Type and Quantity of the Residual Construction Material of Low-rise Building Construction in Makassar

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Abstract. Waste material is considered as residual material which is not used during construction projects. These materials are unable to be reused, returned, recycled, or salvaged which have significant impact to environment. The residual material that occurs is caused by inaccurate planning and inefficient use of material in the project. This research is intended to identify quantity of residual material in the construction of low-rise buildings. Data was collected from 25 housing and shophouse projects. It then analysed using quantitative analysis to determine the type and quantity of the construction waste material. The result shows that the highest waste material for housing is sand while for shophouse projects is bricks.

1. Introduction
The use of materials in the construction industry can cause residual material. The rest of this material is part of unused materials in the implementation of construction projects and is not a part of the building. So that the more remaining material that occurs, the more inefficient use of material in the project.

Alternatives to overcoming and minimizing the rest of the construction materials, as well as improving company performance began to be felt necessary to find. Minimization of the huge remaining material will help the contracting company to increase profits as much as possible. Several studies focusing on rearrange the way to deal with residue by using recycle and reusable method. Moreover, it also focuses on the impact of burning waste material the construction process.

The method of recycling is still difficult to implement in Indonesia, because the trash cans have not been sorted according to the type of waste. Therefore, the garbage put together in one shelter. In addition, it requires sophisticated technology applications that require high costs, and the results of recycling have not been studied to be utilized. This method of combustion will adversely affect air pollution and the environment. In the method of reusing remaining material, it is usually limited to materials that are not part of the building structure (non-consumable material), such as formwork and scaffolding [1].

This research is related to the handling of the remaining material that might be done in Indonesia, namely through material management to minimize the remaining material that occurs in the field, this is due to cost considerations. technology that is still simple, and at the same time is environmentally conscious.

2. Literature Review
Material is an important component in determining the cost of a project. More than half of the project cost is absorbed by the uses of material. During the construction stage, material usage in the field often
results in significant number of residual material. So, the efforts to minimize the remaining material are important to apply. Materials used in construction can be classified in two major parts, they are:

a. Consumable materials, is a material that will eventually become part and physical structure of the building, for example: cement, sand, gravel, brick, reinforcing iron, steel, and others.

b. Non-consumable materials, is a supporting material in the construction process and is not a physical part of the building after finishing, for example: scaffolding, formwork and temporary retaining walls.

The flow of construction materials starts from delivery to the location, construction process, until the last position will end in one of the four positions below, namely:

a. Physical structure of the construction
b. Excess material (leftover)
c. Reuse in the same project
d. Waste

The rest of the core construction materials will continue to grow in accordance with the progress of development carried out, in addition to affecting project costs will also cause new problems that can disrupt the project environment and surroundings. Control of the quantity of the remaining material can be done in several ways including:

a. Looking for ways to reuse the remaining material.
b. Recycle the remaining material into useful items
c. Destroy the remaining material by burning
d. Look for ways to reduce the remaining material that arises [2].

Preventing the remaining material by means of prevention is the best way, because it is felt to be more economical, lower and safer than other solutions. Expenditures to control the remaining material from the outset will be more profitable than expenses incurred due to the arising of the remaining material. Therefore the magnitude of the quantity of the remaining material that occurs is very closely related to material management.

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The remaining material that arises can be categorized into two parts, namely:

a. Demolition waste is the remaining material arising from the demolition or destruction of old buildings.

b. Construction waste is the remnants of construction materials originating from the construction or renovation of privately owned, commercial buildings and other structures. The rest of the material is in the form of rubbish consisting of concrete, brick, stucco, wood, pipes and electrical components [4].

Construction Waste can be classified into two categories based on its type: direct waste and indirect waste. Direct waste is the remaining material that arises in the project because it is damaged and cannot be used anymore which consists of:

a. Transport and delivery waste (remaining transportation & shipping)
   All remaining material that occurs when transporting material in the work location, including dismantling and placement in storage such as throwing / throwing cement, ceramics when moved.

b. Site storage waste (remaining storage)
   The residual material occurs due to the accumulation / storage of material in unsafe places, especially for sand and broken stone material. or in a humid environment, especially for cement material.
c. Conversion waste (residual deformation)
   The residual material occurs due to cutting material with an uneconomic form such as concrete steel materials, ceramics, etc.

d. Fixing waste (remaining installation)
   Material that is scattered damaged or wasted during use in the field such as sand, cement, coal, etc.

e. Waste cutting
   The rest of the material is produced due to cutting of materials such as piles, concrete steel, brick, ceramics, concrete iron, etc.

f. Application and waste residue
   The remaining material that occurs such as mortar that fell / scattered at the time of execution or mortar is left behind and has hardened at the end of the work.

g. Criminal waste (residual due to criminal acts)
   The residual material occurs due to theft or acts of destruction at the project site.

h. Wrong use waste (remaining usage errors)
   Use the type or quality of material that is not in accordance with the specifications in the contract, the board of directors will instruct the contractor to replace the material in accordance with the contract, thereby causing the remaining material in the field.

i. Waste management (residual error management)
   The occurrence of material residue is due to wrong decision making or doubt in making decisions, this is due to weak project organization, or lack of supervision [5].

Indirect waste is the residual material that occurs in the form of a cost loss, there is an excess use of the material and planned volume, and there is no physical residual material in the field. This indirect waste can be divided into three types, namely:

a. Waste substitution (the remainder of the turnover)
   The remaining material that occurs due to its use deviates from its original purpose, thus causing the loss of costs that can be caused by three reasons;
   1. Too much material is purchased
   2. Damaged material
   3. Increasing certain material needs

b. Production waste (the rest of the production)
   The remaining material caused by excessive use of material and the contractor is not entitled to claim the excess volume because the basis of payment is based on the volume of the contract, for example uneven masonry walls cause excessive use of mortar due to thick plastering.

c. Negligence waste (residual due to negligence)
   The rest of the material that occurs due to an error at the site (site error), so that the contractor uses more material than specified, for example: excavation of the foundation that is too wide or deep caused by error / carelessness of workers, resulting in excess use of the volume of concrete at the time of foundation casting [6].

Waste prevention should be the main consideration. It is the avoiding of using much materials than needed which create less waste. It can be done by in several ways. For instance, selling the timber that has been used as concrete formwork. However, when it is not possible to prevent waste, thus waste should be managed wisely. Construction waste should be managed wisely using the following approach:

a. Reusing, where using the same material again with the same usage without turning it to any other form. For example, using the same multiplex several times for concrete formwork.

b. Recycling, where turning particular materials into other useful forms when directly reusing is not possible. Various components of construction and demolition waste can be recycled. For example, steel have the highest recycling percentage over the materials recovered from construction and demolition sites.
c. Disposal is the last choice should be considered, as it means removing, sometimes materials are unusable after first usage. Therefore, in this case burning and landfill is included.

![Figure 1. Waste hierarchy summary [7]](image)

3. Research Methodology
An outline scheme of the work program of this study is describe with the following methods:
1. Preliminary Study in presenting ideas or problems to be discussed, namely the study of the remaining material in the construction of low-rise buildings. Conducting literature studies that support this research. Formulate the problem that will be examined and discussed in this study.
2. Research variables are material requirements, material storage, material transfer, material usage, and material handling
3. Data retrieval in the assessment of material requirements index is done by inventorying secondary data on construction projects that have been. As a guide, the questionnaire is used as a measurement tool. Inventory secondary data from interviews to contractors, consultants, planners, government agencies or other randomly chosen construction implementers.
4. Processing data using descriptive and inferential statistics to determine the index of material requirements, worker productivity and tool use. Estimated average waste cost is calculated using the following equation

\[
\text{Estimated average waste cost} = \text{Estimated waste quantity} \times \text{material price}
\]

4. Result and Discussion
Determination of the type of material to be quantified based on the concept of the Pareto Law in which obtained 7 types of material for residential houses and shop houses are sand, brick, wood, concrete steel, tile, ceramic and cement. From the above results, a quantitative analysis of the remaining material is carried out by calculating the volume of ready-made material in the field reduced by the volume of design material based on project plan drawings and the Bill of Quantity (BOQ), then reduced by the remaining material in the field which can still be used if there is. The results obtained are for the highest residential dwellings with sand with an average remaining construction material ranging from 13.6% while for the highest shop houses are bricks with an average remaining construction material ranging from 12.08% as shown in Table 1.

The main causes of the residual construction material in this project are:

a. Changes from the initial design
b. Orders must be placed with a certain volume in one order or can’t be done in small quantities.
c. Damage from tiles and ceramics during material delivery.
d. The sand material sent is not in the volume that should be in one truck
e. The material is not according to specifications
f. Damage in handling material during the construction process
Table 1. Percentage of remaining material volume

| Type of Material | Average amount percentage | Estimated average waste cost per project |
|------------------|---------------------------|------------------------------------------|
| **Residential**  |                           |                                          |
| Brick            | 15.92%                    | Rp. 254,000 - Rp. 635,000               |
| Sand             | 17.96%                    | Rp. 1,142,000 - Rp. 1,713,000           |
| Tile             | 10.92%                    | Rp. 214,000 - Rp. 877,400              |
| Wood             | 14.34%                    | Rp. 924,500 - Rp. 1,571.650            |
| Concrete Steel   | 6.94%                     | Rp. 84,000 - Rp. 210,000               |
| Ceramics         | 16.34%                    | Rp. 156,200 - Rp. 296.780              |
| Cement           | 12.94%                    | Rp. 124,500 - Rp. 311.250              |
| Others           | 4.64%                     | Rp. 243,000 - Rp. 510.300              |
| **Shops House**  |                           |                                          |
| Brick            | 17.08%                    | Rp. 164,000 - Rp. 410.000              |
| Sand             | 13.14%                    | Rp. 1,520,000 - Rp. 2,280.000          |
| Tile             | 13.14%                    | Rp. 183,000 - Rp. 750.300              |
| Wood             | 11.47%                    | Rp. 1,328,000 - Rp. 2,257.600          |
| Concrete Steel   | 8.45%                     | Rp. 79,000 - Rp. 197.500               |
| Ceramics         | 14.45%                    | Rp. 213,000 – Rp. 404.700              |
| Cement           | 16.24%                    | Rp. 111,000 - Rp. 277.500              |
| Others           | 6.03%                     | Rp. 315,000 - Rp. 661.500              |

For the lowest material the rest is concrete steel. The low residual of this material is due to the relatively high price so that construction implementers continue to use scraps of residual steel concrete in construction even though it does not meet the criteria of propriety of a reinforced concrete structure.

5. Conclusion
The remaining dominant construction materials in the form of sand and bricks where for residential projects respectively 17.96% and for shop-house projects 17.04%. Pure sand and bricks have no impact on the environment, where the rest of this type of construction material can still be reused again.

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