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Study on Molding Properties of Obsidian Perlite

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Abstract: *This study suggests a molding technology of obsidian perlite powder to improve mechanical properties. Molding experiment of obsidian perlite and characteristic test of molded body were carried out. By examining the characteristics and trends of the perlite product, we show the basic data on the experiment of the perlite product.*

Keywords: *obsidian perlite, molding, mechanical properties*

1. Introduction

Powder can be effectively used in various ways, such as compounding and molding, and thus contrasted by a rigid material. A number of products have been fabricated using the advantages of powder in the industry (e.g., pharmaceuticals and machinery parts) in response to the demands for technological innovation [1]). A foamed material with the porous structure is one of those developed powder materials. It has attracted attentions due to the lightweight as well as the excellent thermal and sound insulation by confining the air in its pore structure. Obsidian perlite investigated in this work is a foamed material used for lightweight building material and soil improvement material. There have few studies related to this material in spite of its potential for the industry. Therefore, this study investigates a solidification molding technology of obsidian perlite powder to improve mechanical properties.

2. Characteristics of Obsidian Perlite

Obsidian perlite used in this study was produced by Ajimu Perlite Co. Ltd. from obsidian gemstone obtained in Ajimu district, Oita prefecture, Japan [2][3]). This gemstone is characterized by rhyolite and few phenocryst in chemical composition, contrasted by continuous glass gob shown in a typical obsidian [3]. The investigated obsidian perlite consists of 75-78% SiO_2, 12-16% Al_2O_3, 2-5% Na_2O, and 2-4.7% K_2O.

The thermal conductivity of obsidian perlite was measured to be 0.068 $W.mK^{-1}$, suggestive of high thermal-insulation ability. The density was 0.1-0.3 $kg \cdot L^{-1}$ as a lightweight material. In addition, the obsidian perlite used in this study possessed a higher hardness than does a commercial perlite [3]), making it difficult to measure compressive strength by a conventional method. We instead measured the perlite strength using the compressive displacement (D_c) of material filled in a cylindrical container. The compression rate (R_c) was then determined as the ratio of the compressive displacement to the sample thickness (t), i.e., $R_c=D_c/t\times100(\%)$. Figure 1 shows the schematic illustration of the compression machine used in this work. Figure 2 shows the compressive curve of the present obsidian perlite depending on the particle size.

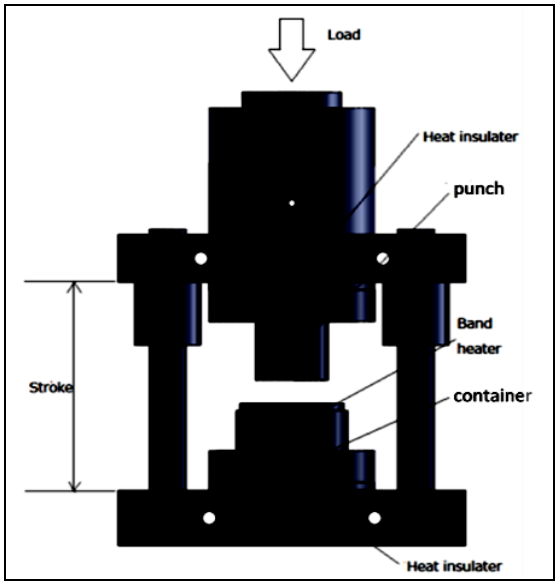

Figure 1. *Compression overview*

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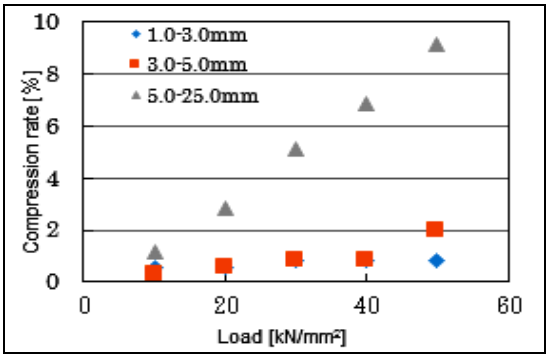


Figure 2. *Variation in compression rate depending on the applied load*

3. Fabrication of Obsidian Perlite Molded Body

The perlite molded body was fabricated by blending two types of obsidian perlites with different ranges of particle size: 0.1-1.0 mm and 1.0-3.0 mm. Sodium silicate was employed to bide the obsidian perlite particles, due to a good binding capability between glass and ceramic as well as superior heat resistance. Aqueous solution of 40% sodium silicate and 60% perlite was mixed and then molded in a mold of 24 mm × 18 mm × 200 mm. Removing the mold, the molded sample was heated at 200°C and 400°C, respectively, for 2 h. Figure 3 summarizes the manufacturing procedures of obsidian perlite molded body.

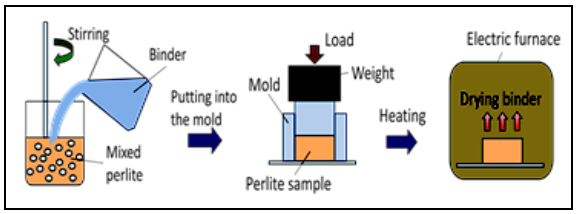
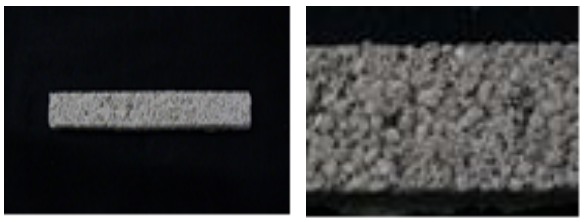


Figure 3. *Overview of manufacturing procedures*

Figure 4 shows the structure of the perlite molded body fabricated at a large perlite percentage of 33% and 200 degrees. Sodium silicate effectively joined perlite particles. However, large pores between particles were confirmed, which required strong force to avoid the fragmentation of the molded body. Figure 5 suggests an increase in the density of the molded as the fraction of large perlites was decreased. As the proportion of large grain pearlite increases, the number of points of contact with each other decreases and the bending strength decreases.



(a) Overview *(b) Enlarged view*

Figure 4. *A perlite molded body formed at 200°C. The perlite fraction was 33%.*

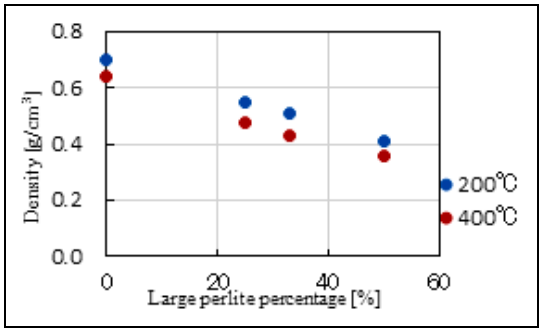


Figure 5. *Variation in the density of the perlite molded body depending on the fraction of large perlite*

3.1 Bending Strength of Obsidian Perlite Molded Body

Bending strength of the perlite molded body was evaluated at room temperature on the basis of JIS1664:2004 procedures [4]). Samples with a fraction of large perlite of 0%, 25%, 33%, and 50% were pressed up to a load of 600 N using a small hand press. This process is schematically shown in Figure 6.

Bending strength test was performed at room temperature, immediately before the experiment, the specimen was dried by heating at 200°C for 30 minutes.

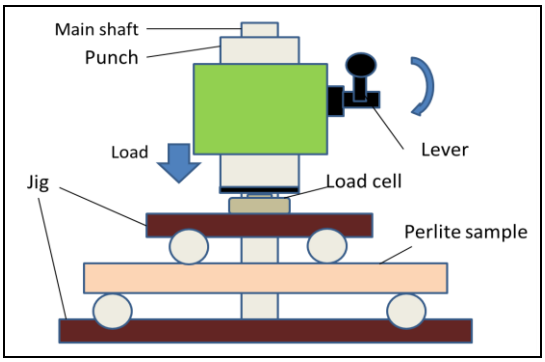


Figure 6. *Scheme of the bending test*

Figure 7 shows the perlite molded body after the bending test. Both samples were fractured near the center in the length direction. Fracture surfaces demonstrate the fracture of perlite particles in most cases, suggestive of stronger bonding strength of sodium silicate in comparison to that of perlite particles.

(a) 200°C (33%) *(b)200°C (25%)*

Figure 7. *Fractured molded bodies after the bending test. Both samples were formed at 200°C: (a) 33% and (b) 25% in the perlite fraction*

Figure 8 presents the influence of large perlite fraction upon the bending strength. Increasing fraction of large perlite gave rise to the deterioration in bending strength. Recalling Figure 5, such a reduction of bending strength resulted from the decrease in material density, i.e., increasing pore area. It is thus required to use small-sized perlite particles to obtain a strong molded body.

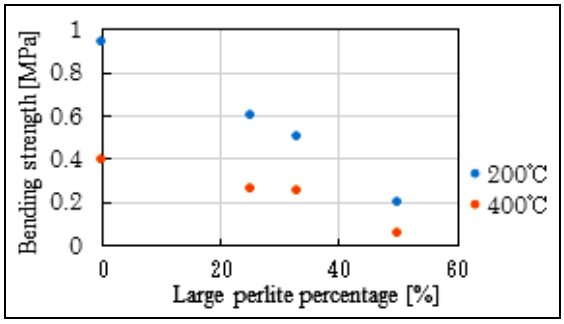


Figure 8. *Relation between the bending strength and the fraction of large perlites*

4. Conclusions

- Perlite molded body was successfully fabricated by molding an aqueous solution of obsidian perlite and sodium silicate.
- Increasing fraction of large perlite led to the formation of large pores between perlite particles, resulting in the decrease in material density.
- Bending strength of the perlite molded body was increased with decreasing fraction of large perlite.
- Using this material as a base material, it is expected to improve the performance of the pearlite molded body by mixing materials that meet the requirements.

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