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Factors Affecting Concrete Recycling Adoption in the Construction Projects

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Abstract. Recycling addresses environmental issues associated with solid waste by minimizing overall resource consumption and environmental impact. In the construction industry, concrete recycling is crucial because concrete is the most dominant waste of construction and demolition waste. However, its implementation is at a low level in numerous countries because construction managers refuse to adopt concrete recycling in practice. This study's objective is to identify factors that are affecting decisions in adopting concrete recycling from the construction managers' perspective. To achieve this objective, open-ended interview data with construction managers are analyzed. Eleven factors affecting decisions in adopting concrete recycling were identified. The factors are recycling factories, availability of raw material, quality, cost, reliable standard, government encouragement, legally, acceptance factor, proper planning, skilled workforce, and management. This research contributes to the body of knowledge in the analysis of factors that influence the acceptance of concrete recycling from industry practitioners' perspectives, which could help researchers and industry practitioners develop strategies to reduce the rejection of concrete recycling among construction managers. The findings of this research would help improve the success of adopting concrete recycling in the construction industry.

1. Introduction

The construction industry plays a crucial role in the socio-economic development of any country [1]. Nowadays, the construction industry is rapidly growing because of the increase in the standard of living, demands of infrastructure projects, changes in consumption habits, as well as a natural increase in population. This growth has contributed significantly to the waste generation that waste emanates during the planning, design, procurement, and construction stage [2]. Construction waste is one of the contemporary environmental problems facing the world as it is one of the sources of pollution, which has become a severe problem for every nation [3]. Therefore, the adoption of recycling construction waste is essential to reduce its impact on the surrounding environment [4].

The study focuses on concrete waste, among other construction waste, because it represents the most significant percentage of construction waste [5]. Some factors that affect the adoption of concrete recycling include (1) cost of collecting, (2) transporting materials, (3) purity of recycled materials, and (4) cost of sorting and recycled materials that meet relevant specifications and required standards [6]. However, there are still many other factors regarding the adoption of concrete recycling. Understanding the factors affecting concrete recycling in construction projects may assist researchers



and industry practitioners in identifying opportunities for improvement. Therefore, it is necessary to explore the factors that are affecting the adoption of concrete recycling in a domestic environment.

The objective of this paper is to identify factors that are affecting the adoption of concrete recycling from industry practitioners' perspectives. The author addresses this objective by analyzing open-ended interview data with construction managers in construction projects. In addition to providing additional insights into the adoption of concrete recycling, the study's findings also offer a comprehensive list of factors affecting concrete recycling. Researchers and practitioners can use that finding to develop action plans that promote success in concrete recycling.

2. Background

2.1. Factors affecting recycling construction materials

Researchers and practitioners are investigating topics related to recycling construction waste material. Studies have determined the key factors that are affecting in adopting recycling construction waste. For example, there are four factors affecting construction waste recycling in Kuwait: (1) purity of recycled material, since choosing between recycling and other appropriate disposal methods is determined by the concentrations of harmful substances in recycled construction materials; (2) cost of collection and transport; (3) cost of sorting, transformation into reusable material, and the disposal costs of any residual material to landfills or incineration and (4) necessity for recycled materials to meet the pertinent required specifications and standards [7]. In another study, the research data collected from various research sources and questionnaire surveys with cement manufacturers, contractors, and construction managers in Thailand, the critical factors influencing the industrial sector are quality, source of law and regulations, standard, price, and confidence [8]. There are three key factors, namely economics, market, site activities, and environmental factors. The results revealed that the market and site activities factor was the most influential factor in making waste recycling decisions, as it has the highest weight among the three factors. Critical issues of concern are the number of recycled markets available and the intense competition in the industry [9]. Although these studies provide insights into the factors affecting adopting concrete recycling, the results also illustrate that different factors are affecting concrete recycling in a local environment. Therefore, exploring those factors is essential.

2.1.1. Concrete recycling in Malaysia

Researchers explored various topics related to construction waste recycling and mention some factors that affect concrete recycling. Respondents believe that appropriate construction waste management practices reduce their profits, and promotion and encouragement by the government and CIDB is still lacking [10]. Another study suggests that the barriers to recycling demolition waste in Malaysia are cost implications and lack of environmental education [11]. Also, financial incentives and an increase in overhead costs are considered as the major factors in adopting recycling construction waste [12]. In other words, although these studies provide insight into the factors that influence the adoption of recycling construction and demolition waste, the results also show that many factors influence the adoption of recycling different types of waste materials.

2.2. Positioning of this study

Notably, different factors are affecting the adoption of concrete recycling in different nations. On the other hand, prior studies have yet to provide an in-depth understanding of the factors that are affecting concrete recycling in the local context. Therefore, the present study investigates the factors that influence the adoption of concrete recycling. The author addresses this goal by analyzing individual interviews with construction managers in construction projects across the country. Also, the results of this study provide a comprehensive list of factors that affect concrete recycling for researchers and practitioners to develop tools that enhance success in concrete recycling.

3. Methods

Data collected through individual interviews with construction managers. Qualitative data is analyzed using the thematic analysis method. The following subsections describe the process for collecting data for the study and methods for analyzing data.

3.1. Data Collection

This study collects data on the factors affecting the adoption of concrete recycling through open-ended interviews with construction managers. Individual interviews allow investigators to explain better and understand respondents' opinions and experiences. Moreover, open questions encourage participants to contribute detailed information about their experience and ideas. Therefore, construction managers were interviewed using these methods to gain their unique perspectives, practical knowledge, and expertise on this topic [13].

The target population in this study is construction managers of construction companies that have a G7 license from the Construction Industry Development Board (CIDB). Companies in other licensing categories cannot undertake construction projects with a value exceeding RM 10 million. However, companies with a G7 class license can carry out construction projects without restrictions. Therefore, this research deliberately selects construction managers from G7 construction companies. We target construction managers because they are more experienced and knowledgeable than others in the construction project. Also, we focus on G7 construction companies because it has tremendous experience, knowledge, and also works in massive projects where construction waste is more than projects for companies with a lower rating.

Structured individual interviews begin with an introduction to the topic and an open-ended question. The starting question is: what are the challenges you are facing for the adoption of concrete recycling? Additional open-ended questions are given to participants based on the answers received. The following questions aimed at a deeper understanding of the information gathered and to clarify whether the participants' statements were correctly understood. If the participant was unable to answer or process the questions asked, the interviewer tried to rephrase the interview question differently and gave time for an answer. After each interview, the discussions are summarized and sent to the participants to verify the validity of the data and to avoid any misunderstanding. The data collection of this study involves interviewing fifteen valid respondents. We stopped at the fifteenth interview due to repeated information and saturation status [14].

3.2. Data Analysis

The data analyzed manually using the thematic analysis method. Thematic analysis is an accessible, flexible, and increasingly popular method of qualitative data analysis [15]. This method has been employed by Rahman and Ayer [16] and Radzi et al. [17] to analyze qualitative data associated with construction management topics. The thematic analysis was carried out based on the six steps described in Braun and Clarke [18].

First, the researcher transcribed the interview data, read, reread, and noted the initial ideas. The second stage is writing initial analysis codes. The researcher coded for many potential themes and patterns as possible from the data, then search for themes based on the initial codes. The third stage is reviewing the information for analysis to develop the subthemes. The fourth stage is to identify the themes. The author continually reviews the information for analysis themes, codes, and transcription of the interview to ensure that the themes were true to the independently coded responses. The fifth phase is to review the themes. To ensure saturation of the data, the author continually reviewed the themes, defined and refined them, checking if themes work to the coded extracts and the entire data set. The final (sixth) stage is to issue the report.

4. Results and Discussion

Figure 1 overviews the factors that affect concrete recycling findings from the interviews with fifteen construction managers. The factors can be divided into two main groups: external and internal factors. External factors are often out of a contractor's control (for example, availability of factories specialized in concrete recycling). At the same time, internal factors include variables that are within a contractor's (for example, the appointment of the workforce with adequate experience for the project). The external factors consist of variables that relate to recycling factories, availability of raw material, quality, cost, reliable standard, government encouragement, legal, and acceptance. Conversely, the internal factors include variables related to proper planning, skilled workforce, and management. These variables are described in the following subsections.

4.1. External factors affecting concrete recycling

4.1.1 External factor 1: Resources.

The first external factor – resources include the availability of recycling factories and raw materials. According to construction managers, the lack of specialized recycling factories is one of the obstacles affecting the adoption of concrete recycling. One respondent state:

“Recycling concrete waste needs modern factories that separate the concrete waste from each other and extract aggregate than can be used in the new concrete. However, these factories are still not available locally.”

In other words, the availability of specialized recycling plants plays an essential role in ensuring the success of concrete recycling by re-separating and extracting aggregates from waste for the production of new concrete. Therefore, the public sector should establish recycling centers that cover waste separations. These centers should be available in all towns and cities, especially those that contain large numbers of construction waste. The public sector can cooperate with the private sector and encourage stakeholders to enhance the use of these centers. This procedure can be done through specific plans and goals that help in this field.

Next, another factor that can hinder construction managers' decisions in adopting concrete recycling for resources includes the availability of raw materials. If a country that is rich in raw materials, construction managers prefer purchasing raw materials because these materials guarantee the quality of their projects, in addition to the owners' reluctance to use concrete recycling. Therefore, as indicated by the respondents, the availability of raw materials significantly affects the progress of concrete recycling in that local environment.

4.1.2 External factor 2: Process

From the analysis of individual interviews with construction managers, processes that affect concrete recycling include quality, cost, and standards. First, according to the interview, construction managers rate quality as one of the main factors for accepting concrete recycling. Notably, the quality of recycled concrete is hard to anticipate, including its rate of deterioration, due to the product's high-water absorption that affects its physical and chemical properties. Furthermore, new concrete with recycled concrete aggregate is considered as low-quality concrete because it has lower strengths and hardening properties compared to new concrete with natural coarse aggregate. Conversely, its quality is still sufficient for land reclamation, land leveling, and sub-base of roads. However, evaluation of results and efficiencies should be used to escalate their quality as much as possible. Therefore, having standards to require manufacturers to produce recycled concrete with acceptable quality is necessary.

Second, costs involve market price and cost to transport construction materials and waste. Transporting construction materials and waste plays a major influence in making decisions for setting up factories for recycling, and other additional investments because the processes are both costly and require massive labor and time. One of the respondents suggests:

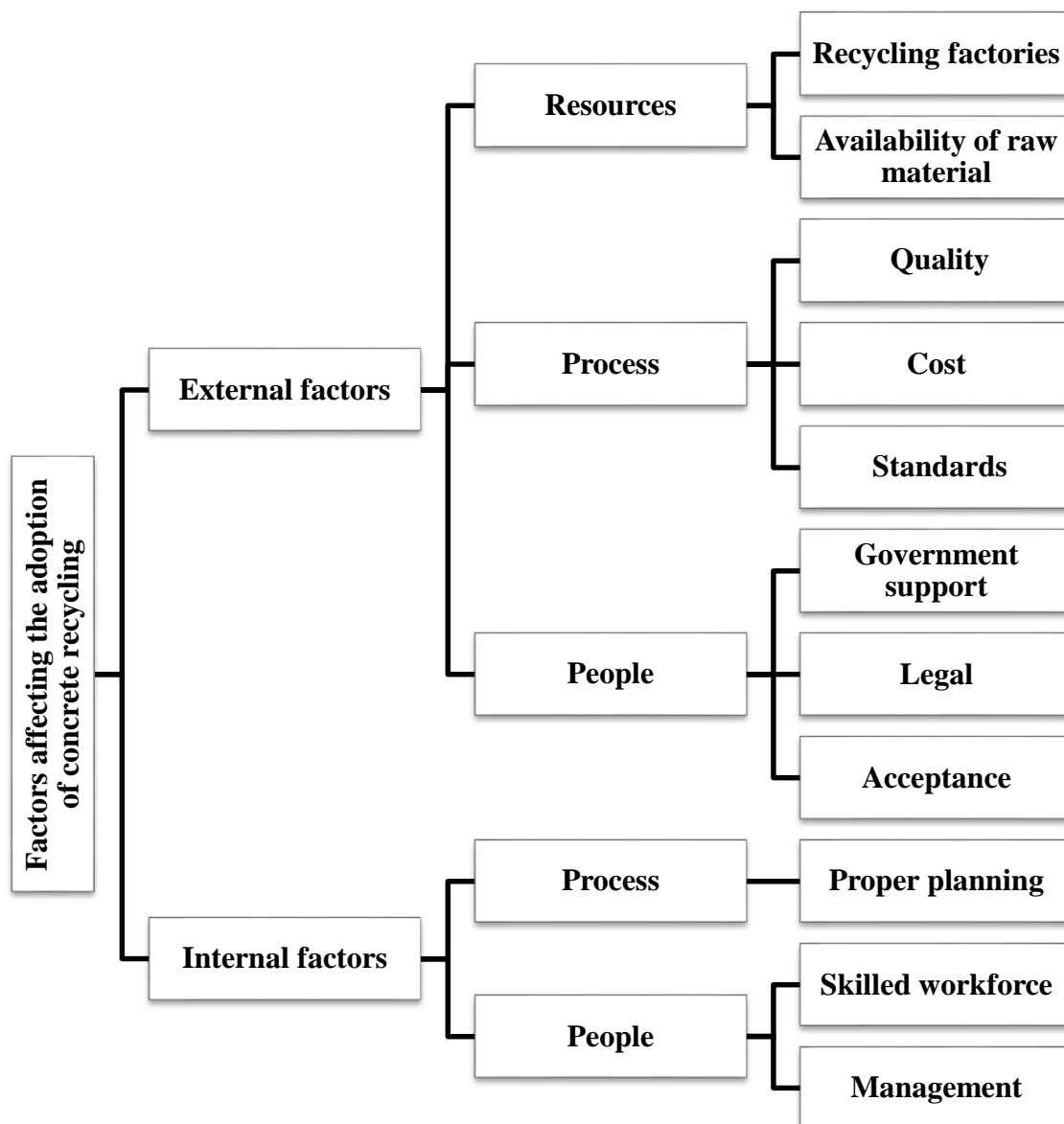


Figure1. Factors affecting the adoption of concrete recycling.

“The process of recycling concrete waste requires hard work and time as well, and this will make the price of recycled concrete more expensive than natural resources. While other respondents expressed their concerns about the inability to control selling prices so that the price of recycled concrete is lower than the price of natural resources”.

Also, persuading a market to purchase recycled materials has many challenges since the quality of recycled concrete is low compared to the new concrete. On the other hand, developing a higher quality of recycled concrete needs additional costs that can reduce profit margins for manufacturers. This suggests that all of these costs concern each stakeholder regardless of manufacturers, contractors, or project owners.

Last, respondents suggest that reliable standards are influencing the external process of adopting concrete recycling. Participants indicate that the local government does not have clear and reliable rules related to using recycled concrete as aggregate in the new concrete [19]. One of the respondent’s responses includes:

“The majority of construction players do not recycle concrete waste. This situation happens because there is no standard for concrete recycling as guidelines at the national level for them to follow. As a result, manufacturers lack confidence in commercializing recycled concrete in practice as there is a lack the proper guidance.”

Standards can be used as guidelines for manufacturers and can be applied according to engineering aspects. To adopt new standards, the public and private sectors must cooperate. Both sectors need to study relevant research and comparison procedures that require a long time.

4.1.3. External factor 3: People.

Factors in this category include government encouragement, legal, and acceptance. First, respondents hoped that the government would encourage concrete recycling. Responses from the interviewees include:

“Success of recycling of concrete waste depends on government support through the provision of modern technologies that work on recycling of concrete waste also by encouraging companies to recycle concrete waste. However, policymakers should be aware that stakeholders will prioritize business decisions over government incentives. Conversely, mandating concrete recycling in public projects will directly lead to the promotion and commercial stimulation of sustainable recycled concrete production. Therefore, the government should encourage the use of recycled materials, including recycled concrete in public projects.”

Participants also suggest that the government should study the benefits and profound implications of providing appropriate support and issuing policies when finding solutions to problems, obstacles, and requirements. Also, the government can reduce the reluctance among construction managers by providing research funds and tax incentives to research institutes or facilities and universities to spread the benefits of emerging innovations [20]. Therefore, it is useful for the government to promote and implement policies that meet the expectations of all stakeholders, especially to enhance the production and use of recycled materials in an integrated way.

Next, for legal, respondents suggest that the law and regulations need to be amended to encourage the use of recycled materials. The government should issue national policies to enhance opportunities for the use of recycled materials. The public sector should be a leader in this direction by setting a budget and purchasing these environmentally friendly materials. Also, the production of recycled concrete from construction and demolition waste will enhance environmental protection. To achieve this plan, government support and law enforcement are required for concrete recycling.

Last, construction waste recycling relies on approval and confidence in the recycled materials itself in achieving specific goals. Trust and approval can be obtained through regulations and qualification criteria. Without formal rules or standards, stakeholders may be reluctant to apply the material. Currently, there are no reliable regulations or standards for recycled concrete. Furthermore, the conventional approach to select materials is to use natural materials with assured quality [21]. On the other hand, recycled concrete is not stigmatized with positive images, which causes difficulties in adopting or qualifying them as high-quality materials. This perception has a significant negative impact on trust and approval of recycled concrete for construction work, especially for large scale projects that require strict quality control. However, as a way to reduce construction costs, recycled concrete is gradually gaining popularity in low-quality works, for example, reclamation and sub-base. In other words, stakeholders are still skeptical of this recycled concrete despite its availability.

Table 1. Factors affecting the adoption of concrete recycling

	Contractor 1	Contractor 2	Contractor 3	Contractor 4	Contractor 5	Contractor 6	Contractor 7	Contractor 8	Contractor 9	Contractor 10	Contractor 11	Contractor 12	Contractor 13	Contractor 14	Contractor 15	Total no. of hits
External Factors																
Recycling factories	√	√	√	√			√		√			√			√	8
Availability of raw material		√	√		√				√		√			√		6
Quality						√	√		√	√	√	√				6
Cost							√	√	√		√	√				5
Standards							√			√						2
Government support	√		√								√		√			4
Legal							√									1
Acceptance	√		√	√		√	√			√	√		√		√	9
Internal Factors																
Skilled workforce			√	√	√		√	√		√	√		√	√	√	10
Management	√	√	√	√		√				√	√		√	√	√	10
Proper planning		√				√			√	√	√		√	√		7

4.2. Internal factors affecting concrete recycling

4.2.1. Internal factor 1: People.

Factors in this category include management and skilled workforce. First, for management, participants suggest that construction managers' competencies play a significant role in ensuring the success of construction waste recycling. Precisely, construction managers should possess skills in solving issues and problems at construction sites, in addition to managing numerous people and various types of individuals. Besides that, construction managers should have skills for monitoring, supervision, identifying, planning, and scheduling projects. While most of these skills can be associated with soft skills such as analytical and problem-solving, communication, teamwork, and planning [22, 23], participants also suggest that construction managers should possess knowledge of concrete recycling. Therefore, these results illustrate that the competencies of construction managers are affecting the success of concrete recycling.

Next, for the skilled workforce, participants suggest that workforce competencies play an essential role in ensuring the success of concrete recycling. Specifically, workers must acquire the skills needed to solve the problems in construction sites. Having a workforce with the appropriate skills can help reduce mistakes during construction works. Moreover, the ability to make adjustments to materials that can be modified and repaired at the construction site plays an essential role in recycling construction waste materials.

4.2.2. Internal factor 2: Process.

Factors in this category include proper planning. From the interview data, construction managers suggest that having proper plans is one of the factors that contribute significantly to the success of construction waste recycling. While several respondents provided similar responses, an example of the responses include:

To implement concrete recycling in construction projects, the recyclable materials should be specified and handled correctly to avoid confusion at the worksite. Then, appropriate procedures on processing the recyclable materials, for example, procedures for separating them from other waste and the separated waste, should be available. Also, the recyclable materials should be quantified by estimating the quantities of waste in order to provide suitable transportation and to estimate any additional cost.

Also, respondents suggest that the proper planning and know the materials that can be recycled and arranged a wide and suitable place for them is essential before the start of the project. Planning includes studying the site, as well as searching for new materials and using modern technologies that help reducing waste materials. Some construction managers suggest using pre-made components that minimize construction waste. Therefore, this finding suggests having proper planning is necessary to facilitate the adoption of concrete recycling in practice.

5. Conclusion

This study identifies the factors that influence the success of the adoption of concrete recycling by analyzing the data of the interview with fifteen construction managers using the thematic analysis. The major findings from the analysis include external factors that influence the success of concrete recycling include (1) recycling factories, (2) availability of raw material, (3) quality, (4) cost, (5) reliable standard, (6) government encouragement, (7) legal, and (8) acceptance factor. Also, internal factors that influence the success of concrete recycling consist of (1) proper planning, (2) skilled workforce, and (3) management.

The results shed light on the factors that could affect the success of concrete recycling, especially the external factors, which are the most influential factors according to the interviews with construction managers. In addition to providing additional insights to concrete recycling, researchers and practitioners can benefit from the current study, which promotes success in concrete recycling. Therefore, studying these factors will help to enhance the success of concrete recycling. The key theoretical contribution of this study is by conveying a better understanding of factors affecting concrete recycling.

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