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A SCIENTIFIC APPROACH TO PRESERVATION OF CULTURAL HERITAGE - SIB SAGAR (ASSAM) CENTRALLY PROTECTED MONUMENT

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Abstract

Sibsagar monuments in Assam, a north-east state of India is large masonry structure built using sandstone, terracotta bricks, lime surkhi mortar/plaster, mud and tiles. The monuments have been exposed to decay for centuries, some time for millennia. Due to long period of exposing the monument, environmental change, the monuments are continuously deteriorated. In this article, it is discussed important weathering and deteriorating agents like as temperature, relative humidity, atmosphere, rain water, surface water, ground water, biological growth, and human vandalism along with a scientific approach to preservation of monuments. The efforts have been made that this approach to protection of the monument was significantly, weather resistance and good for health of the monuments.

Keywords*: Deterioration factors; Preservation; Pollution; Silane/Siloxane.*

Introduction

Sibsagar is recently called as Sivasagar. The meaning of Sibsagar is the Ocean of Lord Shiva. Ahom kings had ruled over Assam (India) for about 600 years and Sibsagar was the capital city during Ahom kingdom. It has lots of heritage places in its lap of the times of Ahom kingdom. It is situated between 26.45^{o} N and 27.15^{o} N latitudes and 94.25°E and 95.25°E longitudes in eastern part of Assam, about 360 km north-east of Guwahati. Sibsagar occupies a special position in the cultural scenario of Assam in India on account of its unique history, multi-racial population and their diverse and distinctive practices and beliefs as Assam is the meeting ground of ethics streams from north-west and the east [1].

Man-made historical, cultural, religious and architectural importance sites, which are more than hundred years old, are termed as historical monuments. Different types of monuments used different organic as well as inorganic raw materials such as stones, bricks (terracotta), lime surkhi mortar, lime surkhi plaster, mud, and tiles etc. So deterioration of building materials shows by different factors like environment, pollution, biological, mechanical and chemicals [2]. Such monuments attract thousands of national and international tourists,. Not only this but also, it gives information regarding the history of state as well as country and great person. Hence it is essential and important to preserve and conserve them. Here it is interested to explain some preservation and chemical conservation work of centrally protected monuments at Sibsagar, district: Sibsagar, Assam. The monuments (Sibdol, Bishnudol, and Devidol) are not only enlisted in protected site but also important in tourism aspect.

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Monuments are simply classified into two categories, one is living monuments and another one non-living monuments. Sibdol, Bishnudol and Devidol temple at sibsagar is living temple. The Sibdol was built up sandstone, lime surki Mortar, and lime surkhi plaster by reigning queen Phuleswari Devi, has circular *sikhar* (vertical head or upper part of the temple), decorated with honey comb design, with one *angasikhara* (miniature rekha replicas) at each of the *rahapaga* (plan form of projection of the garbhagriha). Over the *sikhara* is placed two *kalasas* (a metal pot with a large base & small mouth placed on sikhara), one above the other [3]. Bishnu Dol Temple was built up bricks, sand stone, lime surkhi mortar, lime surkhi plaster by Kuwori Ambika during Ahom kingdom and little smaller in size than Shivadol, this temple carries a unique architectural value in itself. Bishnudol Temple is dedicated to Lord Vishnu. Although the doors of Vishnu Temple are opened round the year, but the visit of Vishnu Temple during Badha month of Panchaang is highly recognized. Devidol was built up bricks, sand stone, lime surkhi mortar and lime surkhi plaster is dedicated to Goddess Durga. Devidol is also known as Joidol. Durga temple's tower is designed in its vertical elevation with an undulating pattern.

The monuments erected with sandstone, bricks, lime and *surkhi* have been exposed to decay for centuries, sometimes for millennia [4-6]. Due to the long period of exposing the monument and environmental changes, the monuments are continuously deteriorated. The deteriorating factors [6, 7] of monuments are basically depends upon its surrounding environment, pollution, biological condition, chemical, human vandalism etc. The enhanced rate of air pollution in urban and industrial are as caused by firing of fossil fuels is changing the amount of deleterious ingredients in the air which are transmitted onto rain and surface waters. The condition of the monuments depend on use of them, also plays a vital role, which deteriorate the monuments. With this object, it was the particular interest to explain the environmental as well as preservation condition of the monument. Therefore, in this paper, here we explained a scientific conservation and preservation against weathering agent especially with reference to Bishnudol and Devidol temple at Sibsagar, district: Sibsagar, Assam.

The following important weathering and deteriorating agents are temperature, relative humidity, atmosphere, rain water, surface water, groundwater, biological growth etc. [8, 9].

Relative Humidity and Temperature

The action of temperature, rainwater and moist becomes the masonry humid due to percolation, absorption and condensation. At Sibsagar, Assam shows the large variation throughout the year in temperature range between maximum 38^{o}C to 29^{o}C and minimum 25^{o}C to 8^{o}C (Fig.1) and relative humidity also between maximum 100 to 98% and minimum 68 to 37% (Fig.2), for April 2016 to March 2017.

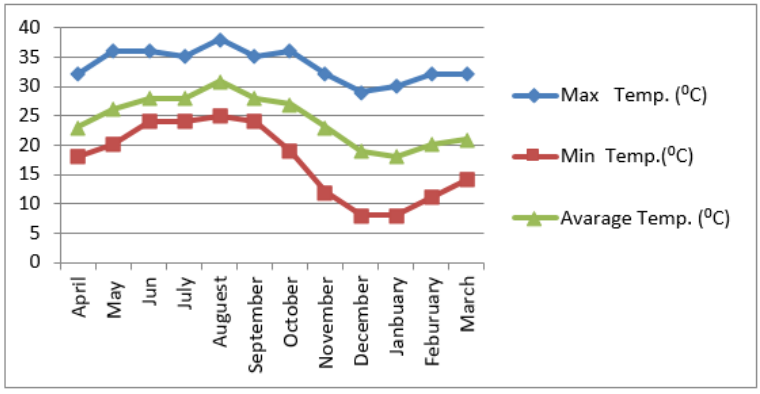

Fig 1. Temperature variation graph during the year April 2016 to March 2017.

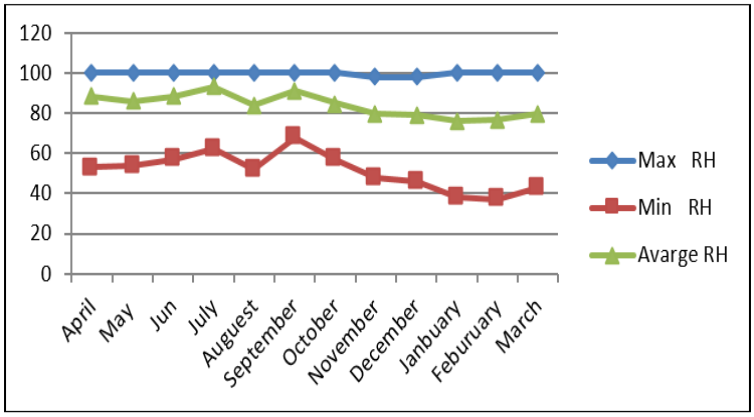

Fig 2. Relative humidity graph during the year April 2016 to March 2017.

In the early morning, humidity in the air nearby to the surface of monument can be high as 98 to 100% and temperature as low as 8°C to 25°C. In the circumstances of the afternoon relative humidity drop downs about to 50%. In this condition the surface of monument should suffer to drying phenomena. According to above discussion about the temperature and relative humidity, surface of monuments swells upon absorption of water and contraction upon the drying process must produce stresses at the building materials. Temperature and relative humidity cycles repeated continuously, can contribute to overall weathering process of surface as well as weakening and crumbling the monument.

Atmosphere

Clean air is the foremost requirement to sustain healthy lives of human kind and our historical building. The atmosphere is the prime reservoir for rampant impurities in rainwater and surface water which wash out by precipitation and affect the monument surface, contacting the building materials in aqueous solution. The following ingredients may be aggressive and active in the destruction of minerals like as CO_2, SO_2, SO_3, NH_3, NO^{3-}, and Cl^-. Following dissolved gases and ions are also concentrated in soot and dust on the surface of monuments. Soot and dusts are accumulating on the surface and form a solid coating chemical attack on the surface of monument is due to the solvent action of water and to its acidic impurities [6]. CO_2, SO_2 and SO_3 are the critical impurities which responsible to rapid deterioration of monuments. This type of deterioration makes the monument surface rough which is responsible to retain the water always on the surface as essential for growth of microphytes in the long period rainy season at the Sibsagar monuments compared to other region in India.

Rainwater

North-east region shows the heavy rainfall during the year. Rainfall distribution pattern [10] of the north east region where the monument is located (Sibsagar District) also shows heavy rain between the months of April to October during the year but starting period of rain is March and till the end of November. July, August and September is the peak season of the rain (Fig. 3). Due to heavy rain in Sibsagar District is causes thick and luxurious growth of vegetation. The monuments show the expansion at wet season and constriction at dry season and make the massive surface due to the macro- and micro-vegetation growth and give the unappropriated look to the monument as well as deteriorate faster. The composition of

rainwater is closely associated with the composition of atmosphere. The pH of rainwater ranges from 4 to 7, with an average value of approximately 6 where air is not contaminated.

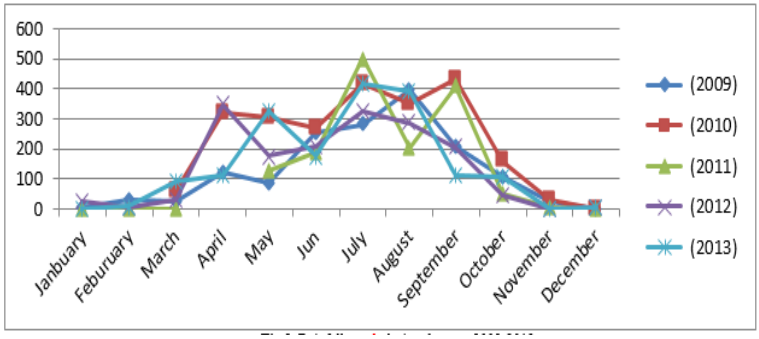

Fig 3. Rainfall graph during the year 2009-2013.

Groundwater

Monuments may encounter occasional direct contact with ground water along with deeper foundations. The preservation of groundwater is yet important, but not for the in-situ preservation of archaeological sites; however when this is combined with hydrological forces and the tendency of moisture to be transported horizontally through soil [11], the high moisture levels that may be seen in Sibsagar due to nearby a large pond at monuments baseline and Brahmaputra River remains problematic. The water is widely recognized as a building's feud. In spite of, the baseline and outer surface of Sibsagar monuments appears wet all the time in rainy season, this may be the result of high groundwater.

Biological growth

Lichens have a symbiotic relationship to algae and fungi whose effect on monument surface is much issued. Sometimes they are presumed protective but more often destructive. The symbiotic system of lichens is described by slow growth and ability to attach themselves to monuments surface without supporting soil, so they are the pioneer in the formation of humus, which supports higher plants later [6]. They are making the rough surface to deteriorating masonry and destroyed the aesthetic value of monuments. The rough surface and spongy character of the lichens, algae and fungus retains water for some time and keeps the monuments surface damp underneath, this may contribute to damage later on. The rhizomes of lichens, algae and fungus as well as root system of higher plants produce H^+ cation very small quantity [12]. They are easily exchanges negatively charged nutrient, this exchange is also important to breaking up minerals. Once the break-up process has started, it is strongly accelerated by the action of carbonic, humus and various other complex organic acids which are produced from the organic remains. As ever a film of colloidal-size clay has obtained on the surface, the acid-interacting clay continuous its attack on the un-weathered materials underneath [13].

Human Vandalism

The human vandalism also invites many conservation and preservation problems. Human activities often cause irreversible changes on monument surface. These changes affect not only the aesthetic value of monuments but also cause structural damage [14]. The Shivdol, Bishnudol and Devidol temples at Sibsagar are living temple that's why here find out big variety type anthropic activities. The devotee of God always used to different types of worship

materials which is produced many types of harmful matters. These harmful matters are highly responsible to deteriorate the monuments. [15]

Effect of Birds

Shivdol, Bishnudol and Devidol temple is widely affected by birds. Birds, particularly pigeons, cause a noticeable damage of monuments in respect of aesthetical and chemical aspects due to deposition of pigeon's guano. Pigeon's guano is an excellent growth medium for chemoorganotrophic micro-organisms. These micro-organisms cause a corrosive action on building materials by releasing acid metabolites.

Experimental

Materials and preservation sites

LR grade ammonia solution, LR grade non-ionic liquid detergent (Teepol), was used for chemical cleaning purpose and LR grade sodium pentachlorophenate for biocidal treatment purpose procured by Central Drug House, New Delhi. Solvent less silicon concentrate based on Silane/Siloxane (Wacker BS-290, Germany) procured by Savison & Company (Kolkata, India) for hydrophobic treatment. Different type and size of soft bristle nylon brushes and paint brushes had been used to application of chemicals to the monuments. Bishnudol Temple & Devidol Temple had chosen for study and preservation purpose.

Procedure

Bishnudol and Devidol at Sibsagar, centrally protected and a holly historical place has taken for preservation purpose. Preservation of protected sites has been needed several steps. First one was superficial dry cleaning, second one was chemical cleaning by means of wet chemical methods, third one was biocidal treatment method to re-arrest the growth of spores of micro & macro vegetation by biocidal treatment methods and fourth one was hydrophobic treatment to make the monument water resistant.

Superficial Dry Cleaning

The superficial dry cleaning has been done through the using different type and size of soft nylon bristle brushes, paint brushes and some essential tools whenever required to remove the dust, dirt, pigeon guano (pigeon excreta), spider net and macro and micro vegetation growth etc. from the outer surface of monuments.

Chemical Cleaning

Effected area from lichens, algae, fungi and moss etc. firstly soak with 2-3 % aqueous solution of ammonia mixed-up 1-2% aqueous solution of non-ionic liquid detergent then gently scrubbing with different type and size hair like soft nylon bristle brushes depending upon the condition of monument surface, wash out thoroughly with the deionized water. The cleaned surface kept dried for further next action.

Biocidal Treatments

The cleaned and dried area by wet chemical methods was subjected to 2-5% aqueous solution of Sodium pentchlorophenate and repeated this treatment after an interval of about one week to kill and re-arrest the spores of micro and macro vegetation. The biocidal treated surface kept completely dried for further next action.

Hydrophobic Treatments

The completely dried surface area was subjected to dilute solution of silicone based on silane /siloxane (Wacker BS-290) in organic solvent of Mineral Turpentine Oil (MTO) (ratio of Wacker BS 290: MTO was 1:14 W/V) by the help of different size and type paint brushes to

make the surface suitable for imparting water repellency (fig. 5). Physical data of silicone based on silane/siloxane are [16-17]:

- appearance colorless - hazy
- silane/siloxane content - approx. 100 (%)
- density at 25°C - approx. 1.05 (g/cm³)
- viscosity at 25°C - approx. 20 (mm²/s)
- flash point (DIN EN ISO 2719) - approx. 38 (°C)

Results and Discussions

Bishnudol and Devidol temple was suffered from several deteriorating problems due to effect of environment and heavy rainfall during the year. It was not affected aesthetic value only of the monuments but also building materials. So, to minimize these problems and intervention it was essential to chemical treatment and preservation because deteriorated materials make the monument surface more porous and increase the retention time of water which was increase the deterioration rate. The scientific treatment and preservation of monuments shows the best results (Fig. 4).

Fig. 4. Before treatment (left) and after treatment (right) of Bishnudol temple

After treatment, monuments maintain not only its aesthetic value but also reduced the environmental effect to the monuments surface. Our scientific preservation approach is based on using wet chemical cleaning methods. Liquid Ammonia, non-ionic liquid detergent and de-ionized water are used as cleaning agents. In this treatment Sodium pentachlorophenate is used as a biocidal. Silicone based Silane/siloxane water repellent shows the excellent results of monument surface (Fig. 5). Results of the scientific treatment and preservation are making the monuments surface fully water resistance and hinder the regrowth of spores of micro- and macro- vegetation. So an account of this remedy, the monument will be long life to not only present generation but also future generation to known our incredible history and historical research.

Fig. 5. After preservation of sand stone surface of Sculpture (right) imparting water repellence and un-preserved sandstone surface (left).

Effect of Liquid ammonia and non-ionic liquid detergent

Monuments surface was covered with micro and macro vegetation growth. Pigeon guano is an accelerator to vegetation growth when it comes in contact to moisture and provided foody substrata. Atmospheric pollutant was also settling down on the monuments surface. All above said living and non-living material are produced acids. Rhizomes of vegetation growth produce acid and dissolved the binding materials of monuments. Once deterioration processes started due to dissolution of binding materials it cannot possible to stop easily and heavy rainfall during the rainy season also enhance the deterioration process. Effect of rainfall was already explained in the introduction heading. Roots, hyphae, lichens, algae and fungus penetrate inside the monument surface and very difficult to remove it. They are softened with weak alkaline water due to neutralization process. Acids are produced by rhizome of micro- and macro-vegetation on the surface of monuments. The most useful weak alkali which evaporates easily is ammonia. Others alkali are too strong and are not easily washed out. This is the reason for which it was decided to use neutralizing agent ammonia due to our scientific approach to minimum loss and maximum output. An aqueous solution of ammonia (2-5%) mixed up 1-2% non-ionic liquid detergent was employed. This ammonical aqueous solution softens the root and the growth comes out easily with the help of scrubbing different type of nylon brushes. After ensuring the complete removal of vegetation growth, the monument surface washed out thoroughly using with 1-2% aqueous solution of non-ionic liquid detergent with the help of soft bristle nylon brushes. The non-ionic liquid detergent is electrically neutral cleaning agents, do not contain or contribute to the formation of soluble salts. Non-ionic liquid detergent provides better wetting of the monument surface and, therefore, successfully facilitate the removal of accretion. So, it is preferred to use Non-ionic liquid detergent. After this process, the monuments were washed out thoroughly with the de-ionized water to flow down remaining any type of ammonical substrate, detergent and harmful traces.

Effect of Sodium pentachlorophenate

After scientifically wet chemical cleaning, the surface of monuments kept clean and dry to further next step treatment but after cleaning, yet micro spores remains in the deep surface and travel by air, by birds faces also to reach the monument surface and found the suitable environment, they grow up [18]. It is essential to kill those spores of micro- and macro-vegetation to check the re-growth. Sodium pentachlorophenate was used as biocidal. It is the sodium salt of pentachlorophenolate. It is soluble in water and toxic by ingestion, inhalation and skin absorption and is good preservative for wooden materials. Aqueous solution of Sodium Pentachlorophenate (2-5%) was applied with the help of paint brushes on the cleaned and dried surface after an interval of one week to kill and re-check the micro- & macro- vegetation growth. Results were sound and satisfactory.

Effect of silicon based silane/siloxane

After biocidal treatment, the surface of monuments kept completely dried to further action. Actually water-repellent agents used for the hydrophobic treatment from silicone based silane/siloxane of monument surface. Nearly all water-repellent agents used for the hydrophobic treatment of stone form silicone resin films as a final product. After application, SILRES® BS 290 reacts with the atmospheric moisture or pore water in the substrate, thereby generating the active ingredient while liberating alcohol. The active ingredient greatly lowers the water absorbency of the substrate. Since neither pores nor capillaries are clogged, the substrate retains a very high degree of water vapors permeability. Silane/siloxane acts as consolidation and good as well as water proofing agent finally looks object in good preservation state (Fig. 6).

Fig 6. Before treatment (left) and after treatment (right) of Devidol temple at Sibsagar,

Conclusion

As discussed above, the major factors responsible for the decay of monuments at Sibsagar monuments are temperature, relative humidity, atmosphere, rain water, surface and ground water, biological growth, human vandalism and effect of birds etc. Scientific preservation of monuments minimize the deteriorating factors and providing the reinforcement to the building material for futuristic. The results indicate that this approach to protection of the monument was significantly and weather resistance. After treatment, water vapors permeability was unaffected and the breathing of the monuments was retained. These results suggest that this approach is a good for health of the monuments against the deterioration rate of the harmful agents.

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