# Assessment on the Circular Economy for Waste Minimization in the Construction Industry

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## ABSTRACT

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*The movement towards sustainability and resiliency has become a central talking point for the Malaysian government. Waste that is immeasurably generated from the construction activities should be appropriately managed to preserve the environment. This study was conducted to assess the level of knowledge about the concept of Circular Economy (CE) as an approach for waste minimization via a survey questionnaire sent to the G7 contractors in the Klang Valley area. The ultimate version of the questionnaire consisted of 38 questions, and it was sent to 360 targeted G7 contractors. 135 questionnaires were returned with a response rate of 37.5%. The results reveal that most of the contractors were knowledgeable about the potential of the CE concept as an approach for waste minimization. Environmental sustainability would be attained when the CE concept is used to minimize the waste generated from the construction activities. The integration of adaptative reused is found to be suitable to enhance the implementation of the CE concept. The results revealed considerable potential for the CE concept to be used as a waste minimization approach in the construction industry. In this sense, the enhancement of the CE concept implementation throughout the construction cycle could set up a direction for future research.*

***Keywords:*** *Waste, Circular Economy, Environmental Sustainability, Adaptative Reused, Malaysia*

## INTRODUCTION

The construction industry has a pivotal role in expanding many countries' economies, especially developing country. It is frequently prescribed for an economic prime mover in generating a better Gross Product Domestic (GDP) of the country. Even though the construction industry's contribution towards GDP is not as enormous as other industries such as manufacturing, the construction industry is constantly being targeted to stimulate the level of economy in any country. In the history of development economics, the construction industry has been thought of as a critical factor in the economic growth of any country. For instance, in Malaysia, despite the challenging situation of COVID-19, the construction industry has managed to contribute RM31.4 billion value of work done in the first quarter of 2021 (Department of Statistics, 2021).

A primary concern of activities involved in the construction industry is the generation of construction and demolition (C&D) wastes. C&D waste is denoted as one of the spates of solid waste primarily generated from any kind of construction activities (Wu et al., 2017). According to CIDB (2020), construction activities had contributed approximately 30% of the total waste generated in Malaysia. It is reported that the average waste generated is 28.6 tonnes daily, and it kept increasing. In addition, the C&D waste generated is often ended up in the landfills in which will cause harmful environmental impacts, including high energy consumption, solid waste generation, rising in greenhouse gas (GHG) emissions, pollution, environmental damages like soil erosion, sedimentation and flash floods (Crawford, 2011; Udawatta et al., 2015). Bakshan et al. (2015) further added that the amount of waste sent to landfills would compel limited spaces and over-stretched landfills.

The linear based-practice of *"take-make-consume-dispose"* widely practised in the construction industry has encouraged a large volume of waste generation. The nature of the construction industry involved various stakeholders, including the clients, contractors, consultants, etc.; the involvement of these diverse organizations adding with the lack of commitment towards preserving the resources and the environment, has opened the opportunity for the waste generated to be disposed of cheaply. Therefore, researchers attempted to evaluate the impact of considering a more circular approach instead of linear, integrated into the construction industry and achieving a more sustainable outcome of the construction industry (Esa et al., 2017; Geng & Song, 2014; IMSA, 2013). Therefore, a more circular approach must be adopted to eliminate or minimize waste generation in the construction industry.

In this context, the Circular Economy (CE) concept was recognized as a fundamental approach to shifting a linear-based practice to a more circular approach where the planned development works will not jeopardize the environmental aspects (Mhatre et al., 2020). The rethinking process of products design needs to be incorporated by considering the idea of *"made to be made again"* (United Nations, 2020). According to Ellen MacArthur Foundation (2017), the concept of CE is defined as a durable and sustainable resolution to differentiate between economic prosperity and environmental detriment. Several authors agreed that the concept of CE would provide a great platform to minimize the impacts created by the C&D waste generation; in which priority is given towards the production and management of the waste generated from the construction activities (Esa et al., 2017; Ghisellini et al., 2018).

This study aims to assess the current awareness and knowledge regarding the potential of CE as an approach to a better waste management system among the construction players in Malaysia. The authors will explore the level of awareness and knowledge on the concept of CE among Malaysian construction players, attempt to show that the implementation of CE will provide many benefits to the Malaysian construction players and propose suitable mechanisms to be integrated into the CE concept as an approach to minimize the waste generation. First, to get a comprehensive insight into the issue, an extensive literature review was conducted to better understand the potential of CE to be adopted as an approach to waste minimization. The necessary information about C&D waste and CE were gathered and analyzed. Finally, a quantitative method in the form of a questionnaire survey was distributed to the targeted respondents (Grade 7 Contractors) to enhance the findings obtained from the extensive literature review. The data obtained were then analyzed using Statistical Package for Social Sciences (SPSS). The critical components of C&D waste and CE were discussed in Section 2 of this study. In Section 3, an elaboration on the content of the questionnaire and an explanation on the selection of the targeted respondents were deliberated. The results are presented in Section 4, and finally, conclusions are derived in detail in Section 5.

## LITERATURE REVIEW

Much of the current literature on CE pays particular attention to revamp the linear-based economy to be more sustainable and environmentally friendly (Morseletto, 2020; Patwa et al., 2021; Salmenperä et al., 2021; Velenturf & Purnell, 2021). According to Alhawari et al. (2021), CE is a concept that will directly influence the improvement of social, economic, and environmental aspects by emphasizing the element of regeneration, focusing on reducing raw materials consumption. Many recent studies have shown that the importance of implementing CE is to shift the linear methods to circular methods with priority is given towards preserving the resources (Benachio et al., 2020; Bilitewski, 2012; Esa et al., 2016; Hartley et al., 2020; Zhu, 2014). Thus, CE is a prominent approach to transform the linear-based economy towards a more circular approach by making use of as high as possible the available resources.

There is an unambiguous relationship between CE and waste management (Salmenperä et al., 2021). For instance, the UK has seriously considered integrating CE in managing the waste generated from construction activities. According to WRAP (2021), implementing CE will create new opportunities for the construction industry to grow; by reducing waste, driving greater resource productivity, delivering

a more competitive economy, addressing issues related to resource scarcity and reducing the environmental impacts.

Previously, a number of studies have postulated that the CE concept required the integration of 3R principles of reduce, reuse and recycle to successfully manage the waste generated from the construction activities (Esa et al., 2016; Lu et al., 2011). The 3R principles is a well-known waste management hierarchy whereby the generated waste should be treated according to its suitable waste prevention mechanisms (Esty & Winston, 2006; Peng et al., 1997). However, Wolsink (2010) argued that the 3R principles should be improvised by giving attention to the idea of *'re-imagine'* and *'re-design'* to ensure an environmentally thinking design could be produced. Esa et al. (2016) further added that the inclusion of *'re-imagine'* and *'re-design'* as part of the construction activities would force the construction players to re-evaluate the construction processes and design-out of the waste as a priority to utilize the efficiencies of the resources. Table 1 summarizes the elements that need to be considered to achieve the full impacts of CE integration as an approach to minimize waste generation.

**Table 1:** Principles of Waste Minimization Based on CE

| No | Principle | Description |
|---|---|---|
| 1 | Re-imagine | "revising the traditional way of producing building by focusing on the environmental impacts of the end-products rather than profitability alone". |
| 2 | Re-design | "a consideration is given on how we can design a building that could minimize the waste generations rather than aesthetic value alone". |
| 3 | Reduce | "the design, manufacture, purchase, or use of materials to reduce their quantity or toxicity before they reach the waste stream". |
| 4 | Reuse | "waste materials can sometimes be used again for the same intended purpose or a different purpose". |
| 5 | Recycle | "series of activities that include the collection of used, reused, or unused items that would otherwise be considered as wastes and then these items are sorted and processed into raw materials or remanufactured into new products". |

*Source: (Esa et al., 2016; Wolsink, 2010)*

The authors are attempted to assess the current level of knowledge about the CE concept among the construction players. Therefore, vital information about the CE concept is gathered from the literature and summarized in Table 2. Each information was assigned with a coding to simplify the analysis process.

**Table 2:** Summary of CE

| Coding | Information | References |
|---|---|---|
| ICE1 | Eliminating the waste and adding value to the products | Bertino et al. (2021), Minunno et al. (2018), Ruiz et al. (2020) |
| ICE2 | Turning waste into a new resource or material | Foster (2020), Lederer et al. (2020) |
| ICE3 | Integration of 3R principles of reduce, reuse and recycle | Esa et al. (2016), Salmenperä et al. (2021), Velenturf and Purnell (2021) |
| ICE4 | Saving the congested landfill, energy and reducing greenhouse gas emissions as well | Esa et al. (2016), Vaverková et al. (2020) |
| ICE5 | Achieving environmental sustainability | Esa et al. (2017), Patwa et al. (2021), Rizos et al. (2017) |
| ICE6 | Enhance the performance of construction waste management | Esa et al. (2016), Romero-Hernández and Romero (2018), Salmenperä et al. (2021) |
| ICE7 | New paradigm towards a sustainable future | Berg et al. (2018), Suárez-Eiroa et al. (2019) |
| ICE8 | Suitable to be integrated throughout the construction cycle | Benachio et al. (2020), Esa et al. (2017) |
| ICE9 | Supporting the idea of Sustainable Development Goals (SDG) | Rodriguez-Anton et al. (2019), Schroeder et al. (2019) |

Furthermore, there are contradictions and ambiguity in the theory of knowledge regarding the concept of CE. Therefore, it is imperative to shift the differences in this understanding on the benefits that the construction players could obtain if they consider implementing CE to minimize the waste generated from the construction activities. Numerous benefits could be identified from the literature, and all those benefits are summarized in Table 3. Again, each benefit was assigned with a coding to ensure the smoothness of the analysis process.

**Table 3:** Benefits of CE

| Coding | Benefits | References |
|---|---|---|
| BCE1 | Improvement on the reusing rate of materials through innovation technology | Bertino et al. (2021), Foster (2020), Ginga et al. (2020) |
| BCE2 | Minimization of raw resources | Iuga (2016), Liakos et al. (2019) |
| BCE3 | Enhancement on waste management system | Esa et al. (2016), Romero-Hernández and Romero (2018), Salmenperä et al. (2021) |
| BCE4 | Better planning and monitoring of waste management system | Esa et al. (2016), Tomić and Schneider (2020), Winans et al. (2017) |
| BCE5 | Increase the value and quality of recycling materials | Allwood (2014), Lederer et al. (2020), Liakos et al. (2019) |
| BCE6 | Improvement on the selection of materials that allows the elements of reuse and recycle at the end of life cycle | Esa et al. (2016), Rahla et al. (2021), Zanni et al. (2018) |
| BCE7 | Reduction of waste generation and hazardous materials produced from the construction materials | Minunno et al. (2018), Ruiz et al. (2020) |
| BCE8 | Reduce the pressure on the over-stretched landfills | Esa et al. (2016), Vaverková et al. (2020) |
| BCE9 | Reduce the cost of construction materials by using the recycling materials | Allwood (2014), Foster (2020), Lederer et al. (2020) |
| BCE10 | Allowing flexibility in design to adapt to any changes in future | Bai et al. (2020), Mendoza et al. (2017) |
| BCE11 | Reduce the environmental impacts throughout the construction cycle | Esa et al. (2016), Rizos et al. (2017) |

# METHODOLOGY

## Questionnaire Survey

A quantitative method in the form of a questionnaire survey was employed in this study from December 2020 until February 2021. According to Chua (2012), one of the best methods to acquire primary data regarding the related topics is a questionnaire survey. Sekaran and Bougie (2016) further described that the questionnaire needs to be well-designed to inspire the response rate; therefore, the authors will be provided with reliable data to produce meaningful analysis. Additionally, a well-designed questionnaire would also help the authors gather valid and reliable data and recommendations (Bernard & Bernard, 2013). In this study, a self-administered questionnaire is designed to assess the level of knowledge on CE concept among the construction players in Malaysia. The primary data focus on the awareness of the CE concept, the benefits that could be gained if the CE concept is being integrated as an approach to minimize waste and the suitability of the CE concept as an approach to minimize waste. An extensive literature review is carried out to determine the variables to be included in the questionnaire.

The questionnaire is divided into four (4) parts, consisting of 38 questions, as shown in Appendix A. Part A elicits information on the respondents' background, including their gender, highest academic qualification, position in the organizations and working experience in the construction industry. The

respondents were also asked about the circumstances linked to their awareness of the emerging concept of CE. The respondents were asked either they have heard about the CE concept before or not. The adaptability of CE as an approach for waste management and the level of awareness on the principles of CE were also asked. The respondents are required to declare if their organization have ever used a waste management system that employed one of the principles of CE. If the respondents are aware of CE's existence, they must inform the platform (radio and TV, internet, newspaper and magazine, public service announcement, government document, others) that they got that information. All questions in this part are closed-ended. In Part B, the respondents were assessed their level of knowledge on CE as an approach for waste management. In this part, the respondents are required to rate the given information related to CE using the Likert scale of 1 to 5; 1 representing not aware and 5 representing fully aware. Similarly, in Part C, the respondents are required to rate using the Likert Scale 1 to 5; 1 representing strongly disagree and 5 representing strongly agree on the given benefits of implementing CE as an approach for waste management. Finally, in Part D, a closed-ended question is included in determining the level of agreement among the respondents on the suggestion of using CE as an approach for waste management.

Moreover, a sampling process is imperative in the quantitative method to uphold the reliability and validity of the study (Brannen, 2017). The sample population need to be identified to determine the sample size. In this study, the sample size was calculated by adapting the procedure developed by Krejcie and Morgan (1970). The main aim of the study is to assess the level of knowledge and awareness about the CE concept; hence, the sample population was randomly selected among the Malaysian contractors registered with Construction Industry Development Board (CIDB). The targeted contractors were taken from the CIDB directory currently registered with the CIDB under Grade 7 (G7). Only the G7 contractors registered in Klang Valley will be focused. Rapid development in Klang Valley has influenced the decision of the authors to select contractors from the Klang Valley area (Department of Statistics, 2021). Based on the CIDB directory, there are 4,610 G7 contractors registered in the Klang Valley area. From the procedure developed by Krejcie and Morgan (1970), the sample size for the study was 357.

In all, 360 questionnaires were distributed to the potential G7 contractors listed in the CIDB directory using a web-based survey. A web-based survey is the only medium of distribution used in this study due to the restriction of the COVID-19 pandemic situation. The potential respondents were contacted to get their consensus on the initial involvement in this study. The potential respondents are then being invited to answer the questionnaire through email or WhatsApp. The questionnaire was sent, either through email or WhatsApp, which include an explanation about the study title, its objectives, the final date by which it should be replied and a declaration of confidentiality. In addition, a general remainder will be sent to the potential respondents 14 days and 7 days before the due date.

## Statistical Analysis

Statistical Package for the Social Sciences (SPSS) for Windows (Version 27.00) is used to analyze the data statistically. Frequencies were used to analyze the result obtained from Part A, B and E respectively. Field (2013) mentioned that the frequencies would identify the number of occurrences of each response selected by the respondents. By applying the frequencies, it will help the authors to decide which is the most reliable response given by the respondents. For Part C and D, the results were analyzed descriptively using the mean and standard deviation values to rank the variables. Mean is a process to determine the average level obtained from the response, while standard deviation will show the spreading of the response from the mean (Pallant, 2020). Usually, the mean and standard deviation will be reported together to give a better picture of the analyzing processes.

# RESULTS AND DISCUSSIONS

Only 135 questionnaires were returned within three (3) months after they were distributed; thus, the total response rate was 37.5%. According to Esa et al. (2017), the norm response rate in the construction industry related research is around 20% to 30%. Therefore, the response rate gathered from this study is sufficient to be used for analysis purposes. All the questions were satisfactorily completed. As mentioned, the results were analyzed using SPSS for statistical analysis. Details of the data and analysis are presented below.

## Results of Part A

As mentioned in Section 3.1, Part A of the questionnaire was focused on the respondents' background and their level of awareness of the CE concept. Table 4 summarizes the information related to the respondents' background. Most of the respondents were male and had a degree as their highest academic qualification. A variety of positions involved in the survey; namely Engineer (26.7%), Site Supervisor (20.7%), Quantity Surveyor (18.5%), Others including Project Executive, Project Coordinator, Project Administration, Assistant Engineer, Site Safety etc.(16.3%), Project Manager (9.6%) and Architect (8.1%). The respondents involved in the survey have vast working experience in the construction industry. 62.2% of the respondents had involved between 1 to 5 years in the construction industry, 24.4% between 5 to 10 years, 9.6% between 10 to 20 years and 3.7% above 20 years.

Most of the respondents had heard about the CE concept (74.1%). Besides that, 74.8% of the respondents agreed that the CE concept is suitable to be integrated as an approach for waste minimization. Nevertheless, the majority of the respondents (67.4%) had applied one of the principles of CE (see Table 2) in their waste management system. As being suggested by Esa et al. (2016) and Wolsink (2010), there are five (5) principles that need to be considered in integrating the CE concept as an approach for waste minimization. The respondents were asked to choose the widely considered principles to be implemented as waste minimization mechanisms. In this question, the respondents can choose more than one principle. Reuse and recycle were the most chose principles among the respondents with 89%. Finally, in Part A, the respondents must inform which platform they used to gain information about the CE concept. Similarly, they can choose more than one platform in this question. Most of the respondents obtained information about the CE concept from the internet (87.6%).

**Table 4:** Summaries of Respondents' Background

| Variables | Number of Respondents | Percentage (%) |
|---|---|---|
| Gender | | |
| Male | 79 | 58.5 |
| Female | 56 | 41.5 |
| Academic Qualification | | |
| Certificate | 8 | 5.9 |
| Diploma | 22 | 16.3 |
| Degree | 65 | 48.1 |
| Master | 39 | 28.9 |
| Others | 1 | 0.7 |
| Position | | |
| Project Manager | 13 | 9.6 |
| Architect | 11 | 8.1 |
| Engineer | 36 | 26.7 |
| Quantity Surveyor | 25 | 18.5 |
| Site Supervisor | 28 | 20.7 |
| Others | 22 | 16.3 |
| Working Experience | | |
| 1 to 5 years | 84 | 62.2 |
| 5 to 10 years | 33 | 24.4 |
| 10 to 20 years | 13 | 9.6 |
| Above 20 years | 5 | 3.7 |
| Existence of CE | | |
| Yes | 100 | 74.1 |
| No | 35 | 25.9 |
| CE as an approach for waste management | 101 | 74.8 |
| Yes | 34 | 25.2 |
| No | | |
| Employment of CE Principles | | |
| Yes | 91 | 67.4% |
| No | 44 | 32.6% |
| Principles of CE | | |
| Re-imagine | 96 | 75.6% |
| Re-design | 96 | 75.6% |
| Reduce | 106 | 83.5% |
| Reuse | 113 | 89% |
| Recycle | 113 | 89% |
| Platform of Information | | |
| Radio and TV | 35 | 27.7% |
| Newspaper and Magazines | 43 | 33.3% |
| Internet | 113 | 87.6% |
| Government Documents | 37 | 28.7% |
| Public Service Announcement | 37 | 28.7% |

## Results of Part B

Even though most of the respondents are aware of the existence of the CE concept, it is imperative to assess the level of knowledge about the CE concept among the respondents. The level of knowledge was assessed based on the relevant information about the CE concept gathered from the literature (see Table 3). This information will be assessed using a Likert Scale of 1-5 (1 represents not aware and 5 represents fully aware). The data obtained were analyzed by determining the mean and standard deviation value to rank the information; the higher the mean value, the higher the rank position. Table 5 summarizes the relevant information regarding the CE concept.

As shown in Table 5, it is apparent that most of the respondents agreed that *achieving environmental sustainability* (ICE5) is the obvious information that they knew about the CE concept with a mean value of 3.41. The respondents ranked *saving the congested landfills, energy and reducing greenhouse gas emissions* (ICE4) as the second information in understanding the CE concept with a mean value of 3.39. The following information ranked by the respondents is *turning waste into a new resource or material* (ICE3) with a mean value of 3.35. Overall, these results indicate that the respondents were aligned with the most elaboration given by previous studies regarding the CE concept (Esa et al., 2017; Patwa et al., 2021; Salmenperä et al., 2021; Velenturf & Purnell, 2021).

**Table 5:** Summary of CE Relevant Information

| Information | Mean | Standard Deviation | Rank |
|---|---|---|---|
| ICE1 | 3.18 | 1.18 | 9 |
| ICE2 | 3.33 | 1.18 | 4 |
| **ICE3** | **3.35** | **1.17** | **3** |
| **ICE4** | **3.39** | **1.15** | **2** |
| **ICE5** | **3.41** | **1.15** | **1** |
| ICE6 | 3.32 | 1.14 | 5 |
| ICE7 | 3.21 | 1.17 | 8 |
| ICE8 | 3.26 | 1.20 | 7 |
| ICE9 | 3.31 | 1.21 | 6 |

## Results of Part C

In this part, the question asked the respondents to identify the benefits they could gain if they integrated the CE concept as an approach to waste minimization. A list of variables had been assembled based on the previous studies (see Table 3). There are eleven (11) benefits that have been identified if the CE concept is used as an approach for waste minimization. The respondents were required to assess the benefits using a Likert Scale of 1 to 5; (1 represents strongly disagree and 5 represents strongly agree). Again, in this question, mean and standard deviation were employed to analyze the data. Finally, the benefits will be ranked accordingly; the higher the mean, the higher the rank position. Table 6 presents the breakdown of the benefits of the CE concept for waste minimization according to the respondents.

It can be seen from the results in Table 6 that the integration of CE as an approach for waste minimization will *enhance the waste management system* (BCE3) and *provide a better planning and monitoring of waste management system* (BCE4) in the construction industry with a mean value of 4.10. However, BCE3 was ranked first due to a smaller value of standard deviation. As mentioned in the literature review, the adoption of CE as an approach for waste minimization will significantly improve waste management in the construction industry (Esa et al., 2016; Romero- Hernández & Romero, 2018; Salmenperä et al., 2021; Tomić & Schneider, 2020; Winans et al., 2017). Ajayi et al. (2017) argued that waste management issues failed to be addressed due to poor coordination among the construction players. Therefore, CE will enhance the planning and monitoring mechanisms of waste management in the construction industry. The next benefit ranked by the respondents is *reducing the environmental impacts throughout the construction cycle* (BCE11) with a mean value of 4.07. Several reports have

shown that the waste if not properly managed, will create negative impacts on the environment, as mentioned by Bakshan et al. (2015), Crawford (2011) and Udawatta et al. (2015).

**Table 6:** Summary of CE Benefits

| Benefits | Mean | Standard Deviation | Rank |
|---|---|---|---|
| BCE1 | 3.84 | 0.95 | 11 |
| BCE2 | 3.94 | 0.95 | 10 |
| **BCE3** | **4.10** | **0.87** | **1** |
| **BCE4** | **4.10** | **0.89** | **2** |
| BCE5 | 4.00 | 9.86 | 6 |
| BCE6 | 4.04 | 0.93 | 4 |
| BCE7 | 4.01 | 0.99 | 5 |
| BCE8 | 4.00 | 0.92 | 7 |
| BCE9 | 3.96 | 0.86 | 9 |
| BCE10 | 3.99 | 1.02 | 8 |
| **BCE11** | **4.07** | **0.97** | **3** |

## Results of Part D

Part D was designed to seek a suitable mechanism to be integrated into the CE concept as an approach for waste minimization. A suitable mechanism needs to be determined to enhance the implementation of the CE concept. In this part, a closed-ended question with five (5) mechanisms (*adaptive reused; deconstruction; design for deconstruction (DFD); design for reused (DFR) and off-site construction method)* related to the CE concept were included. Frequency was used to analyze the results obtained from the respondents. The respondents were required to assess the given mechanisms and allowed multiple responses for this question. Table 7 summarizes the selected mechanisms from the respondents.

The majority of the respondents agreed that *adaptive reused* is the most suitable mechanism to be integrated into the CE concept, with 62.4%. While 56.4% of the respondents considered the *off-site construction method* as the second suitable mechanisms to be integrated. Next, followed by *design for reused (DFR), deconstruction* and *design for deconstruction (DFD)* with a 51.1%, 49.6% and 45.9% respectively.

**Table 7:** Summary of Mechanisms

| Mechanism | Frequencies | Percentage (%) | Rank |
|---|---|---|---|
| Adaptive Reused | 83 | 62.4 | 1 |
| Deconstruction | 66 | 49.6 | 4 |
| Design for Deconstruction (DFD) | 61 | 45.9 | 5 |
| Design for Reused (DFR) | 68 | 51.1 | 3 |
| Off-site Construction Method | 75 | 56.4 | 2 |

## CONCLUSIONS

The study aims to assess the level of knowledge and awareness regarding the availability of the CE concept as an approach for waste minimization. According to the aim, the study was undertaken to identify the potential benefits of implementing CE and determine the suitable mechanisms to be integrated into the CE concept as an approach for waste minimization. This study has identified the following:

a) Surprisingly, the CE concept was found to be popular among contractors. They are aware of the existence of the CE concept and had basic knowledge about it, including the suitability of CE as an approach for waste minimization and the principles of CE. They are also attentive to the aspect where CE is very significant towards preserving the environment and directly will enhance sustainability for the future generation.

b) The findings reveal that *enhancement of the waste management system*, *better planning and monitoring of waste management system*, and *reducing the environmental impacts throughout the construction cycle* are the highest rank of benefits if the CE concept is implemented as an approach for waste minimization. With the benefits that could be gained, there is no reason for the contractors to opt not to improvise the way they are managing the waste.
c) Finally, the mechanisms of *adaptative reused*, *off-site construction method* and *design for reused (DFR)* were suitable to be integrated into the CE concept. The integration of those mechanisms would help to enhance the implementation of the CE concept for waste minimization.

The most prominent finding to emerge from this study is that the level of knowledge about the CE concept is high, considering this concept is relatively a new concept in Malaysia. Overall, this study strengthens the idea that there is a need to shift the linear-based practice of the construction industry to a more circular approach so that the amount of waste generated could be reduced. The CE concept is suitable to be used as an approach for waste minimization in the construction industry. This study lays the groundwork for future research by looking at the opportunities to integrate the CE concept throughout the construction cycle.

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