Study of Deterioration and Conservation of A mosaic Pavement in the Baron's Palace, Egypt

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Abstract

The Baron's Palace was built in 1911, The Supreme Council of Antiquities according to the Prime Minister Decision No. 1297 of 1993 Considered it as an archaeological Building. This palace includes a mosaic pavement. A mosaic is a decorative surface finishing technique. It is made by inserting elements made of hard materials into a soft layer that holds them in place as it sets. ***Opus tessellatum*** is the most common type of ancient pavement and it used in the mosaic pavement of The Baron's Palace. Its units called tesserae. It includes geometric and floral patterns. It suffers from many deterioration factors for example erosion, salts crystallization, decay of mortars, disintegration of tesserae and missing parts. Laboratory investigations and analysis of tesserae and mortars were carried out. Investigations and analyses indicated that the mosaic tesseare made of glass. Scanning Electron Microscope (SEM) examination showing cracks, air bubbles and disintegration in the glass network. Energy Dispersive X-ray (EDX) analyses indicated that calcium or a mixture of calcium and potassium was used as a flux for the glass tesseare. X-ray diffraction (XRD) analyses showed that the mosaic mortar consists mainly of Portland cement. Recommendations of treatment and conservation of this mosaic pavement were reported.

1- Introduction

The Palace's builder was the Belgian – Baron Edouard Louis Joseph Empain (1852-1929) the prodigal son of a village school teacher who became one of Europe's greatest colonialist

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entrepreneurs of the 20th century. Empain had extensive business interests in Indonesia and in time became a well known amateur Egyptologist. He arrived in Egypt during January, 1904, intending to rescue one of his Belgian company's overseas projects, which was the construction of a railway line linking Matariya to Port Said. He then came up with the idea of acquiring low-cost land and using it to build a residential area linked to Cairo by fast public transportation. [1] He set up the Heliopolis Oasis Company in the following year. His efforts culminated in 1907 with the building of the new town of Heliopolis, out in the desert ten kilometers from the center of Cairo. For his own home he chose a prestigious location in Heliopolis and ordered Alexander Marcel, a French architect and a member of the prestigious French Institute, to build him a Hindu palace. Some say it was supposed to be more or less a copy of the temples of Angkor Wat in Cambodia that he had seen during his travels in that country, while others say it is modeled on the fabulous Hindu temples of Orissa. [2] Empain brought the best Indonesian artists and sculptors for its construction. They built it on an artificial elevation to enable the Baron to watch the rising of Heliopolis. He was finished building of his palace in 1911. The palace's striking exterior was the responsibility of Marcel, who reproduced a motley of busts, statues, elephants, snakes, Buddha's, shivers and Krishna's. The sophisticated interior was the responsibility of his French associate, Georges-Louis Claude. This team was also responsible for the construction and decoration of the Oriental Pavilion attached to the Royal Palace of Laeken in Belgium. The palace building itself has two main floors, with other

1) Howard S., Belgian Companies in Egypt, International Bond & Share Society,London, 1998, Pp. 23-26.

2) Cook, W., Surrounded by barbed wire and shrouded in superstition: The crumbling Egyptian palace of tragic Belgian millionaire who raised a city from the desert,Dailymail, United Kingdom, September, 2012, Pp. 62-63.

underground divisions. [3] The exterior of the building is ordained with chiseled stone, relief architecture, with the focal point being a Hindu style dome. He made a decision that the place where he lives in should exclusively be unparalleled in the whole world. Balconies of this palace were decorated with statues of elephants. It has a tower on a base that moves a full cycle every hour to allow someone to see all views around in all directions. On the walls of the palace there are statues made of marble for wonderful dancers from India and amazing elephants. Windows studded with small pieces of Belgium glass. It is interesting to consider that the palace was created so as not to lose sight of the sun the whole day. [4] The mosaic pavement typology of the Baron's Palace is "Opus Tessellatum", it means Pavement made of small, regularly shaped, usually quadrangular, elements (generally 5 to 20 millimetres wide) placed side by side in rows. These elements, called tesserae, are obtained by cutting different materials such as stone (often marble or limestone), ceramic or glass. fig.(1), The palace suffer from many deterioration factors and phenomena. This thesis aims to study the material composition of this mosaic pavement, its deterioration phenomena and discussion a proposal for treatment and conservation from further degradation.

2- Condition Assessment of the mosaic pavement

Many deterioration phenomena were found in the mosaic pavement, their include disintegration of tesserae from the floor, cracks and micro cracks, lacunae, loose of mortar between tesserae, disintegration of tesserae with ground layer, deterioration of mortar, erosion of tesserae, crystallization of salts, stains and layers of dirt, figs. (2).Condition Assessment of the mosaic pavement is divided

3) Van Loo, Anne and Bruwier, Marie-Cécile (eds.), Héliopolis, Brussels: Fonds Mercator, 2010, 229 p., richly illustrated ISBN 978-90-6153-930-8 .

4) Cook, W., Surrounded by barbed wire and shrouded in superstition: The crumbling Egyptian palace of tragic Belgian millionaire who raised a city from the desert,Dailymail, United Kingdom, September, 2012, Pp. 62-63.

into two sessions, Structural Deterioration and Surface Deterioration .[5]

Structural Deterioration

Structural Deterioration of the mosaic pavement includes:

Lacuna, Area of a mosaic where the tessellatum is missing. [6]

Crack, Linear break that is visible on the surface of the mosaic and may also penetrate into its lower layers.

Detachment Between Mosaic Layers, Separation or void between two layers of the mosaic. A detachment is generally not visible and can be detected by the corresponding hollow sound produced when the surface of the mosaic is tapped.fig.(2),(3).

Surface Deterioration

Surface Deterioration of the mosaic pavement includes:

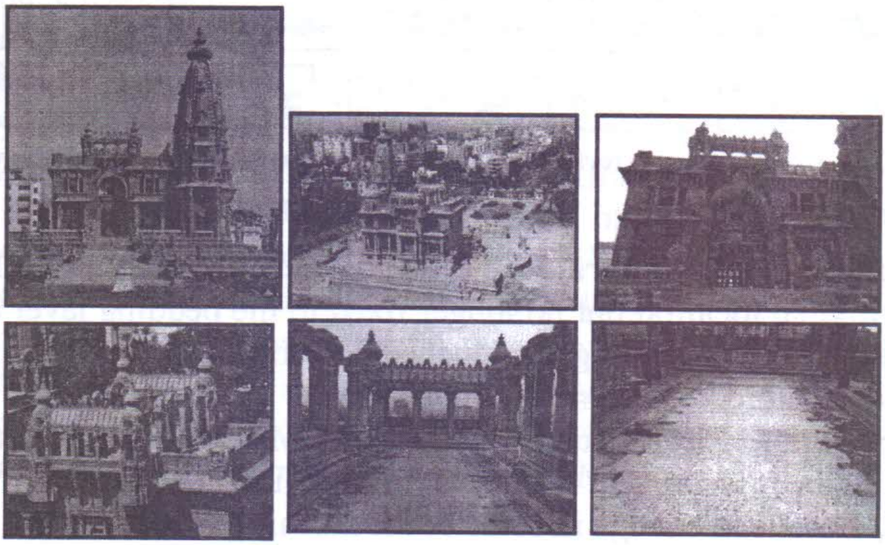

Fig. (1) Shows the Baron's Palace and the mosaic pavement.

5) Technician Training for the Maintenance of In Situ Mosaics, Getty Conservation Institute, Los Angeles, USA, 2008, Pp. 116-121.

6) Philippot, P: The problem of lacuna in mosaics, in Mosaics No.1 ICCROM, Rome, 1977, Pp. 12-22.

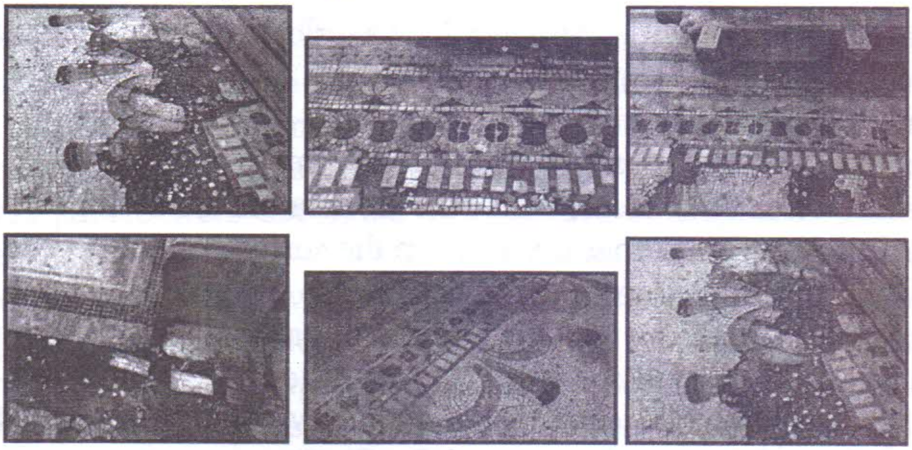

Fig. (2) Shows the mosaic pavement deterioration for example, lacuna, cracks, detachment between mosaic layers, detached tesserae, and deteriorated Tesserae.

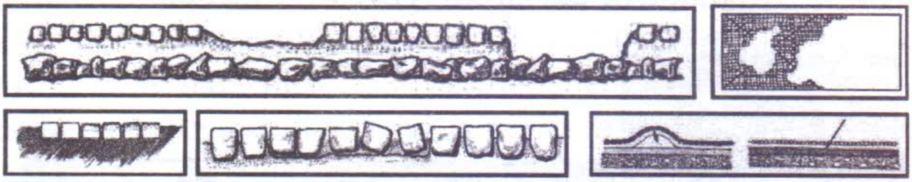

Fig. (3) Shows Lacuna, deteriorated mosaic tesserae and detachment between mosaic layers.

Detached and Deteriorated Tesserae, Tesserae that are still in their original location but no longer fixed to the bedding layer and, as a result, move when lightly touched. Deteriorated tesserae can be broken, fractured or otherwise damaged. (7)

Deteriorated Mortar Between Tesserae, Mortar in the interstices between the tesserae that is lost or no longer in good condition.

Stain, Localized change in color of the mosaic surface.

Incrustation, Mineral crust of Variable thickness and area that is often hard and compact.

Crystallization of Salts, Mineral crust of Salts, efflorescence or white powder- like crystals.fig.(4)

7) Urena, E.: The Mosaic of the good shepherd in: Mosaic No.1 ICCROM, Rome 1977.

Deterioration of the Baron's Palace mosaic pavement was caused by environmental factors which linked to the presence of water specially, it was located in the roof of the palace. Water may derive from rain and condensation which water vapor in humid air is transformed into liquid water when it comes in contact with a surface colder than the air, such as the surface of mosaic. If the salts crystallize within the mosaic, they fracture the materials enclosing them. If they crystallize on the surface of the mosaic, they form efflorescence, generally white powder-like or whisker-like crystals, loosely adhering to the mosaic surface. (8) After a long period of time, salts can also form incrustations or mineral crusts that are often hard and compact, and can strongly adhere to the mosaic. On the other hand effects of air pollution, changes in temperature and thermal expansion of the mosaic materials also caused deterioration of the mosaic pavement. (9)

3- Materials and methods

Many samples of tesserae and mosaic mortar were examined and analyzed with different methods. X-ray diffraction analysis (XRD) was used to identify the characterization of mortars and mosaic tesserae. X-ray diffractometer (Philips, PW 1840) with Ni-filtered CuKα radiation at operating conditions of 40 kV/30 mA and a scan speed of 2° (2θ)/min. was used for this purpose. Elemental analysis for the major and trace concentrations for samples of tesserae were determined by energy dispersive. Mosaic tesserae were examined by using scanning electron microscopy (SEM).

8) Technician Training for the Maintenance of In Situ Mosaics, Getty Conservation Institute, Los Angeles, USA, 2008, Pp. 67-73.

9) Espinosa-Marzal, R. M. Et al,. Mechanisms of damage by salt. In book: Limestone in the Built Environment: Present-Day Challenges for the Preservation of the Past, Geological Society of London, Special Publication No. 331 Edited By B. J. SMITH, London, 2010. Pp. 75-77.

4- Results and Discussion

4-1 Examinations and analyses of colored mosaic tesseare

The colored mosaic tesserae were studied by SEM /EDX to determine the sources of colors and the kind of fluxes which add to the glass matrix to reduce the firing temperature in addition to determine the chemical composition of the mosaic tesserae. Investigation by SEM of the mosaic tesserae samples showed the erosion, disintegration by the salt crystallization, cracks, loose some parts, voids and air bubbles may be related to problems in the manufacturing processes, [(10)] figs. (5). Analyses by EDX unit were indicated that the source of the green color in mosaic tesserae is *copper which used at ratio 1. 16 % and iron at ratio 1. 97 %* in addition to cobalt at ratio 0. 51 % . [(11)] The result showed that the source of flux is calcium which exists at ratio 10.55 % in addition to traces of potassium at ratio 0.78 % , fig. (6). Regarding to the red color of mosaic tesserae, the results indicated that the source of the red color is iron which used at ratio 3. 95 %. The result showed that the source of flux is calcium which exists at ratio 11.04 % in

Fig. (4) Shows different deterioration phenomena of the mosaic pavement.

10) Huisman, D. J., Pols, S., Joosten, I., Van Os, B. J. H., & Smit, A. (2008). Degradation processes in colorless Roman glass: cases from the Bocholtz burial. Journal of Archaeological Science, 35, 398-411.

11) Veloccia , M.L.: Conservation problems of Mosaic Insitu . in Mosaics , No.1. ICCROM, Rome, 1977.

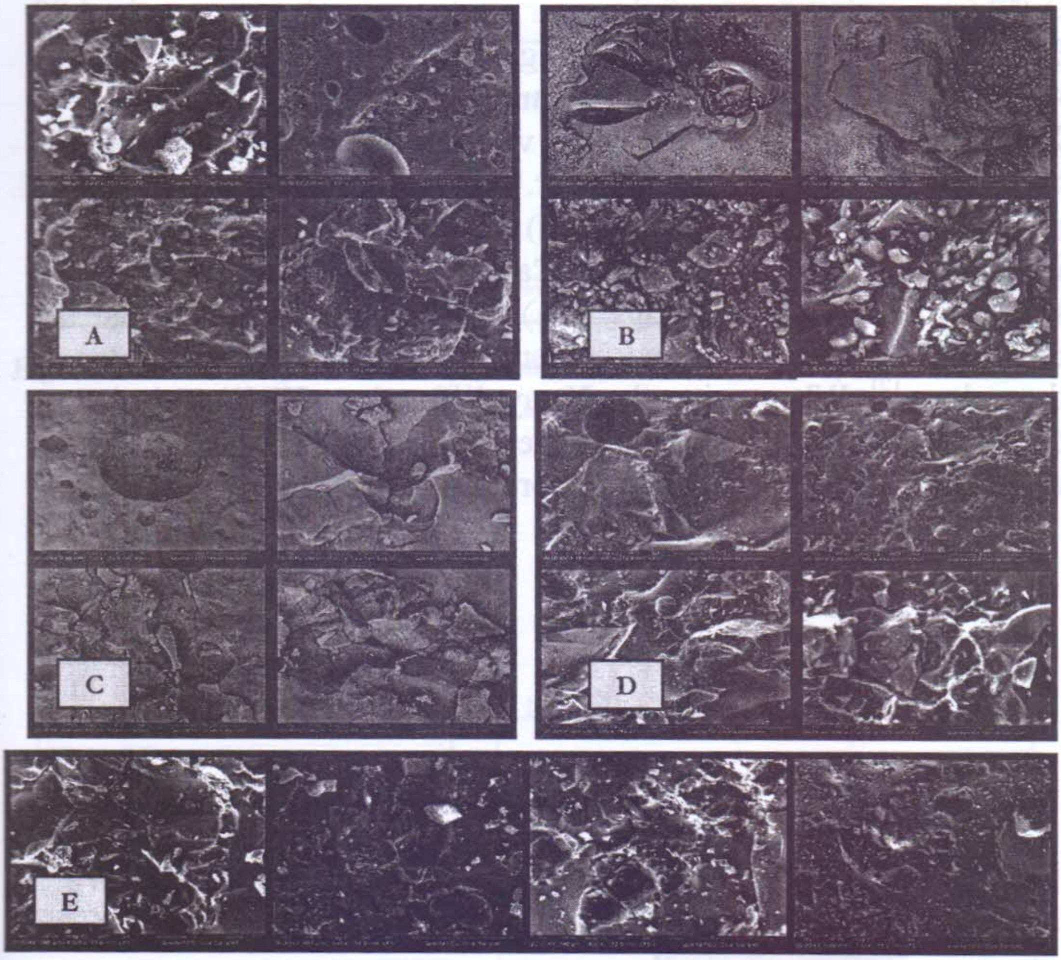

Fig. (5) SEM photomicrographs of mosaic tesseara samples (A) green (B) red (c) white (D) blue (E) yellow, showing cracks in glass network, loose some parts, pores, disintegration between parts, air bubbles and salts crystallization.

addition to potassium at ratio 1.01 % , fig. (7). On the other hand results indicated that the source of the white color in mosaic tesserae is calcium which used at ratio 12. 57 % and the source of flux is calcium in addition to traces of potassium at ratio 0.38 %, fig. (8). Related to results the source of blue color is copper at ratio 0.89 % in addition to cobalt at ratio 0.47 % and the source of flux is calcium at ratio 13.69 % , fig. (9). Finally, results indicated that the source of yellow color in mosaic tesserae is iron which used at ratio

0. 47 % and the source of flux is a mixture of calcium at ratio 4.88 % and potassium at ratio 1.7 % , fig. (10).[12]

4-2 Analyses of the mosaic pavement mortar

X-ray diffraction (XRD) analysis was used to identify the mineral composition of the mosaic mortar. It showed that, mortar consists mainly of quartz card No. (5-0490) and calcite, Card No. (5- 0586), in addition to traces of gypsum, Card No. (6-0046) and halite as a salt. Card No. (5- 0628) figs. (11). This results indicated that the mosaic mortar was Portland cement also, related to the mortar of the palace [2]. When using the X-ray diffraction (XRD) techniques, the chemical products to be analyzed in a sample should be present in quantities of several percent in order to detect the corresponding

12) Huisman, D. J., Pols, S., Joosten, I., Van Os, B. J. H., & Smit, A. Op. Cit., 2008, 398-411.

Element	Wt %	At %	K-Ratio	Z	A	F
C K	4.09	7.87	0.0050	1.0549	0.1170	1.0004
O K	26.52	38.34	0.0612	1.0371	0.2234	1.0006
NaK	4.98	5.01	0.0224	0.9705	0.4603	1.0058
MgK	0.39	0.37	0.0022	0.9948	0.5677	1.0115
AlK	1.35	1.16	0.0094	0.9655	0.7047	1.0215
SiK	47.69	39.27	0.3605	0.9936	0.8015	1.0014
K K	0.78	0.46	0.0065	0.9635	0.8718	1.0145
CaK	10.55	6.09	0.0927	0.9657	0.9084	1.0012
FeK	1.97	0.82	0.0171	0.8778	0.9857	1.0028
CoK	0.51	0.20	0.0043	0.8597	0.9916	1.0043
CuK	1.16	0.42	0.0098	0.8477	0.9963	1.0000
Total	100.00	100.00				

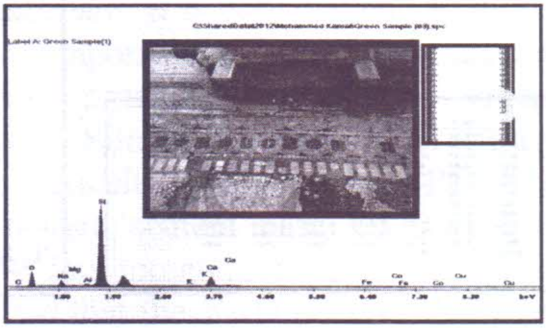

Fig. (6) Shows EDX pattern of the green mosaic tesserae.

Element	Wt %	At %	K-Ratio	Z	A	F
C K	2.84	5.78	0.0034	1.0686	0.1122	1.0003
O K	20.60	31.43	0.0471	1.0627	0.2190	1.0008
NaK	7.27	7.71	0.0344	0.9757	0.4828	1.0061
MgK	0.29	0.29	0.0017	1.0001	0.5694	1.0121
AlK	1.55	1.41	0.0109	0.9707	0.7059	1.0226
SiK	50.48	43.88	0.4038	0.9989	0.7996	1.0015
K K	1.01	0.63	0.0084	0.9689	0.8673	1.0152
CaK	11.04	6.73	0.0971	0.9712	0.9038	1.0020
MnK	0.59	0.26	0.0050	0.8671	0.9755	1.0010
FeK	3.95	1.73	0.0343	0.8830	0.9860	1.0000
CoK	0.38	0.16	0.0032	0.8648	0.9893	1.0000
Total	100.00	100.00				

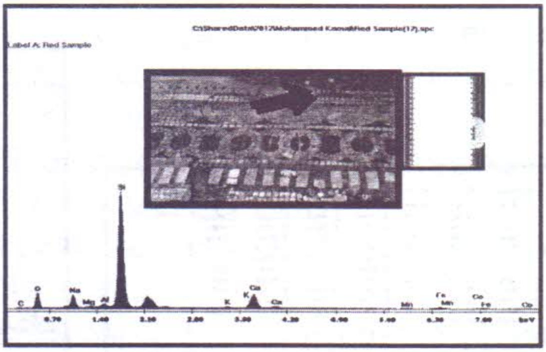

Fig. (7) Shows EDX pattern of the red mosaic tesserae.

Element	Wt %	At %	K-Ratio	Z	A	F
C K	4.27	8.19	0.0093	1.0532	0.1168	1.0004
O K	24.99	36.04	0.0555	1.0358	0.2143	1.0006
NaK	6.63	6.85	0.0329	0.9690	0.4968	1.0062
MgK	0.19	0.18	0.0011	0.9833	0.5840	1.0122
AlK	0.50	0.43	0.0036	0.9641	0.7215	1.0234
SiK	49.17	40.39	0.4025	0.9921	0.8236	1.0016
K K	0.38	0.22	0.0032	0.9420	0.8748	1.0169
CaK	12.57	7.23	0.1108	0.9641	0.9119	1.0005
MnK	0.37	0.16	0.0031	0.8605	0.9759	1.0006
FeK	0.51	0.21	0.0044	0.8762	0.9843	1.0000
CoK	0.23	0.09	0.0019	0.8581	0.9899	1.0000
Total	100.00	100.00				

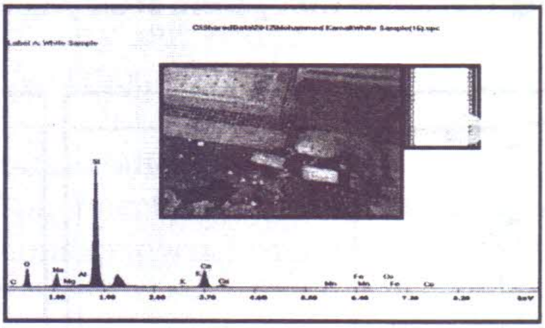

Fig. (8) Shows EDX pattern of the white mosaic tesserae.

Element	Wt %	At %	K-Ratio	Z	A	F
C K	4.59	8.97	0.0057	1.0886	0.1173	1.0003
N K	2.26	3.79	0.0031	1.0462	0.1305	1.0006
O K	31.17	31.88	0.0462	1.0378	0.2011	1.0006
NaK	4.60	4.89	0.0214	0.9711	0.4775	1.0061
MgK	0.29	0.28	0.0017	0.9958	0.5086	1.0123
AlK	0.80	0.69	0.0057	0.9661	0.7240	1.0234
SiK	49.32	41.19	0.4038	0.9941	0.8222	1.0017
CaK	13.69	8.01	0.1218	0.9664	0.9134	1.0011
MnK	0.32	0.14	0.0027	0.8628	0.9748	1.0036
FeK	1.60	0.67	0.0138	0.8765	0.9834	1.0021
CoK	0.47	0.19	0.0040	0.8604	0.9892	1.0031
CuK	0.89	0.32	0.0078	0.8486	0.9961	1.0000
Total	100.00	100.00				

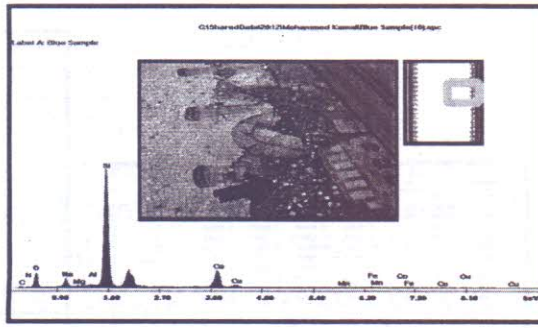

Fig. (9) Shows EDX pattern of the blue mosaic tesserae.

Element	Wt %	At %	K-Ratio	Z	A	F
C K	5.09	8.97	0.0067	1.0475	0.1251	1.0004
O K	34.60	45.77	0.0950	1.0299	0.2664	1.0006
NaK	6.89	6.15	0.0414	0.9639	0.4830	1.0051
MgK	0.24	0.21	0.0013	0.9801	0.5546	1.0100
AlK	2.03	1.59	0.0138	0.9590	0.6969	1.0182
SiK	41.84	31.52	0.3256	0.9870	0.7875	1.0009
K K	1.70	0.92	0.0142	0.9363	0.8862	1.0069
CaK	4.68	2.38	0.0428	0.9583	0.9146	1.0004
MnK	0.18	0.06	0.0013	0.8950	0.9872	1.0008
FeK	0.47	0.18	0.0041	0.8705	0.9933	1.0000
CuK	0.14	0.05	0.0012	0.8525	0.9974	1.0000
Total	100.00	100.00				

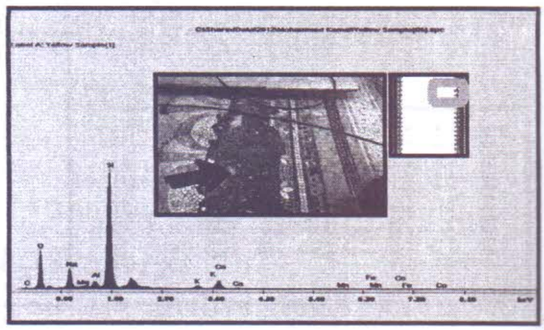

Fig. (10) Shows EDX pattern of the yellow mosaic tesserae.

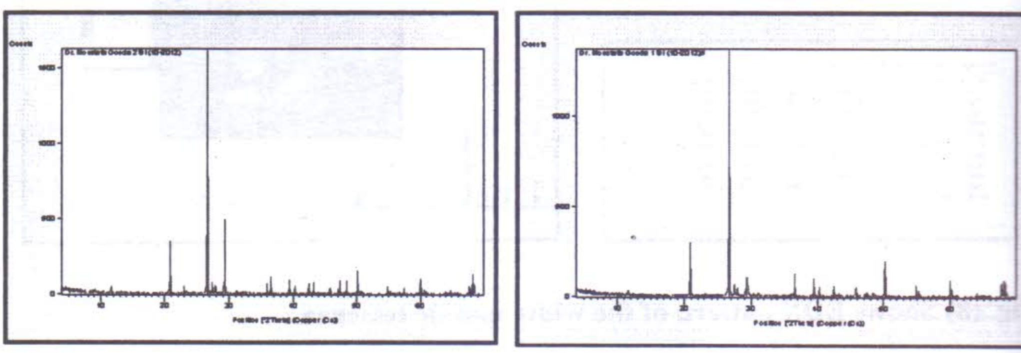

Fig. (11) Shows XRD patterns of mosaic pavement mortar.

peaks on the XRD pattern. This means, it is very difficult to detect the anhydrous mineralogical components of Portland cement. Moreover, the main hydration product of Portland cement (tobermorite, CSH / Calcium Silicate Hydrate) is nearly amorphous , so that it is very difficult to detect it by XRD. The other main component of a mature cement past, $Ca\ (OH)_2$, in general is transformed within a few months into $Ca\ CO_3$ due to carbonation by CO_2 of the air, so that the XRD peak of this final product can not be distinguished from the XRD calcite peak belonging to limestone aggregate. All these things together mean that it is practically impossible to distinguished a cement mortar after some months or a few years of curing. (13) Gypsum could be formed by sulfur dioxide oxidation and subsequent sulfation of calcite, (14) which is present both in the cement paste and in sand:

$$CaCO_3 + SO_3 + H_2O \longrightarrow Ca\ SO_4.2H_2O + CO_2$$

The presence of SO_2 as a pollutant in the area of the palace could be because of busy car traffic in the streets and the industrial activity which cause the environmental SO_2 content or adding to the mortar.

5- Recommendations of Treatment and conservation

The first step which must be carry out before restoration and conservation processes is documentation of the mosaic pavement.

5-1 The mosaic pavement documentation

Documentation of the mosaic pavement was carried out using A CAD computer program. Dererioration phenomena was appeared in this documentation, fig., (12).

The mosaic pavement needs restoration and treatment for deterioration phenomena and conservation to protect it from further

13) Ukrainczyk, N., XRD and TGA Investigation of Hardened Cement Paste Degradation, 11th Conference on Materials, Processes, Friction and Wear MATRIB'06, Vela Luka, 22-24.06.2006., Pp. 243-249.

14) Mohamed , M.A.: Deterioration of Mosaics in the Mamluk Buildings in Cairo . In : Mosaicos n 5 , Conservacion in situ , palencia , ICCROM , 1990 .

deterioration in the future. Treatment and restoration include many processes as follows :

5-2 Tools of Restoration and Conservation

The tools most commonly used for stabilization interventions are: spatulas, tweezers, small rubber bowls for small-scale operations, trowels, mortar buckets for larger-scale operations, hand drills, syringes and needles for grouting with liquid mortar. Sieves of different sizes are used to prepare the aggregates. Water buckets, sponges and hand held water sprayers are used to give a good finish to the mortars, while wet floor cloths and plastic sheets insure that the mortars dry slowly. (15)

5-3 Cleaning

Cleaning should be carried out gradually, starting with the removal of less strongly adhering deposits, like soil, before proceeding to more strongly adhering deposits, such as micro-organisms (lichens, etc.). While cleaning, water should be used in minimal amounts and changed as soon as it becomes dirty. Chemicals should not be used for cleaning as they can damage mosaics. Cleaning can be carried out with or without water. The most commonly used cleaning tools are scalpels, dental tools, wooden sticks, chisels, various kinds of brushes (never metal brushes), paintbrushes, manual blower bulbs, vacuum cleaners, sponges and hand held water sprayers. Each tool has specific characteristics and must therefore be used for specific operations. The incorrect use of a tool can damage the mosaic and break the tool. (16) fig. (13).

5-4 Pre - Consolidation

If the surfaces of preparatory layers inside lacunae are fragile, they can be consolidated with limewater before undertaking stabilization operations.

5-5 Repairing Mortars

15) Technician Training for the Maintenance of In Situ Mosaics, Getty Conservation Institute, Los Angeles, USA, 2008, Pp. 67-73.

16) Unger , H: practical Mosaics , studio vista , London , 1968.

Mortars are used for all mosaic stabilization operations. A mortar is the combination of a binder (lime, etc.), aggregates (sand, gravel, etc.) and the appropriate quantity of water. This mixture is used while still soft and malleable, and fulfills its structural function when it sets and becomes hard. (17) The main types of interventions requiring mortar are, resetting detached tesserae in their original position and orientation, filling interstices between tesserae, applying edging, filling lacunae and cracks and grouting voids located between the preparatory layers of the mosaic.

5-6 Resetting Detached Tesserae

Placing detached tesserae back in their original position and with their original orientation using mortar. (18) For example to reset detached tesserae, the use of a lime-rich mortar made of lime putty and a fine aggregate is recommended.A liquid mortar containing very fine aggregates should be used to fill a void between preparatory layers, by injection using a syringe. Hydraulic lime should be used as a binder because the mortar must be able to set without being in contact with air. fig. (13).

5-7 Filling Between Tesserae

Applying mortar in interstices between tesserae.

5-8 Grouting Between Preparatory Layers

Introducing a grout (liquid mortar) into a void caused by a detachment between preparatory layers. (19)

5-9 Fill a Lacuna using Hydraulic Mortar

To make a surface fill of a lacuna that will be exposed to the weather and walked on, a hydraulic mortar should be used because

17) F. Puertas et al., Characterization of mortars from Italica mosaics: Causes of deterioration, proceedings of 5th conference of the international committee for the conservation of mosaics, Conimbriga, 1994, Pp. 197-202.

18) Whir, R.: The Restoration of Mosaic in Germany in : Mosaics No.1 , ICCROM , Rome , 1977.

19) T.C.,Roby: Consolidation of A floor mosaic during the excavation of a Byzantine Church in Petra, Jordan, proceedings of 5th conference of the international committee for the conservation of mosaics, Conimbriga, 1994, Pp. 31-38.

it is harder and more resistant. Aggregates of the appropriate color and size should be chosen carefully for, as with any surface mortar, aesthetic issues have to be considered. [20] When looking at the mosaic, attention should not be drawn to the intervention mortars. The color and texture of the mortar should therefore blend in visually with those of the mosaic so that the mosaic surface always remains visually dominant. [21] fig. (13).

5-10 Fill a very deep lacuna

To fill a very deep lacuna, either a hydraulic mortar applied in one layer, or a nonhydraulic mortar applied in several layers, can be used. [22] The thicker the mortar layer needs to be, the larger the aggregates should be to improve strength and to diminish shrinkage and cracking of the mortar. [23]

5-11 Edging Repair

Application of a sufficiently thick layer of mortar along the edges of a mosaic that functions as a fill. [24]

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20) Ferrangi, D. et al., In situ consolidation of wall and floor mosaics by means of injection grouting techniques, In: Mmsaics No. 3, Conservation in situ, Aquilea, 1983, Rome, ICCROM.

21) M.C., Ceriotti, Proposals for reconstructing missing sections in mosaics, proceedings of 5th conference of the international committee for the conservation of mosaics, Conimbriga, 1994, Pp. 141-144.

22) R. Nardi, Preventive Conservation of Mosaics at archaeological sites, proceedings of 5th conference of the international committee for the conservation of mosaics, Conimbriga, 1994, Pp. 213-218.

23) Papageorghiou, The Mosaics of Cyprus: Problems of Conservation, proceedings of 3th conference of the international committee for the conservation of mosaics, Conservation in situ, Aquileia, 1983, Pp. 31-38.

24) Sickels-Taves, Lauren B. (1995) "Creep, Shrinkage, and Mortars in Historic Preservation" Journal of Testing and Evaluation, JTEVA Vol. 23, No. 6 (November), pp. 447-452.

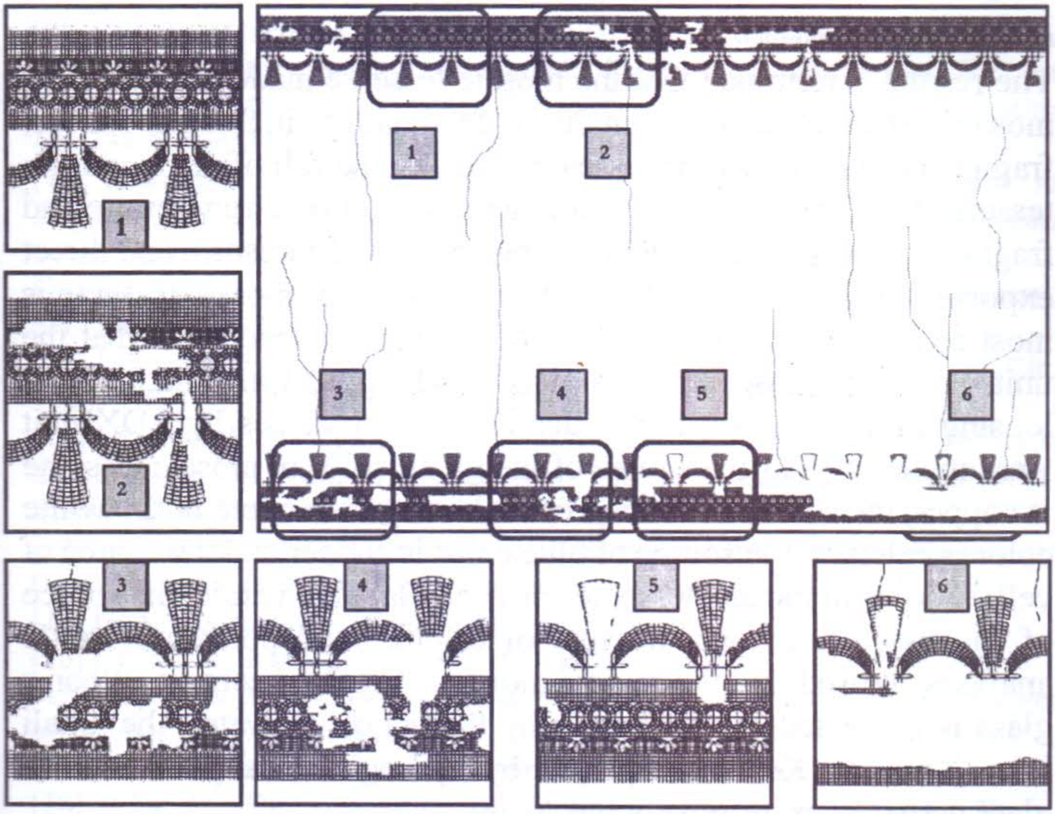

Fig. (12) Shows documentation of the mosaic pavement and its deterioration phenomena using A CAD computer program.

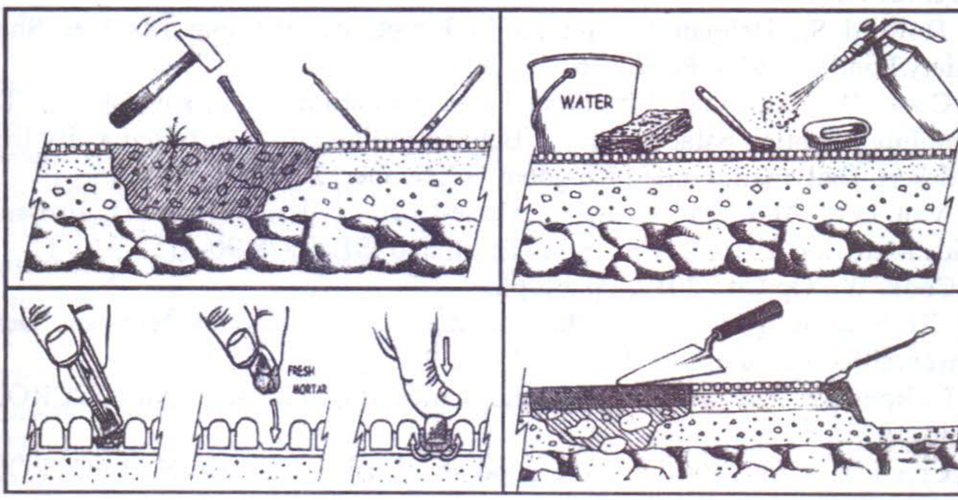

Fig. (13) Shows treatment and conservation processes of A mosaic pavement.

6- Conclusion

The results determined that the mosaic tesseare made of glass. The mosaic tesserae suffer from high degradation including failure, fragile and flaking off the tesseare surfaces and fall of many mosaic tesserae from the floor. The binding mortars suffer from failure and fragile due to chemical alteration by sources of moisture and direct exposure to environmental conditions. Failure of mosaic tesserae is most commonly water related. SEM examination indicated that the units are highly susceptible to glaze cracking, spilling and material loosing in addition to mortar degradation. Analyses by EDX unit were indicated that the source of the green color in mosaic tesserae is copper, the source of the red color is iron, the source of the white color is calcium, the source of blue color is copper and the source of yellow color in mosaic tesserae is iron. Related to results the source of flux is calcium or a mixture of calcium and potassium. XRD analyses showed that the mosaic mortar is Portland cement. When a glass is subjected to weathering by the action of water, the alkali ions (Na^+ and K^+) are replaced by hydrogen ions (H^+) and the glass network progressively breaks up.

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دراسة تلف وصيانة أرضية فسيفساء بقصر البارون، مصر.

ملخص البحث

قام البارون البلجيكي ادوارد لويس جوزيف أمبان بإنشاء ضاحية مصر الجديدة وشيد فيها قصره المعروف بقصر البارون وانتهي من بنائه عام 1911م والقصر من الداخل حجمه صغير، فهو لا يزيد علي طابقين ويحتوي علي سبعة حجرات فقط. الطابق الأول عبارة عن صالة كبيرة وثلاث حجرات ، أما الطابق العلوي فيتكون من أربعة حجرات. يوجد بسطح القصر أرضية من الفسيفساء الملونة والتي تحتوي علي زخارف هندسية ونباتية وقد قام المجلس الأعلى للآثار بتسجيل القصر كمبني أثري بموجب قرار رئيس الوزراء رقم 1297 لعام 1993م. وقد تعرضت أرضية الفسيفساء لعوامل تلف مختلفة بسبب تعرضها بشكل مباشر للظروف الجوية مثل مياه الأمطار والتكثف والتغيرات في درجات الرطوبة والحرارة والتلوث الجوي والعامل البشري المتمثل في الإهمال وعدم إجراء الصيانة الدورية اللازمة لها. أدي ذلك إلي وجود مظاهر تلف متنوعة من أهمها فقدان في وحدات الفسيفساء مما أدي إلي وجود فجوات ووجود شروخ وانفصالات ما بين الطبقات المختلفة للفسيفساء بالإضافة إلي تلف المونة وتآكل وحدات الفسيفساء ووجود أتربة واتساخات. تم إجراء الفحوص والتحاليل المختلفة لأرضية الفسيفساء حيث تم فحصها بواسطة الميكروسكوب الإلكتروني الماسح الذي أتضح أن قطع الفسيفساء تم صنعها من الزجاج ووجود شروخ دقيقة وانفصالات في الجسم الزجاجي المكون لها. تبين من تحليل قطع الفسيفساء بواسطة وحدة EDX الملحقة بالميكروسكوب الإلكتروني الماسح أن قطع الفسيفساء من الزجاج الملون بالألوان المختلفة واتضح أن النحاس والكوبلت في وجود الحديد هم مصدر اللون الأخضر وتبين أن النحاس هو مصدر اللون الأزرق والحديد هو مصدر اللون الأحمر والكالسيوم هو مصدر اللون الأبيض والحديد هو مصدر اللون الأصفر، كما أظهرت النتائج أن المادة المصهرة المستخدمة هي الكالسيوم أو خليط من الكالسيوم والبوتاسيوم. أظهرت نتائج التحليل لمونة الفسيفساء باستخدام حيود الأشعة السينية أن المونة المستخدمة هي مونة الأسمنت وهي المونة التي استخدمت كذلك في عمليات بناء القصر بشكل عام. أجريت عملية توثيق لأرضية الفسيفساء وتم توقيع مظاهر التلف المختلفة عليها وذلك باستخدام برنامج كاد بواسطة الحاسب الآلي. من خلال نتائج الفحوص والتحاليل ودراسة الوضع الراهن لأرضية الفسيفساء وما بها من تلف وتدهور تم وضع توصيات وخطة مقترحة لعمليات العلاج والصيانة المختلفة لأرضية الفسيفساء والتي اشتملت علي عمليات التنظيف والتقوية ومعالجة واستكمال الفجوات وإعادة تثبيت قطع الفسيفساء المنفصلة إلي أماكنها الأصلية وترميم الحواف واختتم البحث بالنتائج المستخلصة من الدراسة.