Short carbon fibre effect on compressive strength of lava stone composite

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Abstract. Lava stone can be found around volcanoes and it has been widely used in human civilization. Composite which is an alloy of two or more materials who’s each material still can be identified clearly. Composites with lava stone and matrix epoxy resin will have the properties of a combination of these materials. The mechanical properties of these composites can be improved by adding other materials which have a higher mechanical strength. In this study, carbon fibre was used as an additional reinforcing material. The lava stone powder used is the powder from sawing lava stone process. The lava stone powder was pulverized by a ball mill process for 4.5 hours. The matrix used was epoxy resin with a ratio of 2: 1 resin and hardener. The carbon fibre used is a short fibre with a length of 6 mm. The compressive test results on the lava stone-short carbon fibre composite showed the highest compressive strength was found in the composite with the addition of 1% carbon fibre (84.42 MPa) and epoxy 30%.

1. Introduction
Lava stone can be found around volcanoes and it has been widely used in human civilization. Lava stone is mostly used as a building material[1][2], even temples on the island of Java use lava stone as a material. Lava stone processing has been done cutting bulk stone into the intended shape and size. This process generates a lot of waste and not yet used.

Waste from the lava stone processing process is waste that can be used other than as material for filling land and only has a very low economic value. One of the wastes from the waste treatment process is lava rock powder which is produced from the sawing process. Waste in the form of powder can be used as a composite. Composite which is an alloy of two or more materials whose each materials still can be identified clearly[3][4].

Composites with lava stone and matrix epoxy resin will have the properties of a combination of these material[5]. The mechanical properties of these composites can be improved by adding other materials which have a higher mechanical strength[6][7]. In this study, carbon fibre was used as an additional reinforcing material.

Carbon fibre is a synthetic material that has a very high tensile strength[8][9]. Carbon fibre is usually woven into a fabric with a thickness of a certain form of yarn [10][11][12]. The disadvantage of carbon fibre fabrics is that they are anisotropy[13][10]. The anisotropy
properties of composites can be improved by adding fibres with irregular directions so that their mechanical properties are more uniform (isotropy). In this study, short fibres were used to facilitate the process of making composites. This study is a preliminary study and using only one type of short carbon fibre (length 6 mm).

2. Material and methods
The lava stone powder used is the powder from sawing lava stone process. The lava stone powder was pulverized by a ball mill process for 4.5 hours.

![Figure 1 Ball Mill Jar for Desktop Ball Mill](image1)

The matrix used was epoxy resin with a ratio of 2:1 resin and hardener. The carbon fibre used is a short fibre with a length of 6 mm.

![Figure 2 Short Fibre Carbon](image2)
The process of making a composite is by weighing 20 grams of resin, and adding 10 grams of hardener. The mixture of resin and hardener is stirred manually, then add 35 grams of lava stone powder. After the mixture of resin and lava stone powder was stirred added short carbon fibre.

the process of making the test object for the testing process using a mould made of PVC with an inner diameter of 25.4 mm and a length of 28 mm. Because the required length of the test object is only 25.4 mm, the test object is cut according to the required length using a lathe. This cutting is done because it is necessary to get a flat and parallel surface. The uneven surface of the specimen will cause the compressive force to be concentrated on the longer part so that the data obtained is not valid.

Figure 3 Lava Stone – Carbon Fibre Composite Sample

The compressive test was done using a Universal Testing Machine with a maximum capacity of 30,000 kgf.

3. Results and discussion

The results of the compressive test on the composite can be seen in Figure 4.
The compressive test results on the lava stone-short carbon fibre composite showed the highest compressive strength was found in the composite with the addition of 1% carbon fibre (84.42 MPa), while the lowest is the composite with the addition of 3% carbon fibre. The compressive strength of the lava stone composite with the addition of carbon fibre was 11.30 MPa higher than lava stone composite without the addition of carbon fibre.

Composites with 30% resin have the highest strength found in composites with the addition of 1% short carbon fibres, this happens because at this carbon content the bond between carbon fibre and resin is most effective in composites with 1% short carbon fibres.
This can be proven in Figure 5 where the fracture that occurs is a fracture between grains and between fibres and resins. This can be proven in Figure 5 where the fracture that occurs is a fracture between grains resins.

![Figure 6 Fractography of Composite Lava stone (resin 30%)](image)

Fracture in composites with carbon fibres that occur are also fractures between grains (Figure 6). Carbon fibre has a higher strength than the compressive strength of the composite so that it will not break with the compressive force that occurs in the composite.

![Figure 7 Fractography of Composite Lava stone – short carbon fibre (resin 30%)](image)

The increase in the strength of the lava stone composites with the addition of 1% carbon fiber occurs because more energy is needed to break the bonds between carbon fiber and epoxy resin.
The addition more carbon fiber to the lava composite decrease the compressive strength of the composite, it caused by bonding between the carbon fiber and the epoch is "disturbed" by the presence of lava stone powder.
Lava stone and carbon fiber composites from this research will be used as a laminate composite for lava stone composite and steel sheet.

4. Conclusion
The addition of short carbon fibres to the lava stone composite can increase the compressive strength of the composite. The addition of a fibre that increases the compressive strength of the composite is 1% (weight) short carbon fibre. The addition short carbon fibre more than 1% does not increase the compressive strength of the composite.

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