

Health and Safety Performance in the Ghanaian Construction Industry: The Government's Responsibility

Benjamin Boahene Akomah^{1*}, R. Prasanna Venkatesan¹, T. Shanmuga Priya¹, Chi, Nai-Wen (Jack)²

¹ School of Civil Engineering, VIT University, Vellore 632014, Tamil Nadu, India.

benjamin.ekomah@cctu.edu.gh/ekomah.benjamin2019@vitstudent.ac.in, prasanna.venkatesan@vit.ac.in, shanmugapriya.t@vit.ac.in

² Department of Civil Engineering, National Taipei University of Technology, Taipei 106344, Taiwan.
nwchi@ntut.edu.tw

Abstract

Poor health and safety (H&S) performance is a defining feature of the Ghanaian construction sector due to the government's inadequate efforts to sanitise the construction space from the menace. The relative importance index and the multivariate technique were used to analyse the data in this study. Data was collected from experts using a structured questionnaire from 635 participants. The analysis from the RII revealed that strict implementation and enforcement of occupational health and safety laws by empowering responsible state agencies is the most significant government responsibility that can enhance H&S. Meanwhile, the multivariate analysis identified government and legislative efforts, along with enforcement agency efforts, as critical roles. The study's findings indicate the need for the government to enact an Occupational Health and Safety Act that would supersede the existing Factories and Shops Act. Furthermore, it highlights the importance of ensuring stringent enforcement of H&S laws by mandated state agencies and the introduction of H&S courses into construction-related educational curricula. This research contributes to the body of literature by establishing that government efforts in health and safety are intrinsically linked with improved legislation and its effective enforcement by relevant institutions. The results suggest that government efforts on H&S should be complemented by strong legal frameworks and robust enforcement mechanisms, not just the mere enactment of laws. To strengthen the government's position on this subject, there is a need for the continuous review and update of H&S legislation and policies. Additionally, the operational capacity of enforcement bodies must be enhanced to keep pace with changing technological trends, best practices, and evolving risks.

Keywords: Construction health and safety performance, Enforcement agency efforts, Government and legislative efforts, Multivariate analysis

Received: June 26, 2025 / Revised: July 16, 2025 / Accepted: August 25, 2025 / Online: August 31, 2025

I. INTRODUCTION

One of the most important sectors of the global economy is the construction industry (GCI) [1], [2]. The world economy depends so much on its growth. It has a crucial impact on society, the economy, and infrastructure development. The industry can be categorised into four primary sectors: industrial construction, heavy engineering construction, residential construction, and building construction. Like the global construction industry, the Ghanaian construction industry plays a critical part in developing Ghana's infrastructure [3], [4]. The construction industry contributes approximately 2.3% to the nation's total employable population's workforce [5]. As one of the driving forces behind Ghana's industrialisation, the sector encompasses specialised contractors [2], [6], [7]. In percentage terms, the industry accounted for 7% of the jobs in 2015 [8]. The 2022 year-end market size of the sector was US\$11.3 billion [9]. In terms of economic contributions, the industry is one of the critical industries [10], [11], [12]. In Sub-Saharan Africa, the sector is

among the thriving construction industries [9], [10]. Such a thriving industry calls for further consideration to increase its contributions.

Globally, countries have made several attempts to improve safety records in the construction sector. However, the observed lack of governmental intervention in Ghana to address the construction industry's Health and Safety (H&S) challenges and the persistent suboptimal performance on the subject suggest a perceived absence of prioritisation. While the government is mandated to advance H&S [13], [14], the efficacy of its long-term strategic implementation in this domain has been demonstrably unconvincing. Ghana's construction industry experiences subpar H&S performance due to two primary factors, as identified by [15], [16]: a disjointed legal system and a lack of urgency among state entities responsible for ensuring safety. Health and safety in the construction industry is a global subject due to the enormous risk associated with the sector's activities [13], [17], [18]. Enhanced H&S performance requires

government intervention to ensure that firms commit to positive practices to improve industrial safety [19], [20]. The primary function of the government entails establishing, modifying, and adapting legislation to address the needs and demands of contemporary society [21]. Government legislative intervention, enforcement, and consistent monitoring push construction firms to incorporate worker education, training, and best practices into their operational culture [22], [23], [24], [25]. Poor health and safety performance is the product of management deficiencies [26], [27] and government failure to act. The H&S issues in the Ghanaian construction industry are discouraging and a significant challenge. It requires a constitutionally mandated regulatory body to ensure enforcement and adherence. [28], [29]. The paper seeks to identify and determine the government's activities that would improve H&S in the sector. While a substantial body of research has proposed various recommendations for government intervention to improve occupational health and safety in the construction industry, there is a notable absence of structured and statistically validated evidence to empirically confirm the effectiveness of these interventions and to definitively guide necessary policy actions. The originality of this study is its use of a prescriptive and analytical approach, which marks a shift from a traditional descriptive one.

II. LITERATURE REVIEW

A. Government

The H&S of construction workers is being ignored in defiance of the Constitution and other laws [14], [30], [31], [32], and the laws appear ineffective in addressing this issue. The government's promise to protect workers' lives by providing a comfortable and secure work environment appears to be disregarded. Despite the insufficiency of current legislation in addressing the intricate nature of building operations and the associated dangers, the government has not taken appropriate action through the Department of Factories Inspectorate (DFI) [27], [33], [34]. The agency has been less functional for years due to a lack of human, material, and other logistical resources. The industry is widely regarded as the most hazardous among all other sectors [1], [13], [35] and, therefore, requires customised legislation to oversee its activities due to its fragmented and specialised nature. The Factories, Offices, and Shops Act, enacted 46 years prior, and the Labour Act, implemented 22 years ago, both predate substantial advancements in industrial practices. Neither legislative instrument has undergone significant revisions to adequately influence contemporary industrial operations. For the government to live up to its responsibility of protecting workers [36], it will necessitate consistent legislative and governance ingenuity to influence the functioning of industrial operations [37], [38].

B. Digital technologies and government regulation in Ghana's construction sector

The African Union's Draft AI Policy [39] establishes a continental framework for harmonizing artificial intelligence governance, urging member states to develop national strategies that balance innovation with risk mitigation, a call heeded by pioneers like Mauritius (2018 AI Strategy), Kenya (National Digital Master Plan 2022-2032), and Egypt (multiphase AI Strategy) through focused policies on economic integration, skills development, and regulatory oversight [40]. South Africa and Nigeria are advancing sector-specific regulations through

stakeholder consultations, acknowledging the inadequacy of existing data laws like POPIA and NDPA [40], while Rwanda prioritises local innovation and knowledge economies [41]. Ghana's 10-year National Artificial Intelligence Strategy (2022) aligns with this trend, emphasising ethical frameworks, talent development, and sectoral applications such as AI for agriculture and healthcare, including plans for a Responsible AI Office inspired by EU human-centric standards [41]. However, construction-specific AI regulations remain nascent despite this strategy, with drone operations partially governed by aviation laws requiring permits [42], [43], while AI applications operate in a policy vacuum, reliant on legislation ill-suited for construction-specific risks like algorithmic safety failures or data privacy breaches [8], [44]. This regulatory lag, exacerbated by infrastructural deficits and enforcement inconsistencies [45], contrasts sharply with AU objectives and peer nations' progress, exposing critical safety vulnerabilities as AI permeates high-risk construction activities. For Ghana to make any impact in the construction sector, there will be an urgent need to develop construction-tailored AI regulations aligned with AU guidelines, accelerate workforce upskilling [45], and foster inclusive stakeholder collaboration to harness digital potential for tangible safety outcomes.

III. METHODOLOGY

A quantitative research design was adopted for this study. Consistent with this methodology, a questionnaire was selected as the optimal instrument for data acquisition. Identifying the relevant factors to achieve the study's aim began with observing and scanning safety practices in the construction and consulting industries, and consulting industry practitioners for their perspectives. This was followed by a literature search to identify some of the predictors other authors have proposed as government involvement that could influence health and safety.

The search resulted in the identification of nine significant explanatory factors as presented in Table 1. These factors were modelled into a questionnaire to elicit the opinions of industry professionals.

TABLE 1: GOVERNMENT PREDICTOR VARIABLES THAT CAN IMPACT H&S

Government-related factors	Source
Strict implementation and enforcement of H&S laws by empowering H&S agencies.	[26], [37], [46], [47], [48], [49], [50]
Introduce H&S regulations, H&S guidance, and a code of practice in the construction industry.	[49], [51], [52], [53], [54]
Incorporate H&S courses into the educational curriculum for construction and related programmes at the tertiary, technical, and vocational school levels.	[55], [56], [57], [58]
Restructure and empower the Department of Factory Inspectorate at the national, regional, and district levels to undertake frequent inspections.	Researchers' own identified factor
Institute punitive measures and fines for breaches of H&S laws, regulations, and codes of practice.	[59], [60], [61], [62], [63]
Introduce the Occupational Health and Safety at Work Act to replace the Factories and Shops Act.	Researchers' own identified factor
Establish a National Health and Safety Commission, Health and Safety Inspectorate Executives, and Health and Safety Committees to handle safety issues in the construction industry.	Researchers' own identified factor

Provide adequate human and financial resources for the functioning of the National Health and Safety Commission.	Researchers' own identified factor
Introduce national H&S certification for firms and make it renewable.	Researchers' own identified factor

A five-point Likert scale was adopted, with 1 labelled “very low influence” and 5 “very high influence.” The questionnaire was divided into two sections: the bioinformation and government-related factors sections. The survey technique was judged acceptable for the chosen approach since it aids in the collection of vast amounts of data. The completed questionnaire was distributed to respondents by hand and through e-mail. In this study, a population of 7925 specialists was used. Architects, quantity surveyors, professional engineers, contractors, and lecturers were included in this all-in population.

A sample size of 635 was drawn from the population using a simple random sampling technique. According to [64], a sample size of 400 is considered appropriate for a population above 5000. This guided the selection of the sample size for the current study. For a model to be considered robust, a sample size greater than 200 is required, as postulated by [65]. To avoid potential selection duplication issues, participants were vetted to ensure they were not selected twice, bearing in mind the multiplicity of professional affiliations of most experts. The breakdown of the different participants selected is as follows: engineers (202), quantity surveyors (152), contractors (142), lecturers (76), and architects (63). A preliminary analysis was performed using the relative importance index (RII) to determine the relative significance of all the factors.

The RII was determined using the formula,

$$RII = \sum W/A \times N \quad (1)$$

where ‘ $\sum$ ’ constitutes the total frequency; ‘W’ is the weighting of factors indicated by respondents (1–5), ‘A’ is the highest weight, and ‘N’ represents the total number of participants [66]. The index of a factor closer to 1 was considered highly important. On the other hand, factors with indices closer to zero were indicative of low importance. In addition to establishing the significance of the factors, the variable structure of the factors was accomplished using exploratory factor analysis (EFA) [67]. A factor loading of 0.5 or more was used. A higher factor loading indicates the extent of the relationship between the predictor variable and the government-related factor. The EFA was complemented using confirmatory factor analysis (CFA) to confirm the association between observable and hidden variables, and to perform fit analysis. SPSS version 26 was used to conduct the EFA analysis. For the confirmatory factor analysis (CFA), however, AMOS version 22 was employed. The model fit analysis was performed using the following indices and their recommended cutoff points proposed by [68], [69], [70], [71], namely; degree of freedom greater or equal to 0 (acceptable fit), comparative fit index (CFI) ($0.90 \geq$ – acceptable fit, $0.95 \geq$ – good fit), and parsimony comparative fit index (PCFI) (less than 0.80 – good fit). Also, root mean square error of approximation (RMSEA) (less than 0.80 – acceptable fit), root mean square error of approximation 95% confidence interval (RMSEA 95% CI) (0.00–0.08 – good fit), and normed fit index (NFI) (greater than 0.90 – good fit). In addition to the

earlier mentioned indices, is incremental fit index (IFI) (greater than 0.90 – good fit), parsimony normed fit index (PNFI) (less than 0.80 – good fit), root mean square residual (RMR) (less than 0.05 – good fit), and goodness-of-fit index (GFI) (greater than 0.90 – good fit).

A. Model assessment and fit indices

Model evaluation in structural equation analysis is conducted using fit indices [72]. Fit indices in structural equation modelling offer valuable insights about the adequacy of the fit between the data and the model [73]. The following is a description and interpretation of each index utilised in the model’s evaluation.

B. Chi-square (χ^2)

The Chi-square (χ^2) is a statistical test used to establish the relationships between variables or the difference between observed data and expected data [74], [75]. In factor modelling, the chi-square value is employed to evaluate a model’s overall fit to the observed data. It contrasts the experiential covariance matrix with a hypothesised proposed covariance matrix [76].

C. The normed fit index (NFI)

The difference between the chi-squares of the target and null models is known as the normed fit index, or NFI. In statistical modelling, as an incremental measure of goodness of fit, it is unaffected by the number of variables or constraints. [70], [70], [71], [77]. The NFI presupposes that all correlations are either equal to zero or are equal, thereby establishing a foundation for the creation of a realistic model [78].

D. The root mean square error of approximation (RMSEA)

The RMSEA is a statistical measure that quantifies the difference between the population and model-implied population covariance metrics, taking into account the degrees of freedom [76], [79].

E. The comparative fit index (CFI)

The CFI is a statistical metric that assesses how much a model developed by a researcher enhances the fit relative to a null model [76].

F. The incremental fit index (IFI)

The IFI in structural equation modelling is derived from comparing the fit of a substantive model with that of a baseline model [80], [81].

G. The root mean square residual (RMR)

The average absolute value of the covariance residuals is quantified by the RMR [82]. The square root of the average of the squared residuals can be used to determine the root mean square residual [77], [83].

H. The parsimony comparative fit index (PCFI)

The PCFI considers a model’s level of complexity in structural equation modelling [84]. According to [69], a PCFI value of 0.6 indicates an acceptable fit.

I. Parsimony normed fit index (PNFI)

Parsimony normed fit index (PNFI) is a modification of the normed fit index (NFI). Structural equation modelling considers a model’s complexity using the PNFI [84]. It also compares values in alternative models [85], considers the number of

degrees of freedom used to achieve a certain level of fit, and compares models with different degrees of freedom [77].

J. Goodness-of-fit (GFI)

Goodness-of-fit, as a hypothetical test in statistics, seeks to determine how well a sample data fits a distribution from a given population [78]. According to [70], it assesses the relative magnitude of variance and covariance.

IV. FINDINGS

A. Participants bioinformation

A total of 454 valid questionnaires were received, comprising 125 engineers, 134 quantity surveyors, 49 architects, 84 contractors, and 62 lecturers, as shown in Fig. 1 below. The response represents 71.50% of the 635 questionnaires distributed. Engineers and quantity surveyors constituted the majority (57%) of the respondents. The least is architects.

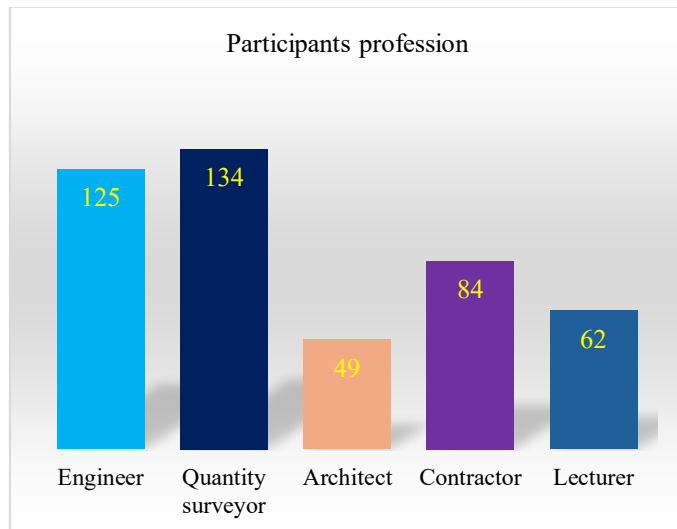


Fig. 1. The distribution of valid responses

The data in Fig. 2 shows that a more significant percentage of the subjects had 6-20 years of working experience. In contrast, participants with 21 years or above experience are the least. Respondents with 6-10 years of working experience are 27.8%, 11-15 years (22.7%), and 16-20 years (22.2%). Out of the total number, 15% had 2-5 years of working experience. The results indicate that the participants selected for the study possessed the knowledge pool to provide the needed information.

Professionals working experience

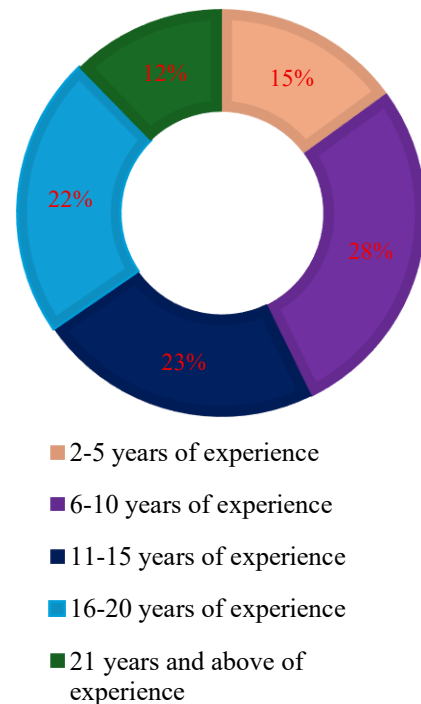


Fig. 2 Years of experience of participants

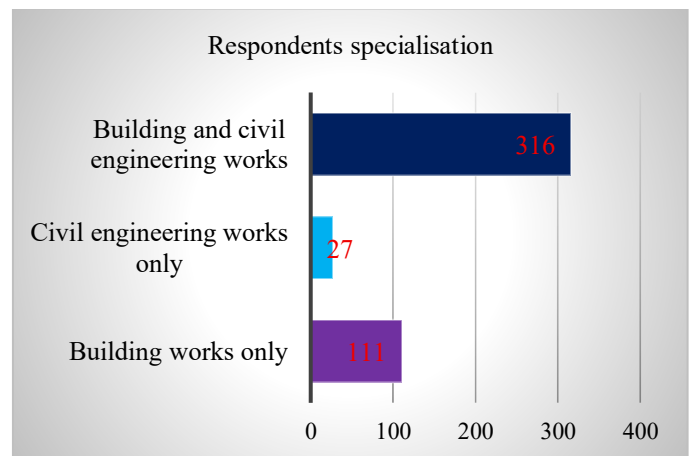


Fig. 3. Participants' current specialisation

The data presented in Fig. 3 above demonstrates that a greater proportion of the participants (316), forming 69.6% are professionals who have specialised in building and civil engineering work. Participants with specialisation in only building work are 111 (24.4%). Very few of the subjects (5.9%) have specialisation solely in civil engineering work.

B. Government-related factors using the relative importance index

The nine (9) government-related factors (GRF) that can impact H&S performance in the construction sector were examined using the relative importance index as presented in Table 2 below. The result revealed that the government effort that could significantly impact health and safety performance in the Ghanaian construction industry (GhCI) is the strict

implementation and enforcement of H&S laws by empowering H&S agencies (GRF6). This factor scored a relative importance index (RII) of 0.903. However, the introduction of health and safety regulations, health and safety guidance, and a code of practice in the construction industry (GRF3) placed second. Incorporating H&S courses into the educational curriculum for construction and related programmes at the tertiary, technical, and vocational school levels (GRF9) ranked third. The RII of the second and third rated factors are 0.901 and 0.900, respectively. Contrastingly, respondents found the introduction of national H&S certification for firms and making it renewable (GRF4) relatively less significant.

TABLE 2: GOVERNMENT-RELATED FACTORS

Factor Code	Government-related factors	RII	RANK
GRF6	Strict implementation and enforcement of H&S laws by empowering &HS agencies.	0.903	1
GRF3	Introduce H&S regulations, H&S guidance, and a code of practice in the construction industry.	0.901	2
GRF9	Incorporate H&S courses into the educational curriculum for construction and related programmes at the tertiary, technical, and vocational school levels.	0.900	3
GRF8	Restructure and empower the Department of Factory Inspectorate at the national, regional, and district levels to undertake frequent inspections.	0.899	4
GRF7	Institute punitive measures and fines for breaches of H&S laws, regulations, and codes of practice.	0.896	5
GRF1	Introduce an Occupational Health and Safety at Work Act to replace the Factories and Shops Act.	0.895	6
GRF2	Establish a National Health and Safety Commission, Health and Safety Inspectorate Executives, and Health and Safety Committees to handle safety issues in the construction industry.	0.887	7
GRF5	Provide adequate human and financial resources for the functioning of the National Health and Safety Commission.	0.881	8
GRF4	Introduce national H&S certification for firms and make it renewable.	0.878	9

C. Multivariate statistical analysis

The test for sampling adequacy of the nine variables defining GRF was determined using the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity. The analysis yielded a KMO of 0.892 and a sphericity of $p < 0.000$, less than $p < 0.05$. The obtained estimates indicated that factor analysis was suitable for the government-related explanatory variables. After the factor analysis, the GRF independent variables were grouped under two components as referenced in Table 3. The first and second components recorded four (4) items each with thresholds over the cutoff point of 0.5. The first component was classified as government and legislative efforts (GLE); however, the second component was identified as enforcement agency efforts (EAE). GRF9 was excluded because its cutoff value was less than 0.5.

Using a cutoff point of 0.3, the corrected item-total correlation for the items using the Cronbach alpha indicated strong internal consistency [86]. The estimated figure for component one (GLE) was 0.840. Meanwhile, component two (EAE) was 0.839, as indicated in Table 4.

TABLE 3: EXPLORATORY FACTOR ANALYSIS OF GOVERNMENT-RELATED VARIABLES

Government-related factors	Components	
	1	2
Establish a National Health and Safety Commission, Health and Safety Inspectorate Executives, and Health and Safety Committees to handle safety issues in the construction industry.	0.792	
Introduce H&S regulations, H&S guidance, and a code of practice in the construction industry.	0.682	
Introduce an Occupational Health and Safety at Work Act to replace the Factories and Shops Act.	0.656	
Introduce national H&S certification for firms and make it renewable.	0.655	
Institute punitive measures and fines for breaches of H&S laws, regulations, and codes of practice.		0.836
Strict implementation and enforcement of H&S laws by empowering &HS agencies.		0.717
Restructure and empower the Department of Factory Inspectorate at the national, regional, and district levels to undertake frequent inspections.		0.616
Provide adequate human and financial resources for the functioning of the National Health and Safety Commission.		0.545

TABLE 4: UNIDIMENSIONALITY AND RELIABILITY OF GOVERNMENT-RELATED FACTORS

Component	Latent component	Cronbach Alpha
Component 1	Government and Legislative Efforts (GLE)	0.840
Component 2	Enforcement Agency Efforts (EAE)	0.839

Furtherance to the EFA was confirmatory factor analysis (CFA). Using the fit indices in the methodology section, the goodness of fit of the GRF construct was assessed. The GRF model yielded a chi-square of 4.773, 19 degrees of freedom (df), and a probability of $p = 0.0000$. The appraised chi-square figure suggests that the model is a good fit [75]. The estimated CFI and NFI of 0.958 and 0.948, respectively, indicate that the model is a good fit. A PNFI value of 0.643, less than 0.80, and an RMR (0.019) less than 0.05 also suggest the model is a good fit. The GFI estimate (0.952) exceeded the 0.90 limit, indicating a good fit. PCFI estimate was 0.650, RMSEA (0.071), RMSEA 95% CI (0.063-0.073), NFI (0.948), and IFI (0.958). Generally, the hypothesised model could be described as a good fit.

Eight indicator variables were selected for the final CFA analysis from the nine subjected to statistical testing [70], [87]. Analysis of 454 cases for this construct revealed eight indicator variables, organised into two components: GLE (GLE1, GLE2, GLE3, GLE4) and EAE (EAE1, EAE2, EAE3, EAE4).

The unidimensional characteristics of the government-related model are presented in Table 5 and graphically represented in Fig. 4. These eight predictor variables (GLE1, GLE2, GLE3, and GLE4) and (EAE1, EAE2, EAE3, and EAE4) were selected for the final CFA analysis [70], [87]. Figure 4 is a CFA model depicting two latent constructs, namely, GLE and EAE. The unique variance of (0.16) for E1, E2, E3, E5, and E6 indicates a strong reliability. This means a larger proportion of the items' total variances are explained by the common factors, suggesting that GLE1, GLE2, GLE3, EAE1, and EAE2 are more reliable measures of the underlying government-related factors that influence construction health and safety. The estimates reveal that 16% of the variances in E1, E2, E3, E5, and E6 are unaccounted for by GLE and EAE. The loading estimates on the single-headed arrow of all eight variables, four each from the unobserved constructs to observed variables, show that the indicator variables are good measures of GLE and EAE. They demonstrate a strong positive relationship between the indicators and latent constructs. The covariance between the two latent constructs, GLE and EAE, is 0.21. This indicates that the two constructs are separate, distinct, but related. The residual variances of the GLE and EAE constructs are 26% and 29%, respectively. These represent the variances in the unobserved constructs unexplained by the model's structure or indicator variables (GLE1, GLE2, GLE3, GLE4) and (EAE1, EAE2, EAE3, EAE4).

TABLE 5: FINAL CONCEPTUAL MODEL INDICATOR VARIABLES FOR GRF

Latent Component	Indicator Variable	Measurement Variable	Label
(GLE)		Establish a National Health and Safety Commission (NHSC), Health and Safety Inspectorate Executives (HSIE), and Health and Safety Committees (HSCs) to handle safety issues in the construction industry.	GLE1
		Introduce health and safety regulations (HSR), health and safety guidance (HSG), and a Code of Practice (HSCoP) in the construction industry.	GLE2
		Introduce an Occupational Health and Safety at Work Act (OHSA) to face out the Factories and Shops Act.	GLE3
		Introduce national H&S certification for firms and make it renewable.	GLE4
(EAE)		Institute punitive measures and fines for breaches of H&S laws, regulations, and codes of practice.	EAE1
		Strict implementation and enforcement of H&S laws by empowering H&S agencies.	EAE2
		Restructure and empower the Department of Factory Inspectorate at the national, regional, and district levels to undertake frequent inspections.	EAE3
		Provide adequate human and financial resources for the functioning of the National Health and Safety Commission.	EAE4

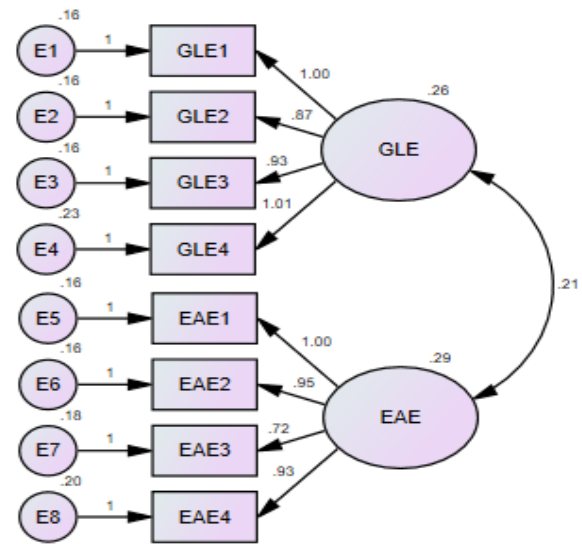


Fig. 4. CFA Model for Government-Related Factors (GRF)

The correlation coefficients, standard errors, and statistical test results for the final model consisting of eight indicators are displayed in Table 6. The square of multiple R, often known as R-squared or R^2 in the table, was used to measure the proportion of variance in the dependent variable that is accounted for by the predictors [74]. The R^2 assesses the degree to which the model accurately represents the observed data, demonstrating the level of agreement between the model's predictions and the actual data points [88], [89]. On the other hand, the p-value is the likelihood of obtaining a result that is both equal to and more extreme than the actual observation, assuming that there is no effect or difference. It is the quantitative representation of the likelihood that an observed discrepancy may have arisen solely due to random variability. The probability (P) is a metric that quantifies the probability that any observed difference between groups is attributable to random chance [87], [90]. An exceedingly small p-value indicates that the null hypothesis would be exceedingly unlikely to predict an extreme observed outcome [91].

When stated in different units or scales, beta coefficients, also known as standardised coefficients, offer a way to assess the strength and direction of the association between variables. Standardising the coefficients makes comparisons easier by establishing a similar scale for all the variables [92].

Each correlation value was less than 1.00, and each p-value was less than the 0.05 threshold for significance. As a result, the estimates were considered both rational and statistically significant. The variable EAE1 registered a standardised coefficient of 0.801. This was discovered to be the highest of any of the indicator variables.

The correlation and R^2 values show that there is a strong linear relationship between the latent factors and predictor variables. This indicates a strong linear relationship between the indicator variables and the unobserved variables (GLE and EAE). In addition, the R^2 values were also close to the desired value of 1.00, indicating that the factors explained more of the variance in the indicator variables. The results suggest that the indicator variables significantly predict the unobserved

components because all the measured variables are significantly associated with the two components (GLE and EAE).

TABLE 6: FACTOR LOADING AND P-VALUE OF GRF

Hypothesised relationships (Path)	Unstandardised coefficient (λ)	Standardised coefficient (λ)	P-Value	R-Square	Significant at the 5% level
GLE1 $\leftarrow$ GLE	1.000	0.788	0.00	0.621	Yes
GLE2 $\leftarrow$ GLE	0.871	0.747	0.00	0.558	Yes
GLE3 $\leftarrow$ GLE	0.928	0.760	0.00	0.578	Yes
GLE4 $\leftarrow$ GLE	1.005	0.729	0.00	0.532	Yes
EAE1 $\leftarrow$ EAE	1.000	0.801	0.00	0.641	Yes
EAE2 $\leftarrow$ EAE	0.950	0.729	0.00	0.627	Yes
EAE3 $\leftarrow$ EAE	0.717	0.676	0.00	0.457	Yes
EAE4 $\leftarrow$ EAE	0.933	0.750	0.00	0.563	Yes

V. DISCUSSION

A. Government-related factors (GRF) using the relative importance index

The study identified nine government-related factors that can impact H&S. These factors were subjected to ranking using the relative importance index. The study's findings showed that the factors with the most significant influence were the stern implementation and enforcement of H&S laws by empowering H&S agencies, the introduction of regulations, guidance, and a code of practice in the construction industry, and the incorporation of H&S courses into the educational curriculum for construction and related programmes at the tertiary, technical, and vocational school levels. On the other hand, supplying sufficient human and financial resources for the functioning of the National Health and Safety Commission, introducing national H&S certification for firms, and renewing the same were identified as the least government-related factors. The data analysis results show that respondents value the enforcement and implementation of the law. Health and safety improve when external agencies intensify monitoring and enforce compliance [93]. The findings of [15] and [27] revealed that the penurious safety performance in the sector is attributable to the lack of enforcement and implementation. This finding collaborates with [94] and [95]. It is impossible to separate the pursuit of a safe construction industry from oversight and enforcement. They agreed that a lack of monitoring and enforcement influences workers' ability to work safely. The effectiveness of H&S implementation relies critically on the implementation management model [21]. According to [96] and [97], implementing H&S regulations is to avoid or prevent risk and safeguard the health and safety of firms. This presupposes that the introduction of the regulation alone is not enough unless it is coupled with compliance.

As emphasised by [98], H&S guidance documents must define workers' duties, rights, and responsibilities within their employment engagement. H&S guidance is essential to health and safety management [99]. However, [99] favoured infographic guidance. The lack of a code of practice for practitioners poses a challenge [100] because it sets out the ground rules that regulate workers' actions [101].

The results of respondents revealed that H&S would be enhanced if H&S courses are incorporated into the educational curriculum for construction and related programmes at the tertiary, technical, and vocational school levels. This will create

behavioural awareness and improve students' knowledge of H&S [102], [103], [104]. The derived indices for all the explanatory variables demonstrated exceptionally high significance levels, as classified by [105]. As stated by [105], indices between 0.839 and 1.000 are deemed highly significant.

B. Government-related factors (GRF)

This section discusses the results obtained using the multivariate analysis. The variables extracted were regarded as accurate indicators of their respective components. The Cronbach alpha coefficients of the first and second components indicate that the variables employed are unidimensional and possess sufficient internal reliability. The government-related CFA model indicates a two-factor model consisting of the abovementioned components and eight variables. The fit indices for adaptability and integration suggest that the proposed model is a good fit. The correlation coefficients and p-values are reasonable and statistically significant. Below is the discussion of the two latent variables.

Enforcement agency efforts (EAE)

The findings of the study align with the research conducted by [106] about the use of punitive measures and penalties in addressing violations of H&S regulations. Punitive measures and penalties promote a good safety culture, encourage compliance, enhance accountability, and also serve as a deterrence. Using them carefully, create a healthy and safe working environment. The resultant effect is a reduction in site accidents and other health-related issues, and encourages construction firms to invest in safety protocols. Nevertheless, [62] suggested that imposing exorbitant penalties and severe sanctions for violations might have detrimental effects.

Restructuring and empowering the Department of Factories Inspectorate (DFI) at the national, regional, and district levels to undertake frequent inspections is crucial. Expanded agency presence at these levels is hypothesised to increase organisational visibility and improve monitoring capabilities. This, in turn, facilitates the collection of up-to-date information, which can then be utilised to inform and enhance future strategic and policy decisions. The reorganisation and strengthening of the DFI would enable the agency to transition from a reactive posture to a proactive one in its enforcement responsibilities and focus on early hazard identification and consistent application of safety standards. It would also promote a safety-first culture, enhance safety training and awareness, and empower workers to speak up about unsafe conditions on site.

Providing the Commission with adequate human and financial resources is essential for its operational effectiveness [107]. This would enable the body to conduct comprehensive research, leading to the proactive identification of emerging health and safety risks. Furthermore, a well-resourced Commission could more effectively disseminate critical safety information, raise awareness, and promote best practices. A resource increase would enhance the attraction and retention of highly qualified personnel.

Government and legislative efforts (GLE)

The study is consistent with [108] and [106], who indicated that establishing a National Health and Safety Commission,

Health and Safety Inspectorate Executives, and Health and Safety Committees can impact safety performance. The establishment of health and safety committees would influence national policy and practice in the industry as a result of the collection of localised H&S risks. The institution of a National Health and Safety Commission would direct all policy formulation; it would provide technical advice, and lead public awareness to improve the industry's safety culture. Implementing H&S regulations in the construction sector enhances credibility and establishes a reputation for safety. Additionally, regulations create the enabling working environment that prioritises the workers' safety needs first. According to [109], H&S structures instil discipline in the industry. H&S regulations influence innovation and corporate safety, and improve safety [110], while a code of practice regulates employee behaviour [101]. Respondents identified the enactment of an Occupational Health and Safety at Work Act as a potentially highly impactful intervention. Such legislation establishes a comprehensive legal framework, clearly delineating the roles and responsibilities of all stakeholders. This clarity is seen as a crucial step toward enhancing accountability and compliance across the industry. On certification, [111] averred that it is a means of reducing accidents and fatalities. This signals competence, commitment, and continuous improvement.

VI. IMPLICATIONS OF THE STUDY

The findings of the study suggest a need for a robust but balanced regulatory enforcement model and highlight the critical link between resource allocation and regulatory effectiveness. Decentralising the DFI to national, regional, and district levels, the study implies a strategic shift from a centralised, reactive model to a proactive, locally-embedded enforcement system that would enhance agency visibility, improve monitoring capabilities, and facilitate the collection of real-time data. This suggests that government investment in regulatory bodies is not merely an administrative cost but a strategic necessity for advancing research, disseminating information, and attracting qualified professionals, all of which are essential for staying ahead of emerging risks and fostering a culture of safety.

The findings underscore the importance of a clear and comprehensive legislative framework. The perceived high impact of the Occupational Health and Safety at Work Act suggests that a lack of defined roles and responsibilities among stakeholders is a major barrier to effective H&S management. The enactment of such legislation would provide a foundational legal structure that fosters accountability and consistency in the industry.

Finally, the study's support for health and safety certification reinforces its importance as a key mechanism for improving safety performance.

VII. CONCLUSION

Based on the results deduced from the relative importance index of the GRF, it can be concluded that the most significant predictors that can influence H&S in the industry are firm implementation and enforcement of H&S laws by state agencies, introduction of H&S regulations, guidance, and a code of practice, and the incorporation of H&S courses into educational

curriculum for construction-related programmes at the tertiary, technical, and vocational school levels.

On the other hand, the EFA established a strong association between instituting punitive measures and fines for breaches of H&S laws, regulations, and codes of practice; establishing a National Health and Safety Commission, Health and Safety Inspectorate Executives, and Health and Safety Committees to handle safety issues in the construction industry; strict implementation and enforcement of H&S laws by empowering H&S agencies; and provision of adequate human and financial resources for the functioning of the National Health and Safety Commission.

However, the CFA showed that instituting punitive measures and fines for breaches of H&S laws, regulations, and codes of practice; establishing a National Health and Safety Commission, Health and Safety Inspectorate Executives, and Health and Safety Committees to handle safety issues in the construction industry; introducing Occupational Health and Safety at Work Act to replace the Factories and Shops Act were closely related to their latent constructs. Enforcement agency efforts influence safety performance more than government and legislative efforts. This implies legislation loses meaning and impact if not supported or backed by sturdier enforcement. The impetus for adherence is derived from robust enforcement measures [112], [113].

A construction industry without an efficient regulatory framework is bound to be chaotic. The results of the government-related factors have some implications. The government needs to enact a single-point law, "Health and Safety at Work Act," to deal with all health and safety-related issues. The current law is outdated and not specific enough to deal with the complexities of the construction industry. A new law should define the responsibility of all stakeholders, make risk assessment and the institution of safety management systems mandatory, and establish clear guidelines for accident reporting. Specific regulations for the industry should be designed, qualified personnel to enhance enforcement should be attracted and trained, and given the necessary resources to perform their responsibilities. To achieve all these, a National Health and Safety Commission, Health and Safety Inspectorate Executives, and Health and Safety Committees need to be established to administer the law, monitor the activities of contractors and stakeholders, and provide training for contractors and other stakeholders as and when necessary.

To effectively implement the new law, the government would need to increase the visibility of mandated agencies in all regions and districts and resource them with the required human and financial resources and logistics to make them mobile to enhance monitoring and enforcement. Better still, the government can expand the DFI in the various districts across the country to ensure regulatory compliance across the sector.

As a deterrent measure, the state can institute caution systems, fines, and sanctions depending on the magnitude of the offence to curb H&S indiscipline. The focus of such measures should be to encourage, educate, train, create awareness, and sensitise contractors and employees. Persons found culpable of H&S breaches should be fined, with such payment made directly into a state account. Fines should be determined by the law to avoid abuses. Sanctions and fines are crucial for behavioural

change but can also be inimical and should be cautiously applied [104].

To encourage firms and stakeholders to take responsibility, the government can establish a national construction H&S certification system that would be renewable yearly by awarding points for safety-worthiness and compliance. This can be a public-private partnership, as it exists in other sectors in the country, to increase efficiency and promote other local businesses. The state should make it a national norm to include this certification in tender evaluation criteria for public and private contracts. Firms that consistently obtain a point score below a specific benchmark after two or three cautions can be blacklisted for a year or two to help change their orientation on H&S.

VII. LIMITATIONS OF THE STUDY

The study results indicate the perspectives of construction professionals in Ghana, and as such, they should not be overgeneralised. Nevertheless, the results may be beneficial in environments with comparable characteristics.

The observable variables and the fundamental factors are assumed to have a linear relationship in the EFA technique. The findings may be influenced if this assumption is not met. Once more, the utilisation of EFA involves an element of subjectivity. This is as a result of the number of factors that should be extracted, the number of components, and the factor loading that is deemed sufficient. Many authors have proposed factor loadings that are considered adequate, but the specifics vary depending on the field. The sufficiency of structural models is assessed by the CFA using the chi-square test. Nevertheless, the chi-square test is sensitive to sample size, particularly in models with large samples. Confirmatory factor analysis approaches have limitations in accurately detecting the degree and nature of agreement or disagreement. To reduce the subjective nature of applying EFA and address the limitations of the chi-square test, one can utilise generalised linear models, non-linear models, or neural networks.

In order to mitigate the impact of sample bias caused by the presence of subgroups with varying population sizes, it would have been advantageous to employ a stratified sampling approach. This would include prioritising subject selection in a manner that ensures the number of individuals chosen from each group is proportionate to their respective population sizes.

ACKNOWLEDGMENT

We are grateful to all the respondents who participated in the study and to Mr. Chris Kurbom Tieru for his contributions.

REFERENCES

- [1] B. B. Akomah and P. V. Ramani, 'Confirmatory factor analysis of the positive factors influencing the performance of Ghanaian construction projects', *Constr. Innov.*, vol. 25, no. 4, pp. 1250–1286, June 2025, doi: 10.1108/CI-08-2022-0190.
- [2] B. B. Akomah and P. V. Ramani, 'Local government institutions in Ghana: Core partners in health and safety performance in the construction industry', *Heliyon*, vol. 9, no. 9, p. e19423, Sept. 2023, doi: 10.1016/j.heliyon.2023.e19423.
- [3] J. Asante, E. Kissi, and E. Badu, 'Factorial analysis of capacity-building needs of small- and medium-scale building contractors in developing countries: Ghana as a case study', *Benchmarking Int. J.*, vol. 25, no. 1, pp. 357–372, Feb. 2018, doi: 10.1108/BIJ-07-2016-0117.
- [4] S. Gyimah, D.-G. Owusu-Manu, D. J. Edwards, J. I. T. Buerthey, and A. K. Danso, 'Exploring the contributions of circular business models towards the transition of green economy in the Ghanaian construction industry', *Smart Sustain. Built Environ.*, vol. 14, no. 3, pp. 859–880, Apr. 2025, doi: 10.1108/SASBE-09-2023-0265.
- [5] S. Kwaku Amoah, 'The Role of Small and Medium Enterprises (SMEs) to Employment in Ghana', *Int. J. Bus. Econ. Res.*, vol. 7, no. 5, p. 151, 2018, doi: 10.11648/j.ijber.20180705.14.
- [6] B. B. Akomah, M. Zakari, and E. Enoch Ayeh, 'Impact of cost of construction projects in Cape Coast metropolis', *Bul. Institutului Politeh. Din Iași*, vol. 66, no. 1, pp. 95–112, 2020.
- [7] B. B. Akomah, Z. Mustapha, and E. K. Ofosu, 'Contractors' commitment to early completion of projects', *Aust. J. Sci. Technol.*, vol. 4, no. 2, pp. 283–288, 2020.
- [8] D. Osei-Asibey, J. Ayarkwa, A. Acheampong, E. Adinyira, and P. Amoah, 'Framework for Improving Construction Health and Safety on Ghanaian Construction Sites', *J. Build. Constr. Plan. Res.*, vol. 09, no. 02, pp. 115–137, 2021, doi: 10.4236/jbcepr.2021.92009.
- [9] GlobalData, 'Ghana Construction Market Size, Trend Analysis by Sector (Commercial, Industrial, Infrastructure, Energy and Utilities, Institutional and Residential) and Forecast, 2023–2027', 2023. Accessed: Aug. 12, 2025. [Online]. Available: <https://www.globaldata.com/store/report/ghana-construction-market-analysis/>
- [10] B. B. Akomah and P. V. Ramani, 'Employee-Related Factors Influencing Health and Safety in The Ghanaian Construction Industry: A Confirmatory Factor Analysis of Professionals' Perspectives', *Int. J. Occup. Saf. Health*, vol. 14, no. 4, pp. 533–546, Nov. 2024, doi: 10.3126/ijosh.v14i4.59386.
- [11] A. V. K. Blay Jnr, A. S. K. Kukah, A. Opoku, and R. Asiedu, 'Impact of competitive strategies on achieving the sustainable development goals: Context of Ghanaian construction firms', *Int. J. Constr. Manag.*, vol. 23, no. 13, pp. 2209–2220, Oct. 2023, doi: 10.1080/15623599.2022.2048343.
- [12] K. Agyekum, C. Goodier, and J. A. Oppon, 'Key drivers for green building project financing in Ghana', *Eng. Constr. Archit. Manag.*, vol. 29, no. 8, pp. 3023–3050, Aug. 2022, doi: 10.1108/ECAM-02-2021-0131.
- [13] B. B. Akomah and P. V. Ramani, 'Local government institutions in Ghana: Core partners in health and safety performance in the construction industry', *Heliyon*, vol. 9, no. 9, p. e19423, Sept. 2023, doi: 10.1016/j.heliyon.2023.e19423.
- [14] I. O. Famakin, C. Aigbavboa, and R. Molusiwa, 'Exploring challenges to implementing health and safety regulations in a developing economy', *Int. J. Constr. Manag.*, vol. 23, no. 1, pp. 89–97, Jan. 2023, doi: 10.1080/15623599.2020.1850201.
- [15] D. Donkoh and E. Aboagye-Nimo, 'Stakeholders' role in improving Ghana's construction safety', *Proc. Inst. Civ. Eng.-Manag. Procure. Law*, vol. 170, no. 2, pp. 68–76, 2017.
- [16] I. Yimam, 'Assessment of Safety and Health Management Practices in Building Construction: The Case of Arada and Lideta Sub City Projects', 2025.
- [17] D. S. Upadhyaya and M. S. Malek, 'A bibliometric and scientometric approach-based review of Indian cultural and environmental indicators influencing health and safety in construction industry', *Int. J. Indian Cult. Bus. Manag.*, vol. 34, no. 2, pp. 184–203, 2025, doi: 10.1504/IJICBM.2025.144472.
- [18] H. Ayouz, A. Alzubi, and K. Iyiola, 'Using benevolent leadership to improve safety behaviour in the construction industry: a moderated mediation model of safety knowledge and safety training and education', *Int. J. Occup. Saf. Ergon.*, vol. 31, no. 1, pp. 167–180, Jan. 2025, doi: 10.1080/10803548.2024.2414613.
- [19] D. Talini and A. Baldasseroni, 'Workplace health promotion', *Med. Lav.*, vol. 110, no. 4, pp. 321–324, Aug. 2019, doi: 10.23749/mdl.v110i4.8525.
- [20] Z. Mustapha, B. B. Akomah, and O. E. Kwaku, 'Unveiling the Driving Factors of Emerging Trends in the Ghanaian Construction Industry: An Evaluative Analysis of Push and Pull Factors', *J. Civ. Eng. Front.*, vol. 5, no. 01, pp. 13–21, June 2024, doi: 10.38094/joccf50181.
- [21] N. Umeokafor, K. Evangelinos, and A. Windapo, 'Strategies for improving complex construction health and safety regulatory

- environments', *Int. J. Constr. Manag.*, vol. 22, no. 7, pp. 1333–1344, May 2022, doi: 10.1080/15623599.2019.1707853.
- [22] M. Ajmal, A. S. N. Isha, and S. M. Nordin, 'Safety management practices and occupational health and safety performance: an empirical review', *Jinnah Bus. Rev.*, vol. 9, no. 2, pp. 15–33, 2021.
- [23] E. F. Boadu, R. Y. Sunindijo, and C. C. Wang, 'Health and Safety Consideration in the Procurement of Public Construction Projects in Ghana', *Buildings*, vol. 11, no. 3, p. 128, Mar. 2021, doi: 10.3390/buildings11030128.
- [24] M. Zakari, B. Boahene Akomah, W. M. Nkomo, T. Abilgah, and W. D. Thwala, 'Impact of Safety Training and Communication on Construction Project Productivity: Case Study of Cape Coast', *J. Civ. Eng. Front.*, vol. 6, no. 01, pp. 11–17, Dec. 2024, doi: 10.38094/jocf60197.
- [25] Emmanuella Osagioduwa Osifo, Ewere Stephanie Omumu, and Modestus Alozie, 'Evolving contractual obligations in construction law: Implications of regulatory changes on project delivery', *World J. Adv. Res. Rev.*, vol. 25, no. 3, pp. 1315–1333, Mar. 2025, doi: 10.30574/wjarr.2025.25.3.0896.
- [26] P. Arocena and I. Núñez, 'An empirical analysis of the effectiveness of occupational health and safety management systems in SMEs', *Int. Small Bus. J. Res. Entrep.*, vol. 28, no. 4, pp. 398–419, Aug. 2010, doi: 10.1177/0266242610363521.
- [27] B. B. Akomah, R. Leiringer, N. A. Boakye, and R. Fugar, 'Safety on construction sites: the role of the employer and employee', in *Proceedings of the West Africa Built Environment Research (WABER) Conference Accra, Ghana, 27-28 July 2010*, Reading, United Kingdom: School of Construction Management and Engineering, University of Reading, 2010, pp. 477–49.
- [28] D. E. Hagan, Z. Mustapha, B. B. Akomah, and P. K. Aidoo, 'Occupational Health and Safety Practices in Cape Coast Metropolis', *Balt. J. Real Estate Econ. Constr. Manag.*, vol. 9, no. 1, pp. 112–121, Jan. 2021, doi: 10.2478/bjreecm-2021-0009.
- [29] A. Moradi and M. Yazdi, 'Mastering the Landscape of Occupational Health and Safety: Regulations, Best Practices, and Avoiding Pitfalls', in *Safety-Centric Operations Research: Innovations and Integrative Approaches*, vol. 232, M. Yazdi, Ed., in *Studies in Systems, Decision and Control*, vol. 232, Cham: Springer Nature Switzerland, 2025, pp. 151–167, doi: 10.1007/978-3-031-82934-5_8.
- [30] A. P. Sitanggang, E. H. Manurung, and D. Purwanto, 'Occupational Safety and Health (K3) Budget for Construction in Accordance with the Omnibus Law', *SENTRI J. Ris. Ilm.*, vol. 3, no. 2, pp. 823–827, Feb. 2024, doi: 10.55681/sentri.v3i2.2330.
- [31] D. Osei-Asibey, J. Ayarkwa, A. Acheampong, E. Adinyira, and P. Amoah, 'Impacts of accidents and hazards on the Ghanaian construction industry', *Int. J. Constr. Manag.*, vol. 23, no. 4, pp. 708–717, Mar. 2023, doi: 10.1080/15623599.2021.1920161.
- [32] P. S. Jamir Singh, A. E. Oke, J. Aliu, T. Isaiah Kayode, R. Azura Ramli, and M. Haizzan Yahaya, 'Building safely, living well: combating substance abuse in the construction industry', *Int. J. Constr. Manag.*, pp. 1–10, Jan. 2025, doi: 10.1080/15623599.2025.2455995.
- [33] S. R. Zulkefle, 'Construction Safety and Health Implementation for Foreign Workers in Malaysia', vol. 14, no. 2, 2024.
- [34] N. A. Boakye, B. B. Akomah, and F. K. Fugar, 'Ensuring the health and safety of Ghanaian construction workers by decentralising government agencies: An exploratory study', Reading: School of Construction Management and Engineering, University of Reading, 2010, pp. 295–304.
- [35] S. P. M.G., A. K.S., S. Rajendran, and K. N. Sen, 'The role of psychological contract in enhancing safety climate and safety behavior in the construction industry', *J. Eng. Des. Technol.*, vol. 23, no. 4, pp. 1189–1210, June 2025, doi: 10.1108/JEDT-07-2023-0315.
- [36] M. Bhagat and D. Juneja, 'Development of a safety management program for the construction industry of Nepal', presented at the 2nd International Conference on Advanced Earth Science and Foundation Engineering (ICASF 2023): Advanced Earth Science and Foundation Engineering, Mohali, India, 2024, p. 020006, doi: 10.1063/5.0193690.
- [37] K. Adetunji, M. Saidin Misnan, M. Zahierruden Ismail, F. Nadiyah Abdul Rahim, and Z. Abdul-Samad, 'Approaches to Improving Occupational Health and Safety of the Nigerian Construction Industry', in *Civil Engineering*, vol. 2, H. Tosun, N. Gürsakal, and A. Sebatli-Saglam, Eds, IntechOpen, 2024, doi: 10.5772/intechopen.113011.
- [38] C. F. Oduoza, R. Alamri, and D. Oloke, 'Best practice for safety management – case of major oil processing country in the Middle East', *Eng. Constr. Archit. Manag.*, vol. 32, no. 3, pp. 1857–1874, Mar. 2025, doi: 10.1108/ECAM-02-2023-0126.
- [39] Union, African., 'African Union. 2024. Continental Artificial Intelligence Strategy: Harnessing AI for Africa's Development and Prosperity', 2024. Accessed: Aug. 12, 2025. [Online]. Available: <https://au.int/en/documents/20240809/>
- [40] S. Sulaiman, D. Olën, and M. Bezuidenhout, 'AI regulation and policy in Africa – Legal developments', *The Legal 500 – The Clients Guide to the best Law firms, top Lawyers, Attorneys, Advocates, Solicitors and Barristers*, M O N T H L Y R E V I E W, 2025. Accessed: Aug. 12, 2025. [Online]. Available: <https://my.legal500.com/developments/thought-leadership/ai-regulation-and-policy-in-africa/>
- [41] T. G. Kwarkye, 'Ghana's Pathway to AI Governance and Its Implications for Africa', *Cent. Int. Gov. Innov.*, pp. 1–9, 2025.
- [42] T. A. Gyamfi, K. O. Adjei, and S. O. Bonney, 'Strategies to Improve Building Construction Sustainability Through Utilization of Drones in the Building Construction Sector', *Procedia Comput. Sci.*, vol. 236, pp. 209–216, 2024, doi: 10.1016/j.procs.2024.05.023.
- [43] D. J. Tetteh-Agblakah, 'Investigation of Efficiency Improvements in Large-scale Infrastructure Projects in Ghana through Construction 4.0 Technologies', *Int. J. Appl. Nat. Sci.*, vol. 2, no. 2, pp. 86–98, Jan. 2025, doi: 10.61424/ijans.v2i2.183.
- [44] V. S. Pillai and K. Matus, 'Regulation of AI Technologies in the Construction Industry', *SSRN Electron. J.*, 2019, doi: 10.2139/ssrn.3439826.
- [45] C. Fosu, D. Owusu, and S. Sefah, 'The Role of AI in Transforming Construction Innovation and Enhancing Safety Standards in Ghana', *International J. Res. Publ. Rev.*, vol. 6, no. 1, pp. 440–453, 2025.
- [46] N. Umeokafor, D. Isaac, K. Jones, and B. Umeadi, 'Enforcement of Occupational Safety and Health Regulations in Nigeria: An Exploration', pp. 93–104, 2014.
- [47] David Chinalu Anaba, Azeez Jason Kess-Momoh, and Sodruddeen Abolore Ayodeji, 'Health, safety, and environmental (HSE) standards in industrial operations: A comprehensive review', *Int. J. Appl. Res. Soc. Sci.*, vol. 6, no. 7, pp. 1321–1332, July 2024, doi: 10.51594/ijarss.v6i7.1269.
- [48] A. G. Friebe, R. E. Potter, and M. Dollard, 'Health and safety representatives' perceptions of occupational health and safety policy developments to improve work-related psychological health: Applying the theory of planned behaviour', *Saf. Sci.*, vol. 172, p. 106410, Apr. 2024, doi: 10.1016/j.ssci.2023.106410.
- [49] Alex Olanrewaju Adekanmbi, Nwakamma Ninduwezuor-Ehiobu, Ayodeji Abatan, Uchenna Izuka, Emmanuel Chigozie Ani, and Alexander Obaigbena, 'Implementing health and safety standards in Offshore Wind Farms', *World J. Adv. Res. Rev.*, vol. 21, no. 2, pp. 1136–1148, Feb. 2024, doi: 10.30574/wjarr.2024.21.2.0557.
- [50] K. Fayyaz, M. Shahzaib, A. Aziz, M. Irfan, W. Salah Alaloul, and M. A. Musarat, 'Cultural Factors Impacting Health and Safety (H&S) Practices in a Developing Construction Economy', *Sustainability*, vol. 17, no. 3, p. 911, Jan. 2025, doi: 10.3390/su17030911.
- [51] S. O. Ajayi, N. Lister, J. A. Dauda, A. Oyegoke, and H. Alaka, 'Influencing sub-contracted operatives' attitudes and behaviours towards improved health and safety culture in construction', *Eng. Constr. Archit. Manag.*, vol. 31, no. 6, pp. 2286–2305, June 2024, doi: 10.1108/ECAM-03-2022-0265.
- [52] D. England, *Where Next for Health and Safety?*, 1st ed. Leeds: ICE Publishing, 2024.
- [53] M. K. Buniya, I. Y. Wuni, O. S. Yousif, and M. K. S. Al-Mhdawi, 'Quantifying the impact index of key barriers to safety program initiatives in the Iraqi construction industry', *Constr. Innov.*, July 2024, doi: 10.1108/CI-08-2023-0185.
- [54] R. Filip, R. Millard, D. Thomas, and M. Webster, 'Introduction, understanding temporary works duties and recent updates', in *Temporary Works Part Two: Further Principles of Design and Construction*, R. Filip, Ed., Emerald Publishing Limited, 2025, pp. 1–17, doi: 10.1108/978-1-83608-524-920251001.
- [55] K. A. M. Ali, P. R. Gau, and A. A. A. Bakar, 'Study on effect of anti-bribery management system to the quality of authority organization operational management in construction industry', *IOP Conf. Ser. Earth*

- Environ. Sci., vol. 1369, no. 1, p. 012004, June 2024, doi: 10.1088/1755-1315/1369/1/012004.
- [56] F. M. Alqahtani, N. S. Alqahtani, F. S. Algarni, I. A. Almuhaideb, F. Alessa, and M. A. Noman, 'Development of an educational program for occupational health and safety in Saudi Arabia', *J. Eng. Res.*, vol. 13, no. 2, pp. 551–560, June 2025, doi: 10.1016/j.jer.2024.04.018.
- [57] K. I. Ismara et al., 'The Implementation of Occupational Health and Safety Using Zerosicks in Indonesia Vocational Education', *Elinvo Electron. Inform. Vocat. Educ.*, vol. 9, no. 1, pp. 76–89, July 2024, doi: 10.21831/elinvo.v9i1.60586.
- [58] T. Chinengundu, 'Analysis of the South African Construction Technology Curriculum and Assessment Policy Statement Vocational Didactics'.
- [59] Isnawati and D. P. Faeni, 'The role of occupational safety and health education in improving knowledge and awareness of students at Sumur Batu 4 State elementary school, Musytari: Neraca Manajemen', *Musytari J. Manaj. Akunt. Dan Ekon.*, vol. 6, no. 7, pp. 91–100, 2024, doi: <https://doi.org/10.8734/musytari.v6i7.4521>.
- [60] T. W. Yiu, 'Means to Incentivize Safety Compliance at Work', in *Construction Incentivization*, S. O. Cheung and L. Zhu, Eds, in *Digital Innovations in Architecture, Engineering and Construction*, Cham: Springer International Publishing, 2023, pp. 197–214. doi: 10.1007/978-3-031-28959-0_9.
- [61] S. K. Bhattarai, D. Dahal, and U. Neupane, 'Assessment of Compliance and Welfare of Construction Workers at Selected Building Construction Project in Kathmandu: Implications for Labor Act Implementation', *J. Recent Act. Infrastruct. Sci.*, vol. 9, no. 1, pp. 25–44, Apr. 2024, doi: 10.46610/JoRAIS.2024.v09i01.003.
- [62] A. O. Arewa, S. Theophilus, A. Ifealebuegu, and P. Farrell, 'Analysis of Penalties Imposed on Organisations for Breaching Safety and Health Regulations in the United Kingdom', *Saf. Health Work*, vol. 9, no. 4, pp. 388–397, Dec. 2018, doi: 10.1016/j.shaw.2018.01.004.
- [63] T. Cvetkovski and N. Weston, 'Mining Work Health, Safety Laws and Serious Industrial Crimes in Australia: Down the Shaft of Jurisdictional Inconsistency', *Laws*, vol. 14, no. 4, p. 49, July 2025, doi: 10.3390/laws14040049.
- [64] L. R. Gay, G. E. Mills, and P. W. Airasian, *Educational research: competencies for analysis and applications*, 10th ed. Boston: Pearson, 2014.
- [65] R. P. Bagozzi and Y. Yi, 'Specification, evaluation, and interpretation of structural equation models', *J. Acad. Mark. Sci.*, vol. 40, no. 1, pp. 8–34, Jan. 2012, doi: 10.1007/s11747-011-0278-x.
- [66] J. Ayarkwa, D.-G. Joe Opoku, P. Antwi-Afari, and R. Y. M. Li, 'Sustainable building processes' challenges and strategies: The relative important index approach', *Clean. Eng. Technol.*, vol. 7, p. 100455, Apr. 2022, doi: 10.1016/j.clet.2022.100455.
- [67] M. W. Watkins, 'Exploratory Factor Analysis: A Guide to Best Practice', *J. Black Psychol.*, vol. 44, no. 3, pp. 219–246, Apr. 2018, doi: 10.1177/0095798418771807.
- [68] R. B. Kline, 'How to evaluate local fit (residuals) in large structural equation models', *Int. J. Psychol.*, vol. 59, no. 6, pp. 1293–1306, Dec. 2024, doi: 10.1002/ijop.13252.
- [69] L. Hu and P. M. Bentler, 'Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives', *Struct. Equ. Model. Multidiscip. J.*, vol. 6, no. 1, pp. 1–55, Jan. 1999, doi: 10.1080/10705519909540118.
- [70] B. M. Byrne, *Structural Equation Modeling With AMOS: Basic Concepts, Applications, and Programming*, Third Edition, 3rd edn. Routledge, 2016. doi: 10.4324/9781315757421.
- [71] B. M. Byrne, *Structural equation modeling with AMOS: basic concepts, applications, and programming*, Second edition (Online-Ausg.). in *Multivariate applications series*. New York: Routledge, 2010.
- [72] O. Adedokun and T. Egbelakin, 'Structural equation modelling of risk factors influencing the success of building projects', *J. Facil. Manag.*, vol. 22, no. 1, pp. 64–90, Jan. 2024, doi: 10.1108/JFM-01-2022-0002.
- [73] B. M. Stone, 'The Ethical Use of Fit Indices in Structural Equation Modeling: Recommendations for Psychologists', *Front. Psychol.*, vol. 12, p. 783226, Nov. 2021, doi: 10.3389/fpsyg.2021.783226.
- [74] U. Sekaran and R. Bougie, *Research methods for business: a skill-building approach*, Seventh edition. Chichester, West Sussex: Wiley, 2016.
- [75] R. B. Kline, *Principles and practice of structural equation modeling*, 4th ed. in *Principles and practice of structural equation modeling*, 4th ed. New York, NY, US: The Guilford Press, 2016, pp. xviii, 534.
- [76] K. F. Cook, M. A. Kallen, and D. Amtmann, 'Having a fit: impact of number of items and distribution of data on traditional criteria for assessing IRT's unidimensionality assumption', *Qual. Life Res.*, vol. 18, no. 4, pp. 447–460, May 2009, doi: 10.1007/s11136-009-9464-4.
- [77] R. E. Schumacker and R. G. Lomax, *A beginner's guide to structural equation modeling*, 3rd ed (Online-Ausg.). New York: Routledge, 2010.
- [78] J. C. Loehlin and A. A. Beaujean, *Latent variable models: an introduction to factor, path, and structural equation analysis*, Fifth edition. New York London: Routledge, 2017.
- [79] T. A. Brown, *Confirmatory factor analysis for applied research*, Second edition. in *Methodology in the social sciences*. New York London: The Guilford Press, 2015.
- [80] G. S. Ching, W.-C. Lien, and P.-C. Chao, 'Developing a scale to measure the situational changes in short-term study abroad programs', *Int. J. Res. Stud. Educ.*, vol. 3, no. 5, Aug. 2014, doi: 10.5861/ijrse.2014.771.
- [81] K. F. Widaman and J. S. Thompson, 'On specifying the null model for incremental fit indices in structural equation modeling', *Psychol. Methods*, vol. 8, no. 1, pp. 16–37, 2003, doi: 10.1037/1082-989X.8.1.16.
- [82] C. M. Ringle, S. Wende, and J.-M. Becker, 'SmartPLS 4'. SmartPLS, Bönningstedt, 2024. Accessed: Aug. 12, 2025. [Online]. Available: <https://www.smartpls.com/>
- [83] R. H. Hoyle, Ed., *Handbook of structural equation modeling*, Second edition. New York: The Guilford Press, 2023.
- [84] M. Ghaleb and M. M. Yaşlıoğlu, 'Structural Equation Modeling (SEM) for Social and Behavioral Sciences Studies: Steps Sequence and Explanation', vol. 6, 2024.
- [85] T. Sánchez, J. L. Castejón, R. Gilar, and A. Ordoñez, 'Confirmatory Factor Analysis of the Assessment Instrument Teacher of the Escuela Politécnica Nacional', in *Proceedings of the 18th LACCEI International Multi-Conference for Engineering, Education, and Technology: Engineering, Integration, And Alliances for A Sustainable Development* "Hemispheric Cooperation for Competitiveness and Prosperity on A Knowledge-Based Economy", Latin American and Caribbean Consortium of Engineering Institutions, 2020. doi: 10.18687/LACCEI2020.1.1.110.
- [86] J. C. Nunnally and I. H. Bernstein, *The assessment of reliability*, 3rd edn. Psychometric Theory, 1994.
- [87] T. Dahiru, 'P-Value, a true test of statistical significance? a cautionary note', *Ann. Ib. Postgrad. Med.*, vol. 6, no. 1, pp. 21–26, Mar. 2008, doi: 10.4314/aipm.v6i1.64038.
- [88] A. Moses, D. Chen, P. Wan, and S. Wang, 'Prediction of electrochemical corrosion behavior of magnesium alloy using machine learning methods', *Mater. Today Commun.*, vol. 37, p. 107285, Dec. 2023, doi: 10.1016/j.mtcomm.2023.107285.
- [89] H. Alabduljabbar, K. Khan, H. H. Awan, R. Alyousef, A. M. Mohamed, and S. M. Eldin, 'Modeling the capacity of engineered cementitious composites for self-healing using AI-based ensemble techniques', *Case Stud. Constr. Mater.*, vol. 18, p. e01805, July 2023, doi: 10.1016/j.cscm.2022.e01805.
- [90] S. Greenland, 'Connecting simple and precise P-values to complex and ambiguous realities (includes rejoinder to comments on "Divergence vs. decision P-values")', *Scand. J. Stat.*, vol. 50, no. 3, pp. 899–914, Sept. 2023, doi: 10.1111/sjos.12645.
- [91] D. R. Bickel, 'The p-value interpreted as the posterior probability of explaining the data: Applications to multiple testing and to restricted parameter spaces', *Sankhya A*, vol. 86, no. 1, pp. 464–493, Feb. 2024, doi: 10.1007/s13171-023-00328-4.
- [92] M. Fonseca, 'Demystifying standardized coefficients: Understanding their importance in clinical research', *Editage Insights*. Accessed: Aug. 12, 2025. [Online]. Available: <https://www.editage.com/insights/demystifying-standardized-coefficients-understanding-their-importance-in-clinical-research>
- [93] J. Bynner, 'Reliability and Validity Appraisal Through Structural Equation Models', *Bull. Sociol. Methodol. Methodologie Sociol.*, vol. 28, no. 1, pp. 41–55, Sept. 1990, doi: 10.1177/075910639002800103.
- [94] B. Chigara and T. Moyo, 'Factors affecting the delivery of optimum health and safety on construction projects during the covid-19 pandemic in Zimbabwe', *J. Eng. Des. Technol.*, vol. 20, no. 1, pp. 24–46, Jan. 2022, doi: 10.1108/JEDT-01-2021-0053.

- [95] A. Ebekoziem, 'Construction companies' compliance to personal protective equipment on junior staff in Nigeria: issues and solutions', *Int. J. Build. Pathol. Adapt.*, vol. 40, no. 4, pp. 481–498, Dec. 2022, doi: 10.1108/IJBPA-08-2020-0067.
- [96] L. Morgado, F. J. G. Silva, and L. M. Fonseca, 'Mapping Occupational Health and Safety Management Systems in Portugal: outlook for ISO 45001:2018 adoption', *Procedia Manuf.*, vol. 38, pp. 755–764, 2019, doi: 10.1016/j.promfg.2020.01.103.
- [97] M. N. González García, M. Segarra Cañamares, B. M. Villena Escribano, and A. Romero Barriuso, 'Construction's health and safety Plan: The leading role of the main preventive management document on construction sites', *Saf. Sci.*, vol. 143, p. 105437, Nov. 2021, doi: 10.1016/j.ssci.2021.105437.
- [98] M. Ziemann, C. Chen, R. Forman, A. Sagan, and P. Pittman, 'Global Health Workforce responses to address the COVID-19 pandemic: What policies and practices to recruit, retain, reskill, and support health workers during the COVID-19 pandemic should inform future workforce development?', 2023.
- [99] H. Lingard, N. Blismas, J. Harley, A. Stranieri, R. P. Zhang, and P. Pirzadeh, 'Making the invisible visible: Stimulating work health and safety-relevant thinking through the use of infographics in construction design', *Eng. Constr. Archit. Manag.*, vol. 25, no. 1, pp. 39–61, Feb. 2018, doi: 10.1108/ECAM-07-2016-0174.
- [100] R. Jayasekara, L. Kodithuwakku, C. Siriwardana, S. Samaraweera, and N. P. Hetti, 'Ensuring Biological Hazard Preparedness in Health and Safety of Construction Sector: A Framework for a Code of Practice', in *12th International Conference on Structural Engineering and Construction Management*, vol. 266, R. Dissanayake, P. Mendis, K. Weerasekera, S. De Silva, S. Fernando, and C. Konthesingha, Eds, in *Lecture Notes in Civil Engineering*, vol. 266, Singapore: Springer Nature Singapore, 2023, pp. 357–371. doi: 10.1007/978-981-19-2886-4_26.
- [101] J. B. H. Yap, M. Skitmore, C. G. Y. Lam, W. P. Lee, and Y. L. Lew, 'Advanced technologies for enhanced construction safety management: investigating Malaysian perspectives', *Int. J. Constr. Manag.*, vol. 24, no. 6, pp. 633–642, Apr. 2024, doi: 10.1080/15623599.2022.2135951.
- [102] Awolusi Ibukun, Akinsemoyin Aliu, Chakraborty Debaditya, and Al-Bayati Ahmed, 'Worker Safety and Health Activity Monitoring in Construction Using Unmanned Aerial Vehicles and Deep Learning', in *Construction Research Congress 2022*, in *Proceedings*, 2022, pp. 463–473. doi: 10.1061/9780784483961.049.
- [103] A. Rauzana and W. Dharma, 'The knowledge and awareness of occupational health and safety requirements among civil engineering students in an Indonesian university'.
- [104] A. Pedro, Q. T. Le, and C. S. Park, 'Framework for Integrating Safety into Construction Methods Education through Interactive Virtual Reality', *J. Prof. Issues Eng. Educ. Pract.*, vol. 142, no. 2, p. 04015011, Apr. 2016, doi: 10.1061/(ASCE)EI.1943-5541.0000261.
- [105] O. Genç, 'Identifying principal risk factors in Turkish construction sector according to their probability of occurrences: a relative importance index (RII) and exploratory factor analysis (EFA) approach', *Int. J. Constr. Manag.*, vol. 23, no. 6, pp. 979–987, Apr. 2023, doi: 10.1080/15623599.2021.1946901.
- [106] C. G. Daughton, 'Wastewater surveillance for population-wide Covid-19: The present and future', *Sci. Total Environ.*, vol. 736, p. 139631, Sept. 2020, doi: 10.1016/j.scitotenv.2020.139631.
- [107] I. Nuñez and M. Villanueva, 'Safety capital: the management of organizational knowledge on occupational health and safety', *J. Workplace Learn.*, vol. 23, no. 1, pp. 56–71, Feb. 2011, doi: 10.1108/13665621111097254.
- [108] R. E. Zisook, A. Monnot, J. Parker, S. Gaffney, S. Dotson, and K. Unice, 'Assessing and managing the risks of COVID-19 in the workplace: Applying industrial hygiene (IH)/occupational and environmental health and safety (OEHS) frameworks', *Toxicol. Ind. Health*, vol. 36, no. 9, pp. 607–618, Sept. 2020, doi: 10.1177/0748233720967522.
- [109] T. Wright and H. Conley, 'Advancing gender equality in the construction sector through public procurement: Making effective use of responsive regulation', *Econ. Ind. Democr.*, vol. 41, no. 4, pp. 975–996, Nov. 2020, doi: 10.1177/0143831X17745979.
- [110] J. Shin, Y. Kim, and C. Kim, 'The Perception of Occupational Safety and Health (OSH) Regulation and Innovation Efficiency in the Construction Industry: Evidence from South Korea', *Int. J. Environ. Res. Public Health*, vol. 18, no. 5, p. 2334, Feb. 2021, doi: 10.3390/ijerph18052334.
- [111] J. Kaur, T. S. Kochhar, S. Ganguli, and S. R. S. 'Evolution of Management System Certification: An overview', *Innov. Inf. Commun. Technol. Ser.*, pp. 82–92, Feb. 2021, doi: 10.46532/978-81-950008-7-6_008.
- [112] ITCILO, 'International Training Centre of the International Labour Organization (ITCILO), Your Health and Safety at Work: Legislation and Enforcement 2022', International Training Centre of the International Labour Organization (ITCILO), 2022. Accessed: Aug. 15, 2025. [Online]. Available: https://training.itcilo.org/actrav_cdrom2/en/osh/legis/1emain.htm
- [113] A. K. Eyiah, N. A. Kheni, and P. D. Quartey, 'An Assessment of Occupational Health and Safety Regulations in Ghana: A Study of the Construction Industry', *J. Build. Constr. Plan. Res.*, vol. 07, no. 02, pp. 11–31, 2019, doi: 10.4236/jbcepr.2019.72002.