Analysis of Construction Wastes: Case Study of Commercial Housing Projects in Bandar Lampung City

Fritz Akhmad Nuzir[1,2*], Muhamad Ali Massa'id[1], Naura Diva Ratasya[2]

[1]Department of Architecture, Faculty of Engineering, Universitas Bandar Lampung, Lampung, 35142, Indonesia
[2]Center for Sustainable Development Goals Studies (SDGs Center), Universitas Bandar Lampung, Lampung, 35142, Indonesia

Keywords:
Waste; construction; materials; commercial housing; architectural works

Corresponding author:
Fritz Akhmad Nuzir
Department of Architecture, Faculty of Engineering, Universitas Bandar Lampung
Lampung, 35142, Indonesia
Email: fritz@ubl.ac.id

Abstract

Construction waste is a significant environmental issue, particularly in rapidly developing urban areas of Indonesia. In Bandar Lampung City, total solid waste reaches 850 tons annually that cause environmental damage and soil pollution. This study analyzes the types of construction waste, their causes, and handling methods in commercial housing projects. The data collected through structured interviews and field observations, then analyzed using descriptive statistical methods. Results show that the most frequently generated wastes are cement packaging, wasted cement, wasted sand, brick fragments, and ceramic tile scraps. The dominant causes include inefficient unloading methods (25%) and unused cutting waste (25%), followed by excessive waste from application processes (19%) and weather effects (13%). Common handling methods identified are burning, reselling, reusing, and burying waste materials. The findings provide recommendations for improving construction waste management practices to support environmentally friendly housing development in Indonesia.

INTRODUCTION

Construction waste is a critical issue in Indonesia, particularly over the past decade, driven by rapid urban development and housing demand. This problem, although also occurring globally, has specific challenges in the Indonesian context, including limited enforcement of waste management regulations and reliance on conventional construction methods. In contrast, countries such as China have adopted more efficient housing construction practices, producing less material waste and achieving faster project completion compared to conventional methods. Usually, construction waste is generated from activities such as new construction, renovation, demolition, and maintenance of buildings and infrastructure (Islam et al., 2019). The construction phase generates various types of construction waste, including sand, cement, colored cement, bricks, paint, ceramics, and zinc (Syahputri, Firdasari and Purnama Lisa, 2023). Some construction materials require relatively simple processing, while others undergo complex manufacturing processes, such as iron, steel, copper, glass, plastics, and cement. Unfortunately, the efficiency of material use in construction projects is often low, making construction waste a major contributor to the global waste stream. According to data, construction waste is estimated to account for approximately 30% of the total global solid waste, reaching 1.2 to 2 billion tons per year (Kaza et al., 2019).

With the continuously growing population, the total solid waste generation in Bandar Lampung reaches 850 tons per year (Statistics Indonesia, 2024). Referring to the global estimate that construction waste accounts for 30% of total solid waste, the construction waste generated in the city is projected to reach 255 tons annually. The increasing urbanization in Bandar Lampung City has led to a growing demand for housing, which, in turn, has driven higher construction activity, particularly in the residential sector. This condition inevitably increases the volume of construction waste, which poses a risk of environmental damage if not properly managed. According to Henvy et al. (2023), construction waste can have negative effects such as soil contamination and environmental degradation.

The study was conducted in the Tebet Raya Lampung Residential Area, which was selected after a survey of all commercial housing developments in Bandar Lampung City. The selection was based on identifying the residential project with the highest number of housing units under construction. Tebet Raya Lampung was selected as it had 20 residential units under construction, distributed in four clusters that is Lotus, Skania, Harvey, and Elona. To ensure proper construction waste management and develop environmentally friendly planning, it is essential to identify the most common types of waste generated in construction projects. Therefore, this study aims to analyze construction waste in residential development projects in Bandar Lampung City, with a research focus on the architectural work phase due to time constraints.

LITERATURE REVIEW

Identification Results and Ranking of Construction Material Waste

Waste is the remaining result of a production process, either from industrial or household activities (Zakky 2020). Based on the definition, the remaining results of production processing or materials that do not or do not have economic value or use in the production process or use are called waste. When viewed according to its nature, waste can be categorized into corrosive waste, flammable waste, explosive waste, reactive waste, and toxic waste (Harefa 2020). Waste reduction with a traditional approach is an unsustainable method because it is less flexible and there is no long-term thinking (Seadon 2010). However, there are still traditional sustainable methods such as composting waste materials. Composting is one of the environmental techniques (technologies) that can contribute to improving urban waste management by introducing organic waste reduction with the concept of reuse which is often taken as the first step in many cities (Nuzir, Hayashi, and Takakura 2019).

Waste Grouping

Waste grouping can be distinguished based on its form, based on its compounds, and based on its source (Rahma 2021). Waste groups based on their form: (1) solid waste, is something that is solid such as food packaging, plastic, used tires and others; (2) liquid waste, is a type of waste that is liquid, such as used washing water, soapy water, used cooking oil, and so on; (3) gas waste, is waste that is in the form of gas, such as carbon dioxide, carbon monoxide and others are called gas waste.

Waste groups based on their compound: (1) non inert, is a waste that can be decomposed by natural bacteria and fungi. Examples of this waste are leaves, vegetable waste, and animal waste; (2) inert, is a type of waste that is not easy or even cannot be decomposed naturally (cannot rot). Examples of inorganic waste include iron, plastic, glass, and steel (Brilian Harefa, 2022).

Waste groups based on their source: (1) household waste is waste material produced from household activities; (2) industrial waste is industrial activities that produce waste material; (3) agricultural waste is waste that comes from agricultural activities; (4) construction waste is waste consisting of materials that are no longer used, originating from the construction, repair, or renovation process; (5) radioactive waste is waste material that is generated from the use of nuclear energy.

Waste Construction Materials

The following are wastes that may become or be generated in construction projects according to Syahputri, Firdasari, and Purnama Lisa (2023), namely: (1) sand; (2) cement; (3) colored cement; (3) bricks; (5) paint; (6) ceramics; and (7) zinc. Meanwhile, according to Henvy, Sophia, and Darmawan (2023) in their journal, construction waste is divided into; (1) waste wood that is no longer used again; (2) cement packaging; (3) waste from steel or iron pieces; (4) paint containers with metal materials; (5) paint containers with plastic materials; (6) waste from excavating the earth; and (7) crushed stone.

Waste Construction Causes

According to Pertiwi, Herlambang, and Kristinayanti (2019), the causes of construction waste are categorized as follows: (1) Design: incomplete documents when construction begins, design changes during the construction process, design information that is not fully available, changes in material specifications after work is underway; (2) Purchase or procurement of materials: errors in ordering, either excess or insufficient quantities from those needed, goods ordered do not match the specified specifications, constraints in purchasing because materials are only available in large quantities, ineffective procedures for sending goods from suppliers to the project location; (3) Material handling: storage of materials that do not comply with recommended standards, damage due to transportation methods from the warehouse to the work area, inefficient material unloading methods, use of low-quality materials, equipment used is inadequate for construction work, use of materials that are not in perfect condition, poor material processing, such as ineffective cutting; (4) Workers: errors in applying work methods during the project, lack of worker experience in the construction sector, lack of workforce skills, inefficient working hour arrangements, unprofessional worker attitudes; (5) Construction Management: suboptimal project planning and scheduling, poorly organized work site management, lack of supervision of workers in the field, inappropriate or ineffective construction methods, poor communication between related parties, minimal efforts to prevent material waste, less than optimal material control; (6) Management of Remaining Materials: unusable cutting material, use of wet materials in excess of needs, large amounts of waste generated from the material application process; (7) Location Conditions: less than supportive work environment, project location conditions that do not meet normal standards; (8) External Conditions: weather conditions, criminal acts that cause damage and material losses.

Construction Waste Handling Methods

In previous research by Suartika Putra, Dharmayanti, and Parami Dewi (2018), it was found that handling construction material waste was selling construction material waste that still had a selling value, reusing it for future projects, and disposing of construction material waste to the nearest landfill. Meanwhile, according to Andiani (2011), the handling of construction material waste is categorized as follows: (1) Selling waste material; (2) Giving it away for free; (3) Reusing it in projects.

Architectural Works

Architectural work is one of the non-structural construction work items that includes wall installation work, plastering work, painting work, flooring work, ceiling work, frame work, and roof covering work (Syahputri, Firdasari, and Purnama Lisa 2023). While categorized under "architectural works" for the purposes of this study, several of these items, such as bricklaying, plastering, and ceiling installation, are integral parts of the overall construction process and generate waste materials commonly classified as general construction waste. The scope in this table includes both structural finishing and interior work components.

Table 1. List of Waste Construction Material.

No.	Work Stage	Construction Waste
1	Bricklaying work	Red brick Sand Cement
2	Wall plastering work	Sand Cement
3	Ceramic installation work	Sand Cement Ceramics
4	Painting work	Plastic paint bucket Metal paint bucket
5	Ceiling installation work	Ceiling pieces Zinc pieces Cornice/putty
6	Door and window frame installation work	Remaining pieces of iron/steel Remaining pieces of iron/steel
7	Roof covering installation work	Remaining pieces of spandek

METHODS

Structured interviews were conducted to identify the types of material waste generated in a single workday, as well as to understand the causes of waste generation and the waste management practices implemented. Four interview respondents were selected, all of whom were experienced site supervisors. Each housing cluster was overseen by a different site supervisor those are Lotus cluster by Supervisor A, Skania cluster by Supervisor B, Harvey cluster by Supervisor C, and Elona cluster by Supervisor D. The interviews were conducted in person, twice daily during each workday at 1:00 PM, to gather information about ongoing work and the types of waste generated, and at 4:00 PM, to record and verify the total waste produced throughout the workday.

The initial observation was conducted at 10:00 AM at the start of the workday to assess the ongoing activities, with a specific focus on architectural work. The second observation took place at 1:00 PM to identify the materials being wasted, followed by the final observation at 4:00 PM to record the total waste generated throughout the workday. The data collected from each housing cluster will be aggregated and presented in the form of diagrams, accompanied by descriptive explanations. This method is used to rank the most dominant materials appearing in the construction project and to provide a detailed description of the analysis results.

RESULTS AND DISCUSSION

1. Identification Results and Ranking of Construction Material Waste

The following data was collected from each cluster over the 14-day research period at the Tebet Raya Lampung Residential Area. Construction material waste generated in a single day is marked with the number "1", while waste that was not generated is marked with the number "0".

Lotus Cluster

Table 2. below presents the data collection for Cluster Lotus over 14 days.

Table 2. Construction Material Waste Generation in Lotus Cluster

Material Waste	Day-													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Red brick	1	1	1	0	0	1	1	1	1	1	1	1	1	1
Sand	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cement	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cement packaging	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ceramic tile scraps	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Plastic paint bucket	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Metal paint bucket	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceiling board scraps	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Zinc scraps	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Leftover iron	0	0	0	0	0	0	0	0	0	0	0	0	0	0

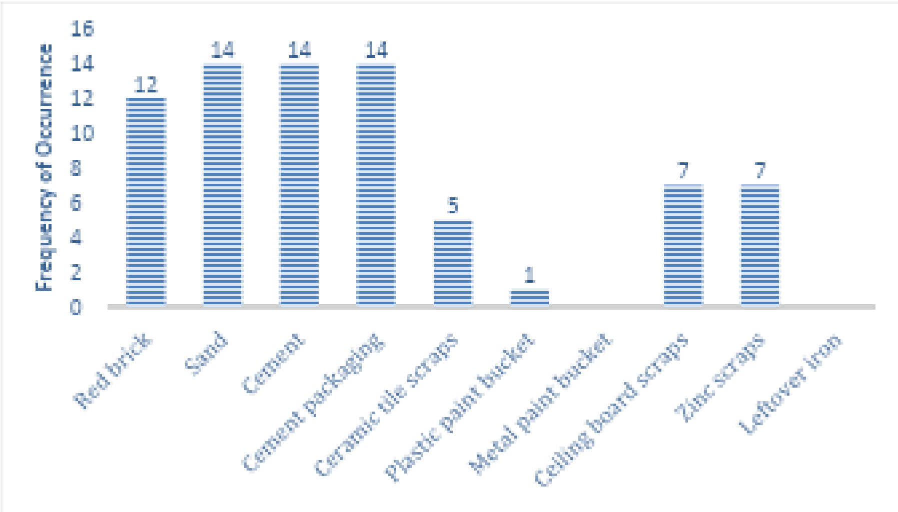

Fig. 1. Bar Chart of Waste Generation in Cluster Lotus
(Source: Nuzir, 2024)

From the construction of Cluster Lotus, four materials had the highest frequency of occurrence sand, cement, cement packaging, and red bricks. Meanwhile, materials that were less frequently generated included ceiling board scraps, zinc scraps, ceramic tile scraps, plastic paint buckets, metal paint buckets, and leftover iron.

Skania Cluster

Table 3. below presents the data collection for Cluster Skania over 14 days.

Table 3. Construction Material Waste Generation in Skania Cluster

Material Waste	Day-													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Red brick	1	1	1	0	1	1	1	1	0	1	1	0	1	1
Sand	1	1	1	1	1	1	1	1	0	1	1	1	1	1
Cement	1	1	1	1	1	1	1	1	0	1	1	1	1	1
Cement packaging	1	1	1	1	1	1	1	1	0	1	1	1	1	1
Ceramic tile scraps	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plastic paint bucket	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Metal paint bucket	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceiling board scraps	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Zinc scraps	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Leftover iron	0	0	0	0	0	0	0	0	0	0	0	0	0	0

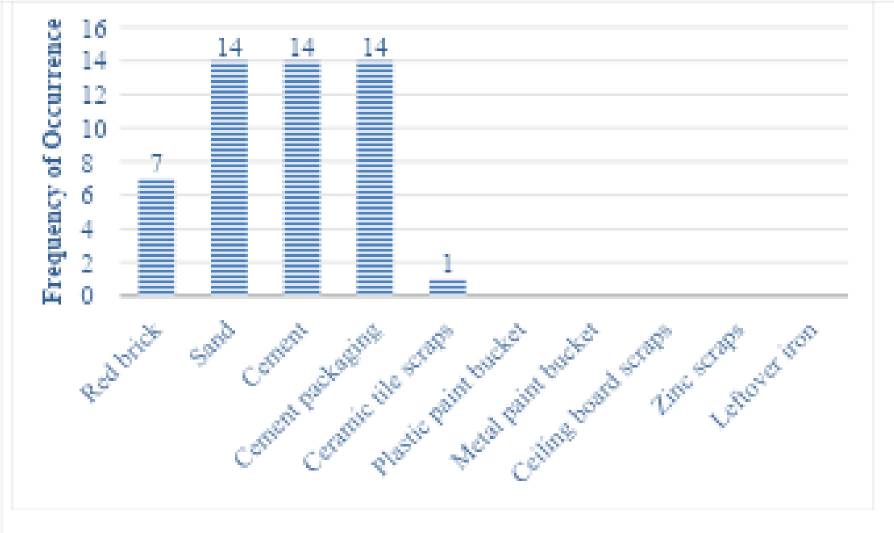

Fig. 2. Bar Chart of Waste Generation in Cluster Skania
(Source: Nuzir, 2024)

In Cluster Skania, four construction materials were found to have the highest frequency of occurrence sand, cement, cement packaging, and red bricks. Meanwhile, materials that were less frequently generated included ceiling board scraps, zinc scraps, plastic paint buckets, ceramic tile scraps, metal paint buckets, and leftover iron.

Harvey Cluster

Table 4. below presents the data collection for Cluster Harvey over 14 days.

Table 4. Construction Material Waste Generation in Cluster Harvey

Material Waste	Day-													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Red brick	1	1	1	0	1	1	1	1	0	0	0	0	0	0
Sand	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cement	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cement packaging	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ceramic tile scraps	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Plastic paint bucket	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metal paint bucket	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceiling board scraps	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zinc scraps	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leftover iron	0	0	0	0	0	0	0	0	0	0	0	0	0	0

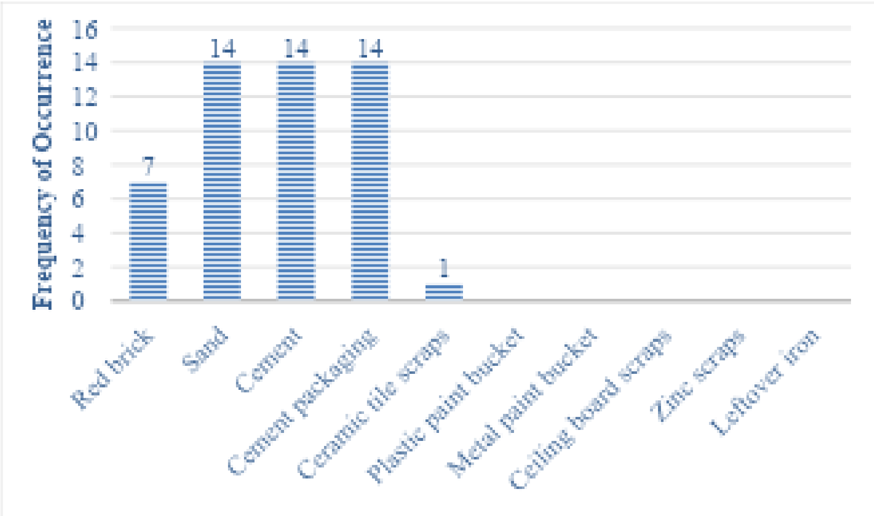

Fig. 3. Bar Chart of Waste Generation in Cluster Harvey
(Source: Nuzir, 2024)

In the construction of Cluster Harvey, three construction materials were identified as the most prevalent sand (14), cement (14), and cement packaging (14). The remaining materials were utilized less frequently, with red bricks appearing on seven occasions, ceramic tile scraps appearing once, and plastic, metal, ceiling board, zinc, and leftover iron materials not having any recorded appearances.

Elona Cluster

Table 5. below presents the data collection for Cluster Elona over 14 days.

Table 5. Construction Material Waste Generation in Cluster Elona

Material Waste	Day-													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Red brick	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Sand	1	1	0	0	0	0	1	1	1	1	1	1	1	1
Cement	1	1	0	0	0	0	1	1	1	1	1	1	1	1
Cement packaging	1	1	1	1	1	0	1	1	1	1	1	1	1	1
Ceramic tile scraps	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Plastic paint bucket	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Metal paint bucket	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceiling board scraps	0	1	0	1	1	0	0	0	0	0	0	0	0	0
Zinc scraps	0	1	0	1	1	0	0	0	0	0	0	0	0	0
Leftover iron	0	0	0	0	0	1	1	1	1	1	0	0	0	0

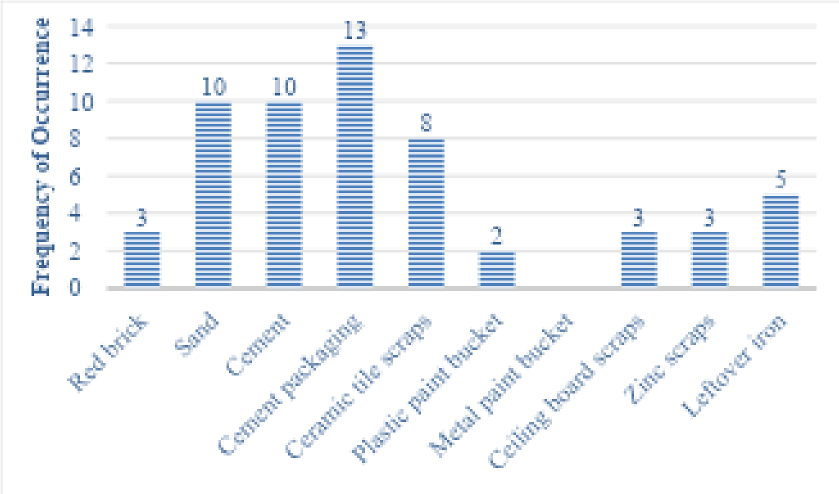

Fig. 4. Bar Chart of Waste Generation in Cluster Elona
(Source: Nuzir, 2024)

From the construction of Cluster Elona, four construction materials had the highest frequency of occurrence: cement packaging (13), cement (10), sand, and ceramic tile scraps. Meanwhile, materials with a lower frequency of occurrence included leftover iron, red bricks, ceiling board scraps, zinc scraps, plastic paint buckets, and metal paint buckets.

2. Analysis of Waste Material Waste Generated

The construction material waste generation analyzed was taken from the architectural work phase, which involved different tasks. However, since the materials used were the same, a radar chart was used to identify the most frequently occurring waste. Below is Fig. 5, which illustrates the construction material waste generated during the housing development.

From the radar chart above, the most frequently occurring construction waste materials are cement packaging, discarded cement, wasted sand, unused brick fragments, and ceramic tile scraps. Meanwhile, the least generated waste materials include leftover iron or steel scraps, unused zinc sheets, unused ceiling board scraps, metal paint cans, and plastic paint buckets.

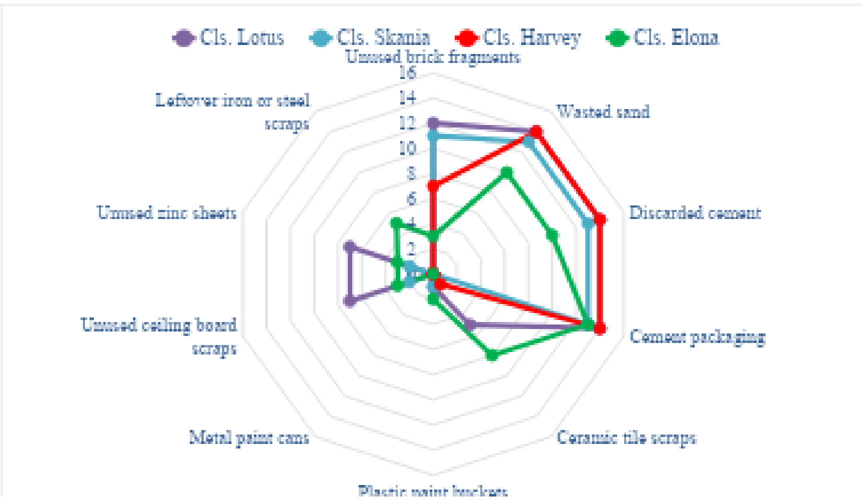

Fig. 5. Waste Recapitulation
(Source: Nuzir, 2024)

3. Causes of Construction Waste

The following data presents the causes of construction material waste generation, obtained from interviews with four site supervisors on the Tebet Raya Lampung housing project. The list of questions was presented in Table 6-9, with responses marked as "VALID" indicates that the site supervisor confirmed the listed factor as a cause of construction waste in the project, and "NOT VALID" means the factor was not considered a cause in the specific context of this project.

Table 6. Interview Results of Site Supervisor A

Factor	Criteria	Result
Design	Incomplete documents at the start of construction	NOT VALID
	Design changes	VALID
Material Procurement or Purchasing	Errors in ordering (excess or shortage of required materials)	NOT VALID
	Ordered items do not meet specifications	NOT VALID
	Purchases cannot be made in small quantities	VALID
	Transportation/delivery procedures from the supplier to the project site (warehouse)	NOT VALID
Material Handling	Improper material storage	NOT VALID
	Damage due to transportation methods from the warehouse to the worksite	NOT VALID
	Inefficient unloading methods	VALID
	Use of low-quality materials	NOT VALID
	Inadequate tools and equipment	NOT VALID
	Utilization of imperfect materials	NOT VALID
	Poor material processing (inefficient cutting)	NOT VALID
Workers	Errors in work methods during the project	NOT VALID
	Inexperienced workers	NOT VALID
	Lack of worker skills	NOT VALID
	Inefficient working hours	NOT VALID
	Poor worker attitude	NOT VALID
Construction Management	Poor planning and scheduling	NOT VALID
	Poor site management	NOT VALID
	Inadequate worker supervision	NOT VALID
	Inefficient construction methods	NOT VALID
	Lack of communication	NOT VALID
	Insufficient waste prevention measures	NOT VALID
	Weak material control	NOT VALID
Residual Material Management	Unused cutting waste	VALID
	Excessive mixing of wet materials	NOT VALID
	High waste generation from application processes	NOT VALID
Site Conditions	Poor working site conditions	NOT VALID
	Unusual project site conditions	NOT VALID
External Conditions	Weather Influence	NOT VALID
	Criminal Waste Leading to Damage and Loss	NOT VALID

The interview results with Site Supervisor A indicate the causes of construction waste generation, including design changes, the inability to purchase materials in small quantities, inefficient unloading methods, and unused cutting waste

Table 7. Interview Results of Site Supervisor B

Factor	Criteria	Result
Design	Incomplete documents at the start of construction	NOT VALID
	Design changes	NOT VALID
Material Procurement or Purchasing	Errors in ordering (excess or shortage of required materials)	NOT VALID
	Ordered items do not meet specifications	NOT VALID
	Purchases cannot be made in small quantities	NOT VALID
	Transportation/delivery procedures from the supplier to the project site (warehouse)	NOT VALID
Material Handling	Improper material storage	NOT VALID
	Damage due to transportation methods from the warehouse to the worksite	NOT VALID
	Inefficient unloading methods	VALID
	Use of low-quality materials	NOT VALID
	Inadequate tools and equipment	NOT VALID
	Utilization of imperfect materials	NOT VALID
	Poor material processing (inefficient cutting)	NOT VALID
Workers	Errors in work methods during the project	NOT VALID
	Inexperienced workers	NOT VALID
	Lack of worker skills	NOT VALID
	Inefficient working hours	NOT VALID
	Poor worker attitude	NOT VALID
Construction Management	Poor planning and scheduling	NOT VALID
	Poor site management	NOT VALID
	Inadequate worker supervision	NOT VALID
	Inefficient construction methods	NOT VALID
	Lack of communication	NOT VALID
	Insufficient waste prevention measures	NOT VALID
	Weak material control	NOT VALID
Residual Material Management	Unused cutting waste	VALID
	Excessive mixing of wet materials	NOT VALID
	High waste generation from application processes	VALID
Site Conditions	Poor working site conditions	NOT VALID
	Unusual project site conditions	NOT VALID
External Conditions	Weather Influence	VALID
	Criminal Waste Leading to Damage and Loss	NOT VALID

The interview with Site Supervisor B identified the causes of construction waste generation, including inefficient unloading methods, unused cutting waste, excessive waste from the application process, and weather conditions.

Table 8. Interview Results of Site Supervisor C

Factor	Criteria	Result
Design	Incomplete documents at the start of construction	NOT VALID
	Design changes	NOT VALID
Material Procurement or Purchasing	Errors in ordering (excess or shortage of required materials)	NOT VALID
	Ordered items do not meet specifications	NOT VALID
	Purchases cannot be made in small quantities	NOT VALID
	Transportation/delivery procedures from the supplier to the project site (warehouse)	NOT VALID
Material Handling	Improper material storage	NOT VALID
	Damage due to transportation methods from the warehouse to the worksite	NOT VALID
	Inefficient unloading methods	VALID
	Use of low-quality materials	NOT VALID
	Inadequate tools and equipment	NOT VALID
	Utilization of imperfect materials	NOT VALID
	Poor material processing (inefficient cutting)	NOT VALID
Workers	Errors in work methods during the project	NOT VALID
	Inexperienced workers	NOT VALID
	Lack of worker skills	NOT VALID
	Inefficient working hours	NOT VALID
	Poor worker attitude	NOT VALID
Construction Management	Poor planning and scheduling	NOT VALID
	Poor site management	NOT VALID
	Inadequate worker supervision	NOT VALID
	Inefficient construction methods	NOT VALID
	Lack of communication	NOT VALID
	Insufficient waste prevention measures	NOT VALID
	Weak material control	NOT VALID
Residual Material Management	Unused cutting waste	VALID
	Excessive mixing of wet materials	NOT VALID
	High waste generation from application processes	VALID
Site Conditions	Poor working site conditions	NOT VALID
	Unusual project site conditions	NOT VALID
External Conditions	Weather Influence	VALID
	Criminal Waste Leading to Damage and Loss	NOT VALID

The interview with Site Supervisor C identified the causes of construction waste generation, including inefficient unloading methods, unused cutting waste, excessive waste from the application process, and weather conditions.

Table 9. Interview Results of Site Supervisor D

Factor	Criteria	Result
Design	Incomplete documents at the start of construction	NOT VALID
	Design changes	NOT VALID
Material Procurement or Purchasing	Errors in ordering (excess or shortage of required materials)	NOT VALID
	Ordered items do not meet specifications	NOT VALID
	Purchases cannot be made in small quantities	NOT VALID

	Transportation/delivery procedures from the supplier to the project site (warehouse)	NOT VALID
Material Handling	Improper material storage	NOT VALID
	Damage due to transportation methods from the warehouse to the worksite	VALID
	Inefficient unloading methods	VALID
	Use of low-quality materials	NOT VALID
	Inadequate tools and equipment	NOT VALID
	Utilization of imperfect materials	NOT VALID
	Poor material processing (inefficient cutting)	NOT VALID
Workers	Errors in work methods during the project	NOT VALID
	Inexperienced workers	NOT VALID
	Lack of worker skills	NOT VALID
	Inefficient working hours	NOT VALID
	Poor worker attitude	NOT VALID
Construction Management	Poor planning and scheduling	NOT VALID
	Poor site management	NOT VALID
	Inadequate worker supervision	NOT VALID
	Inefficient construction methods	NOT VALID
	Lack of communication	NOT VALID
	Insufficient waste prevention measures	NOT VALID
	Weak material control	NOT VALID
Residual Material Management	Unused cutting waste	VALID
	Excessive mixing of wet materials	NOT VALID
	High waste generation from application processes	VALID
Site Conditions	Poor working site conditions	NOT VALID
	Unusual project site conditions	NOT VALID
External Conditions	Weather Influence	NOT VALID
	Criminal Waste Leading to Damage and Loss	NOT VALID

The interview with Site Supervisor D identified the causes of construction waste generation, including damage caused by material transportation from the warehouse to the worksite, inefficient unloading methods, unused cutting waste, and excessive waste from the application process.

Table 10. Recapitulation of Construction Waste Generation Causes

No	Criteria	Total Votes
1	Inefficient unloading methods	4
2	Unused cutting waste	4
3	High waste generation from application processes	3
4	Weather Influence	2
5	Design changes	1
6	Purchases cannot be made in small quantities	1
7	Damage due to transportation methods from the warehouse to the worksite	1

Below is Fig. 6. which visualizes the causes of waste generation, the numbers in the figure show the percentage of votes from the interviews based on Table 9.

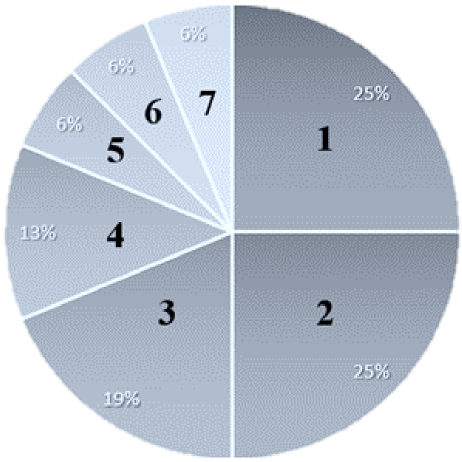

Fig 6. Causes of Waste Generation
(Nuzir, 2024)

Fig. 6 shows that the dominant causes of construction waste generation are inefficient unloading methods and unused material cuttings, each accounting for 25% of the total. These fall under the categories of material handling and leftover material management.

Meanwhile, other causes of construction waste generation include excessive waste from application processes (19%), weather influences (13%), design changes, the inability to purchase materials in small quantities, and damage due to transportation methods from the warehouse to the construction site, each contributing 6%.

4. Construction Waste Management Methods

Based on the results of interviews and observations during the housing construction at the research site, four construction waste management methods were identified, as shown in Table 10.

Table 10. Construction Waste Management Methods

No	Handling Methods	Material Waste
1	Waste management by burning	Wood, gypsum scraps, cement packaging, etc.
2	Waste management by reselling	Cement packaging, metal scraps
3	Waste management by reusing	Paint buckets
4	Waste management by burying	Bricks, ceramic fragments, sand & cement mixture

1. Handling of Waste Materials by Burning

Waste materials handled using this method include wood, gypsum scraps, cement packaging, and other easily flammable materials.

Fig 7. Burned Waste Materials
(Nuzir, 2024)

According to the respondents, this method is the most frequently used because it is efficient. However, it is not an environmentally friendly approach as it causes air pollution and has the potential to cause respiratory diseases.

2. Selling construction waste materials

This method is applied to used materials that still have economic value, such as cement packaging and metal scraps.

Fig 8. Construction Waste Materials that are Sold
(Nuzir, 2024)

3. Reusing construction waste materials

The materials that are reused include used buckets and wood. Used buckets are utilized as containers for tools and as water storage for mixing paint, while wood, especially formwork boards, can be reused multiple times due to its durability.

Fig 9. Reused Construction Waste Materials
(Nuzir, 2024)

4. Burying construction waste materials

This method is carried out in two locations, inside the constructed housing units and outside the units. Waste materials that are buried include brick fragments, broken ceramics, and discarded sand and cement mixtures from the application process, which eventually blend with the fill soil. Meanwhile, other waste materials, such as ceramic pieces and other construction scraps, are buried outside the housing units.

Fig 10. Construction Waste Materials that are Buried
(Nuzir, 2024)

CONCLUSION

The waste material generation results from each cluster show different frequencies. In the construction of the Lotus cluster, the highest frequency waste materials found were sand, cement, cement packaging, and red bricks. Meanwhile, materials that appeared less frequently included ceiling cuttings, zinc cuttings, ceramic cuttings, plastic paint buckets, metal paint buckets, and iron scraps. In the Skania cluster, the most frequently generated waste materials were sand, cement, and cement packaging, all with the same frequency, followed by red bricks. The materials that appeared less frequently included ceiling cuttings, zinc cuttings, plastic paint buckets, ceramic cuttings, metal paint buckets, and iron scraps. In the Harvey cluster, the most frequently generated waste materials were sand, cement, and cement packaging. Meanwhile, other materials had lower frequencies, including red bricks, ceramic cuttings, plastic paint buckets, metal paint buckets, ceiling cuttings, zinc cuttings, and iron scraps.

In the Elona cluster, the four most frequently generated waste materials were cement packaging, cement, sand, and ceramic cuttings. Meanwhile, waste materials with lower frequencies included iron scraps, red bricks, ceiling cuttings, zinc cuttings, plastic paint buckets, and metal paint buckets.Overall, the most frequently generated architectural waste materials in the residential construction project were cement packaging, wasted cement, unused brick fragments, and ceramic cuttings. On the other hand, the least frequently generated waste materials included iron or steel scraps, unused zinc scraps, unused ceiling scraps, metal paint cans, and plastic paint buckets.

The dominant causes of construction waste generation were inefficient material unloading methods and unused cuttings, each accounting for 25% of the total and categorized under material handling and waste material management. Other causes of construction waste generation included excessive waste from application processes (19%), weather conditions (13%), design changes, inability to purchase materials in small quantities, and damage caused by transportation methods from the warehouse to the construction site, each contributing 6%.

There were four waste management methods used in the residential construction project waste disposal by burning, reselling waste materials, reusing waste materials, and burying waste materials.

Although the study focused on the architectural work phase, many of the most frequently generated waste materials, such as cement, sand, and bricks, are fundamental construction materials rather than exclusively architectural. This suggests that waste reduction strategies should target overall construction processes, not only finishing works. Current practices such as burning, selling, reusing, and burying waste offer partial solutions but often lack systematic management. Burning, for example, is quick but environmentally harmful; selling and reusing can extend material life but require better sorting and storage; burying may address site cleanliness but can create long-term environmental issues. A more comprehensive construction waste management plan, integrating prevention, recycling, and policy enforcement, is essential for sustainable housing development.

ACKNOWLEDGEMENT

The authors would like to thank the Department of Architecture, Faculty of Engineering, Universitas Bandar Lampung for continuous support in this research. Also, authors would also like to thank the Center for Sustainable Development Goals Studies (SDGs Center) Universitas Bandar Lampung and Real Estate Indonesia (REI) Lampung Province which providing data and information for the authors to complete this research.

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