

Ethical Conduct of Civil Engineers in Construction Projects in a Fragile Developing Economy: Evidence from Khartoum State, Sudan

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Abstract:

Background: Unethical practice in construction erodes safety, quality and public value, and its effects are most acute in fragile, low-governance economies. This study assesses the self-reported ethical conduct of civil engineers in construction projects in Khartoum State, Sudan, across seven ethical dimensions derived from international codes of practice and the ethical decision-making literature

Materials and Methods: A cross-sectional survey using a 36-item, five-point Likert questionnaire was administered electronically to a random sample of practising civil engineers ($N = 70$; $n = 60$ complete item responses). Data were analysed using descriptive statistics, 95% confidence intervals, one-sample t -tests against the neutral midpoint, Cohen's d effect sizes, the Relative Importance Index (RII) and the coefficient of variation (CV) as a consensus indicator.

Results and Conclusions: All 36 items differed significantly from neutrality ($t(59) \geq 7.74$, $p < 0.001$) with very large effects ($d = 1.00$ – 6.20). The overall RII was 0.936. Professional integrity and honesty (RII = 0.973) and accountability and transparency (RII = 0.973) ranked highest, whereas safety, health and public welfare ranked lowest (RII = 0.866; mean $d = 1.61$). The weakest items were the availability of retaliation-free channels for reporting safety violations (RII = 0.830), willingness to report safety concerns at the cost of delay (RII = 0.853) and enforcement of worker-safety regulations, which also showed the lowest consensus (CV = 0.90).

Key Word: Engineering ethics; civil engineers; construction industry; professional integrity..

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I. Introduction

The construction industry is one of the major contributors to infrastructure development, job creation and economic development, but is often cited as one of the most vulnerable sectors to unethical practices and corruption^{1,2}. Big and single contracts, many middlemen, complicated technical specifications that are difficult for clients to check, and the discretion of site and supervising engineers, provide a constant source of opportunities for bribery, collusive tendering, specification fraud and concealment of defects^{3,4}. The consequences are much more than financial deficits. Poor workmanship can cause building collapses, workplace accidents and fatalities, environmental damage and long-term loss of public trust in the engineering profession^{5,6}.

Civil engineers have a crucial role within this framework. As designers, consultants, contractor representatives and project managers, they turn technical specifications into physical assets and are guardians of quality and safety. Therefore, international professional organizations acknowledge that the protection of public safety, health and welfare is the highest responsibility of engineers^{7,9}. The influence of these established principles on day-to-day behavior depends on one's ethical judgment, corporate ethos and strength of external entities^{10,11}.

Poor and vulnerable nations under more duress. Sudan has suffered from economic instability and political chaos for a long time, and since April 2023, the military conflict has ruined Khartoum's infrastructure. The country has often been among the countries with the highest levels of perceived public-sector corruption¹³. The rebuilding after the war would need an extraordinary level of construction efforts in Khartoum State, rendering the ethical competence of its engineering professionals crucial for public safety and national rehabilitation. Notwithstanding these challenges, there is a notable scarcity of empirical data regarding the ethical practices of Sudanese civil engineers: the majority of construction ethics studies are derived from the United Kingdom, Australia, Hong Kong, South Africa, Nigeria, and Malaysia^{14,17}.

This research addresses that deficiency. The purposes are to: (i) investigate the present ethical conduct of civil engineers in Khartoum State in seven facets; (ii) determine the relatively strongest and weakest facets and components; (iii) evaluate the extent of professional consensus on each; and (iv) recommend evidence-based approaches to enhance ethical practices. The research offers the first multi-faceted, empirically validated

foundation of engineering ethics in Kharoum and highlights a systemic disparity between individual integrity standards and organisational safety assistance.

II. Literature review

Professional ethics refers to the standards of conduct that a profession prescribes for its members in view of the special trust society places in their expertise¹⁸. Engineering ethics has traditionally been approached at two levels: micro-ethics, which concerns the decisions of individual engineers, and macro-ethics, which concerns the collective social responsibility of the profession and its role in technology policy¹⁹. Classical ethical theories – utilitarianism, duty-based ethics, rights ethics and virtue ethics – provide complementary lenses for resolving dilemmas such as whether to report a defect that will delay a project^{20,21}. In practice, these theories are operationalized through codes of ethics. The ASCE Code of Ethics, revised in 2020, orders engineers' responsibilities to society, the natural and built environment, the profession, clients and employers, and peers, and explicitly states that engineers shall first and foremost protect the health, safety and welfare of the public⁷. Comparable principles appear in the NSPE Code and the FIDIC Code of Ethics, which stresses integrity, impartiality, competence and the rejection of bribery in all its forms^{8,9}.

Ethical decision-making models:

Rest²², mentioned proposes a four component model in which moral awareness, moral assessment, moral purpose and moral action all play a role in ethical conduct, and in which deficiencies can occur in any phase. Jones proposed that a matter is considered to be ethical according to its 'moral intensity', which includes the importance and probability of the outcome, societal agreement, and proximity. Treviño's¹⁰ interactionist model of person and circumstance highlights the relationship between such personal traits as cognitive moral growth and locus of control and contextual factors such as organizational culture, incentive mechanisms and hierarchical frameworks. The theory of planned conduct suggests that intentions are determined by attitudes, subjective standards and perceived behavioral control²³. This last concept pertains directly to engineers who could advocate for safety standards but feel compelled to comply with hazardous directives from customers or employers. Ho argued that ethical decision-making in the construction industry is very much dependent on situational and organizational factors rather than individual beliefs¹².

Unethical practices in construction:

Systematic reviews classify unethical practices in construction into bribery, fraud, collusion and bid-rigging, embezzlement, conflicts of interest, nepotism, extortion and the deliberate compromise of quality and safety²⁴. In the tendering stage, Zarkada-Fraser and Skitmore showed that decisions to collude are shaped by perceptions of peer behaviour and the likelihood of detection³. Vee and Skitmore surveyed Australian construction professionals and found that unfair conduct, negligence, conflicts of interest, collusive tendering, confidentiality breaches and fraud were widely experienced¹⁴. Furthermore, South African professionals regarded collusion, bribery, negligence, fraud and dishonesty as pervasive, and that awareness of codes of conduct fail to guarantee compliance¹⁶. In Malaysia, ethically problematic behavior also penetrates the design phase through strategic under-specification and the exploitation of information asymmetry¹⁶. According to Lohne et al, unfair bidding, poor documentation and negligence are the most common problems from the contractors' perspectives²⁴.

Evidence from developing countries:

This problem is more serious in developing countries where corruption in construction is said to undermine both the quality and the choice of public investment, favoring projects that are either superfluous or too expensive¹. A study in Nigeria found that unethical conduct is due to low compensation, lack of enforcement, greed and a culture of impunity and that professionals are 'ambivalent' about ethics – they support codes in theory but allow their violation in practice^{17,25}. Openness, accountability and punitive actions are significantly related to corruption free project outcomes in the Indian context. The data in this body of literature suggest that the institutional context of engineers influences the ethical standards of developing nations more than their awareness of ethical rules²⁶.

Factors influencing ethical behavior:

According to Treviño¹⁰ and Ho¹², the influence elements can be divided into three levels. Personal moral judgment is shaped by ethical principles, religious and cultural affiliations, educational background, ethical instruction, and professional experiences. At the organizational level, good leadership, an ethical environment, behavior guidelines, incentive structures and support for internal disclosures are all essential, as engineers are reluctant to blow the whistle when reprisal is expected. The probability and cost of detection are externally influenced by the efficacy of regulators and professional registration bodies, transparency of procurement processes, independence of the judiciary and social norms^{5,6}. Mason in 2009 argued that there is a lack of unity of

professional codes among different building professions, which leads to the reduction of their normative effect and that a unified industry code would be more effective²⁷. Anti-bribery management frameworks such as ISO 37001, provide organizational structures for both prevention and detection²⁸.

The Sudanese context:

The construction industry in Sudan is regulated by the Sudan Engineering Council. It registers engineers and promotes ethical practices. There are also national building codes and laws on public procurement. However, the country's ongoing economic challenges, high inflation, limited regulatory capacity and lack of transparency in public procurement have created a fertile ground for unethical practices¹³. The destruction of large parts of Khartoum's infrastructure since 2023 indicates that the ethical standards of the engineering workforce will directly impact the safety and cost-effectiveness of the reconstruction process.

Three gaps arise. First of all, there is a serious lack of empirical studies on ethical practices among civil engineers in Khartoum. Second, most of the previous research has focused on one area (corruption or procurement, for example) rather than a more complete picture that meets professional standards. Third, the majority of studies do not separate personal standards of integrity from the organizational conditions (eg mechanisms for reporting and authority to refuse dangerous directives) which allow those standards to be acted upon. In this way, the present research utilizes seven dimensions of ASCE⁷, NSPE⁸, and FIDIC⁹ as follows: professional integrity and honesty (PI), compliance with regulations and standards (CR), accountability and transparency (AT), awareness of ethical guidelines (AW), safety, health, and public welfare (SH), competence and continuing professional development (CP), and honesty in professional discourse (HC).

III. Research Methodology and Design

Research design:

A post-positivist, quantitative, descriptive–analytical cross-sectional survey design was adopted, consistent with the prevailing approach in construction-ethics research^{14,15}. The research process is summarized in Figure 1.

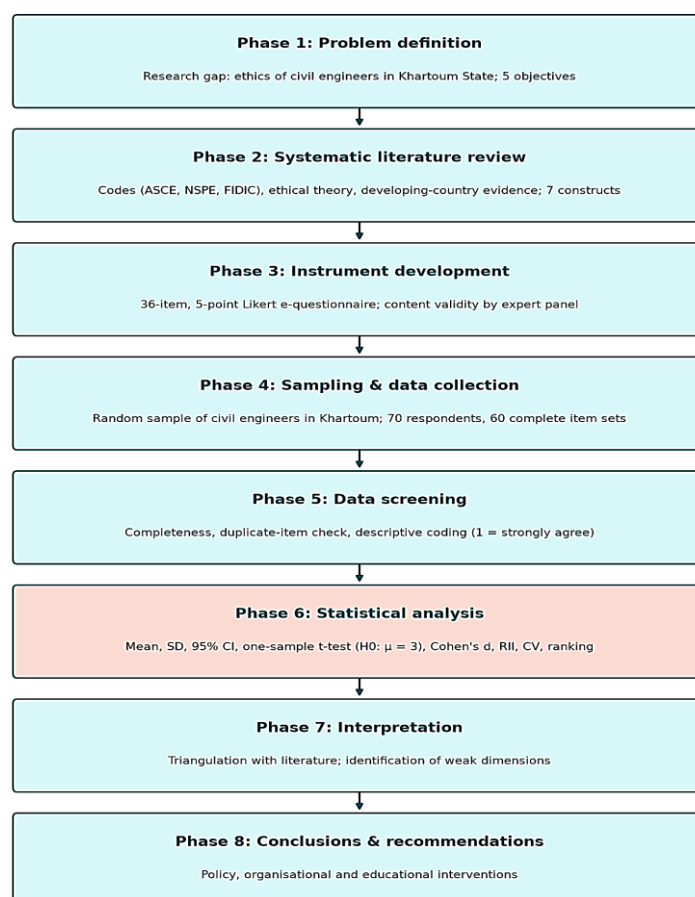


Figure no1: Shows metabolic parameters of patients of the three groups before treatment.

Population, sample and data collection:

The population comprised practicing civil engineers working on construction projects in Khartoum State. A random sample was invited to complete an electronic questionnaire. In total, 70 engineers responded; 60 provided complete responses to all attitudinal items and were retained for inferential analysis ($n = 60$). For an unknown population, $n = 60$ yields a margin of error of approximately $\pm 12.7\%$ at 95% confidence for proportions; however, given the very large observed effects ($d \geq 1.0$), the statistical power of one-sample t-tests at $\alpha = 0.05$ exceeds 0.99 for every item²⁹.

Instrument:

The questionnaire comprised two sections. Section 1 recorded education, years of experience and job position. Section 2 contained 36 statements measuring the seven dimensions (five or six items each) on a five-point Likert scale coded 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree and 5 = strongly disagree³⁰. Content validity was established through review by a panel of academic staff in civil engineering, whose comments were incorporated before distribution.

1. Data analysis

Analyses were performed in Microsoft Excel and verified in Python (SciPy). For each item the following were computed:

- Mean (M), standard deviation (SD) and standard error $SE = SD/\sqrt{n}$;
- One-sample t-test against the neutral midpoint ($\mu_0 = 3$): $t = (3 - M)/SE$, $df = n - 1$, with two-tailed p-values;
- 95% confidence interval: $M \pm t_{0.025,59} \times SE$;
- Cohen's $d = (3 - M)/SD$, interpreted as small (0.2), medium (0.5) and large (0.8)²⁹;
- Relative Importance Index $RII = (6 - M)/5$, which re-expresses the reverse-coded mean on a 0.2–1.0 agreement scale; $RII \geq 0.8$ is classed as high³¹;
- Coefficient of variation $CV = SD/M$ as an index of consensus, with $CV > 0.50$ indicating weak consensus;
- Dimension scores as the mean of item means, with composite t-tests using the mean item SD.

Participation was voluntary and anonymous; no identifying data were collected. Given the sensitivity of ethics research, respondents were assured that responses would be reported only in aggregate.

IV. Results

Table 1. Demonstrated that, most participants had a bachelor's degree (57.1%), while 21.4% were at the post-graduate level. The cohort was predominantly in the 11-20 years experience of their careers, while only 7.1% had >20 years. Site engineers were the most significant group for the project managers (38.6) and consulting engineers (35.7). Engineers from contracting firms were poorly represented (4.3).

Table no1: Respondent profile ($N = 70$)

Variable	Category	n	%
Education	Diploma	15	21.4
	Bachelor's	40	57.1
	Master's	10	14.3
	Doctorate	5	7.1
Experience	<5 yrs	15	21.4
	5-10 yrs	20	28.6
	11-20 yrs	30	42.9
	>20 yrs	5	7.1
Position	Project manager	15	21.4
	Site engineer	27	38.6
	Consulting engineer	25	35.7
	Contractor engineer	3	4.3

Table no2: Descriptive and inferential statistics by ethical dimension ($n = 60$; all $p < 0.001$)

Code	Dimension	Items	Mean	Mean SD	t(59)	Mean d	RII	Rank
PI	Professional integrity and honesty	5	1.133	0.373	38.75	5.14	0.973	1
CR	Compliance with regulations and standards	5	1.350	0.752	17.00	2.61	0.930	5
AT	Accountability and transparency	5	1.133	0.373	38.75	5.14	0.973	2
AW	Awareness of ethical regulations	6	1.289	0.675	19.62	3.00	0.942	3
SH	Safety, health and public welfare	5	1.670	0.831	12.39	1.61	0.866	7

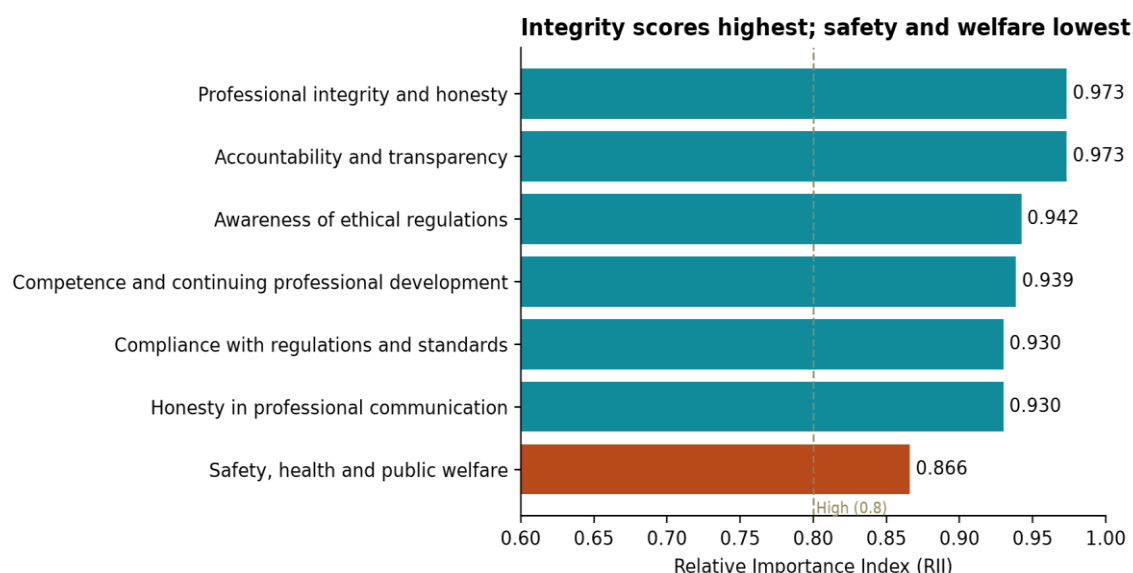


Figure no2: Relative Importance Index by ethical dimension

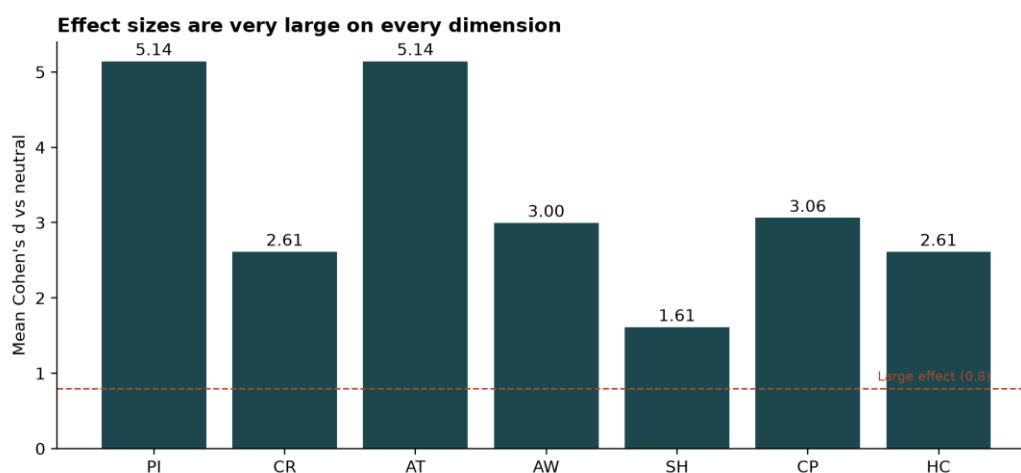


Figure no3: Mean Cohen's d effect size versus the neutral midpoint, by dimension

Table 2, Figures 2 and 3 illustrated that, all seven dimensions were rated significantly on the agreement side of the scale (Table 2). The overall mean across the 36 items was 1.318 (RII = 0.936), indicating forceful self-reported endorsement of ethical conduct. Professional integrity and honesty ($M = 1.133$, $RII = 0.973$) and accountability and transparency ($M = 1.133$, $RII = 0.973$) ranked jointly first, followed by awareness of ethical regulations ($RII = 0.942$) and competence and CPD ($RII = 0.939$). Compliance with regulations and honesty in communication tied fifth ($RII = 0.930$). Safety, health, and public welfare ranked clearly last ($M = 1.670$, $RII = 0.866$), with the smallest mean effect size ($d = 1.61$)

Table no3: Five highest- and seven lowest-rated items

Rank	Code	Item	Mean	SD	95% CI	t(59)	d	RII
1	PI1	Engineers accurately present project progress and clients' financial status	1.067	0.312	0.99–1.15	48.04	6.20	0.987
2	AT1	Engineers bear responsibility for errors and omissions in execution	1.067	0.312	0.99–1.15	48.04	6.20	0.987
3	PI2	Bribery and corruption cases are rare in construction projects in Khartoum State	1.117	0.324	1.03–1.20	45.06	5.82	0.977
4	AT2	Sufficient transparency in bidding and procurement	1.117	0.324	1.03–1.20	45.06	5.82	0.977
5	PI4	Strong commitment to avoiding conflicts of interest	1.133	0.343	1.04–1.22	42.18	5.45	0.973
30	CR3	Worker safety regulations are strictly enforced on site	1.583	1.418	1.22–1.95	7.74	1.00	0.883

31	AW3	Ethical understanding derives mainly from institutional policies/codes	1.583	1.418	1.22–1.95	7.74	1.00	0.883
32	HC3	Falsifying qualifications or exaggerating experience is rare	1.583	1.418	1.22–1.95	7.74	1.00	0.883
33	SH4	Feel empowered to refuse instructions that jeopardise safety	1.600	0.807	1.39–1.81	13.44	1.74	0.880
34	SH1	Public safety, health and welfare is the highest consideration in decisions	1.633	0.863	1.41–1.86	12.27	1.58	0.873
35	SH2	Would report serious safety concerns even if causing delay or cost	1.733	0.880	1.51–1.96	11.14	1.44	0.853
36	SH5	Clear channels exist to report violations without fear of retaliation	1.850	0.860	1.63–2.07	10.36	1.34	0.830

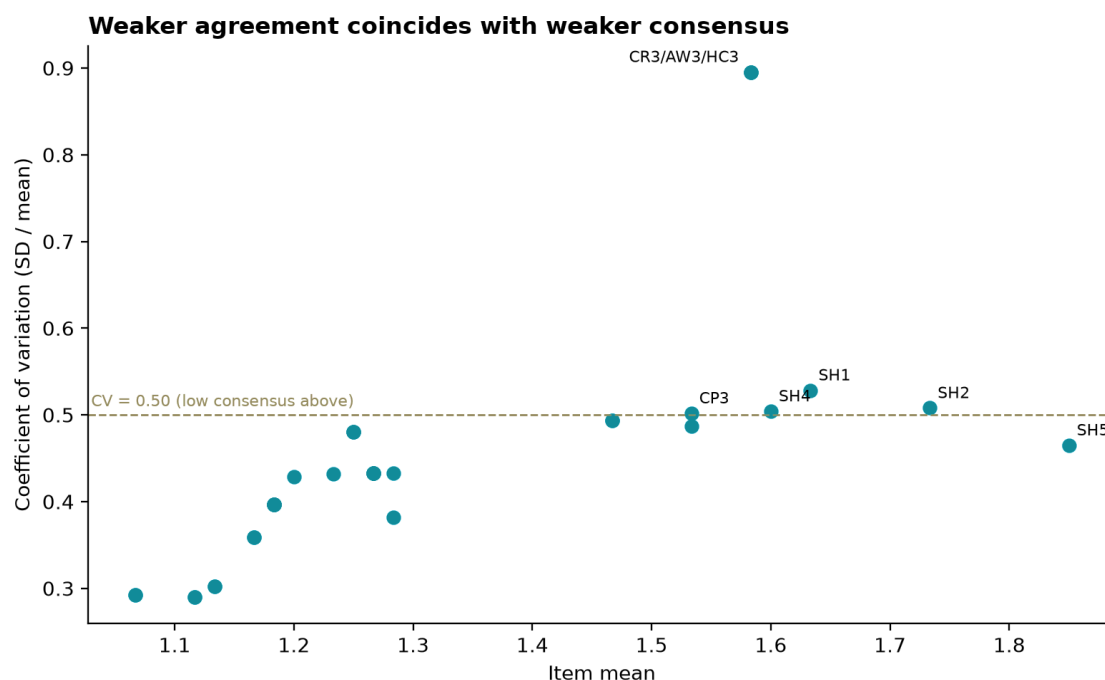


Figure no4: Item mean versus coefficient of variation

In Figures 4 and Table 3 shown, all items differed substantially from the neutral midpoint (minimum $t(59) = 7.74$, $p < 0.001$) with effect sizes ranging from large to enormous ($d = 1.00$ – 6.20). The most appreciated aspects were the accuracy of the documentation of progress and financial status of projects (PI1, $M = 1.067$) and responsibility for mistakes and oversights (AT1, $M = 1.067$), followed by the rare occurrence of corruption (PI2) and transparency in procurement procedures (AT2) ($M = 1.117$). The least rated item was the availability of a clear channel to report safety or health violations without the fear of retaliation (SH5, $M = 1.850$, $RII = 0.830$), followed by the readiness to report serious safety issues even at the cost of delays or increased costs (SH2, $M = 1.733$) and the prioritization of public safety above everything else (SH1, $M = 1.633$). Similarly, the provision of CPD resources by employers (CP3, $M = 1.533$) and compliance to international site safety standards (SH3, $M = 1.533$) were among the least robust.

The CV ranged from 0.29 to 0.90. Integrity and accountability items showed strong consensus ($CV \approx 0.29$ – 0.30). By contrast, the enforcement of worker-safety regulations (CR3), reliance on formal institutional codes (AW3) and the rarity of falsified qualifications (HC3) exhibited markedly weak consensus ($SD = 1.418$, $CV = 0.90$), implying a polarised group of respondents who disagreed. Four of the five safety items lay at or above $CV = 0.50$. The positive association between item mean and CV indicates that where agreement is weaker, opinions are also more divided.

V. Discussion

The robust affirmation of integrity, accountability, and honesty aligns with the normative principles of international standards ASCE⁷ and FIDIC⁹ and may also mirror the religious and cultural values that shape professional behaviour in Sudanese culture. Nevertheless, the nearly maximum scores ($M \approx 1.07$ – 1.17) for assertions like 'bribery and corruption cases are infrequent' starkly contrast with the external indications of significant perceived corruption in Sudan¹³ and with the literature on construction-related corruption in similar

economies^{1,13}. This discrepancy reflects the 'ambivalence' articulated by Ameh and Odusami²⁵ in 2010 and aligns with social desirability bias, which exaggerates self-reported data on delicate subjects^{32,33}. The outcomes should therefore be seen as a robust normative endorsement rather than as evidence of behavioral adherence.

The most substantive finding is that safety, health and public welfare – the dimension placed first by every major code – ranked last, and that the weakest items concern institutional enablers rather than personal values: retaliation-free reporting channels, the authority to refuse unsafe instructions and willingness to accept delay or cost to raise safety concerns. Engineers demonstrate moral awareness and judgement according to Rest's model²², but they face constraints when transitioning to moral action. In Ajzen's²³ terms, perceived behavioural control is low. This is consistent with the interactionist perspective of Treviño's¹⁰ and the finding of Ho's¹² that organizational and situational pressures often dominate individual ethics in construction. The weak consensus on how to enforce worker-safety regulations also suggests uneven safety practice across firms and projects.

Awareness of ethical regulations was high, but reliance on formal institutional codes showed the weakest consensus, and respondents drew ethical understanding from a mix of international codes, professional associations, and colleagues. This fragmented source of ethical knowledge echoes Mason's²⁷ in 2009 critique of multiple codes and points to the need for a unified, enforced national code. Similarly, while engineers reported personal commitment to competence and CPD, employer provision of CPD resources was among the lowest-rated items—again indicating that the organizational rather than the individual layer is the binding constraint.

For regulators, the results support prioritising whistle-blower protection and independent safety-reporting mechanisms over further awareness campaigns. For firms, they highlight the value of formal ethics programmes, stop-work authority and anti-bribery management systems such as ISO 37001²⁸. For educators, they suggest that ethics curricula should move beyond code awareness to scenario-based training in ethical action under pressure. These measures are particularly time-sensitive for the post-conflict reconstruction of Khartoum.

VI. Conclusion

The current investigation establishes the first multi-faceted, statistically validated benchmark for the ethical practices of civil engineers in Khartoum State. Four inferences may be drawn. Initially, engineers indicate a robust consensus about ethical standards across all seven categories (overall RII = 0.936; all $p < 0.001$). Secondly, the aspects of integrity, honesty, and accountability obtain the highest level of endorsement. Third, the dimension of safety, health, and public welfare is the most deficient, exhibiting its weakest elements being institutional: routes for reporting without fear of reprisal, the power to decline harmful directives, and the acceptance of delays for safety considerations. Fourth, a lack of agreement on the implementation of site-safety standards and the application of formal norms signifies variable practices across the industry. The primary assertion is that the ethical dilemma within Khartoum's building industry is more attributable to the institutional frameworks than to the individual values of engineers.

VII. Recommendations

The research recommendation are:

1. The Sudan Engineering Council should establish a modern ethical code in line with ASCE (2020) and FIDIC (2021).
2. Clear disciplinary procedures must be integrated into the ethical code.
3. Legislative protections for whistle-blowers should be created, including secure reporting channels for safety or corruption issues.
4. Continuing professional development, including an ethical component, should be mandatory for registration renewal.
5. E-procurement and autonomous audits are necessary for public rebuilding projects.
6. Site engineers need official stop-work authority to maintain safety.
7. Ethics and compliance initiatives must include anti-bribery frameworks and conflict-of-interest registries, with dedicated funds for training and reporting.
8. Engineering curricula should incorporate ethics and provide mentorship for new engineers.

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