

A Study of the Damages to Historical Monuments due to Climatic Factors and Air Pollution and Offering Solutions

Shoureshe Kanani, Hassan Zandi

Abstract—Historical monuments as architectural heritage are, economically and culturally, considered one of the key aspects for modern communities. Cultural heritage represents a country's national identity and pride and maintains and enriches that country's culture. Therefore, conservation of the monuments remained from our ancestors requires everybody's serious and unremitting effort.

Conservation, renewal, restoration, and technical study of cultural and historical matters are issues which have a special status among various forms of art and science in the present century and this is due to two reasons: firstly, progress of humankind in this century has created a factor called environmental pollution which not only has caused new destructive processes of cultural/historical monuments but also has accelerated the previous destructive processes by several times, and secondly, the rapid advance of various sciences, especially chemistry, has led to the contribution of new methods and materials to this significant issue.

Keywords—Air Pollution, Climatic, Historical Monuments

I. INTRODUCTION

HOUSES and edifices are the most memorable places for the tourists who travel the world in order to see the heritage, past, and culture of people all over the globe. There are many of such houses and buildings in all corners of the world. According to educational experts, showing the cultural heritage to the youth not only creates national pride in them but also helps them follow the example of their honorable past. But since the necessary budget is not allocated to identifying the problems and restoration of these buildings, this lasting heritage is in danger of falling into oblivion. One of the major, and at times controversial, issues in the field of architecture and urbanism in countries nowadays is conservation of urban areas and historical architecture and different opinions about how to preserve these spaces and valuable ancient buildings concerning which, sometimes, disagreements go beyond the realm of architecture and urbanism and involve socio-political issues. Many studies have been performed about conservation of historical monuments [1]-[4].

Shoureshe Kanani is with the Department of Architecture, Islamic Azad University, Mahshahr Branch, Khozestan, Iran (corresponding author to provide phone: 00989171224278; e-Mail: hasanznd@yahoo.com). Hassan Zandi is with the Department of Architecture, Islamic Azad University, Mahshahr Branch, Khozestan, Iran (corresponding author to provide phone: 00989171224278; e-Mail: hasanznd@yahoo.com).

With regard to architectural and urban traditions as well as richness of the precious monuments of the past, Iran is undoubtedly one of the most remarkable countries in the world. Protection of cultural and historical buildings and environments is important due to two reasons: first, preservation of the material and spiritual heritage of our ancestors and, second, using them in education and research for the purpose of discovering the principles and values utilized in these monuments. Valuable historical monuments are those whose construction dates back to the eras during which the construction principles and calculations of the present day were not employed. Consequently, these monuments are seriously damaged by the natural destructive factors with instant or gradual function or by the human destructive factors. In this article, damages to historical monuments due to climatic factors and air pollution are discussed and suitable solutions are recommended.

II. DESTRUCTIVE FACTORS IN HISTORICAL STRUCTURES

Destructive factors in historical monuments can be categorized as follows:

- Natural factors with instant function, natural disasters (earthquake, lightening, fire, flood, drift and movement of earth...)
- Natural factors with gradual function
- Physical factors (wind, sunlight, changes in moisture, changes in temperature, acid rain, air polluters...)
- Chemical and electrochemical factors found in nature
- Vegetable destructive factors
- Biological and microbiological factors
- Complex factors
- Social factors due to profiteering or negligence and mismanagement in the third world societies
- Inherent and internal factors due to the weakness of techniques or lack of knowledge about the climate or available material

In this study we will focus on climatic and physical factors but other factors will also be examined. The aim of this study is to diagnose the problems of historical buildings due to climatic factors and air pollution in various parts of Iran with different climatic conditions and recommending suitable solutions.



Fig. 1 plants growing between stones (stone caravansary Dokooahak village, Shiraz, Iran)



Fig. 2 destruction and erosion of an earthen building due to climatic factors (Damab castle, Isfahan, Iran)

III. DISCOVERED BUILDINGS

After discovery, buildings which are not buried beneath earth and are exposed to natural and climatic factors are in a condition that due to precipitation, the environment is suitable for the growth of fungus and moss and after the mortar becomes loose and crumbles, the façade of the walls is covered in various kinds of ivies. Besides, the surrounding soil becomes penetrable due to accumulation of rotten leaves and, therefore, moisture easily finds its way to the foundation and after a while the remnants of the abandoned building completely collapse.

But if we employ experts and skillful technicians for preserving such buildings, using the available equipment, they may efficiently deal with all the above-mentioned factors and prevent a probable destruction. These days, using especial methods and techniques such as electro-osmose we can strengthen old buildings with a weak foundation and by depositing materials such as Calcium Silicate beneath the columns we can provide a solid base for the building. Besides, techniques for adjusting temperature and moisture and ventilation are so advanced which can safely preserve sensitive and perishable objects such as documents, books,

cloth, etc. in museum halls and storerooms and even in the basements (during the war).

IV. THE EFFECTS OF AIR POLLUTION ON THE BUILDINGS

Normal environmental destructive factors such as severe fluctuations in temperature and moisture and the seasonal changes in these two factors, fire... are not new; they have always existed and have had their destructive effect on the cultural heritage over the years. But in the twentieth century, especially during the recent decades, destructive mechanisms have become so sophisticated and their pace so fast that if proper attention is not paid, complete collapse of part of the historical monuments and other cultural heritages might really occur. And perhaps it is because of this serious warning that, recently, various institutions and centers have employed researchers and experts in different scientific fields such as chemistry, physics, restoration of historical monuments, biology, geology, archeology, osteology... who meticulously study these historical/cultural properties and the mechanisms of their destruction. Undoubtedly, one of the major responsibilities of such centers would be the scientific and accurate study of disintegration processes of various materials and, in fact, diagnosis of the problems of these monuments. And in this regard, the effect of environmental pollution especially chemical and acid rains in deteriorating the construction materials and, consequently, historical monuments is very important. And the results of such studies will directly contribute to conservation, restoration, and maintenance of our cultural heritage. One of the gases which contaminates the air in industrial regions is antheri sulfur gas which, eventually, changes into sulfuric acid and affects many substances. The corrosive effect of this acid on materials which are exposed to open air such as construction stones and metals is quite conspicuous.



Fig. 3 Decomposition of stones due to acid rains

V. THE EFFECT OF MOISTURE ON HISTORICAL MONUMENTS

Relative humidity and air temperature have definite effects on the stability and strength of monuments. Relative humidity of a specific amount of air is defined as the ratio between the amount of moisture in a specific amount of air and the moisture required for saturation of the same amount at the same temperature. There are two types of moisture: ascending and descending.



Fig. 4 Moisture along with fluctuations in temperature can lead to disintegration of the façade (plasterwork) in cold regions (Alavian dome, Hamadan, Iran)



Fig. 5 penetration of moisture into the pores of the building and freezing between the bricks which shatters them in cold regions (Alavian dome, Hamadan, Iran)

• *Ascending moisture*

This type of moisture is created due to penetration of water into the walls and its upward movement as a result of capillary action. Various factors are involved in creating this phenomenon including:

- Lack of suitable landscape around the building
- Building gardens and planting trees near the building.
- Blockage of sewage wells and plumbing system.
- Elevation of underground water.
- An increase in the absorption capacity of the materials such as bricks.
- Using non-hydrophilic materials such as cement, tarpaulin, and gloss paint which capture the moisture within the walls and foundation and lead to its ascension to the upper levels of the building.



Fig. 6 Damages due to ascending moisture (Jewish Synagogue, Hamadan, Iran)

VI. DESCENDING MOISTURE

Descending moisture is the moisture from precipitation. The following factors cause descending moisture:

- Sloping the roof.
- Installation of gutters in improper places of the building. For example, in cold regions, if gutters are place outside the building, due to freezing they will not function and water rises up behind the gutters and, then, penetrates into different parts of the building.
- If insulation layers (tiles, tarpaulin...) are not fixed or changed in time, moisture will penetrate into the building.
- A wrong prediction of the height of the insulation appropriate with the height of snow.
- Improper use of the roof which might damage it.
- Constant care and maintenance of the building in different seasons; cleaning the gutters and drainpipes and mowing the weeds.
- Using insulation materials which do not suit the climatic condition of the region such as using tarpaulin for curved, steep surfaces.



Fig. 7 Damages due to descending moisture (Vakil Bath, Shiraz, Iran)

VII. RESULTS

Damages to historical monuments due to moisture are:

- Appearance of moisture spots on the floor
- Constant smearing of the walls (ascending)
- Erosion and abrasion of the walls which is the result of ascending moisture
- Steady blurring of the inner walls which may be due to saturation of the air moisture
- Appearance of scattered spots which gradually change. It may be due to penetrability of materials within the wall
- Curing and appearance of saline materials (salt peter) which may occur as scattered or steady spots
- Appearance of tiny fungus due to lack of ventilation, stale air, lack of sunlight, or organic factors

Taking into consideration the above-mentioned issues, there is no reason why man cannot find appropriate ways for conservation of buildings which have endured natural disasters for many years and only recently due to air pollution or some other factors have been rapidly destroyed. Therefore, nowadays, the issue of conservation and restoration of historical buildings has gained an international significance and besides the exclusive activities of the countries, UNESCO also has established important centers such as Centre de Rome or Institut Royal du Patrimoine Artistique de Bruxelles for guiding museum owners and training experts for conservation of monuments. Also by organizing committees and international conferences, UNESCO tries to improve coordination between nations so that mankind may preserve the cultural and artistic heritage which has endured for thousands of years and transfer it to the future generations in a suitable condition.

VIII. CONCLUSION

The reason why limestone decays, especially during the past fifty year is air pollution and the stone's potential for changing into sulfate. The properties of rain water are also responsible for decomposition of historical monuments: penetration of water into the pores and walls, climatic changes, microscopic creatures, the effect of animal excrements on the façade of the building, damages due to wind along with dust. And during the recent years, most countries have found out that the global architectural heritage is perishing.

Terms such as leprosy or malady of stones are usually heard. The symptoms of this deteriorating disease are getting worse and it seems almost incurable. Historical monuments which have endured for centuries have been severely damaged over the past fifty years. The reason is air pollution in the cities and industrial centers because the air in these regions is mostly saturated with the smoke produced by the consumption of fuel in the factories and houses. Smut and gases such as andheri carbonate and andheri sulfur are among the harmful

substances which are released into the air as a result of burning petroleum and coal. The latter gas is dissolved in water, fog, rain, and snow and initially changes into sulfurous acid and then, gradually, into sulfuric acid which is well-known for its destructive and wearing effects.

From what went above, we can conclude that a collaborative effort is required for conserving the heritage of the past and we must keep these ancient monuments from destruction.

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