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THE FACTORS INFLUENCING TO CRANE OPERATION IN ENGINEERING WORKS.

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ABSTRACT

This research aims to investigate the factors influencing the operation of cranes in engineering work through a quantitative study utilizing the Analytical Hierarchy Process (AHP). This tool systematically evaluates complex and interdependent safety factors, enabling structured decision-making and improving the precision in determining root causes affecting crane safety. questionnaire was completed by experts such as construction engineers, construction managers, safety engineers, and Tower Crane operators with more than ten years of field experience. The findings reveal that the enforcement of legal regulations and associated penalties is the most significant factor, with a weight of 68.92%. This is due to the legal requirement for employers to ensure that employees involved in crane operations comply with established safety standards. However, inefficiencies in law enforcement and the lack of stringent penalties for non-compliance have hindered effective implementation. The second most significant factor is the non-compliance of businesses and users with legal requirements, with a weight of 10.88%, followed by adherence to crane operation standards (10.46%) and the failure of crane importers to comply with legal requirements (9.74%). In Thailand, the Ministerial Regulation on Standards for Management, Operation, and Safety of Machinery, Cranes, and Boilers, B.E. 2564 (2021) serves as the principal legal framework guiding employers and users to ensure workplace safety. Despite this, government agencies responsible for oversight lack the effectiveness needed for law enforcement, leading to frequent crane-related accidents. It is recommended that government agencies adopt proactive measures, such as providing training and knowledge dissemination to businesses and operators, to enhance safety in crane operations.

Keywords: Factors; Accidents; Crane Operations; Engineering, Construction.

1. Introduction

The industrial sector in Thailand has witnessed continuous development and expansion across both the construction and manufacturing industries. This growth has been supported by the transfer of technology from foreign countries through various forms of assistance, whether at the government-to-government or private-sector level. As a result, technological advancements in machinery have progressed rapidly, steering the Thai way of life increasingly toward industrialization. The use of machinery and labour-saving equipment has become more prevalent.

[1] In Thailand Law who used the machine, Crane and boiler. Need to follow by the Law [2] Cranes are one such type of machinery that has been widely adopted, regardless of the scale of operations. Consequently, users must acquire the knowledge and skills to operate cranes correctly and safely while minimizing operational errors. This includes selecting appropriate lifting gear, calculating sling tension, applying proper rigging methods for securing and transporting materials, and ensuring that operators possess the required certification [3] Sayun Chimpradit (2023) These foundational skills are essential for users of all types of cranes—tower cranes, mobile cranes, and stationary cranes—and must align with legal standards and engineering principles. The research clearly indicates that to work with cranes, operators must have knowledge and experience in the work.

Cranes are a human-made phenomenon, but their use has occasionally led to tragic incidents. Historical records of crane-related accidents reported in the media include:

- [4] On November 29, 2016, at 3:30 PM, a crane collapse occurred at the construction site of Shrewsbury International School on Rama IX Road, resulting in five fatalities (including supervisors, engineers, and workers) and one injury.
- [5] On August 30, 2018, at 1:30 PM, a crane collapse occurred at the construction site of The Rise Rama 9 condominium, where the crane operator attempted to lift precast concrete slabs that became entangled with the structure. The operator forced the lift, causing the crane to collapse, leading to one fatality.
- [6] On January 23, 2019, at 1:00 PM, a crane collapsed at the Lumpini Place Rama 3 condominium project, resulting in five fatalities.
- [7] On June 19, 2019, at 10:00 AM, a crane collapsed during renovations at the River Garden Hotel on Charoenkrung Road, Bang Rak district, causing one injury.

[8] W. Kongsong (2010) emphasized that engineering inspection processes involve investigating damages, degradation, collapse, or failure, identifying the root causes of problems, providing recommendations for repairs and maintenance, and determining liability for damages or degradation. These processes also contribute to the preparation of expert witness testimony in court proceedings, enabling judges to make decisions in accordance with the law. [9] C. Alongkorntaksin (2015) developed a training program focused on tower crane inspections. This experimental research covered daily pre-operation inspection

processes, with an emphasis on improving inspection practices and enhancing the competency of trainees. The findings revealed that the training program achieved an efficiency level of 88.16/83.92, surpassing the set threshold of 80/80. Consequently, the program contributed to a reduction in tower crane-related accidents. Given the above, it is crucial to study the factors influencing the use of cranes in engineering operations. The findings from this study will inform analyses aimed at identifying solutions and developing practical guidelines for future implementation.

2. Research Objective

2.1 To study the level of factors affecting the safe use of cranes in engineering work.

3. Materials and Methods

3.1 Materials

The research utilized a questionnaire designed by applying the AHP to analyze the weighting of factors influencing crane operation in engineering tasks. AHP is a widely used decision-making process for diagnostic and analytical purposes, recognized as one of the most effective and efficient methods globally. [10] This methodology was devised in the late 1970s by Professor Thomas Saaty, who earned a Ph.D. in Mathematics from Yale University, USA. The AHP approach decomposes factors into hierarchical components, represented in a structured diagram, and assigns values through pairwise comparisons of these factors. The results are then calculated to determine the relative priority of each factor and option. In this study, the AHP method was implemented by gathering opinions from a sample population and analyzing the data using an AHP-based approach. This approach allowed for the determination of the weight of importance for primary and secondary criteria. The analysis utilized a nine-level pairwise comparison scale, as shown in Table 1.

Table 1. Pairwise Comparison Scale

Preference Level	Numerical Value
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

Source: Saaty, T.L. (1980). The Analytic Hierarchy. New York: McGraw-Hill.

3.2 Method

This study employed a qualitative research approach, involving field data collection using a questionnaire designed with the AHP. The questionnaire was completed by experts such as construction engineers, construction managers, safety engineers, and Tower Crane operators with more than ten years of field experience. The collected data were analyzed and summarized using descriptive statistical methods. The conceptual framework focused on factors influencing crane operation in engineering work, with details as follows:

Independent Variables

1. Legal Enforcement and Penalties (A):
    - Ineffectiveness of relevant agencies in enforcing regulations (A1).
    - Outdated or inadequate legal frameworks governing crane operations (A2).
    - Insufficient penalties for legal violations related to crane operations (A3).
2. Non-compliance with Legal Requirements by Businesses and Users (B):
    - Lack of knowledge among crane operators (B1).
    - Absence of safety plans regarding crane operations in business practices (B2).
    - Failure to adhere to engineering principles and ethical standards (B3).
3. Crane Operation Standards (C):
    - Lack of adherence to international crane standards (C1).
    - Absence of domestic standards for crane operation (C2).
    - Lack of other relevant standards for crane operations (C3).
4. Non-compliance by Crane Importers (D):
    - Failure to monitor changes in relevant laws (D1).
    - Removal of safety equipment from cranes (D2).
    - Failure to study international and other relevant standards (D3).

Dependent Variable

The dependent variable is crane operation in engineering work. This relationship between variables is illustrated in Figure 1.

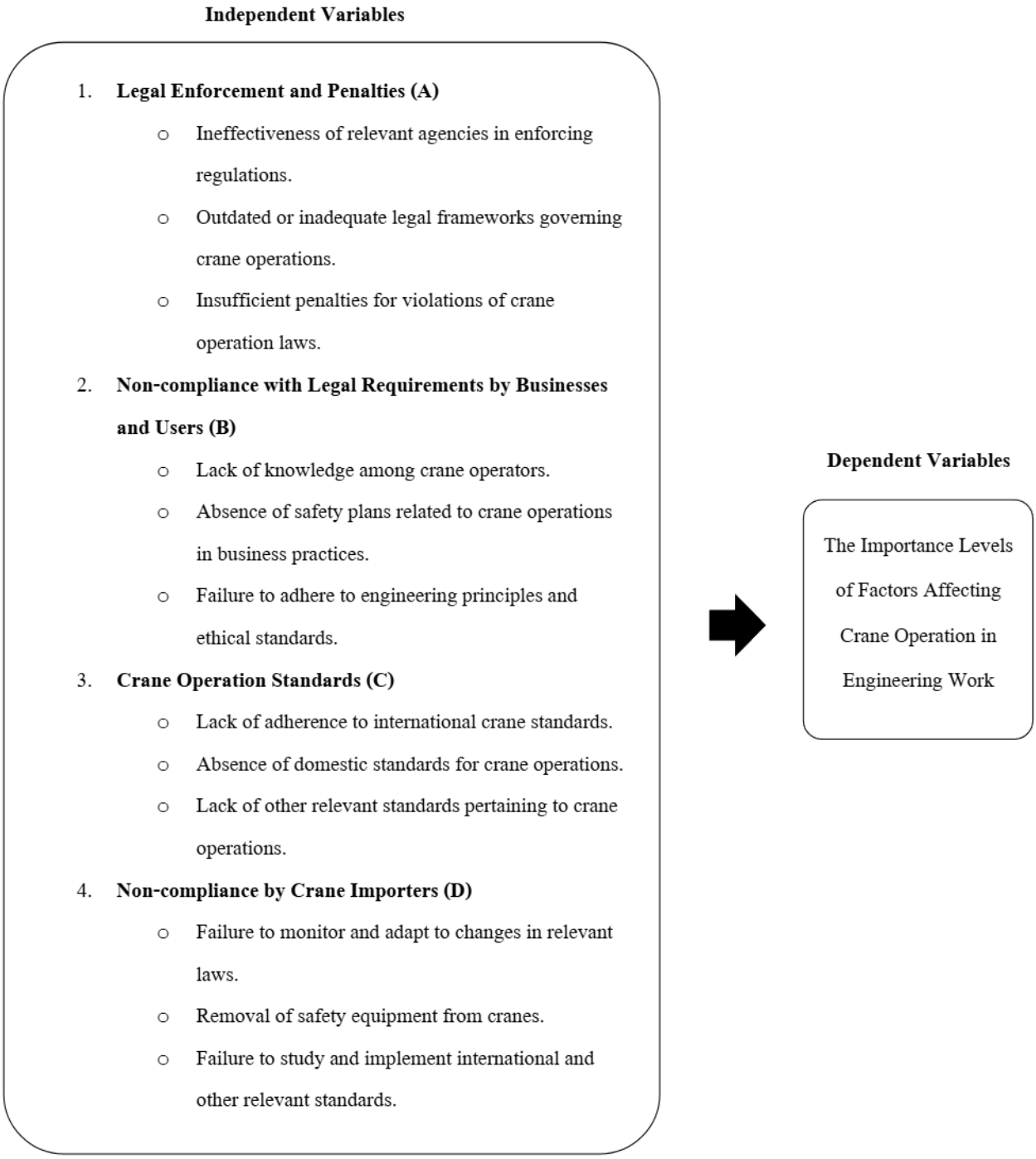

Figure 1: Conceptual Framework of Factors Influencing Crane Operation in Engineering Work

The analysis of key factors influencing crane operation in engineering work was conducted using the Analytic Hierarchy Process (AHP). This involved pairwise comparisons of six pairs of primary factors:

1. Legal Enforcement and Penalty Measures (A) vs. Non-compliance by Businesses and Users (B)
2. Legal Enforcement and Penalty Measures (A) vs. Crane Operation Standards (C)

3. Legal Enforcement and Penalty Measures (A) vs. Non-compliance by Crane Importers (D)
4. Non-compliance by Businesses and Users (B) vs. Crane Operation Standards (C)
5. Non-compliance by Businesses and Users (B) vs. Non-compliance by Crane Importers (D)
6. Crane Operation Standards (C) vs. Non-compliance by Crane Importers (D)

The analysis extended to sub-factors affecting crane operations, with pairwise comparisons of 12 pairs:

1. Ineffective enforcement by relevant authorities (A1) vs. Absence of modern and effective crane operation laws (A2)
2. Ineffective enforcement by relevant authorities (A1) vs. Lack of penalties for crane law violations (A3)
3. Absence of modern and effective crane operation laws (A2) vs. Lack of penalties for crane law violations (A3)
4. Lack of user knowledge in crane operations (B1) vs. Absence of safety plans for crane operations in businesses (B2)
5. Lack of user knowledge in crane operations (B1) vs. Non-compliance with engineering principles and ethics (B3)
6. Absence of safety plans for crane operations in businesses (B2) vs. Non-compliance with engineering principles and ethics (B3)
7. Failure to reference international crane standards (C1) vs. Absence of national crane operation standards (C2)
8. Failure to reference international crane standards (C1) vs. Lack of other crane-related standards (C3)
9. Absence of national crane operation standards (C2) vs. Lack of other crane-related standards (C3)
10. Neglect in studying legal changes (D1) vs. Reduction of safety equipment in cranes (D2)
11. Neglect in studying legal changes (D1) vs. Failure to adopt international and related standards (D3)
12. Reduction of safety equipment in cranes (D2) vs. Failure to adopt international and related standards (D3)

[11] The sample size was determined based on Krejcie and Morgan's formula, allowing a 5% margin of error, resulting in a final sample of 33 respondents in Bangkok, Thailand. [12] A structured questionnaire was developed and validated using the Index of Item Objective Congruence (IOC), assessed by three experts, with only items scoring $\geq$0.80 retained. The AHP methodology was applied to prioritize procurement factors using pairwise comparisons, and data analysis was conducted following standard AHP procedures.

4. Results

3.1 Analysis of Key Factors Influencing Crane Operation in Engineering Work: The analysis of the key factors influencing the use of cranes in engineering comprises the following: (1) factors related to the enforcement of laws and associated penalties, (2) factors regarding non-compliance with legal requirements by establishments and crane operators, (3) factors related to crane usage standards, and (4) factors associated with non-compliance by crane importers with crane-related regulations. The AHP was applied to evaluate these factors, with the following designations: (A): Enforcement of laws and penalties, (B): Non-compliance with legal requirements by establishments and operators, (C): Standards for crane usage, and (D): Non-compliance by crane importers with crane-related regulations. The analysis utilized weight data derived from scores

provided by a sample population through questionnaires. The prioritization of key factors was performed, followed by the creation of a standard comparison table based on the AHP methodology. The results of the comparative analysis are as follows: (A) is more significant than (B) by a factor of 6.60. (A) is more significant than (C) by a factor of 6.60. (A) is more significant than (D) by a factor of 6.80. (B) is more significant than (C) by a factor of 1.10. (B) is more significant than (D) by a factor of 1.10. (C) is more significant than (D) by a factor of 1.13. The average weight comparisons for each key factor were presented in the form of a matrix table to facilitate the determination of the weights of the primary factors influencing crane usage in engineering work, as summarized in Table 2.

Table 2: Geometric Mean Weight Comparisons in Matrix Form of Key Factors Influencing the Use of Cranes in Engineering Work.

Factor	A	B	C	D
A	1.00	6.00	6.60	6.80
B	0.15	1.00	1.10	1.10
C	0.15	0.91	1.00	1.13
D	0.15	0.91	0.88	1.00

The analysis of weights and inconsistency ratios for the key factors affecting crane operation in engineering work, using the AHP method, revealed the following results: The factor of legal enforcement and penalties (A) received the highest weight at 68.92%, making it the most significant factor. The next most important factor was non-compliance with laws by enterprises and users (B) with a weight of 10.88%, followed by the factor of crane operation standards (C) with a weight of 10.46%, and the factor of crane importers not complying with crane regulations (D) with a weight of 9.74%. The inconsistency index was 0.0008, which is below the threshold of 0.100, indicating that the data analysis was highly accurate, as shown in Table 3.

Table 3: Weights of the Key Factors Affecting Crane Operation in Engineering Work

Factor	Weight	Inconsistency Ratio
A	68.92 %	0.0008
B	10.88 %	0.0008
C	10.46 %	0.0008
D	9.74 %	0.0008

3.2 Analysis of Sub-factors Related to the Enforcement and Legal Penalties:

3.2.1 Analysis of Sub-factors of Enforcement and Legal Penalties Affecting Crane Operation in Engineering Work: The analysis of sub-factors related to enforcement and legal penalties, consisting of three steps, includes: (1) lack of effectiveness in enforcing laws by the relevant authorities, (2) absence of laws governing crane operations and outdated regulations, and (3) lack of penalties for violations of crane-related laws. The AHP method was applied, defining A1 as the step of ineffective law enforcement by relevant authorities, A2 as the step of absence of laws governing crane operations and outdated regulations, and A3 as the step of lack of penalties for violations of crane-related laws. The analysis of average weight data, collected from a sample population, prioritized the sub-factors related to the enforcement of laws and penalties impacting crane operations in engineering work. These results were then organized into a standard comparison table applying the AHP method. The comparative analysis yielded the following results: A1 (Ineffectiveness of law enforcement by relevant agencies) is more significant than A2 (Absence of laws governing crane operations and outdated regulations) by a factor of 7.60. A1 (Ineffectiveness of law enforcement by relevant agencies) is more significant than A3 (Lack of penalties for violations of crane-related laws) by a factor of 7.60. A2 (Absence of laws governing crane operations and outdated regulations) is more significant than A3 (Lack of penalties for violations of crane-related laws) by a factor of 1.10. The average weight comparisons for each sub-factor were organized into a matrix table to facilitate further analysis of the weight of sub-factors related to the enforcement of laws and penalties affecting crane operations in engineering work, as shown in Table 4.

Table 4: Geometric Mean Weight Comparisons in Matrix Form of Sub-Factors Related to the Enforcement of Laws and Penalties

Factor	A1	A2	A3
A1	1.00	7.60	7.60
A2	0.13	1.00	1.10
A3	0.13	0.91	1.00

The analysis of the weight of sub-factors related to the enforcement of laws and penalties impacting crane operations in engineering work was conducted by calculating the average weights through the application of the Analytical Hierarchy Process (AHP) using computer software. The findings revealed the following: Ineffectiveness of law enforcement by relevant agencies (A1) was identified as the most significant sub-factor, with a weight of 79.15%. Absence of laws governing crane operations and outdated regulations (A2) ranked second, with a weight of 10.76%. Lack of penalties for violations of crane-related laws (A3) ranked third, with a weight of 10.10%. The analysis yielded an inconsistency index (INCONSISTENCY INDEX) of 0.00087, which is below the threshold of 0.100, indicating a high level of accuracy in the data analysis. The results are summarized in Table 5.

Table 5: Weights for Sub-factors of Legal Enforcement and Penalties

Factor	Weight	Inconsistency Ratio
A1	79.15 %	0.00087
A2	10.76 %	0.00087
A3	10.10 %	0.00087

3.2.2 Analysis Results of Sub-factors Related to Non-compliance with Laws by Enterprises and Crane Operators Affecting Crane Operations in Engineering: The analysis of sub-factors related to non-compliance by enterprises and crane operators impacting crane operations in engineering includes three steps: the lack of knowledge in crane operation, the absence of safety plans for crane operations within the business, and non-compliance with engineering principles and ethics. The application of the AHP method defines B1 as the lack of knowledge in crane operation, B2 as the absence of safety plans for crane operations within the business, and B3 as non-compliance with engineering principles and ethics. The data analysis results from the prioritization of the sub-factors influencing crane operations are then organized in a comparison table based on the AHP method. The standard comparison results are as follows: The lack of knowledge in crane operation (B1) is less than the absence of safety plans for crane operations within the business (B2) with a value of 6.00, The lack of knowledge in crane operation (B1) is greater than non-compliance with engineering principles and ethics (B3) with a value of 3.00, The absence of safety plans for crane operations within the business (B2) is less than non-compliance with engineering principles and ethics (B3) with a value of 8.8. as shown in Table 6.

Table 6: Geometric Mean Comparison of Sub-factor Weights in Matrix Format for Sub-factors Related to Hiring Preparation

Factor	B1	B2	B3
B1	1.00	0.17	3.00
B2	6.00	1.00	8.80
B3	0.33	0.11	1.00

The results of the sub-factor weight analysis for non-compliance by enterprises and operators, conducted using the AHP, revealed the following: B2 (Lack of Safety Plans by Enterprises) emerged as the most significant factor, with a weight of 76.22%**.** B1 (Lack of Knowledge by Operators) ranked second, with a weight of 16.70%**.** B3 (Non-Adherence to Engineering Principles and Ethics) ranked third, with a weight of 7.08%**.** The consistency of the analysis was verified with an Inconsistency Index of 0.0500**,** which is below the threshold of 0.100, indicating a high level of accuracy and reliability in the findings as shown in Table7.

Table 7: Weights of Sub-Factors Related to Non-Compliance with Legal Requirements by Enterprises and Operators Impacting Crane Operations in Engineering Work

Factor	Weight	Inconsistency Ratio
B1	16.70 %	0.050
B2	76.22 %	0.050
B3	7.08 %	0.050

3.2.3 The analysis of sub-factors related to crane usage standards affecting operations in engineering projects involved three steps: (1) the lack of reference to international crane standards, (2) the absence of national crane usage standards, and (3) the absence of other relevant crane standards. The AHP method was applied, defining C1 as the lack of reference to international crane standards, C2 as the lack of national crane usage standards, and C3 as the absence of other relevant crane standards. The analysis of the average weights, derived from data gathered from the sample group, where participants ranked the importance of the sub-factors related to crane usage standards in the questionnaire, resulted in the following comparison values: The lack of reference to international crane standards (C1) was deemed more significant than the lack of national crane usage standards (C2), with a value of 0.15, The lack of reference to international crane standards (C1) was deemed more significant than the lack of other relevant crane standards (C3), with a value of 1.17, The lack of national crane usage standards (C2) was more significant than the lack of other relevant crane standards (C3), with a value of 1.40, as shown in Table 8.

Table 8: Geometric Mean Comparison of Sub-factors Regarding Crane Usage Standards in Matrix Format Affecting Crane Operations in Engineering Work

Factor	C1	C2	C3
C1	1.00	0.15	0.17
C2	6.60	1.00	1.40
C3	6.00	0.71	1.00

The analysis using the AHP method revealed the lack of national crane usage standards (C2) had the highest weight, with a value of 52.22%. This was identified as the most significant sub-factor regarding crane usage standards. The next most significant factor was the absence of other relevant crane standards (C3), with a weight of 40.45%. Lastly, the lack of reference to international crane standards (C1) had the lowest weight, with a value of 7.32%. The inconsistency index was 0.005, which is below the threshold of 0.100, indicating a high level of accuracy in the data analysis, as shown in Table 9.

Table 9: Weights of Sub-factors Regarding Crane Usage Standards Affecting Crane Operations in Engineering Work

Factor	Weight	Inconsistency Ratio
C1	7.32%	0.005
C2	52.22%	
C3	40.45%	

3.2.4 Results of the Analysis of Sub-factors Regarding Crane Importers' Non-compliance with Crane Regulations Affecting Crane Operations in Engineering Work: Using the AHP method, the analysis identified three sub-factors: (1) failure to study changes in the law, (2) the removal of safety equipment from cranes, and (3) failure to study international standards and other related standards. These were defined as follows: D1 is the failure to study changes in the law, D2 is the removal of safety equipment from cranes and D3 is the failure to study international standards and other related standards. The data analysis of the average weights derived from data gathered from the sample group, where participants ranked the importance of the sub-factors related to the non-compliance of crane regulations by importing operators in the questionnaire. The results were organized into a standard comparison table using the AHP. The standard comparison values obtained were as follows: the failure to study changes in the law (D1) was less significant than the removal of safety equipment from cranes (D2), with a comparison value of 8.80; the failure to study changes in the law (D1) was more significant than the failure to study international standards and other standards (D3), with a comparison value of 1.00; and the removal of safety equipment from cranes (D2) was more significant than the failure to study international standards and other standards (D3), with a comparison value of 8.80, as shown in Table 10.

Table 10: Geometric Mean Comparison of Weights for Each Sub-factor Regarding Crane Importers' Non-compliance with Crane Regulations in Matrix Format

Factor	D1	D2	D3
D1	0.10	0.13	1.00
D2	8.00	1.00	8.80
D3	1.00	0.11	1.00

The analysis using the AHP method revealed that the removal of safety equipment from cranes (D2) was the most significant sub-factor, with a weight of 80.74%. The second most important sub-factor was the failure to study changes in the law (D1), with a weight of 9.78%. The least significant sub-factor was the failure to study international standards and other related standards (D3), with a weight of 9.48%. The inconsistency index was found to be 0.000, which is below the acceptable threshold of 0.100, indicating a high degree of accuracy in the data analysis, as shown in Table 11.

Table 11: Weights of Sub-factors Regarding Crane Importers' Non-compliance with Crane Regulations Affecting Crane Operations in Engineering Work

Factor	Weight	Inconsistency Ratio
D1	9.78%	0.000
D2	80.74%	
D3	9.48%	

5. Discussion

The findings of this study, which identify the factors influencing the operation of cranes in engineering work, are summarized as follows. This study highlights that legal enforcement factors are the most significant in influencing crane operations in engineering work, accounting for a weight of 68.92%. Within this category, the ineffectiveness of law enforcement by relevant authorities emerged as the most critical sub-factor, with a weight of 79.15%, followed by the absence of specific legislation governing crane operations and outdated legal frameworks, which held a weight of 10.76%. Additionally, the lack of penalties for legal violations related to crane operations accounted for a weight of 10.10%, The second most significant factor influencing crane operations in engineering work is non-compliance with legal regulations by businesses and operators, accounting for a weight of 10.88%. Within this category, the absence of safety plans related to crane operations in business practices was identified as the most critical sub-factor, with a weight of 76.22%. This was followed by a lack of operator knowledge in crane operation practices, which accounted for 16.70%, and the failure to adhere to engineering principles and ethical standards, with a weight of 7.08%, The third significant factor affecting crane operations in engineering work is the lack of standards for crane usage, with a total weight of 10.46%. Within this category, the absence of domestic standards for crane operations emerged as the most critical sub-factor, accounting for 52.22%, followed by the lack of other related standards, which contributed 40.45%. Additionally, the failure to reference international crane standards accounted for 7.32%, The fourth factor influencing crane operations in engineering work is non-compliance with crane-related laws by crane importers, accounting for a weight of 9.74%. The most critical sub-factor in this category is the removal of safety equipment from cranes which holds a weight of 80.74%. This is followed by the failure to study changes in legal regulations, accounting for 9.78%, and the lack of consideration for international standards and other related standards, which contributes 9.48%, as illustrated in Figure 2.

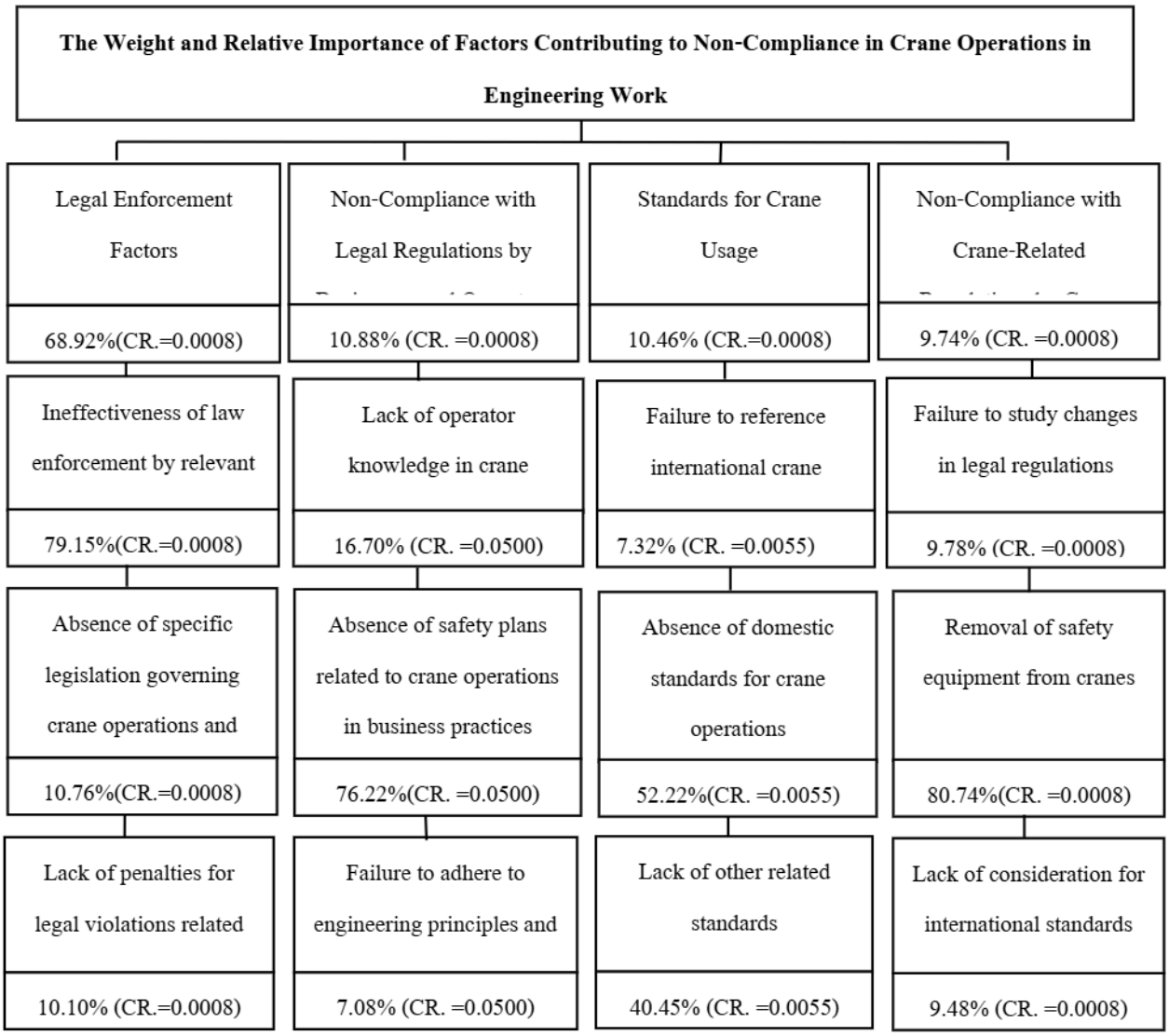

Figure 2. Analysis of Weighting Factors and Inconsistency Ratios Affecting Crane Operation in Engineering Work.

Conclusion

From the study of factors influencing the operation of cranes in engineering work, the findings can be discussed as follows:

5.1 Enforcement and Legal Penalty Factors**.** This study identifies significant issues related to the enforcement and penalties under crane-related laws. Key sub-factors include ineffective enforcement mechanisms which received high weight scores in the analysis, which contribute to widespread negligence and non-compliance with crane regulations and legal requirements among crane operators and business owners. [13] Consequently, these issues directly compromise the safe

operation of cranes. Furthermore, attitudes, perceptions, and emotional responses to external stimuli play a significant role in shaping behaviour, (Decho Sawananon, 2012)

5.2 Non-compliance by businesses and crane operators emerged as the second most significant factor influencing crane safety. The sub-factors, ranked by importance, include the absence of safety plans related to crane operations in business practices, insufficient knowledge and expertise among crane operators, and failure to adhere to engineering principles and professional ethics. Many businesses perceive safety measures as additional operational costs rather than essential practices, while crane operators often lack the necessary knowledge to perform their duties safely.

5.3 Standards for crane operations emerged as the third most significant factor influencing crane safety. The sub-factors, ranked by importance, include the lack of national standards for crane usage, the absence of other related standards for crane operations, inadequate estimation procedures, and failure to reference international crane standards. Among these, the lack of national standards for crane usage and related operational standards were identified as the most significant. Interviewees emphasized that while cranes are primarily imported into Thailand and adhere to international manufacturing standards, there is a significant shortage of accessible and comprehensive operational manuals for employees. This gap highlights the need for businesses and governmental agencies to develop standardized manuals and guidelines to enhance operational safety and mitigate risks associated with insufficient knowledge.

5.4 Non-compliance by crane importers was identified as the fourth most significant factor influencing crane safety. The sub-factors, ranked by importance, include, the reduction in the usage of safety equipment on cranes failure to stay updated on legal changes, and lack of adherence to international and other relevant standards. Among these, the removal of safety equipment from cranes poses the highest risk, as it disables automatic stop mechanisms that activate when the crane approaches critical thresholds. [14] Additionally, many cranes are not subjected to annual inspections by certified engineers (Sethawath Noochim, 2019), significantly increasing the likelihood of unsafe operations. This practice may stem from unawareness among operators and business owners or the absence of enforcement mechanisms. Furthermore, this practice often goes unchecked because no regulatory body conducts regular inspections. This aligns with statements from interviewees who acknowledged the dangers associated with removing safety equipment but noted that, in the absence of oversight, such actions are taken to reduce maintenance, repair, and operational costs, including the costs of selling cranes.

6. Recommendations

A recommendation for future research is to examine the factors contributing to the lack of enforcement and legal penalties by governmental agencies regarding the use of cranes.

Addition the topic of teaching cranes should be included in the university curriculum.

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Conflicts of Interest Statement

The authors declare no conflicts of interest regarding the publication of this article.

Remark

This research article forms part of the requirements for the Doctor of Philosophy (Ph.D.) degree in Engineering Law and Inspection, at the Faculty of Engineering, Ramkhamhaeng University, Bangkok, Thailand.

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