Jurnal Rekayasa, Teknologi, dan Sains, Volume 8, No.1, Januari: 01-53

JURNAL REKAYASA, TEKNOLOGI, DAN SAINS
ISSN 2541-4720 (Print)
ISSN 2549-984X (Online)

INFORMASI ARTIKEL
Disubmit: 23 Januari 2024
Diterima: 28 Januari 2024
Diterbitkan: 31 Januari 2024
at: http://ejurnalmalahayati.ac.id/index.php/teknologi/index

The effect of mechanical properties of polyester resin in powdered basalt composites on compression tests

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ABSTRACT

Indonesia is one of the countries that has the most volcanoes in the world, namely 129 volcanoes that are still active and 500 that are inactive. Volcanic eruptions produce lava which reaches the earth's surface and solidifies to form igneous rock. The igneous rocks that are formed include granite, andesite and basalt. Basalt is a dark colored rock, fine grained, and is an igneous rock. These rocks most often form as extrusive rocks (lava flows). Basalt rock has a composition similar to gabbro rock. Hand lay-up is the simplest method and is an open method of composite fabrication. The manufacturing process using this method is by pouring the resin by hand into woven fibers, particles or sheets, then applying pressure and spreading it evenly using a roller or brush. This process is carried out repeatedly until the desired thickness. In this research, compressive strength tests were carried out with a total number of samples or specimens, namely 24. Compression testing was carried out using the HT-2402 computer universal testing machine. Of the variety of test object specimens that can be dry printed and tested only polyester resin with a content of 20-25%. The compressive strength test with the highest strength was obtained on basalt powder sample code TK.P.2 which had a maximum compressive strength value of 3477 kgf.

Keywords*:basalt, compression, polyester*

1. INTRODUCTION

Indonesia is one of the countries that has the most volcanoes in the world, namely 129 volcanoes that are still active and 500 that are inactive. Volcanic eruptions produce lava which reaches the earth's surface and solidifies to form igneous rock. The igneous rocks that are formed include granite, andesite and basalt.

Each rock has a different density, the density of each mineral is determined by the elements that form it and the density of the bonds of the elements in the crystal structure. The density of basalt rock is 2.5 – 3.0 grams/cm3. Generally, the chemical composition of basalt is, Na2O, MgO, Al2O3, SiO2, K2O, CaO, TiO2, FeO, K2O, MnO, and Fe2O2 (Easwara Prasad et al., 2020).

Apart from that, basalt stone is also widely used in construction, making composite materials, as a protective coating, thin fiber, special fabrics and others. Another important fact is that basalt rock forms about 30% of the earth's crust, which makes it almost unlimited as a raw material for making products using mineral resources. Due to its availability and low cost as well as valuable functional characteristics, basalt stone is often used for road construction coatings, basalt fiber, etc (Penczek et al., 2005).

DOI: https://doi.org/10.33024/jrets.v8i1.13983

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In Indonesia, basalt rock is generally used as raw material for making roads and buildings. Meanwhile, in other countries such as China and Europe, basalt rock is used as basalt ceramics, basalt fibers and so on (Gao et al., 2019).

The rapid development of the construction industry in Indonesia has encouraged researchers to create alternative building materials that have better properties than existing materials. One alternative material is a composite material which is a material formed from a combination of two or more materials, where the mechanical properties of the forming materials are not the same.

Making composite materials using a polyester resin matrix and basalt powder as reinforcement will produce composite materials with certain mechanical properties. One of the mechanical properties of the composite material is influenced by the basal particle sizes of 40, 60, 150 and 270 mesh with variations in polyester resin of 10%, 15%, 20% and 25% which will form different mechanical properties. This practical work was carried out to determine the optimization of the ratio of polyester resin in powdered basalt composites during compression testing. In this practical work report, the problem is limited to Optimizing the Ratio of Powdered Basal Composite Polyester Resin with Particle Sizes of 40, 60, 150 and 270 Mesh for Compressive Testing(Rudawski & Błażewicz, 2014).

2. METHODS

Basalt is a dark colored rock, fine grained, and is an igneous rock. These rocks most often form as extrusive rocks (lava flows). Basalt rock has a composition similar to gabbro rock. The difference between the two is in the mineral grains. In basalt rock the grain size is finer (Birawidha et al., 2021; Erlendsson, 2012).

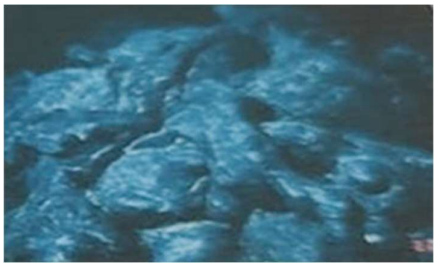
According to Hyndman (1985), most basalt is formed as "badrock" on earth. Compared to other types of rock, basalt is more commonly formed as base rock. Most of the basins (seas) on earth are lined with basalt. Although basalt is less common in continental crust, lava flows and basalt floods also quite often cover the land surface.

Olympus Monsis one of the volcanoes on the planet Mars. Like most other volcanic features on Mars, this volcano was formed by basaltic lava flows. Olympus Mons is the highest mountain on Mars and the largest volcano in our solar system (Davallo et al., 2010; Gao et al., 2019; Prasad et al., 2019).

(a). Basalt Stone

(b). Mars

(c). Basalt Rock Area



(d). Seabed Basalt

Figure 1. Basalt rocks and their formation Source: Hyndman, 1985

The process of forming a rock is different from the process of forming other rocks. For example, the process by which metamorphic rocks are formed is different from the process by which sedimentary rocks are formed. However, the process of forming basalt rock is part of the stage

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of extrusive igneous rock formation. It is called extrusive because rock solidification occurs above the earth's surface (Birawidha et al., 2021; Dholakiya, 2012).

1. Composites really depend on the strength of the form. This powder composite has advantages such as resistance to wear, not easily cracking, and having good binding power with a matrix.
2. The matrix is resin. The phase in the composite that has the largest (dominant) portion or volume fraction. The matrix has the function of transferring stress to the powder, creating bonds, protecting the powder, and binding the powder so that it can work well.

Hand lay-upis the simplest method and is an open method of composite fabrication process. The manufacturing process using this method is by pouring the resin by hand into woven fibers, particles or sheets, then applying pressure and spreading it evenly using a roller or brush. This process is carried out repeatedly until the desired thickness.

3. RESULTS AND DISCUSSION

Compressive strength tests were carried out with a total number of samples or specimens, namely 24. Compression testing was carried out using the HT-2402 computer universal testing machine. Where the specimens that are ready to be tested in this practical work are formed referring to the ASTM D-695 standard with dimensions measuring 19.5 mm. The shape of the specimen refers to the ASTM D-695 standard, so the testing process procedures follow this standard.

Compressive strength testing process at the BRIN Lampung Lab - Nonmetal. From the compressive strength test table data, the best results were taken from each variation of the mixture of polyester resin and catalyst. The best results are taken with the maximum compressive force value.

The results obtained in the table for the compressive test value for the 40-mesh particle composite have a maximum compressive strength (Fm) value in the sample code TK.C.3, namely 3237 kgf. The 60-mesh particle composite has a maximum compressive strength (Fm) value in sample code TK.G.3 of 3249 kgf. The 150-mesh particle composite has a maximum compressive strength (Fm) value in sample code TK.K.3 of 3182 kgf. The 270-mesh particle composite has a maximum compressive strength (Fm) value in the sample code TK.O.2 of 3477 kgf.

From Figure 4.23, the compressive test graph shows that the compressive strength value of the 40-mesh basalt powder particle composite in the sample code TK.A.1-TK. B3, obtained a value of zero or the specimen was not tested because it cracked or shattered. In the sample code TK.C.1-TK.C.3, the compressive strength value increases until it reaches the largest maximum compressive strength value obtained in the sample code TK.C.3, namely 3237 kgf. Meanwhile, in the sample code TK.D.1-TK.D.3, the largest maximum compressive strength value was obtained in the sample code TK.D.2, namely 2568 kgf. There was a decrease in the compressive strength value in the sample code TK.D.3, namely 2504 kgf. It is possible that the mixture of basalt powder, resin and catalyst is less homogeneous because the addition of more catalyst than sample code TK.D.2 dries more quickly.

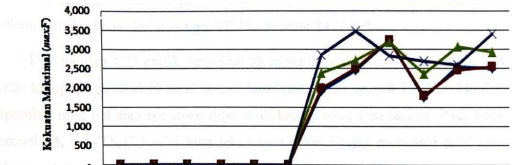
In the compressive strength value of the 60-mesh basalt powder particle composite with sample code TK.E.1-TK.F.3, a value of zero was obtained or the specimen could not be tested because it was cracked or destroyed. In the sample code TK.G.1-TK.G.3, the compressive strength value increases until it reaches the largest maximum compressive strength value obtained in the sample code TK.G.2, namely 3249 kgf. Meanwhile, in the sample code TK.H.1-TK.H.3, the compressive strength value increases until it reaches the largest maximum compressive strength value obtained in the sample code TK.H.3, namely 2568 kgf. This shows that the powder is perfectly bound by the matrix.

Compared with the compressive strength test results on the 150-mesh basalt powder particle composite sample code TK.I.1-TK.J.3, a value of zero was obtained or the specimen was not tested because it was cracked or destroyed. Experiencing an increase until it reached the highest maximum compressive strength value, 150 mesh basalt powder with sample code TK.K.3 showed the largest value with a compressive strength of 3182 kgf. Meanwhile, the sample code TK.L.2 shows the largest value with a compressive strength of 3066 kgf. This is because the mixture in sample TK.K.3 is stronger, so the matrix binder mixture has more optimal compressive strength elements compared to sample code TK.L.2 in the analysis results.

Furthermore, the results of the strength test on the 270-mesh basalt powder particle composite sample code TK.M.1-TK.N.2 obtained a value of zero or the specimen was not tested because it was cracked or destroyed. Basalt powder 270 mesh with sample code TK.O.2 shows the largest value with a strength of 3477 kgf. Meanwhile, the sample code TK.P.3 shows the largest value with a

DOI: https://doi.org/10.33024/jrets.v8i1.13983

strength of 3410 kgf. This shows that the powder is perfectly bound by the matrix.



	10% (1/10)	10% (1/20)	10% (1/30)	15% (1/10)	15% (1/20)	15% (1/30)	20% (1/10)	20% (1/20)	20% (1/30)	25% (1/10)	25% (1/20)	25% (1/30)
Basal 40 mesh	-	-	-	-	-	-	1930	2474	3237	1766	2568	2504
Basal 60 mesh	-	-	-	-	-	-	1984	2507	3249	1800	2468	2568
Basal 150 mesh	-	-	-	-	-	-	2381	2721	3182	2379	3066	2938
Basal 270 mesh	-	-	-	-	-	-	2869	3477	2832	2699	2600	3410

Figure 2. Compression Test Results

In the compressive strength test, the values obtained were not constant because in the testing process the compressive testing machine did not stop automatically at sample code TK.H.1, producing a composite that had air bubbles (Void). Adding too much catalyst also affects the compressive strength of polyester, where adding catalyst causes the compressive strength to decrease. A decrease in the lowest compressive strength value causes the specimen being tested to crumble.

This is due to the uneven distribution of particles and matrix in this specimen. So, the power in this specimen does not work optimally. In the sample code TK.P.2, it was found that the results of the specimens that were compressed for recording did not meet the requirements because the testing machine that carried out the pressing process did not stop applying the load so that the specimen was pressed until it flattened due to human error, so the valuet1on the specimen could not be obtained and the results of the compression test were flat.

From the results of compressive strength tests of 40, 60, 150 and 270 mesh, things that influence the compressive strength value occur because the strength of the material is more even or more homogeneous, this is due to the existence of a mutually supportive relationship between the reinforcing material and the matrix of the composite which causes a bond. the strong one. In this compressive strength test, the results were better for 270 mesh particles than 40, 60 and 150 mesh particles.

This is because basalt powder is finer than 40, 60 and 150 mesh basalt powder. Because the addition of more resin and catalyst makes the specimen denser and reduces the voids that occur. So that 20-25% more stable polyester resin can be obtained, the results of the compressive strength test are not low and the strength value results are high.

4. CONCLUSION

Based on the research results, it can be concluded as follows:

1. Of the variety of test object specimens that can be dry printed and tested only polyester resin with a content of 20-25%.
2. The compressive strength test with the highest strength was obtained on basalt powder sample code TK.P.2 which had a maximum compressive strength value of 3477 kgf.
3. In this compressive strength test, 20-25% more stable polyester resin results can be obtained, this shows that the powder is perfectly bound by the matrix and in the compressive strength test it is not low and the results are higher than 10-15% polyester resin.

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