

## **A Study to Assess the Efficiency of some Gap Filling Materials for Ancient Ceramic Tiles**

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### **Summary:**

This research deals with the study of some Gap Filling Materials for ancient ceramic tiles, and evaluating them in terms of efficiency, even with the passage of long periods of time, and if exposed to different atmospheric fluctuations. The Complete of missing parts of ceramic tiles is one of the most important stages in the treatment and maintenance stages, because it is a kind of preservation of pottery and ceramic relics of damage and shattering that are being collected or parts of which were lost. In addition, the supplement material must meet a set of basic conditions, including that it has a stable chemical composition, amenable to the formation, amenable to additives and colorants, compatible with different environmental conditions, and that it also has an appropriate density.

The tiles investigated and analyzed by; Digital optical microscope USB, X-ray diffraction analysis XRD and Scanning electron microscope (SEM-EDX). It was necessary that the selected complementary materials are being experimented and studied to identify and measure the different physio-mechanical properties of them such as (porosity - density - water absorption - pressure resistance - shrinkage) before application to reach the best mixtures that can be used in the process of completing ceramic tiles. Among these, materials the mixture: Kemaboxy 150 + modern ceramic powder + fiberglass, in addition to the mix: Araldite 1306 + modern ceramic powder + fiberglass.

The mixture, which contained Kemaboxy 150, gave the most value for pressure resistance, porosity and water absorption. Moreover, it gave very good results in the process of completing the ancient ceramic tiles that were recommended for using by restorers in the different sites. The completion process is an important modification, as it serves as a reinforcement and strengthening of the ceramic monuments and tiles whose state requires completion.

As it works to serve the structural cohesion and give it the strength of historical neighborhoods, the complementary material must be homogeneous with ceramic objects, and of the same composition. In addition, to restore the antiquity to its original form. The third step, which complete the previous stages, that is a good storage operation.

### Conditions that must be met in the completion materials:

That the complement material is capable of forming or casting through its flexible state when used. As well as being dyed at the time, That the supplemental material is subjected to additives, dyes, and colorings, or to add some fillers , that the finishing material for ceramic tiles bear different environmental conditions, ability in surface coatings such as acrylic colors and other colors in color frills. That the complementary material is of high value suitable for ceramic tiles, it is possible to be retrieved upon its return.

### Examples of some finishing materials for ceramic tiles:

**1- Gypsum:** Gypsum is a natural and synthetic material with different properties, all composed of  $\text{CaSO}_4$ .

**2- Medical gypsum:** It consists of aqueous calcium sulfate by not less than 93%, and it is considered the purest form of gypsum today and is mainly used for medical purposes, and characterized by a time of suspension that is not less than two minutes and usually no more than four minutes.

**3- Plaster of Paris:** Gypsum consists of  $\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$  semi-hydrated calcium sulfate, gypsum is an easy-to-use material to complete, and it was widely used in the past due to its ease of obtaining it.

**4- Dufix:** It is one of the substances, whose composition depends on the presence of calcium sulfate with cellulose ethers. Which is a substance that is miscible with water, and considered a stable material with little shrinkage, as it is one of the materials that is easy to operate and its period of operation is suitable for the purposes of completion, and its drying period ranges from half an hour to an hour, and is easy to recover Mechanics.

### Fillers and additives

**Grog Modern Pottery Powder:** It is considered one of the best fillers that are being used in completing ceramic tiles, due to the similarity between its properties and the properties of the original body as they have the same mineral composition, in addition to that it will not interact with the artifact, and it is possible to add a binder to bind the pottery or porcelain powder material to be a mixture suitable for completion.

**Microballons:** It is a fine spherical granule with a white color, characterized by being easy to be formed and being compressible, and gives an easy smoothing surface, as it is characterized by low weight and increase in density upon completion of large areas and it is prepared by adding a Paraloid solution B-72 at a concentration of 30% dissolved in acetone and alcohol in a ratio of 1: 1, then the Microbalon is added to the Paraloid B-72 in a 1: 3 ratios, respectively.

### **KEMAXIT 200**

- It is a gypsum product based on slow-acting gypsum.
- Meets American standard ASTM C 28 for uncertainty time.
- It meets the requirements of ISO 6591-1 and the Egyptian specifications No. 2254 for packaging.

Fulfill the technical requirements of the CMBI 1120 plant.  
 – Provides a smooth, strong surface that can be cleaned with water.  
 - It is considered a final surface without paint, and it can be coated with various types of paints.

The study provides researchers and restorers with important information about the nature and properties of restoration materials. In addition, it reveals the extent of effectiveness of these materials in the different treatment stages so that restorers can choose the best.

Latest and most successful materials and the most appropriate application methods in the field of restoration and maintenance of ceramic monuments in order to achieve a successful treatment. The study is subjected to a set of complementary materials to evaluate them and know their stability after exposure to various artificial-aging factors in order to reach the best materials for use in the restoration and maintenance of the ceramic monuments under study.

### **1- Archaeological documentation:**

Archaeological description to the plate bears archaeological number 6305: it consists of four ceramic tiles from the Ottoman period decorated with floral motifs and flowers, which consist of a vase branching of irises and carnations in blue and light blue on a white floor in the Museum of Islamic Art in Cairo.

### **2- Photographic documentation and visual investigation:**

- Photographic documentation of the ceramic tile panel was carried out in all its details, and then a visual examination with the naked eyes and magnifying lenses of the ceramic tiles under study carried out at the Museum of Islamic Art in Cairo.  
 - The dimensions of the painting were fully documented before starting the dismantling and restoration works and displaying them again:

Length: 110 cm x Width: 35 cm with the surrounding frame.

### **3- Digital optical microscope examination:**

The digital optical microscope used to enlarge small things with light to know the optical properties of the sample, and it consists of a group of objective and ocular lenses to examine the samples, and the enlargement power reaches 1500-2000 times.

USB digital microscope used to examine colored materials, in terms of shape, size and color of those colored materials. Moreover, to study the surface components of each of the colors, aspects of damage- as well as previous restoration work. In addition, the digital microscope used for its ease of use and the possibility of controlling it through a computer, and examining parts that are difficult to see with the naked eyes, Examination and digital microscopy of the ceramic tile at the Museum of Islamic Art show a magnification of x 250.

### **4- Analysis by X-ray Diffraction Method:**

Analysis by X-ray diffraction is a good way to study the nature of crystallized materials, and it is also the usual method for identifying the mineral components of the clay and all crystalline materials, the samples were analyzed in the X-ray analytical laboratory at the Ministry of Antiquities.

### 5- Examination and analysis using the Scanning Electron Microscope (SEM) with EDX unit:

Electron Microscope (SEM) is one of the most important modern technologies that are indispensable in the field of restoration in particular, and the field of archaeology in general, and it gives us a deep picture of the morphology of the archaeological sample.

### 6- The influence of artificial-aging factors on ceramic tile mortars

In this regard, two types of statutes of limitations have been made:

#### A - Heat aging according to EM 14066: 2003

1. The samples were exposed to a temperature of 105° C in the oven for 24 hours to reach a constant weight, and then the samples were weighed.
2. The samples were immersed for 4 hours in water.
3. the samples have been taken out and put in the oven for 18 hours at a temperature of 60° C.
4. The samples were left at room temperature for two hours before starting the next cycle, and that cycle was repeated 21 times.
5. Weights were followed up after each session, and weights were accurately recorded in a table.
6. The final weight was subtracted from the initial weight and percentages were calculated. Then the values were measured for the physical properties.

#### B - Salt obsolescence through the application of European specifications 12370:2000

1. The samples placed in an oven at a temperature of 60° C for 24 hours in order to reach a constant weight.
2. The samples completely immersed in one type of salt at a concentration of 5% NaCl.
3. Samples left to cool at room temperature for two hours before starting a new weathering cycle, and the salt weathering was repeated successive cycles.

### Discussing the results:

By comparing the results of using the old traditional complementary materials and modern supplementary materials that were selected through three groups, we found that:

**The first group (A1), (A2):** two types of gypsum were chosen, and the bonding Addibond 65 was standardized for comparison between the effect of treated gypsum and the effect of Dufix on the change of the values of the different properties of the two mortars.

(A1) consists of Kemaxit 200 (treated gypsum) + Addibond 65 adhesive + fiberglass.

As for (A2), it is composed of (Metylan dufix) trade name + water + Addibond 65 adhesive + fiberglass.

**The second group (B1), (B2):** Modern porcelain powder mortar was standardized with a difference of solvent (Paraloid 72 - Paraloid 44) for comparison between the effect of using Paraloid B72 and Paraloid B44 on changing the different properties of the two mortars.

(B1) consists of modern porcelain powder + Paraloid B44 dissolved in acetone at a concentration of 40% + fiberglass. As for mortar (B2), it consists of porcelain powder + Paraloid B72 dissolved in acetone at a concentration of 40% + fiberglass.

**The third group (C1), (C2):** The mortar (C1), which has the same composition and proportions of materials for the mortar (C2), it was chosen according to the difference of the binder material, which is epoxy kemaboxy 150 + a hardener. For a comparison between the use of Araldite 1306 and the effect of Epoxy 150 on changing the values of different properties to the two mortars (C2)(C1).

(C1) mortar consists of kemaboxy 150 + modern porcelain powder + fiberglass, while (C2) mortar consists of Araldite 1306 + modern porcelain powder + fiberglass.

Through a comparison of the different properties and tests, it was found that Kemaboxy 150 is the strongest supplemental material that has been tried, and the highest value of resistance to pressure, porosity and water absorption. Hence, it is recommended using and applying Kemaboxy 150 + modern porcelain powder + fiberglass to complement the ceramic tiles.

The main objective of the research was achieved, which is to identify the distinctive properties of the different selected complementary materials, and choose the most suitable ones to be applied to the ceramic plate and then the ceramic antiquities afterwards, and the Kemaboxy 150 substance gave the best results.

## References:

- 1- (Baumgart), W. et all, *Process Mineralogy of Ceramic Materials* , Ferdinand Enke publishers Stuttgart, 1984.
- 2- (Burden), L. et all, *The reconservation of 105 Bronze Age ceramics*, *The Conservator*, 2004.
- 3- (Buys), S., & Oakley, V., *The conservation and restoration of ceramic*, Butterworth Heinemann Ltd, Oxford, 1993.
- 4- (Faulding), R., & Thomas, S., *Ceramic Tiles in Historic Buildings: Examination, Recording and Treatment*, *Journal of Architectural Conservation*, 2000.
- 5- (Geschke), R., *Ceramic gap-fills for ceramic restoration*, Routledge, *The Conservator*, 2004.
- 6- (Guidelines for the Storage and Display of Archaeological Metalwork), *English Heritage*, 2013.
- 7- (Marc), P., & Jacques, G., *Handbook of soil Analysis Mineralogical, Organic and inorganic methods*, springer, 2006.
- 8- (Marry), K. P., *Preservation in Archaeological Science*, *Institute Francais d'Archaeologie Oriental, le Caire*, 2002.
- 9- (Mas), A. et all, *Ceramic tiles waste as replacement material in Portland cement*, *Advances in Cement Research Volume 28 Issue 4*, 2015.
- 10- (Otabek), A., *Research of basic Methods of Conservation and Restoration of Pottery*, *National Research Institute of Cultural Heritage, Conservation science Division, State Museum of History of Uzbekistan*, 2013.
- 11- (Stanley), P. N., *CONSERVATION ON ARCHAEOLOGICAL EXCAVATIONS With particular reference to the Mediterranean area*, ICCROM, Rome, Italy, 1995.
- 12- (Thornton), J., *Training ceramics and glass conservation at Buffalo State College: An American Perspective illustrated by treatment case histories*, In: *The Conservation of Glass and Ceramics*, Editor: Tennent, N. H., Science Publishers, William Road, London, 1999.

13- (Wolf son), M. M., *An introduction to x-ray crystal, group*, Cambridge University Press, 1980.

(alrshida), muhamad saed eabd alhafiz . dirasat m qarnt liltaathirat limukuinat hawamil wa'ardiat altaswir ealaa asqf eamayir 'usrat muhamad eali waturuq aleilaj walsiyanat ttbyqa ealaa bed alnamadhij almukhtarih , risalat dukturah , qism altarmim , kuliyyat alathar , jamieat alqahirih .2016.

(algharib), walid kamil eali muhamad algharib . dirasat eilaj wasianat alathar alfakhkhariyat walburunziat almustakhrajat min alhafayir ttbyqaan ealaa namadhij athryt min mintaqat athar alritabi bial'iismaeiliat , risalat majstir , qism altarmim , kuliyyat alathar , jamieat alqahira . 2001.

(ebdalrhim), alshiyima' . dirasat taqniat waeilaj wasianat alathar alfakhkhariyat alqibtiat almulawanat ttbyqa ealaa bed alnamadhij alfakhkhariyat min almutahaf alqabtaa , risalat majstir , qism altarmim , kuliyyat alathar , jamieat alqahira . 2003.

(ahmd), ainjy saed 'ahmad . dirasatan tahliliatan wataqniat lilfakhkhar alatharii min hafayir aljabal alqablii bihadbih aljizat mae tarmim bed alqitae alathuriat almukhtarat , risalat majstir , qism altarmim , kulayh alathar , jamieat alqahira . 2009.

(hsin), 'iibrahim eabd alqadir . wasayil wa'asalib tarmim wasianat alathar wamuqtanayat almutahif , jamieat alriyyad , almamlakat allearabiya alsaudia . 1979.

(qtb), hamada sadiq ramadan . dirasat tatbiqiat fa tahlil watatawur alkhazf alatharii wa'ieadat tarmim bed alnamadhij almukhtarat , risalatan dukturat , kuliyyat alathar , qism altarmim , jamieat alqahira . 2012.

(ebdalhmyd), husam aldiyn . al'usus aleilmiat alta tunazim eamaliat tarmim alathar , majalat kuliyyat alathar . jamieat alqahirat 1989.

(kamil), eabdallh mahmud 'ahmad . dirasat mikanikiat tilifu almaharib aljisiyat alathariat bialmunshat aldiyniat al'iislamiyat waturuq eilajiha ttbyqaan ealaa ahd almaharib aljisiyat almukhtarat bimadinat alqahrt , risalat majstir , kuliyyat alathar , qism altarmim , jamieat alqahira . 2008.

(lwakas), alfarid . almawadu walsinaeat eind qudama' almisriyn , maktabat madbuliun , altibeat al'awaliu , alqahr .1991.

(mhmd), humda muhamad muhamad . dirasat m qarnt litaqyim almawadi altaqlidiat walhadithat almustakhdimat fa tajmie waistikmal alathar alfakhkhariyat almustakhrajat min alhafayir , risalat majstir , qism altarmim , kuliyyat alathar , jamieat alqahirati. 2018.