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Article

Conservation of Weathered Sandstone Inscription on the Historic Water Well at Muhammaden Anglo-oriental College, Aligarh

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ABSTRACT

Water is life and life on earth is linked to water. Our existence is dependent on water in many ways and one could say that our whole civilization is built on the use of water. The construction of wells and harvesting of water from it was a dominant feature of human society till the advent of modern era, and is still in remote areas the wells are operational. During the time of Muhammadan Anglo-Oriental (MAO) College (Aligarh Muslim University at present), these wells have played a pivotal role to quench the thrust of water and other needs. They are part and partial of the built heritage of MAO College. Although, there is a great attempt to preserve the Sir Syed Hall campus comprising Victoria gate, University, Mosque, and other historical buildings. However, no one has bothered to include the decimal status of the water well which is also the part of present AMU buildings. This paper comprises about the present conditions of water wells of the MAO College. This study is to investigate the mineral composition, mechanical, and chemical cleaning and the restoration of deteriorated sandstone inscription on the water well. It also includes major factors influencing on deteriorated problems of sandstone. The conservation efficiency was investigated by scanning electron microscopy and X-ray diffractometer technique.

Key words: Built heritage, Conservation, Inscription, Restoration, Sandstone, Scanning electron microscopy, Water well, X-ray diffractometer.

1. INTRODUCTION

Conservation of built heritage is scarcely taken seriously in our country, which may entail us to lose our past. The conservation movement is a grassroots effort led by individuals determined to foster a greater appreciation for the cultural, social, historical, and architectural qualities of the built environment. The individuals set in motion the preservation of buildings that have become the part of our collective identity and contribute daily to the beauty and education of our city and country [1,2]. Conserving historic areas are an indispensable process toward our nation's rich culture and heritage, which helps us to reconstruct our nation's past. Heritage has now been generally recognized by society as an important asset, but the actual preservation and conservation process poses a very real challenge. Therefore, there is an immense need of awareness for the conservation and restoration of historic buildings and monuments of the nation, because it provides a sense of identity and continuity in a fast-changing world for our future generations [3,4].

Sandstone was and continues to be the most popular building stone. The very first evidence of the use of this stone are in Mauryan dynasty and even Ashoka's edict engraved on pillars was found to be made up of sandstone. Sandstone is a sedimentary rock consisting of round or angular granules of silica (SiO_2) (most commonly found in nature are known as quartz) that has been deposited and combined with each other by SiO_2, calcium carbonate ($CaCO_3$), iron oxide (Fe_2O_3), or clay minerals. Therefore, sandstone may differ in its color, hardness, and durability [5]. Sandstone main mineral composition is found to be SiO_2 (quartz) [6].

The deterioration of historic stone building or monument is very similar. While there are a few stones that seem little affected by centuries of exposure to the weather, the majority of stones are undergoing gradual and episodic deterioration. A high proportion of the world's cultural heritage is built of stone, and it is slowly but inexorably disappearing. Before using more complex methods for analyzing the problem and causes of deterioration in stone, simple visual examination plays an important role in quantifying the stone decay. A single examination can convey the state of the stone at a particular moment, but it does not capture the rate of decay, so therefore, this process required a series of inspections [7]. Before taken any initiative to reduce or prevent the loss of our heritage, it is important to first characterize about the type or types of stones involved in the object [8]. It requires more than a single technique to measure stone deterioration, since decay takes many different forms. Some techniques, such as 3D laser scanning and fluorescence light detection and ranging, are used only at the surface to diagnose the extent of stone decay. Other techniques, such as ultrasonic measurements, thermography, or magnetic resonance imaging (MRI), are designed to probe below the surface, and these are useful where decay consists of a loss of cohesion within the stone, or the development of detached layers, blisters, or internal voids. In the process of characterizing stone, it is important to recognize that

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while some stones have a similar composition and their properties may show more or less characters in common [9]. Therefore, there is an utmost need to describe the decay and to measure its extent, severity, and rate. Then next, it is important to understand the causes and mechanisms of decay [10-13].

Before we can take any action to prevent or to remedy the deterioration of stone, we must understand the causes of deterioration. Sometimes, the cause is obvious but sometimes there may be several different causes acting at once [14]. The major causes of decay in stones are physical, chemical, and biological weathering in which air pollution, salts, and biodeterioration play crucial role in deterioration of stone [15-20]. In the Stone Weathering and Atmospheric Pollution Network (SWAPNET) meeting held in Malta in 2007, it is reported that the progress in understanding the rapid decay of certain stones is affected mainly by air pollution [21]. Damage to stone by air pollution is still a massive problem in parts of central Europe, China, India, Russia, and other industrialized regions [22]. For example in India, while scrubbers were installed to reduce SO_2 near the Taj Mahal, a lack of water, power outages, and the corresponding use of diesel generators were found to be reducing the effectiveness of the scrubbers and decrease the air quality near the site [23]. Climate change due to increase in air pollution is a real threat to our monuments and it cannot be ignored.

Along with the problem of air pollution, soluble salts also represent one of the most important causes of stone decay. Salts cause damage to stone in several ways. The most important is the growth of salt crystals within the pores of a stone, which can generate stresses that are sufficient to overcome the stone's tensile strength and turn the stone to a powder [24]. It is reported in the deterioration of many of the world's greatest monuments, which are supposed to be attributed with the salt problem, from Angkor Wat in Cambodia [25] to monuments of Venice (Italy) [26], and from monuments of Petra (Jordan) [27], to the Great Sphinx of Giza in Egypt [28].

In 1932, Schaffer said in his report, "The Weathering of Natural Building Stones" that the "Living organisms also contribute to the decay of stone and similar materials and, although their action is, generally, of somewhat less importance than certain of the other deleterious agencies which have been considered, their study presents numerous features of interest" [29]. It is reported by several researchers in the biodeterioration studies of important cave painting sites of Altamira (Spain) which have found that cyanobacteria, algae, and networks of heterotrophic bacteria increase stone deterioration through their metabolic products, biomediated dissolution, as well as mechanical alteration. It is expected that the control of moisture, food, and light levels appears to be the most effective prevention methods of biodeterioration. There are also some of the other important causes of stone decay which are sudden and rapid in their effect such as earthquake, fire, flood, terrorism, vandalism, neglect, tourism, and intrinsic factors, along with the common problems of air pollution, salt growth, and biodeterioration [8].

There are many factors and manifestations of the deterioration of sandstone inscription on the water well of Muhammadan Anglo-Oriental (MAO) College, which is characterized by different mineral components, responsible for increasing the intensity of weathering process causing cracking, fragmentation, and decomposition of the sandstone inscription. In the present study, I have used two different techniques for investigating the mineral composition as well as for quantifying the causes of deterioration of the object. Therefore, the conservation efficiency was investigated by X-ray diffractometer (XRD) and scanning electron microscopy (SEM) techniques. Based on the scientific analysis results, conservation and restoration of the object was done accordingly. Furthermore, the photographic documentation of various damage phenomena of the object was carried out as well followed by the entire restoration and conservation process.

2. MATERIALS AND METHODS

Following materials and methods were used in this research and are detailed as follows.

2.1. Stone Decay and Material Identification

First, we have to characterize the stones for the material identification. It will help in describing the decay and to measure its extent, severity, and rate. It helps us to identify the causes and mechanisms of decay. Only then we can understand the characteristics of any particular stone in a given environment.

2.1.1. Visual examination

The visual examination method is the first stage of the examination process, which is adopted to evaluate the condition and diagnose the deterioration of sandstone inscription on water well. At present, the object is in very bad condition, there is layer of carbon deposits and atmospheric pollutants and at the same place, the soluble salt is coming out from the surface of the object as shown in Figure 1. Therefore, before any treatment, it is decided to examine the compositions of object through various characterizations.

2.1.2. Examination by SEM

SEM analysis provides accurate information on surface morphology, grains size, grains distribution, texture and deterioration, as well as mineral composition of the object. The analysis was done using the model "LEO 435VP SEM," through an accelerating voltage of 30 kV, indicated the morphology of object. This analysis was done by University Sophisticated Instrumentation Facility unit at Aligarh Muslim University, Aligarh, India.

2.1.3. Examination by XRD

XRD analysis gives mineral components of sandstone inscription on the water well of MAO College. It helps to diagnose damage phenomena of sandstone, understanding its nature, and its mineral changes by the environmental surrounding to identify the rate and evaluation of deterioration and weathering sandstone. This analysis was carried out by "Miniflex-II XRD" through CuKα radiation at the Department of Chemistry, Aligarh Muslim University, Aligarh, India.

Figure 1: The deposition of carbon, other atmospheric pollutant, and coming out of soluble salts from the object.

2.2. Treatment and Conservation of the Object (Sandstone Inscription on the Water Well)

2.2.1. Recording and documentation

The object is an inscription on the well of size "131 cm × 87 cm." It is made up of light brown sandstone containing the name of the donor who has contributed to construct the well. At present, the inscription is in very bad condition, there is layer of carbon deposits and atmospheric pollutants, and at the same place, the soluble salt is coming out on the surface of the inscription shown from Figures 1-3. It is a basic and important process because it is sometimes difficult to record these inscriptions due to cracks, gaps, or removal of ink. Proper photographic documentation should be done of various damage phenomena which is carried out in object and should be followed by the restoration and conservation process.

2.2.2. Cleaning of the object

The cleaning process aims to restore the stone object surface to its nature revealing the details of the stone inscriptions. This process is done after the detail examining of the object. At present, the inscription is in very bad condition due to different factors, as there is a layer of dirt and carbon deposits and other atmospheric pollutants, growth of algae and fungus in the pores of surface, and even at some place soluble salts are coming out on the surface of the object.

Two methods of cleaning are used in this process:

1. Mechanical cleaning
2. Chemical cleaning.

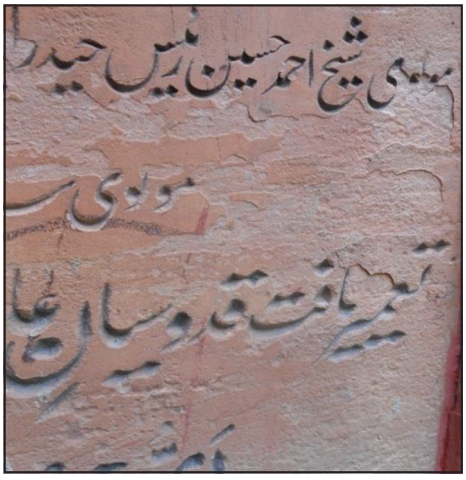

Figure 2: The surface erosion due to the removal of soluble salts and removal of ink from the object.

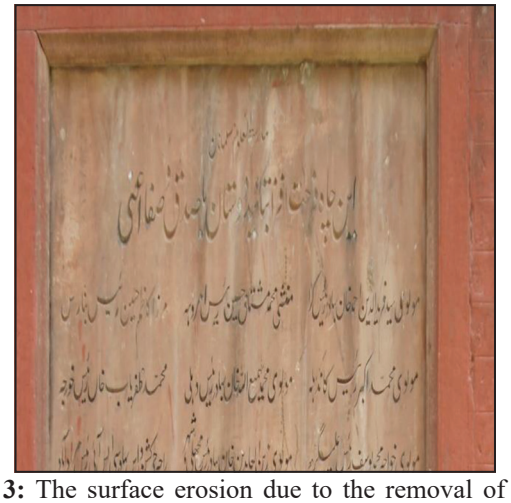

Figure 3: The surface erosion due to the removal of soluble salts and removal of ink from the object.

2.2.2.1. Procedure of mechanical cleaning

First, the removal or desalination of dust and dried salts was carried out. It is most often first step for the prevention of further deterioration in stone. Then, the loosely deposits of salts on the object surface were removed with the help nylon brush, as shown in Figure 4. For the removal of soluble salts from the object, the capillary suction was done with the help of wet paper pulp method, as shown in Figure 5. The forced extraction of saline solution from the interior of the sandstone to its surface may be effectively performed through application of reduced pressure or suction force. The wet paper pulp method helps to compresses after the application over, object was allowed to dry in a natural way, as shown in Figure 6. In the process of drying, salts are pushed out of capillaries and absorbed by the paper pulp. Later, the dry paper pulp was removed, washed, and reapplied on the object. This process was repeated till all the salts were removed from the object.

2.2.2.2. Procedure of chemical cleaning

In this process, first, we have prepared the chemical solvent for chemical cleaning of the object. For that, distilled water was taken six parts, with liquor ammonia two parts and liquid detergent two parts equally. Then, the solution was stirred until it was completely dissolved. The chemical solvent was applied on specific area with the help of brush, as shown in Figure 7. It was left for a considerable time

Figure 4: The removal of dust and dried salts with the help of nylon brush and applying of wet paper pulp on the object for the capillary suction.

Figure 5: The removal of dust and dried salts with the help of nylon brush and applying of wet paper pulp on the object for the capillary suction.

to allow the chemical loose the deposit from the surface of the object then it was brushed nicely and the process is repeated, as shown in Figure 8. Later, the whole object was washed and cleaned with running water, as shown in Figure 9. Excess water on object was absorbed with the help of blotting sheet by applying on the wet area of object, which is also shown in Figure 10. At last, it is exposed in sunlight entire a day for the complete dehydration of the object, shown in Figure 11.

Figure 6: The paper pulp is left for drying in natural light.

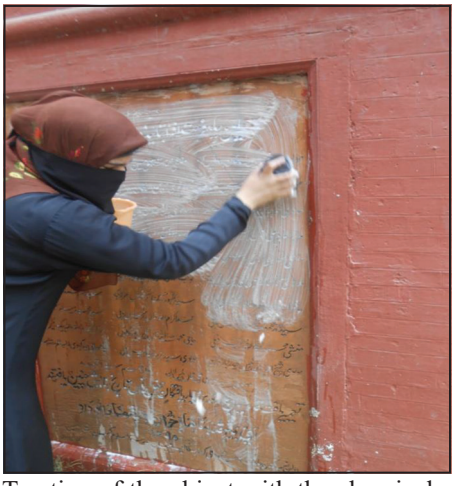

Figure 7: Treating of the object with the chemical solvent and repeated the process of treating through chemical solvent with the aid of brush.

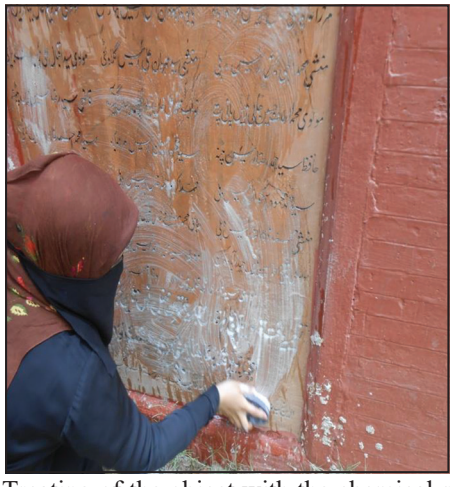

Figure 8: Treating of the object with the chemical solvent and repeated the process of treating through chemical solvent with the aid of brush.

Figure 9: The washing of chemical with water and later the blotting sheet is used to absorb moisture from the object.

Figure 10: The washing of chemical with water and later the blotting sheet is used to absorb moisture from the object.

Figure 11: The exposure of sunlight for the entire day to complete dehydrate the object and later demonstrated the process of refilling of black ink in lose part of sandstone inscription (text carved) on water well.

Figure 12: The exposure of sunlight for the entire day to complete dehydrate the object and later demonstrated the process of refilling of black ink in lose part of sandstone inscription (text carved) on water well.

Finally, restoration of the lose ink from the sandstone inscription on water well is done. It is refilled with the help of black oil paint, as shown in Figure 12.

3. RESULTS AND DISCUSSION

Through the results obtained from the research, the visual examination results proved existence of some sand deposits on the surface of the object, as well as some salts crystallized on its surface or inside the cracks and gaps, it also proved that sandstone has poor physical structure, where it is easily disintegrated by hand pressure, being cementing materials were decomposed, causing loss of cohesion between the granules. The visual examination of the object proved that it suffered from presence of gaps, oblique, and vertical deep cracks, in addition to spread of phenomenon of cracking, exfoliation, erosion, loss of some parts of the sandstone by severe weathering or earthquakes, and crystallization of salts mainly depend on water saturation and pore size distribution.

The SEM images have shown that the object is coarse texture of disordered coarse quartz grains, some are round and some other are

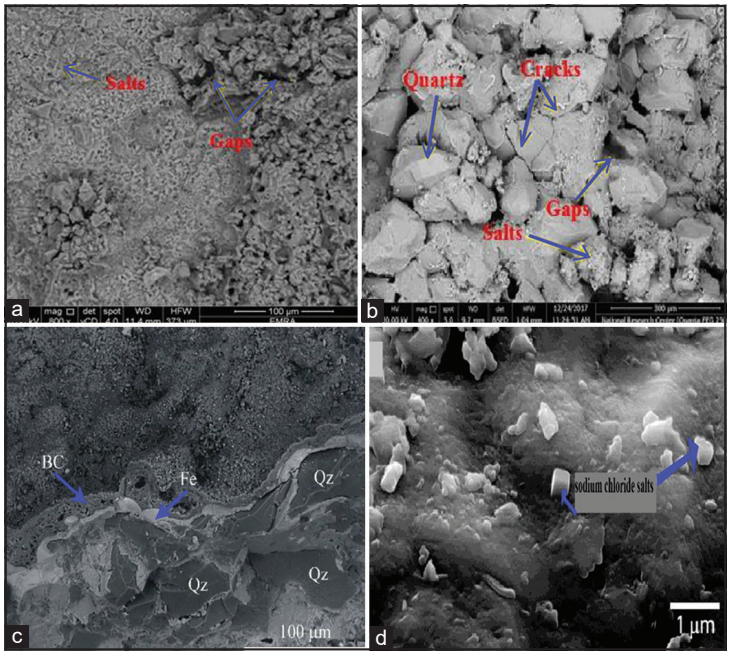

Figure 13: (a and b) The scanning electron microscopy images of the sample of sandstone inscription on water well of Muhammadan Anglo-Oriental (MAO) College shows the existence of quartz grains, some gaps, and cracks under ×400 and under ×800. (c and d) The scanning electron microscopy (SEM) image of the weathering crust developed on the sandstone inscription, black crust, Fe (Fe_2O_3) incrustation between quartz grains, Qz (quartz), and SEM image of salt loaded on the sandstone, cubes of sodium chloride (Nacl) salts.

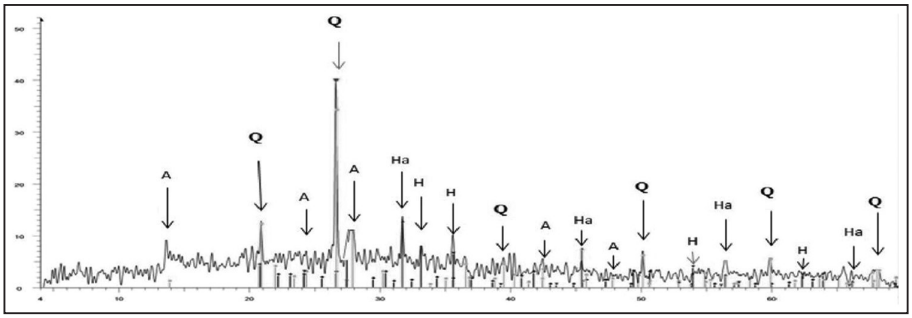

Figure 14: The X-ray diffractometer pattern of the sample of sandstone inscription, the peak of graph is showing presence of Q – Quartz, A – Albite, Ha – Halite, and H – Hematite minerals. After the complete treatment of the object, the process of conservation and restoration is completed; the final result can be clearly shown in Figure 15a and b.

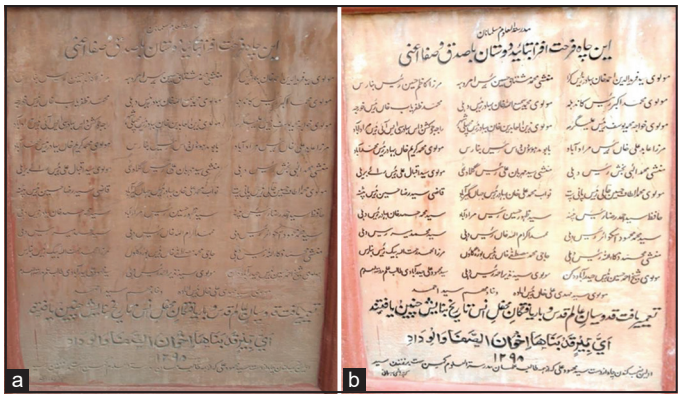

Figure 15: (a and b) The sandstone inscription on the water well before treatment and after the complete treatment.

angular, and it suffers from erosion, where there are some gaps, cracks, and crystallization of sodium chloride salts in form cubes. There are also black crust (BC), Fe (Fe_2O_3) incrustation between quartz grains, and Qz (quartz) found in the sandstone inscription, which are clearly shown in Figure 13a-d, respectively.

In the next examination of sandstone sample which is done with the XRD showed, the existence of compounds such as quartz (SiO_2), albite ($NaAlSi_3O_8$), halite (NaCl), and hematite (Fe_2O_3), indicating that the cementing material is Fe_2O_3, as well as crystallization of halite salts, which is clearly shown through the pattern of XRD graph in Figure 14. The peak in the graph is showing the presence of quartz (SiO_2) compound in highest percent. Hence, quartz is found to be the main mineral composition in the sandstone inscription. XRD indicated some intense and sharp many other small and less intense peaks at 2θ (Theta) values. The peak resemblance at 2θ/degree value indicated that the object has strong crystalline nature.

4. CONCLUSION

The construction of well and harvesting of water from the well was a dominant feature of human society till the advent of modern era, and it is still there in remote areas where the wells are operational. In case of MAO College, these wells have played a pivotal role to quench the thrust of water and other needs. They are part and partial of the built heritage of MAO College, although, there are massive attempts to preserve the S.S Hall campus comprising Victoria gate, University, Mosque, and Central Vista. However, no one has bothered to include the decimal status of the well which is also the part of MAO building. It is not very early to suggest the specific and detailed guidelines for the conservation of any heritage complex, since it requires a lot of research and analysis to develop a conservation plan for any particular site. However, some general guidelines can be given to maintain any built heritage site. The problems in most of the heritage areas are similar and are due to the lack of maintenance and management. This is a common practice with all the heritage buildings of national importance.

The present study found a number of important results in identifying the type of sandstone, nature of the texture, and diagnosis of the deterioration. The results are based on the scientific studies, examinations, and analysis. The study helps us to prove that the sandstone inscriptions on water well of MAO College suffered from various deterioration phenomena such as cracking, peeling, erosion, disintegration, and crystallization of salts on the surface or inside the cracks and gaps of the sandstone. The process of documentation, restoration, and conservation of the object is taken place with the precise selection of appropriate materials and methods required for the treatment on the basis of nature of the deteriorated object. Furthermore, for the cleaning of the object, mechanical cleaning along with chemical cleaning methods was adopted in the process. The study also focused toward the need to raise the archaeological awareness of the people and specialists to understand the utmost need for preserving these historical inscriptions along with MAO water wells in their original shape, which can be easily restored with the minor intervention process.

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