Utilization of Plastic Waste as An Alternative Tile Business to Reduce Plastic Waste and The Risk of Roof Collapse Due to Earthquake (Financial Aspect Perspective)

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Abstract. Indonesia is prone to natural disasters such as earthquakes and tropical cyclones because of Indonesia's geographical location on the ring of fire, the equator and its long coastline. These two disasters often cause damage to roof tiles. Clay roof tiles, which are currently widely used, are proven to be vulnerable to shocks, making them even more dangerous when natural disasters occur. To mitigate the occurrence of these disasters, lightweight and environmentally friendly roof tiles were developed using raw materials derived from household plastic waste which have characteristics such as light construction, durability and weather resistance, making them very tough and economically profitable in terms of long service life. The use of roof tiles made from recycled plastic contributes to reducing plastic waste, is cheaper and stronger and more durable. The aim of this research is to analyze the feasibility of a plastic tile product business on a laboratory scale and a business scale. The financial aspect results obtained from each alternative on a laboratory scale are IDR. 5,293 and business scale Rp.5,288. The financial aspect of the business scale has positive NPV results, IRR of 58%, PP of 1 year, BEP of 695,510 units with price of IDR 365,882,218.

Keywords: Earthquakes, Plastic waste, Financial aspect, Plastic roof tile, Bangkalan.

1 INTRODUCTION

The recycling of residential plastic waste holds significant importance due to various reasons. To begin with, it presents a substantial harm to the environment as a whole[1]. Plastic materials have a protracted decomposition process that spans several centuries in natural environments, resulting in the gradual buildup of refuse within both terrestrial and marine trash disposal sites [2]. The aforementioned phenomenon not only gives rise to the issue of visual pollution, but also poses a significant threat to marine organisms and ecosystems, hence disturbing the intricate ecological equilibrium [3]. Through the process of recycling plastic, it is possible to mitigate the quantity of garbage that is ultimately deposited in landfills, consequently leading to a reduction in pollution levels [4]. This, in turn, serves to safeguard and preserve our natural environment[5]. Additionally, the practice of recycling plastic contributes to the conservation of valuable natural resources[6]. Plastic is derived from finite resources,

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namely fossil fuels. The act of recycling plastic contributes to a reduction in the need for fresh plastic manufacture, ultimately leading to the preservation of these valuable resources[7], [8]. The significance of this matter is more pronounced when taking into account the limited availability of fossil fuels and the environmental consequences linked to their extraction and refinement[9]. Moreover, the recycling of plastic trash assumes a pivotal function in the preservation of energy resources. The process of manufacturing plastic from its raw components necessitates a substantial quantity of energy[10]. The act of recycling plastic allows for the conservation of energy that would otherwise be expended during the production process. Furthermore, apart from the aforementioned environmental benefits, the recycling of plastic waste also yields economic rewards. The recycling business has the capacity to generate employment opportunities and foster economic expansion [11]. The advertisement of domestic plastic trash recycling also cultivates a culture centred around sustainability and conscientious consumption[12]. The initiative promotes increased mindfulness among consumers regarding their plastic consumption, aiming to decrease their dependence on disposable plastics and instead opt for more environmentally sustainable alternatives [2][13]. This initiative serves to enhance public consciousness regarding the detrimental effects of plastic trash on the environment, while also empowering individuals to make well-informed decisions that, when combined, can yield substantial positive outcomes[14]. In summary, the practice of recycling residential plastic waste a pivotal role in avoiding adverse environmental impacts, preserving finite natural resources, minimizing energy usage, and fostering the principles of sustainability. Through the process of recycling plastic, we are able to preserve our ecosystems and save our finite natural resources[15].

There exists an extensive number of markets that specialise to recycled high-density polyethylene (HDPE) lumber. The utilization of HDPE plastics as a primary material in residential building has become more prevalent[16]. The strength produced from HDPE plastic is a type of plastic that is usually often found in various types of bottles, such as milk bottles, detergent bottles, shampoo bottles, moisturizer bottles, oil bottles, toys, and some plastic bags. This type of plastic can be said to be the safest to reuse or recycle. HDPE plastic is a type of plastic that has the most sturdy and rigid properties. The strength of HDPE plastic is in the manufacturing process which uses pressure at high temperatures. It can be said that HDPE type plastic is non-flammable. This sustainable construction material finds application in various areas, including but not limited to decking, fencing, and wall cladding. It represents a viable and environmentally friendly substitute for timber[17]. The predicted growth of the global market for recycled plastic materials, specifically HDPE, is expected to be substantial in the forthcoming years. Many companies are currently engaged in the practise of integrating recycled plastic into their goods, while also making efforts to improve the overall quality of recycled materials. The increase observed in this industry is primarily attributed to the rising demand for sustainable and environmentally friendly alternatives across many sectors such as packaging, construction, electronics, automotive, furniture, and textiles[18].

For several generations, traditional clay roof tiles have been utilized as a reliable and visually appealing option for roofing purposes. The tiles in question are crafted from naturally occurring clay and are renowned for their rustic aesthetic and enduring allure. Nevertheless, they are accompanied with certain drawbacks. One significant limitation

pertains to their mass [19]. Clay tiles exhibit a notable increase in weight compared to alternative roofing materials, hence presenting installation difficulties and necessitating supplementary structural reinforcement. Moreover, clay tiles exhibit vulnerability to the occurrence of cracks and fractures, particularly in regions characterised by recurrent freeze-thaw cycles[20]. In addition, frequent care is necessary for these materials, encompassing cleaning and resealing procedures, in order to mitigate water damage and extend their longevity. The replacement of clay roof tiles with recycled plastic roof tiles holds significant importance and offers numerous benefits for various reasons. First and foremost, the use of clay-based materials contributes to the mitigation of environmental consequences associated with clay extraction and production procedures, as well as the management of plastic waste disposal. The conversion of plastic trash into roof tiles offers a viable solution for reducing reliance on primary resources and promoting the preservation of natural resources. In addition, plastic roof tiles have numerous benefits in comparison to conventional clay tiles[21]. These roofing solutions provide characteristics like as light-weight construction, durability, and weathering resistance, rendering them very resilient and economically advantageous in terms of longevity. Furthermore, it is worth noting that plastic roof tiles frequently utilise recycled HDPE as their primary constituent. This choice of material is particularly advantageous due to its versatility and widespread accessibility[22]. This practice fosters sustainability and mitigates the need for the manufacture of new plastic materials. The utilisation of recycled plastic roof tiles can additionally contribute to a reduction in energy usage. The production of clay tiles necessitates the use of elevated temperatures, leading to substantial energy consumption and the release of greenhouse gas emissions[23]. On the other hand, the production of plastic roof tiles using recycled materials is characterised by reduced energy consumption and a lower emission of hazardous gases. In addition, the utilisation of roof tiles made from recycled plastic contributes to the promotion of a society that is both economically wealthy and environmentally sustainable. The establishment of recycling enterprises fosters favourable conditions for job development and economic growth. Moreover, the provision of cost-effective and environmentally friendly roofing alternatives can have advantageous implications for communities, particularly in regions susceptible to natural calamities or areas characterised by resource constraints[24].

The design resulting from the use of plastic waste into plastic roof tile products has several benefits. The benefits obtained from the research can reduce the potential for plastic waste, especially in the Bangkalan area, and help DLH in processing plastic waste. Apart from that, the use of plastic waste is expected to provide economic benefits as proven through analysis of financial aspects by preparing plans or estimating costs used in the production process. The steps taken are of course to identify the process of making plastic roof tile products.

2 METHODS

The objective of this study is to evaluate the results of a feasibility analysis conducted for the aim of implementing plastic tile manufacturing. The investigation of the findings of feasibility analysis in the plastic tile production process represents a form of research

employing quantitative methodologies. The quantitative approaches employed in this study primarily concentrate on the analysis of feasibility studies pertaining to the technical and economic elements of HDPE plastic roof tile manufacture.

2.1 Machine and Material

The HDPE plastic utilized as the research material is derived from plastic waste gathered from waste pickers in nearby areas of Kamal sub-district, Bangkalan Regency. The HDPE plastic is further fragmented using a mechanical chopping apparatus. The size of the flakes produced by the chopping machine falls within the range of 10 to 20 mm.

The host-press machine used in this research has a length of 800 mm and is divided into 2 parts, they are the pneumatic system frame and the engine control part. The size of the pneumatic system has a width of 410 mm and a height of 440 mm. The size of the engine control part has a width of 300 mm and a length of 310 mm. Figure 1 show layout of hot-press machine.

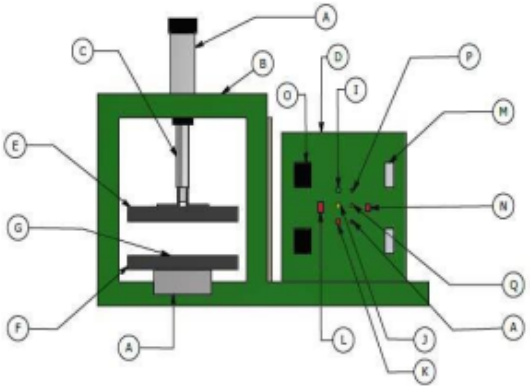

Fig. 1. Layout of hot press machine

Description:

A. Pneumatic air cylinder
B. Main frame
C. Pneumatic road roller
D. Electrical box
E. Upper heating place
F. Bottom heater holder
G. Mould set
H. Buffer
I. Pneumatic lift button
J. Pneumatic down button
K. Pneumatic push button
L. Temperature control on/off switch
M. Heater control MCB
N. Pneumatic control on/off switch
O. Temperature controller
P. Lift indicator led
Q. Down indicator led
R. Press indicator led

Setting parameter that was used on experiment was heating duration 30 minute, pressing temperature 160ºC feeding composition 250 gram. Dimension of roof tile was shown on figure 2.

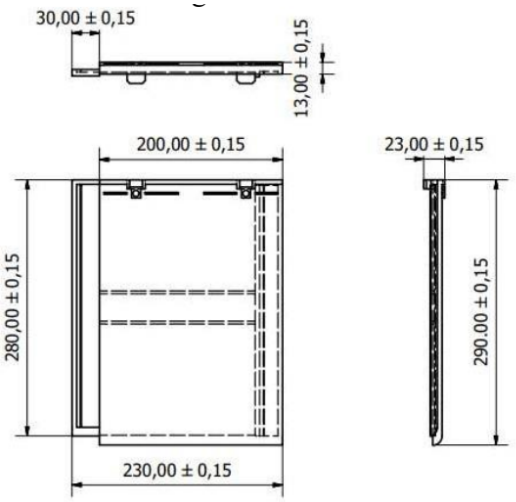

Fig. 2. Dimension of recycled roof tile

The process of data collection pertaining to financial factors in order to ascertain the outcomes of a company feasibility analysis encompasses multiple stages it similar with this research [25], which include:

1. Determine the monetary value associated with the procurement of raw materials. Costs are incurred during the process of acquiring raw materials and transforming them into finished products.
2. Determine the expenses associated with the production process. Costs incurred throughout the production process are derived from the requirements associated with the execution of the plastic roof tile manufacturing process.
3. Determining the cost associated with the quantity of product outputs. The determination of the cost associated with the quantity of product outputs is achieved by examining the hourly production rate of product outputs inside a single manufacturing process. The objective is to determine the expenses associated with sustaining the production process. The allocation of resources to support the production process involves assessing the requirements for supporting activities, such as infrastructure and personnel.
4. The cost of the initial investment. The determination of initial investment costs in the production of plastic roof tiles is contingent upon the requisite tools and supporting facilities employed in the manufacturing process.

3 RESULTS AND DISCUSSION

The roof tile produced from recycled HDPE plastic exhibits an identical shape to the commercially available roof tile. The streamlined form of this object facilitates unimpeded water flow. The designs have an aesthetically pleasing coloration, which

can be attributed to the amalgamation of HDPE plastic shreds as the primary constituents. In order to circumvent the sorting procedure that necessitates the allocation of additional storage capacity.

The roof tile products produced from the hot press machine have not been tested for strength in the laboratory, testing can be done in further research.

3.1 Routing Sheet

The routing sheet is a comprehensive document that offers in-depth insights into the many stages of the production process. It outlines the sequential order of activities, specifies the equipment utilized, provides information on regular operation times, machine capacities, and includes other pertinent details[26][27]. The manufacturing process for plastic tile products on a large-scale company operation yields the following routing sheet. It assumes a machine efficiency of 90%, a machine efficiency yield of 95%, and a reject ratio of 0.001% of the entire production on the production line is maintained. Routing sheet of Recycled Industry show on table 1.

Table 1. Recycled Roof tile HDPE business routing sheet

Work Elements	Teoritical Engine Capacity (kg)	Actual Engine Capacity (kg)	Input	Output	Machine required (machine)
Raw Material Picking and Washing	17,14	14,66	49,30	49,25	3,36
Raw Material Shredding	8,57	7,33	49,25	49,20	6,71
Drying stage	30,00	25,65	49,20	49,15	1,92
weighing of raw materials	45,57	38,96	49,15	49,10	1,26
Material pressing using Pneumatic hydraulic	1,71	1,47	49,10	49,05	33,46
Sanding	5,37	4,59	49,05	49,00	10,67

Table 1 presents the outcomes derived from the business routing sheet pertaining to the production of plastic tiles on a business-level scale. The collected results are utilized for the purpose of determining the quantity of machines employed in the production process. There are three distinct processes that include the utilization of machinery. Specifically, the process of chopping raw materials necessitates the operation of six machines, the pressing process requires the usage of 33 machines, and the sanding process involves utilizing a total of 10 machines.

3.2 Determination of Cost Production

The cost of goods produced in the manufacture of plastic tile products in each alternative can be generated. Table 2 presents the production costs associated with a business unit engaged in the manufacturing of plastic tiles, taking into account the magnitude of the business operations. Based on the computation of the cost of goods created, the resulting value is Rp. 1,037,058,213. Additionally, the total cost of goods manufactured is determined to be Rp. 1,192,616,945. When adjusted to Rp. 155,558,732, the estimated profit amounts to 15% of the cost of products sold. The 15% percentage is based on Indonesia's inflation rate of around 2-5% per year and because in general, a safe profit margins is 19%-15%.

Consequently, the total selling price is Rp. 5,288. The current selling price per unit, which includes a 15% profit margin, remains lower than the price of comparable plastic tile products. Therefore, the production process can be considered economically viable in relation to the pricing of plastic tile products[28][29].

Table 2. COGM

Activities classification	Activities	Total
Cost of Production	Initial investment cost	Rp 437.250.000
	Storage cost	Rp 259.550.000
	Labour cost	Rp 268.800.000
	Cost of Goods Produced per unit	Rp 4.292
Total of initial investment		Rp965.600.000
Operational expenses	Annual administration	Rp8.659.880
	Water and electricity	Rp15.000.000
	Transportation	Rp7.200.000
	Depreciation	Rp38.198.333
Total of Operational expenses		Rp69.058.213

3.3 Initial Investment

Investment refers to the initial capital that is allocated for the purpose of conducting a business venture[30]. The fabrication of plastic tile products involves the utilization of various equipment for investment purposes[31]. Multiple investments are required, including in the areas of buildings, land, equipment, material handling, and tools. The capital expenditure necessary for the plastic roof tile manufacturing procedure.

Table 3 summarizes the outcomes of the primary capital allocation for the plastic tile manufacturing operations conducted at a commercial level. The attainment of the necessary outcomes for initiating an investment on a business scale entails the completion of various components. The selection of a suitable location for conducting the production process, based on predetermined size and capacity, is a crucial aspect in the construction phase. This phase involves an investment of Rp. 43,600,000. The selection of the machine component required for the manufacturing of plastic roof tiles has been established based on the production capacity, necessitating a total investment of Rp. 333,350,000. The storage area involved in the process of inventorying supplies and products utilizes raw material racks and drying racks, requiring a total investment of Rp.7,500,000. The equipment area pertaining to the execution of the production process encompasses a variety of utilized equipment. The utilization of the equipment incurred an expenditure of Rp. 5,800,000. The original investment cost amounts to Rp. 437,250,000.

Table 3. Initial Investment

Margin	Cost per unit (Rp)	Quantity	Total Cost (Rp)
Raw material warehouse	400.000	15 m^2	6.000.000
Raw Material Washing Station	400.000	5 m^2	2.000.000
Shredding Bin	400.000	12 m^2	4.800.000
Drying Station	400.000	15 m^2	6.000.000
Weighing Station	400.000	6 m^2	2.400.000
Machine Station	400.000	27 m^2	10.800.000
Sander Station	400.000	6 m^2	2.400.000
Product Storage Area	400.000	20 m^2	8.000.000
Toilet	400.000	3 m^2	1.200.000
	Total on Building Cost		43.600.000
Hot-pressing Machine	10.000.000	33	330.000.000
Sander Machine	350.000	3	1.050.000
Chopping Machine	1.300.000	6	1.300.000
Machine Table	200.000	5	1.000.000
	Total on Machine Cost		333.350.000
Raw Materials Storage Rack	600.000	5	3.000.000
Drying Storage Rack	900.000	5	4.500.000
	Total on Storage Cost		7.500.000
First Aid	150.000	1	150.000
1 tonne Digital Scale	1.500.000	1	1.500.000
Fire Extinguisher	500.000	2	1.000.000
Fan	100.000	9	900.000
Hammer	30.000	3	90.000
Water Tank	510.000	1	510.000
Washing Tub	100.000	1	100.000
Tang	30.000	3	90.000
Scraper	20.000	3	60.000
Lights	100.000	9	900.000
Garbage Disposal	200.000	2	400.000
Gloves	10.000	10	100.000
	Total on Tool Cost		5.800.000
Land	500.000	109 m^2	54.500.000
	Grand total initial investment		437.250.000

3.4 Depreciation

Depreciation in HDPE roof tile industry is derived from the capital invested in the manufacturing process of plastic roof tiles. The depreciation that occurs in any investment utilized has a duration that varies between 3 to 20 years. The depreciation results of each component of the investment are determined by calculations based on

the investment year and the total value of each component. Depreciation is a necessary consideration in the context of commercial operations, encompassing the devaluation of assets such as buildings, machinery, storage facilities, and equipment. The determination of each period is achieved by calculating the number of years encompassed within each segment. The duration of the building item part is 20 years, while the machine item section has a duration of 10 years. Similarly, the storage section has a duration of 10 years, and the equipment item section has a duration of 3 years. The determination of depreciation is achieved by dividing the amount of investment utilized over a specific period. The cumulative depreciation across all sections yielded sum of Rp. 38,198,333. The cost of the building section amounts to Rp. 2,180,000, while the machine section incurs a cost of Rp. 33,335,000. The cost of the storage component is Rp. 750,000, while the equipment section amounts to Rp. 1,933,333.

3.5 Inventory Value

The valuation of inventory or the cost of materials is a crucial aspect of the production process in product manufacture. The determination of inventory value is conducted in alignment with the specific requirements and production capabilities. Two materials are utilized in this process, specifically plastic and wax raw materials. Two materials are utilized in this process, specifically HDPE plastic, which yields a cumulative amount of Rp. 234,200,000, and wax, which amounts to Rp. 25,350,000 annually. The cumulative value of the inventory amounts to Rp. 259,550,000 year.

3.6 Labour Cost

Labour is a part that is needed during the product manufacturing process. Labour costs used in the production process of making plastic roof tiles.

Table 4. Labour cost on recycled HDPE roof tile business

Job Title	Salary (Rp)	Number of employee	Monthly salary (Rp)	Annual salary (Rp)
Marketing	2,400,000	2	4,800,000	57,600,000
Washing operator	2,200,000	1	2,200,000	26,400,000
Shredding operator	2,200,000	2	4,400,000	52,800,000
Drying operator	2,200,000	1	2,200,000	26,400,000
Machine operator	2,200,000	4	8,800,000	105,600,000
Total				268,800,000

Table 4 presents the findings of the labour cost requirements for the plastic tile production process. The determination of salary values on a monthly basis is adjusted

according to the Regional Minimum Wage in the Bangkalan area, which amounts to Rp.2,200,000. Additionally, for the marketing department, the salary value is set at Rp.2,400,000. The number of employees is determined based on the company's needs in carrying out the production process. The required outcome in terms of labour costs amounts to Rp. 268,800,000 annually.

3.7 Calculation of Net Present Value, Internal Rate of Return, and Payback Period

The determination of the Payback Period (PP), the calculation of the Net Present Value (NPV), the calculation of the Internal Rate of Return (IRR), and the calculations obtained in the production of plastic roof tiles over a period of 10 years.

Table 5. Calculation of Net Present Value, Internal Rate of Return, and Payback Period.

Year	Outcome (Rp)	Income (Rp)	Net Cash Flow	Multiplic atio Factor	NPV (Rp)	NPV Cumul ative (Rp)
1	1.305.3 43.213	0	1.305.3 43.213	1,00	1.305.3 43.213	1.305.3 43.213
2	339.74 3.213	1.243.7 97.127	904.05 3.914	0,94	848.87 6.914	456.46 6.299
3	339.74 3.213	1.243.7 97.127	904.05 3.914	0,88	797.06 7.525	340.60 1.226
4	339.74 3.213	1.243.7 97.127	904.05 3.914	0,83	748.42 0.211	1.089.0 21.437
5	339.74 3.213	1.243.7 97.127	904.05 3.914	0,78	702.74 1.982	1.791.7 63.419
6	339.74 3.213	1.243.7 97.127	904.05 3.914	0,73	659.85 1.627	2.451.6 15.046
7	339.74 3.213	1.243.7 97.127	904.05 3.914	0,69	619.57 8.992	3.071.1 94.038
8	339.74 3.213	1.243.7 97.127	904.05 3.914	0,64	581.76 4.312	3.652.9 58.350
9	339.74 3.213	1.243.7 97.127	904.05 3.914	0,60	546.25 7.570	4.199.2 15.920
10	339.74 3.213	1.243.7 97.127	904.05 3.914	0,57	512.91 7.906	4.712.1 33.826

The results of NPV, IRR, and PP at the laboratory scale were obtained from data table 5. The results obtained from the Net Present Value (NPV) analysis indicate a profit of Rp.4,243,883,625 over a 10-year period, demonstrating a positive outcome or feasibility. The resulting Internal Rate of Return (IRR) obtained is 58% over a period of 10 years. The net present value (NPV) obtained yields a one-year term to achieve profitability within a ten-year timeframe.

3.8 Calculation of Break-Even Point

The calculation for determining the Break Even Point (BEP) obtained for each alternative in the production of plastic roof tiles can be outlined as follows:

Table 6. BEP of Recycled HDPE roof tile business [32]

Expenses	Amount
Operating Expenses	68.608.213
Selling Price	5,288
Average Price	4,302
BEP Unit	996
Total	68884
BEP Price	0.187987207
Total BEP	364,962,140

Table 6 is the result of the BEP calculation on a business scale. The results obtained are two determinations, namely BEP unit and BEP price. The BEP unit results obtained from the laboratory scale resulted in a total of 68884 units. The price BEP result obtained from the business scale is Rp.364,962,140.

3.9 Business Feasibility Assessment

This study aims to analyze the outcomes of a business feasibility assessment conducted on plastic tile products, focusing on technical, financial, and marketing issues. The assessment of the viability of a plastic tile product enterprise involves a series of distinct phases for its determination. The plastic tile production process utilizes various aspects that are subjected to study in order to ascertain the feasibility of the business. Each component of the results can be explained based on the specific requirements employed.

Table 7. Financial Analysis [32]

Feasibility Indicator	Result
NPV	Positive
IRR	58%
PP	1 year
BEP Unit	69510
BEP Price	Rp. 365,882,218

4 CONCLUSION

Sensitivity analysis is conducted to ascertain the feasibility threshold of the plastic tile product business by examining four criteria. Parameter one is derived based on the combination of employee wages and COGM. Parameter two is determined by considering interest rates and periods. Parameter three is influenced by the relationship between raw materials, product HPP, and the combined parameters are established by examining the interplay between raw materials, employee salaries, and product COGM.

The execution of parameters is accomplished by implementing two distinct approaches, specifically laboratory scale and commercial scale. The outcomes of parameter one exhibit a proportional relationship with the business's regional minimum wage, specifically when the regional minimum wage is Rp. 3,800,000. In this scenario, the corresponding cogs value is Rp. 6,200. The outcome of parameter two, given a 74% increase in the interest rate, yields a duration of 10 years. The outcome of parameter three, wherein there is an increase of Rp. 7,200 in the price of raw materials, leads to a corresponding cost of goods sold (COGS) of Rp. 6,200. The aggregate outcome occurs when there is a rise of Rp. 800,000 in the price of raw materials and an increase of Rp. 6,000 in the regional minimum wage, together with an increase of Rp. 2,800,000 in the price of raw materials and an increase of Rp. 6,000 in the regional minimum wage, resulting in a total production cost of Rp. 6,231. According to the author's empirical observations and data gathered from the Indonesian Agency for Meteorological, Climatological and Geophysics, the determination of items and promotions in the East Java region involves assessing the probable presence of frequent earthquakes and tropical whirlwinds. The regions that exhibit a propensity for whirlwinds encompass Ponorogo, Situbondo, Sidoarjo, and Bangkalan. The regions prone to earthquakes include Blitar, Lumajang, Kediri, Malang, Probolinggo, and Pasuruan.

For next research, the feasibility should also be assessed from the perspective of sustainability, technical, and social factors, not only economic factors. It's important to conduct detailed tests on the durability and long-term performance of the plastic tiles under extreme weather conditions, conducted any mechanical or thermal stress tests to evaluate the tiles' resistance to cracking, heat, and UV exposure, and important to know how do the plastic roof tiles perform in terms of insulation, energy efficiency, and fire resistance compared to other traditional roofing materials such as clay or metal.

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