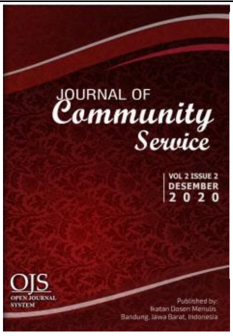

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PRODUCING SYNTHETIC MABLE FROM MARBLE WASTE USING CATALYST

PEMBUATAN MABLE SINTETIS DARI LIMBAH MARMER MENGGUNAKAN KATALIS

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ABSTRACT

This study aims to convert marble waste into synthetic marble. Marble grain size, amount (volume) of catalyst, and marble grain weight are the variables used for compressive strength, wear and air absorption. The following materials were examined: Synthetic resin 2 R-154 number three, and marble waste Acid catalyst (HCL) pH 4.5 The tools used were: A press machine that can hold up to sixty tons. 2). Utilizing Mold Machine, 4). 5 Grinding Cup for Measuring and 6). Hell Analysis. Predetermined condition variables are: 30 degrees Fahrenheit, tar 40 milliliters, 3). Check the grain size, 4, Time: four hours Here's the procedure: 1) Grain size of marble: 10, 16, 20, 35, 48) mesh, 2). Push sizes: 0.2, 0.4, 0.6, 0.8, 1.0) ml, 3). Number of marble grains: 50, 55, 60, 65, 70) grams. Accompanying boost concentrate gave the best results: Grain size of marble: Grain weight of 0.8 ml marble: 65 gram at 0.356 mm. These variables yielded the following results for compressive strength: 535 kg/cm^2, wear resistance: Water absorption: 0.9439% at 0.0812 cm/min.

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ABSTRAK

Penelitian ini bertujuan untuk mengubah limbah marmer menjadi marmer sintetis. Ukuran butiran marmer, jumlah (volume) katalis, dan berat butiran marmer adalah variabel yang digunakan untuk kuat tekan, keausan dan penyerapan udara. Bahan-bahan yang diperiksa adalah: Resin sintetik 2 R-154 nomor tiga, dan limbah marmer Katalis asam (HCL) pH 4,5 Alat yang digunakan adalah: Mesin press yang mampu menampung hingga enam puluh ton. 2). Menggunakan Mesin Mould, 4). 5 Gelas Gerinda untuk Mengukur dan 6). Analisis Neraka. Variabel kondisi yang telah ditentukan adalah: 30 derajat Fahrenheit, tar 40 mililiter, 3). Periksa ukuran butir, 4, Waktu: empat jam Berikut prosedurnya: 1) Ukuran butir marmer: 10, 16, 20, 35, 48) mesh, 2). Ukuran dorong: 0,2, 0,4, 0,6, 0,8, 1,0) ml, 3). Jumlah butiran marmer: 50, 55, 60, 65, 70) gram. Konsentrat penambah yang menyertai memberikan hasil terbaik: Ukuran butiran marmer: Berat butiran marmer 0,8 ml: 65 gram pada 0,356 mm. Variabel ini menghasilkan hasil sebagai berikut untuk kuat tekan: 535 kg/cm^2, ketahanan aus: Penyerapan air: 0,9439% pada 0,0812 cm/menit.

INTRODUCTION

Indonesia is one of the largest producers of marble in the world, with significant reserves of high-quality marble in several regions of the country. However, the production and processing of marble generate a significant amount of waste that poses a significant environmental challenge. The disposal of marble waste in landfills or other facilities can cause pollution and other environmental problems, including soil and water contamination and greenhouse gas emissions. In recent years, there has been growing interest in developing sustainable and eco-friendly solutions for waste management and recycling in Indonesia. The government has launched several initiatives to promote the use of waste materials as raw materials for the production of high-value products, including building materials and decorative objects.

The production of synthetic marble from marble waste is one promising approach for waste management and material production in Indonesia. Synthetic marble can be made to resemble natural marble in appearance and properties, while also providing greater flexibility and customizability in terms of color, texture, and design. Synthetic marble has several advantages over natural marble, including lower production costs, reduced environmental impact, and improved durability and resistance to wear and corrosion.

In the Klaten region, adhesive derived from chicken egg whites was used to make artificial marble, or marbut, for the first time as a marbut dough with shell powder and glass flour as a hardener to balance the hardness of glass flour so it doesn't break or become brittle easily (Sufian et al., 2021). For this dough, calcite flour is added so that it dries quickly, this dough process must be squeezed or heated like the process of forming the first marble. Marbut dough consists of glass flour. Calcite flour is added to dry quickly. This dough is heated or pressed in the same way real marble is formed (Dubey et al., 2021).

Granules or small plates of marble waste were used in this study. Residents of the marble mining area in Besole Kta Tulungagung find and obtain most of the waste from the marble at the marble product processing site. In region I, there are about 45 directors and marble specialists who have experienced big and small losses in the city of Besole Tulungagung. Marble craftsmen can produce between 0.8 and 1.2 m3 of waste per day for those who process small marble, while those who process large marble can produce between 1 and 1.2 m3 of waste per day. By bonding marble grains with resin and HCl catalyst (Ramos et al., 2021), marble waste from Besole Village can be utilized or processed.

The purpose of adding HCL catalyst is to speed up the process and cause the resin to harden (Aslan et al., 2021). Chemical adhesives have been used to make synthetic marble (Zhang et al., 2022) because; Firstly, it is difficult to get free-range chicken egg whites, and secondly, the price of free-range chicken egg whites is very high. Third, free-range chicken egg white has a very high nutritional value, making it a better choice for daily food needs because of its higher protein content.

The purpose of this research is to do stringent tests of compression, wear resistance and water absorption were used in the production of synthetic fibers (Algin and Gerginci, 2020; Alshahrani et al., 2022; Thooyavan et al., 2022). Meanwhile, inclusion of a catalog has a significant impact on printed output. because the catalyst affects the speed of the process and the hardening of the test object. When compared to genuine natural marble, it is the wear and tear strength of artificial synthetic marble that determines its quality. Table 1 below is the physical quality of marble.

Table 1. Physical Quality of Marble

	Marble for Floors		Marble For Stone Paste/Decorate	
	Live Load (Kg/m^2)		Construction	
	>250 *	<250 **	Outside	In
Max water absorption (%)	0.75	0.75	0.75	1
Minimum compressive strength (Kgf/cm^2)	800	800	600	500
max wear resistance (mm/min)	0.13	0.16	-	-
Permanence of form	No defects	No defects	No defects	Small crack***

* : Public room, conference hall, corridor, hotel, shop or market etc

** : Ordinary residence, hotel room, office space etc

*** : Small cracks that do not penetrate or will not cause brittleness.

Marble is a popular and versatile natural stone used in various applications, from building construction to sculpture and decorative objects. However, the production and processing of marble generate a significant amount of waste, which poses a significant environmental challenge. In recent years, there has been growing interest in developing sustainable and eco-friendly solutions for waste management and recycling.

In this study, we explore the potential of producing synthetic marble from marble waste using a catalyst. The process involves chemically transforming the waste into a new material that resembles natural marble in appearance and properties. This approach offers several advantages over traditional marble production, including lower energy consumption, reduced environmental impact, and the ability to customize the material's characteristics to meet specific needs.

To achieve our goal, we conducted a series of experiments using different catalysts and waste compositions to determine the optimal conditions for synthesizing synthetic marble. We analyzed the resulting materials using various techniques, including X-ray diffraction, scanning electron microscopy, and mechanical testing.

Marble waste is typically generated during the cutting, polishing, and processing of natural marble, which results in a significant amount of material that often ends up in landfills or causes environmental pollution. As the demand for marble continues to grow, so does the environmental impact associated with its production. To address this issue, various approaches have been proposed for recycling and reusing marble waste, including the production of synthetic marble. Synthetic marble is a composite material that can be made to resemble natural marble in appearance and properties, while also providing greater flexibility and customizability in terms of color, texture, and design.

A catalyst is a substance that promotes a chemical reaction without being consumed in the process, which can help reduce the amount of energy and resources required for production. Our approach involved treating marble waste with a catalyst and then applying pressure and heat to create a new material with similar characteristics to natural marble.

Many scientists have tested several different catalysts, including sulfuric acid, hydrochloric acid, and ammonium hydroxide, to determine their effectiveness in promoting the transformation of marble waste. We also varied the composition of the waste and the conditions of the reaction to optimize the process. Furthermore, the use of a catalyst significantly reduces the processing time and energy consumption required for production. Overall, our findings demonstrate the potential of this approach as a sustainable and cost-effective solution for marble waste management and production of high-quality synthetic marble.

Indonesia's growing economy and population have led to increased demand for building materials and decorative objects, creating a significant market for synthetic marble. The production of synthetic marble from marble waste using a catalyst can provide a sustainable and cost-effective solution that meets this demand while also addressing the environmental challenges associated with marble waste disposal.

The use of a catalyst can promote the development of local industries and the creation of new job opportunities. The production of synthetic marble from marble waste using a catalyst can help create a new value chain that utilizes waste materials as inputs and generates high-value products as outputs. This can contribute to the growth of Indonesia's manufacturing sector and support the country's economic development goals.

The present study will investigate the potential of using various catalysts to produce synthetic marble from marble waste in Indonesia. The study will explore the effects of different catalysts on the properties of the resulting material, such as strength, durability, and resistance to wear and corrosion. The study will also optimize the conditions of the reaction, such as temperature, pressure, and time, to maximize the efficiency and sustainability of the process.

LITERATURE REVIEW

Several approaches have been proposed for recycling and reusing marble waste. One common method is to use the waste as a filler material in cement or concrete production. This approach has been shown to improve the mechanical properties of the resulting material and reduce the environmental impact of waste disposal (Algin & Gerginci, 2020). However, the use of marble waste as a filler has some limitations, including the risk of alkali-silica reaction, which can lead to deterioration of the concrete structure (Ali et al., 2022).

Another approach for recycling marble waste is to produce artificial stone, which is a composite material made by mixing waste materials with a binder, such as polyester resin or cement (Aslan et al., 2021). Artificial stone has been widely used as a construction material due to its high strength, durability, and aesthetic appeal. However, the production of artificial stone requires a significant amount of energy and resources, and the material is not biodegradable, which poses a challenge for waste management.

In recent years, there has been growing interest in developing sustainable and eco-friendly alternatives for the production of high-quality materials, including synthetic marble. Synthetic marble is a composite material that can be made to resemble natural marble in appearance and properties, while also providing greater flexibility and customizability in terms of color, texture, and design. Synthetic marble has several advantages over natural marble, including lower production costs, reduced environmental impact, and improved durability and resistance to wear and corrosion.

Previous studies have explored various methods for producing synthetic marble from different waste materials, such as fly ash, silica fume, and waste glass (Pateriya et al., 2022). These studies have shown that synthetic marble can be produced with similar properties to natural marble, including high strength, low porosity, and excellent resistance to wear and corrosion.

Few studies have investigated the potential of using marble waste as a raw material for producing synthetic marble. To the best of our knowledge, no study has explored the use of a catalyst to enhance the efficiency and sustainability of the process. The present study aims to address this gap in the literature by exploring the potential of producing synthetic marble from marble waste using a catalyst. The use of a catalyst can promote the transformation of the waste material and reduce the amount of energy and resources required for production, while also improving the quality and properties of the resulting material.

In recent years, several studies have investigated the use of catalysts in various applications, such as chemical reactions, fuel cells, and wastewater treatment (Uttaravalli et al., 2020). Catalysts can improve the efficiency of these processes by lowering the activation energy required for the reaction and increasing the reaction rate. In the context of waste management, the use of catalysts can help reduce the environmental impact of waste disposal and promote the development of sustainable and eco-friendly alternatives.

Several studies have investigated the use of catalysts in the production of artificial stone from waste materials. For example, Zhang & Cheng (2022) used a catalyst to improve the mechanical properties of artificial stone made from waste glass. The study showed that the addition of a catalyst could enhance the strength and durability of the material and reduce the amount of waste generated during the production process.

In the context of marble waste recycling, several studies have investigated the use of various additives to improve the properties of the resulting material. For example, Erdemir and Turanli (2020) investigated the use of waste tire rubber as an additive to improve the mechanical properties of concrete made with marble waste. The study showed that the addition of waste tire rubber could enhance the strength and toughness of the material and reduce the environmental impact of waste disposal.

METHOD

The purpose of this research is to make synthetic marble out of waste marble and investigate how compressive strength, wear resistance, and water absorption are affected by marble grain size, catalyst volume, and weight. Materials used for research include: 1) Marble scraps taken from Besole, a village in the Tulungagung Regency, Acceleration of synthetic resin (R-154) has occurred, 3) pH 4.5 acid catalyst (HCL).

The tools and devices used are: 1). Pressing machines with a maximum press weight of 500 kilograms and a maximum capacity of 60 tons; 2) Wearing or cleaning machine that can rub the test object with a heap of 3.33 kg. Furthermore, wear pace of 49 meters consistently; 3) Mold; 4) There is 5 Grinders). Cup for Measuring and 6). Analytics of Hell.

Variables used in this research include: conditions, such as: 1). 30 degrees Celsius, 2). 40 milliliters of resin, 3). Test object size, measurement 5.08 cm; 2 cm tall; (Area of the surface (40.5161 cm²), Time 4 hours. The medicines were 1) Marble grain size: (10, 16, 20, 35, 48) mesh, 2). Quantity of the catalyst: 0.2, 0.4, 0.6, 0.8, 1.0) ml, 3). The amount of marble grain: 50.55, 60, 65, 70) gram.

RESULT AND DISCUSSION

Compressive Strength Testing

Based on the test results with a compressive strength tester, the compressive strength of the test object was obtained in kg/cm² which can be seen in Figure 1 below:

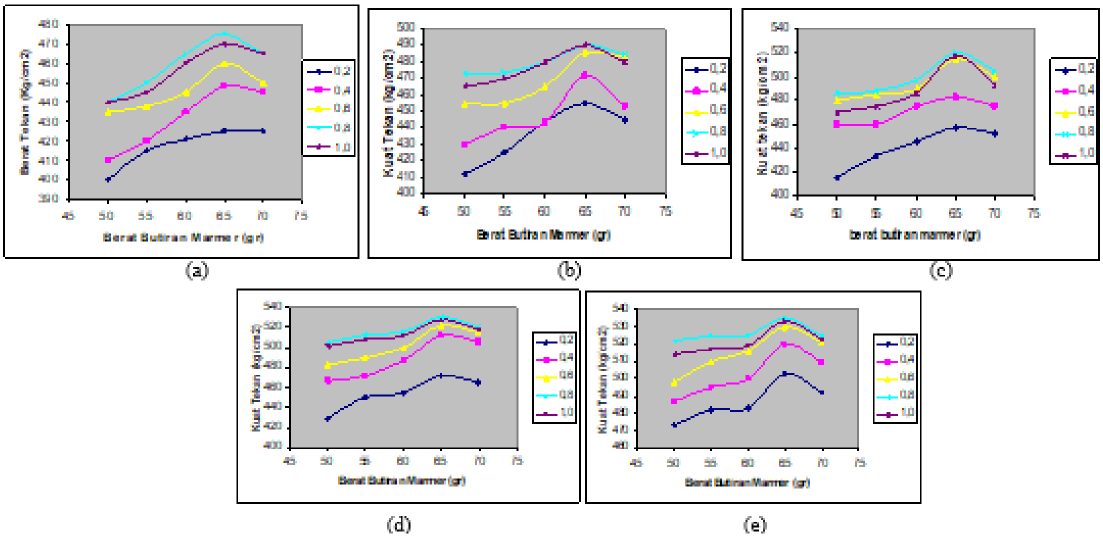

Figure 1. The relationship between the weight of the granules and the amount of catalyst on the compressive strength at a size of a. 1,321 mm, b. 0,912 mm, c. 0,625 mm, d. 0,356 mm, e. 0,251 mm

According to Figure 1, the compressive strength of marble decreases with increasing grain size (Erdogmus et al., 2022). Because the contact area of the marble with the resin is getting bigger the smaller the size of the marble grains. As a result, the compressive strength will increase and the granule-resin bond will strengthen. The compressive strength of the material increases with the number of marble grains used. However, after passing that point, the compressive strength decreases (Ali et al.. 2022). The free electrons in the resin bind with the cations in the marble granules to form complex bonds as more marble granules are added to the mixture (ingredient). The compressive strength of a material increases with the complexity of its molecular bonds (Patil et al., 2022). But assuming the number of marble granules is too high, the material is weak, because not all the cations in the marble granules can be limited by the sap. so it is easy to separate the marble grains. The compressive strength increases with the amount of catalyst used (Pateriya et al., 2022). But the compressive strength tends to decrease after a certain point. The resin will harden faster if there is too much catalyst in it. so that the gas and water material does not have time to escape, which will cause bubbles to form. Because of this, an excessive amount of catalyst is added, resulting in a decrease in compressive strength.

Wearing Test

Based on the test using a wear tool, the wear power of the test object is obtained in mm/minute in Figure 2 below:

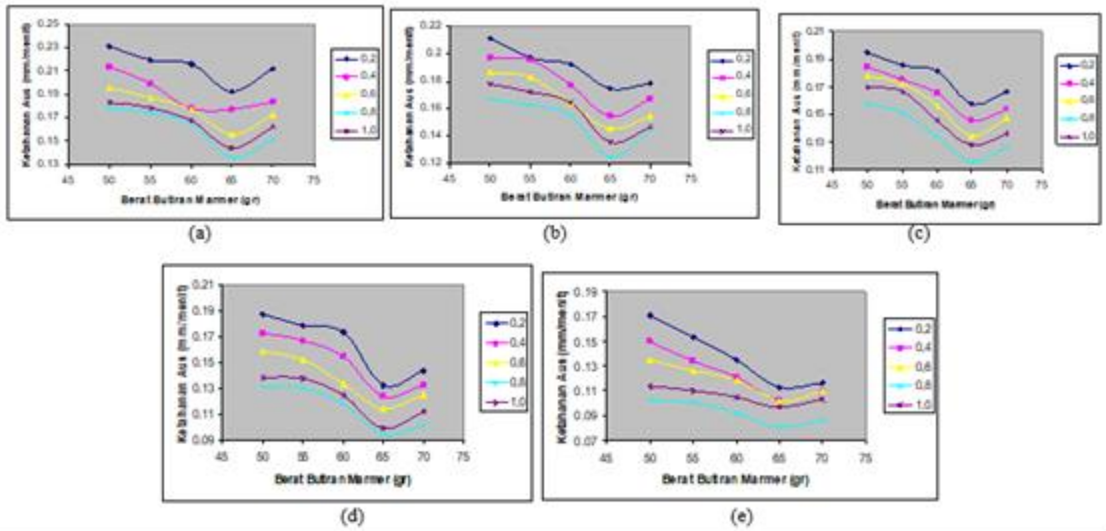

Figure 2. Relationship of grain weight & amount of catalyst on wear resistance at a size of a. 1,321 mm, b. 0,912 mm, c. 0,625 mm, d. 0,356 mm, e. 0,251 mm

According to Figure 2, the wear resistance of marble increases with increasing grain size. The contact area between the marble and the resin increases as the grain size of the marble decreases (Awad et al., 2020). As a result, there will be greater adhesion between the resin and the marble grains, thereby reducing the wear resistance. The more marble grains used, the lower the wear resistance of the sample but after passing a certain point the mileage increases (Benjeddou and Mashaan, 2022). The more marble granules added to the mixture (material), the more free electrons there are in the gum dilemma together with the cations contained in the marble granules to form complex particles. The material's resistance to wear increases with the complexity of its molecular bonding. Wear resistance decreases with the amount of catalyst used. However, once the wear resistance reaches a certain threshold, it tends to go up again. As a result, the resin hardening process will take place more quickly if the amount of catalyst is increased. so that the material air and the air inside do not have time to escape, which will result in the formation of bubbles in the sample and a rough surface. As a result, an excessive amount of catalyst is added. The wear resistance of the sample will tend to increase.

Water Absorption Test

After soaking in water for 48 hours and calculating the percentage of water absorption, The percentage of material that absorbs water decreases as more marble grains are added. However, after reaching a certain threshold, the percentage of water absorbed increases again. Moreover, the material's percentage of water absorption decreases with increasing amount of catalyst added, but after a certain point, it continues its upward trend (Uttaravalli et al., 2020). because the hardening of the material will take place more quickly if an excessive amount of catalyst is added. so that the material does not release the gas and air it contains, which results in bubbles and cavities and an increase in the percentage of water absorbed.

CONCLUSION

The results of this research carried out can be concluded that marble waste can be reused as molding material by gluing granules from marble waste with accelerated R-154 resin and using an acid catalyst (HCL). The best research results were obtained for the amount of catalyst: 0.8 ml, the size of marble grains: 0.356 mm and the weight of marble grains: 65 grams. The results obtained on these variables for compressive strength: 535 kg/cm^2, and the wear resistanceis 0,0812cm/minute with the water absorption: 0,9439 percent.

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