents. Field (2013) notes that it is possible to have a statistically significant Kruskal-Wallis test, but no statistically significant pairwise comparisons. The pairwise comparisons (Dunn, 1964) with adjusted p -values (using Bonferroni's correction for multiple comparisons) (Field, 2013) showed that there were no statistically significant differences between supervisors' high personal standards when comparing the trade workers (mean rank = 100.71) and supervisors (mean rank = 120.67) ($p = 0.368$), trade workers (mean rank = 100.71) and site manager (mean rank = 124.36) ($p = 0.132$), and supervisors (mean rank = 120.67) and site managers (mean rank = 124.36) ($p = 1.000$).

5. Discussion

5.1 *The influence of supervisors on the safety behaviours of FLW*

This study has shown the value that supervisors' personal values have on the safety behavior of FLW. Fleming (2012) and Manu et al. (2017) concurred that intrinsic personal values are potent and are central to improving BBSPs.

The results suggest that integrity/trust, openness/transparency, genuine care and accountability are the top four PQ (in descending order) of a FLW's supervisor that are

‘extremely important’ to increase the SBFW. Flexibility, respect, fairness, consistent high personal standards and ability to empower ranked fifth, sixth, seventh, eighth and ninth respectively, and were deemed to be ‘very important’ to increase the SBFW. Finally, beliefs ranked last (tenth) and was deemed to be ‘slightly important’ to increase the SBFW. Supervisors should therefore firstly focus on the ‘extremely important’ qualities, then the ‘very important’ qualities, and finally, the ‘slightly important’ quality.

The results of this study align with that of Way et al. (2016) (and is corroborated by Simons, 2002 and Simons et al., 2015) who argued that ‘behavioural integrity’ of middle managers positively influences the behaviours of their subordinates and improves performance. Integrity/trust emerged as the prime PQ for supervisors to have. Therefore, supervisors should say what they mean and mean what they say, otherwise over a period of time, FLW may perhaps not be motivated due to lack of confidence in their supervisors’ words. Further, organisations should utilise teambuilding exercises to increase the level of trust among colleagues and their supervisors. All supervisors should commit to mutual values and treat everyone the same way.

Going hand in glove with integrity/trust is openness/transparency, which emerged as the second PQ of a supervisor that can increase the SBFW. When supervisors are open/transparent, FLWs can communicate freely with them. This will likely increase the chance of raising any safety concerns that they may have in the workplace. Consequently, organisations should encourage supervisors to have open and fair dialogue with all FLW. The culture set by senior

management can also help towards achieving a transparent working environment, which leads to an increase in the SBFW.

The outcome of such communication is likely to be more effective when the supervisor genuinely cares for the FLW, which is the third PQ. The FLW should be confident to raise issues with an assurance that the issues will be discussed and resolved because the supervisor genuinely cares about their safety. FLW should feel genuinely cared for by supervisors, as they are likely to sense any ulterior motives over time. This will likely diminish the relationship with their supervisors and hence reduce the number of safe behaviours that they engage in.

This leads to the fourth PQ, which is accountability, where FLW can take their supervisors to task for their commitments towards safety. Accountability is key to increasing the SBFW as it shows a sense of commitment towards the workers.

Once sufficient mastery of these ‘extremely important’ PQ is evident, the next five qualities can be introduced. It is not impossible to benefit from all the qualities at the same time, however monochronic cultures - one thing at a time, make progress quicker than polychronic cultures - multiple things at once (Hall, 1983).

For optimal performance, supervisors would need to adopt a flexible approach, be respectful, fair, have consistent high personal standards, empower FLW to not only communicate but also act to interrupt patterns of unsafe behaviours (and conditions) and finally challenge their beliefs towards safety.

5.2 Site managers, supervisors and FLW: the difference in their supervisors’ personal qualities

The Kruskal-Wallis test showed that there was no statistically significant difference between

the job positions (site manager, supervisor and trade worker) for all the supervisors' PQ ($p > 0.05$) except 'consistent high levels of supervisors' personal standards', where $p < 0.05$. Further investigation of the boxplot diagram of this particular quality showed that the median of the distribution of the data of each 'job position' group was four; the distributions however differed. A pairwise comparison, which shows how each individual group interacts with other groups, was investigated. Based on the adjusted significance values, the pairwise comparison showed that no statistically significant difference existed among the groups. These results infer that safety performance is likely to increase if the respective supervisors of the people in these three groups behave in the same way with regards to these ten PQ.

As with all research, the findings of this study should be implemented with an awareness of its limitations. The utilisation of survey-based data makes the information gathered from participants subject to interpretation and bias. This issue was however overcome by using properly structured questions and a large sample size, which is likely to evidence the true nature of the constructs that were studied. No incentives were provided to persuade participants to respond and their answers had no repercussion on their job. Users of the model presented in this paper should also be aware of the industry in which the data set was gathered.

5.3 Recommendations

Figure 8 shows these PQs and the sequential phases (T1, T2 and T3) that contractors' supervisors should follow to increase the SBFW and therefore enhance safety performance. The upward/forward-curved solid arrows indicate that the SBFW increase as these qualities

increase with time. The downward/backward-curved dashed arrows indicate that the previous phase should be reviewed over time to ensure that there are no lapses.

Interviews were conducted with nine industrial experts. On average, these interviews lasted 38 minutes each. These industrialists were involved in the construction and civil engineering sectors. Presentation slides detailing the findings of this study were sent to them beforehand to inform the discussions. Overall, the respondents confirmed that the results were logical and useful.

They were asked to compare two options and indicate a preferred one. Six out of nine of the respondents preferred option one in Figure 8 (note: the second option is not shown in this paper). Of the other three, one was on site and did not have the two options visually in front of him, one did not expressly state which option was preferred, and the third preferred option two because of its cyclical (“reviewed, actioned and carried on through”) representation.

Respondents noted that T1 is more action-oriented and will be easily understood by management. A respondent said, “*you can almost grasp it without saying anything*”. It focuses on certain values at a time and shows the hierarchy. Another respondent noted, “*it shows its relevance to time and behaviours*”. It was also advised that the backward pass (dashed arrows) could involve retraining, coaching, guidance and mentoring.

Beyond construction contractors benefitting from this paper, construction clients will also benefit from this paper as they can stipulate that contractors foster relationships between supervisors and FLW and monitor these relationships over time.

6. Conclusion

This study proposes an empirically based solution to enhance safety performance for construction contractors by utilising supervisors' personal qualities to increase the SBFW. The solution is based on a progressive three-stage model. In the first stage, personal qualities comprising of integrity/trust, openness/transparency, genuine care and accountability need to be increased among supervisors to increase the SBFW. For better overall results, the second stage requires supervisors to be flexible, respectful, fair, maintain consistent high standards and empowering workers to encourage them to engage in safe behaviours. In the third and final stage of the model, supervisors are required to develop the ability to understand and challenge their own beliefs.

As it has been established that supervisors play an integral role in achieving better safety performance and must therefore be conscious in their interactions with FLW, employers ought to appreciate that supervisors' personal qualities act as external stimuli, which influences the safety behaviours of FLW. Employers must therefore make concerted efforts to enhance the requisite qualities of their supervisors.

This study also shows that the job role does not affect the efficacy of the results, therefore this solution can be utilised at various organisational hierarchical levels. To complement this study, a longitudinal study where the outcomes of this study are implemented is likely to prove useful. It would also establish its effectiveness as a tool for industrial experts. Future studies should extend the scope beyond site managers to senior management, to establish the extent of their influence on the safety behaviours of FLW. Also, additional studies are required to

establish the internal factors that influence the safety behaviours of FLW and how these factors (external and internal) can be empirically measured.

References

- Begur SH and Babu JA (2016) Human Factors in Aircraft Maintenance. International Advanced Research Journal in Science, Engineering and Technology 3(3): 14–17.
- Bolt H, Haslam R, Gibb A and Waterson P (2012) Pre-conditioning for success: Characteristics and factors ensuring a safe build for the Olympic Park (Research Report RR955 for Health and Safety Executive). Sudbury: HSE Books.
- Borys D, Else D and Leggett S (2009) The fifth age of safety: The adaptive age. Journal of Health and Safety Research and Practice 1(1): 19–27.
- Bryman A (2012) Social research methods. Oxford University Press, Oxford, UK.
- Construction, Design and Management (2015) Health and Safety: The Construction (Design and Management) Regulations 2015.
- Department for Business Innovation and skills (2013) UK Construction: An economic analysis of the sector.
- DeVellis RF (2012) Scale development: Theory and applications. SAGE, Thousand Oaks, California.
- Dunn OJ (1964) Multiple Comparisons Using Rank Sums. American Society for Quality, Technometrics 6(3): 241–252.
- Fang D, Wu C and Wu H (2015) Impact of the Supervisor on Worker Safety Behaviour in Construction projects. Journal of Management in Engineering 31(6): 4015001
- Field AP (2013) Discovering statistics using IBM SPSS. SAGE, London.

Finneran A and Gibb A (2013) W099 - Safety and health in construction: Research roadmap Report for consultation.

Fleming M (2012) Assessing employee safety motivation. Research Report RS2010-DG08 (The Workers' Compensation Board).

Geller ES (2005) Behavior-based safety and occupational risk management. Behavior modification 29(3): 539–561.

Gibb A, Finneran A and Cheyne A et al. (2015) Occupational Safety and Health in Networked Organisations. Management of OSH in networked systems of production or service delivery: studies in healthcare, construction and logistics.

Gibb AGF, Lingard H, Behm M and Cooke T (2014) Construction accident causality: learning from different countries and differing consequences. Construction Management and Economics 32(5): 446–459.

Gutierrez R (2012) Why don't people just follow the rules? In *International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production*. Society of Petroleum Engineers, Perth, Australia.

Hall, ET (1983) *The Dance of Life: The Other Dimension of Time*, Anchor Books. Anchor Press/Doubleday.

Health and Safety Executive (2017) Fatal injuries arising from accidents at work in Great Britain 2017.

Health and Safety Executive (2009) Reducing error and influencing behaviour. Sudbury: HSE Books.

Hollnagel E, Woods DD and Leveson N (2006) Resilience engineering: Concepts and precepts.

Ashgate, Aldershot.

Hopkins A (2006) Studying organisational cultures and their effects on safety. *Safety Science* 44: 875–889.

Hudson P (2007) Implementing a safety culture in a major multi-national. *Safety Science* 45(6): 697–722.

Kline RB (1998) Principles and practice of structural equation modeling. Guilford Press, New York.

Manu P, Mahamadu A, Hadikusumo B, Leungbootnak N, Gibb A, and Bell N (2017) Can Personal Values Help to Manage Workers' Occupational Safety and Health Behaviour? *Procedia Engineering* 196 (2017): 911 – 918.

Naoum SG (2013) Dissertation research and writing for construction students. Routledge, London.

Neisser U (1967) Cognitive psychology. Meredith.

Pybus R (1996) Safety Management: Strategy and Practice. Butterworth-Heinemann, Oxford.

Reason J (1990) Human error. Cambridge University Press, Cambridge.

Shapiro SS and Wilk MB (1965) An Analysis of Variance Test for Normality (Complete Samples). *Biometrika* 52(3/4): 591–611.

Simons T (2002) Behavioral Integrity: The Perceived Alignment Between Managers' Words and Deeds as a Research Focus. *Organisation Science* 13: 18–35.

- Simons T, Leroy H, Collewaert V and Masschelein S (2015) How Leader Alignment of Words and Deeds Affects Followers: A Meta-analysis of Behavioral Integrity Research. *Journal of Business Ethics* 132: 831–844.
- Skinner BF (1974) *About behaviourism*. Cape, London.
- Sulzer-Azaroff B and Austin J (2000) Does BBS work? Behavior-based safety and injury reduction: A survey of the evidence. *Professional Safety* 45(7): 19–24.
- Talabi B, Gibb A and Edum-fotwe F (2017) Behavioural Safety in the Engineering Construction Industry: The Perspective of Senior Management. In *Joint CIB W099 and TG59 International Safety, Health, and People in Construction Conference* (Emuze F and Behm M (eds)). Department of Built Environment Central University of Technology, South Africa, pp. 164–176.
- Talabi B, Gibb A and Edum-fotwe F (2015) Behaviour-based Safety (BBS): A Construction Industry's Perspective. In *Proceedings CIB W099 Belfast 2015: Benefitting Workers and Society through Inherently Safe(r) Construction* (Behm M and McAleenan C (eds)). EEI Publishing, Belfast, Northern Ireland, pp. 180–189.
- Watson JB and Rayner R (2000) Conditioned emotional reactions. *American Psychologist* 55(3): 313–317.
- Way SA, Simons T, Leroy H and Tuleja EA (2016) What is in it for Me? Middle Manager Behavioral Integrity and Performance. *Journal of Business Ethics*: 1–13.
- Yin RK (2009) *Case study research: design and methods*. SAGE Publications, Los Angeles, California.

Zin SM and Ismail F (2012) Employers' Behavioural Safety Compliance Factors toward Occupational, Safety and Health Improvement in the Construction Industry. *Procedia - Social and Behavioral Sciences* 36: 742–751.

Table 1. Number of respondents per site

Site	A	B	C	D	E	Total
Number	66	68	33	21	51	239

Table 2. Number of respondents per job category

Position	Number of respondents
Site Manager	38
Supervisor	38
FLW	153
Other	4
Total	233

Table 3. Codes for agreement scale

Agreement scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Code	1	2	3	4	5

Table 4. Cronbach's alpha for supervisors' PQ scale

Cronbach's Alpha	N of Items
.850	10

Table 5. Excerpt of Shapiro Wilk's test of normality for PQ of supervisors

	Current job position	Shapiro-Wilk		
		Statistic	df	Sig
Supervisor's integrity/trust	Site Manager	.777	37	.000
	Supervisor	.802	34	.000
	Trade worker	.752	137	.000
Supervisor's openness/transparency	Site Manager	.754	37	.000
	Supervisor	.810	34	.000
	Trade worker	.767	137	.000
Supervisor's accountability	Site Manager	.655	37	.000
	Supervisor	.853	34	.000
	Trade worker	.752	137	.000
Supervisor's flexibility	Site Manager	.734	37	.000
	Supervisor	.790	34	.000
	Trade worker	.784	137	.000

Table 6. OSWSR test of the supervisors' PQ for FLW

One Sample Wilcoxon Signed Rank Test		
Null Hypothesis	Sig.	Decision
The median of PQ1 equals 3	.000	Reject the null hypothesis.
The median of PQ2 equals 3	.000	Reject the null hypothesis.
The median of PQ3 equals 3	.000	Reject the null hypothesis.
The median of PQ4 equals 3	.000	Reject the null hypothesis.
The median of PQ5 equals 3	.000	Reject the null hypothesis.
The median of PQ6 equals 3	.177	Retain the null hypothesis.
The median of PQ7 equals 3	.000	Reject the null hypothesis.
The median of PQ8 equals 3	.000	Reject the null hypothesis.
The median of PQ9 equals 3	.000	Reject the null hypothesis.
The median of PQ10 equals 3	.000	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.		

Table 7. PQ of supervisors that can increase the SBFW

PQ (high levels)	Agree/ Strongly agree	Disagree/ Strongly disagree	Observed median	P value	Category of importance	Rank
PQ1	89.4	1.4	4	< 0.001	Extremely	1
PQ2	85.7	0.7	4	< 0.001	Extremely	2
PQ8	81.2	7	4	< 0.001	Extremely	3
PQ3	80.8	4.9	4	< 0.001	Extremely	4
PQ4	79.3	6.8	4	< 0.001	Very	5
PQ9	79.2	7	4	< 0.001	Very	6
PQ5	77.4	10.2	4	< 0.001	Very	7
PQ7	72.2	7.9	4	< 0.001	Very	8
PQ10	63.4	14.1	4	< 0.001	Very	9
PQ6	28	34.3	3	0.177	Slightly	10

Table 8. How ‘integrity/trust’ of supervisors differs among the ‘job position’ groups

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of High level of your supervisor’s integrity increases the amount of your safe behaviours is the same across categories of Current job position.	Independent-Samples Kruskal-Wallis Test	.658	Retain the null hypothesis.

There was no statistically significant difference among job positions based on high levels of supervisors’ integrity/trust increasing the safe behaviours of the respondents ($n = 220$), $H(3) = 1.605$, $p = 0.658$

Table 9. How ‘openness/transparency’ of supervisors differs among the ‘job position’ groups

	Null Hypothesis	Test	Sig.	Decision
2	The distribution of High level of your supervisor’s openness/transparency increases the amount of your safe behaviours is the same across categories of Current job position.	Independent-Samples Kruskal-Wallis Test	.338	Retain the null hypothesis.

There was no statistically significant difference among job positions based on high levels of supervisors’ openness/transparency increasing the safe behaviours of the respondents ($n = 217$), $H(3) = 3.369$, $p = 0.338$

Table 10. How ‘accountability’ of supervisors differs among the ‘job position’ groups

	Null Hypothesis	Test	Sig.	Decision
3	The distribution of High level of your supervisor’s accountability increases the amount of your safe behaviours is the same across categories of Current job position.	Independent-Samples Kruskal-Wallis Test	.079	Retain the null hypothesis.

There was no statistically significant difference among job positions based on high levels of supervisors’ accountability increasing the safe behaviours of the respondents ($n = 218$), $H(3) = 6.787$, $p = 0.079$

Table 11. How ‘flexibility’ of supervisors differs among the ‘job position’ groups

	Null Hypothesis	Test	Sig.	Decision
4	The distribution of High level of your supervisor’s flexibility increases the amount of your safe behaviours is the same across categories of Current job position.	Independent-Samples Kruskal-Wallis Test	.108	Retain the null hypothesis.

There was no statistically significant difference among job positions based on high levels of supervisors’ flexibility increasing the safe behaviours of the respondents ($n = 220$), $H(3) = 6.084$, $p = 0.108$

Table 12. How ‘fairness’ of supervisors differs among the ‘job position’ groups

	Null Hypothesis	Test	Sig.	Decision
5	The distribution of High level of your supervisor’s fairness to you increases the amount of your safe behaviours is the same across categories of Current job position.	Independent-Samples Kruskal-Wallis Test	.166	Retain the null hypothesis.

There was no statistically significant difference among job positions based on high levels of supervisors’ fairness increasing the safe behaviours of the respondents ($n = 214$), $H(3) = 5.079$, $p = 0.166$

Table 13. How ‘beliefs’ of supervisors differs among the ‘job position’ groups

	Null Hypothesis	Test	Sig.	Decision
6	The distribution of High level of your supervisor’s beliefs increases the amount of your safe behaviours is the same across categories of Current job position.	Independent-Samples Kruskal-Wallis Test	.158	Retain the null hypothesis.

There was no statistically significant difference among job positions based on supervisors’ beliefs increasing the safe behaviours of the respondents ($n = 219$), $H(3) = 5.200$, $p = 0.158$

Table 14. How ‘consistent personal standards’ of supervisors differs among the ‘job position’ groups

	Null Hypothesis	Test	Sig.	Decision
7	The distribution of Consistent high level of your supervisor’s personal standards increases the amount of your safe behaviours is the same across categories of Current job position.	Independent-Samples Kruskal-Wallis Test	.023	Reject the null hypothesis.

There was a statistically significant difference among job positions based on supervisors’ consistent high personal standards increasing the safe behaviours of the respondents ($n = 217$), $H(3) = 9.547$, $p = 0.023$

Table 15. Pairwise comparison for ‘consistent personal standards’ between each group

Sample1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig
Trade worker-Supervisor	19.957	10.663	1.872	.061	.368
Trade worker-Site Manager	23.641	10.321	2.291	.022	.132
Trade worker-Other	-50.286	28.612	-1.757	.079	.473
Supervisor-Site Manager	3.684	13.219	.279	.780	1.000
Supervisor-Other Manager	-30.329	29.780	-1.018	.308	1.000
Site Manager-Other	-26.645	29.660	-.898	.369	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

Table 16. How ‘genuine care’ of supervisors differs among the ‘job position’ groups

	Null Hypothesis	Test	Sig.	Decision
8	The distribution of Your supervisor’s genuine care for you increases the amount of your safe behaviours is the same across categories of Current job position.	Independent-Samples Kruskal-Wallis Test	.498	Retain the null hypothesis.

There was no statistically significant difference among job positions based on supervisors’ genuine care increasing the safe behaviours of the respondents ($n = 221$), $H(3) = 2.378$, $p = 0.498$

Table 17. How ‘respect’ of supervisors differs among the ‘job position’ groups

	Null Hypothesis	Test	Sig.	Decision
9	The distribution of High level of your supervisor’s respect for you increases the amount of your safe behaviours is the same across categories of Current job position.	Independent-Samples Kruskal-Wallis Test	.230	Retain the null hypothesis.

There was no statistically significant difference among job positions based on high levels of supervisors’ respect increasing the safe behaviours of the respondents ($n = 220$), $H(3) = 4.307$, $p = 0.230$

Table 18. How ‘ability to empower’ of supervisors differs among the ‘job position’ groups

	Null Hypothesis	Test	Sig.	Decision
10	The distribution of High level of your supervisor’s ability to empower you increases the amount of your safe behaviours is the same across categories of Current job position.	Independent-Samples Kruskal-Wallis Test	.494	Retain the null hypothesis.

There was no statistically significant difference among job positions based on high levels of supervisors’ ability to empower increasing the safe behaviours of the respondents ($n = 219$), $H(3) = 2.399$, $p = 0.494$

Table 19. Ranking of importance of supervisors' PQ

PQ	Category of importance	Rank
Integrity/ trust	Extremely	1
Openness/ transparency	Extremely	2
Genuine care	Extremely	3
Accountability	Extremely	4
Flexibility	Very	5
Respect	Very	6
Fairness	Very	7
Consistent high personal standards	Very	8
Ability to empower	Very	9
Beliefs	Slightly	10

Figure 1. Rate of fatal injuries in the UK, Source: Health and Safety Executive (2017)

Figure 2. Evolution of safety, adapted from Pybus (1996)

Figure 3. External and internal influencers of behaviours

Figure 4. Importance of supervisors' PQ

Figure 5. The effect of supervisors' integrity on the SBFW

Figure 6. The effect of supervisors' beliefs on the SBFW

Figure 7. Boxplot for how ‘consistent personal standards’ of supervisors differs among the ‘job position’ groups

Figure 8. Sequential phases for supervisors PQ to enhance safety performance