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Creating Mixtures Similar To The Original By Modifying Gypsum For The Restoration Of Architectural Monuments

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Abstract. The article contains the findings of research on the historical approach used to build the mausoleum of Ismail Samani and the Kalyan minaret. It is revealed that calcium sulfate is mainly used in the compositions of the solutions. These historical solutions are also modified with organic and mineral additives. Based on chemical, differential-thermal analysis (DTA), reed analysis revealed that reed ash, chickpea flour and lime were used in these solutions. Considering the analytic findings, we synthesized the combinations of modified compounds based on local gypsum. The composition along with technology for obtaining converted solutions for the instauration of old city's architectural landmarks of Bukhara have been developed. The developed composition of the modified solution is put into practice. The research demonstrates that the structure and strength of the modified gypsum-based solution are virtually identical to the structure of the mortar used in national architectural monuments

Introduction

Ancient Bukhara, situated in touristic itineraries of Uzbekistan and being home of many monuments and monuments, has long and rightfully attained international recognition. Being historic and distinctive city of Uzbekistan, there are still many notable individuals alive today. Monuments, distinct contemporary works of art of international architecture constructed since the 19th century. They are well known on a global scale.

The distinctive monuments of Bukhara have a thousand years in Central Asian architectural history. These monuments show the constructing materials and creation methods that define the characteristics of architectural history. We can create such materials to maintain the worth of the restoration of architectural monuments. Thanks to thorough and in-depth research of the building industry in general, the construction materials employed specifically.

Despite having been there for a very long time and being constructed using sulfate binders, many historical monuments in Bukhara are still in good shape depending on their location. This shows that a modified calcium sulfate solution was used in those constructions, and that the circumstances were satisfactory in relation to the working environment.

Therefore, to employ modified materials especially modified mortar is important. They are equal or indistinguishable historical materials which were used restoring brick architectural buildings and structures, concerning to preserve the advantage of ancient monuments.

We undertook relevant theoretical and practical research, the findings, in order to survey the physicochemical compositions and properties of the historical mortar. Therefore, to evolve the technology of adapted mortars for architectural monuments of Bukhara.

Resources and Research Methods

In order to complete this assignment, we look at historical examples from the Abdulazizkhan madrasah, the Kalyan minaret, and the tomb of Ismail Samani. They are all distinctive and native architectural structures constructed in IX, XII, XVII centuries, respectively. Z.R. Kadirov studied astringents made of calcium sulfate, which once was employed in the construction of local monuments.

Samples from the Abdulazizkhan madrasah, the Kalyan minaret, and the tomb of Ismoil Samani were employed in the study of medieval masonry mortars. Local lime from the workshops and plant in Kagan, Bukhara region, natural clay (loess loam), chickpea from nearby brick battles, and vegetable ash from nearby reeds were employed as mineral additives during the production of the composition of the modified

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(same) mortar. The two primary components of loess loam are quartz (SiO2) and kaolinite Al2Si2O5(OH)4. In accordance with the most recent standards and methodologies, the characteristics of modified mortars were investigated.

According to the classical technology of building materials, all of the fundamental physical-mechanical and physical-chemical features of constructive materials, and in particular, mortar, masonry cement, and baked bricks. They are directly influenced by the chemical, mineralogical, and fractional compositions of the initial components. The ratio of the main oxides contained in these materials. From the foregoing, it can be inferred as main prerequisites for obtaining high-quality building materials [4–9], specifically masonry mortar that satisfies the specified requirements for physical–mechanical and physical-chemical properties and is operational control of the chemical composition of raw materials. During the chemical analyzing various building materials, especially, mortar, as well as hydrated materials, it is important to determine the content of silicon oxides (SiO_2), aluminum (Al_2O_3), iron ($FeO + Fe_2O_3$), calcium (CaO), magnesium (MgO), sodium (Na_2O), potassium (K_2O), sulfur (SO_3) and calcination loss (PPP). Much less than often, it is necessary to determine the content of other oxides presented in small quantities, for example, titanium oxides (TiO_2), phosphorus (P_2O_5), manganese (MnO_2), chromium (Cr_2O_3), etc. The scheme for conducting chemical, i.e. silicate analysis is as follows: after decomposition of the sample by weight method, it is determined by weight the content of silicic acid, with its mandatory subsequent removal in the form of four-fluoride silicon - SiF_4. In the filtrate, after the separation of silicic acid, the oxides of iron, aluminum, calcium and magnesium were determined complex-metrically, and the content of oxides of titanium, phosphorus, manganese, and sometimes chromium was determined photo- color-metrically. From individual attachments, the PPP, the content of sodium, potassium and sulfur oxides were determined.

The majority of chemical and physical processes are known for involving the release or absorption of heat. The goal of thermal analysis is to understand the phase changes that take place in systems or in particular compounds in relation to the associated thermal impacts. For this, the studied sample is gradually warmed while the temperature is continuously recorded in accordance with the automatic recorded readings. The generated temperature curves allow one to assess the type, strength, and temperature at which particular thermal impacts become noticeable. Only then, the gathered information can be utilized to analyze the substance under mineralogical makeup survey and the types of phase transitions that take place when it is heated. DTA is used to track changes in the energy of system during the heating process. A number of specific endothermic and exothermic effects are used to describe the physical and chemical processes that take place with the absorption or release of heat on a continuous differential temperature curve. The thermo gravimetric approach uses the mass of the studied substance, while heated as a gauge for chemical changes occurring in the substance. Since the mass change curves provide extra information, this technique is a significant addition to differential-thermal analysis and helps to characterize the quantitative side of the ongoing processes more accurately.

Phase transformations and regions of stability or changes in solution samples using differential-thermal research, i.e. thermo graphic and thermo gravimetric analysis, together with Professor Z.R. Kadyrov, were performed on the Hungarian derivatograph of the F. Paulik-I. Paulik-L. Erdey system, on which simultaneously synchronous recording of the differential curve of thermal analysis with curves of linear size change (shrinkage) and weight loss was carried out. Sensitivity of the galvanometer, DTA-1/3, DTG-1/5, TG - 200, T -900°C, at a heating rate of 10 degrees/min in platinum crucibles. Sample holder corundum crucible with a diameter from the standard (Al10 mm_2O_3). Differential and temperature recording was carried out by Pt-Pt / Rh thermocouple. Heating curves were removed at the size of the attachment on average. Simultaneously, on other samples from the material under study, changes in linear dimensions were recorded using torsional scales with a mirror reference.

It is now understood that roentgen analysis is a more versatile and modern approach to investigating materials than other physicochemical approaches. Together with it, complicated materials can be subjected in qualitative and quantitative phase analyses, and the crystal lattice structure of specific compounds can be ascertained.

Various methods of research are utilized according to the goal and the type of object of X-ray analysis: powder and Debye-Scherer methods for polycrystalline samples, and Laue method for monocrystalline materials.

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Building materials are typically examined using the powder method and primarily with ionization registration of diffracted X-ray radiation, in particular polycrystalline compounds that are astringent as bodies. This exceptional sensitivity of the method to specific minerals is a huge plus.

A distinct radiograph is provided with typical inter plane distance values and a certain intensity of the related reflections when studying the crystals of each individual substance.

Most of the water crystals and minerals that make up the building materials and products of their hydration have already been accurately radiographed by numerous researchers, and these radiographs have been provided in various reference books. The international file cabinet has the most comprehensive list of radiographic properties of different minerals.

As stated above, the X-ray unit DRON-4.0 MoK-radiation, Zr-filter was used to obtain the powder technique diffraction patterns of mortar and clay mortar samples. The counter disk speed, which is used to take the radiograph, was 2 degrees/min. The internal standard was Mon crystalline quartz. The wavelength of cobalt radiation is 1.78529 A_{α}^{0}, the tube voltage is 25 kV and the filament current of the tube is 20 kV. When identifying we used the phases, tables and reference books compiled by the authors of the works [10-12], as well as the ASTM file on X-ray powdered graphs ASTM [13].

Thus, the physical and chemical analysis of the compositions of old materials of brickwork in ancient architectural monuments and the compositions of modified mortars based on calcium sulfates were studied according to recognition and currently used methods on existing devices.

The sequels reported and their confabulation

In order to enhance the physical and mechanical properties of mortars, various organic additives were used for their preparation in the past [14, 15], including "shiresh" [14, 15], camel milk (suzme) [15], carpentry glue [16], the decoction of glutinous rice [20], egg white [18], dextrin, citric acid, and wine. [14,19,20] Mineral fillers, or additives having pozzolanic qualities, are combined with gypsum binder to boost water resistance by lowering solubility of calcium sulfate in water and fostering the creation of insoluble compounds that shield calcium sulfate dehydrate. [14,15].

The results of our research on the study of the chemical composition of historical mortars of architectural monuments of Bukhara and modified mortars, using the above methods, are given in Table No. 1 and No. 2, respectively.

Table 1
Chemical composition of mortar
Mausoleum of Ismail Samaniy and Kalyan Minaret

Naim. Sample	Content of oxides per air dry matter, wt%										SPT
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	P_2O_5	Cl^-	
1B*)	24.63	4.04	2.40	39.92	3.00	0.68	0.48	0.50	0.01	).02	23.90
1C**)	21.83	4.09	2.72	38.56	2.00	0.59	0.46	0.56	-	-	24.11
2V***)	15.89	3.22	2.70	40.30	2.50	0.71	0.49	0.61	-	).02	33.14
3V	55.89	9.78	3.99	10.45	2.70	1.28	1.91	1.89	0.04	).03	12.37

*)- samples of the upper part of the wall of the mausoleum of Ismail Samani;
**)- samples of the lower part of the wall of the mausoleum of Ismail Samani;
***)- design samples of Kalyan Minaret

Table 2
Results of chemical analysis of modified solutions

Naim. Samples	Content of oxides per air dry matter, wt%										SPT
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	P_2O_5	Cl^-	
1M	24.02	4.34	2.70	40.422	3.50	0.60	0.56	0.60	0.02	).01	23.80

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2M	53.79	10.88	4.49	10.95	2.5	1.48	1.51	1.99	0.03	0.04	12.77

From Table 1 it can be seen that the chemical composition of the samples studied consists of the following oxides: SiO 2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3, Na_2O, K_2O. Consequently, the main chemical composition of the samples of solutions of the mausoleum Ismail Samaniy (1 V and 1C) consists of calcium oxides va silicon. The main chemical composition of the samples of solutions of the Kalyan minaret (2B) also consists of calcium and silicon oxides. At the same time, in the studied of mortar, the PPP content was 23.9 and 33.14%, respectively. Similar is the resulting composition of the modified solution (Table 2).

A comparison of the studies mortar compositions from the Ismoil Samani Mausoleum and the Minaret Kalyan with information from literary sources revealed that, while calcium oxides and silicon were the main components of solutions in the masonry of architectural monuments built in the IX–XII centuries, the monument Shohi–Zinda built later, for instance in Samarkand, contains not only these oxides but also aluminum oxide [14]. This stance was reinforced by our investigations into the mortar and brickwork of the Abdulazizkhan Madrasah (sample No. 3B), constructed in Bukhara in the middle of the XVII century.

The Ismail Samani Mausoleum and the Kalyan Minaret's brickwork's mortar composition is different from those of architectural monuments from a later era because it contains more aluminum oxide. It can be speculatively assumed that clay mixtures were also added to the mixtures in late mortars based on this provision.

For a more reliable confirmation of this issue, it was advisable to conduct DTA. The results of DTA studies have shown that the mineralogical composition of the samples consists of the following thermal effects. At temperatures 246 and 627 ^{0}C, exothermic effects were observed, and at temperatures of 162, 187, 220, 331, 376, 416, 489, 728 ^{0}C - endothermic.

The results of a study of the mortar of brickwork of architectural monuments of Ismail Samani and Kalyan Minaret showed that diffraction maxima appeared at d = 0.756; 0,422; 0.306 and 0.208. These dimensions show the presence of gypsum in the solution. In addition, the mixture contains quartz (d = 0.334; 0.245; 0.228 nm), albite (d = 0.310; 0.402 nm) and dolomite (d = 0.290; 0.241; 0.219; 0.202 nm).

In the samples of the lower part of the mausoleum of Ismail Samani, diffraction maxima occurred at d = 0.756; 0,427; 0.306 and 0.208 nm. These dimensions show the presence of gypsum in the solution. In addition, the mixture contains quartz (d = 0.334; 0.245; 0.228 nm), basanite (d = 0.606; 0.281 nm), albite (d = 0.310; 0.402 nm), KSH (d = 0.324 nm), wedge-enenitidis (d = 0.893 nm) and calcite (d = 0.187 nm). The operating circumstances of the structure can be used to explain the variation in the size of the maximum diffraction maxima of the solutions on the top and lower parts of the brick walls. The lower portion of the wall was once heavily buried at one point, which exposed it to the aggressive elements of the buried soil. KPSH, clinoenetite, and calcite were thus generated in addition to the other minerals in the solution of the lower section of the wall.

4. Summary

These mortars are gypsum-lime with an organic and mineral pre-brew, as shown by the results of the physical and chemical investigation of the brickwork used in the construction of Ismoil Samaniy's mausoleum and Kalyan Minaret. They were also taken into consideration when doing more study, while creating the technology of modified mortar for the restoration of early architecture. As a result of the investigation, updated options for the preservation and restoration of architectural landmarks of Bukhara were discovered.

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