Application of circular economy in the Indonesia construction industry

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ABSTRACT. The Circular Economy (CE) is a concept that aims to keep the value of products, materials, and resources economically as long as possible while minimizing the waste produced. The CE concept is adapted from the 3R principle (Reduce, Reuse and Recycle). The construction industry is one of the largest waste-producing industries. In fact, 30% of the waste in landfills is construction waste. This study aims to identify and analyze the application of circular economy in the construction industry in Indonesia. There are two main stages in this study. The first stage was to identify construction practitioners' awareness of the circular economy. The second stage is to document the implementation of 3R on various types of construction projects such as building, road, and bridge projects. The questionnaire was used to collect data. Around 120 project managers of medium to large scale construction companies in Indonesia were used as respondents. Important Performance Analysis (IPA) is used to represent construction practitioner awareness of CE. The results show that most construction practitioners in Indonesia have understood the importance of construction waste treatment in the context of a circular economy. However, only a few construction companies that seriously take care of construction waste treatment. Most construction waste is only released to the landfill area through the third parties. Only about 36% of contractor reused and recycled waste is in the construction site.

1. Introduction
The human population in the world is expected to exceed 6 billion by 2045, with cities in Asia and Africa recording large growth [1]. Compared to the increase in the human population, the amount of waste is also expected to increase. In 2050, the world is expected to produce 3.40 billion tons every year, increasing dramatically from 2.01 billion tons in 2018 [2]. Increasing the amount of waste every year is inseparable from industrial development activities to meet increasing human needs.
The building's life cycle broadly includes the stages of planning, construction, utilization and deconstruction or demolition [3]. The life cycle produces waste at every stage, including construction. The construction waste is produced during the entire construction process such as when there is material damage, excess procurement, and human error [4]. Much amount of waste comes from the results of construction industry activities, especially in construction and demolition activities. 40% of industrial waste in the world comes from the construction industry [5].
In recent years Circular Economy (CE) has been widely discussed throughout the world as an alternative to the old economic model, namely, "take, make and dispose", as well as a solution to the problem of efficient use of resources and environmental problems. The circular economy concept is an example of an approach to managing resources sustainably and minimizing waste [6].
By managing resources efficiently, the amount of waste produced will decrease. This management process can be carried out at each phase of the building's life cycle. The CE system ensures that added value in products (resources) is stored in economic circles as long as possible to avoid waste deposits in landfills [7]. The concept of CE has similarities with the concept of sustainability, which is both based on environmental problems and its application requires cooperation from many stakeholders. But CE is more focused on how to use resources and waste better. In addition, the concept of sustainable thinking about benefits to the environment, the community, and sustainable concept players, while the CE concept prioritizes benefits to the perpetrators themselves, and benefits to other parties are only a bonus [8]. The CE concept itself is adapted from the principles of 3R (Reduce, Reuse and Recycle), this aims to optimize production, reduce pollution, emissions, and waste [9].

The Indonesian government realizes and pays attention to the problem of waste. In 2017 the Indonesian government announced plans to invest up to EUR 850 million (IDR 15 trillion) over the next four years to develop a national program to manage waste management from land-based sources. Indonesia as a developing country has had a blueprint for the construction sector as a grand design and grand strategy called Indonesian Construction 2030. Based on Law No. 23 of 2009 and Law No. 18 of 2008, the government also supports the implementation of a CE by targeting reduced waste in 2025 to reach 30% of the total waste produced. CE can be a solution to reduce the amount of waste. However, this regulation applies to general waste, not specifically to construction industry waste. Some Indonesian construction companies also began to implement the CE concept, which uses recycled materials by utilizing containerized wood or wood shavings, utilizing sludge from the remaining liquid from the concrete manufacturing process to harden road and embankment infrastructure, utilizing the remaining pieces of reinforced concrete (less than 1 m) and old building materials used as recycled materials. However, not all construction companies implement the CE principle in construction practice. This paper aims to analyze the awareness of construction practitioners in Indonesia in implementing Circular Economy. This study also documents the 3R practices carried out in the Indonesian construction industry.

2. Literature Review

Several previous studies tried to convey the background that influenced the implementation of CE. Over the past decade, growing attention has been given throughout the world to new concepts and models of developing CE, with the aim of providing a better alternative to the dominant economic development model, which has the concept of "take, make and waste" [10]. The negative effects caused by the dominant economic development model threaten economic stability and the integrity of natural ecosystems that are important for the survival of humanity [11]. Countries such as China and Germany have used this term in their laws, although the emphasis may vary. A large number of these studies concern the implementation of CE in China. This country seems to be very committed and interested in CE because of its enormous environmental, human health and social problems.

Some studies discuss the principles of CE. Principles for Increasing material productivity including eliminating waste by defining good materials that allow them to be in a closed loop of material [12]. The principle of maintaining or increasing the value of materials, environment, and economy is put forward by [13]. [14] conducted a study to develop a strategy for managing construction and demolition waste in Malaysia based on the CE concept. In the study also mentioned waste reduction strategies at each stage of the building life cycle. Research on waste management along the building life cycle in Canada was carried out by [4]. In the study also mentioned the potential for reuse and recycle of various types of construction waste. [15] conducted a study on waste management in Malaysia. The study discusses current waste management and the challenges that must be faced in applying the circular economy (3R) concept. Finally, [16] proposed a CE aspect along the building life cycle.

According to [14], the CE must be integrated into the construction industry to ensure a reduction in waste generation and to create a sustainable future. The CE can be successfully implemented at three different levels, namely, Micro, Meso, and Macro levels. Micro Level, Focusing on the production
area. This level requires the adoption of cleaner production processes and more environmentally friendly designs; Meso Level, The eco-friendly design encourages the introduction of trade in the waste system; and Macro Level, A more advanced collaboration network among industries that drives the elements of Reuse, Reduce and Recycle

3. Research Methodology

This study uses 2 stages of research. The first stage is an analysis of awareness of construction practitioners related to CE. The second stage is the identification of the implementation of CE in the construction industry in Indonesia. The method used in the first stage of the research is a quantitative approach, in the form of an online survey. The survey was conducted for 3 months. The questionnaire was distributed to 120 respondents and produced 83 valid responses (68.3%). The research respondents consisted of designers, project supervisors, contractors, owners, and material suppliers. The questionnaire was divided into 5 sections with a total of 20 questions. For each question, a five-point Likert scale was used to measure the respondent's level of understanding and implementation of CE in construction projects. An appropriate rating is given from '1' - the lowest level to “5” - the highest level. Respondents can also provide qualitative opinions for each question. Importance-Performance Analysis (IPA) is used to analyze and represent the results of the research. Variable used in awareness analysis are described in Table 1.

Table 1. Circular Economy Aspects

| Project Phase         | Code | Circular economy aspect                                      |
|-----------------------|------|-------------------------------------------------------------|
| Design & Planning     | X1   | Design for adaptability and flexibility                     |
|                       | X2   | Design for standardization & Modularity                     |
|                       | X3   | Design out the waste/ Set target for allowable wastage      |
|                       | X4   | Increase the lifespan                                      |
|                       | X5   | Specify recycled / Eco-label materials                      |
| Procurement           | X6   | Design for product disassembly                              |
|                       | X7   | Use secondary materials                                     |
|                       | X8   | Take-back schemes/ Reverse Logistics                       |
| Construction          | X9   | Minimize on-site construction waste                         |
|                       | X10  | Reuse materials                                             |
|                       | X11  | Recycle materials                                           |
|                       | X12  | Off-site construction/ fabrication                          |

In the second stage of the study, secondary data collected from 17 medium and large scale construction projects — both government and private— were used to describe the implementation of 3R in construction projects in Indonesia. The types of construction projects studied include building projects, roads, and bridges. To get more realistic results and represent the real conditions of the construction site, a Focus Group Discussion (FGD) was held by inviting 18 participants consists of designers, project supervisors, and contractors.
4. Result

As explained earlier, this study involved 83 valid respondents from medium to large-scale government and private companies. The respondents of this study consisted of designers (23%), project supervisors (16%), contractors (44%), owners (7%), and supplier materials (10%). Of this 78% of respondents have more than 10 years experience in construction projects and have been involved in green construction (see Figure 1).

![Figure 1. Respondent profile](image)

Data collected from questionnaires were then analyzed using Important performance analysis (IPA). From Figure 2, it can be seen that the average understanding of respondents regarding the importance of CE in the construction industry is good (4.1 of 5.0). There is a clear need to get the benefits of a CE in a transparent and measurable manner. However, the actual implementation of the CE is still not significant (3.5 of 5.0).

![Figure 2. Result of CE Awareness](image)

The results of qualitative opinion indicate that implementation of CE is still low due to several factors. For designers, who work on government projects, the time provided for designing is very limited, so they did not have time to apply Value engineering and think of eco-label material as an alternative material. For contractors, they prefer to use third parties to deal with construction waste disposal problems. Most of them are reluctant to do Reuse, Reduce or Recycle on construction waste, because of the very tight construction schedule. For the owner, especially in government projects, there are still no regulations that require the use of green materials and the rules for processing construction waste. The use of Green material or eco-label material is considered to increase construction costs 1-1.5%.

Construction waste must be processed for re-use and recycled before the last mechanism, which is waste disposal to landfill. In this paper, we try to document the implementation of 3R to reduce,
reuse and recycle as a general practice used to reduce waste by the construction industry in Indonesia. Based on data from 23 construction projects in Indonesia, there are several strategies carried out to reduce construction waste in the design, procurement and construction phases. This research also documents how to use the remaining construction materials that can be reused, both in the project and used for other industrial purposes. As seen in Table 2, various waste management strategies were carried out by designers and contractors in reducing construction waste. However, not all designers and contractors implement these strategies. There are 4 waste reduction strategies that we documented from the designer. From this strategy, 82% of designers have used standard or modular components to reduce construction waste, especially in high-rise buildings. The use of proper material, especially eco-label materials is still rarely implemented by designers. For contractors and project supervisors, we document 6 waste reduction strategies implemented in the procurement and construction phase. The results showed that most contractors (82%) hired third parties to resolve waste disposal problems. Only about 36% of contractors carry out the 3R process before disposing of their waste into the Final Disposal Site. They do not care if the waste is disposed of to final disposal or recycled elsewhere. The waste reduction process carried out at the project site is to sort the remaining material at the project (42%) and request the sub-contractor to handle their material waste (32%).

Table 2. Waste minimization strategy implemented by designers and contractors

| No | Waste Minimization strategy | Stages                      | % Implementation |
|----|-----------------------------|-----------------------------|------------------|
| 1  | Set Target of Allowable wastage | Design & Planning | 32% of designer |
| 2  | Standardization and modularization | Design & Planning | 74% of designer |
| 3  | Usage of the eco-labeling product | Design & Planning | 26% of designer |
| 4  | Proper material selection | Design & Planning | 56% of designer |
| 5  | On-site sorting technique | Procurement                 | 42% of contractor/Sub Contractor |
| 6  | Employ Sub-contractor with ability to manage waste effectively | Procurement | 32% of contractor/Sub Contractor |
| 7  | Proper storage location for waste material | Construction | 66% of contractor/Sub Contractor |
| 8  | Reuse and recycle waste material for temporary/supporting work inside the project | Construction | 36% of contractor/Sub Contractor |
| 9  | Avoid confusion among multiple contractors on site to manage construction waste | Construction | 27% of contractor |
| 10 | Hire 3rd party to manage construction waste | Construction | 82% of contractor |

As explained above, the remaining material in the project can be reused or re-processed in another form (Recycle). This research documents the form of 3R implementation in the project environment and its processing by third parties. The research objects used are building projects, road and bridge projects. Table 3 shows the utilization of the remaining construction materials for reuse and recycling in the Micro, Meso and Macro level of CE.
Table 3. Reuse and Recycle of construction waste material

| Type of Material | Type of Infrastructure* | Reused and Recycle in the construction Industry |
|------------------|-------------------------|-------------------------------------------------|
|                  | Building | Road | Bridge | Project (Micro) | Between Industry (Macro) |
| Clay Brick       |          | √    |        |                | Substitute sand in making Paving block |
| Clay Roof        |          | √    |        |                | Raw material for concrete roof tiles. |
| Ceramic          |          | √    |        |                | Ceramic Craft, Mosaic ceramic Glass based Craft. |
| Glass            |          | √    |        |                | Asphalt waste can be recycled |
| Asphalt          |          | √    | √      | √              | Asphalt waste is used as waterproofing material. Formed as artificial stone such as paving block. Mounted in the seaford as coral reef. |
| Concrete         |          | √    | √      | √              | Cast as Concrete floor rebate, Work floor for putting utility equipment. |
| Stone            |          | √    | √      | √              | Use as concrete mixture, use as pavement material. |
| Timber           |          | √    | √      | √              | Re-use as formwork and buffer Composite plastic wood powder. Activated Charcoal/ Briquettes. |
| Metal & Steel    |          | √    | √      | √              | Recycle in the iron factory |

5. Conclusion

The results of the study show that most construction practitioners in Indonesia have understood the importance of construction waste treatment in the context of a circular economy. However, there are still a few construction companies that seriously take care of construction waste treatment. Most construction waste is only released to the landfill area through the third parties. Only about 36% of contractors reuse and recycle waste at construction sites. In order to successfully implement the circular economy in the Indonesian construction industry, the government must take decisive steps by making regulations related to reducing construction waste.

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