

Analysis Of Factors Affecting Construction Waste Reduction Using The Structural Equation Modeling Method

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Abstract

Construction waste consists of materials that are not desired directly or indirectly by the construction industry. This includes inert and non-biodegradable building materials such as sand, blocks, concrete, plaster, wood, iron, broken tiles, bricks, masonry, insulation, nails, electrical cables and reinforcement, as well as all residual materials (waste) originating from the Construction Project Site.

Data collection methods in this research were carried out by sending questionnaires via personal chat or via e-mail in the form of Google form to members of contractors, planning consultants, as well as construction supervision/management consultants and other parties operating in the territory of Indonesia, then the data The questionnaire was analyzed using Structural Equation Modeling (SEM) with the help of SPSS and AMOS programs.

Factors that influence the reduction of construction waste include Contractual (X1) with an influence value of 0.154. Material Transportation (X2) with an influence value of 0.140. Material Storage (X4) with an influence value of 0.203. Use of Construction Materials (X6) with an influence value of 0.352. Professional Ethics (X7) with an influence value of 0.177. Managerial Action (X8) with an influence value of 0.329. Government Subsidies (X10) with an influence value of 0.337 and Government Regulatory Policy (X11) with an influence value of 0.294. Furthermore, factors that do not have a significant influence are Place Management and Planning (X3), Location Operations (X5) and Sustainability (X9). The most dominant factors influencing the reduction of construction waste include Use of Construction Materials (X6) with an influence value of 0.352 and government subsidies (X10) with an influence value of 0.337.

Keyword: Construction Waste Reduction, Structural Equation Modeling (SEM).

INTRODUCTION

Indonesia, as a developing country, has experienced continuous growth in economic, business, and governmental activities in recent years, which requires the provision and support of adequate infrastructure, particularly in the construction sector (Thoengsal et al., 2020). The construction industry plays a strategic role in supporting economic growth by providing various public facilities and infrastructure needed by society (Wibowo, Mochamad Agung, 2017). However, along with the rapid growth of the construction industry, serious problems have emerged in the form of increasing construction waste generation, which has significant environmental, social, and economic impacts (Mohammed et al., 2022).

Construction waste has become a global issue in both developing and developed countries due to its contribution to environmental pollution, resource inefficiency, increased project costs, and reduced productivity and time efficiency in project implementation (B. Manoj & Madhav et al., 2016). This waste is generated throughout various stages of construction activities, ranging from planning and construction to renovation and demolition. Nagapan et al. (2012) define construction waste as waste materials generated directly from construction, renovation, and demolition activities, including excavation or earthworks, civil construction, site clearance, demolition activities, as well as building repair and renovation works.

In general, construction waste consists of materials that are unwanted either directly or indirectly by the construction industry. These materials include inert and non-biodegradable building materials such as sand, concrete, wood, steel, bricks, plaster, ceramic tiles, electrical cables, nails, reinforcement bars, and other leftover materials originating from construction project sites (Makwana et al., 2016). Gulghane et al. (2015) emphasize that construction waste is one of the most serious problems in the construction industry and requires systematic and sustainable management.

In urban areas, the construction industry is widely recognized as one of the major contributors to environmental pollution due to its heavy reliance on raw material extraction and demolition activities (Bakshan et al., 2015; Wang et al., 2014, cited in Farzad et al., 2019). In Indonesia, despite the rapid development of the construction sector, the level of construction waste management remains relatively low and has not been optimally integrated into construction project practices (Wibowo, M. Agung & Koestalam, 2015). Therefore, construction waste management has become a critical area that requires serious attention within the context of sustainable development in Indonesia (Saad et al., 2022).

To effectively reduce and manage construction waste, a comprehensive understanding of the factors causing construction waste generation is required (Luangcharoenrat et al., 2019).



Construction waste management refers to systematic efforts to minimize waste generation from the project feasibility stage through to the operation and maintenance phase (Wibowo, Mochamad Agung, 2017). The benefits of implementing an effective construction waste management system can be achieved through proper planning, efficient material management, and enhanced awareness and competence of construction stakeholders.

From a regulatory perspective, the Indonesian government has issued Government Regulation Number 81 of 2012 concerning the Management of Household Waste and Waste Similar to Household Waste, which also regulates the management of construction and demolition waste materials. This regulation provides technical guidelines for the collection, transportation, utilization, and disposal of construction waste materials as part of efforts to mitigate environmental impacts.

Based on these conditions, this study aims to analyze the factors influencing construction waste reduction in Indonesia. Data collection was conducted through the distribution of questionnaires using Google Forms, which were sent online to contractors, planning consultants, supervision/construction management consultants, and other relevant stakeholders operating across Indonesia in 2023. The factors analyzed include contractual aspects, construction material transportation, on-site waste management, planning and material storage, operational site conditions, material usage, construction material reduction practices, professional ethics, managerial actions, sustainability, government subsidies, government regulatory policies, and incentive policies for construction waste reduction. Data analysis was performed using the Structural Equation Modeling (SEM) method.

The novelty of this study lies in the integration of construction material usage and government regulatory policy variables into an SEM framework to analyze construction waste reduction in Indonesia. Similar studies have been conducted in other countries, such as Liu, Yi, and Wang (2020) in Guangzhou, China, and Kolaventi (2017) in India. However, studies that comprehensively examine construction waste reduction factors using Structural Equation Modeling within the Indonesian context remain limited.

Several previous studies have also investigated construction waste management using SEM and PLS-SEM approaches, including Mohammed et al. (2021), who examined 3R (Reduce, Reuse, and Recycle) modeling for sustainable construction waste reduction, and Wibowo, Mochamad Agung (2017), who developed a construction waste management model for infrastructure projects in Indonesia using AMOS-SEM. Ajayi and Oyedele (2018) also explored waste-efficient material procurement through structural equation modeling. Nevertheless, research that integrates technical, managerial, and government policy aspects into a single SEM



framework in Indonesia is still scarce.

Therefore, based on the above background, it is crucial to conduct research on the analysis of factors influencing construction waste reduction using Structural Equation Modeling (SEM) across Indonesia to support more effective, efficient, and sustainable construction waste management practices.

METHODOLOGY

The sampling technique used in this study is non-probability sampling. Non-probability sampling is a sampling technique that does not provide equal opportunities for each element or member of the population to be selected as a sample (Sugiyono, 2022). This study employs a non-probability sampling approach using purposive sampling.

Purposive sampling was chosen because the researcher has prior knowledge that the required information can be obtained from a specific target group capable of providing the desired information, as the selected respondents possess relevant knowledge and experience and meet the criteria established by the researcher (Ferdinand, 2014).

RESULTS AND DISCUSSION

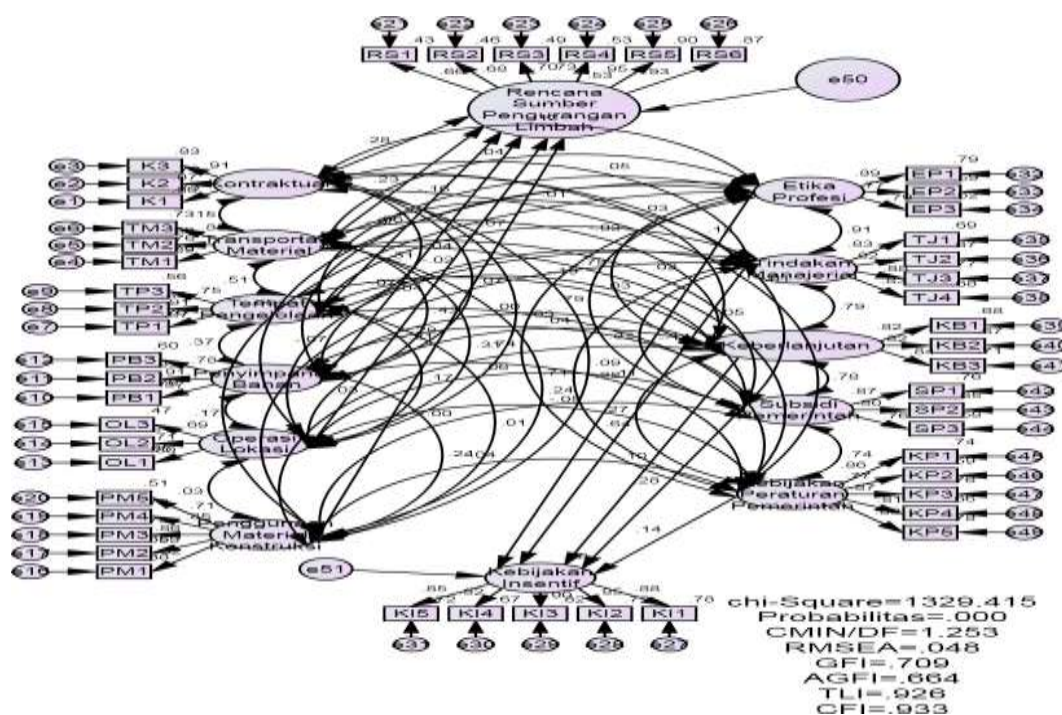


Figure 1. Structural Equation



The Contractual Variable Influences the Construction Waste Reduction Source Planning (Hypothesis1)

The results of hypothesis testing (H1) indicate that the contractual variable has a positive and significant effect on construction waste reduction source planning. This implies that better contractual arrangements enhance construction waste reduction planning. When waste reduction source planning is carried out in accordance with contractual plans—such as minimizing avoidable contractual errors—material waste can be reduced. Construction activities can commence promptly once construction contract documents are completed, and allowable material loss limits are predefined in the contract. When contractual planning is properly implemented, it encourages improved construction waste reduction source planning at the project site by preventing material wastage and reducing the generation of construction waste.

Construction Material Transportation Influences the Construction Waste Reduction Source Planning (Hypothesis 2)

The results of hypothesis testing (H2) show that the construction material transportation variable has a positive and significant effect on construction waste reduction source planning. This means that improved construction material transportation enhances waste reduction source planning. When transportation planning is properly implemented—such as ensuring delivery vehicles can access designated transportation routes within the project area, protecting materials during unloading, and applying effective unloading methods—material damage can be minimized. Proper construction material transportation planning contributes to reducing material damage, preventing construction waste generation, and avoiding material wastage at the project site.

On-Site Management and Planning Influences the Construction Waste Reduction Source Planning (Hypothesis 3)

The results of hypothesis testing (H3) indicate that the on-site management and planning variable does not have a positive and significant effect on construction waste reduction source planning. The contribution of on-site management and planning to waste reduction source planning is relatively small. This condition is attributed to insufficient control of construction materials at project sites by responsible project personnel. Material usage often does not align with initial planning, and project leaders tend to pay limited attention to recording the types, sizes, and quantities of materials and building components used on-site. Consequently, inadequate on-site management and planning contribute to the generation of residual materials



and construction waste.

Construction Material Storage Influences the Construction Waste Reduction Source Planning (Hypothesis 4)

The results of hypothesis testing (H4) reveal that construction material storage has a positive and significant effect on construction waste reduction source planning. This indicates that better material storage practices enhance waste reduction planning. When material storage is properly managed—such as ensuring materials are well maintained, applying appropriate storage methods, and carefully transporting materials from storage areas to points of use—material deterioration can be prevented. Proper storage practices help avoid duplicate processing, reduce material damage due to poor handling, and ultimately lower project costs while minimizing construction waste.

Site Operation Influences the Construction Waste Reduction Source Planning (Hypothesis 5)

The results of hypothesis testing (H5) demonstrate that site operation does not have a positive and significant effect on construction waste reduction source planning. The contribution of site operation to waste reduction planning is minimal. This is due to construction workers' lack of careful inspection before using materials, insufficient attention to material suitability, and low workmanship quality, which often leads to material damage and increased construction waste generation.

Construction Material Usage Influences the Construction Waste Reduction Source Planning (Hypothesis 6)

The results of hypothesis testing (H6) indicate that construction material usage has a positive and significant effect on construction waste reduction source planning. This suggests that improved material usage practices enhance waste reduction planning. Proper preparation for material usage, efficient utilization to avoid surplus materials, and the provision of waste bins for subcontractors contribute to effective waste management. Residual materials can be managed and reused, thereby reducing construction waste. Appropriate construction material usage significantly supports waste reduction efforts at the project site.

Professional Ethics Influence Construction Waste Reduction Incentive Policies (Hypothesis 7)

The results of hypothesis testing (H7) show that professional ethics have a positive and significant effect on construction waste reduction incentive policies. This indicates that higher

professional ethics among stakeholders lead to improved incentive policies. Strengthening stakeholders' work ethics in construction waste reduction activities is essential for enhancing incentive-based policies. Promoting ethical behavior among construction stakeholders facilitates the effective implementation of incentive policies related to waste reduction.

Managerial Actions Influence Construction Waste Reduction Incentive Policies (Hypothesis 8)

The results of hypothesis testing (H8) demonstrate that managerial actions have a positive and significant effect on construction waste reduction incentive policies. This implies that stronger managerial roles enhance incentive policies. Managers play a critical role in project success through planning, implementation, and control of construction activities. Effective managerial actions significantly contribute to construction waste reduction through the implementation of incentive-based policies.

Sustainability Influences Construction Waste Reduction Incentive Policies (Hypothesis 9)

The results of hypothesis testing (H9) indicate that sustainability does not have a positive and significant effect on construction waste reduction incentive policies. The contribution of sustainability to incentive policies is relatively small. This is due to the increasing scale of construction activities, which often results in land consumption, environmental pollution, and large amounts of residual construction waste, thereby limiting the effectiveness of sustainability considerations in shaping incentive policies.

Government Subsidies Influence Construction Waste Reduction Incentive Policies (Hypothesis 10)

The results of hypothesis testing (H10) reveal that government subsidies have a positive and significant effect on construction waste reduction incentive policies. This indicates that increased government subsidies enhance incentive policies. Government subsidies serve as a strong driver for advancing sustainable construction waste recycling systems. Providing subsidies for waste sorting and recycling activities increases recycling rates, while subsidies for recycling companies generate substantial environmental benefits.

Government Regulatory Policies Influence Construction Waste Reduction Incentive Policies (Hypothesis 11)

The results of hypothesis testing (H11) show that government regulatory policies have a positive and significant effect on construction waste reduction incentive policies. This suggests



that stronger government regulations enhance incentive policies. Regulatory actions aimed at improving the effectiveness of construction and demolition waste regulations, promoting recycling practices, and implementing efficient waste disposal fees significantly contribute to construction waste reduction incentive policies.

Correlation Between Two Exogenous Variables: Construction Waste Reduction Source Planning and Construction Waste Reduction Incentive Policies (Hypothesis 12)

Hypothesis 12 examines the correlation between the two exogenous variables: construction waste reduction source planning and construction waste reduction incentive policies.

CONCLUSIONS

Based on the discussion of the results from the analysis of construction waste reduction using the Structural Equation Modeling (SEM) method across Indonesia, the following conclusions can be drawn:

The factors that significantly influence construction waste reduction include contractual factors (X1) with an effect value of 0.154, material transportation (X2) with an effect value of 0.140, material storage (X4) with an effect value of 0.203, construction material usage (X6) with an effect value of 0.352, professional ethics (X7) with an effect value of 0.177, managerial actions (X8) with an effect value of 0.329, government subsidies (X10) with an effect value of 0.337, and government regulatory policies (X11) with an effect value of 0.294. Meanwhile, factors that do not have a significant influence are on-site management and planning (X3), site operation (X5), and sustainability (X9).

The results of the structural equation model analysis indicate that the most dominant factors influencing construction waste reduction are construction material usage (X6), with an effect value of 0.352, and government subsidies (X10), with an effect value of 0.337.

SUGGESTION

Based on the research results summarized in the conclusions above, the researchers offer several recommendations, as follows:

1. Future research could increase the sample size, given the increasing amount of waste generated by construction projects, to ensure more representative results.
2. Future research could be expanded by incorporating additional factors and adopting other theories to broaden understanding of the factors influencing construction



waste reduction.

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