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## INVESTIGATION OF THE EFFECT OF MESH SIZE AND FRACTION VOLUME ON BENDING STRENGTH CHARACTERISTICS OF GEOPOLYMER COMPOSITE

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### ABSTRAK

Material komposit adalah material yang terdiri dari dua jenis material atau lebih yang memiliki sifat berbeda, dengan menggabungkan secara makroskopis, dan ikatan antar muka yang baik antara satu material dengan material lainnya. Saat ini material komposit polimer banyak diaplikasikan pada industri transportasi darat, laut, dan udara, selain itu komposit polimer dengan sifat tahan api telah dikembangkan dengan penambahan geopolimer yang memiliki keunggulan menghasilkan performa yang tinggi. Penelitian ini bertujuan untuk mengetahui pengaruh ukuran mesh dan fraksi volume serbuk bata ringan terhadap kuat lentur. Manfaat dari penelitian ini secara langsung meningkatkan nilai ekonomis limbah bata ringan dan menghasilkan material canggih yang tangguh dengan biaya yang murah. Bahan pengisi komposit menggunakan limbah bata ringan dan diayak menggunakan ayakan dengan mesh 50, 100, 150, dan 200 pada fraksi volume 45%, dan fraksi volume 0%, 15%, 30%, 45%, dan 60% pada mesh 200. Sedangkan matriks komposit menggunakan polimer termoset Ripoxy R-804. Berdasarkan hasil penelitian, penambahan serbuk bata ringan dengan variasi ukuran partikel serbuk bata ringan dan fraksi volume menunjukkan penurunan ketahanan kuat lentur dibandingkan tanpa serbuk bata ringan.

**Kata kunci:** komposit, bata ringan, lentur, ripoxy.

### ABSTRACT

*Composite material is a material consisting of two or more type materials that have different properties, by combining macroscopically, and good interfacial bonds from one material to another. Currently, polymer composite materials are widely applied in the land, sea, and air transportation industries, moreover polymer composites with fire resistance properties have been developed with the addition of geopolimer that has the advantage of producing high performance. This study aims to determine the effect of mesh size and volume fraction of lightweight brick powder on flexural strength. The benefits of this research directly increase the economic value of lightweight brick waste and produce a tough advanced material at a low cost. The composite filling material used lightweight brick waste and sieved using a sieve with a level of 50, 100, 150, and 200 at a volume fraction of 45%, and a volume fraction of 0%, 15%, 30%, 45%, and 60% at a mesh 200. While the composite matrix used the thermoset polymer Ripoxy R-804. Based the result, addition of lightweight brick powder with variations in particle size of the*

*lightweight brick powder and volume fraction showed a decrease in flexural strength resistance compared to those without lightweight brick powder.*

**Keywords:** *composite, lightweight brick, flexural, ripoxy.*

## 1. INTRODUCTION

Composite material is a material consisting of two or more type materials that have different properties, by combining macroscopically, no reaction physic or chemical, and good interfacial bonds from one material to another [1]. Composites are generally composed of reinforcement and a matrix as a binder between the fibers so that they are always in position. Composite characteristics are influenced by each fiber and matrix material, differences in the composition of the reinforcement variables result in differences in each of these variables, while the type of matrix will affect the characteristics of the bond with the reinforcement [2]. Combination with interfacial bonds aims to find new materials that resemble the original properties of each of the constituent materials [3].

Currently, polymer composite materials are widely applied in the land, sea, and air transportation industries with the increasing demand for strong materials, corrosion resistant, lightweight, and affordable [4]. Moreover, polymer composites with fire resistance properties have been developed with the addition of geopolymer that has the advantage of producing high performance [5]. Geopolymer is a source of aluminosilicates or a source of silica and alumina in the form of an organic polymers [5], with mechanical properties that are fire resistant, and good compressive strength [6]. Geopolymer materials have been widely applied as composite substitutes to increase fire resistance, for example using coal fly ash[7][8][9], roof tile soka-clay recycle [4][5][10], tile recycle [6] with a polymer-based matrix thermoset [10][11][12] and thermoplastic [13]. The use of this geopolymer material in composites directly has a positive effect on the properties of fire resistance and resistance to loads.

In materials engineering, besides being developed in designs with high durability [14], polymers are also widely developed for example as coatings, paints, glazing, adhesives, to binders used in polymer composites [3]. Ripoxy R-802 is a type of vinyl ester resin polymer that was developed and obtained by modification of bisphenol A epoxy resin. Ripoxy R-802 vinyl ester resin has advantages such as resistance to acids, water, organic solvent resistance [9], and flame resistance [5]. While composite reinforcement materials, utilize waste-based materials, such as agricultural waste [2], non-toxic industrial waste, until building construction waste [15]. Light weight brick is one of the wall construction materials of a building structure that leaves a lot of waste shards or materials that are not selected and cannot be used as a construction material [16]. lightweight brick has a density of 600 – 800 kg/m<sup>3</sup> [17] lighter compared to clay base material [18] and coal fly ash [19] which is another material as a geopolymer composite reinforcement with good fire resistance. Besides good fire resistance, composites with geopolymer materials must-have criteria of resistance to load resistance, one of which is flexural resistance [20].

This study aims to determine the effect of mesh size and volume fraction of lightweight brick powder on flexural strength. This research directly contributes to the innovation and development of fuel-resistant geopolymer composites and has the potential as a metal replacement for low-cost vehicle panels and bodies. The benefits of this research directly increase the economic value of lightweight brick waste and produce a tough advanced material at a low cost.

## 2. METHODOLOGY

Referring to the previous experimental research conducted by Tarigan (2013) [12], research polymer composites with the addition of geopolymer powder were carried out in several stages, there are, preparation of tools and materials preparation, specimen manufacture, testing material composite, and analysis data.

The composite filling material used in this research uses lightweight brick waste obtained from building construction fragments. Furthermore, the lightweight bricks were pulverized and sieved using a sieve with a mesh fineness level of 50, 100, 150, and 200 at a volume fraction of 45%, and a volume fraction of 0%, 15%, 30%, 45%, and 60% at a mesh fineness level of 200. While the composite matrix used the thermoset polymer Ripoxy R-804 produced by PT Justus Kimia with the catalyst used the type of methyl ethyl ketton peroxide (MEKPO) with the use of 2.9% of the total resin weight and the promoter type P-EX (mixture of 60% cobalt naphthenate). and 40% dimethylaniline) using 0.58% by weight of resin [12].The manufacture of glass molds applies the manufacture of polymer composites by the hand lay-up method. The mold is prepared based on the size of the test specimen according to the ASTM D790-02. the standard for flexural test. Flexural testing or bending testing in this study uses a universal testing machine or UTM for polymers. The test method is carried out according with the three-point bending method [19][20] as shown Figure 1.

### 3. RESULTS AND DISCUSSION

The results of this study discuss the effect of mesh size with each using a volume fraction of 45%, and the effect of volume fraction with each using a mesh of 200 which is plotted in the flexural or bending stress diagram in MPa units.

Figure 2 shows the mesh size of the lightweight brick powder has an effect on the bending value of the composite, with the addition of a meshing size of 50 the flexural stress value will decrease compared to that without light brick powder, and this value will decrease further at mesh sizes 100 and 150, but at mesh size 200 the value of the flexural stress that the composite can absorb until it breaks increases compared to the mesh size of 150. The decrease in the value of the flexural stress that can be accepted is due to geopolymer-based material being a brittle material [21], thus causing a tendency for the composite to be more brittle. While the flexural stress value will increase at a mesh size of 200 from a mesh size of 150 due to the smaller the powder granules in the composite, the more the number of granules with the same volume [7][20], so that the area of the granules bound to the matrix will increase cumulatively, and potentially increasing the resistance to bending stress.

Figure 3 in general also shows a decrease in the value of resistance to bending loads with the addition of lightweight brick powder compared to without using lightweight brick powder. Figure 3 also shows that the addition of a 15% volume fraction of lightweight brick powder will reduce the flexural resistance of the composite and then continue to decrease until the addition of a volume fraction of 60%. The decrease in the value of the flexural stress that can be accepted is due to geopolymer-based material being a brittle material [21], thus causing a tendency for the composite to be more brittle. In Figure 3 there is a phenomenon of an increase in flexural resistance at the volume fraction of 45% compared to the volume fraction of 30%, Furthermore, flexural resistance will decrease at 60% volume fraction. Increase in value from volume fraction 40% is due to the reinforced composite with a smaller particle size having a larger and larger contact surface between the reinforcement and its matrix, so that when exposed to a load, Directly, the load will shift through the reinforcement with the matrix, this causes the larger the contact surface, the higher the composite strength [20]. Meanwhile, the decrease in flexural resistance in the volume fraction of 60% is because the flexibility of the matrix to fill the inter-grain area will decrease compared to the volume fraction, so it tends to form cavities between the powder and the matrix and this has the potential to reduce its mechanical strength [22].

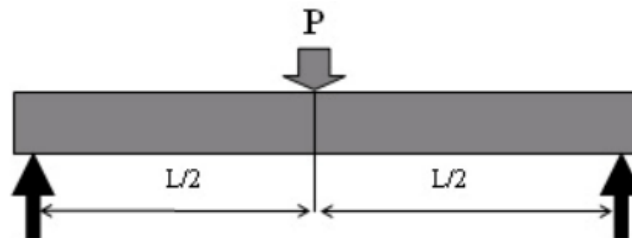


Figure 1. Three-point bending stress scheme [19][20]

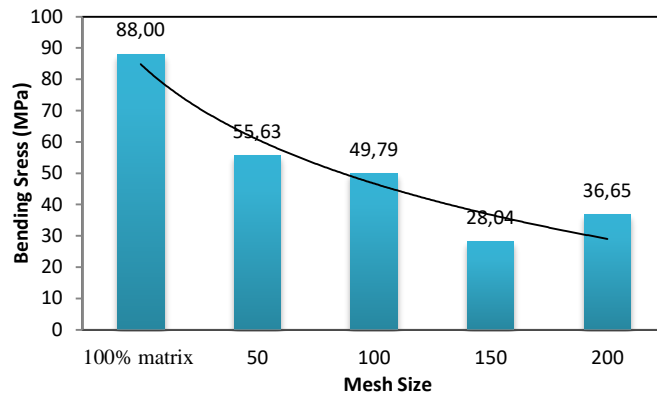


Figure 2. Mesh size to the bending stress characteristic diagram

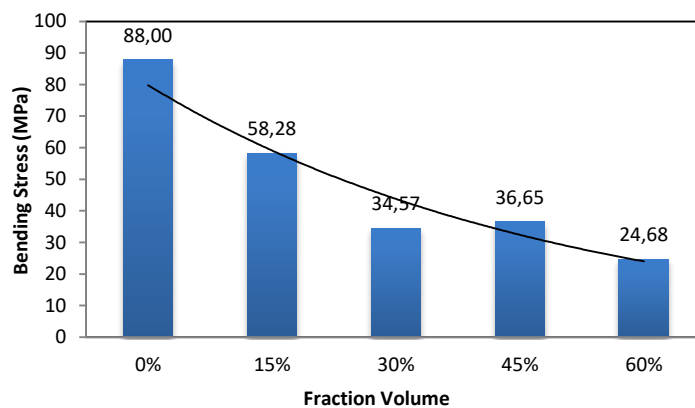


Figure 3. Fraction volume to the bending stress characteristic diagram

Figure 2 and Figure 3 generally show the addition of lightweight brick powder to Ripoxy R-804 polymer as a filler, the flexural stress value tends to further reduce the flexural resistance compared to composites without the addition of lightweight brick powder or only Ripoxy R-804 matrix. There is a tendency to decrease the value of flexural stress on the addition of lightweight brick powder to the composite because it uses powder, the composite will be included in the brittle category, it is shown that all the flexural test fractures on the composite tend to be straight lines [20], as shown Figure 4 by a macro photo with (a) 5x and (b) 10x zoom at mesh 100. In addition, the lightweight brick powder in this composite is only as a filler and does not function as an actual reinforcement in the composite.

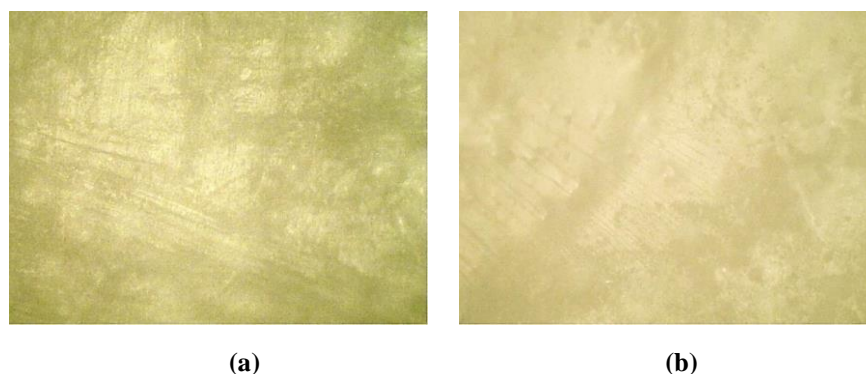


Figure 4. Fracture macro photo at 100 mesh (a) 5x zoom, and (b) 10x zoom

#### 4. CONCLUSION

Based on the results of this study, the addition of lightweight brick powder affects the flexural strength resistance of ripoxy-light brick powder composite. The addition of lightweight brick powder with variations in particle size of the lightweight brick powder and volume fraction showed a decrease in flexural strength resistance compared to those without lightweight brick powder.

#### ACKNOWLEDGMENTS

The author would like to thank the Directorate General of Vocational Education, Ministry of Education, Culture, Research, and Technology which has funded the Penelitian Dosen Pemula scheme or PDP for the 2022 fiscal year with an agreement or contract number 128/SPK/D4/PPK.01.APTV/VI/2022.

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