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ISSN (P)0853-2877 (E) 2598-327X

STUDY ON THE UTILIZATION OF WASTE AND WASTE CONSTRUCTION MATERIAL WITH THE CONCEPT OF REUSE & RECYCLE AS ARCHITECTURAL ELEMENTS

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Article info
MODUL vol 26 no 1, issues period 2026
Doi : 10.14710/mdl.26.1.2026.130-137
Received : 4 march 2025
Revised : 4 december 2025
Accepted : 4 june 2026

Abstract

Sustainability issues are present as a result of construction development, one of which is a contributor to carbon emissions. This study aims to explore the types of waste and specifically analyze the processing methods of used building materials and plastic waste to determine their suitability as architectural elements. This study uses a deductive qualitative method, which is a field data analysis approach using the Hierarchical Recycling theory to conclude the findings. Observations were conducted on two primary subjects: the application of construction demolition waste at Bocor Alus Cafe and the plastic recycling process at Paste Lab. The results identify a clear distinction in processing: construction waste, such as doors and windows, is most effective through Component Reuse which requires minimal energy, while plastic waste requires specific Recycling stages such as shredding and melting to become functional architectural components. The study concludes that applying these concepts not only reduces waste but also aligns with Islamic principles of environmental preservation and sustainability.

Keywords: *Reuse; Recycle; Sustainability; Construction Waste*

INTRODUCTION

According to the book Islam and Ecology by Foltz, Denny and Baharuddin explains the basic framework based on the Quran which is a source of inspiration from various fields of comprehensive science about everything, both humans and the development of world civilisation, but the changing views of modern humans say that nature is a machine, boring, worthless and has no purpose, the view of modern humans that began in the 19th century led to loss of awareness of the sacred dimension and the importance of scientific thought and science to prove and satisfy humanity. Therefore, the exploration of the Quran as an alternative basis for finding the meaning of nature and human beings is carried out to provide another rationale for the sustainable use, protection and preservation of nature for mankind. (Foltz, Denny & Baharudin, 2003).

Globally, the construction sector consumes 50% of natural resources, 40% of energy, and 16% of water. In relation to providing human needs for infrastructure, all construction activities need to pay attention to saving natural resources and reducing the amount of waste from construction activities. In some projects, recyclable materials such as wood, concrete, red brick, metal contribute 75% of the total waste. (Widjanarko, 2009). Construction has a significant effect on the environment and therefore needs to minimise its effect on the environment by implementing environmental management based on commitment and specifically defined goals (Hendrickson and Horvath, 2000).

Material selection is crucial in development to fulfill the elements of firmness, utility, and venustas, yet excessive use negatively impacts nature (Puspita et al., 2023). Excessive use of materials can have a negative impact on nature (Puspita et al., 2023). According to Bossink and Brouwer (1996), an estimated 15% to 30% of construction waste is disposed of in landfills (Lumbangaol et al., 2023). Indonesia's carbon emissions were impacted by deforestation and degradation in 2011 (Roshaunda et al., 2019). Deforestation can contribute 18.3% of carbon emissions (Karuniastuti, 2016). Massive utilisation of nature for exploitation can cause natural disasters (Reflita, 2015). Development activities need to be planned in relation to the sustainability of natural resource utilisation (Widjanarko, 2009).

Therefore, this study aims to not only explore the types of waste but specifically to analyze the processing methods of used building materials and plastic waste to determine their suitability as architectural elements. The

benefit of the study is to know the methods of processing used waste and plastic waste. Thus, reducing waste and supporting sustainability.

LITERATURE REVIEW

Theoretical Framework of Waste Management

The environment is something that affects the growth of living things while the environment is on every side of living things so it takes a balance to maintain the balance between the two. Waste is a big problem for the environment because it disrupts the health, comfort and beauty of the environment (Aristawati et al., 2023). To address this, the Recycling Hierarchy (Berge, 2000) is used as the main theoretical framework. This concept divides waste management into: (1) Reuse, (2) Recycle, (3) Energy recovery.

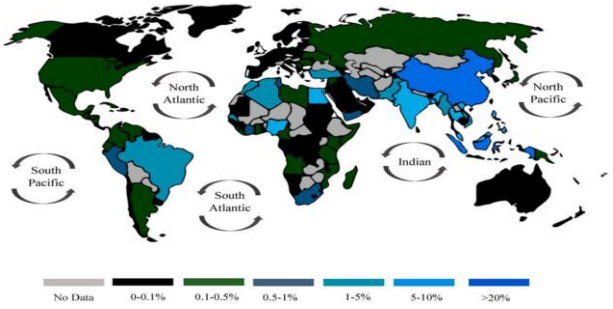

Figure 1. Map of plastic producing countries (Sharma et al., 2021)

Reuse Concept

The concept of Reuse or reuse is the process of reusing materials that are considered useless in the process, little or no reprocessing, which is divided into two, namely Repairing, which is the process of taking materials whose life has expired, then repaired so that they can be reused, and Remanufacturing, which is taking several used components from several materials and then making them into one new material or item that is intact (Kralj & Markic, 2008). Reuse has many advantages over other methods because it does not require excessive energy to be reused (Smith, 2004). Reuse can be divided into three things, namely Building reuse, component reuse, material reuse. Utilisation as a building component is recommended in non-structural parts such as walls, doors, floors and ceilings. Material reuse processing (1) construction waste is selected to see the condition, (2) the material is ready to be used to be applied to the building (Dwithama, 2018).

Recycle Concept

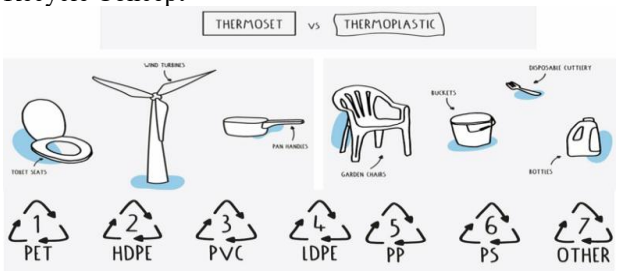

Figure 2. Type of plastic (Winnerdy & Laoda, 2020)

Plastic is a waste that is a big problem, there are two types of plastic, namely thermosets that have a character that cannot melt when recycled and thermoplastic types of plastic that can be recycled. Space and equipment requirements are as follows: (1) Collection point where to collect and classify plastic, (2) Community point where to gather to maintain local community and cooperation, (3) Machine shop providing machine repair services, (4) Shredder workspace plastic shredding machine to form small pieces, (5) Extrusion workspace machine to melt plastic, (6) Sheet Press workspace a mould and press machine, (7) Injection workspace machine producing melts using human power, (8) Mix workspace space to explore product design (Winnerdy & Laoda, 2020).

In addition to building waste, there is the potential for plastic waste which has always been a threat to Indonesia because it always increases every year (Novrizal, 2022). Utilisation of waste plastic as a safe asphalt mixture (Sumadilaga, 2017). Plastic waste as an alternative road construction material to realise sustainability (Dwijayanti et al., 2024). The principles of sustainability include reducing, reusing, recycling (Iqbal & Muhsin, 2014). The use of used waste materials can save and protect the environment but does not rule out the beauty of the building (Iqbal & Muhsin, 2014).

Building Life Cycle

Building Life Cycle (Standard EN) Understanding the building life cycle is essential to pinpoint where waste can be diverted. The life cycle has five stages: planning, programming, design, construction, and use (Harapan, 2021). (See Table 1. Life Cycle Stage) This study focuses on stage C3 (Waste Processing for Reuse, Recovery, Recycling) to identify how architectural components can be derived from the end-of-life phase.

Table 1. Life Cycle Stage (www.en-standard.eu accessed on 19 November 2024)

Production	A1	Raw Material Supply
	A2	Transport
	A3	Manufacturing
Construction	A4	Transport
	A5	Construction Installation
Service Life	B1	Use
	B2	Maintenance
	B3	Repair
	B4	Replacement
	B5	Refurbishment
	B6	Operational Energy Use
	B7	Operational Water Use
End Of Life	C1	Deconstruction & Demolition
	C2	Transport
	C3	Waste Processing for Reuse, Recovery, Recycling
	C4	Disposal
Potential Benefits & Loads	D	Reuse, Recovery, Recycling Potential Benefits Beyond System Boundary

Concept and Methods of Sourcing

Before materials can be reused, they must be sourced properly. According to (Ervianto et al., 2012), there are distinct methods for obtaining materials:

1. Scavenger: collecting from individuals who sell directly.
2. Auctions: formal bidding for large-scale demolition materials.
3. Direct Negotiation: Buying directly from building owners during demolition.
4. Collectors: Buying from entrepreneurs who have already stockpiled materials.

Precedent Studies on Material Application

Several previous studies have demonstrated the application of these concepts. These precedents serve as a benchmark for analyzing the findings in this study:

Residential Application: Rubilang Homestay

Figure 3. Rubilang Homestay (Nurdiaz & Irfanda, 2023)

This house is a combination of a homestay on the first floor and a private house on the second floor. Rubilang Homestay has a reuse concept where the owner searches for used materials before construction, such as used ceramics from house demolition, used doors and windows from antique material collectors, used stair railings, used table and chair furniture, and lamp decoration materials made from used rattan (Nurdiaz & Irfanda, 2023).

Commercial Application: Restaurants in Bandung

Figure 4. Reuse Used Wood in Restaurants (Primadani, 2019)

Based on the journal article 'Study of Used Wood Material Application Strategies in Restaurant Interior Design Elements in Bandung'. 2 The restaurant observed is a restaurant that uses used wood materials in interior elements. The difference is that Restaurant A uses re-finished used wood material so that the used wood material looks like new material again. While Restaurant B uses used materials that maintain their

original condition to achieve an urban industrial interior theme (Primadani, 2019).

Material Innovation: glass bottles used for facades

Figure 5. Reuse Concept on Poly Brick Glass Bottle (Arifa K., Puspitasari, Lahji, 2021)

Utilisation of used glass bottle material as a structured building facade that functions as a building aesthetic as well as thermal and visual comfort in the building. The advantages of this material, reducing glass bottle waste, reducing incoming light and regulating the flow of air entering from between the bottle arrays, but the maintenance of this material must be regulated regularly because it is easily broken and mossy if no maintenance is done (Arifa K., Puspitasari, Lahji, 2021).

Material Innovation: Cardboard for acoustic panels

Figure 6. Cardboard material (Arifa K., Puspitasari, Lahji, 2021)

This cardboard material system works by utilising used cardboard that is compacted using a hydraulic press. This process results in a slightly bumpy and dense texture, with a wide variety of colours that still look unique. The next step is to harden the cardboard material by coating it with wax to create a waterproof surface (Arifa K., Puspitasari, Lahji, 2021).

Plastic Innovation: paving blocks made from PET plastic

Figure 7. Plastic Paving Block (Winnerdy & laoda, 2020)

Local initiatives in Indonesia related to plastic recycling for paving blocks. Among them are conducted by: Hendro Wibowo in 2013 in Sukaluyu Village, East Telukjambe District, Karawang. The reason PET material was chosen as the type of plastic used is that apart from having a high value, this effort is also expected to help reduce the amount of plastic waste (Winnerdy & laoda, 2020).

METHODS

This study discusses material innovation with reuse and recycle methods in Yogyakarta using a deductive qualitative method. Qualitative research prioritises holistic and comprehensive observations, where the conditions of the research subject are in their natural conditions (Groat & Wang, 2013). The research flow is structured to avoid redundancy between observation and discussion:

a. Framework Establishment: Conducting a literature review on Hierarchical Recycling and Life Cycle theories to create categorization variables.
b. Field Data Collection: Observation and interviews at two locations: “Bocor Alus Café: Representing the Reuse method (Construction waste)”, “Paste Lab: Representing the Recycle method (Plastic waste)”.
c. Data Analysis: The collected data is categorized based on the framework (Sourcing, Processing, Application) and discussed to draw conclusions.

Furthermore the detailed methodology on diagram 1 can be explained as :

1. A review of the waste paradigm on environmental impact and the role of architecture on waste issues.
2. Literature review of the concept of material reuse & recycle in the Hierarchical Recycling theory to identify the role of architecture in reducing waste and supporting sustainability.
3. Field data collection using observation methods to observe the field condition of the application of reuse & recycle theory in the scope of architectural material innovation in the building of 80's Bocor Alus Cafe and The Samirono Hotel.
4. Discussing how the process occurs in the field and concluding the concept of reuse & recycle towards the impact of waste reduction and sustainable material innovation.

5. Draw conclusions regarding the findings of the reuse and recycle concept, and provide insight into the benefits of the concept in helping to reduce waste that impacts environmental sustainability.

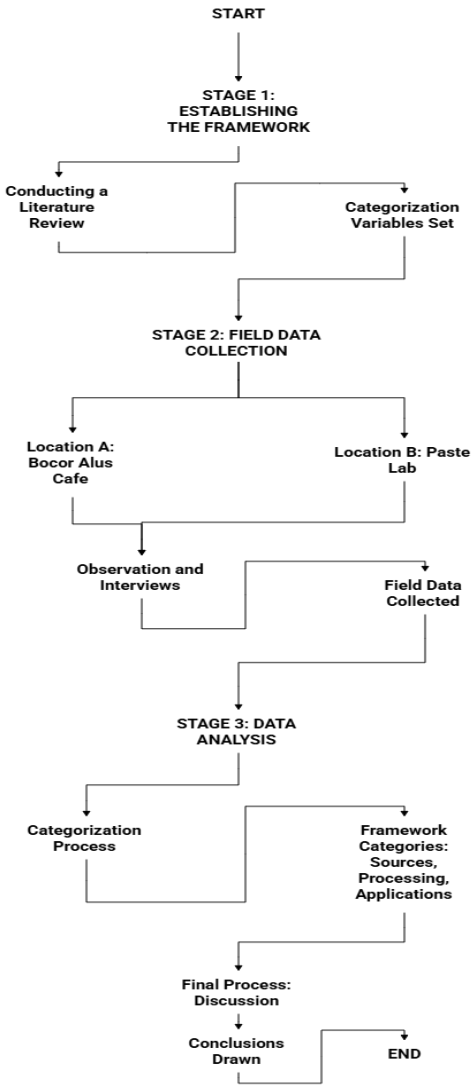

Diagram 1. The steps of the study (Author, 2024)

RESULT

Observation 1: Reuse of construction waste at Bocor Alus 80's Café

The observation was conducted at 80's Bocor Alus Café in Bantul (figure 9-12). Documentation regarding the physical building utilizes Google Maps archives because the building has recently been demolished due to the owner changing business orientation to focus on antique properties. Despite the demolition, the building remains a prime example of construction waste application, utilizing walls, doors, and windows as main components. (Mediastika, 2013).

Figure 9. 80's Café Leaks in Bantul
(Google maps accessed on 12 December 2024)

Sourcing and selection process, based on the observation, the café obtained materials through specific channels: collectors and building demolition auctions. A collection site was identified near the café, containing various demolition wastes such as sanitary ware, roof materials, chairs, and tables. The selection process involved sorting waste that was unfit for use from waste that still held potential for reuse.

Figure 10. Construction waste selection site (Google maps accessed on 12 December 2024)

Application of components, the study identified a creative "Component Reuse" approach. Used doors and windows were not merely installed as openings but were assembled to function as structural wall elements. This application required no significant industrial processing; it only involved maintenance to remove dirt accumulated due to the age of the goods.

In addition to structural elements, the café utilized used chairs and tables. These items were simply repainted to enhance their aesthetic aspect. This confirms that the level of reuse falls into the "High Category" because components like windows, cabinets, chairs, and doors did not require excessive energy to be processed, aligning with Dwithama's (2018) statement on reuse efficiency.

Figure 11. Application of waste to wall elements (Google maps accessed on 12 December 2024)

Figure 12. Application of waste as furniture (Google maps accessed on 12 December 2024)

Observation 2: Utilization of Plastic Waste at Paste Lab

Utilization of Plastic Waste at Paste Lab In contrast to the construction waste reuse, the observation at Paste Lab (Sleman) highlights a recycling workflow. This workshop focuses on processing plastic waste into usable items such as furniture and architectural louvers (building shading) for The Samirono Hotel (fig 13-15).

Figure 13. Workshop condition of paste lab (Author, 2024)

Material Specification Paste Lab specifically utilizes HDPE (High-Density Polyethylene) plastic waste derived from bottle caps, soap bottles, and jerry cans. Interviews revealed that HDPE is selected because it possesses high rigidity for structural shape while retaining enough flexibility to prevent breakage.

Figure 14. Type of plastic used (Author, 2024)

Recycling Process Workflow The transformation from waste to architectural element involves a four-stage mechanical process, based on (Winnerdy & Laoda, 2020) there is a need to recycle, among others, as follows:

Figure 15. Process Recycle (Author, 2024)

1. Collection point: Plastic materials are collected, washed, and sterilized to ensure safety before processing.
2. Shredder workspace: A machine breaks down the whole plastic forms into small, uniform pieces.
3. Extrusion and Sheet Press workspace**:** The chopped plastic is melted (extrusion) and pressed into solid plastic plates/sheets ready for forming.
4. Mix workspace**:** CNC (Computer Numerical Control) machines cut the plastic plates into desired shapes for assembly according to consumer demand.

DISCUSSION

Sourcing Strategies

Analysis of Waste Sourcing Strategies The field findings validate the sourcing theories described by

(Ervianto et al, 2012). Bocor Alus Café effectively utilized Auctions and Collectors, which is the optimal method for acquiring large structural components like doors and windows in bulk. In contrast, Paste Lab relies on a network of Scavengers and Collection Points, reflecting the scattered nature of consumer plastic waste. This confirms that the material type dictates the sourcing channel.

Categorization of Utilization Types

The study establishes a clear distinction between the two approaches. Reuse utilizes leftover construction materials suitable for use without long processing only needing minor restoration like painting. Conversely, recycle reprocesses materials that are no longer functional in their original form through sorting, shredding, and melting.

Based on the synthesis of literature review and observations, the specific utilization types for architectural elements are mapped below:

Table 2. Types of waste utilization (Author, 2024)

Type of Material	Material	Reuse Product	Recycle Product
Waste	Plastic	-	Furniture, Secondary skin, Eco-brick, Paving Block, Interior decoration
	Cardboard	-	Acoustic panel
	Glass	Plastic bottle as a wall	-
	Wood	Main construction, Roof construction, Decoration, Finishing Product Interior	-
	Brick wall	Backfill soil	-
Construction waste material	Tile	Tile floor dan Wall	-
	Door	Door, Wall	-
	Window	Window, Wall, Decorative	-

Table 2 illustrates that Construction Waste (tiles, doors, windows, wood) is predominantly processed through Reuse strategies. These materials retain their form and function. On the other hand, Consumer Waste (Plastic, Cardboard) requires Recycle processing to gain the structural integrity needed for architectural elements like acoustic panels or paving blocks. This categorization clarifies the distinct roles of reuse and recycle in sustainable architecture.

CONCLUSION

The implementation of reuse and recycle concepts in architectural design is proven to create functional and innovative materials while supporting environmental sustainability. This study specifically concludes that the choice of processing method is determined by the material characteristics. Construction demolition waste is most effective when applied through Component reuse, as demonstrated by Bocor Alus Café, because it retains the original form and minimizes energy consumption. Conversely, consumer waste such as plastic requires Recycling (mechanical processing) to transform into structural architectural elements, as shown by Paste Lab.

These findings clarify the practical application of the Waste Hierarchy in architecture, validating that distinct waste types require distinct sourcing and processing strategies. Furthermore, these practices align with Islamic principles, emphasizing that the environment is a trust that must be protected and preserved to support human life. The author recommends that future studies calculate the quantitative difference in carbon emissions between buildings utilizing these reused/recycled materials compared to those using conventional materials to provide concrete data on their environmental impact.

Acknowledgement

Thanks to Diponegoro University, Engineering Faculty and IAI for supporting this journal and thank you to 80's Cafe, Paste lab, and The shamirono Hotel for giving permission to observe the process and products produced.

REFERENCES

Aristawati, Y., Budiman, H., Agustiananda, P. A. P., & Ramli, N. I. (2023). Recycling in Islamic Perspective Case Study of Architectural Works Using Waste Building Materials. *International Journal of Engineering*, *5*(2). https://journal.uty.ac.id/index.php/IJETS/article/view/271/167

Bossink,B.A.G., and Brouwers,H.J.H. (1996) 'Construction waste: quantification and source evaluation', Journal of Construction Engineering and Management, vol.122, no.1, pp.55-60

Bower,B.T. (1977) 'Economic Dimensions of Waste Recycling and Re-use: Some Definitions, Facts, and Issues', in D.W.Pearce and Walter, I. (eds) Resource Conservation: Social and Economic Dimensions of Recycling,Longman Group Ltd., London, pp.1-19

Dwithama, K. (2018). Penerapan Reuse Material Bekas Sebagai Bahan Material Pada Bangunan. *Ismetek*, *2*, 36–43.

Dwijayanti, K. P., Kyla, A. J., & Ansusanto, J. D. (2024). *Penerapan Kembali Limbah Plastik Sebagai Alternatif Bahan Konstruksi Jalan yang Ramah Lingkungan dan Berkelanjutan*. *1*, 35–42.

Ervianto, W. I., Soemardi, B. W., Abduh, M. (2012), Kajian Reuse Material Bangunan dalam Konsep Sustainable Construction di Indonesia. Jurnal Teknik Sipil, Vol. 12, No.1.

Iqbal, R. M., & Muhsin, A. (2014). *KAJIAN PEMANFAATAN MATERIAL HABIS PAKAI MENUJU ARSITEKTUR BERKELANJUTAN*. *2*(1), 1–12.

Karuniastuti, N. (2016). Bangunan ramah lingkungan. *Forum Teknologi*, *05*(1), 8–15. http://ejurnal.ppsdmmigas.esdm.go.id/sp/index.php/swarapatra/article/view/110/94

Lumbangaol, P. H., Sidabutar, R. A., & Simanjuntak, S. (2023). Alasan Penggunaan Material Bekas Pada Bangunan. *SJoMe*, *4*(2), 101–113.

Puspita, D. A., Triantoro, S. W., Sholikah, M., & Recaron, V. (2023). PENGARUH PENGGUNAAN MATERIAL BEKAS TERHADAP BANGUNAN DAN LINGKUNGAN (STUDI KASUS: RUMAH BUTET KERTARADJASA). *Seminar Nasional Arsitektur Pertahanan*, 104–112.

Sharma, B., Shekhar, S., Sharma, S., & Jain, P. (2021). The paradigm in conversion of plastic waste into value added materials. In *Cleaner Engineering and Technology* (Vol. 4). Elsevier Ltd. https://doi.org/10.1016/j.clet.2021.100254

Winnerdy, F. R., & Laoda, M. (2020). Daur Ulang Plastik untuk Bahan Bangunan. *Jurnal Strategi Desain Dan Inovasi Sosial*, *1*(2), 157. https://doi.org/10.37312/jsdis.v1i2.2354

Reflita, R. (2015). Eksploitasi Alam dan Perusakan Lingkungan (Istibath Hukum atas Ayat-Ayat Lingkungan). *Substantia*, *17*(2), 147–158. https://jurnal.ar-raniry.ac.id/index.php/substantia/article/view/4101

Roshaunda, D., Diana, L., Caroline, L. P., Khalisha, S., & Nugraha, R. S. (2019). Penilaian Kriteria Green Building Pada Bangunan Gedung Universitas Pembangunan Jaya Berdasarkan Indikasi Green Building Council Indonesia. *Widyakala Journal*, *6*, 29. https://doi.org/10.36262/widyakala.v6i0.181

Shinta Arifa K., Popi Puspitasari, Khotijah Lahji (2021), REFERENSI UNTUK PERANCANG: REVIEW PRODUK INOVASI MATERIAL RAMAH LINGKUNGAN, Prosiding Seminar Intelektual Muda 6, Rekayasa Lingkungan Terbangun Berbasis Teknologi Berkelanjutan hal: 7-13.

Nurul Bariyah (2021), Pemanfaatan Kayu Bekas (Reclaimed Wood) di Kota Pontianak dan Pencapaian *Sustainable Development Goals,* Prosiding Seminar Nasional SATIESP 2021, No.ISBN: 978-602-53460-8-8

Darvorin Kralj & Mirko Markic (2008), Building Materials Reuse and Recycle, WSEAS TRANSACTIONS on ENVIRONMENT and DEVELOPMENT.

Foltz R. C., Denny F M., Baharuddin A. (2003), Islam and Ecology A bestowed Trust, Cambridge, Massachusetts.