Effect of ball mill process and resin to compression strength of lava stone composite

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Abstract. Lava stone is a stone produced from a volcano. Mixing lava rock powder and resin will produce a new material, lava stone composite. The mechanical properties of lava rock composites differ from those of the constituent materials. These lava rock composites will be used as armor on military vehicles. The resin content used was 25, 30 and 35% while the lava stone powder was grinding with a ball mill for 3, 4.5 and 6 hours. Ball mill jar used have a capacity of 350 ml made of stainless steel. The ball used is made of ytria with diameters 10 and 5 mm the total of Ytria balls used are 10 mm were 78 pcs and 5 mm were 348 pcs. Composites that have the highest compression strength are composites with 35% resin and lava stone powder which is grinding at 6 hours. The most ductile composites is composites with 30% resin and lava stone powder which grinding at 4.5 hours. The most suitable composites used to withstand shock loads are composites with 30% resin and lava stone powder grinding with a ball mill for 4.5 hours.

Keywords: composite, compression, epoxy, lava stone

1. Introduction
Lava stone is a stone produced from a volcano. This type of rock is widely found in active volcanoes. Java lava island is widely available in Mount Merapi, Mount Kelud and Mount Semeru. This dive lava is only used as a building material whose price is relatively cheap and has no added value. Another use of lava stone is as tableware (grilled steak). The use of lava stone as cutlery makes added value of the lava stone, in addition it can create new jobs opportunities.

Lava stone has a compressive strength between 17.5 to 42.1 MPa [1]. Lava has the advantage of resistance to heat impact [2] and low specific gravity [1]. The use of lava stones in human civilization has been done since human civilization began.

Composites are a new material that is made by combining two or more materials [3,4]. Mechanical properties are a combination of its materials. Hard material combine with ductile material will produce new material with mechanical properties combines of these materials [3,5,6]. The Composites will have hardness below the first material but have has ductility from the second materials.

Composites are categorized according to the matrix. In general, composites are categorized as polymer matrix composites (PMC), metal matrix composites (MMC) and ceramic matrix composites (CMC). Polymer composites have the advantage of being low in density and easy to
produce compared to other types of composites \[7,8\]. The polymer specific gravity starts from 1.1 kg dm\(^{-3}\), while the lowest MMC specific gravity is 1.8 kg dm\(^{-3}\) for magnesium MMC, but the stronger MMC has density more than 2.7 kg dm\(^{-3}\) \[9\].

Composites of Lava rock in this study were in powder condition. The powder used was obtained from lava stone processing, the size of lava stone powder was reduced by using a ball mill. The size of the powder is affected to the strength of the composite. Powder which has a smaller grain size has a wider surface compared to large powder \[10,11\]. Smaller grains have wider contact area so the compressive strength will be higher compared to coarser grains. In this study the effect of lava rock powder size and resin content was examined on the compressive strength of lava stone composites

2. Material and methods
The material used was lava stone from the volcano obtained from the north side of Merapi mountain (Klaten regency, central java). Lava stone is obtained in powder from sawn stone waste, while the resin used was epoxy resin. Lava stone powder is made using a ball mill. Ball mill jar used have a capacity of 350 ml made of stainless steel. The ball used is made of Ytria with diameters 10 and 5 mm the total of Ytria balls used are 10 mm were 78 pcs and 5 mm were 348 pcs.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{ball_mill_jar_and_grinding_ball_media.png}
\caption{Ball mill jar and grinding ball media}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{desktop_ball_mill.png}
\caption{Desktop ball mill}
\end{figure}
Lava stone powder that is processed per grinding is 120 grams. The grinding process is carried out for 3, 4.5 and 6 hours respectively, the rotation of the jar is 200 rpm. The jar rotation was electronically controlled. The resin used is epoxy resin with the ratio of resin and hardener was 2:1. composites made are with resin 25, 30, 35 and 35% resin (weight). The lava stone powder used to make composites are the lava stove powder grind at 3, 4.5 and 6 hours with ball mill. composites are printed using a press made of PVC pipes with an inner diameter of 25.4 mm and a length of 30 mm. The composite is disassembled from the mould after 24-hours curing process in the mould.

![Composites sample in the mould](image)

A mixture of liquid resin and lava stone powder is poured into a mould that has been sprayed with a liquid mould release agent. The composite size is not in comply with ASTM standards for compressive tests, to obtain the length the specimens catted using a lathe machine.

Compressive testing is carried out in the material testing lab majoring in mechanical engineering, State University of Malang. The testing machine used is Universal Testing Machine (UTM) which has a maximum strength of 30,000 Kgf. This machine uses hydraulic power and is controlled by a computer.

3. Results and Discussion

![Compression - Strain of 25% Resin Lava Stone Composite](image)
Compression test results for composites with 25% resin can be seen in figure 4. Compression test results for composites with 25% resin can be seen in figure 4. Compression stress maximum occurs on the composites with lava stone powder processed 4.5 hours in ball mill. The maximum compression stress is 80.07 MPa. Compression test results for composites with 30% resin can be seen in figure 5. The highest compression stress occurs on lava stone composites with lava stone powder grinded at 4.5 hours. The highest compression is 73.14 MPa.

![Figure 5. Compression - strain of 30% resin lava stone composite](image)

Compression test results for composites with 35% resin can be seen in figure 6. The highest compression stress occurs on lava stone composites with lava stone powder grinded at 6 hours. The highest compression is 65.31 MPa.

![Figure 6. Compression - strain of 30% resin lava stone composite](image)
The highest compression test for lava stone composite with 25, 30 and 35 % resin is composite with 25% resin and lava stone powder grinded 4.5 hours (see figure 7). Composite strength with 25% resin and 6 hours powder lava stone were grinded at 4.5 hours is highest compared to composites with other composite compositions, but when compared with the ductility of the composite it is still below the composite with 30% resin and kava stone powder which is grinding 4.5 hours, which is 26.66% for composites with 30% resin and 19.74% for composites with 25% resin.

![Figure 7: Comparison of higher compression test of resin lava stone composite](image)

The choice of composite composition depends on the use of the composite. In this study composite will be used as a layer of armour layer protection on military vehicles. The armour layer receives a high shock load and requires material has capability absorb a lot of energy from the shock load. The impact load energy can be absorbed by tough material. The two of composite compositions must be calculate to find the most toughness composites. The calculation results of the area under the curve in Figure 7 shows the highest area in the compression test results of lava rock composites with 30% resin.

4. Conclusion
Composites that have the highest compression strength are composites with 35% resin and lava stone powder which is grinding at 6 hours. The most ductile composites is composites with 30% and lava stone powder which grinding at 4.5 hours. The most suitable composites used to withstand shock loads are composites with 30% resin and lava stone powder grinding with a ball mill for 4.5 hours.

5. Acknowledgment
A great appreciation was delivered to the State University of Malang for funding PNBP trough a research contracts no: 20.3.XX / UN32.14.1 / LT / 2020

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