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Comparative Analysis of an Antic Stone with Restored Stone of Restoration Project

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ABSTRACT: Comparative analysis of properties of stone is essentially a first step towards the scientific understanding of a conservation project and is unavoidable, if any restoration work is to be carried out. A state listed monument of the mediaeval temple architecture in Nagari style was selected for evolving an appropriate methodology. It is situated in Mandi, Himachal Pradesh, a northern Himalayan state of India. This temple was completely destroyed in major earthquake of 1905 and the restoration work was carried out using locally available stone of similar quality from the same live quarry as per the practice of the time. Thus Trilokinath temple provides the opportunity to study the medieval stone against the stone from the restored work and fresh sample from the quarry. The thin sections were used to understand the character and mineralogical composition of the stone along with structural properties of the stones.

1 INTRODUCTION

1.1 Stones of India

Natural stone deposits are found in abundance in the Indian sub continent. These have been used as a building material from ancient times and have transformed India into a land of archaeological architectural wonder and world heritage. In India Stones belonging to all the systems known in the world are available but a few of the rocks from the geological formation of India were chosen for use in the construction of buildings (Batra 1996). Monuments and structures standing tall in various parts on its soil for centuries together bear testimony not only to skilled workmanship, artistry and architectural practices of their times but also to the excellent building material of which they have been fashioned from. The temples and monuments, the palaces and forts, built during varying ages are not just beautiful to behold; they also point to the durability of the stone as a building material. While every endeavor was made to select the stones that possess the requisite strength, an attractive color and appearance and those, which can receive dressing whether ordinary or ornamental without much labor, were selected. The stones selected were granite, charnockite, the limestone, khondolite, marble, sandstones, basalt, Deccan trap, quartzite and laterite as described by Batra (1996).

1.2 Use of stone in Indian architecture

The Taj Mahal at Agra, built of Makrana white marble from Rajasthan is a world famous architectural wonder. Sandstone has been widely used in erecting forts and palaces and these have been embellished with granite and marble. Use of natural stones as the mainstay of Indian architecture has continued till the present time. The designers of Rashtrapati (President's Palace) and Sansad Bhavan (Parliament house) and other government institutions have kept up the tradition by using sandstone as building material. Even today, facades, floors and other spaces of modern buildings, be they government institutions, public places, commercial establishments or private

residences, use natural dimensional stones in some amount or the other. Sandstone and granite facades, marble and Kota (flaggy limestone) floors, granite counters are visible everywhere. Domestic consumption of natural dimensional stones has been estimated at more than 100 Million Euros per annum (INR. 5000 Crores).

1.3 Diagnosis of stone deterioration

Any undesirable change in the properties of a material is termed as deterioration. Deterioration of building stone begins immediately upon the completion of an artifact or structure and continues progressively for as they are in contact with any kind of environment. Deterioration of building stone begins immediately upon the completion of an artifact or structure and continues progressively for as long as they are in contact with any kind of environment. Artistic merit or historical significance do not, by any means exclude these works of art and architecture from the working of the laws of nature! The active components of the environment that influence the condition of building stones are: solar radiation, seasonal and daily temperature changes, wind, humidity from different origins, water soluble salts, atmospheric pollutants and particularly important in the primarily tropical climate of India, biological agents (both plants and animals) as shown by Torraca (1987). Thin section - Diagnosis of Stone Deterioration, briefly explores the mechanisms through which these active components of the external environment affect the internal properties and structure of stone subsequently determining the type and extant of stone deterioration (Arnold 1988)

2 INVESTIGATIONS AND ANALYSIS

2.1 Introduction

The historical timeline of the temple starts from 1520 when it was constructed to commemorate the coronation of the Mandi king. The temple became an integral part of the local religious life, as the Shiva is most important Hindu deity of the region. The kangra earthquake of 1905 (Middlemiss 1910), which had shaken the entire region, also brought the havoc to this magnificent temple and major part of it was destroyed. It came under the ASI control after the independence and two major restoration and renovation projects were undertaken in sixties and eighties. The main supporting column of the Mandapa (main prayer hall) was constructed from the locally available stone claimed to be from the same quarry as the original stone quarry. Similarly the stone were used for construction of the window arches of the main hall.

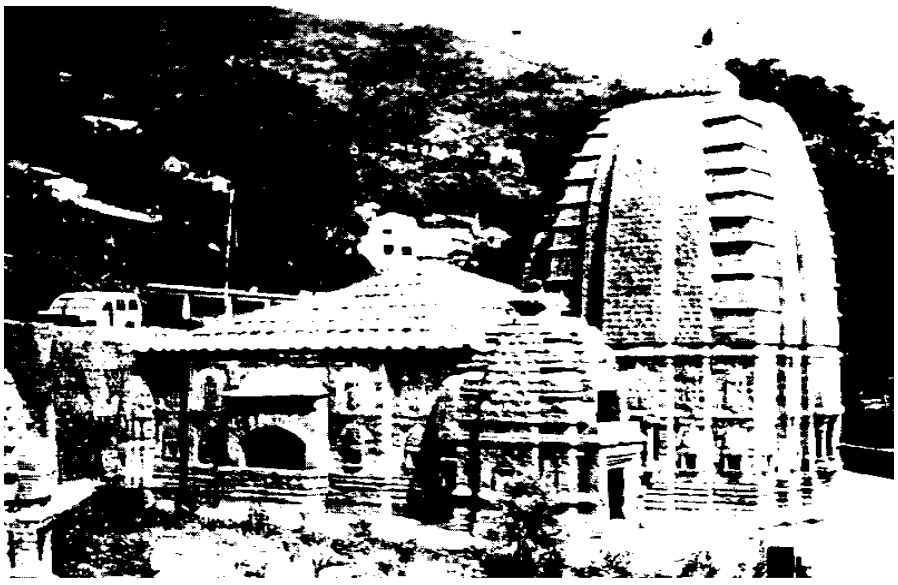
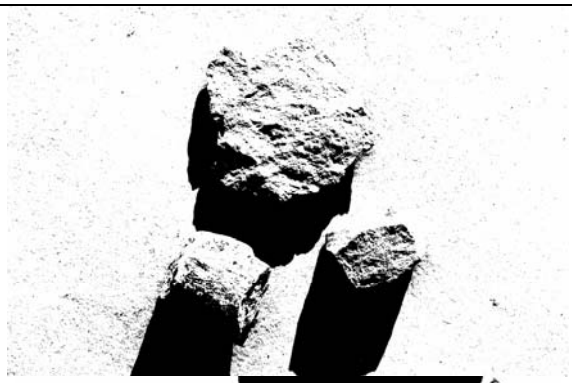


Figure 1 : Perspective view of Triloknath Shiva Temple, Mandi, Himachal Pradesh, India

2.2 Collection of the samples

The samples were collected from the site consisting of the stone samples of the original stone used in 1520 and restored stone used during the restoration work. A fresh stone was also collected from the quarry in the vicinity claimed to be the supplier of the original stone. The samples are named as R1, R2 and R3 for the original stone, restored stone and the fresh stone respectively. As seen in the table 1 the three samples show a marked variation in textural.

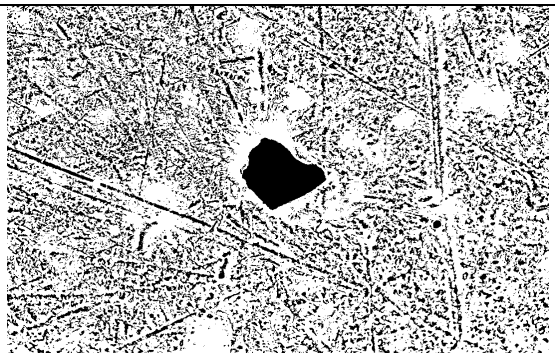
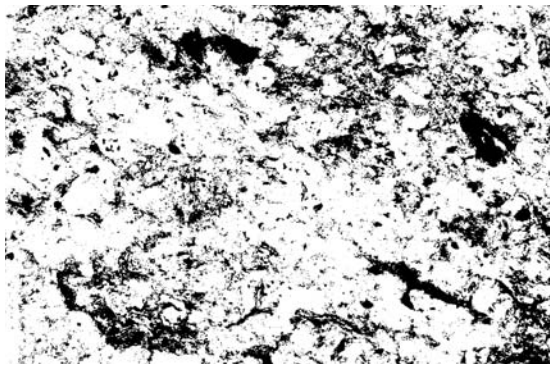
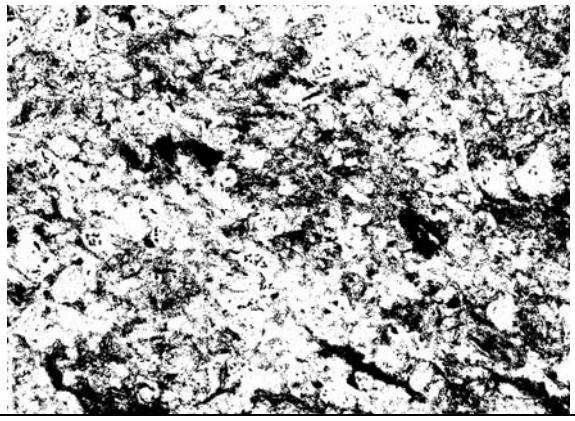
Table 1 : Comparative sizes of the stone samples

Serial number	Descriptions	Image
1	Three samples collected from the site consisting of different stones.	
2	The R1 is the original stone of the temple construction used during the 1520**.**	
3	R2 is the “restored stone” from the temple	
4	R3 is the fresh stone from the quarry	

2.3 Identification of the stones

The thin section of the stone also used to understand the character of the stone and mineralogical composition. The stone of original construction time was labeled R1 and the restored stone was labeled as R2. The fresh stone from the quarry was labeled as R3.The table 2 shows a thin section image of the samples. The table 2 shows very clearly the variation in compactness of the samples.

Table 2 : Comparative table of thin section.

5	R1 (original stone of the temple) Under magnification.	
6	R2 (restored stone) Under Magnification.	
7	R3 (“fresh” sample from the nearby quarry) Under magnification**.**	

All these samples were tested in the lab for their structural the mineralogical properties and compared for understanding the restoration work. This is intended to apply the universally accepted principles of reversibility and minimum intervention. Furthur investigations like the chemical investigations are recommended for determining the exact nature and properties of the stones.

2.4 Geological analysis of the stones

These rocks are mostly derived from marine sediments. They are usually laid down in successive layers called strata or beds. Bedding planes are planes of feasibility between beds, which may be contact plane of different litho logy or may be entirely within a rock of one composition. Each bed may be composed of thin bedding planes called laminate. The sandstone in Mandi region could be classified as a Sunder Nagar group, part of Shale structural belt as mentioned in Srikantia (1996). The Sunder Nagar Group is restricted to the main Shali Belt. The type area is located two kilometers south of sundernagar in Mandi district and outcrops are seen between Bhangroutu and Mandi.

3 LITERATURE REVIEW

3.1 Stone characterization

Most of the techniques for characterization are well established and some of them are very well summarized by E. C. Robertson (1982). A useful atlas of petrological sections is given by MacKenzie and Adams (1994). Gauri and Yerrapragada (1992) extend the interpretation of mercury porosimetry data in a manner reminiscent of that of W. D. Robertson (1982) and cite a number of the seminal papers on pore structure determination.

3.2 Case studies

There have been many important studies in this field of geological and technical investigations in relation to heritage conservation in recent past. Zezza (1990, 1994) has used digital image processing to map different forms of surface weathering. Starting with photographs, false color images are produced that are indicative of particular forms of decay.

4 CONCLUSIONS

4.1 Physical properties

The physical properties of sandstone includes following:
Color: The color varies from red, green, yellow, gray and white. The variation is result of the binding material and its percentage constituent.
Water Absorption: The capacity of water absorption is not more than 1.0%
Hardness: Lies between 6 to 7 on Moh's Scale Density 2.32 to 2.42 Kg/m^3
Porosity: The porosity varies from low to very low.
Compressive Strength: Varies from 365 to 460 Kg/m^2

4.2 Mineralogical and geological properties

The following can be inferred from the above slides and information. The grain size is more compact in the restored stone compare to the original stone of the temple, but highest in the fresh sample from the nearby quarry. The stone of original construction of the temple and restored stone are similar in nature with few differences. Restored stone has higher number of Muscovite elements. (White mica is a Non-ferromagnesian rock-forming silicate mineral with tetrahedral arranged in sheets. Sometimes called potassic mica.) Similarly plagioclases1 are higher in the restored stone.
The sandstone could be classified as a sundernagar group, part of shali structural belt.

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