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Overview of Recyclable Waste Materials for Building Constructions and Demolitions (C&D)

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Abstract
The depleting of resources and the increasing of construction and demolition (C&D) waste creates an urgency for the construction industry player to start recycling. This paper aims to discover the list of recyclable waste along the potential construction products from recyclable sources to create awareness to building industry players to recycle due to various benefits. The method used for this study are data retrieval and systematic literature review. The results have proven building industry should practice recycling because it does have impacted the world positively and convene sustainability. As a result, the building industry players will have high awareness on the issue and new arrays of building materials to practice whilst not jeopardizing the earth.

Introduction

After the end of Covid-19 pandemic, the construction Industry is projected to rebound with a growth of 11.5% in 2022 following the growing investment in large-scale transport and energy projects (MordorIntelligence, 2021). The construction market will positively impacted Malaysia economically as Bursa Malaysia Construction Index has climbed 10 basis points as at year-to-date 18 April 2022. However, this also has created drawbacks on the environment. The depleting of virgin resources for construction materials, the increase rate of waste disposal due to construction activities and shortage of land for waste disposal are some of the negative repercussions. Making things worse, previous study concludes that global wastage is going to rise from 1.3 billion tonnes in 2018 to 27 billion tonnes by 2050 (David et al., 2019).

In the effort of continuous improvement, various strategies in supporting green construction activities were already been done by the Malaysian government for instance, haulers are encouraged to be used on-site as it allows waste to be separated and more easily transported to be recycled off- site. Although recycling plastics, paper, aluminium, food waste and other household items are already have been the talk of the town, recycling construction waste materials is still lacking in practice by the industry players. It was reported that difficulty in sorting, transforming, and disposing, collection and transportation of waste are some of the reasons behind it.

Nevertheless, the establishment of the Green Building Index (GBI) and increasing attention towards international sustainability assessment standards, such as Greenmark,

LEAD and BREEAM have managed to raise awareness of the broader issues associated with sustainability in construction sector (Papargyropoulou et al., 2011). Designers, builders, contractors and other industry players has also slowly being encouraged to do their part in supporting 'recycle' of waste materials to join the pledge in supporting sustainability by awarding them in certain ways. Recycling construction waste such as wood, Metal, Bricks, Crushed concrete and Gypsum or drywall,[1] including timber, aluminium or plastic scaffoldings, formworks and moulds used on-site and off-site construction, and bamboo are among the long list of materials that can be salvaged to produce another product. Recycling waste can greatly help in saving cost and can help avoid environmental issues.

The aim of this research is to identify recyclable construction waste materials available to instil awareness in construction industry player. Hence, the study includes:

- To identify prominent materials that are usually practiced in construction waste material recycling
- To understand the effects and processes of recycling of each material

Literature Review

Definition of 'Recycle' in Construction Industry

The act of 'recycle' involves collecting, segregating, processing and manufacturing the collected goods to turn them into new products. This process basically converts the old and used materials or components of a material to a new reusable product either with the same purpose or for some other purposes to lessens the request for landfill spaces whilst reducing pollution and the use of energy. Recycling also can potentially benefiting in terms of reducing the consumption of natural resources, air pollution from incineration, and water pollution from landfilling (Ahmad et al., 2021). Some example of the construction waste that can be recycled are wood, Metal, Bricks, Crushed concrete and Gypsum or drywall.

Process cycle of recycling Construction waste materials

Before applying recycled materials in a building, it is important for the way the material is being processed beforehand as these materials need to undergone filter stage to eliminate all unwanted foreign matter. All these building materials will generally be easier to recycle if it is composed by one substance and readily dissembled into individual material, for instance, materials such as steel, concrete, and wood. Some waste segregation at source is already practiced in Malaysia's construction site, with the ultimate aim to recycle materials with some value. Waste materials such as scrap metal are separated and stored on site to be sold on to waste recycling companies, while other wastes are mixed together into one container and either sent to landfill, burned or illegally buried on site. Haulers are encouraged to be used on-site as it allows waste to be separated and more easily transported to be recycled off- site. Among others, these recycled products will be utilized and re- purpose in highway pavement, aggregates, thermal insulation, additives in building materials, and also used as prime structure element.

Benefits of recycling construction materials

First and foremost, utilization of recycled components helps the industry to reduce the use of virgin products. The materials manufactured by these secondary elements will also use lesser energy, resources to obtain and convert into new products again, compared to the primary virgin types of resources. Thus, waste recycling offers benefits including reduces the dependency upon new resources which eventually can minimize costs for transportation and

production energy. Construction recycling is possible to decrease building material's embodied energy up to 95% percentage and help save the environment (Tsiotas et al., 2010). Other prominent benefits are by diminishing landfill sites by cutting down waste disposal capacity. This will lead to other profit maximization and cost saving by cutting the cost of removing and hauling of construction waste to landfill, thus reducing the landfill fees. In the end, it will also lower landfill emission and incinerators. All these benefits are benefiting the industry in so many ways. Eventually, the act of recycling waste materials can improve the image of the construction Industry, improve productivity and Improve Resource management. On top of that, recycling can also provide supplimentary income source.

Methodologies

The systematic literature review was conducted with data processing method such as data retrieval, where several examples of Sustainable Materials and how to process and manufacture them will be discussed. The main database used is Science Direct and followed by Google Scholar as additional database. These articles are used to provide understanding of overall topic and basis of selecting prominent materials that are usually practiced in construction waste material recycling. Materials discussed are the list of construction waste that are prominently stated in most literature review. Google search engine was also used to retrieve company data, products and other information regarding available products with recycled waste.

Findings and Discussion of Results

Recycling can be profitable to industry player as previous research mention that the net benefit of reusing and recycling of waste materials is estimated at 2.5% of the total project budget. Although not all, but some types of waste can also be used as alternatives to virgin materials in the process of creating new construction materials. Other concerning reason to consider, it is said that steel, cement, paper, plastic and aluminium are the five materials that contribute 55% of global CO^2 emissions from industry and 20% of global CO^2 emissions from energy use and industrial processes. These are the common materials that can be recycled among other recyclable materials such as glass, cardboard, various metals, tires, textiles, and electronics.

Common construction and demolition (C&D) waste that can be recycled are wood, metal, bricks, crushed concrete and gypsum or drywall. Previous research also found that construction waste generated in landed residential construction projects in Malaysia is usually composed of bricks and blocks, concrete, wood, metals, roofing materials, plastic, and glass compared to high-rise building housing construction generated more than 80% wood as the waste. Nevertheless, the composition of plastic, glass, ceramic, and the packing products was found quite low.

The result focus on common C&D materials that have largely contributes construction needs and wastage in the sector: wood, concrete, masonry, metal and steel. While plastic is also included as it contributes to wide range of building recycled products due to its strong flexible properties. Discussions on these materials are as below:

Wood

The construction and demolition (C&D) sectors are the largest producer of waste including wood waste which has wide array of functionalities in construction works. Wood is considered a renewable product, but this valuable natural resource is depleting each year.

From 2002 to 2021, Malaysia lost 2.77Mha of humid primary forest which brings a total area of humid primary forest in Malaysia decreased by 17% in this period. Therefore, it is critical for people across industries to understand the importance of recycling wood. Recycled wood is used to create valuable products that would otherwise use virgin materials to create at a higher cost. This multipurpose resource can also be recycled or reused several times as mold or formwork, timber hoarding at site and temporary quarters for the workers (Hamid et al., 2020). Due to the high generation of timber on site, up to 30 % were reused to avoid wastage. Wood recycling mostly requires a reduction in size to small particles such as chips and fibers. Normally, waste wood is shredded and separated from foreign elements such as metal before sending them to construction and demolition waste recycling facilities in a form of wood chips to be recycled. Same as fibers, wood waste will go through homogenization by defibration to turn them into paper, medium-density fiberboards (MDF), and wood fiber-based insulation boards. They can also be used to generate energy.

Construction Aggregates/Debris: Crushed Concrete, cement & others

Concrete is one of the most substantial building materials in the world which is made by combining cement, aggregate and water in quantifiable portion. This explains why the demand for construction materials and natural aggregates exceeds 26.8 billion tons/year and the increasing world cement production from 1.39 billion tons in the year 1995 to 4.1 billion tons in the year 2020 (Marey et al., 2022). This urge the needs for optioning a greener approach as concrete is considered the second largest producer of CO^2 emissions globally. During construction and demolition (C&D), waste such as crushed concrete, marble waste, and quarry dust for example can be used as aggregates in concrete. Fly ash is also a type of waste that is commonly recycled into concrete as fly ash can heighten the strength and durability of concrete whereby quarry dust consists of rough, angular particles contributes in strengthen the concrete bind due to better interlocking. These C&D waste including crushed concrete waste are process to become recycled aggregate concrete (RAC) or green concrete (GC). Various studies have positively reported that GC is a more environmentally friendly material and has the same functionalities and properties as conventional concrete (CC) in terms of building life-cycle performance, with low costs and a reduction in environmental impact. Concrete roof tiles from demolitions can also be used for gravel fill along with crushed concrete and cement aprons waste were re-used for backfilling aggregate.

Metal/Steel

Metal and steel are the common materials to recycle. It is divided to ferrous metal and non- ferrous metal. Steel scrap has significant economic value and the demand has exceeded its availability due to the long- life of steel products. Market for metal waste such as ferrous, copper and brass metal formwork are high and most profitable since recycling of metal waste of the same material can be done over and over again without degradation of the material itself. Structural steel alone normally contains as high as 85 to 90% of recycled content. Steel is the biggest potential asset as it does not degrade with use. Frequently, beams or girder from dismantled buildings are recycled or often be used again straight away. Wide range of structural and non- structural steel products can be made by adding other elements to create alloys which increase tensile strength, hardness, melting point and resist metal fatigue. Although recent studies described steel as 100% recyclable, this is said contradict to reality as contamination due to residual elements can occur to scrap metal and its rate can increase with every cycle of recycling process. Nevertheless, this problem is not a hassle when steel is

used to make huge structural shapes such as bars, beams, and columns, and other steel products which have more lenient residual element restrictions. In steel recycling, Electric arc furnace (EAF) process uses a large proportion of scrap as input, convert them into new steel by re- melting process to remove residual elements. However, not all contaminants can be extracted, and that is why the use of steel produced by this process is limited to large structural shapes.

Masonry

Masonry such as brick is probably used in most building works in Malaysia as it is a common material for wall. It is also one of the oldest manufactured building materials in the world. Bricks can be very substantial in contributing to sustainability. Along the years, so many attempts to incorporate different types of waste into the production of fired clay bricks including sludge, fly ash, polystyrene, kraft pulp residue, sawdust, and others. Not only can be made up of other recyclable elements, crushed brick can also be a form filling material while hardcore masonry is used as a backfill (Hamid et al., 2020). However, previous study on using crushed aggregates including bricks in the production of concrete blocks as a replacement for natural aggregate in concrete has showed positive influence on the thermal conductivity, but negatively influenced the mechanical properties.

Plastics

Plastic is not biodegradable and cannot naturally decompose. Earliest signs of degradation will take hundreds of years but even then, they only grow smaller but not decaying. This material is driving our continuous climate change issues as millions of tons have been produced each year and only about 9% is recycled. Currently, recycling is taken as one of the most important steps in plummeting environmental pollution impacts and has been taken as one of the most dynamic actions in the plastics industry. There are a wide scope of usage when it comes to plastics as this new engineering materials has a unique property that can combined with various material. Converting waste plastics into useful building materials gain advantages such as cheap, easy availability, easy to mould, durable, waterproof, insulating, use less energy and durable as it got high compressive strength. Among others, plastics has been proven worthy in products such as modified cement mortars, floor tiles, flexible pavements, roof tiles, and composite bricks.

Conclusion

The depleting of resources and the increasing of construction and demolition (C&D) waste creates an urgency for the construction industry player to start recycling. Common construction and demolition (C&D) waste that can be recycled includes wood, Metal, masonry such as brick, Crushed concrete, construction aggregates and plastics. Overall, study has covers various benefits of recycling the construction and demolition (C&D) waste and finding the possibility of the end product to turn into new materials in the next construction project. The perks include cutting down the dependency of virgin resources, production energy, cost, landfill area, and harmful emissions, whilst improving the image and productivity of our construction industry concurrently.

However, the reality is harder than it preaches where problems such as difficulty in sorting, transforming, and disposing along the difficulty in time management and difficulty in collection and transport, and contamination of potential waste are lingering on construction player especially contractors. Thus, Intensive research of recycling material waste is needed

to protect the environment, minimize waste, save fossil fuels, improved recycling process, optimizing the use of available resources, improves intellectual capital, enhanced organizational performance and credibility, and helping in reducing costs (Kralj, Davorin. 2008). This practice will improve when the industry started to move towards sustainability as a whole, and each project will actually help projects that come after it (BINAMAMPAN (2018).

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