

*International Seminar on  
Conservation of Stone Objects with  
Special Reference to Limestone Objects.*



**Government Museum,  
Chennai - 600 008.**

**18<sup>th</sup> to 21<sup>st</sup> December, 2001**

**International Seminar on  
Conservation of Stone Objects with  
Special Reference to Limestone Objects**

*Jointly Organised*

*by*

Government Museum, Chennai,

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and

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**Government Museum  
Chennai- 600 008**

**18<sup>th</sup> to 21<sup>st</sup> December, 2001**

*The Organising Committee:*

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Commisioner of Archaeology & Museums,  
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**Dr.V.Jeyaraj, *Member Secretary,***

Curator, Chemical Conservation and  
Research Laboratory, Government Museum, Chennai.

Abstracts have been printed in alphabetical order of the titles of the articles.

# **A SHORT NOTE ON THE PRESERVATION OF THE BRICK-BUILT HERITAGE OF CHENNAI**

**N. Harinarayana,**

Director of Museums (Retired),  
Government of Tamil Nadu, Chennai - 600 008.

Currently there is serious campaigning going on for the preservation of the built heritage of Chennai. Chennai itself being just over three hundred and fifty years old, the built heritage of the city naturally comprises mostly of colonial period buildings of different styles. Among them, there are a few redbrick buildings with a charm of their own.

Brick is similar to stone as a building material in some respects but has its own problems concerning conservation. The brick built heritage of Chennai will be enumerated, the condition of the buildings noted and the approach to its conservation suggested in this paper.

# **ASSOCIATION OF SPECIALISED MICROBIAL POPULATION WITH ROCKS OF AJANTA AND AURANGABAD CAVES**

**\* R.R. Deshpande and \*\* A.D. Agate**

Since sulphur and iron oxidisers are implicated in weathering process and sulphate reducers have a role to play in corrosion, it was decided to study the association of these specialised microorganisms, if any, with rocks of Ajanta and Aurangabad caves.

It was found that out of eleven samples tested, five showed the presence of *Thiobacillus thiooxidans* and four showed the presence of *Thiobacillus ferrooxidans*. Only two of the samples showed the presence of both these organisms. However, none of the samples tested harboured any sulphate reducers. Presence of sulphur and iron oxidisers in the rock samples of Ajanta and Aurangabad caves is shown probably for the first time. It is difficult to establish a clear out cause - effect relationship, because samples of sculptures were not freely available to test, but it could pave a way for further studies in this connection, if other similar ecosystems from were to be tried.

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# AUTHENTICATION OF STONE SCULPTURES

**C. Santhalingam,**

Archaeological Officer, Madurai.

Stone sculptures need authentication in two ways, one is the identification of the sculpture and other in the dating of it. For identification the scholar who desires to study the sculpture must have some knowledge of iconography, literature, religious scriptures and *puranic* stories. The sculpture itself may provide some clue for the correct identification. Normally, the problem arises in the identification of figures when they are in groups. For example, in the group of figures like *Vishnu* with his consorts, *Muruga* with his consorts, *Sapthamathrika* panel, *Rishabha Vahana* groups and some other folk gods and portrait sculptures.

In dating the sculptures, scholars usually rely upon the physical features, dressing pattern and ornamentation. But by these clues, only tentative dates could be arrived for the sculptures. On the other hand inscriptions, particularly engraved on the sculpture itself help us to fix the exact date of the sculptures. Even then these dates are arrived only on palaeographical grounds. But fortunately some of the sculptures are having inscriptions with exact date and help us to fix the actual date of the sculptures.

In this way this paper deals with some inscribed sculptures recently discovered in the core *Pandya* region and their role in the authentication of stone sculptures.

# **BRINGING CONSERVATION TO CLASSROOMS – AN ATTEMPT**

**Rita Jain**

Art Conservator,

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Janpath, New Delhi-110 001.

An attempt of making school children familiar with the terms like museum artefacts and conservation of works of art by holding awareness programmes in some schools of Delhi.

# **CONSERVATION OF LIMESTONE STRUCTURES**

**Prof. Dr. G. Deivanayagam,**  
Head of the Department of Architecture,  
Tamil University, Thanjavur.

In the context of conservation of stone, limestone conservation is very much delicate. Comparatively limestone is softer than the other stones. But they are having their own beautiful textures and enchanting mild colours, which enhances the elevational beauty of the buildings.

Limestones are coming under calcareous sediments and there are four varieties available for masonry works. The combination of these stone surfaces in a façade gives 'rich beauty' to the building. For example, the façade of the Government Museum, Egmore is having the everlasting natural beauty by having sandstone surface layers.

The conservation of limestone is not simple but needs a sensitive touch. This paper tries to explain the conservation factors in detail.



# **CONSERVATION OF SILVER-GELATIN PHOTOGRAPHIC PRINTS - A CASE STUDY**

**S. GiriKumar**

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New Delhi

The paper discusses the treatment of an early 20<sup>th</sup> Century Silver-Gelatin Photographic print. The print was pasted on to straw-board and was badly stained by tea spilt on it. It also had silvering at some areas. The print is taken off the board and cleaned by various mechanical and chemical means. This treatment also helped in reducing the silvering on the surface.

# **CONSERVATION OF STONE OBJECTS AN EXPERIENCE IN GOVERNMENT MUSEUM AND PICTURE GALLERY, BARODA**

**A. R. Shah,**  
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Government Museum and Picture Gallery,  
Baroda.

The Government Museum and Picture Gallery, Baroda, a State Museum of Gujarat State, is one of the renowned museums in India. The Central Conservation Laboratory of this museum is looking after the conservation of the collection of this museum and those of the government museums in Gujarat. This Laboratory also extends its conservation services to the private museums, trust museums and the private collectors in order to preserve the cultural heritage in their possession.

This museum laboratory had conserved a group of stone sculptures for the Dakshina Murti Temple in the EME School campus. The sculptures were made of three types of stones, namely sand stone, schist and marble. The deterioration were also of three types viz. Sculptures affected by moss, lichen and salt action. Besides these they were covered with accumulated dust and dirt and the colour had been changed due to keeping them under the open sky.

This paper deals with the various chemical treatments and chemicals used to avoid the biological growth on the sculptures, the physical protection from sun, rain etc., provided to the sculptures in detail.

# **DETERIORATION AND CONSERVATION TREATMENT OF MARBLE MAUSOLEUM OF THE HOSHANG SHAH GHORI AT MANDU, DISTT. DHAR (M.P.)**

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Among the many magnificent buildings erected by the Sultans of Malwa there is the Mausoleum of Hoshang Shah Ghori in Mandu Fort, dating back to the 15<sup>th</sup> Century AD. The buildings, entirely made of white marble, are a fine specimen of Indo-Islamic architecture. The monument's condition has deteriorated badly over the centuries. In addition to the usual weathering, the blackening of marble surfaces due to growth of algal microflora in the exposed situations was observed to be the principal factor contributing to the slow deterioration of the standing monument. In order to improve the aesthetic appearance and also to protect the stone elements against further biological deterioration the whole monument recently underwent a suitable cleaning treatment.

The article describes about the method adopted by the A.S.I. on conservation treatment of these historically important monuments. The results of analysis-of the marble sample collection from the tomb are also presented.

# **DETERIORATION OF STONWORK AND METHODS OF RESTORATION**

**Dr.M.Sekar\***

**Ms.K.P.Pavithra\*\***

**Ms.Sandhya Mathews\*\***

India has a rich heritage of monumental buildings built of stone. Many of these monuments are many centuries old. All these structures have deteriorated with time since weathering is a law of nature. This paper deals with the various causes for such damages and looks at the possible methods of restoration.

The main types of deterioration associated with stonework are attack by polluted water and soluble salts, frost action, thermal stress, erosion, lichens, moulds, algae and other growth. The onslaught of urban and industrial development led to the unprecedented levels of air pollution, which within a short time has resulted in considerable damage of stonework in the exposed buildings. The main chemical agents leashed out into the atmosphere are Carbon dioxide, Nitrogen oxide, ammonia, hydrogen fluoride, hydrochloric acid, hydrogen sulphide and sulphur dioxide.

In undertaking restoration work of the affected structure, the sequential action suggested are diagnosis, cleaning, pre-consolidation, consolidation, surface protection, reconstitution, and maintenance. The repair methods range from stitching of the cracks to redressing of the stone when the original surface has eroded. The various cleaning methods that could be adopted are washing, dry blasting, wet grit blasting, mechanical cleaning, chemical cleaning with acid or alkali and the sophisticated laser cleaning. The maintenance of the stonework is aided with preservatives like polymers, epoxy resins and waxes.

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# **GEOLOGICAL ASPECTS OF ROCKS USED FOR ART OBJECTS (SCULPTURES)**

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There are three forms of stone sculptures. They are (1) Intaglio, (2) Relief and (3) Round sculptures. A brief note on the tradition of stone sculptures from the prehistoric period to Renaissance is given. Discussion with special reference to great masters sculptures, Egyptians, Greeks, Romans and Indian Art with examples are dealt with. A brief note on the geological and mineral subsistence of selected atone varieties used for sculptures are examined. The following specific rocks such as granite (Igneous), limestone, sandstone (Sedimentary) and marbles (Metamorphic) are the various types of rocks dealt with the carving of stone sculptures. The various constituents of rocks are also dealt with briefly in this paper.

# **HOW THE YOUNG SCULPTORS FORESEE THEIR FUTURE? AN ANTHROPOLOGICAL STUDY**

**Shaik Abdul Munaf,**  
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The journey of stone sculptor started with the manufacture of Palaeolithic artefacts by prehistoric men and then onwards the stone Sculptors developed magnificent sculptures with their wonderful artwork at various places throughout the world and precisely with special reference to Rayalaseema area in Andhra Pradesh. The earliest stone sculptors made their emergence by their artistic works of 'Venus of Willendorf', Megaliths, and achieved its peak during the regime of kings where the art of stone sculpture encouraged a lot. Technological changes made the art lovers to change their perception and deviated more towards modern entertainment resources like Television, Cinema, and recently Internet. This has led to the problems of stone sculptors and their future become questionable.

An attempt is made to study the problems of traditional stone sculptors particularly young sculptors at Sri Venkateswara Institute of Traditional Sculpture and Architecture, Tirupati. The young sculptors are not quite happy with their future prospects. Holistic study of Traditional Stone Sculptors and their involvement in the conservation process can help the conservators for the better understanding of problems of conservation of stone objects.

# **INTERNATIONAL LAW FOR PROTECTING OBJECTS OF ART FROM ILLEGAL TRAFFICKING AND THEFT**

**C.Paranthaman**

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International Law provides measures protecting conservation of stone objects and from Illegal Trafficking and Theft. In order to protect the world's heritage the UNESCO provides by way of conventions and the recommendation to the member states. UNESCO's First Convention was for protection of cultural property in the event of armed conflict 1943.

The paper focuses on other UNESCO's conventions like the recommendations of International Principles Applicable to Archaeological Excavation 1956 and Seventeenth Session held at Paris in the year 1978. The oldest law for protecting cultural property enacted by France in 1809 relating to controlling of the Transfer of State Archives.

The Study of European Countries pressurising a liberal export policy may begin with Great Britain, regarding license for exporting cultural materials and works or produced more than 100 years. A special reference is made regarding the Laws in India. Especially, The Indian Treasure Trove Act, 1878, The Ancient Monuments Preservation Act, 1904. The Ancient Monuments and Archaeological Sites and Remains Act, 1958 and The Antiquities and Art Treasures Act, 1972. Important cases law particularly Om Prakash Narang and another Vs. Delhi Administration (AIR 1979 S.C. Page 1791) is discussed.

All the above enactment relating to Ancient and Monuments, Historical and Archaeological Acts followed in member countries need thorough review for the purpose of introducing objective machinery to deal with the offences relating to Illegal Trafficking and Theft of lime stone objects, so as to enable the authorities vested with the powers to confiscate the personal properties of the offenders.

# **LASERS FOR THE CONSERVATION OF CULTURAL HERITAGE**

**Dr. P. Stephen Fowles**

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Stone is commonly viewed as a durable material but the surface of sculpture is often left in a perilous state by the effects of chemical and physical agents that undermine the structural integrity of the surface. An increased knowledge of the potential fragility of stone surfaces has meant that conservation methodology has now moved towards a policy of minimal intervention. This has in turn led to the development of new methods that are less invasive than was previously the case, an example being laser-based techniques for the cleaning, recording, non-contact replication and analysis of sculpture.

This paper describes the laser cleaning and recording techniques being used for the conservation of stone objects at the Conservation Centre of the National Museums and Galleries on Merseyside (NMGM) in Liverpool (UK). Laser cleaning has now become an established methodology at NMGM as it offers many potential advantages, most notably the high degree of control and precision and the environmentally friendly nature of the technique. NMGM is also at the forefront of using laser scanners for three-dimensional (3D) recording and the making of non-contact replicas. A laser scanner enables the recording of digital data from the surface of an object; this information provides a precise 3D record of the object at a fixed point in time. The data has a range of uses including virtual museums, academic study, surface monitoring and the non-contact production of replicas.



# MEDIEVAL MONUMENTS OF PUDUKKOTTAI STATUS OF GRANITE

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Government Museum, Pudukkottai,

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Pudukkottai lies between latitudes 9° 50-30" N and 10° 44' N longitudes 78'-25-5"E. Historically the Pudukkottai tract was the meeting ground of the boundaries of the famous Tamil kingdoms-the Pallava, Chola and Pandya and later of the Vijayanagar empire. Hence the region has a collection of the main representative styles of South Indian Architecture, all at an optimal level of excellence. Pudukkottai has the distinction in having the largest number of ancient monuments in Tamil Nadu and they attest to the mastery of the local artists.

The granite quarries in Pudukkottai supplied materials sophisticated enough to be suitable for delicate temple carving. Suitable stones for construction of the temples were selected to withstand the test of time, according to the rules and norms prescribed in the *Silpa Sastra* texts. However, some of the monuments have suffered the wrath of weathering due to their continuous exposure to the open sky for thousands of years together. The deterioration and decomposition on the surface of the granite holdings of some of the early Chola monuments and their present status are discussed in the paper.

# **OVERVIEW OF THE LEGISLATIVE FRAMEWORK FOR THE PROTECTION OF OUR CULTURAL PROPERTY AND SUGGESTIONS FOR IMPROVING IMPLEMENTATION**

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## **Abstract**

Every country is justly proud of its cultural heritage. India is especially blessed in this regard due to its having been the cradle of civilisation for the past 10,000 years. Therefore, conserving and restoring heritage monuments sites to their original state has become important. There is a legislative framework for protection of monuments whose custody has been taken over by the Union or State Governments. The high value that that antiques command especially in the illegal art market is due to the poor prospects of their being replicated. The masters who produced them have died long ago. Laws have been framed to regulate traffic on in such antiques. It is illegal to trade in them or export them without permission. Therefore, there is need to protect them so that they do not end up in the illegal art market.

# **PRESERVATION AND CONSERVATION OF STONE ANTIQUITIES USING LASERS**

**Prof. P. K. Palanisamy,  
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If ancient works of art are to be appreciated in all their glory by succeeding generations they need to be conserved, and cleaned of damaging dirt and pollution. In India, variety of monuments depicting cultures of different times, have to be conserved in order to make our nation as the most promising tourist centre. For museums and galleries, achieving this has presented all kinds of problems, as conservation treatments have usually been heavily dependent on the science of chemistry, which can have side effects. Since the invention of Lasers in the early 1960s, the conservation of art, antiques and sculptures has gained some new form. Since there are some problems such as decoloration in chemical based cleaning, laser has now potential benefits in the field of conservation of antiques and sculptures. The intriguing properties of lasers, the mechanism involved in the stone cleaning by lasers and also some of the recent developments of the laser technology of cleaning are presented in this paper.

# PRESERVATION OF STONE MONUMENTS

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In India, the ancient monuments are made of three types known as *Nagara*, *Dravida* and *Vesara* with special reference to temples. They were made with various media like stone, wood, brick, stone-cum-brick, etc. Each temple/monument faces different type of problems due to various reasons like age, temperature, environmental pollution, vegetation as well as human vandalism.

If a monument is to be conserved there are many aspects to be taken into consideration to carry out a proper conservation because it is not merely mixing sand with cement or lime and supplying over the structure. In other words, the conservator should know the inherent problem of that particular structure in question as well as the problems created by other agencies as mentioned above. Unless these vital aspects are understood the conservator cannot and will not achieve his goal.

The monument which is going to be conserved should be documented in all respects such as video recording from various angles especially the sunken / fallen portion, out of plumb area, vertical or horizontal cracks or void, etc. Materials which were used in original construction, and having knowledge about the percentage of each and every material in the original usage.

If a monument is partially collapsed or hanging precariously, the conservator should make proper drawings with scale so that the portion, which is to be reconstructed will not differ either in quality or in quantity or in area after conservation.

Alexander Cunningham had initiated a systematic survey of such ancient important monuments in way back 1861. Adopting that principle some of the well known monuments were conserved with archaeological principle in this country. To cite a few examples Fatehpur Sikri and Sikhandra in 1815, Qutub in 1826, Ahmed Nagar in 1867, Taj Mahal in 1868, and Thatta in 1885 were conserved.

While conserving, the following aspects are to be carried out:

- a) Removal of existing vegetation.
- b) Recking / scooping out of dead mortar through the joints or voids and filling/pointing.
- c) Where there is no evidence especially on fort wall or *tirumadil* such wall tops should be given rough packing.
- d) During the colonial period, at many monuments buttress walls were constructed just to safeguard the ancient structures. The best example is *tirumadil* of Kailasanatha Temple at Kanchipuram where more than a dozen such walls were constructed. They were removed after proper grouting the wall as well as strengthening the foundation.
- e) If any ancient temple is taken for conservation, it is not an easy task though it looks outwardly very easy, but in fact it is very tough and challenging one, especially the monument of *misra* type (usage of core material is stone and brick) because it will pose various problems at the time of reconstruction right from *upana* to *stupi*.

The Archaeological Survey of India, Chennai Circle, Chennai during the recent years has completed conservation of more than 100 temples successfully without deviating from the ancient method. For doing conservation, the conservator should have the knowledge of art and architecture, ancient knowledge about the raw materials, well versed with modern technique of methodology, besides capable of using modern materials also. At the same time, it is the mandatory part of the conservator to devote his time and energy to see that the monument in question which taken up for conservation has not changed structurally of aesthetically. Once this is achieved, it is needless to say that a proper conservation is successfully carried out to the given monuments.

# **PRESERVATION OF STONE OBJECTS IN THE GOVERNMENT MUSEUM, VELLORE**

**M. Gandhi,**

Curator,

Government Museum, Vellore-632 004.

Cultural objects help trace history and culture of a country or race. Therefore it is the duty of Curators to preserve the artefacts of bygone days for posterity. Our forefathers carefully carved sculptures, constructed religious and secular monuments and installed carvings. Many images carved out of stone were erected and worshipped. Further our ancestors left for us paintings and woodcarvings.

Though stone withstands ages and climatic changes, it is necessary to preserve them to our posterity. Images chiseled out of granite stand for long ages. But sculptures out of limestone and sandstone need care to preserve them to the future generations.

Stone sculptures and architectures of earlier ages bear witness for culture and history of contemporary rulers and people. New findings of art objects and epigraphy change the history of the dynasties and kings. Ornaments and weapons have similar pattern even though found in different countries they reigned by different kings. They show that they had cultural contacts and trade links among different dynasties of the contemporary world.

This paper deals with limestone , sandstone, sculptures, the mutilations done to the objects, the type of preservation and dowelling, which is a restoration of stone sculptures.

# PROBLEM OF BATS ON INDIAN MONUMENTS

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The activity of bats has caused serious conservation problems in many monuments like Ajanta, Ellora, Pittalkhora, Kanheri and many other temples and domes. Their excreta spreads obnoxious and foul smell, ugly look to the monument and is detrimental to both aesthetic look and physical strength of the building materials. The urine of bat is both acidic and hygroscopic in nature and readily reacts chemically with the components of the stone. The slow decomposition of the urea, an important constituent of bat urine, creates favourable conditions for insect activity enhancing the biodeterioration of the cave paintings and other monuments, which they inhabit.

The problem of bat eradication from monument is still unsolved. Toxic chemicals should never be used for bat control because they cause dead and dying bats to scattered throughout the building, yard and neighbourhood, thus, increasing the chance of contact between bats and people. Certain bat repellents were used but once the repellent wears off, the bats will recolonise in the monuments.

There is a popular myth about bats that they are blind and try to get tangled in hair. In ghost stories, no haunted house is complete without a few bats flying around; and Halloween brings to mind scary images of witches, goblins and bats. Bats seem frightening and mysterious. They dart around at night, hang upside down in caves and roost in abandoned buildings. But most stories about bats aren't true. Bats don't get tangled in people hair and they are not blind.

All bats can see but many do not use their eyes to find food. Instead, they use their ears. They can find their way in the dark, can avoid obstacles and can detect food by using ECHOLOLOCATION. It is seen that if the voice box or sense of hearing of such bats is destroyed, they are unable to avoid even large objects. There are some bats, which do not use echolocation. They depend on their vision and keen sense of smell to find ripe-fruit. These bats have large eyes and their faces resemble those of little foxes, hence, given a common name "Flying Foxes".

There are more than 900 kinds of bats and the scientists have placed them in the order "CHIROPTERA" which means, "Hand wings".

Bats are of the grand order Archonta, grouped together with the monkeys and the flying lemurs.

Bats amount to approximately a quarter of all mammal species' and the bats are the only mammals that can fly. Bats evolved from the early insectivores quite early in the evolution of Eutherians, possibly as much as 50 million years, (as dates the bat fossil).

Bats are vital to the ecosystem because of their several advantages. Fruit-bats brings us over 450 commercial products including 80 medicines. The anti-coagulant from the saliva of vampire bats has been synthesised and is now used in medication for human heart patients. Each bat can eat up to 3,000 mosquitoes and other flying insects each night. Bats are able to eat so much because they have high metabolism and spend a lot of energy in flight. Killing of bats will result in more mosquitoes and bugs.

Unfortunately, bats are prosecuted because of their preference to live in man-made structure. Bats usually find themselves very comfortable in the dark recesses of the building for their inhabitation. The monuments are no exception from their usage as good dwelling places. If the monuments are caves, then the structure offers very convenient environment for the rampant activity of the bats. Bats are nuisance at the monument. Though they do not cause severe damage to the structure by gnawing and chewing but their very presence at the monuments have the sickening effect, as their droppings may cause odour problems.

The normal life span of a bat is 10-20 years. Each bat gives birth to 1 or 2 pups in late May or early June. Insectivorous bats in temperate climates hibernate during winter because of insect scarcity. Atmospheric conditions i.e. temperature and humidity, during hibernation are very important to bats.

The bat's entry into monuments can be controlled by putting bat boxes along the sides of the point of entry of bats into monuments and closing that point of entry by wire meshes for the period till bats actually divert their way to bat boxes.

This paper discusses other various issues and suggestions for control of bats menace and their eradication keeping in view the various laws of Wildlife Protection Act in India.



# **PROBLEMS RELATING TO TRANSPORT AND DISPLAY OF STONE SCULPTURES IN THE DISTRICT MUSEUMS IN TAMILNADU.**

**P. Sam Sathiaraj**  
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The Department of Museums in the Government of Tamilnadu has 20 District Museums, most of them in their District Headquarters. The District Museums are of multidisciplinary type. But in most of the District Museums Archaeological galleries stand predominant with a fairly good collection of sculptures. Even though the collection is rich, the District Museums often face problems in transporting the sculptures from the place of acquisition and also in the process of display. Traditional methods of lifting and loading the sculptures involve problems like defacing the fine details and prominent part of the figures like the nose and fingers. Many reasons are attributed to the cause of these problems. Improper methods applied and lack of experience and expertise of the Curator and the District Museum staff may be some of the reasons for these problems. Limitations of funds allotted to the District Museums for adapting sophisticated methods of lifting, loading, packing and transporting the sculptures is also another reason for the occurrence of these problems. Limited staff members in the District Museums also play a vital role.

Improper display of sculptures in the District Museums due to want of space in side the galleries and improper methods adapted in display both inside and in the open space out side the museum. Long exposure to rain and hot sunlight causes deterioration of stone sculptures in the District Museums. Improper labeling also creates problems in the display of stone sculptures and stone inscriptions in the District Museums.

# **REHABILITATION AND RETROFIT OF EARTHQUAKE DAMAGED MONUMENTS IN GUJARAT**

**Dr. M.S. Mathews,**  
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Earthquakes pose a serious threat to architectural heritage principally composed of masonry construction. Factors such as age and weathering of building materials, exposure to past seismic events and the inherent weakness of masonry in carrying tensile stresses amplify the vulnerability of masonry monuments to future seismic events. The rich architectural heritage of regions like Gujarat is at stake due to repeated seismic events over the centuries. Today, there are internationally accepted methods for mathematical modeling to predict the behaviour of structures under seismic loading and numerous anti-seismic rehabilitation and retrofit techniques to safeguard this heritage.

## **Earthquakes, Their Causes, Ground Motion and Effects on Structures**

Ground motion generated by sudden displacements within the earth's crust is called an earthquake. Earthquakes are caused by various natural phenomena such as tectonic processes, volcanic eruptions, sudden failure of parts of the ground, etc. Body waves (P-waves and S-waves) generated from the focus of an earthquake reach the epicentre to transform into surface waves (Rayleigh and Love waves), which ultimately cause the devastation. In the case of Gujarat, the earthquake had its epicentre at Lodai village, 25 km from Bhuj, measured 7.9 on the Richter scale and lasted 90 seconds.

Earthquake ground motion results in horizontal, vertical and twisting motion of structures. The response of a structure to earthquake loading is dictated by the dead weight of the structure, its fundamental period of vibration and its efficiency of energy absorption. The dead weight of the structure has a direct bearing on the force effect caused by motion. Out-of-plane bending and in-plane shear are mechanisms by which masonry walls counter lateral loads and when the lateral forces exceed the internal resistance of the material, the masonry walls fail by typical mechanisms like the 'pushing-out of panels' or 'x-cracking'.

## **Damage to Monuments in Gujarat**

The author had undertaken an extensive survey of quake-affected regions and studied 28 monuments damaged by the earthquake in Ahmedabad,

Patan and Kutch. The architectural heritage of Gujarat presents a rich blend of Hindu, Jaina and Islamic building traditions with the indigenous art of woodcarving. The minarets of the mosques of Gujarat and its step wells are unique structures. Most of these monuments are made of Sandstone from the quarries of Dhangandhra in Gujarat.

The minarets of Gujarat, victims of several earlier seismic events are a diminishing heritage. The minarets of Shah Alam's Rauza, Achyut Kuki's mosque and Bibiji ki Masjid have come a cropper this time. A number of 15<sup>th</sup> and 16<sup>th</sup> Century (A.D.) structures, the Mausoleum of Syed Usman, Isanpur Mosque, Sarkhej group of monuments and Bhadra fort are some of the other monuments damaged. Kutch has lost a number of its 9<sup>th</sup> and 10<sup>th</sup> Century AD structures like the Jain temple and Surya Mandir at Kanthkot, and Rao Lakha Chatri at Bhuj 19<sup>th</sup> Century AD. A typology of damage for typical structures has been arrived at, depicting all the possible damage and collapse mechanisms. Based on the European Macroseismic Scale, a damage chart for a typical monumental structure in Gujarat has been developed.

### **Anti-Seismic Retrofit and Rehabilitation**

Repair refers to post earthquake repair of damages, caused by seismic ground motion that does not improve the seismic resistance of a structure beyond its pre-earthquake state. "Seismic strengthening" involves technical interventions in the structural system of a building to improve its strength and ductility and thereby improving its seismic resistance. Strengthening a building before an earthquake is "rehabilitation" and strengthening after is "retrofitting". About 25 anti-seismic techniques developed in European countries like Italy and Germany are applicable to the Gujarat case.

These anti-seismic retrofit and rehabilitation techniques have been classified as:

- A) Methods to strengthen masonry components
- B) Methods to improve structural integrity of the structure as a whole
- C) Methods to isolate seismic waves from the structure.

In case of a structure that has been completely destroyed by seismic activity, archaeological principles give a basis for their reconstruction from original salvaged materials. This is called archaeological reconstruction.

## **Mathematical Modeling**

The analysis of the behaviour of historical structures under dynamic loading is essential for their safety assessment and design of retrofiting measures. A good understanding of the structural behaviour is an essential step before any intervention. Use of Finite Element Method in analyzing the behaviour of the structure under dynamic loading gives an indication where regions of non-elastic phenomena are to be expected, and where cracking, joint opening or loss of structural continuity may occur, and thus can be helpful in designing retrofiting measures. Seismic modeling and analysis of a Chatri in Bhuj, partially damaged in the earthquake has been conducted and results compared to the actual damage.

## **Conclusion**

Structures cannot be made earthquake-proof, only resistant to earthquakes. There is a need to adopt and adapt these internationally accepted anti-seismic retrofit and rehabilitation techniques to conditions in India and simultaneously train manpower in their use, to ensure conservation of our monuments for posterity.

## RITUALS PLAY THE ROLE OF PRESERVATION AND CONSERVATION

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The rituals being performed in all the Hindu temples, in one way, play a notable role in the preservation of the icons of the temples.

At the time of *Kumbhabhisekham*, which happens every twelve years, a medicine called *Ashtabandhana* is applied to the stone icons. This medicine, prepared out of eight different materials, protect the icons from germs.

Different types of *abhisekhas* being performed to the icons also protect the icons from decay. One is *Vibhuti* (cow-dung powder) *abhisekha*. A German scholar has scientifically proved that *Vibhuti* contains oxygen, and due to this content, *Vibhuti* acts as an antiseptic agent. The work called *Kalagni Rudra Upanishad* mentions the medicinal importance of *Vibhuti* and the method to prepare *Vibhuti*, out of cow-dung. Sandal paste *abhisekha* also protects the icons. Like *Vibhuti*, sandal paste also contains oxygen. The venomous creatures and insects cannot approach the icons due to the aforesaid *abhisekhas*. Milk, turmeric powder, honey, coconut water *abhisekhas* also have medicinal effect.

New Moon day festival is considered to be an important one. On this day, the images are taken out in procession. The falling of the rays of the moon illuminates the deities, and again it is believed that the rays improve the vigour and vitality of the icons. It is apt to remark here, that the moonlight has strong impact on seawater, and due to that, on that occasion, the sea-waves are very rough and are arising to a considerable level. The falling of the Moon-Rays should definitely have the power of eliminating the germs of the icons. Bathing of the icons in the Seawater on Full Moon Day also protects the icons from erosion.

Some water festivals have medicinal effect on icons. *Cauveri* festival is the predominant one. As the river water has medicinal and mineral properties, which it acquires while flowing on mineral beds, and herbs and creepers, the images bathed in this water get preserved. In the *Coutralanathaswamy* temple at Coutralam, the water from the Falls, is being used at the time of the bathing ceremonies of the icons. As the water touches various medicinal plants, definitely, it should have the power of eliminating impurities of the icons.

The performance of the *Homas*, also play a vital role in safeguarding the icons. As the firewood is taken from different medicinal plants, the smoke emanating out of the fire, has the power of killing germs and other insects. The smoke, emanating out of *Sambrani* (Camphor), also has the medicinal effect of annihilating the insects.

*Maghamakham* festival is considered to be the most important festival, celebrated once in twelve years at Kumbakonam on the Full Moon Day the 11<sup>th</sup> Solar month *Magha* (Hindu month corresponding to the Gregorian-January-February) when Guru (Jupiter) enters the Zodiacal sign *Simha* (Leo). If bathing of the deities, take place at this, time it is believed that the icons will be saved from the attack of fungus, which is mainly responsible for disfiguring the image. Another festival being celebrated basing on the movement of the planets, is the *Kumbhamela* held at Allahabad. It is held in the month of *Magha* when the Sun and Moon pass through Aries and Jupiter is in Aquarius. Further Nasik *Mela*, comes three years later, with the Sun and the Moon in Aries and Jupiter in Leo. Three years after this, with the Sun, Moon and Jupiter passing through Libra comes the turn of Ujjain. All the aforesaid festivals protect the icons of the temples from decaying. The famous image of Gomateeshwara at Sravanabelegola (Karnataka State), is being preserved in better condition even now, is mainly, due to the anointing ceremony performed in every twelve years. At this time, pouring of thousands of pots of water, milk, curd, take place on the icon. It has been scientifically proved that the *mantras*, uttered by the priests, have the power of eradicating germs, present inside the Sanctum Sanctorum. The vibration of the mantra is the main cause, *Pancha Kavya* abhisekha also

preserves the icons from the attack of germs. Pancha Kavya is a mixture of milk, curd, butter, ghee and urine of cow. The pasting of *Namam* or white clay, on the *Vaishnavite* images has also some effect in protecting the icons. The religious habit of putting *tilak*, on the forehead of the idols, with *kumkum* (crimson powder) has also medicinal impact. Wearing of the garland, made of *Rudraksha*, around the neck of the idols, also protect the idols from insects. The medicinal value of *Rudraksha* is mentioned in the work called *Rudraksha Jabala Upanishad*. Wearing of the garlands of *Vilva*, and *Tulasi* leaves also has medicinal power of killing germs.

Bathing ceremonies is forbidden in the case of stucco images. A kind of oil, mainly prepared out of the secretion of a kind of cat called *cievat* cat, is applied over the stucco images. Due to such, stucco images of some of the temples, are even now in a good preserved condition. The best examples, are mainly present in the temples at Tiruvettar (Kanyakumari District), Sirkali (Tanjore District). Another kind of oil, prepared out of *Samprani*, is also being applied to stucco images. One Tamil work called Tamil *Nanmanimalai*, prescribed the method to prepare stucco. If all the stucco images are prepared according to the description of the work, there is no chance for the attack of germs on the icons. The aforesaid explanation clearly brings to limelight the role of rituals, in preserving the icons.

# **SOME FUNCTIONS OF STONE AS GLEANED FROM SANGAM LITERATURE**

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The civilisation of mankind had started with the use of stone tools. As a nomad and food gatherer, the prehistoric man with his limited knowledge, used the stones strewn around his rock shelters and on the foot of the hills for manufacturing stone implements, that were used by him for hunting and other purposes. Such stone tools made out of quartzite, assignable to palaeolithic period are available in a number of places in Tamil Nadu. As he advanced in the tool making technique, softer variety of stones such as chert, quartz, chalcedony etc., were used for manufacturing tools during Mesolithic Age. In the succeeding Iron Age, the utility of stone had enlarged to a greater extent. The *Sangam* literatures (3<sup>rd</sup> Century BC to 3<sup>rd</sup> Century AD) which were compiled in the later part of the Iron Age, adduce a lot of references about the use of stone in the material life of the people. Therefore a pragmatic study is undertaken on these literary sources to trace the functional aspects of stones in the ancient *Tamilagam*, between 3<sup>rd</sup> Century BC and 3<sup>rd</sup> Century AD. This paper highlights some of these aspects.



# **STONE OBJECTS AND BIODETERIORATION WITH SPECIAL REFERENCE TO LIME OBJECTS**

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Stone objects are affected by biological agents, called biodeteriogen. The causes of deterioration of stone objects are physical, chemical, biological, accidental etc. Besides these internal causes are also responsible for the deterioration. Most of the lichens produce acids, which are harmful to stone objects. Mass and liverworts produce brown spots called 'Foxing' which may be removed by chemicals. This paper deals with the biological agent which causes deterioration, types of deterioration, causes of deterioration, their eradication etc.

# **STONE OBJECTS AND THEIR ENVIRONMENT**

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Industries and transport systems are very essential in the modern world. But factories, automobiles exhaust many gases, which are deleterious to the art treasures made of stone. Now the Taj Mahal, the Marble Miracle, is severely affected by fumes of refineries. The Mahabalipuram stone sculptures are very much affected by saline sea breeze. We can classify the environmental factors into two categories: viz. Natural and man-made factors. Sun, microorganisms, rain, wind, fire, earthquake, natural agencies and vandalism, mishandling, improper packing and transportation, display, conservation etc., Besides theft and vandalism affect our stone treasures in temples and museums very much. This paper discusses about the friendly environment to the stone objects.

# **STONE SCULPTURES AND THEIR PRESERVATION MEASURES IN TAMILNADU**

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Stone was at first used as tools by the Palaeolithic people. Rocks were chosen by the early man for creating stone tools, Palaeoglyphs, later bas-reliefs, sculptures etc., as they were durable when compared to other materials available to the man. Sculpturing could be said as an oldest and most widespread art of the world.

During my study I have visited to all the archaeological museums in Tamil Nadu and I studied the stone sculptures in the museums and temples on the conservation point of view. Except the Government Museum, Pudukkottai all the other museums have displayed in the stone sculptures in the sculpture garden either in front or by the side of the museums. They are either displayed on brick masonry pedestals or kept in position in pits made in the ground with out any cover over them. They have been displayed in side the museum on pedestals made of wood, sometimes on brick structures, some times just kept against the walls of the building. Moss and lichen have affected mostly the sculptures kept in the open. The sculptures kept on display out side the museum buildings in the Government Museum, Chennai are cleaned regularly by the Chemical Conservation Laboratory of the Museum. When the sculptures are brought to the district museum, the Curators of the museums physically clean them. Some times they give a water wash to remove the accretions. Any tarry materials are found they use some organic solvents such as kerosene, acetone etc. The Museums also arrange Conservation Courses with the help of the Chemical Conservation and Research Laboratory to clean the archaeological objects especially the stone objects. In temples the traditional methods of preservation are still

followed. The Chemical Conservation and Research Laboratory besides treating their stone collection also had helped in preserving the sculptures in temples, churches and other institutions in the past and still continues.

The well-established Chemical Conservation and Research Laboratory is available in Chennai and the conservation needs of the Government Museum and District Museums are taken care of by it. As far as the State Department of Archaeology is concerned the Conservation Laboratories at Chennai and Madurai take care of the stone objects. The Conservation Engineering Branch of the Archaeology Department takes care of the stone monuments under the control of the State Department of Archaeology. The conservation of stone sculptures and other objects are concerned, the Chemical Branch of the Archaeological Survey of India takes care of. The Conservation Engineering Branch of the department takes care of the stone monuments. Besides these, there are Trusts and other organisations such as INTACH, have involved in conservation activities in a small way.

# **STONE STRUCTURES WITHIN NATURAL CAVERNS: NEED FOR CONSERVATION AND PROTECTION**

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Because of its easy availability and durability, stone was one of the widely used media for executing works of art-both secular and religions. Brahmanical followers accepted stone much later when compared to the Jains and the Buddhists. The Jains in particular due to their extreme form of body mortification, unostentatious living and concept of non-violence, during their early phase inhabited natural caverns located at inaccessible heights. These, scattered throughout Tamil Nadu indicate signs of habitation as suggested by Tamil-Brahmi inscriptions, stone beds and sculptures. The stone beds are at times fine polished with or without pillow lofts. These are prone to vandalism and natural deterioration. Places such as Tondur, Uranithangal, Karuppankunru, Neganurpatti are fine examples where stone beds deep within the cavern are in a good state of preservation whereas those outside are weathered and subjected to unwanted graffiti marks and defacement by the people who visit the caverns. Some of the sculptures are facing weathering and defacement due to unchecked weathering and oil accretion on the stone sculptures. These stone structures hence call for urgent conservation and preservation.

# **THE ROLE OF CURATOR IN PRESERVING STONE SCULPTURES**

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Stone objects are very durable. But in unfavourable environment they deteriorate. Presence of soluble salts, movement of water, growth of moss and lichen, lack of care in handling are some of the factors responsible for the deterioration of stone objects. Curators are the custodians of the stone objects in museums. Curators have a major role in the preservation of stone sculptures. Curators should know the characteristics of stones, their deterioration, their handling, method of transportation, conservation measures etc. This paper deals with the responsibility of preserving the stone objects in a museum.

# **THE STATUS OF PRESERVATION OF THE AMARAVATI LIMESTONE SCULPTURES IN GOVERNMENT MUSEUM, CHENNAI**

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&

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The Government Museum Chennai is a multidisciplinary museum known for its collections. It is a pioneer institution in India having collection sections such as anthropology, archaeology, art, numismatics, botany, geology, zoology, chemical conservation and children's museum. It started with a few hundred geological specimens in 1851 AD, with the consent of the Court of Directors of the British East India Company. This Museum is known for its rich collection of bronzes, stone sculptures, pre-historic collections, tribal materials, coins, paintings, natural history specimens etc. Amaravati limestone sculptures were brought to the museum during 1870s and were embedded into the walls with the available technology of the period, amidst a lot of criticism. Similarly other stone sculptures are also fixed either to the ground or to lime-brick structure except in a few cases. This paper deals with the history of Amaravati Sculptures in the Chennai Museum, their condition, action taken to preserve them to posterity, various projects, present status and the future action to be taken.

# **THREE MAIN PROBLEMS OF SCULPTURES**

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Artefacts do not get preserved by their entry only in a museum. Conservation is based on scientific study, treatment and suitable upkeep. Stone sculptures are acquired by museums from varied sources such as monuments, stone houses of temples, archaeological sites excavated recently or from private collection. Thus an object reaches a museum after changing several hands or shall we say several environments or from different geographical locations. Our aims should be to keep them in good state of preservation for posterity by understanding their problems three main problems have been studied in detail.

1. Technical study of the stones used for making these sculptures to authenticate them and study their provenance and history of technology.
2. Scientific study of the deterioration process resulting into crusts or erosion or weathering. This helps in devising suitable treatment methodology.
3. Suitable display and storage technology as to retard their decay as long as possible. No decay should happen of objects due to wrong display and storage techniques.



# **TRADITIONAL AND MODERN POULTICING METHODS IN THE REMOVAL OF OIL ACCRETIONS FROM STONE SCULPTURES**

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&

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Tamil Nadu is a treasure house of stone tools, sculptures, stone monuments, free sculptures and parts of the monuments are available in temples, museums, art galleries and also in private collections. Due to various reasons they acquire oil accretions which mar the appearance of stone objects and monuments to appear ugly. In order to preserve the stone sculptures people applied oil or ghee. This prevented the salt absorption by the sculptures. Traditionally the sculptures are cleaned to remove oil and other accretions by the application of flour, cooked rice, sandal powder paste on the sculptures by the simple principle of capillary action. When the sculptures are brought to museum and similar places from the places of their occurrences, problems start increasing. The main problem in the museums is human touch. The oily perspiration of the human hands is transferred to the sculptures as most of the sculptures are on open display in the galleries.

The sculpture collection in the Government Museum, Chennai are kept on open display and therefore almost every one has an access to touch the stone sculptures. This continuing practice makes the sculptures appear black and spoils their aesthetic beauty. Though it makes the sculptures impervious to water. This looks like a patina to some eyes. Normally this is cleaned with the help of rectified spirit, acetone, benzene and sometimes with ammonia. But the removal of oil accretions proved to be difficult. This paper deals with various poulticing methods adopted in the Sculpture Galleries in the Government Museum, Chennai using Fullers Earth, rice flour, paper pulp with benzene, ammonia etc. with oil free covering with cling wrap.

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