THE ROLE OF SAFETY CULTURE IN THE PREVENTION OF OCCUPATIONAL ACCIDENTS IN CONSTRUCTION: A CONCEPTUAL AND APPLICATIVE APPROACH

M.G. BOBOCEA - National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania, giu.bobocea@yahoo.com
O.R. CHIVU - National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania
C. DEDIU - National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania
A. TRIFU - National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania
M.N. MARINESCU - National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania
L. BUȚU - National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania

Abstract: *The construction sector is characterized by a high level of occupational risk, where accidents frequently result from the interaction of technical, organizational, and human factors. In this context, safety culture plays a crucial role in shaping workers' behavior and improving overall safety performance. This paper aims to analyze the role of safety culture in preventing occupational accidents in construction through a conceptual and applied approach. A Safety Culture Index (SCI) is proposed as a quantitative model for assessing the level of safety culture within construction organizations. The model is based on the weighted aggregation of key factors, including safety leadership, training, communication, worker participation, risk perception, procedural compliance, and working conditions. Each factor is evaluated using a Likert scale, allowing for a structured and practical assessment framework. Furthermore, the study introduces a functional relationship between the Safety Culture Index and the probability of occupational accidents, modeled as an exponential function, highlighting a nonlinear inverse correlation. The results demonstrate that improvements in safety culture lead to significant reductions in accident probability, particularly at low and medium levels of safety maturity. The proposed model provides a practical tool for evaluating and monitoring safety culture in construction environments, supporting decision-making processes and enabling proactive risk management strategies.*

Keywords safety culture; construction industry; occupational accidents; risk assessment; Safety Culture Index (SCI); safety management; preventive strategies; occupational safety and health (OSH).

1. INTRODUCTION

The construction sector is internationally recognised as one of the most exposed areas in terms of occupational risks, characterised by a high frequency of occupational accidents and significant operational complexity [1]. The activities carried out on construction sites involve dynamic interactions between technical, organizational and human factors, which leads to the emergence of risk situations that are difficult to control in the absence of effective prevention mechanisms [2]. In this context, organisations such as the International Labour Organization

and the Health and Safety Executive stress the importance of integrated occupational safety and health management approaches, in which the cultural dimension plays a key role [3].

The concept of safety culture has evolved significantly in recent decades, being considered a determining factor in influencing workers' behaviors and reducing the likelihood of accidents. Security culture reflects the set of values, perceptions, attitudes and practices common within an organisation, which determine how risks are perceived and managed [4]. Unlike traditional approaches, focused exclusively on compliance with procedures and the implementation of technical measures, the modern perspective highlights the need to integrate human and organizational factors in occupational risk assessment [5].

In the construction industry, where the variability of working conditions is high and economic and time pressures are significant, the safety culture becomes a critical element in ensuring a safe working environment. The lack of a solid organisational culture can lead to the normalisation of deviations from procedures, the underestimation of risks and the adoption of unsafe behaviours, thus increasing the likelihood of accidents occurring [6]. In return, a developed security culture helps to strengthen individual and collective responsibility, improve communication and increase compliance with security requirements [7].

However, one of the main challenges in the analysis of security culture lies in the difficulty of quantifying it. Most existing studies approach security culture from a qualitative perspective, which limits the possibility of integrating it into analytical models and decision support tools. In this sense, the development of quantitative models, capable of transforming the concept of security culture into a measurable indicator, is an important research direction [8].

Starting from these considerations, the present paper proposes a model for evaluating the safety culture based on a synthetic index – Safety Culture Index (SCI) – which allows the quantification of the level of safety culture by aggregating relevant factors specific to the construction sector. The model integrates essential dimensions such as safety leadership, training, communication, worker participation, risk perception and compliance with procedures, thus providing a structured approach that is applicable in practice.

In addition, in order to highlight the practical relevance of the proposed model, the paper introduces a functional correlation between the level of safety culture and the probability of accidents at work, demonstrating that improving organizational culture can lead to a significant reduction in occupational risks. This approach contributes to transforming the safety culture from a theoretical concept into an operational tool, useful in occupational safety and health management.

Therefore, the main objective of the article is to develop and exemplify a conceptual and applicative model for assessing the safety culture in construction, as well as highlighting its role in the prevention of occupational accidents. The results obtained can be a support for specialists in the field of occupational safety and health, in order to improve prevention strategies and optimize organizational performance in the field of safety.

2. METHODOLOGY

This paper uses a mixed methodological approach, conceptual-applicative, with the objective of developing a model for assessing the safety culture in the construction sector and highlighting the relationship between it and the probability of accidents at work. The theoretical foundation of the model is based on the analysis of the literature and the guidelines developed by international bodies such as the International Labour Organization and the Health and Safety

Executive, while the applicative component consists of building and testing a synthetic evaluation index.

2.1 Security Culture Assessment Model (SCI)

Defining the concept.

In order to quantify the safety culture, a composite index has been defined, called Safety Culture Index (SCI), based on the weighted aggregation of relevant factors specific to construction activities. The mathematical model used is:

$$SCI = \sum_{i=1}^{n} w_i * x_i \quad (1)$$

where:

- wi = weight of factor i
- xi = factor i score
- n = total number of factors analyzed

Selection of factors (model variables)

The selection of factors was made based on their relevance in influencing safety behaviors and organizational performance, including the following indicators: safety leadership, occupational safety and health training, communication, worker participation, risk perception, compliance with procedures and working conditions. Based on the literature (e.g. International Labour Organization, Health and Safety Executive), the model includes:

Table 1. the main variables used in a model for analyzing organizational safety behaviors and performance in the field of occupational safety and health

Code	Factor	Description
x_1	Security Leadership	Management involvement
x_2	OSH Training	Quality and frequency of training
x_3	Communication	Submission of security information
x_4	Worker participation	Involvement in decisions
x_5	Risk perception	Level of Awareness
x_6	Compliance with procedures	Degree of compliance
x_7	Working conditions	Physical and technological environment

Data collection and evaluation

The evaluation of each factor was carried out using a five-level Likert scale, where the values are between 1 (very poor) and 5 (very good).

1 = very weak
2 = weak
3 = medium
4 = good
5 = very good

The scores were obtained by:

- the application of structured questionnaires to workers on construction sites,
- conducting internal audits in the field of occupational safety and health,
- direct observations on working behaviors and conditions.

To ensure the consistency of the assessment, standardised tools were used and OSH specialists were involved in the data collection and validation process.

Determining the weights of the

The weights associated with each factor were determined using the expert method, by consulting occupational safety and health specialists. This approach allows the relative importance of each factor in influencing the security culture to be reflected. The distribution of the weights was made so that their sum is equal to 1, ensuring the comparability of the results.

Table 2. The weights assigned to each factor included in the organizational security culture evaluation model

Factor	**Weighting**
Leadership	0.20
Training	0.15
Communication	0.15
Participation	0.10
Risk perception	0.15
Procedures	0.15
Conditions	0.10

2.2 Model normalization

In order to facilitate the interpretation of the results, the SCI index has been normalized by referring it to the maximum possible value:

$$SCInorm=\frac{SCI}{SCImax} \quad (2)$$

where:

$$SCImax=\sum wi \cdot 5$$

2.3. Classification of the level of security culture

The values obtained are classified into three levels of performance:

Table 3. Clasificarea nivelului culturii de securitate pe baza valorilor obținute prin calculul indicelui SCI, Security Culture Index

SCI Range	**Level**
0 – 2	Low
2 – 3.5	Environment
3.5 – 5	High

This classification allows for the rapid identification of areas that need improvement and supports decision-making in security management.

In order to highlight the relationship between safety culture and occupational risk, an exponential function was used in the form of:

$$P(A) = \alpha * e^{-\beta * SC1} \quad (3)$$

where:

P(A) = probability of accidents

α.β = empirical coefficients

Increase in SCI → exponential decrease in accidents

3. RESULTS AND DISCUSSIONS

The application of the proposed model for the assessment of security culture was carried out using a set of hypothetical data, corresponding to the seven factors defined in the methodology. Based on the assigned scores and the weights established by the expert method, a security culture index was obtained:

$$SCI = 3.8 \quad (4)$$

According to the proposed classification, this value indicates a high level of safety culture, suggesting the existence of strengthened organizational practices in the field of occupational safety and health. The detailed analysis of the contribution of each factor highlights that high scores for leadership, adherence to procedures and risk perception had a significant impact on the final value of the index.

On the other hand, the moderate scores recorded for training, worker participation and working conditions indicate the existence of areas with potential for improvement, which confirms the usefulness of the SCI model as an organizational diagnostic tool.

Table 4. Rezultatele aplicării practice a modelului SCI, Security Culture Index

Factor	Score xi	Weight Yes
x_1	4	0.20
x_2	3	0.15
x_3	4	0.15
x_4	3	0.10
x_5	4	0.15
x_6	5	0.15
x_7	3	0.10

$$SCI = (0.20 \cdot 4) + (0.15 \cdot 3) + (0.15 \cdot 4) + (0.10 \cdot 3) + (0.15 \cdot 4) + (0.15 \cdot 5) + (0.10 \cdot 3)$$

$$SCI = 0.8 + 0.45 + 0.6 + 0.3 + 0.6 + 0.75 + 0.3 = 3.8$$

$$\boldsymbol{SCI = 3.8 \rightarrow high\ level\ of\ security\ culture} \quad (5)$$

Analysis of the relationship between SCI and accident probability

In order to assess the influence of the safety culture on occupational risk, the exponential functional relationship was used:

$$P(A) = e^{-0.7 * SC1} \quad (6)$$

Based on this relationship, a set of values corresponding to the SCI range ∈ [1, 5] was constructed, which allowed the graphical representation of the dependence between the level of safety culture and the probability of accidents at work.

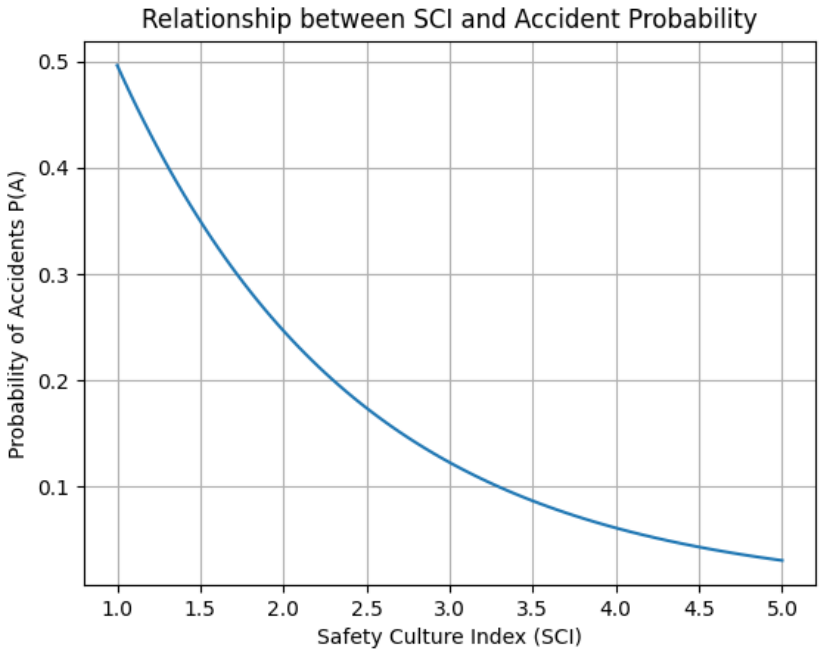

Figure 1. The relationship between the Safety Culture Index (SCI) and the probability of accidents at work

The graph obtained highlights a **nonlinear inverse relationship**, characterized by a rapid decrease in the probability of accidents at low values of the SCI index and a tendency to stabilize at high values. Thus, for SCI values below 2, the probability of accidents is relatively high, indicating a low level of risk control. In the range 2–3.5, the probability reduction is significant, suggesting the effectiveness of measures to improve the security culture. For values above 3.5, the decline becomes slower, which indicates that a level of organizational maturity has been reached.

4. INTERPRETATION OF THE RESULTS

The results obtained confirm the hypothesis that safety culture is a determining factor in the prevention of occupational accidents in construction. The exponential relationship identified suggests that investments in the development of security culture have a significant impact especially in organizations at low or medium levels of maturity.

This observation is particularly relevant in the context of construction sites, where the implementation of relatively simple measures, such as improving communication or increasing management involvement, can lead to significant risk reductions. In contrast, for organizations with an already high level of security culture, further improvements require more complex interventions aimed at continuous process optimization and integration of advanced technologies.

The results obtained are in line with studies in the literature, which highlight the role of safety culture in influencing workers' behaviors and reducing accidents. The theoretical models developed in the field, including those associated with James Reason's research, emphasize that accidents are not the result of isolated causes, but of the interaction between several levels of the organizational system, in which the safety culture acts as a protection mechanism.

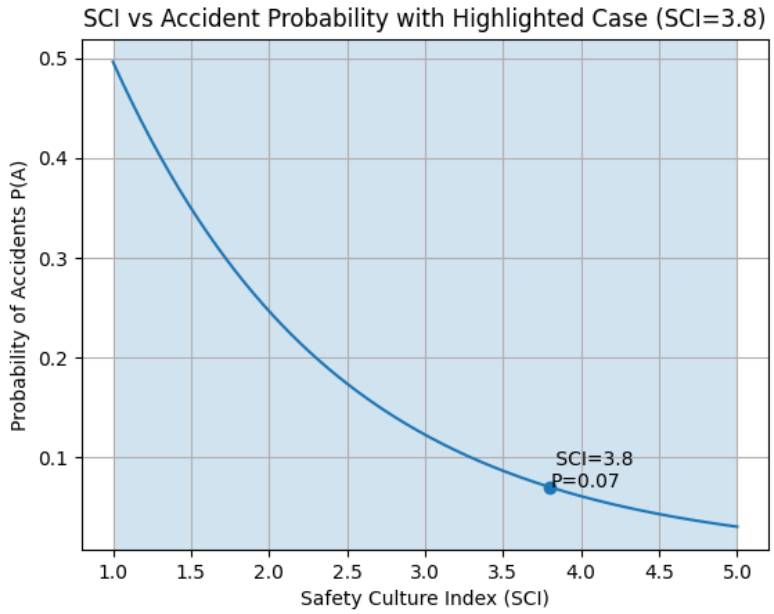

Figure 2. The relationship between the Safety Culture Index (SCI) and the probability of accidents, with the highlight of the analyzed case (SCI = 3.8)

In this context, the proposed SCI model contributes to the operationalization of this concept, providing a quantifiable tool that can be integrated into risk analysis and decision-making.

Practical implications

From an application perspective, the results highlight that the periodic assessment of the security culture can support:

- identification of weaknesses at the organizational level,
- prioritising intervention measures,
- monitoring the evolution of OSH performance.

Also, the use of a synthetic indicator such as SCI allows the comparison of different construction sites or work teams and facilitates the implementation of proactive accident prevention strategies.

5. CONCLUSIONS

The present paper highlighted the essential role of the safety culture in the prevention of occupational accidents in the construction sector, a field characterized by a high level of risk and a complex operational dynamics.

Through the proposed approach, safety culture is no longer treated exclusively as an abstract concept, but is transformed into a quantifiable indicator, integrated into a conceptual and

applicative model, capable of supporting decision-making in the field of occupational safety and health.

One of the main results of the research is the development of an evaluation model based on the Safety Culture Index (SCI), which allows to quantify the level of safety culture by aggregating relevant factors, such as safety leadership, training, communication, worker participation, risk perception, compliance with procedures and working conditions. The flexible structure of the model and the use of an intuitive rating scale facilitate its application in real-world conditions, providing construction organizations with a practical tool for diagnosing and monitoring safety performance.

The application of the model to a hypothetical dataset has demonstrated its usefulness in highlighting the level of security culture and in identifying the factors that significantly influence the results. The value obtained for the SCI index allowed the analyzed organization to be classified in a high level of maturity, but also highlighted certain areas that need improvement, confirming the operational nature of the proposed model.

Another important aspect of the work is the establishment of a functional relationship between the level of safety culture and the probability of accidents at work.

The modeling of this relationship by an exponential function has highlighted the existence of a nonlinear inverse correlation, according to which the increase of the SCI index leads to a significant reduction in the probability of accidents, especially in the case of organizations with low or medium levels of safety culture. This observation has relevant practical implications, suggesting that investments in the development of organizational culture can generate substantial benefits in terms of occupational risk reduction.

The results obtained are in line with current trends in the literature and with the recommendations made by international bodies such as the International Labour Organization and the Health and Safety Executive, which emphasize the need to integrate human and organizational factors in safety management. In this context, the SCI model contributes to the operationalization of the concept of safety culture and its integration into occupational risk assessment.

From an application point of view, the use of the SCI index can support organizations in identifying vulnerabilities, prioritizing intervention measures and monitoring the evolution of performance in the field of occupational safety and health. The model can also be used to compare different construction sites or work teams, facilitating the implementation of proactive and prevention-oriented strategies.

However, the paper has certain limitations, mainly determined by the use of hypothetical data and the simplified nature of the functional relationship used to model the probability of accidents.

In this regard, the future research directions aim at the empirical validation of the model based on real data sets, as well as its extension by integrating advanced predictive methods, which allow more accurate prediction of occupational risks.

In conclusion, the research demonstrates that the development and strengthening of safety culture is a key element in the prevention of occupational accidents in construction, and the use of quantitative tools such as the SCI index can significantly contribute to improving organizational performance and creating a safer and more sustainable working environment.

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