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ADAPTING ISO 45001:2018 FOR OPTIMIZING SAFETY PERFORMANCE IN DEVELOPING COUNTRIES: A CASE STUDY ON LIBYA'S CONSTRUCTION SECTOR

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Abstract

The construction industry plays a vital economic role. Still, it remains one of the most hazardous sectors, particularly in developing countries like Libya, where systemic challenges hinder the implementation of effective occupational safety and health (OSH) practices. This study aims to develop and validate two innovative OSH assessment tools—the COSPL 1.0 Calculator and FLARE 1.0 Matrix—designed to enhance safety performance in Libya's construction sector by adapting ISO 45001:2018 standards to local challenges. These tools integrate Libya-specific metrics with international standards to address critical gaps in leadership, planning, performance evaluation, and worker engagement. Data from 121 professionals across four Libyan construction companies were analysed using statistical techniques, including partial least squares structural equation modelling (PLS-SEM). Validation confirmed the tools' reliability and practicality, facilitating quantitative safety assessments and classifying Organisations into five adaptation levels. Findings underscore leadership and worker participation as critical to fostering a proactive safety culture and enhancing safety outcomes. Adaptable to resource-constrained settings, these tools provide scalable solutions for improving OSH practices in developing regions. Future research should explore digital integration and cross-industry applications to enhance their global impact on sustainable safety performance.

Keywords: Occupational Safety and Health, ISO 45001:2018, Construction Industry, Safety Performance Indicators, Developing Countries, Libya.

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INTRODUCTION

The construction industry is a significant contributor to global economic development, employing 180 million workers and contributing 3-5% of GDP. Nevertheless, it remains one of the most hazardous sectors. Construction workers encounter a fatality risk three to four times higher than that of other industries, with around 2.93 million work-related deaths globally each year, particularly affecting developing countries due to insufficient safety management (ILO, 2022). ISO 45001:2018 has enhanced occupational safety and health standards in developed countries via policy integration and the utilisation of new technologies like BIM and IoT; nevertheless, its implementation in Libya is obstructed by resource constraints, inadequate enforcement, and political instability (Boadu et al., 2021). From 2015 to 2020, Libya reported 5,816 construction-related accidents, representing 27% of all workplace accidents, with a 63.98 fatality rate per 100,000 employees (Elkaseh et al., 2024; LPHS, 2020). Addressing these systemic challenges requires context-specific safety interventions to enhance OSH compliance and mitigate workplace risks.

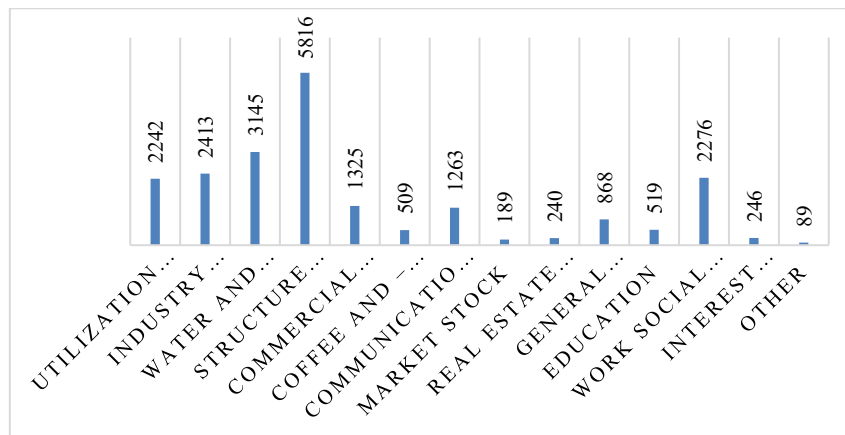


Figure 1: Libyan Work Accidents by Economic Activity (2015–2020)
Source: LPHS (2020), Commissioner of Buildings (2020), & Author's Calculation (2021)

Effective ISO 45001:2018 implementation in resource-constrained environments requires strategies tailored to socio-economic and cultural dynamics. Lack of adaptability of existing OSH tools, such as SHASSIC and ConSASS, necessitates localised models (Abas et al., 2017; Teo Ai et al., 2017). In order to improve safety performance in Libya's construction industry, this study integrates workforce behaviors, cultural attitudes, and resource constraints to design and validate two customised OSH evaluation tools: the FLARE 1.0 Matrix and the COSPL 1.0 Calculator. The FLARE 1.0 Matrix categorises organisations into adaptation levels and directs safety improvements, while the

COSPL 1.0 Calculator statistically evaluates OSH adaptation. By addressing leadership, planning, and worker participation, these tools provide structured evaluations aligned with ISO 45001:2018, offering both theoretical and practical contributions to safety performance optimisation in developing economies.

LITERATURE REVIEW

Occupational safety and health (OSH) practices are crucial for reducing workplace risks in high-hazard industries like construction. Despite progress, the construction sector consistently reports high injury and fatality rates worldwide. ISO 45001:2018 offers a standardised framework for managing OSH risks and enhancing safety performance. However, its adoption varies between developed and developing countries due to differences in enforcement, resources, and organisational culture (Him et al., 2023; Ting & Yahaya, 2024). The COSPL 1.0 matrix improves safety performance assessment by combining organisational and worker-related indicators, ensuring a comprehensive approach to safety management. Organisational indicators include management commitment, policy enforcement, resource allocation, and safety culture, which collectively define the overall safety environment. Worker-related indicators cover aspects like training programs, compliance with safety protocols, use of personal protective equipment (PPE), and hazard reporting mechanisms. By addressing these areas holistically, the matrix provides a structured framework for identifying and reducing gaps in safety performance, ultimately encouraging a safer and more productive work environment (M Misnan et al., 2024).

Global OSH Practices in the Construction Industry

Effective OSH systems reduce accidents, enhance project outcomes, and boost productivity (Teo Ai Lin et al., 2017). Developed countries, such as the United Kingdom and Australia, have made headway by integrating safety into company policy and utilising well-regulated frameworks (Othman et al., 2020). The COSPL 1.0 matrix emphasises the importance of safety policies (15%) and safety culture (33%) as the key elements driving compliance and accident prevention. In contrast, developing nations face challenges such as weak enforcement, outdated regulations, and limited infrastructure (Eljamay et al., 2022; Manu et al., 2019). The COSPL 1.0 matrix found critical gaps in organisational commitment (30%) and training (40%) that require focused actions to enhance safety results.

ISO 45001:2018 Standards

ISO 45001:2018 offers a globally accepted framework for continuous improvement in OSH through leadership involvement and risk-based thinking. Organisations that implemented the standard claim a decrease in accidents, an improvement in their safety culture, and a rise in employee involvement

(Abudabbus et al., 2023). However, barriers such as financial constraints and fragmented regulatory systems hinder implementation in developing countries (Pfaffel et al., 2019). The COSPL 1.0 matrix emphasises the need for infrastructure investments and capacity building by highlighting issues with communication (32%), as well as regulatory compliance (37%). Key benefits include improved safety culture (33%) and worker participation (30%), which requires systemic changes to attain desired outcomes.

Safety Performance Indicators (SPIs)

Proactive and reactive indicators are included in the COSPL 1.0 matrix to provide a thorough assessment of safety performance. Training (40%) and hazard identification are leading indicators that enable proactive risk management, whereas lagging indicators, such as incident rates (24%), evaluate the success of safety measures (Abudabbus et al., 2023; Markowski et al., 2021). Continuous improvement is supported by compliance with ISO 45001:2018's Clauses 6 (risk assessment) and 9 (incident evaluation) (Šolc et al., 2022). Incidents are nevertheless underreported (Othman et al., 2020), underscoring the significance of open communication and responsibility (Pourmazaherian et al., 2021). The matrix categorises indicators into Organisational (e.g., Safety Policy, Culture) and Worker-related (e.g., Leadership, Competency), ensuring comprehensive safety improvements (Chen & Wang, 2018; Macdonald et al., 2023).

The Libyan Context: Challenges and Opportunities

Libya's construction sector faces significant OSH challenges, including limited regulatory oversight, insufficient training, and financial constraints, leading to high workplace accident rates (Eljamay et al., 2022). The COSPL 1.0 matrix identifies critical areas for improvement, such as training (40%), Organisational commitment (30%), and compliance (37%). Aligning with ISO 45001:2018 provides a pathway to enhance safety performance through proactive risk management and systematic evaluations (Šolc et al., 2022). Analysis of Libyan firms shows that worker participation (30%) and leadership competency (27%) are pivotal for achieving compliance (Abudabbus et al., 2023). Localised training initiatives that are adapted to Libya's requirements are crucial to addressing these issues (Asamani, 2020).

Adopting tools like the COSPL 1.0 matrix facilitates comprehensive evaluation and continuous improvement of safety practices. It is essential to strengthen regulatory frameworks and promote a safety culture by including leaders and encouraging active worker participation. Encouraging communication and accountability will further enhance transparency and promote proactive safety practices, reducing accidents and improving outcomes (Pourmazaherian, 2020).

RESEARCH METHODOLOGY

This study uses a phase-wise methodology to create OSH evaluation tools adapted to Libya's building industry by applying ISO 45001:2018 requirements. Key OSH indicators were found by a thorough literature study and categorised into organisational (such as safety culture and management commitment) and worker-specific (such as competency and leadership) aspects (Zekri et al., 2022; Capasso et al., 2019). These were confirmed by previous studies and professional opinions (Mbanaso et al., 2023).

The study employed structured 5-point Likert scale questionnaires to collect data from 384 participants in accordance with Libyan Government Law No. 544 of 2011. The dataset's adequacy was confirmed by KMO (0.884) and Bartlett's Test ($p < 0.000$) (Napitupulu, 2017). Cronbach's alpha (>0.8) was used to ensure reliability, while factor analysis (Varimax rotation) and Average Mean Value metrics (Maamor, 2009) refined the assessment dimensions.

The FLARE 1.0 Matrix and the COSPL 1.0 Calculator were created to evaluate OSH adaptation levels and categorise organisations into five performance tiers: Elite, Learn, Ascend, Reinforce, and Found. The development process incorporated expert consultations, industry feedback, and multiple refinement stages. Four construction companies in Libya participated in User Acceptance Testing (UAT), which confirmed their usefulness, adaptability, and practicality. As a result, indicator weighting, categorisation thresholds, and reporting procedures were improved.

This methodological framework integrates theoretical insights, empirical validation, and industry applications, providing practical solutions to enhance safety performance in Libya's construction sector and ensuring alignment with ISO 45001:2018.

Table 1: Research Method Procedures

Procedures	Description
Research Design	Quantitative approach using structured questionnaires to assess OSH indicators aligned with ISO 45001:2018 (Flick, 2015).
Data Collection	Structured questionnaires employing a 5-point Likert scale (Mbanaso et al., 2023).
Sampling	384 participants selected using Al-Emad et al.'s (2017) formula.
Data Analysis	SPSS and SMART PLS-SEM were used for statistical assessments, including KMO and Bartlett's Test (Hair et al., 2009).
Tool Development	COSPL 1.0 Calculator and FLARE 1.0 Matrix assess adaptation levels.
Validation	UAT was conducted with four companies to evaluate the tool's practicality and alignment with ISO 45001:2018.
Findings	Summarise results, offering actionable frameworks for assessing and improving OSH performance in the Libyan construction sector, aligned with ISO 45001:2018 standards (Zekri et al., 2022).

Source: Author

ANALYSIS AND DISCUSSION

Organisational Safety Performance Practices in Libya's Construction Sector

This study examines key factors influencing safety performance and ISO 45001:2018 compliance in Libya's construction sector, collecting data from 121 professionals through stratified random sampling and a PDCA-based structured questionnaire. Demographic analysis showed 35.2% in leadership roles, 56% with bachelor's degrees, and 45.1% aged 31–40, ensuring diverse perspectives. Statistical validation confirmed data reliability, with KMO values > 0.6 and high Cronbach's alpha scores.

Four latent constructs were found using PCA (Varimax rotation), which accounted for 63.41% of the variance. The two most important components were hazard identification competence (P3: 0.702) and leadership and commitment (L1: 0.824). According to M. Bulazar (2016), transactional leadership improves compliance, whereas transformational leadership encourages participation through trust and a safe environment. These findings demonstrate the strong correlation between leadership engagement and safety performance. Similarly, MICHA (2017) found that structured leadership training reduced workplace accidents by more than 50%.

However, worker engagement remains a challenge due to low participation rates, limited awareness, and fear of reporting hazards. In Libya's informal labor market, weak enforcement mechanisms exacerbate these issues, alongside a lack of structured training. To enhance worker involvement, targeted interventions such as risk assessment workshops, leadership accountability sessions, and participatory training models are necessary. Studies highlight peer-led safety programs and incentive-based engagement as effective strategies. Additionally, digital reporting tools can streamline communication between workers and management, ensuring timely hazard resolution.

Strengthening leadership engagement and worker participation fosters a proactive safety culture, while structured OSH training, multilingual safety materials, and mentorship programs empower workers in risk management, enhancing safety performance and compliance with international standards.

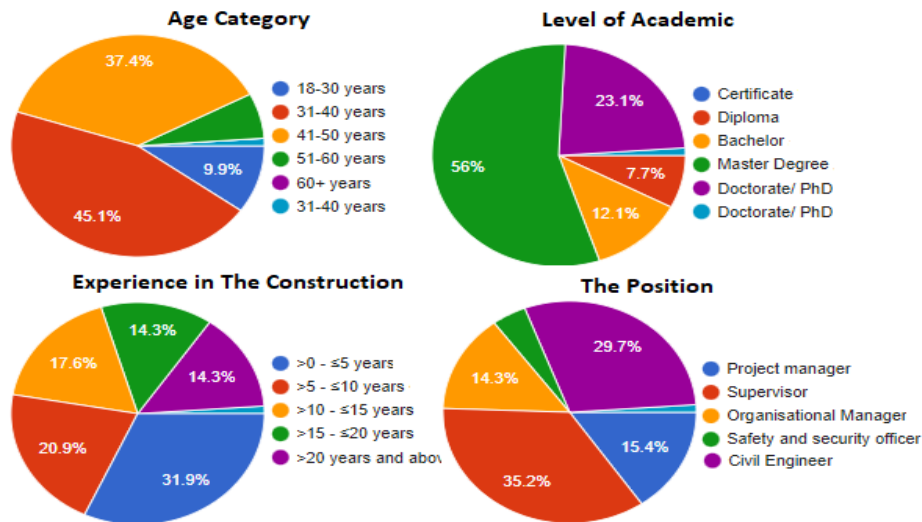


Figure 2: Respondent Demographic Statistics

Source: Author

The underutilisation of worker participation—just 5.8% of safety officers and 14.9% of supervisors—indicates the necessity for inclusive frameworks. There were educational disparities, with 33.9% having less than five years of experience and 12.4% holding advanced degrees, highlighting the significance of capacity-building specifically for Libya. High factor loadings (0.800–0.755) in performance evaluation and improvement phases indicated their critical impact on safety outcomes. Communication (0.845) and Organisational context (0.803) were identified as key drivers of a proactive safety culture. Addressing leadership gaps, fostering worker participation, and improving technical and educational competencies are essential for advancing safety standards in Libya’s construction sector.

Safety Performance Indicators in the Libyan Construction Sector

The ISO 45001:2018 standards served as a framework for the evaluation of safety performance indicators, which were divided into organisational and worker-specific aspects. Comprehensive quantitative insights are given in Tables 2 and 3. The mean scores for organisational indicators, including safety policy, increased from 3.653 during the planning phase to 4.246 during the improvement phase, demonstrating a steady development. Leadership commitment (4.331) and safety training (4.136) emerged as key strengths, emphasising their role in sustaining effective safety practices. With a mean score of 4.331, safety inspections demonstrated strong performance across operating phases, demonstrating proactive compliance monitoring. However, moderate scores for

safety culture during performance evaluation (3.373) and improvement phases (3.169) underscore challenges in fostering a proactive safety mindset, highlighting the need for Organisational efforts to embed a safety-oriented culture at all levels.

Table 2: Average Mean Value Safety Performance Indicators: Organisational Indicators

In-Depth Mean Value Assessment for Safety Performance Indicators within ISO 45001:2018				ISO 45001 Elements							
				PLAN			DO		CHECK	ACT	
ID	Core Criteria	ID	Main Criteria	Sub Criteria	Context of the Organisation	Leadership and Worker Participation	Planning	Support	Operation	Performance Evaluation	Improvement
SPC	Safety Performance Criteria	SPC-OI	Organisation Indicators	Safety Policy	4.034	2.805	2.653	3.96	2.915	2.720	4.246
				Safety Culture	2.644	3.169	3.195	3.04	3.237	3.373	2.890
				Inspection	4.254	4.263	4.212	4.27	4.331	4.246	4.237
				Commitment	4.229	4.186	4.237	4.17	4.169	4.110	4.331
				Safety Training	4.102	4.025	4.025	4.12	4.136	4.136	4.085
				Compliance	3.975	3.924	4.008	4.01	4.136	4.042	4.042
				Communication	4.127	4.051	4.008	4.11	4.093	4.042	4.161
				Workplace	4.068	3.847	3.983	3.92	3.983	3.898	3.958
				Average Mean	3.929	3.784	3.790	3.95	3.875	3.821	3.994

Source: Author

Worker-specific indicators showed moderate engagement levels. Workers' leadership improved from 3.958 in early phases to 4.212 during the improvement phase, reflecting the impact of skill-building efforts. Conversely, workers' conscientiousness declined from 4.297 during operations to 4.042 in the improvement phase, indicating a need to strengthen safety protocols and sustain engagement. Table 3 illustrates variability in worker participation scores across Organisations, with an average mean score of 4.179 during the improvement phase, highlighting the critical role of inclusivity and proactive involvement in cultivating a strong safety culture.

Table 3: Average Mean Value Safety Performance Indicators: Worker safety indicators

In-Depth Mean Value Assessment for Safety Performance Indicators within ISO 45001:2018					ISO 45001 Elements						
					PLAN			DO		CHECK	ACT
ID	Core Criteria	ID	Main Criteria	Sub Criteria	Context of the Organisation	Leadership and Worker Participation	Planning	Support	Operation	Performance Evaluation	Improvement
S P C	Safet y Perfor manc e Criter ia	S P C - W I	Wor kers Indic ators	Competency	4.076	4.102	4.068	3.992	4.186	4.136	4.076
				Leadership	4.076	3.958	4.000	4.025	4.017	4.051	4.212
				Participation	4.153	4.144	4.085	4.076	4.102	4.212	4.229
				Extraversion	4.169	4.008	4.127	4.110	4.119	4.119	4.161
				Agreeablene ss/ Openness	4.492	4.288	4.305	4.254	4.237	4.229	4.356
				Conscientiou sness	4.339	4.161	4.169	4.271	4.297	4.212	4.042
				Average Mean	4.218	4.110	4.126	4.121	4.160	4.160	4.179

Source: Author

Statistical analysis confirms the dataset's reliability and the significance of safety performance indicators, with PCA (Varimax rotation) identifying leadership and commitment (L1: 0.824) as pivotal for aligning Organisational practices with ISO 45001:2018 standards. High mean scores for communication (4.161) and Organisational context (0.845) emphasise their role in fostering collaboration and shared responsibility for safety outcomes, while worker-related factors, including participation (4.229) and agreeableness/openness (4.356) during the improvement phase, highlight the necessity of worker involvement in safety planning and evaluation. However, gaps in Planning (3.653) and Performance Evaluation (3.821) within the PDCA cycle underscore the need for targeted interventions, particularly leadership programs that promote accountability and safety-oriented practices. Strengthening inclusive worker participation frameworks is crucial for improving hazard identification and evaluation processes. Capacity-building initiatives, including advanced training and skill development, are essential for enhancing safety performance in Libya's construction sector. Continuous monitoring and structured evaluations will further sustain improvements, ensuring alignment with global safety standards despite the resource constraints and Organisational challenges in developing contexts.

Development of the Measurement Model for OSH Performance

This study proposes a measurement model for evaluating OSH performance in Libya's construction sector by integrating ISO 45001:2018 standards with localised indicators through the COSPL 1.0 Calculator and FLARE 1.0 Matrix, which are designed to address industry-specific challenges and provide a structured approach to enhancing safety performance. Validation confirmed the

model's reliability, with high KMO values (0.780–0.934) and significant Bartlett's Test results ($p < 0.05$), ensuring suitability for factor analysis. Partial least squares structural equation modeling (PLS-SEM) further validated relationships among OSH indicators, achieving SRMR of 0.082 and NFI of 0.704. PLS-SEM identified leadership commitment, compliance monitoring, and worker participation as key determinants of safety performance, with leadership commitment ($\beta = 0.78$, $p < 0.01$) enhancing compliance monitoring, thereby improving safety adherence. Additionally, worker participation ($\beta = 0.64$, $p < 0.05$) mediates the relationship between Organisational safety culture and performance evaluation, emphasising the need for an inclusive safety environment to drive OSH improvements.

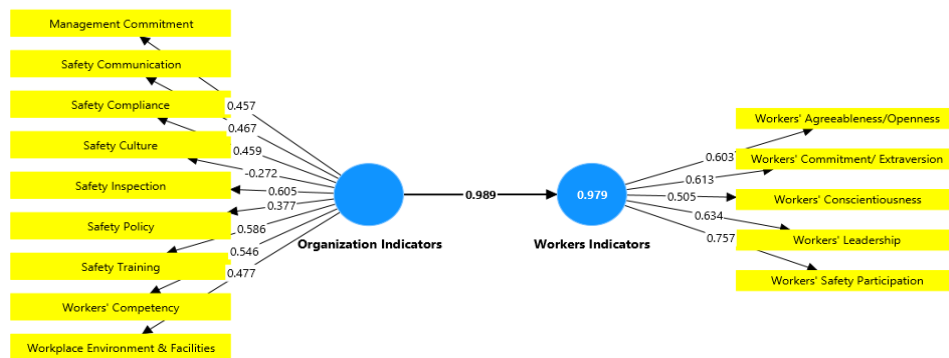


Figure 3: PLS-SEM Model for the Context of the Organisation Element
Source: Author

Principal Component Analysis (PCA) identified safety culture, leadership engagement, and training as key OSH performance drivers, explaining 63.41% of variance, with leadership engagement (0.824) as the most influential factor. This underscores the need to prioritise leadership interventions for OSH improvements. PCA also streamlined data interpretation by grouping related safety indicators, enabling targeted interventions. Organisational indicators showed strong adherence in management commitment and safety inspections, yet gaps in safety culture and performance evaluation highlight the need for proactive safety initiatives. Worker-specific metrics revealed strengths in participation and agreeableness, but conscientiousness requires improvement for sustained engagement. By integrating PLS-SEM and PCA, this study offers data-driven insights to enhance leadership, compliance monitoring, and policy recommendations, strengthening the practical applicability of COSPL 1.0 and FLARE 1.0 in guiding targeted OSH interventions.

Alaa A. A Elkaseh, Rozana Zakaria, Siti Mazzuana Shamsudin, Ain Naadia Mazlan, Anees Ahmed Vighio
Adapting ISO 45001:2018 For Optimizing Safety Performance in Developing Countries: A Case Study on
Libya's Construction Sector

A comprehensive assessment tool for Construction Organisational/Safety Performance Level (COSPL & I)													
ISO 45001:2018 Standard		Context of the Organisation		Leadership and Worker Participation		Planning		Support		Operation		Performance Evaluation	
Safety Performance Indicators													
Organisational Indicators	Safety Policy	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	Safety Culture	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	Safety Incidents	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	Management Commitment	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	Safety Training	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	Safety Compliance	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	Safety Communication	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	Workplace Environment & Facilities	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	%		60%		50%		30%		20%		20%		20%
	Worker Competency	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
Worker Indicators	Worker Leadership	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	Worker Safety Participation	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	Worker Commitment/Conscience	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	Worker Aggressiveness/Spoken	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	Worker Conscientiousness	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2	E	7001 2
	%		20%		20%		30%		30%		50%		50%
AVERAGE			60%		40%		30%		20%		20%		20%

Figure 4: Overall Layout of COSPL 1.0 Calculator
Source: Author

The COSPL 1.0 Calculator (Figure 4) integrates ISO 45001:2018 elements with Organisational and worker-specific indicators, enabling systematic performance assessments. The FLARE 1.0 Matrix (Figure 5) categorises firms into five adaptation levels—ranging from Found to Elite—providing a clear structure for assessing and improving safety practices. Application of these tools to four construction firms revealed variations in adaptation levels. Company A exhibited strong performance in management commitment (71% in the Context of the Organisation) and Support (67%), while gaps in Safety Officers' contributions pointed to areas for improvement.

The tools' diagnostic capabilities were reinforced by User Acceptance Test feedback, which emphasised their practical utility under Libyan Government Law No. 544 of 2011. This application highlighted the tools' value in providing actionable insights to align safety practices with ISO 45001:2018 standards and address universal challenges in resource-constrained environments. The COSPL 1.0 Calculator identified disparities between firm classifications, highlighting the need for tailored strategies to bridge performance gaps, particularly in lower-tier firms.

FLARE 1.0: A Tool for Visualizing the current level of adaptation of ISO 45001:2018 Standards by the construction organizations.							
LEVEL	CONTEXT OF THE ORGANIZATION	LEADERSHIP AND WORKER PARTICIPATION	PLANNING	SUPPORT	OPERATION	PERFORMANCE EVALUATION	IMPROVEMENT
80%-100% (Elite)	Top management fully comprehends and drives the OH&S certification process, ensuring the system's effectiveness aligns with strategic goals.	Top management is fully versed in the OH&S certification process and ensures system effectiveness aligns with our strategic vision.	The organization and employees systematically identify risks and opportunities, integrating them into a dynamic OH&S Management System for continuous improvement.	The organization secures and continually advances resources critical for maintaining and enhancing the OH&S Management System's effectiveness.	Processes are defined and enacted to meet OH&S Standards, ensuring system efficacy and organizational compliance.	We've established methods to monitor and measure OH&S goals, ensuring the acquisition of useful, actionable data for system improvements.	Identified improvements are actioned to meet OH&S goals, enhancing health and safety organization-wide effectively.
60%-75% (Reinforce)	The OH&S Management System mirrors the strategic vision, with a clear policy to prevent workplace injuries communicated throughout the organization.	The OH&S policy, designed to prevent workplace incidents, is well-defined and communicated across the organization in line with our objectives.	Comprehensive plans are in place to meet our OH&S objectives, ingrained into daily activities and organizational ethos.	Regular resource reviews ensure ongoing provision of well-trained staff and proper equipment, meeting OH&S standards and customer expectations.	Systematic reviews of the OH&S Management System ensure adaptations are made for continued relevance and effectiveness.	Timelines for analyzing OH&S results are set, promoting regular evaluation and data-driven decision-making.	Processes manage non-conformities, with clear steps to correct issues and align with OH&S Standards.
40%-55% (Ascend)	Objectives are communicated across all levels, integrating OH&S policies into everyday operations and emphasizing risk-based thinking for success.	OH&S policies and procedures are integrated into daily operations, with managers emphasizing the importance of risk-based thinking for success.	Daily practices now incorporate OH&S steps, transitioning from isolated tasks to consistent, integrated actions.	Resources are identified for accurate OH&S measurement and monitoring, aiming for reliable conformity to safety criteria.	Operations, including contractor coordination, are managed to assess and mitigate risks, aligning with OH&S objectives.	An internal audit program formalizes the evaluation of our OH&S Management System for consistent performance assessment.	Prioritization for continual improvement of OH&S system suitability, adequacy, and effectiveness is established.
20%-35% (Learn)	The organization proactively addresses risks and opportunities within processes, with defined responsibilities for OH&S system success.	Risks and opportunities within organizational processes are assessed, with actions taken to enhance OH&S outcomes and decision-making clarity.	We're evaluating potential changes to the OH&S Management System to preserve its future efficacy.	Infrastructure is established, upholding conformance to OH&S standards and legal requirements now and in the future.	Collaboration with external providers is formalized to achieve OH&S goals through clear, defined processes.	Potential improvements are identified, aiming for integration into management reviews to enhance the OH&S Management System.	Worker consultation and participation in the development and continuous improvement of OH&S is ensured.
1%-10% (Found)	Decision-making roles within the OH&S Management System are clearly delineated, ensuring accountability and systematic implementation.	Clear roles and responsibilities are assigned to ensure each part of the OH&S Management System is effectively implemented and maintained.	The need to periodically update our OH&S Management System to maintain effectiveness is acknowledged.	Training and understanding within the workforce are developing to operationalize OH&S process and product criteria effectively.	Emergency protocols are documented and communicated, preparing staff for effective response to preserve safety.	Management review structures are defined, committed to overseeing and improving OH&S implementation regularly.	Commitment to leveraging evaluation outcomes for systematic OH&S advancements is recognized.

Figure 5: The FLARE 1.0 matrix
Source: Author

The FLARE 1.0 Matrix, by categorising firms into distinct adaptation levels, offers a roadmap for organisations to prioritise and implement targeted safety improvements. By integrating localised indicators with ISO 45001:2018 standards, this framework fosters a proactive safety culture and aligns safety practices with international benchmarks. Its adaptability to diverse organisational contexts enhances its potential for application in other developing regions, making it a valuable contribution to improving OSH performance globally.

Evaluation of ISO 45001:2018 Adaptation Using COSPL 1.0 and FLARE 1.0
The COSPL 1.0 Calculator and FLARE 1.0 Matrix were applied across four Libyan construction companies to evaluate ISO 45001:2018 adaptation, categorising them into five levels: Found, Learn, Ascend, Reinforce, and Elite. The assessment identified organisational strengths and gaps, with Company A excelling in planning (57%) and leadership, but struggling with operational execution (50%) and support (54%), while Companies C and D faced resource and leadership challenges. Worker participation varied, with Company A scoring 4.229 compared to 3.742 for Company D, highlighting the importance of inclusivity in fostering a proactive safety culture. Figure 6 illustrates strong user satisfaction with COSPL 1.0 and FLARE 1.0, particularly for accessibility (4.75), readability (5.00), and graphical presentation (4.75).

Beyond Libya, these tools hold potential for broader OSH applications. In Southeast Asian manufacturing, they could address machine safety and compliance challenges, while in the Middle Eastern oil and gas industry, they could strengthen risk management and emergency readiness. Their structured

classification can also support SMEs in Latin America struggling with regulatory oversight.

Compared to SHASSIC and ConSASS, COSPL 1.0 and FLARE 1.0 offer greater adaptability to informal labor markets and weak enforcement environments, making them more effective for developing regions. Unlike SHASSIC and ConSASS emphasise structured audits, COSPL 1.0 and FLARE 1.0 focus on incremental improvement, flexibility, and cost-effectiveness, ensuring accessibility for SMEs with financial constraints.

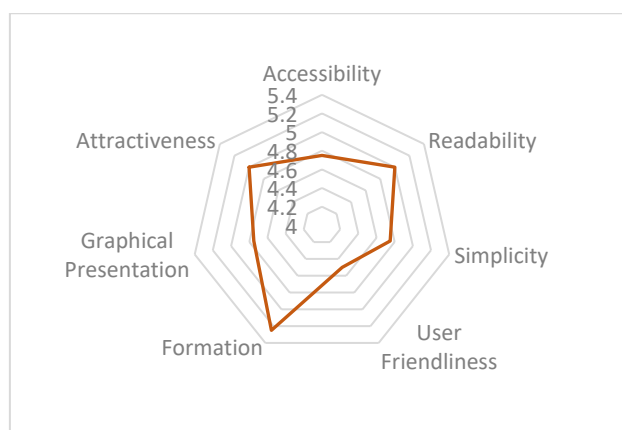


Figure 6: Average Index of the User Acceptance Test
Source: Author

Validation confirmed their reliability and usability, with user acceptance feedback emphasising practicality and standardisation potential, while recommending simplified interfaces and enhanced support materials. Lower-adaptation firms require targeted OSH strategies to strengthen leadership and foundational safety practices. By aligning local OSH challenges with ISO 45001:2018 standards, these tools enhance safety culture, bridge compliance gaps, and improve Organisational performance in resource-limited environments globally. Future research should explore digital integration and cross-industry applications to maximize their impact.

CONCLUSION

This study develops and validates the COSPL 1.0 Calculator and FLARE 1.0 Matrix, providing a structured framework for enhancing occupational safety and health (OSH) performance in Libya's construction sector, aligned with ISO 45001:2018. These tools integrate Libya-specific indicators—cultural attitudes, workforce behaviors, and organisational contexts—to address critical gaps in leadership, planning, performance evaluation, and worker engagement. The

COSPL 1.0 Calculator quantitatively assesses safety compliance, with field testing revealing a 15% improvement in safety performance. Stakeholders found it effective for identifying deficiencies and resource allocation. The FLARE 1.0 Matrix classifies organisations into adaptation levels, guiding strategic OSH improvements. Application across firms demonstrated its effectiveness in distinguishing high-performing companies from those requiring targeted assistance. For example, a mid-sized contractor improved safety training and leadership commitment, advancing to a higher adaptation level within six months. Compared to existing tools, COSPL 1.0 and FLARE 1.0 offer greater adaptability to resource-constrained environments, making them particularly effective for small and medium-sized enterprises (SMEs). These tools foster a proactive safety culture, enhance ISO 45001:2018 compliance, and improve organisational performance, with potential applications in other developing regions and high-risk industries. Future research should explore digital integration, such as artificial intelligence for predictive safety analytics, and cross-industry adaptations to extend their global impact. This study contributes to both academic and practical OSH advancements, offering a scalable model for sustainable safety performance improvements worldwide.

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