Sustainability of Construction Company Waste Management in the Industrial Era 5.0 Post Pandemic Covid-19

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Abstract

Technology dominates human activity in the industrial 5.0 era, where technological developments increase automation and digitalization as well as in the construction sector after pandemic. The increased speed of construction makes the life cycle of goods faster resulting in a continuous accumulation of waste, especially in the case of building construction. This study aims to examine the implementation of construction companies in tackling construction waste in Jakarta post the Covid-19 pandemic. This qualitative research uses a case study approach. Primary data was obtained through in-depth interviews and focus group discussions. Selection of respondents using the convenience sampling method, and data analysis using interactive modeling techniques. Construction companies in Jakarta have concrete actions to reduce construction waste. The company's action strategy is to carry out the stages of the refurbishment, repair and recycling processes combined with elements of technology, policies, guidelines and regulations, in processing construction waste through appropriate procedures and innovate to create environmentally friendly products. In the sustainability action strategy, the company cooperates with the government and local communities in overcoming the problem of waste, minimizing its impact to achieve environmental sustainability in the construction sector. Therefore, the role of innovators in the field of construction waste management is needed, especially companies that are considered capable of solving these problems in order to realize the continuity of economic digitalization towards a better Indonesia so that green tech companies in Indonesia can become leading innovators in terms of processing construction waste management in the industrial revolution 5.0 era post pandemic.

Keywords
Construction, Waste, Management, Sustainability, Technology

1. Introduction
The world of construction cannot be separated from technology. The post-Covid-19 situation can be used as a momentum for the world of construction to change and find new models that are more effective, efficient, competitive and sustainable. Entering the industrial era 5.0 which relies on human resources in terms of creating a balance between economic progress and in solving social problems that occur in the midst of the community environment through a system that connects the virtual world with the real world, so that the industrial era 5.0 can be used as a momentum to realize the concept of development, especially in the infrastructure and construction climate in Indonesia. This is because infrastructure and construction are the most likely to combine human resources with technology 4.0.
Utilization of information technology in the infrastructure sector such as digitizing toll road management, online attendance, the tender process for procurement of goods and services for infrastructure projects through E-Procurement, and the use of drones for infrastructure development in hard-to-reach areas.
Meanwhile, for construction work that involves many people, reengineering and redesigning of the project implementation scheme are carried out so that the project can be completed more quickly and efficiently.

Jakarta is a densely populated metropolis. Based on the DKI Jakarta Provincial Statistics Center, the total population in DKI Jakarta in 2022 it is projected to reach 10.64 million people (www.jakarta.bps.go.id). Indonesia as a developing country is in a very rapid condition in building various types of infrastructure including building construction. Therefore, Jakarta with a high level of construction development, the amount of waste generated from construction projects in this city is increasing every year. Even though construction waste management has been carried out for many years, its performance is still not satisfactory because it faces many challenges and problems.
Construction and demolition waste causes environmental pollution and ecological damage, thus hindering the pace of sustainable development in the construction industry (Cheng et al. 2022). The process of processing construction waste is a difficult problem to fix, especially in Jakarta. It is important to efficiently minimize construction and demolition waste to ease the burden on the environment, but various constraints limit construction waste management strategies (Hasan et al. 2022).
The results of Oviedo's research (2021) provide information for effective decision-making regarding construction and demolition waste policies and regulations, to increase the effectiveness of construction waste management systems, reduce environmental impacts, and provide economic benefits, especially in developing countries.
Key factors determining the construction waste management process are identifying the economic value of discarded materials, potential for on-site segregation, knowledge, experience and training of site operators, accurate prediction of waste management costs, and identifying better construction and demolition waste collection and disposal methods (Newas et al. 2020).
The strategy for reducing waste and managing building construction projects in Jakarta is currently still ineffective, so a qualified strategy must emerge to reduce and manage construction waste that is handled together in a more environmentally responsible way. Thus, this research is useful for stakeholders in the industrial environment who are concerned with sustainable strategies in the industrial era 5.0 regarding construction waste management after the Covid-19 pandemic.

1.1 Objectives This research aims to examine the implementation of construction companies in handling construction waste in Jakarta post the Covid-19 pandemic, as well as the efforts made by construction companies in the context of sustainable management of construction waste in the industrial era 5.0 post the Covid-19 pandemic.

2. Literature Review

Waste is an integral part of a construction process. The objective of the construction waste management plan is to minimize the amount of material entering the landfill during the construction project process by diverting the source from construction and demolition waste, followed by clearing construction debris from the landfill site. It also aims to help optimize waste resources that can be recycled back into the manufacturing process, as well as grouping waste materials that can be reused into the right location. From the beginning of the project planning period, project waste should be prevented, which is an integral part of the entire materials management system. The plan should also indicate the degree of success the recycling plan will achieve, including materials that can be used for recycling, accompanied by a cost estimate to compare recycling costs with disposal costs, specific material handling requirements, and planning a strategy for how the plan will be communicated to the organization's stakeholders, the project team, and subcontractors.
Waste management is part of the project's waste material management which will lead to the final process of efficient and effective construction waste management (Kubba 2010). For this reason, it is necessary that the waste management requirements must be spelled out at the beginning of the work design process so that follow-up actions can be planned at routine pre-construction work meetings so that it can be ensured that contractors and subcontractors receive complete information about the construction waste management work plan accompanied by the implications of waste management requirements beforehand and during the construction process (Kubba 2012).
Commercial construction generally generates between 2 and 2.5 pounds of solid waste per square foot, most of which is recyclable (Kubba 2012). In addition, effective management of construction waste, including proper handling of items that cannot be recycled, will extend the life of existing landfills. By reducing construction waste at the start of a project, it is better than reusing or recycling it. In general, the types of construction and demolition debris that can be recycled are types that include concrete, plastic, rigid plastic, stone, porcelain, tile, wood, carpet, metal, stone, insulation, and more (Kubba 2017).
Zorpas and Lasaridi (2015) state that it is based on an analysis of the environmental impact of construction complemented by some of the latest waste management methods, a strategy to prevent waste accumulation is the most efficient way. Sustainable construction waste management especially for renewable energy and recycled

materials to minimize environmental impact (Umar et al. 2018). The following is a contingency scheme for the stages of construction waste management, elements of consideration start from the most sustainable solution level to the least sustainable solution element.

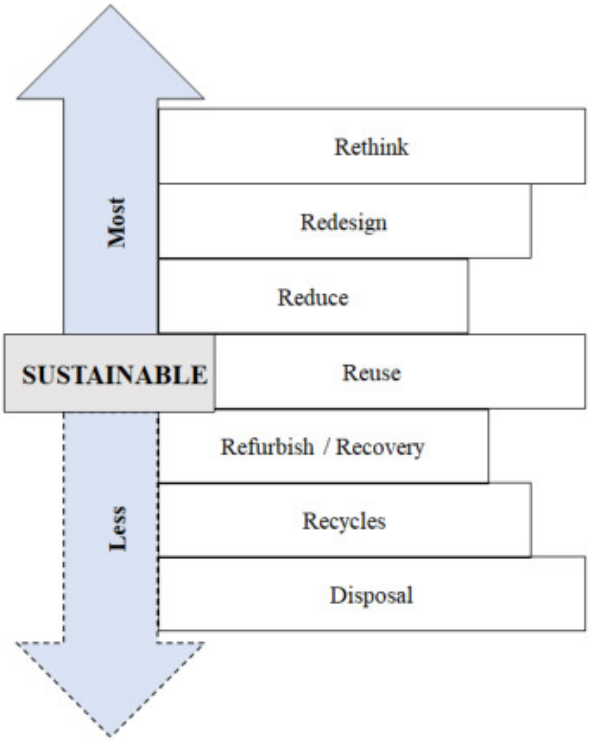

Figure 1. Construction waste management solutions

In addressing the problem of construction waste management, the European Commission (2016) presents a variable scheme that must be considered is a factor in waste management, integration of the demolition process and other construction activities by implementing the Waste Management Plan (WMP) program, along with the results of the use of elements, materials and waste generated, can be seen in Figure 2 below.

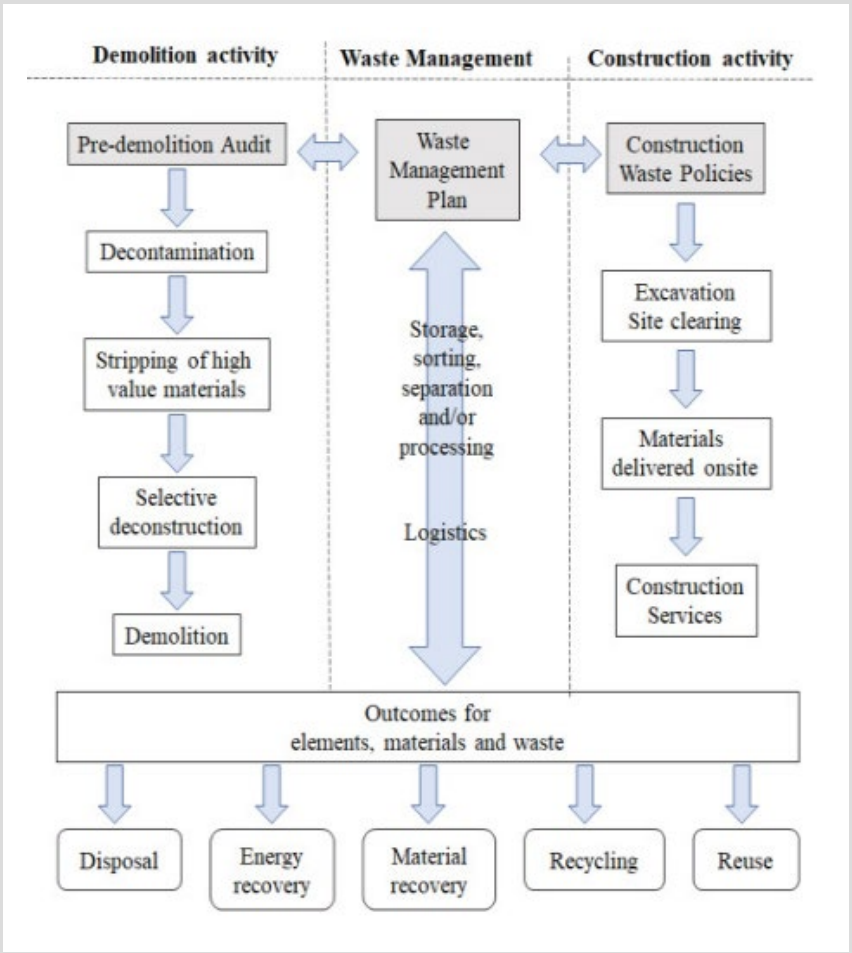

Figure 2. Key elements of the WMP, construction activities, and demolition activities

Construction and demolition waste management practices according to the European Commission 2016 can be explained in the scheme of the European Construction and Demolition Waste Management Protocol. These steps consist of five components: (a) Identification, segregation and collection of waste sources; (b) Waste treatment; (c) Waste logistics; (d) Quality management; and (e) Terms and policy framework.

Effective management of construction waste, including proper handling of items that cannot be recycled, can anticipate exposure to contamination and extend the life of existing landfills. It is better to reduce the landfill at the beginning of the project than to recycle it (Kubba 2016).

The waste management technique that is commonly used is a waste hierarchy that leads to the "Three-R", namely Reduce, Reuse, and Recycle. Waste management with the 3R hierarchical concept then develops into the "Five-R" inverted triangle concept, namely: Reduce, Reuse, Recycle, Recovery, and Disposal; with the following details:

(a) Reduce – reduce construction waste is divided into two ways: (1) Prevention - is an effort made to prevent the use of materials that can produce construction waste; and (2) Minimization - is the effort made to reduce construction waste by preparing plans handling of construction waste.
(b) Reuse – is the reuse of waste usable construction. Reuse can save costs the use of new materials both in the same project and follow-up projects.
(c) Recycle – is a waste recycling process construction into construction materials that have almost the same quality same as new material. Recycle waste by chopping and melting it into new products that will experience a slight decrease in quality.
(d) Recovery – if the recycling process cannot be carried out, then the next solution will be sought to produce energy or new materials by treating waste that cannot be recycled.

(e) Disposal – the waste resulting from the recovery process is sent to the landfill for later treated and processing so as not to damage the surrounding environment.

Sustainable development requires a strategic framework that involves all stakeholders in the construction waste management process, and the impact of this process must also be understood thoroughly in various environmental issues (Yakhief 2020). The framework provides guidance during the construction life cycle to improve the quality of construction waste management.

3. Methods

This research is qualitative descriptive research using a case study approach with data collection in accordance with the research focus, namely the implementation of construction companies in handling construction waste in Jakarta post the Covid-19 pandemic, as well as the efforts made by construction companies in the context of sustainable management of construction waste in the industrial era 5.0 post the Covid-19 pandemic.

Qualitative data analysis in this study used an interactive model where the components of data analysis included reduction, data presentation, and interactive verification during data collection (Sugiyono 2019). Then the discussion will go deeper on how construction companies in Jakarta implement construction waste management post the Covid-19 pandemic, as well as the efforts made by construction companies in the framework of sustainable construction waste management in the post-Covid-19 industrial era 5.0.

In this study, the first stage was conducted in-depth interviews with 7 construction practitioners and consultants from several construction companies in Jakarta. The interview questions were formulated based on a literature review. Then a summary of the results of the interviews was presented in a focus group discussion, followed by a discussion of the results of the interviews with all respondents to get advice on effective strategies for reducing construction waste and how to manage construction waste effectively post Covid-19 pandemic in the industrial era 5.0.

4. Data Collection

Primary data collection techniques were obtained through Focus Group Discussions and in-depth interviews with semi-structured methods. The criteria for research respondents are people who have a good understanding and are directly involved in implementing effective strategies in managing construction waste within a minimum period of the last five years, and understand well how the company's strategy is in managing construction waste effectively post pandemic Covid-19 in the industrial era 5.0. The respondents in question were 7 construction practitioners and consultants from several construction companies in Jakarta.

The duration of the in-depth interviews was approximately one hour for each respondent. Furthermore, the findings from the interviews were discussed in focus group discussions. The meeting began with a presentation of the findings of the researchers, then each respondent shared insights on strategies for minimizing construction waste and effective strategies for reducing construction waste and how to effectively manage construction waste after the Covid-19 pandemic in the industrial era 5.0.

Meanwhile, secondary data was obtained through documents, proposals, reports, publications, books, scientific journals, studies of related regulations, government reports and publication materials, as well as previous research relevant to this research within the last five years.

5. Results and Discussion

5.1 Results

Waste treatment should be an important part of a standard quality assurance program, which must meet certain requirements regarding construction waste management techniques which must be handled regularly throughout the life of the project. The construction waste disposal plan should refer to good waste management, by the method of eliminating waste if company conditions permit, and the process of minimizing the production of waste, and reuse recyclable materials. Ideal waste management practice would imply that the process of minimization, recycling and reuse of waste is a very important part of ensuring that it moves towards a sustainable management of material and energy resources. There are five strategies for construction companies to move from waste disposal to construction waste management, namely:

(a) Comprehensive waste management plan

This planning is required before construction begins so that it is beneficial in the long term for construction companies. At this stage the company must determine the exact amount of material that follow-up actions need to be

taken to reduce the overall waste generated. The waste management process plan includes aspects related to potential sources of waste and a location plan that has a special area for the recycling process, and disposal sites recyclable material.

(b) Selection of the right vendor
It is important to choose a vendor that can properly measure project requirements. Vendors who comply with the standards will prepare the need for waste containers that have an element of flexibility to prevent build-up of construction waste.

(c) Recycle
Placing recyclable material containers around the nearest site to reduce the amount of waste that collects around the construction site area. Materials that can be recycled include wood, concrete, and metal elements.

(d) Reduce packaging
Buying materials in bulk reduces the cost and waste of recyclable packaging. Some packaging actually be reused for different functions

(e) Reuse scraps
Reuse scrap rather than cutting new material, so scrap and offcuts must be properly stored until needed.

Ideal steps to manage construction waste in the post-Covid-19 industrial era 5.0., namely:

(a) Segregate as much reusable construction waste as possible which can be recycled;

(b) Provide a special place to collect and store heaps of construction waste that is easily accessible for recycling;

(c) Implement and implement a construction waste management system to reduce debris by recycling waste materials. In addition, provisions are also made requiring contractors to recycle can at least reach 50% of the amount of waste generated at the construction site;

(d) In the process of constructing a new construction, preference should be given to the type of material containing a sufficiently high content of recycling;

(e) Priority is given to the use of rapidly renewable materials as well as materials that are recovered, salvaged, or refurbished.
When determining the materials to be used and building products that are sustainable processes for a project, you should start equipped with an evaluation process for several types of important characteristics that are expected to have a negative impact on the environment around the construction site, as well as how recyclable and durable they are. This aims to streamline the resources used. The use of products with recycled content can also help develop new market opportunities for recycled materials diverted from these construction landfills.
Going through the stages of the planning process and strategies for efficiency of the materials used during construction will also help reduce the amount of building materials needed to cut the final cost of construction project being carried out. In addition, reuse of construction materials and recycled demolition can reduce materials destined for landfills and cut costs. An effective action plan must be prepared to manage materials through deconstruction, demolition and construction.
The basic principle used is the “Three R’s” principle (i.e. reduce, reuse and recycle). In this case, the process of disposing of construction waste must use these 3R elements as pillars to strengthen other sustainable construction principles, so that later they become appropriate strategic guidelines.
In addition, other identification is also needed through the four main components consisting of elements of technology, policies, guidelines and regulations that are in line with the project life cycle accompanied by the 3R principles. This is done to ensure sustainable handling of construction waste.
The next strategy carried out by construction companies is the sustainability act, in which construction companies work together with the government and local communities in overcoming waste problems, minimizing their impact in order to achieve environmental sustainability in the construction sector in the framework of moving towards green construction.
There are many ways to reduce construction waste piles, one of which is to manage the upstream stage of the project life cycle, namely the planning part. This approach has an immediate impact in implementation and operational processes. In addition, it is in the planning stage must be able to reach the downstream stage of the project, namely deconstruction. The planning and deconstruction stages are keys in reducing waste resulting construction. This planning stage is an important stage that is very closely related by how much construction waste is generated.

5.2 Discussion

The concept of green construction is a strategy to encourage environmentally friendly construction business activities, in order to support environmental preservation and the sustainability of the construction business. An important strategy in implementing the green construction concept is to start developing the green building concept and then proceed with the green construction concept in every infrastructure project and construction process. In this case also supported by the implementation green energy by building waste-fired power plants.

This benefit can be felt in every project that uses the green construction concept which has created positive perceptions in every construction process. Green construction strikes a balance between environmental capabilities and human needs for present and future generations.

Activities that have the potential to generate waste in a life cycle the project is a stage of deconstruction, which often escapes the attention of architects and constructors. In the context of sustainable development, this stage is an important part of construction project management. By accommodating deconstruction as part of the project life cycle, which in turn has an impact on the stages of planning and implementation of construction projects.

Deconstruction is an important stage in the project life cycle. Deconstruction is defined as the careful demolition of a building aims to maximize the reuse of building components and carry out the process of recycling (recycle) of certain types of materials so that the amount of material discharged into the environment is minimal. The benefit of deconstruction is that it extends the life cycle of building materials and allows the formation of a closed cycle so that it does not produce waste.

Sepasgozar et al. (2021) stated that rapid urbanization and infrastructure development projects have increased the unlimited regeneration of construction projects in developed countries. It was also found that the information system that appears in the database on how the integration of Geographic Information Systems (GIS) and Building Information Models (BIM), can help waste management in construction. Through GIS tools, it is possible to carry out several spatial analyzes applied to construction and demolition waste (CDW) management, such as mapping construction waste disposal sites, simulating environmental risks, and finding suitable areas to install landfills and recycling plants. Multi-Criteria Analysis (MCA) methods are usually combined when it is intended to find suitable areas for sewage treatment using GIS software.

Construction companies must implement a penalty system to discipline construction managers to think carefully and responsibly about the C&D waste they generate. For this reason, an information system technology model is needed that can carry out the cost quantification process intended for cost-effective construction material-based waste projects (Nawaz et al. 2022).

Here are three plans to help develop green construction:

(a) Rethink and Reduce Construction Waste

Waste on construction sites must be handled properly because it can cause severe ecological impacts to a large extent. For this reason, construction and demolition (C&D) waste must be able to be recycled or reused. Reducing sources of waste production is done to reduce waste generated and reduce energy use. Therefore, should take steps to reduce resources whenever possible. In addition, must also be able to calculate more precisely in terms of purchasing construction materials to prevent excess material and packaging waste at construction sites. Processes that aim to recover used, but still valuable materials for further use, are efficient and effective strategies for resource efficiency and cost savings. If the remains of construction and demolition can no longer be recovered, the company must immediately sort and identify which building components can be recycled. Concrete from demolition projects is easy to sell and can be reused in an environmentally friendly way.

(b) The Benefits of Good C&D Waste Management

In addition to the environmental benefits of good waste management, actions to reduce the amount of disposal of C&D materials can create new jobs. By reducing the amount of C&D material disposed of can reduce building costs through the costs of purchasing and disposing of materials. Companies must commit to green building practices. Projects that follow sustainable development practices have the potential to obtain good accreditation points, thereby having a significant impact on the project through sustainable construction waste management.

(c) Construction Waste Management Integration Plan

Planned construction waste management will promote the achievement of sustainable programs for recycled materials in construction, starting from the process of storage and sorting, collection and transportation, recycling and reuse, and disposal. Companies implementing a construction waste management plan (CWMP) can evaluate and find new, innovative, and creative ways to improve construction waste management results. To that end, all parties must be committed to achieving the highest level of diversion of construction waste possible.

Although every project is different, a comprehensive waste reduction plan must clearly define the problem in order to find the right solution. Appropriate technologies such as Building Information Modeling (BIM) can be applied in

the pre-construction and construction process phases, requiring collaboration in planning how to salvage materials and estimating the exact quantities needed to eliminate excess supply waste.
Therefore, the construction waste management plan must contain clear messages to all members of the project team, including subcontractors. This is to avoid misunderstandings, so it is necessary to periodically conduct a project orientation to review the waste management plan with all parties at the work site, including where the bins are placed, how materials will be segregated or used. If the project uses a more detailed waste management plan, this ensures that everyone involved in the project knows the final destination of C&D waste.
A significant reduction in construction waste begins with construction company stakeholders being actively involved in a sustainable and environmentally friendly construction process. Supported by an appropriate information technology system, it is possible to plan the flow of construction waste from upstream to downstream efficiently and effectively.

5.3 Proposed Improvements

Industry 5.0 has encouraged people to act quickly, be more creative and more innovative in making policies. The digitization factor in the construction sector is a strategic step in facing the industrial era 5.0. For this reason, digitization must be carried out comprehensively, starting from developing human resources to building a supply chain system. Digitizing the development of the construction workforce must be carried out in a sustainable, consistent, and measurable manner from upstream to downstream. In the upstream sector, this digital development method will more quickly produce a competent workforce with a high value of knowledge, skills and attitudes. Whereas in the downstream sector, digitization will produce a productive workforce because it has high and controlled value standards. This strategy can be realized through work programs based on the application of digital technology such as remote workforce training and certification for all workforce categories which are carried out regularly and continuously.
The concept of green construction is very possible to implement, at an affordable cost compared to many other things that can be saved. Through the application of green construction, it will be able to improve environmental aspects by saving other related aspects.
Several strategies are recommended in the industrial era 5.0. post Covid-19, namely ease of regulation in facilitating construction waste processing procedures, government support in the development of a green construction industry, development of a high-tech recycling construction industry, as well as increased technological innovation in effective and efficient construction waste management, and it is necessary to develop an environmentally friendly green construction waste treatment approach to address this construction waste problem.
In the context of construction waste management, Geographic Information System (GIS) has several suitable applications to increase the effectiveness of construction waste management. Geographic information systems are an important tool in planning the management of construction and demolition waste, as well as for facilitating the spatial analysis and control of embankments, sorting, collection, transport, and final destination of construction and demolition waste increase the recovery and recycling rate of materials (Paz, *et. al.*, 2018).
Engineers and construction companies must implement the use of sustainable and environmentally friendly construction materials. In addition, stakeholders should be routine in carrying out regular site inspections aimed at verifying all processes and actions in construction waste management have been carried out and are functioning properly. In addition, the recycling and transportation of construction waste must be monitored regularly at all times on a regular basis.

6. Conclusion

A well-organized construction organization will generate less waste. It is therefore very important to develop a detailed strategy regarding the area allocated for waste recycling, as well as its storage to increase productivity and efficiency for the company. Reusing and recycling materials on-site will reduce the cost of the final project. Companies must also be responsible for the environment, where construction waste management is one of the company's concrete actions to contribute solutions to future construction waste problems. The problem of waste management at construction sites will have an impact on reducing the amount of construction waste that is disposed of at the construction waste final disposal site.
The sustainability of a comprehensive and economical construction well-planned waste management is a long-term investment for the construction industry. The basic principle used is "Three R's" (namely Reduce, Reuse and Recycle) where these elements are combined with elements of technology, policies, guidelines, and regulations, so

that later they become the right strategic guidelines to strengthen sustainable principles in the right handling construction waste.

In addition, waste management requirements should be planned at the pre-construction stage to ensure that compliant contractors and subcontractors are fully aware of the implications of these requirements on their work before and during construction. At the construction waste management planning stage, it must initially begin with the process of identifying project waste as an integral part of the overall material management stage process in a construction project.

The impact of the Covid-19 pandemic has resulted in several construction works being delayed and behind schedule. However, with the policies and changes that have taken place, the construction sector is expected to become one of the drivers of Indonesia's post-pandemic economic growth, especially for construction companies in the Jakarta area. Therefore, it is important to develop an integrated strategy to treat construction waste from upstream to downstream as a whole to enable the achievement of sustainability goals. The world of construction needs to re-engineer construction management by adjusting and transforming itself in the industrial era 5.0 where technological support 4.0 is absolutely necessary to complete work missions effectively, efficiently and on time and achieve sustainable optimal results.

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Biography

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