Physical and Mechanical Properties Changes of Iraqi Grog, Using Iraqi glass Powder in Different Proportions

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ABSTRACT

The importance of ceramic materials is complete in the strength that binds its atoms as well as its physical and mechanical properties which make its binding material of high hardness and high wear resistance. In this work we use a mixture of two materials, Iraqi grog with Iraqi glass powder. Four mixtures were used 100% grog + 0% glass powder, 90% grog + 10% glass powder and 80% grog + 20% glass powder. Physical tests (porosity test) and mechanical tests (torsion test) were performed. The results referred that the highest porosity value were 32% for the mixture (100% grog powder + 0% glass powder) and the lowest value was 18% when mixed (80% Iraqi grog + 20% glass powder). The highest value for torsion resistance was 7.61 when mixed (80% Iraqi grog + 20% glass powder) and the lowest value was 2.3 when mixed (100% grog powder + 0% glass powder). We conclude from these results that adding Iraqi glass powder to Iraqi grog should improve its physical and mechanical properties.

KEYWORDS

Iraq grog, glass powder, physical & mechanical properties of ceramic materials.

INTRODUCTION

Ceramic materials had an important role in the industry, as the greasy material (porcelain) and develop every day, especially in Europe [1, 2]. The ceramic industry developed through the ages ago until it became directly using natural materials from the ground in the industry without resorting to reductions, so that the cost was greatly reduced in addition to obtaining the required mechanical properties [3, 4]. The importance of ceramic materials is due to its power binds of its atoms as well as physical and mechanical properties [5], which made it a bonding material with hardness and wear resistance this reason that distinguishes it from metals, which enter into many industries [6]. For those reasons and because of availability in Iraqi nature with cheap prices, easily formation, we chose it in this work.

THE RAW MATERIALS

IRAQI Grog

It is a hard material like gravel agglomerated those results from burning kaolin at a temperature of (1250 °C) for two hours [7]. It contains the mullite, an intermediate compound of alumina in silica and crystopillite phases, a phase of silica. The Iraqi grog gives ceramic materials a fixed structure when burning as it turns kaolin into final compounds in which there are no changes during the burning process, such as mullite and crystopillite [8, 9].

IRAQI Glass

When crushing a piece of glass for the purpose of converting it into a white powder color that is opaque and easy to seen in the air, the crushing process leads to doubling the brightness of glass piece area that reflects and breaks its particles light this light does not penetrate through the powder except a very small part [10, 11]. That if we put a normal piece of glass in a liquid larger density of water, it will completely disappear from view and become a piece of glass invisible, this case is similar to the presence of carbon dioxide gas (CO₂) and hydrogen gas H₂ present in the air for the same mentioned reason [12, 13].
Sintering of Ceramic Material

Ceramic sintering is the process by which the compressed powder is converted into solid body whereby the shape of small particles or particle groups is changing into a regular composition at high temperature shedding over time [14, 15].

Sintering Stages

Firstly: the cases of contact increase between the small overlapping particles, and neck growth occurs, then increasing the density by (60 - 65) %. Secondly: the pores are closed gradually and a spread of the particles of the material occurs towards the voids and cylindrical channels then the density increases by (65-90) % [16]. The Third Stage is the movement of voids and crystalline boundaries increases, as the ribbing occurring in the surface of the contacting particles and reaching to the theoretical value of density [16].

Clay burning process

The process of burning clay with a temperature higher than (650) ºC begins with the loss of its elasticity within the limits of this degree, its properties such as resistance are insufficient to use it under different conditions for a long period of time, its prone to failure and breakage, therefore burning at higher temperatures is required to improve its final properties and lead to continue raising degrees, the temperature indicates the decomposition of carbon, almost to (900) ºC depending on the clay mineral as follows[17]:

Decomposition of magnesium carbonate

\[
\text{MgCO}_3 \rightarrow \text{500} \rightarrow \text{MgO} + \text{CO}_2
\]

Decomposition of calcium carbonate at a temperature of (700) ºC in a light manner and intensify at (850 -900) ºC carbon dioxide gas release CO\text{2} as in the equation below:

\[
\text{CaCO}_3 \rightarrow \text{900-700} \text{ ºC} \rightarrow \text{CaO} + \text{CO}_2
\]

Physical Tests

Apparent Porosity

Porosity in the ceramic product depends on the two factors material involved in production first and the sintering process variables second, before the burning process the product of ceramic is highly porous, and most pores are open and connected, during the last stages of the burning process the percentage of open pores decreases, turns into closed and a large number of pores closed fade away [18, 19]. The ceramic bodies usually show a variable degree of porosity, as the porosity is a measure of all the voids in the material, whether open or closed, and accordingly, two type of the real and apparent porosity appears. The apparent porosity is the ratio of volume for pores open to the total volume of the ceramic body either the real is the ratio volume for the total pore (open + closed) to the total volume of the ceramic body [20].

Calculation of apparent porosity

\[
\text{Apparent Porosity} \% = \left( \frac{\text{M}_\text{m} - \text{M}_\text{d}}{\text{M}_\text{m} - \text{M}_\text{s}} \right) \times 100 \tag{1}
\]

Where: M: saturated weight (grams).

Md: Dry weight (grams).

Ms: Hanging Weight (grams).

Bending Strength

The bending resistance test is performed on cylindrical or rectangular bars samples form and subjected to testing until failure. By using three or four loading points at the central loading point, the top surface of the sample is in a compressed state while the bottom surface is in a tensile state. The greatest tensile stress is concentrated on the lower surface of the sample directly below the stress load point. Since failure occurs in the surface exposed to tensile, the tensile test can be replaced by a torsion test, bending or torsion resistance or fracture resistance, which
is an important mechanical property of ceramics during loading. The torsion resistance depends on the sample size, with increase in the sample size exposed to stress, the probability of cracks increases, so the torsion resistance decreases.

The work method

Stages of preparing the Iraqi glass powder and mixing it with the Iraqi Grog

<table>
<thead>
<tr>
<th>Iraqi grog %</th>
<th>glass powder percentage %</th>
<th>article name</th>
<th>mix number</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0</td>
<td>(crock + glass) powder (0-100)</td>
<td>1</td>
</tr>
<tr>
<td>90</td>
<td>10</td>
<td>(90-10)</td>
<td>2</td>
</tr>
<tr>
<td>80</td>
<td>20</td>
<td>(80-20)</td>
<td>3</td>
</tr>
<tr>
<td>70</td>
<td>30</td>
<td>(70-30)</td>
<td>4</td>
</tr>
</tbody>
</table>

Compress Forms

This stage involved preparing wet samples according to the ratios of the mixtures shown in table (1) (2.5) % adding polyvinyl alcohol (PVA) as a binder to gain it an acceptable coherent force for the purpose of transporting it. A semi-dry press was used in one direction from the top. The table (2) shows the dimensions of both the mold used in the pressing process and the dimensions of the sample, in addition to the sample weight and the load carried on it and for the tests used in this study. After pressing the samples it dried in a 150 °C in drying oven for 24 hours to remove any moisture gained.
Table 2. The mold dimensions, model, sample weight, and projected load of samples.

<table>
<thead>
<tr>
<th>property</th>
<th>mold dimensions (mm)</th>
<th>model dimensions (mm)</th>
<th>sample weight (gm)</th>
<th>load used (ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical tests (apparent porosity)</td>
<td>D=13</td>
<td>D=13</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>H=27</td>
<td>T=15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical tests (torsion resistance)</td>
<td>L=130 I=115</td>
<td>W=50 W=25</td>
<td>60</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td>T=25</td>
<td>T=12.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Firing

The wet samples not burnt that were previously formed and dried became ready to sinter at a temperature of (1200 °C) in the electric incineration oven for one hour, then it left inside the oven to cool down to room temperature.

Tests

Physical examinations (apparent porosity)

Apparent porosity was calculated using the American Standard ASTM C373-88 [21]. Also, each recorded result is an average of three values according to the following steps [22].

The samples were dried in the drying oven at a temperature of 150 °C. for 24 hours, allowed to cool down to room temperature, after which the dry weight of the samples is proved. The samples were placed in a resistant glass beaker submerged in distilled water and boiled for 5 hours while ensuring that they were always immersed in water and compensated the evaporated water, then the samples were cooled and left immersed in water for 24 hours. Fix the hanging weight with water of the samples using a scale grid. Immediately after fixing the hanging weights, surfaces samples were dried from the water droplets stuck in them with a damp cotton cloth and then calculated the weight saturated with water. After performing all the previous steps, the percentage of porosity was calculate according to the equation (1-1).

Mechanical examination (torsion resistance test)

The bending resistance is calculated at the stress of the bending of the highest load and at regular loading rate until the fracture occurs. After the sample was formed, the load was added, and then the highest load which the model failed was read.

Torsion strength calculated based on ASTEM STANDARD -C674 [23].

\[
\text{Bending strength} = \frac{(3Pf \times L)}{(2W \times t_2)}
\]

While Pf = projected load to fracture (N).
L = distance between the rests (mm).
W = width of the sample (mm).
t = sample thickness (mm).

RESULTS

Figure 1: The highest value of apparent porosity was at mixture No. (1) (0% glass + 100% grok), which reached (32%), while the lowest value was at mixture No. 3 (20% glass powder + 80% grok), which reached (18%), while Figure (1-2) shows that the highest value of torsion resistance was at mixture No. (3), which amounted to (7.61) mPa, and the lowest value of torsion resistance was at mixture No. (1) That amounted to (2.3) MPa. The reason for the difference in these ratios in the porosity and torsion resistance is that the glass powder with certain limits
worked to reduce the porosity and increase the torsion resistance, so as to fill the voids in the samples after turning the glass powder into a semi-liquid phase that is easy to flow through these voids. While it was observed that the highest value of porosity and the lowest value for torsion resistance were at mixture No. 1 (0% glass powder + 100% grok) due to the large granular size of the Iraqi Grok powder generates more gaps and thus more defects appear which lead to increased porosity and less torsion resistance In addition, the powder is a clay burnt complete its transformation with a rise in temperature. The glass powder with certain limits also worked to improve the torsion resistance of the samples containing the glass powder compared with the pure grok.

![Figure 1](image1.png)

**Figure 1.** The change in the porosity ratio when changing the mixing ratio between the Iraqi glass powder and the Iraqi grock.

![Figure 2](image2.png)

**Figure 2.** Changing the torsion resistance when changing the mixing ratios between the Iraqi glass powder and the Iraqi grock.

**Table 3.** Mixing ratios, porosity values, and torsion strength.

<table>
<thead>
<tr>
<th>Torsion resistance ratios</th>
<th>Porosity%</th>
<th>Mixing ratios (glass + grok)%</th>
<th>Mixture name</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3</td>
<td>32</td>
<td>0+100</td>
<td>1</td>
</tr>
<tr>
<td>5.03</td>
<td>25</td>
<td>10+90</td>
<td>2</td>
</tr>
<tr>
<td>7.61</td>
<td>18</td>
<td>20+80</td>
<td>3</td>
</tr>
<tr>
<td>5.142</td>
<td>20</td>
<td>30+70</td>
<td>4</td>
</tr>
</tbody>
</table>
CONCLUSIONS

1- The results shows that the production of a ceramic material with mechanical properties is better than the different mixing ratios by using a uniaxial semi dry press and then burning at a temperature of (1200) degrees Celsius.

2- The lowest porosity values were reached (18%) at mixture No.3 (20% glass powder + 80% grok powder) while the highest value was (32%) at mixture No. 1 (0% glass powder + 100% Iraqi grok Powder).

3- The highest value of torsion resistance was 7.61 MPa at mixture No.3 (20% glass powder + 80% grok powder) while the lowest value for torsion resistance was at mixture No. 1) 0% glass powder + 100 % Iraqi grok powder).

4- The addition of glass powder to the Iraqi grok improves its physical and mechanical properties.

5- When burning samples forms at higher temperatures, we obtain higher physical and mechanical properties.

REFERENCES


