Evaluation of Building Structural Strength: Insights from Licensed Civil Engineers

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ABSTRACT

This study examined the factors affecting the structural strength of buildings and the challenges encountered by licensed civil engineers in evaluating structural integrity on Siargao Island, Surigao del Norte. Specifically, it investigated foundation design and soil conditions, quality of construction materials, structural design and load-bearing capacity, workmanship, and compliance with building codes and safety standards. A descriptive-comparative design was used involving forty (40) licensed civil engineers in DPWH Siargao Island. Data were gathered using a researcher-made questionnaire and analyzed using weighted mean, standard deviation, t-test, and ANOVA to determine levels of influence and group differences across profile variables.

Findings showed that all factors had a very high influence on structural strength, with soil conditions ranked highest ($M = 3.81$, $SD = 0.48$), followed by materials ($M = 3.78$, $SD = 0.42$), load-bearing capacity ($M = 3.78$, $SD = 0.42$), workmanship ($M = 3.77$, $SD = 0.43$), and building codes ($M = 3.69$, $SD = 0.50$). Key challenges included material degradation, hidden defects, and incomplete documentation. Inferential results indicated significant differences in selected variables, particularly load-bearing capacity when grouped according to sex ($F = 5.153$, $p = .028$) and years of experience ($F = 4.825$, $p = .012$), while no significant differences were observed in most other comparisons. Overall, load-bearing capacity consistently showed statistically significant variation across key professional profiles, underscoring its central role in structural safety assessment and engineering decision-making. The study underscores the need for comprehensive engineering assessment, strict adherence to standards, and improved documentation practices, leading to the development of policy guidelines aimed at enhancing structural performance and sustainability in the locality.

Keywords: Structural strength, licensed civil engineers, construction materials, building codes, structural safety, policy guidelines, long-term building performance.

INTRODUCTION

The structural strength of buildings is critical to public safety, infrastructure resilience, and sustainable development. With the continuous growth of construction activities, the need for reliable structural evaluation has become increasingly important. Structural failures resulting from inadequate design, poor-quality materials, deficient construction practices, and non-compliance with engineering standards can lead to substantial economic losses and risks to human life. Consequently, structural health monitoring and engineering assessment have become essential in evaluating structural integrity, ensuring the safety and serviceability of buildings, and supporting informed maintenance and rehabilitation decisions throughout a structure's service life (Su et al., 2020).

Building structural strength is influenced by several interrelated factors, including foundation design and soil conditions, quality of construction materials, structural design and load-bearing capacity, workmanship and construction practices, and compliance with building codes and safety standards. Previous studies have emphasized that proper geotechnical investigations are essential for reducing uncertainties in foundation design and improving structural reliability (Otake & Honjo, 2022). Likewise, integrated structural design that incorporates appropriate material selection and effective construction practices contributes to enhancing the safety, durability, and long-term performance of buildings (Ming et al., 2022). Furthermore, structural health monitoring and engineering assessment are critical for evaluating structural condition, detecting deterioration, and supporting maintenance and rehabilitation decisions throughout a structure's service life (Su et al., 2020).

Despite extensive research in structural engineering, limited studies have explored the perspectives of licensed civil engineers regarding the factors affecting building structural strength and the challenges encountered during structural evaluation, particularly in the context of Siargao Island. To address this gap, the present study investigates these factors and challenges to generate evidence-based insights that may inform policy development and engineering practices aimed at enhancing structural safety and resilience. Furthermore, the study contributes to the achievement of the United Nations Sustainable Development Goals, particularly SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities), by promoting the development of safe, durable, and sustainable infrastructure.

METHODOLOGY

This study employed a descriptive-comparative research design to examine the factors affecting the structural strength of buildings and the challenges encountered by licensed civil engineers in evaluating structural performance. The respondents were all the 40 licensed civil engineers from the Department of Public Works and Highways (DPWH) in Siargao Island, Surigao del Norte.

Data were gathered using a researcher-developed and expert-validated questionnaire that measured foundation design and soil conditions, quality of construction materials, structural design and load-bearing capacity, workmanship and construction practices, compliance with building codes and safety standards, internal consistency were assessed using Cronbach’s alpha. The study was conducted in Siargao Island, a rapidly developing area with increasing infrastructure and construction activities.

Descriptive statistics, including frequency, percentage, weighted mean, and standard deviation, were used to summarize the data and ranked the challenges that licensed civil engineers encountered when evaluating structural safety. Independent samples t-test and one-way ANOVA determined differences in respondents’ assessments based on profile variables, while Pearson Product-Moment Correlation examined relationships among the study variables. Ethical standards were observed through informed consent, voluntary participation, and the protection of respondents’ confidentiality and anonymity.

RESULTS AND DISCUSSION

This section presents the quantitative findings on factors affecting the structural strength of buildings and the challenges encountered by licensed civil engineers in structural evaluation. It covers respondents’ profiles, assessments of key structural factors, and tests of differences and relationships among variables. The results are interpreted alongside relevant literature to provide an integrated understanding of structural performance factors and engineers’ professional perspectives.

Profile of the Respondents

Table 1. Profile of the Respondents in terms of age, sex, years of professional experience, field of specialization, and types of projects handled

Profile	Category	f	%
Age	20–25 years old	5	12.5
	26-30 years old	19	47.5
	31-35 years old	7	17.5
	36-40 years old	6	15.0
	41-45 years old	3	7.5
Sex	Male	26	65.0

	Female	14	35.0
Years of Professional Experience	2-7	20	50.0
	8-12	15	37.5
	13-18	5	12.5
Field of Specialization	Civil	40	100.0
Types of Projects Handled	Buildings	40	100.0

Table 1 shows the profile of the respondents in terms of age, sex, years of professional experience, field of specialization, and types of projects handled.

In terms of age, the majority of the respondents were 26–30 years old (47.5%), followed by those aged 31–35 years old (17.5%), 36–40 years old (15.0%), 20–25 years old (12.5%), and 41–45 years old (7.5%). The results indicate that most respondents were young professionals who are actively involved in engineering practice and are likely familiar with current construction methods and industry standards.

Regarding sex, most of the respondents were male (65.0%), while female respondents accounted for 35.0% of the sample. This distribution reflects the demographic trend commonly observed in the engineering profession, where male practitioners continue to comprise a larger proportion of the workforce.

As to years of professional experience, half of the respondents (50.0%) had 2–7 years of professional experience, while 37.5% had 8–12 years and 12.5% had 13–18 years of experience. These findings suggest that the respondents had sufficient practical exposure and professional knowledge to provide informed assessments related to the study.

In terms of field of specialization, all respondents (100.0%) specialized in Civil Engineering. This indicates that the participants possessed the technical expertise and educational background necessary to evaluate factors affecting the structural strength of buildings.

With respect to the types of projects handled, all respondents (100.0%) reported involvement in building projects. Their direct experience in the planning, design, construction, and supervision of building structures provides a relevant basis for assessing structural performance and related engineering concerns.

Overall, the respondents constitute a qualified group of civil engineers with relevant experience and project exposure. Their professional background strengthens the credibility of the data gathered and supports the reliability of the study findings.

Table 2. Factors Affecting the Structural Strength of Buildings

Indicators	**M**	**SD**	**Verbal Interpretation**
Foundation Design and Soil Condition Affecting the Structural Strength of Buildings	3.81	0.48	Highly Manifested
Quality of Construction Materials Affecting the Structural Strength of a Building	3.78	0.42	Highly Manifested
Structural Design and Load-bearing Capacity	3.78	0.42	Highly Manifested
Workmanship and Construction Practices	3.77	0.43	Highly Manifested
Compliance with Building Codes and Safety Standards	3.69	0.50	Highly Manifested
Overall	3.77	0.45	Highly Manifested

Table 2 shows that respondents strongly agree that various factors significantly affect the structural strength of buildings, as reflected in the overall mean of 3.77 and standard deviation of 0.45, indicating a high level of agreement and relatively consistent responses. This suggests that respondents share a common understanding of the key determinants that contribute to the safety, stability, and durability of building structures.

Among the indicators, foundation design and soil condition obtained the highest mean (M = 3.81, SD = 0.48), highlighting its perceived importance in ensuring structural stability. This finding emphasizes the critical role of proper geotechnical assessment and foundation design in safely transferring building loads to the ground and preventing structural failure. The result is consistent with the provisions of the National Building Code of the Philippines and its implementing rules and regulations, which emphasize the importance of proper site evaluation, soil investigation, and structural safety in building design and construction (Department of Public Works and Highways [DPWH], 2015). Likewise, quality of construction materials and structural design and load-bearing capacity both obtained a mean of 3.78 (SD = 0.42), indicating that respondents recognize the importance of durable materials and sound engineering design in maintaining structural performance and safety.

Workmanship and construction practices also received a high rating (M = 3.77, SD = 0.43), suggesting that respondents acknowledge the significant influence of construction execution on the overall strength of a building. Even when high-quality materials and proper designs are utilized, poor workmanship can result in defects that compromise structural integrity. Similarly, compliance with building codes and safety standards (M = 3.69, SD = 0.50) highlights the importance of adhering to regulatory requirements established under the National Building Code of the Philippines to ensure safe and resilient structures.

Overall, the findings indicate that structural strength is influenced by a combination of technical, material, and procedural factors. While each factor contributes differently, the consistently high ratings demonstrate that respondents consider foundation integrity, material quality, structural design, workmanship, and compliance with standards as essential components of a safe and durable structure. These findings are aligned with Philippine construction regulations and safety requirements governing building design and structural reliability (DPWH, 2015).

Challenges Licensed Civil Engineers Encountered when Evaluating Structural Safety

Table 3. Challenges

Indicators	**Rank**	**f**	**%**
1. Material degradation and aging of structures.	1	39	97.5%
2. Hidden construction defects and poor workmanship.	2	38	95.0%
3. Incomplete of inaccurate structural documentation.	3	37	92.5%
4. Uncertainty in load estimation and environmental forces.	4	35	87.5%
5. Uncertainty in soil investigations and foundation conditions.	5	33	82.5%
6. Budgetary and time constraints in conducting thorough assessments.	6	33	82.5%
7. Modeling and analytical limitations.	7	29	72.5%
8. Frequent updates and inconsistencies in building codes.	8	28	70.0%
Total	8	40	100%

Table 3 reveals that licensed civil engineers commonly encounter multiple challenges when evaluating structural safety, with material degradation and aging of structures ranked as the most frequently reported (39, 97.5%). The second and third most encountered challenges are hidden construction defects and poor workmanship (38, 95.0%), and incomplete or inaccurate structural documentation (37, 92.5%). Other challenges such as uncertainty in load estimation, soil and foundation conditions, budget and time constraints, modeling limitations, and frequent updates in building codes are also widely experienced, although with slightly lower frequencies.

These findings indicate that most challenges are technical and construction-related, particularly those involving the physical condition of structures and the quality of available project documentation. This suggests that structural evaluation is highly dependent on the accuracy of as-built information and the integrity of existing materials, which directly affect engineering judgment and assessment reliability.

These findings are consistent with studies on building condition assessment, which report that structural evaluation of existing buildings is mainly affected by material deterioration and construction defects, leading to challenges in reliable condition assessment (Faqih & Zayed, 2021). In support of this, the National Structural Code of the Philippines and the Department of Public Works and Highways emphasize that uncertainties in structural evaluation should be addressed through proper site investigation, conservative design assumptions,

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and strict compliance with structural requirements (DPWH, 2015). The NSCP further highlights the importance of engineering judgment and detailed assessment in ensuring the safety and reliability of existing structures.

Table 4. Test of Difference in the Factors Affecting the Structural Strength of a Building When Grouped According to Profile Variables

Independent Variable	Dependent Variable	ρ	p-value	Conclusion
Age	Soil Factors	7.384	<.001	Significant
	Materials Factors	0.831	0.512	Not significant
	Load-Bearing Capacity Factors	1.602	0.190	Not significant
	Workmanship Factors	0.475	0.754	Not significant
	Building codes factors	1.668	0.174	Not significant
	Challenges	3.344	0.018	Significant
Sex	Soil Factors	2.211	0.144	Not significant
	Materials Factors	1.153	0.288	Not significant
	Load-Bearing Capacity Factors	5.153	0.028	Significant
	Workmanship Factors	2.826	0.099	Not significant
	Building codes factors	4.301	0.043	Significant
	Challenges	0.355	0.0554	Not significant
Years of Professional Experience	Soil Factors	0.976	0.384	Not significant
	Materials Factors	6.501	0.003	Significant
	Load-Bearing Capacity Factors	4.825	0.012	Significant
	Workmanship Factors	0.961	0.390	Not significant
	Building codes factors	4.065	0.024	Significant
	Challenges	0.387	0.681	Not significant
Field of Specialization	Soil Factors	0.0300	0.970	Not significant
	Materials Factors	1.0185	0.369	Not significant
	Load-Bearing Capacity Factors	0.3594	0.700	Not significant
	Workmanship Factors	0.7182	0.493	Not significant
	Building codes factors	2.7333	0.075	Not significant
	Challenges	1.2966	0.283	Not significant
Types of Projects Handled	Soil Factors	0.6434	0.530	Not significant
	Materials Factors	0.6829	0.510	Not significant
	Load-Bearing Capacity Factors	4.7504	0.013	Significant
	Workmanship Factors	0.0491	0.952	Not significant
	Building codes factors	0.9086	0.410	Not significant
	Challenges	0.7639	0.472	Not significant

Table 12 shows that several profile variables significantly influenced respondents' assessments of factors affecting the structural strength of buildings. Significant differences were observed in soil factors and challenges when grouped by age; load-bearing capacity and building code factors when grouped by sex; materials, load-bearing capacity, and building code factors when grouped by years of professional experience; and load-bearing capacity factors when grouped by types of projects handled. In contrast, no significant differences were found across all factors when grouped according to field of specialization.

These findings suggest that demographic and professional characteristics influence how licensed civil engineers evaluate structural strength factors. Variations in age, experience, and project exposure may shape engineers' perspectives on structural requirements and construction practices. Notably, load-bearing capacity emerged as the most consistently significant factor across profile variables, underscoring its central role in structural assessment. This finding aligns with studies emphasizing that the safety and efficiency of structural elements such as beams, slabs, and columns depend on accurate load-bearing capacity analysis and proper optimization of structural design to prevent failure (Afolabi, 2020).

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The results further indicate that while fundamental engineering principles remain consistent, differences in professional experience and project involvement can influence the evaluation of structural factors. These findings highlight the importance of skilled labor competence, experience, and workforce capability in improving project performance and ensuring construction quality and safety outcomes. Skilled and unskilled labor significantly affect construction efficiency, productivity, and overall project success, emphasizing the need for proper training and capability development among construction personnel (Hussain et al., 2020).

Proposed Policy Guidelines

This study proposes policy guidelines to enhance the safety, stability, and durability of buildings, based on key factors affecting structural strength, including foundation design and soil conditions, quality of construction materials, structural design and load-bearing capacity, workmanship, and compliance with building codes and safety standards. These guidelines aim to minimize structural risks and strengthen resilience against environmental and construction-related hazards.

1. Strengthen soil investigation and foundation design policies by requiring mandatory geotechnical investigations prior to construction to ensure proper assessment of soil strength and subsurface conditions.

2. Enforce the use of high-quality construction materials through certification, regular testing, and accreditation to ensure compliance with established standards.

3. Standardize structural design and load-bearing requirements by mandating strict review and approval processes to ensure structural safety and adequacy.

4. Enhance workmanship and construction practices by requiring skilled and certified labor, proper supervision, and adherence to standard construction procedures.

5. Strengthen compliance with building codes and safety standards through regular inspections, monitoring, and enforcement of penalties for violations.

6. Promote continuous professional training and capacity building for engineers and construction personnel to update knowledge on modern techniques, materials, and safety standards.

7. Improve structural monitoring and maintenance systems by requiring regular inspections and preventive maintenance to detect early signs of deterioration or defects.

8. Integrate advanced structural analysis technologies to improve accuracy in design, load estimation, and overall structural reliability.

9. Enhance documentation and data management systems by requiring complete and accurate records for all construction projects to support evaluation and maintenance.

10. Strengthen budget allocation and project planning to ensure sufficient resources and realistic timelines for quality construction and safety compliance.

11. Promote interdisciplinary collaboration among engineers, contractors, government agencies, and stakeholders to ensure coordinated implementation of safety practices and standards.

These policy guidelines collectively aim to improve structural integrity, ensure compliance with engineering standards, and promote safer and more resilient infrastructure development.

CONCLUSION

Structural strength of buildings is influenced by multiple interrelated technical factors, including soil conditions, quality of construction materials, structural design and load-bearing capacity, workmanship, and compliance

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with building codes and safety standards. Although these factors consistently showed positive relationships with structural strength, only selected associations and group differences were found to be statistically significant, indicating that structural integrity is not determined by a single dominant factor but by the interaction of several engineering and construction elements. The findings further reveal that certain demographic and professional characteristics of civil engineers—such as age, sex, years of experience, and types of projects handled—significantly influence selected structural assessments, while field of specialization does not. Overall, the results emphasize that ensuring structural strength requires a holistic approach that integrates sound engineering design, quality construction practices, strict regulatory compliance, and the application of professional expertise in structural evaluation and decision-making.

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