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A Conservation-Based Approach for Making a Proper Coating and Mortar Regarding the Physical and Environmental Features of Ziwiyeh Castle[1]

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ABSTRACT

One of the most important procedures to take for the conservation and restoration of the historical works is identifying the chemical components of the material both technically and essentially, as it is necessary to any conservative and restorative projects. This paper aims to offer proper conservative coating for protecting the clay structure of Ziwiyeh Castle, by examining and identifying the main component material and in fact the primary material of its remaining mortar and coating.
After taking samples of the original mortar and coating of Ziwiyeh Castle, codifying and taking them to the laboratory, firstly some wet chemistry tests have been done on them. These tests include examining their being carbonated using Hydrochloric Acid (HCl), identifying the plaster using Barium Chloride($BaCl_2$) and Ammonium oxalate ($(NH_4)_2C_2O_4$), and also examining the resulted mixture's being Carbonated using Phenolphthalein ($C_{20}H_{14}O_4$) for identifying the main material of the samples, and following this, the X-ray Scattering Device(XRD) analysis for finding their component material was done.
The results from all the steps of wet chemistry test were equal and the primary component material of all the three cases was known to be Calcium Oxide. XRD analysis results also confirm these results, and in addition to amounts of Calcite, Quartz, clay and Chlorite were also seen in the test peaks. Regarding these results, Calcite was added to the soil in order to make the conservative mortar and coating, results of which showed Calcite as being an additive for fixing the soil.
KEY WORDS: Ziwiyeh, mortar, coating, conservation

INTRODUCTION

Ziwiyeh Castle was Manayian's capital and it was located in the Northern West of Kurdistan province, and is 40 km far from the Northern East part of Saqqez (Sarfaraz:2002:92). This castle has a clay and adobe structure and is undergoing many damages yearly. With respect to the cold and rainy climate of Ziwiyeh region in Kurdistan, so the atmosphere and the environmental agents are the main threatening factors to this building. The damages mostly take part as physical damages in the unprotected walls or those which do not have a proper conservative layer suitable for the specific climate of that region or resistant against those threatening agents. This factor has been damaging a major part of the clay structure of this castle from the time it was discovered and excavated from 1325 until two years ago, and the conservative program for protecting this castle was executed from two years ago.

This article is one of the first scientific researches which have been done for examining the component material of the mortar and old coating of Ziwiyeh ancient castle. Identifying the component material of the ancient buildings is one of the primary procedures for providing conservative and restorative solutions. Mortar and coating, which are the two main and essential in the structure of every walls of each building, have been as made up with different material, so that to plan a proper conservative project for them nowadays requires scientific examinations and protection based on scientific methods. This study aims to identify the component materials of the original mortar and coating of Ziwiyeh castle in order to find proper conservative mortar and plaster for this building.

The questions and hypothesis of this study

Research question: regarding the specific climate and environmental conditions of Ziwiyeh castle, what sort of material component could be used as the protective layer on the body of the castle and restorative mortar suitable for the protection process of this castle?

1 - This paper of master thesis restoration of historical and cultural objects by Mr. Kaveh Bahramzadeh, in Tehran Art University as: "Preventive conservation of the adobe archaeological sites (case study: stability evaluation of mortar and mud bricks used in Ziwiyeh ancient castle, for provide conservation guidelines)", with Supervisor Dr. Alireza Razeghi is extracted.

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Thesis: the thesis is based on the fact that in the protection project of Ziwiyeh castle, it is required to use mortar and coating which besides being "proper to climate and environmental factors", have cohesion with native material from "basic component material" and " Visual qualities" aspects.

REVIEW OF LITERATURE

This study attempts to apply systematic methods which are based on current universal standards in order to identify and examine the historic mortar and coating used in Ziwiyeh ancient castle. Jeremy C. Wells, who graduated from Pennsylvania University in 2004 in Conservation of the Historic Works, in his Master's thesis project had designed a diagram in which he has firstly set wet chemistry tests for identifying the mortar used in some historic places in Spain as the introduction of his work, and then has mentioned using of some instrumental analysis methods such as SEM, EDS, XRD, FTIR, AAS and AES (Wells, 2004:78).

Lisette. M. Kootker, graduated from Amsterdam University, also in his master's thesis project titled *An Study on the Physical and Chemical Features of the Mortar Used in Necropolis in Egypt*, after doing wet chemistry tests on the samples, has examined and identified them using the instrumental analysis methods such as XRD, and in 6 samples the resulted peaks showed a great amount of Calcite and a small amount of Quartz in the compositions (Kootker, 2007:60).

Evin Caner in 2003, in her master's thesis project, and Osman M. ; Ngoma in 2009,in his PhD thesis project, have always used wet chemistry tests in attempt to identify historic mortars, and have then used instrumental analysis methods such as XRD to accomplish their gained results (Caner, 2003:31) and (Ngoma 2009:60).

Atefeh Shekofteh in her master's thesis project in conservation and restoration of artistic and ancient works in Tehran Art University, has used wet chemistry method and some instrumental analysis methods such as SEM, EDX, XRD and XRF for investigating the main component of mortar used in Tapti Ahar cemetery at Haft-Tappe in Khuzestan, and the results showed mortar of the cemetery are made up with plaster (Shekofteh, 2008:84-79).

One of the most prevalent methods for analyzing the mortar and coating use Hydrochloric Acid (HCL) for dissolution of mortar’s binder and set free the Silica in them. Jeremy C. Wells reports in his thesis that Jedrze jewska in 1960 has published one of the first articles about dissolution of acid in analyzing historic mortars (Wells, 2004:58).

In many of the published articles about examining restoration and historical mortars and coatings (Robert B Jewell and others, 2009), Martha Tavares and Others (Tavares, 2008), Els Verstrynge(2011), Ana Luisa Velosa and Maria Rosario Veiga (Luisa Velosa, 2001), and Anna Campbell and others (Campbell, 2011) have used Phenolphthalein as the detective of mortars and Carbonate coatings and also their rate of carbonization.

METHODOLOGY

This study is based on scientific-experimental method in which library sources, laboratory tests and case studies have been used altogether. The first phase of the research was done based on library studies and towards the goal of the study, during which some similar research projects on the same field had been examined in order to gain a proper direction for achieving data. Based on these studies and on the second phase of the research project, with citing some related literature and towards examining the claimed hypothesis, we have applied wet chemistry tests and XRD instrumental analysis for identifying the historic mortar and coating of Ziwiyeh castle was put on the agenda. Phenolphthalein was also used for testing carbonization of the mortar and conservative coating. Sampling of the material used in the building was done afterwards. After that the samples were coded and were then classified based in the amounts required for the predetermined tests. Among laboratory tests, wet chemistry tests including Hydrochloric Acid test, detecting the existence of plaster using the deposition with Barium Chloride were done firstly and Aluminum Oxalateand also tests for detecting Lime with Phenolphthalein as indicator, and then the powdered samples were made ready for XRD instrumental analysis.In the end, after extracting results and analyzing the data gained from the tests, the main component and other additives in the historical mortar and coating were detected. The resulted XRD peakswere examined and analyzed in these three ways: 1. upon receiving the peaks from the laboratory, a tablewas set for the type and amount of the components of each sample was also received for each sample (tables No. 4, 6 & 8). 2. The original resulted peaks by X'PertHighScore software were examined and analyzed in the laboratory of Tehran Art University, and the results are demonstrated in tables 3, 5 and 7. 3. By comparing the resulted peaks with the similar peaks in some previous researches on this field such as studies of researchers such as Jeremy C. Wells (Wells, 2004), Lisette M. Kootker, 2007 (Kootker, 2007), Evin Caner (Caner, 2003) and Osman M. Ngoma (Ngoma, 2009), the final conclusion was extracted.

On the third phase of this research, i.e. that of making empirical models, with documenting the results gained from examining and detecting components of the original mortar and coating of the castle, 4 coating

samples, and 4 protective mortar samples were modeled and were set as a field work against the atmospheric agents for 6 months. The physical features and scenery qualities of these protective samples were examined based on the instructions offered in the book "A Laboratory manual for architectural Conservators" written by Jeanne Marie Teutonico (Teutonico, 1988:122).

The field of research

The field work of this study is focused on the original mortar and coating used in the historical building of Ziwiyeh castle and sampling mortar and conservative coating. We have sampled the original mortar and coating of the walls of Ziwiyeh castle with regard to the aim of this paper, and after codifying and Set document for each of them, they were classified for being studied, and doing wet chemistry laboratory tests and devise analysis on them. It was not possible to extract samples from different parts of the walls due to the protective layer covering them. Supposing that the whole parts of this castle was built at once, mortar samples were extracted from the only two accessible parts of the building. Only the coating of two of the rooms of the Northern side of the castle is still remaining, and this coating is made up of two layers, each of which had been sampled. The plan of the castle and the sampled areas are shown in illustration No. 1, and explanations about the extracted samples are provided in table No. 1. Samples had been extracted from two parts of the castle, but because of their oneness in color, texture, rigidity and other features, both of them are considered as one single sample and would be referred to as Z.M/90-01 henceforth.

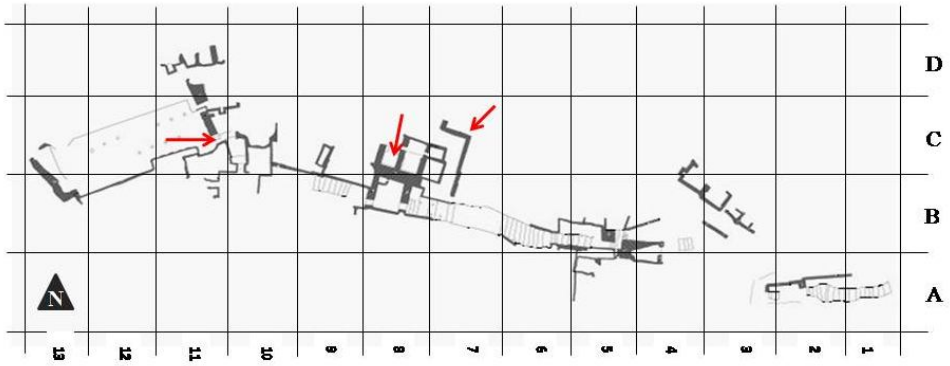

Figure 1) Map of Castle Ziwiyeh with certain places being sampled

	Sampling locations on the map	Type of sample	Size
Z.M/90-01	7 – C	Mortar	12gr
Z.M/90-02	11 – C	Mortar	15gr
Z.C/90-01	8 – C	Coating surface layer	5gr
Z.C/90-02	8 – C	Coarser layer of coating	7gr

Table 1) codes and description of samples of mortar and coating castle Ziwiyeh

In codifying the extracted samples from the original material, and protective samples afterwards, these are the clues: Z is the abbreviated form of the word Ziwiyeh, M of the word Mortar, C of the word Coating, R of the word Restoration, 90 is for the year in which sampling had been done (1390 SH), and 01 is the number of the sample.

Tools of research

We have used many tests for gathering data in this research. Ebrahim Hosseini, in his book titled 'Crystals and minerals' has pointed to the reactions that many of the minerals such as plaster and lime in the reactions with acids (Hosseini, 2005: 58 &59). According to this, the test of the carbonization of the mortar and coatings with using 6 Molar hydrochloric acid (HCL) was set on the agenda. The test of detecting plaster with the use of deposition by Barium Chloride (BaC_{l2}) 20% and Ammonium Oxalate ($(NH_4)_2C_2O_4$) is a method that Atefeh Shekofteh had used in her master's thesis project for identifying mortars used in Tapti Ahar cemetery (Shekofteh, 2008:79). This research is also based on this laboratory method. The test of PH of the resulted solution from the samples was done with using phenolphthalein ($C_{20}H_{14}O_4$) as the indicator, which is a scientific and valid test (Petrusevski, 2007:260). The XRD instrumental analysis has been used in many similar articles and researches (G. Cultrone, 2008:744). This test was done in Isfahan University with Bruker D8ADVANCE made in Germany, with 2θ angle and cooper wire ray lamp. For examining the characteristics of the modeled mortar and coating we have applied the method offered by Jeanne Marie Teutonico (Teutonico, 1988:122) and environmental resistant method for 6 months. All the tools and methods used and applied in this research are

based on the available data source in this field and also extracted from and put into agenda upon the scientific reasoning.

Conducting research tests

In the process of carrying the tests out, firstly we put a little portion of samples of the historic mortar and coating on the watch glass, and then added several drops of Hydrochloric Acid (HCl) 6 molar (figure No. 2). This test was done on one sample of plaster mortar which was made 15 years ago to be applied in the coating of a newly-built wall was as the blank sample of the reaction of the plaster mortars in interaction with acid.

Characterization test of plaster was conducted in this way: first a small amount of the samples were powdered and moved into the testing tubes and some distilled water was added into each tube, then the tubes were heated so that the binder of the samples become well dissolved. A certain amount of the clear solution is extracted from the top of the testing tubes and is transferred into other testing tubes and then a few drops of Barium Chloride ($BaCl_2$) were added into them afterwards (figure No. 3). In the second step of this test, all these steps were repeated again and finally Oxalate ammonium ($(NH_4)_2C_2O_4$) was added (figure No.3). For characterization of solution's carbonization (presence of lime in the selected samples) we have also applied this method and in the final step several drops of Phenolphthalein ($C_{20}H_{14}O_4$) were added. The final step of the test was characterizing the chemical identity of the historical mortar and coatings of Ziwiyeh castle, using XRD instrumental-qualitative analysis that was done by the central laboratory of Isfahan University and the results are demonstrated in the peaks presented in figures 5 to 7 and their related tables.

Data

In the test of tracing carbonate, after adding 6 molar Hydrochloric Acid (HCl) on the samples, all the three samples have a similar reaction and started boiling so that after several minutes all the binder in the samples dissolved, and in there left a little amount of impurity in each of them that was in most cases like black and brown particles, and Z.M/90/01 sample there was a bigger amount of impurity in comparison with the two other samples. This test was also done on the plaster mortar sample. This sample also started boiling after the acid was added into it, and remained in the initial conditions with little variations.

Figure 2)reaction of Samples in to Hydrochloric Acid (HCl) 6 Molar

In tracing plaster test after adding 20% solution of Barium Chloride ($BaCl_2$) into the testing tubes no changes took place in the solutions, and afterwards and in the second step of the test, after adding Ammonium Oxalate ($(NH_4)_2C_2O_4$) no changes took place in the solution and there was no trace of precipitation in the testing tubes. In this test it was expected that if the samples were made of plaster, after adding the chemical material mentioned above in to the testing tubes a white deposit occurs.

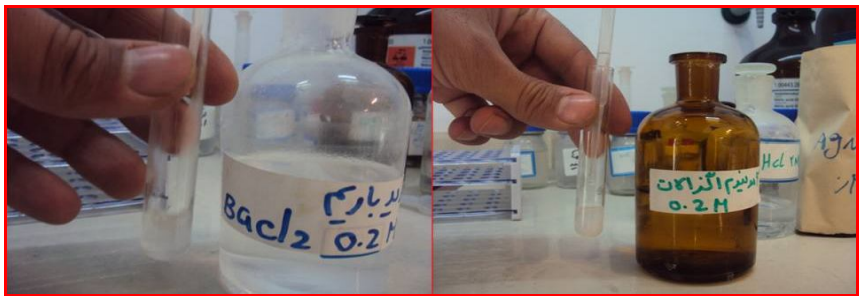

Figure 3) adding barium chloride and ammonium oxalate, non-deposition in samples

In the test of tracing lime and sample's being carbonated, after adding Phenolphthalein in all the three samples, a small color change occurred and the solutions became quite reddish. In Z.C/90-01 and Z.C/90-02 this change in colors were more obvious than in Z.M/90-01 (Figure No.4).

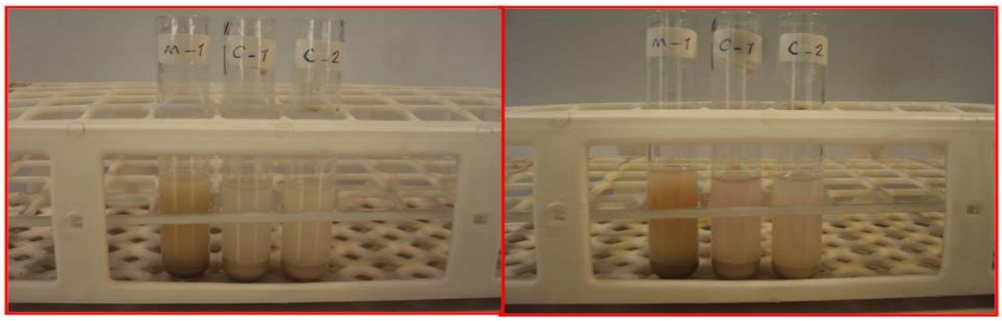

Figure 4) slight color change in the solution after adding phenolphthalein

	HCl 6 molar	$BaCl_2$ %20	$(NH_4)_2C_2O_4$	$C_{20}H_{14}O_4$
Z.M/90-01	boiling and synthesized	No precipitation	No precipitation	became quite reddish
Z.C/90-01	boiling and synthesized	No precipitation	No precipitation	became quite reddish
Z.C/90-02	boiling and synthesized	No precipitation	No precipitation	became quite reddish

Table 2) results of wet chemistry tests on mortar and coating of historic castles zivieh

Results of XRD instrumental analysis for the samples of historical mortar and coatings of Ziwiyeh castle are demonstrated as peaks and the related tables of each one are shown below.

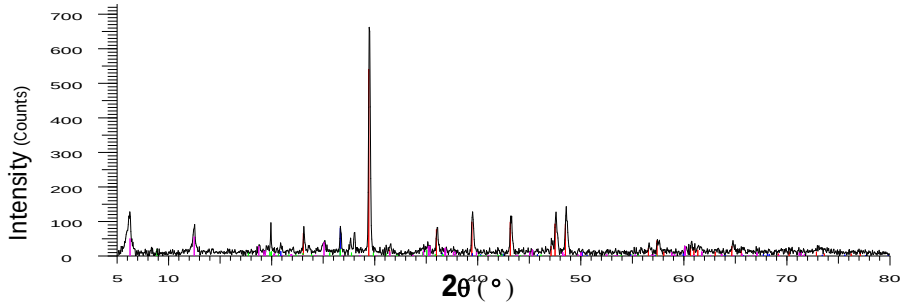

Figure 5) XRD peak of sample No: ZM/90-01 (received from the Central Laboratory of the University of Isfahan)

Ref. Code	Compound Name	Chemical Formula	Score	Scale Factor
01-086-2334	Calcite	Ca (C O3)	55	0.706
01-083-2465	Quartz	Si O2	21	0.065
00-045-1321	Clinochlore-1\ITM#I#I#b\RG, manganoan	Mg3 Mn2 Al Si3 Al O10 (O H)8	16	0.108
00-001-1098	Muscovite	H2 K Al3 (Si O4	Unmatched Strong	0.277

Table 3) Table of XRD peak of sample No: ZM/90-01 (peak analysis by software X'PertHighScore)

Sample Identification and Semi quantification

Line Color	Compound Name	Formula	PDF Number	Concentration (%W/W)
	Calcite, syn	$CaCO_3$	05-0586	73.7
	Quartz, syn	SiO_2	46-1045	6.4
	Muscovite 2M1, syn	$KAl_2Si_3AlO_{10}(OH)_2$	07-0032	5
	Clinochlore-1 ITMIIb-4 RG	$Mg_5Al(Si,Al)_4O_{10}(OH)_8$	46-1322	14.9

Table 4) Table compounds in the sample No: ZM/90-01
(received from the Central Laboratory of the University of Isfahan)

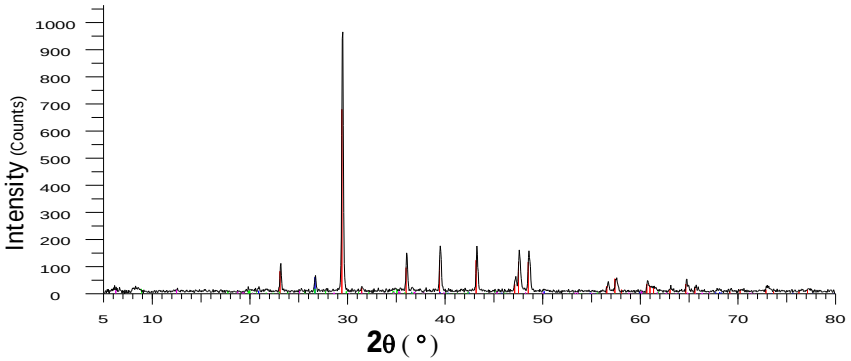

Figure 6) XRD peak of sample No: ZC/90-01
(received from the Central Laboratory of the University of Isfahan)

Ref. Code	Compound Name	Chemical Formula	Score	Scale Factor
01-083-0578	Calcite	Ca (C O3)	66	0.642
01-085-0335	Quartz low	Si O2	26	0.037
00-001-1098	Muscovite	H2 K Al3 (Si O4)3	Unmatched Strong	0.128
00-029-0701	Clinochlore-1\ITM#I#I#b\RG,	(Mg , Fe)6 (Si , Al)4 O10 (O H)8	Unmatched Strong	0.308

Table 5) Table of XRD peak of sample No: ZC/90-01 (peak analysis by software X'PertHighScore)

Sample Identification and Semiquantification

Line Color	Compound Name	Formula	PDF Number	Concentration (%W/W)
	Calcite, syn	$CaCO_3$	05-0586	87.8
	Quartz, syn	SiO_2	46-1045	4.5
	Muscovite 2M1, syn	$KAl_2Si_3AlO_{10}(OH)_2$	07-0032	4.3
	Clinochlore-1 ITMIIb-4 RG	$Mg_5Al(Si,Al)_4O_{10}(OH)_8$	46-1322	3.4

Table 6) Table compounds in the sample No: ZC/90-01
(received from the Central Laboratory of the University of Isfahan)

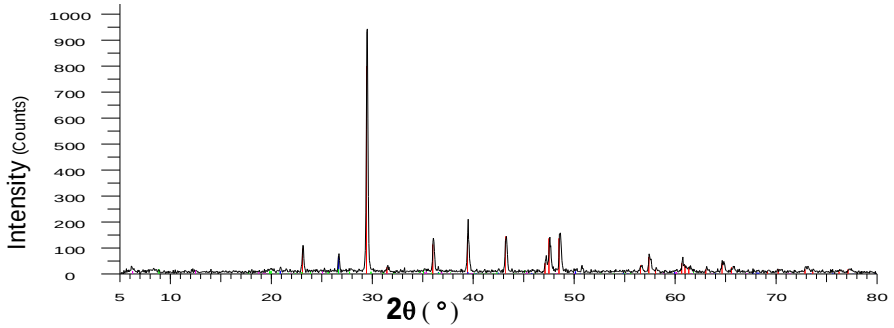

Figure 7) XRD peak of sample No: ZC/90-02
(received from the Central Laboratory of the University of Isfahan)

Ref. Code	Compound Name	Chemical Formula	Score	Scale Factor
01-083-0578	Calcite	Ca (C O3)	72	0.610
01-085-0335	Quartz low	Si O2	23	0.058
00-045-1321	Clinochlore-1\ITM#I#I#b\RG, manganoan	Mg3 Mn2 Al Si3 Al O10 (O H)8	Unmatched Strong	0.114
00-001-1098	Muscovite	H2 K Al3 (Si O4	Unmatched Strong	0.149

Table 7) Table of XRD peak of sample No: ZC/90-02 (peak analysis by software X'PertHighScore)

Sample Identification and Semiquantification

Line Color	Compound Name	Formula	PDF Number	Concentration (%W/W)
	Calcite, syn	$CaCO_3$	05-0586	89.4
	Quartz, syn	SiO_2	46-1045	4.4
	Muscovite 2M1, syn	$KAl_2Si_3AlO_{10}(OH)_2$	07-0032	3.7
	Clinochlore-1 ITMIIb-4 RG	$Mg_5Al(Si,Al)_4O_{10}(OH)_8$	46-1322	2.5

Table 8) Table compounds in the sample No: ZC/90-02
(received from the Central Laboratory of the University of Isfahan)

Data Analysis

In the test of Carbonization, samples were boiled with Hydrochloric Acid and were then synthesized; this shows that the tested samples are carbonated. Carbonates do not have a strong resistant against acids and are easily synthesized and do not require certain conditions (Hosseini, 2005:113). The plaster coating sample that was tested also shows plaster's reaction against acid that its reaction was different from the original samples, the fact that samples slightly boiled could be due to the presence of impurities such as silicates.

Some silicates have low resistance against acids and will start boiling when in contact with them and acids can synthesize and dissolve them (Wells, 2004:59). Gypsum or plaster is dissolvable in warm and intense Sulfuric acid (H_2SO_4) (Hosseini, 2005:58).

In the tracing test of plaster in each step of the test with adding Barium Chloride and Ammonium Oxalate, the resulted solutions from the samples remained without change and there occurred no deposit in them. This shows that these samples of mortar and coating could not be made of plaster.

In wet chemical tests for characterizing historical mortar and coating, Phenolphthalein ($C_{20}H_{14}O_4$) is used as a reagent indicator of carbonated mediums. Phenolphthalein which is like a white powder and then transforms into a transparent solution, becomes transparent in acidic mediums and reddish azure in alkaline mediums (Petrusevski, 2007:260). In lime characterization test with adding Phenolphthalein into the testing tubes containing the resulted solution from samples, there occurred an obvious color change to a reddish and pinkish color, and this shows that the solutions are alkaline and the samples are carbonated.

In investigating and analyzing XRD peaks of the historical mortar and coating of Ziwiyeh castle, it is obviously clear that the high peak belongs to Calcite ($CaCO_3$) or lime stone, in other words the extracted samples are made of lime. In the two samples of the coating, i.e. Z.C/90-01 and Z.C/90-02 samples, the peaks belonging to Calcite are higher and this shows the larger presence of lime in their composition in compare with Z.M/90-01 mortar sample. In fact the mortar sample has more impurity than the two coating samples. The impurities in the samples with respect to XRD test are as follows: Quartz, Muscovite (clay minerals) and Chlorite. The amount of chlorite is larger in the mortar sample.

Conservative Samples and Their Tests

The results gained from different tests for characterizing the component material of the historic mortar and coating used in the Ziwiyeh castle, and analyzing these data showed that the major component of these materials is lime. In making conservative mortar and coating it is attempted to choose materials as additives that in addition to be native , be well adoptive to the area of Ziwiyeh castle from their Visual qualities and keeping the originality of the main material, and in addition to that be resistant enough against the atmospheric and environmental factors. Hence, 4 different compositions of mortar, and four different compositions of conservative coating were made accordingly. 10% of lime was added to one coating and one mortar composition. The maximum characterized amount of the additional lime was determined based on the available research resources on this field (Daryayi, 2011:230-238). The 10% amount of the additional lime requires a certain atmospheric conditions (high humidity). Other additive materials were sand, Straw, white soil and stone powder. The major components and the logic underlying their usage are brought in the table No. 9.

	Base composition	Additive	The Basics of Choosing the additive
Z.RM/90-01	3Native soil + 1 Sand + 1 Straw	------	Native
Z.RM/90-02	3Native soil + 1 Sand + 1 Straw	./5Lime	Originality - Visual - Native
Z.RM/90-03	2Native soil + 1 Sand + 1 Straw	1white soil	Visual - Native
Z.RM/90-04	3Native soil + ./5 San + ./5 Straw	1stone powder	Visual
Z.RC/90-01	3Native soil + 1 Sand + 1 Straw	1/5stone powder	Visual
Z.RC/90-02	3Native soil + 1 Sand + 1 Straw	1/5white soil	Visual - Native
Z.RC/90-03	3Native soil + 1 Sand + 1 Straw	./5Lime	Originality - Visual – Native
Z.RC/90-04	3Native soil+./5 Sand + ./5 Straw	1/5 stone powder	Visual

Table 9) Composition of protective mortar and coating samples tested and Selection logic of Additives

By using a 10×10×1 cm and a 50×5×1 cm mold, a block was made from each of the made up compositions, and then these blocks were investigated and the results are brought in tables No. 10 and 11, and the diagram is designed based on the instructions offered in the book " A Laboratory manual for architectural Conservator"

(Teutonico, 1988:122). This investigation was to visually and the recorded rates are shown comparatively. The high rates show the prominence of the sample in the certain feature. For example in the case of the contraction of the samples, the higher the rate would be, the lesser the rate of contraction and the occurred cracks would be; in the case of the other features, the higher rate shows the prominence of that feature in the sample.

All the compositions were also used to make three separate small laboratory walls, the results of which after 6 months showed that the samples containing lime have demonstrated higher resistance against the atmospheric and environmental factors.

Sample Code / trait	Z.RM/90-01	Z.RM/90-02	Z.RM/90-03	Z.RM/90-04
Application	Mortar	Mortar	Mortar	Mortar
Setting time	4Day	4Day	3Day	3Day
Shrinkage	8 Score	9 Score	7 Score	9 Score
Carbonation	5 Score	6 Score	4 Score	3 Score
Hardness	6 Score	3 Score	7 Score	9 Score
cohesion	7 Score	5 Score	7 Score	8 Score
Other (color, texture, etc.)	pea color Reddish , Soft	white ، Rough	pea color, A bit rough	pea color Grayish ، Soft

Table 10) Data quality check of mortar protective features

Sample Code / trait	Z.RC/90-01	Z.RC/90-02	Z.RC/90-03	Z.RC/90-04
Application	Coating	Coating	Coating	Coating
Setting time	2 Day	4Day	4 Day	3Day
Shrinkage	5 Score	9 Score	9 Score	6 Score
Carbonation	5 Score	4 Score	6 Score	3 Score
Hardness	5 Score	6 Score	3 Score	7 Score
cohesion	7 Score	8 Score	5 Score	6 Score
Other (color, texture, etc.)	pea color ،Soft	pea color Reddish , Soft	white ، Rough	pea color, A bit rough

Table 11) Data quality check of coating protective features

Figure 8) Status of the samples after 48 hours

In Z.RM/90-02 and Z.RC/90-93, 10% lime is added. In tables No. 9 and 10 it is observed that these two samples are weaker in their hardness and adherence features than the other samples, and have also superiority in their contraction and the rate of carbonization, and also their scenery characteristics is more harmonious with the whole building of Ziwiyeh castle. Regarding the theoretical basics in conservation issues which point to the reversibility of the conservative and restorative procedures (Canada's Charter ICOMOS 1983) (Mir Fakhrayi, 2008:155), the two mentioned samples do have this advantage due to their low adherence and hardness, so that it makes easy their probable undoing from the main structures of the castle, and this would cause the least damage to the building.

The guide to the criteria of the conservation of the historical clay buildings has encouraged the conservators for using the traditional material and native traditions in their conservative projects and these two samples of conservative material also meet these features (Warren, 2008:232). These samples (the two superior

ones) have been tested against the atmospheric and environmental factors and underwent the least destruction. Therefore, they do have a good resistance against the threatening factors such as moist, and the scenery and physical features of them are superior to other samples.

Conclusion

The results gained from this study shows that lime is used in the composition of the mortar and the two-layered coating in the ancient castle of Ziwiyeh, and each of these compositions have amounts of impurity in them such as sand and soil, and the mortal of this building contain more impurity.

The usage of lime in the compositions of conservative mortar and coatings proved to be effective in both structural features and their resistance against the atmospheric and environmental factors, hence the hypothesis of this research had been proved and the conservative mortar and coatings are homogeneous to the original material used in the building of Ziwiyeh castle both in their resistance against the atmospheric factors from the scenery qualities and the basic components.

The question which is aroused at the end of this research and would provide a suitable ground for future studied is that regarding the fact that adding lime to the structure of the conservative material of this castle, what percentage of this additive could be most effective and would result best?

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