

## تحضير ودراسة خواص البلاطات ومونة الدرز السيراميكية المقاومة كيميائيا للسوائل القاعدية

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### الخلاصة

حضرت ودرست خواص بلاطات ومونة الدرز السيراميكية المقاومة كيميائيا في هذه الدراسة نظرا لشحة النشر العلمي في هذا الموضوع في حقول المواد السيراميكية. وقد كانت معظم المواد السيراميكية المستعملة هي خامات متوافرة محليا والباقي مواد متوافرة تجاريا.

قيست الخواص الفيزيائية والميكانيكية للبلاطات والمونة المحضرة التي بينت انها تنافس مواد البناء التقليدية. وقد اجري فحص اختبار المقاومة الكيميائية للسوائل القاعدية بتعريض نماذج الاختبار من البلاطات والمونة الى محلول (10%NaOH) مدة اسبوعين. وبينت النتائج عدم وجود اشارات الى تأثر نماذج الاختبار للبلاطات والمونة بالهجوم الكيميائي.

نوقشت النتائج ورسمت أهم الاستنتاجات وذلك لتشجيع انشاء صناعة من هذا النوع في العراق.

# Physical & Mechanical Properties of Chemical Resistance Ceramic Tiles and Mortar to Alkali Solution

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## Abstract

Chemical resistance ceramic tiles and mortar to alkali solution are prepared and characterized in this study due to the lack of this kind of publications in ceramic literature. Most of the utilized materials are readily available raw materials and the other materials are available commercially.

Physical and mechanical properties are measured and indicate that the prepared ceramic tile and mortars are competitive to traditional building materials. Chemical resistance test against alkali solution is also performed by subjecting test specimens to 10%NaOH liquid for two weeks. The results give no indication of chemical attack to specimens of ceramic tile and mortar.

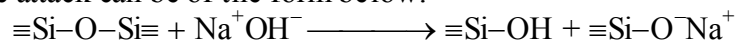
The results are discussed and important conclusions are drawn to encourage creating such kind of industry in IRAQ.

## Introduction

One of the major applications of ceramics is the chemical resistance. In fact, chemical resistivity is a constant concern of materials research and development. The prime factors for feasibility study for a ceramic production plant like ceramic tiles is the availability and accessibility of raw materials, the cost of such materials, economic production plant and achievability of the demanded properties. Accordingly, chemical resistance is a prime factor for ceramic tiles composed of cheaper raw materials [1-2].

Ceramic tiles and mortars are classified as "Traditional Ceramics"; in which ceramics raw materials like silica, kaolin, feldspars...etc are composing this type of ceramics. In contrary, advanced ceramics is generally synthesized through complex chemical process starting from raw material and finalizing in the advanced ceramic materials. Thus, advanced ceramics is not used in applications like tile because it consumes much material that draws clear cost boundaries. The selection of raw materials plus the preparation processes express the traditional ceramics "Technological Root" [1,3,4].

The main component of the traditional ceramic product is usually the Silica ( $\alpha$ -SiO<sub>2</sub>) usually composing 97-98% of natural sand with kaolin, alkali and alkaline oxides as the remainder. When the silica is exposed to liquid of Alkali effect, e.g. water contains alkali ions R<sup>+</sup> like NaOH, the attack can be of the form below:



The rate of the above reaction depends on the concentration of alkali ions in the liquid. If there is enough exposure to solution of Alkali effects, the process of silica network destruction can continue leading to gradually breakdown in the silica network, i.e. enhance the chance for material failure [4-5].

The source of silica in ceramic tiles can be from direct addition of silica to the starting recipe or as a result of firing of kaolin yielding mullite and silica.

There are two strategies which help in enhancing resistance to Alkali solution.

- The first is including the ceramic with oxides of basic effects like alkaline or alkaline earths or increasing the content of those oxides. Here, the fluorspar CaF<sub>2</sub> plays an

important role due to that it absorbs oxygen from the environment composing the alkaline earth CaO and releases the flour into the matrix. The flour plays two important roles, the first, is that it exerts strong basic effects that protect the matrix from Alkali attacks which is very useful in fabricating ceramics tiles, the second is that it enhances adhering effects when used in composition of ceramic mortar.

- The second strategy is enhancing densification during sintering of the ceramic by choosing proper sintering time and temperature. That is to minimize the porosity of the ceramic tile which led to less penetration of solution, and as result, minimizing the chemical attack.

The above mentioned strategies are used in the research, in addition to using chemically resistant filler, namely styrene butadiene liquid resin SBR in the synthesis of the mortar. This addition is intended to enclose the porosity of the mortar to reduce liquid penetration and consequently the chemical attack.

## **Experimental part**

### **A. Preparation of Ceramic Tile:**

The starting raw materials that are composing the ceramic tile are chosen according to percentages shown in table 1.

The soda lime glass was brought from Al-Taji glass manufacturing site. The soda lime glass powder is added to reduce the sintering temperature of the ceramic tile. All the powder raw materials are sieved by 50 $\mu$ m sieve before weighing and mixing.

15 ml of tap water was added to each 100g of the powder blend. Mixing thoroughly and compacting in steel dies. The applied compacting pressure is 100n/cm<sup>2</sup>.

Subsequently, the compacts are sintered in 1000°C for 2hrs. Density, porosity and water absorption are measured according to ASTM C373-88 [6]. The mechanical properties, namely, Charpy impact test and compression strength are also measured according to ASTM C368-88 [7].

### **B. Preparation of Ceramic Mortar:**

To prepare the mortar, three solid materials are used, namely, the flint, fluoro sodium silicate and soda lime glass. The powders are sieved by 50 $\mu$ m sieve before weighing and mixing with the liquid component. The liquid component is the styrene butadiene rubber. The percentages of the mortar blend are shown in table 2. Up to 15 ml of tap water can be added to the blend to achieve a good mixing.

After the mixing process, the mortar is applied to the ceramic tiles to produce complete tile and mortar system. The mortar is also casted in steel dies and left to dry. After one week, the dried mortar casts are subjected to Charpy impact test and compression test.

Both of the ceramic tile and mortar are subjected to chemical resistance test according to ASTM C650-97[8]. Each specimen is washed in distilled water, dried in 120°C for 24hrs and the dry weights are recorded. Then each specimen is immersed in 10% NaOH solution in separate beakers. The specimens are left in that solution for 2 weeks. Then, each specimen again is washed and dried. Visual inspection is applied to detect any affected area of the specimens by the Alkali solution. Also, a second dry weight is recorded for the specimens to detect any change of weight that indicates visually undetectable effect of the alkali solution on the specimens.

## Results and Discussion

Table 3 display density, porosity and water absorption of the prepared ceramic tile and mortar. The water absorption of both the prepared ceramic tile and mortar is undetectable to three significant digits.

These results indicate that the sintering process applied to the ceramic tile was able to close all the open porosity which should be opposing penetration of the Alkali liquid and minimizing the chance for chemical attack. As well, applying SBR to the mortar also succeeds to close the open porosity thus protects the mortar from Alkali liquid penetration and attack.

The mechanical properties of the ceramic tile and mortar are shown in table 4. Specimens 1×1cm base and 4cm height are used to perform the mechanical tests.

It's clear that the measured mechanical properties ceramic tile are superior to that of the traditional building brick. That makes the prepared alkali resistance ceramic tiles feasible in building reservoirs for alkali solution.

The mortar also has better mechanical properties as compared to that of the traditional building brick. Its properties are, to some extent, lower than that of the ceramic tile, which is acceptable due to castables which generally have lower mechanical properties as compared to that of the sintered ceramic of comparable composition.

Finally, the results of chemical resistance to alkali solution are to be discussed. The visual inspection did not show any deterioration of specimen faces for both the ceramic tile and mortar. The only visual detectable effect is some coloring at the upper face of ceramic tile only as seen in figure 1. The origin of this coloring is better explained in terms of the precipitation of minor impurities in the NaOH liquid on the upper face of the tile.

Table 5 shows the weight difference of the ceramic tile and mortar before and after subjecting to chemical resistance test against alkali liquid. The table shows that the weight difference is in forth significant digit which reflects no obvious chemical attach of the alkali liquid for both the ceramic tile and mortar.

## Conclusions

1. Good mechanical properties are achieved for the prepared alkali resistant ceramic tile and mortar compared to that of traditional building brick.
2. Two strategies are used to enhance the ceramic tile and mortar against chemical attach by alkali solution,
  - The first includes materials of alkali effect in the composition of the ceramic tile and mortar;
  - The second strategy are to close the open porosity of the ceramic tile by a proper choice of sintering time and temperature for the ceramic tile and including SBR in the composition of the mortar

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**Fig. (1): The ceramic tile shows some coloring effect on its face after immersing in 10% NaOH solution for two weeks.**

**Table (1): Composition of the ceramic tile recipe**

No.	Raw material	wt%
1	Duekhla kaolin	60
2	Urdhuma flint (silica)	30
3	Soda lime glass	5
4	Fluorspar (CaF)	5

**Table (2): Composition of the ceramic Mortar recipe**

No.	Raw material	wt%
1	Urdhuma flint	35
2	Soda lime glass	30
3	Fluoro Sodium Silicate	10
4	Sodium Silicate penta hydrate	20
5	SBR	5

**Table (3): Physical properties of the ceramic tile and mortar**

	Bulk Density g/cm <sup>3</sup>	Porosity (open+closed) %	Water absorption %
Tile	2.105	10.42	0.000
Mortar	1.951	16.98	0.000

**Table (4): The mechanical properties of the Tile and Mortar**

	Charpy Impact Energy [Joule]	Compression Test [MPa]
Tile	0.98	171
Mortar	0.83	42.45
Building Brick	0.64	28.25

**Table (5): weight difference of the ceramic tile and mortar before and after chemical resistance test**

	Weight before test g	Weight after test g	% Weigh loss g
Tile	12.4343	12.4341	0.0016
Mortar	13.0031	13.0028	0.0023