

Identification of Types of Building Materials with Plastic Waste Mixture and Risk Factors for Their Use in Residential Construction

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ABSTRACT: *The use of plastic waste as a building material for residential buildings has received considerable attention. The manufacture of products using waste has been widely developed. The use of this waste has many advantages, including can provide added value to the product. There have been many studies conducted on the use of plastic waste for making bricks and other products, which show promising results. This study identifies the types of building materials with a mixture of plastic waste and explains the application of these building materials in residential construction. And identifies the types of risks of using building materials with a mixture of plastic waste if used in residential construction projects from the project management side. The Risk Factor Indicators for the use of building materials mixed with plastic waste in the construction of residential houses that will be analyzed are project management risk, financial and strategic risk and resource risk (Materials, tools, worker/HR mobilization) So it is hoped that contractors or implementers of residential construction projects can consider the use of building materials with a mixture of plastic waste so that they can support the realization of a waste-free environment.*

KEYWORDS- *plastic waste, building materials, residential buildings, risk factors*

I. INTRODUCTION

Plastic waste is something that is harmful to the environment because it cannot be decomposed if buried in the ground. In addition to polluting the environment, plastic waste also causes flooding if dumped in rivers. According to Supratikno (2019), plastic is not a biological compound, so it is difficult to degrade (non-biodegradable). It takes 100 to 500 years for plastic to decompose perfectly.

The increasing awareness to utilize plastic waste or environmentally friendly, cheaper, solid and lightweight plastics, is possible as construction materials in the building industry. This leads to the investigation of the application of these materials and how they can be used to benefit the environment and society while at the same time, maintaining sustainable development. Emphasize the need for implementing policies, which will ultimately highlight the benefits of recycling.

Recycling of waste materials from all other waste management systems is now accepted as a proven way to convert waste into financial capital.

According to Erica Corino, et al (2023) From 100 studies, the incorporation of plastic waste into construction materials was described as positive (64%); net neutral (26%); or net negative sentiment (10%), determined by the final recommendation of each study on the material studied. The main benefits and risks include economic, environmental, human health, performance, and social impacts.

Research on the mixture of plastic waste in building materials used in residential construction projects, risk analysis in residential construction, various experiments are more focused on case studies of the success of plastic waste mixtures and experiments in making plastic waste mixture products in building materials in and outside Indonesia. However, it is only limited to

financial analysis modeling, as well as experiments in making finished products or building material products, but has not yet reached the development of Project Management risk factors, Financial Risk and Strategy, and Resource Risk (Materials, tools, worker mobilization / HR) in the use of building materials with a mixture of plastic waste in residential construction. Therefore, the study wants to try to provide an overview of the risk factors, mitigation and advantages as well as calculations of investment value / profits that will be obtained or losses that will be found in the field if using plastic waste mixture building materials as a mixture of building materials in residential construction projects.

II. THEORY

2.1 . Plastics Waste

According to the World Health Organization (WHO), waste is something that is not used, not used, not liked, or something that is thrown away that comes from human activities and does not happen by itself.

Judging from the definition above, it can be concluded that the definition of waste is the remainder of human daily activities in the form of certain materials that can no longer be used so they must be thrown away and destroyed. The final handling of waste is carried out depending on the characteristics and categories of each type of waste.

From various sources, the types of plastic waste can be classified as follows

1. PET or PETE (polyethylene terephthalate) is only for single use and is highly discouraged for repeated use of plastic with a moderate level of danger and difficulty in decomposing. It has no color or is clear

For example, mineral water bottles, soy sauce, soft drinks, or juice

2. HDPE (high density polyethylene) has a moderate level of danger and difficulty in decomposing.

For example, the use of this plastic is usually found in milk bottles, shampoo, plastic bags, or cosmetics. Just like PET, this plastic is not recommended for repeated use.

3. V or PVC (polyvinyl chloride) is a type with a high level of danger and difficulty in decomposing, it has a high PVC content, where if heated or exposed to hot materials

it can endanger organ function (kidneys, body weight, & liver).

For example, in children's toys, plastic lunch boxes.

4. This type of LDPE (low density polyethylene) plastic has a high level of flexibility, this plastic is often the material for products with a long durability level. Although the hazard level is low, this type of plastic has a moderate level of difficulty in decomposing.

For example, you can find it in food packaging products, bread, or dry cleaning bags.

5. PP (polypropylene) plastic is the best material for making food/drink storage products. Some of the colors are clear/transparent, some are solid. This type has a low level of hazard and difficulty in decomposing.

For example, it is used for medicine bottles, straws, baby bottles.

6. PS (polystyrene) has a single-use level and is very dangerous for repeated use. If burned or exposed to heat, this plastic with a high level of hazard and difficulty in decomposing can emit toxic gases that produce air pollution. This type of plastic is the basic material for making styrofoam.

For example, besides styrofoam, drink cups and coolers

7. PBT GF is polybutylene terephthalate with close to 13% fiber reinforcement (glass fiber reinforced) or GF
8. MLP stands for Multi-Layered Plastic, which is a type of plastic that consists of several layers of plastic and other materials. This plastic is usually used to package food, drinks, and small-sized care products.

2.2. Building materials

The maximum use of building materials can be known through the nature of the material, physical appearance, and durability. The nature of the material is determined by physical properties, mechanical properties, chemical properties, and special properties. Physical appearance is determined by size and durability influenced by changes in the material due to its use, duration of use, environmental conditions, conditions of use, and maintenance.

Summarized by K. Artawan (2018) Material is an important component in determining the amount of cost of a project absorbed by the materials used (Nugraha, 1985). Construction materials in a project can be divided into two, namely materials that will later become a permanent part of the structure (permanent materials) and materials needed by the contractor in building the project but will not become a permanent part of the structure (temporary materials) (Erviyanto, 2007).

1. **Permanent Materials** Permanent materials are materials needed by the contractor to form a building and are permanently attached as building elements. This type of material is listed in the contract documents (working drawings and specifications).
2. **Temporary Materials** Materials needed by the contractor in building the project, but will not become part of the building after use. This type of material is not listed in the contract documents, so the contractor is free to determine the materials needed and their suppliers. For this type of material, the contractor does not receive explicit payment. Therefore, the implementer includes the cost of this material in the cost of implementing various jobs included in the contract.

Materials used in construction can be classified into two large parts (Gavilan and Bemold, 1994), namely:

1. **Consumable material**, is a material that will eventually become part of the physical structure of the building, for example: cement, sand, gravel, bricks, reinforcing steel, steel, and others.
2. **Non-consumable material**, is a supporting material in the construction process, and is not a physical part of the building after the building is completed, for example: scaffolding, formwork, and temporary retaining walls.

2.3. Plastic waste mixture in building materials

One alternative utilization of plastic waste that can be used is the use of plastic waste as a cement mixture to produce plastic cement composites and as concrete aggregates to produce construction materials. Plastic also has important characteristics

that can be utilized either alone or as a construction material composite, such as corrosion resistance, durability, good insulator for heat, cold, sound, energy saving, economical, lightweight, and has a long service life.

Table 1.1. Summary of data on types of building materials mixed with plastic waste

No	Building Materials	Mixed Types of Waste plastic	Research result	Source
1	Concrete	HDPE, PET, PP	Can used in non-structural concrete and Cost more cheap	E. Rommel, 2013. Hossein Mohamm adhossein , et al, 2018. Supratikno ,Ratnanik , 2019)
2	Bricks	HDPE, PET, PP	Brick with HDPE mixture has performance insulation more thermal Good than red brick normal, more cheap, and comply with SNI 15-2094-2000	Said and Sungkono, 2016 Yohanto , 2020. Refna SR, 2020 Khanna SK, 2019

3	Paving Blocks	HDPE	Produce paving blocks with grade B and C according to with SNI 03-0691-1996 And more cheap	Burhanudinand Darmanijati ,2018. Handayasariand Artiani , 2019 Khanna SK, 2019. Guadalup e S. et al, 2023
4	Exterior and Interior Ornaments	PP	More durable and long lasting to various weather	(Angela E. et al ., 2020. Guadalup e S. et al, 2023)
5	Rooftile	PP, PBT GF	Produce Roof tiles that meet SNI-0096-2007	(AR Jalil, 2018. Putra Agung MA, et al. , 2023)

(Source :Author's Editing, 2024)

2.4. Risk Factor Analysis

According to Suliswiyadi (2016) Risk identification is the process of identifying and evaluating possible events or conditions that can threaten the goals, projects, or operations of an organization. This process is carried out to help organizations understand the risks they face and to develop appropriate risk management strategies. The following are the stages in the risk identification process:

- a. The initial stage in the risk identification process is to determine the goals or projects to be evaluated. This will help in identifying risks that are specific to the goals or projects.
- b. The next step is to identify possible risks that can threaten the goals or projects. Risks can arise from various sources, such as the environment, technology, humans, and so on. Risk identification can be done using various methods, such as interviews, observations, checklists, or brainstorming.

- c. After the risks are identified, the next step is to conduct risk analysis and evaluation. This involves evaluating the impact of the risk and the likelihood of the risk occurring. The impact and likelihood can be evaluated quantitatively or qualitatively, depending on the source of the risk and the needs of the organization.
- d. After the risks are evaluated, the next step is to evaluate the severity of the risk. This involves determining the severity of the risk and whether the risk should be addressed immediately or can be addressed at a later stage.
- e. Once the risks have been evaluated and assessed, the next step is to develop an appropriate risk management strategy. This strategy can include prevention, risk reduction, or risk transfer through insurance or contracts.
- f. Once the risk management strategy has been developed, the final step is to monitor and control the risks. This will help the organization identify changes in risk and ensure that appropriate risk management strategies are implemented. The risk identification process is an important initial step in risk management. Proper risk identification and careful evaluation will help the organization develop an effective risk management strategy to protect the organization's objectives, projects, or operations.

III. RESEARCH METHODOLOGY

The stages of the study are described as follows:

1. To find out the types of building materials with a mixture of plastic waste, an archive analysis study was conducted, then an expert validation data analysis was conducted 1, to validate the types of building materials and the mixture of materials used in building materials with a mixture of plastic materials used in the construction of houses so that the results are obtained.
2. The results of the initial research product are in the form of a list of building

materials with a mixture of plastic waste and the specifications used to build houses, then the risk factors for their use are analyzed, validated by experts, then the risks are calculated and validated

Grade	1	2	3	4	5
Criteria frequency	Very Low	Low	Average	High	Very high
value	0.1	0.3	0.5	0.7	0.9

by experts so that they can produce risk factors and their mitigation.

IV. RESULT AND DISCUSSION

4.1 The first stage of this research is to confirm the summary results of the meta-

Table 1.4 Weight values Impact

Grade	1	2	3	4	5
Criteria frequency	Very Low	Low	Average	High	Very high
value	0.05	0.1	0.2	0.4	0.8

analysis to determine the mixture of types of plastic waste used in building materials used in the construction of residential houses with expert validation. After the questionnaire was distributed to the experts and the results were obtained, which have been summarized in the table 1.2. below.

Table 1.2. Summary of data on types of building materials mixed with plastic waste after validation from experts

(Source :Author's Editing, 2024)

From the results recapitulation above so obtained results as following :

1. Plastic PP and HDPE types can used in mixtures concrete
2. Plastic LDPE, MLP, PP and HDPE types can be used used in brick

Table 1.5. Probability and Impact Matrix mixture

3. Plastic types LDPE , MLP, PP and HDPE can used in paving block mix
4. Plastic LDPE , MLP, PP, PBT GF and HDPE types can be used used in mixtures Exterior and Interior Ornaments
5. Plastic HDPE and PBT GF types can used in mixtures Rooftile

4.2 Risk Factor Analysis

Risk analysis in the study will use a risk matrix sourced from PMBOK 6th Edition. Data in the form of frequency and impact of risk on the influence of resource accuracy performance is based on the results of the questionnaire. The first thing to do is to calculate the average value of the impact and frequency of risk that was previously weighted based on the risk matrix. The ranking value for the frequency and impact of all Risk Factor variables on the use of building materials with a mixture of plastic waste can be seen in the following table:

Table 1.3. Weight Value Frequency

Source : PMBOK (2017)

No	Building Materials	Mixed type rubbish plastic					
		LDPE	MLP	PP	PET	HDPE	PBT GF
1	Concrete			√		√	
2	Brick	√	√	√		√	
3	Paving blocks	√	√	√		√	
4	Ornamen Exterior and Interior	√	√	√		√	√
5	Rooftile					√	√

Source : PMBOK (2017)

Probability	TREATS				
0.9	0.05	0.09	0.18	0.36	0.72
0.7	0.04	0.07	0.14	0.28	0.56
0.5	0.03	0.05	0.1	0.20	0.40
0.3	0.02	0.03	0.06	0.12	0.24
0.2	0.01	0.01	0.02	0.04	0.08
	0.05 Very Low	0.1 Low	0.2 Moderate	0.4 High	0.8 Very High

Source : Project Management Institute (2017)

Based on the matrix above, then the range of values For determine ranking risk is :

- Risk low : 0.01 – 0.06
- Risk medium : 0.07 – 0.18
- Risk height : 0.19 – 0.72

Experts have confirmed the risk of using building materials mixed with plastic waste in the construction of residential homes. so that it can be summarized in the following table

No	Risk	Risk Score/ Kategori	Mitigation
1	Risk Error in take into account performance time the walk project can influential to project Residential development using material building with mixture plastic waste	0,09 (Medium)	hire experienced professionals time manager
2	Risk delay in workmanship project can influential to project Residential development using material building with mixture plastic waste	0,09 (Medium)	hire experienced professionals time manager
3	Risk incident disaster nature / force majeure can be one of obstacles / risks use material building with mixture material plastic in Residential construction	0,1 (Medium)	Make a spare time and money for this case

4	Risk error in detailing need project can be one of obstacles / risks use material building with mixture material plastic in Residential construction	0,03 (Low)	hire experienced professionals Cost Estimation manager
5	Risk The occurrence Claims Outside the Contract can be one of obstacles / risks use material building with mixture material plastic in Residential construction	0,06 (Low)	Make a clear law in contract
6	Risk Error in determine cost project can be one of obstacles / risks use material building with mixture material plastic in Residential construction	0,07 (Medium)	hire experienced professionals Cost Estimation manager
7	Risk increase price wages and materials can be one of obstacles / risks use material building with mixture material plastic in residential construction	0,09 (Medium)	hire experienced professionals Procurement team, and made a clear contract in the beginning with the suppliers

8	Risk Material damage in the distribution process can be one of obstacles / risks use material building with mixture material plastic in Residential construction	0,1 (Medium)	Made a spare cost for compensation damage material
9	Risk Scarcity material raw plastic in making material can be one of obstacles / risks use material building with mixture material plastic in Residential construction	0,1 (Medium)	Make a spare time for sorting the plastics and make sure the plastic raw in good condition, if the condition worst, we can use the incinerator and collect the fly ash for the mixture of material
10	Risk Limitations material production building is one of risk in use material building with mixture rubbish plastic in Residential construction	0,1 (Medium)	Make a spare time for sorting the plastics and make sure the plastic raw in good condition, if the condition worst, we can use the incinerator and collect the fly ash for the mixture of material

(Source :Author's Editing, 2024)

V. CONCLUSION

Based on the results of research on the Identification of Types of Building Materials with a Mixture of Plastic Waste and Risk Factors for Their Use in Residential Construction, the following conclusions were drawn:

1. Type of Building materials with a mixture of plastics
 - ✓ Plastic PP and HDPE types can used in mixtures concrete
 - ✓ Plastic LDPE, MLP, PP and HDPE types can be used used in brick mixture
 - ✓ Plastic types LDPE , MLP, PP and HDPE can used in paving block mix
 - ✓ Plastic LDPE , MLP, PP, PBT GF and HDPE types can be used used in mixtures Exterior and Interior Ornaments
 - ✓ Plastic HDPE and PBT GF types can used in mixtures Rooftile
2. Risk Factors using materials with plastics mixture have medium rate of risk, and every have mitigations for solution
3. Building Materials with a Mixture of Plastic Waste **WORTH** to use in Residential building construction.

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