Ceramics Pottery Fabrication using Plaster of Paris as Filler: Effect of Particle Size Distribution on Porosity and Modulus of Rupture

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Abstract
This study investigates the influence of Plaster of Paris (POP) mould wastes as filler in manufacturing of ceramic pottery. Five different particle size distributions of the POP waste (25 μm, 36 μm, 45 μm, 63 μm, and 73 μm) have been used as filler. Slip casting method was applied in fabricating ceramic samples. The results showed that, porosity was increased by the additional particle size distribution and decrease with the strength values.

Keywords: Plaster of Paris waste, slip casting, porosity, modulus of rapture.

Introduction
Plaster of Paris (POP), a basic salt of calcium sulfate with a half molecule of water of crystallization (CaSO₄ ½ H₂O) is made by calcining the mineral gypsum. POP itself is not a compact solid but a porous material with a relatively large internal surface consisting of interlocking crystals in the form of plates and needles. Besides that, POP is also known for its porosity and strength and is widely used in ceramic industry for mould casting [1]. After using the POP mould around 150 to 230 times, the mould disposed of in landfills and often dumped directly into ecosystems without adequate treatment.

For the Physical properties, ceramics were measured by porosity, pore size, and pore structure [2]. As the porosity is increased, the strength was found to decrease proportionately. In this regard, in view of the previous investigations reported that the smaller particle size was created finer microstructure which typically produce the higher strength [3].

Methodology
The POP waste, which was in form of used moulds, was collected from local ceramic factories. The POP mold was crushed using a jaw crusher particle size to produce a fine powder, for which the particle size was less than 200 μm. The POP wastes powder were then milled by using planetary mono mill (Fritsch Pulverisette 6, Germany) at 230rpm for 10 minutes [4]. The powder size distributions were classified by using different sieve sizes were prepared; 25 μm, 36 μm, 45 μm, 63 μm and 73 μm. The POP waste powder was characterized by X-ray diffraction (XRD) used for phase identification and X-ray fluorescence (XRF) used for elemental analysis. In this research, ball clay, kaolinite, potash feldspar, silica and POP wastes were used as the raw material for preparing the pottery sample The porosity was measured (Mettler Toledo) following Archimedes principle (ASTM 372) using and determine by using given formula:

\[ P = \frac{W_w - W_d}{W_w - W_s} \times 100\% \]  

Whereas:
- \( W_d \) = mass of air dried specimen (mg)
- \( W_s \) = mass of immersed specimen in liquid (mg)
- \( W_w \) = mass of immersed specimen in air (mg)

Modulus of rupture was determined by using Universal Testing Machine (Shimadzu Autograph, Japan) and the result was analyzed according to ASTM C674-88 (Reapproved 2006) [5].
Result and Discussion

The result of the XRD analysis is shown in Figure 1 proved that these powders are which are Calcium Sulfate Hydrate Bassanite (CaSO₄•0.5H₂O). The highest peak was sulfur trioxide (SO₃) at 55.0 degrees and Calcium oxide (CaO) at 38.5 degrees. While the absence of the other peak is water (H₂O) measured at 6.5 degrees 2θ.

![Figure 1: XRD analysis for Plaster of Paris](image)

Ceramics Analysis by X-Ray Fluorescence (XRF) is conducted for material identification and characterization of Plaster of Paris which can determine the proportions and the identity of the major oxides of materials such as sulfur trioxide (SO₃), Calcium oxide (CaO) and Silicon dioxide (SiO₂) shown at table 1.

<table>
<thead>
<tr>
<th>Element</th>
<th>Concentration, wt %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na₂O</td>
<td>1.347</td>
</tr>
<tr>
<td>MgO</td>
<td>0.445</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>1.814</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>0.590</td>
</tr>
<tr>
<td>SO₂</td>
<td>47.208</td>
</tr>
<tr>
<td>CaO</td>
<td>40.918</td>
</tr>
<tr>
<td>SiO₂</td>
<td>6.786</td>
</tr>
</tbody>
</table>

Table 1: XRF analysis on Plaster of Paris.

Reference to the table above, the concentration of each element is as follows:

Conclusion

The additives of POP waste as recycle and reusable material is an effective method to reduce waste from ceramic sector. The presence of POP waste by increasing particle size distribution of POP was increased the porosity meanwhile the value of strength was decreased.

References