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Non Destructive Investigation of Heritage Masonry Monuments

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Abstract: ***Rajasthan is the most beautiful and vibrant heritage state of India. The unique characteristic of its architecture and construction material and handicraft is very popular through the world. The Rajputana's architecture is significantly depend on Rajput architecture school which was mixture of mughal and Hindu design. Giant havelis, amazing forts and decoratively carved temples are the vital portion of architectural heritage of Rajasthan. Few of most outstanding and marvelous forts along with palaces with parched Aravali land clearly depict history of Rajasthan's celebrated heritage. Almost every city of the enormous desert land Rajasthan is lined with fabulous forts and palaces built by various rulers and architects. These forts and palaces were generally constructed outside the walled city over the high hills. Health monitoring of structures has gained attention of Specialists. In particular health monitoring of Heritage masonry is vigorous. It requires great careful attempts to uphold our heritage structures to keep them in respectable state. Number of techniques are available suitable for heritage structures. Some case studies are reported in this paper to exhibit application of different techniques.***

Keywords: Giant havelis, amazing forts, Rajputana's architecture & Aravali land.

1. Introduction

Deterioration of old age heritage masonry structures has become concern of common person. Erosion of stones with high wind coupled with dust storms is very common. Cracks which can be attributed to many factors are also seen very commonly. Decay of mortars is also critical concern. Thus these require focused approach to study and come out with appropriate solutions which are practically feasible. Use of techniques available in right manner is the key to the problem. Case studies of some stone masonry heritage structures are reported.

2. Basic Need of Heritage Conservation

Heritage connects us to history, the beautiful past we congenital to preserve and handover to our next generations. Heritage generally gives us an intellect of our past and of our cultural uniqueness. Some investigators predicted very frightening data regarding the existence of old heritage buildings. Load bearing behavior of the Historic structures is very complex due to continuous interference between various elements. The behavior of these structures change with deterioration of material and the cracks developed may even amend load path. Here a brief state of heritage buildings and their structural aspects are deliberated including technical research activity, survey of structures, structural behavior, and decay problems in materials, safety evolution and structural damages.

After the Second World War the problem of upgrading and reconstructing the ruined Historic buildings appeared worldwide. The complex load carrying behavior is due to enormous and continuous interface between various structural elements e.g. domes, vaults, arches and pillars. The structural confrontation depends preliminarily on two factors: the geometric features of the structures and typical strengths of the materials used.

3. Experimental Research for Conservation

The study of structure begins by plotting visible damage. Survey drawings should map different kinds of materials, noting any deterioration and any structural indiscretions and damage, paying particular attention to crack patterns and crushing singularities. Geometric indiscretions can be the result of previous distortions, which can indicate the junction between different building phases or changes to the fabric. It is important to discover how the environment may be harmful a building, since this can be worsened by poor original design and/or workmanship (e.g. lack of drainage, raising dampness, and vegetation), the use of inappropriate materials and/or by poor subsequent care. Observation of areas where damage is focused as a result of high compression (zones of crushing) or high tensions (zones of cracking or the separation of elements) and the direction of the cracks, together with a study of soil conditions, may designate the reasons of damage.

The general laydown of technical actions for preservation of such heritage structure includes, Identification of historic ingredients (masonry-binding brick and fieldstone, plaster, paint receiving layer, painted layer, and protective layer etc), Identification of historic methods, Damages, decline or alteration of historic ingredients, corroboration and selection of conservation materials and methods, endorsements for the conservation-restoration works, Inspection of the quality of preservation works.

Different methods of research on preservation of heritage structure are: chemical analysis, Petro graphical - Mineralogical, X-ray diffraction, spectral, chromatographically, micro-chemical analysis, analysis of pigments and organic ties, artificial aging; biological

research; physical study of building materials; checking of microclimate regime of some historic buildings. The practice is based on the arrangement of historic materials, the existing physical condition or the character of obliteration, and on the principle of reversibility. These were clubbed together with the scientists of restoration when applying all the new methods.

The list of tests should be based on initial phenomena views which are important to recognize. Tests typically aim to recognize the mechanical (strength, deformability etc.), physical (e.g. porosity) and chemical (e.g. composition) characteristics of the materials, stresses / distortions of the structure and the presence of any discontinuities within the structure. As a rule, the schedule of tests should be divided into stages, starting with the attainment of basic data, followed by a more detailed examination with tests based upon a valuation of the inferences of the initial data. Non-destructive tests should be preferred to destructive testing that includes any alterations to a structure. If NDTs are not adequate then it is necessary to assess by opening up the structure in terms of reduced structural interference against the loss of culturally significant material. Tests should always be carried out by experts to gauge their consistency correctly and the assess implication of test data carefully. If possible dissimilar NDT methods should be used and the results should be likened.

4. Techniques for Assessment

These structures first have to be addressed by visual inspection e.g. photography, geometric measurements for sections, deflections, changes on surface i.e. physical and chemical, cracking patterns etc. This is followed by use of certain NDT tests e.g. Rebound hammer test, Ultra sonic Pulse Velocity test, Permeability tests, microscopic & chemical examination etc.

5. Case Studies

Some case studies are presented covering Gadisar Lake Pole (Gate) structure- Jaisalmer, Salim Singh ki Haveli- Jaisalmer, Patvon ki haveli- Jaisalmer, Amar Singh ki Chhatri- Nagaur etc.

5.1 Gadisar Pole, Jaisalmer

The structure is beautifully placed on the way to the Gadisar lake. Schmidt rebound hammer test results are shown here.

Schmidt Rebound Hammer Test results

753 FL1 BASE OF ARC GOOD WORK
49.8 43 59 5.5 61.8 N/mm2
754 BELOW ARCH
52.3 46 58 4.0 67.0 N/mm2
755 FLO BASE OF ARCH FAIR
48.7 44 51 2.9 59.4 N/mm2
756 BELOW ARCH GOOD
52.2 48 58 3.7 66.7 N/mm2
757 LEFT WALL BETWEEN ARCH GOOD COND
53.8 51 56 1.7 70.2 N/mm2
758 LEFT WALL BETWEEN ARCH POOR COND
45.0 32 55 10.2 52.0 N/mm2
759 RRO ABOVE ARCH SPRINGS BAD ONE
45.5 41 55 5.0 53.0 N/mm2
760 RRO BELOW ARCH SPRINGS GOOD ONE
54.0 51 57 2.3 70.6 N/mm2
761 RRI GOOD ONE BELOW ARCH SPRING
52.0 48 58 3.8 66.3 N/mm2

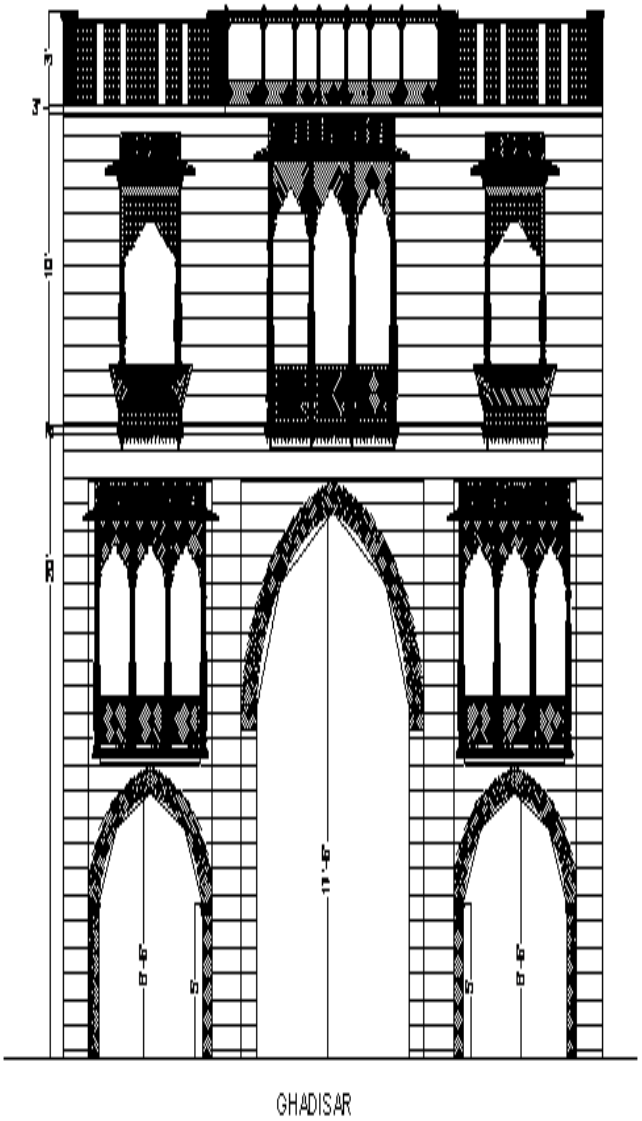

Figure 1: Gadisar Lake Pole (Gate), Jailsalmer

5.2 Salam Singh Ki Haveli, Jailsalmer

The structure has beautiful look for its combination of structural form. Schmidt rebound hammer test results are shown here.

Schmidt Rebound Hammer Test results

764 PILLAR OCTAGONAL SIDE CABIN ROOM
43.3 43 44 0.5 48.8 N/mm2
765 WALL OF VERENDHA BAD OPEN JOINT OF MORTAR
31.2 22 37 6.0 27.0 N/mm2
766 PLASTER WALL GOOD SIDE VERENDHA
19.3 17 24 2.4
767 SILL STONE SIDE VERENDHA RH VD
53.0 52 55 1.3 68.5 N/mm2

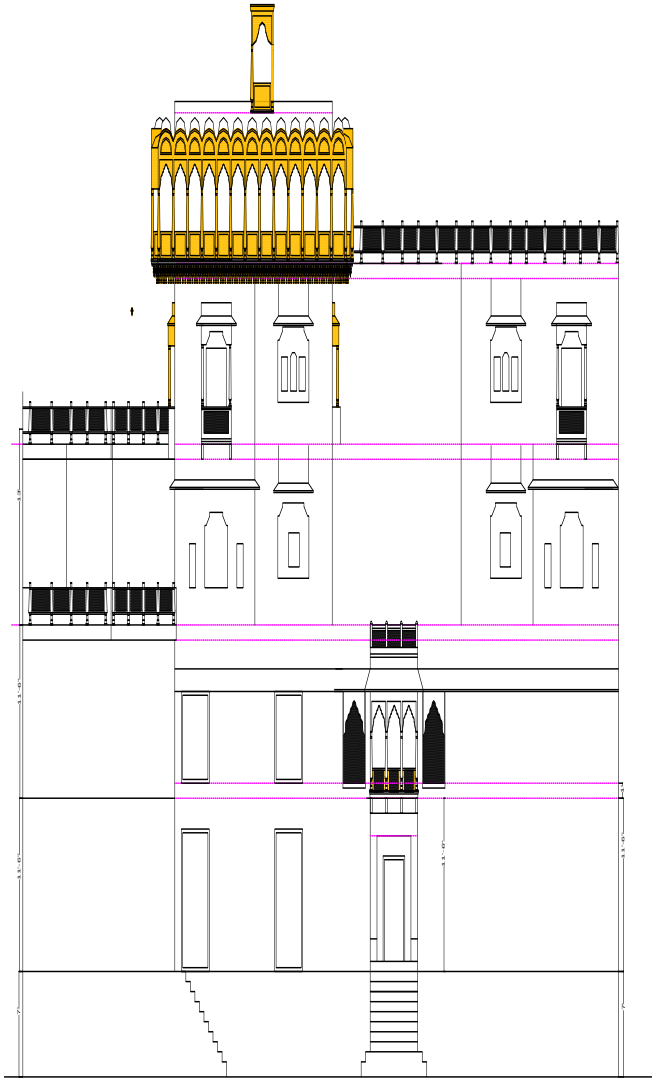

Figure 2: Salim Singh Ki Haveli, Jailsalmer

6. Conclusions

Study of these cases reported above, indicate that non Destructive Assessment require experience and expertise. Schmidt rebound hammer show quality of stone used in the masonry at the time of observation. Strength shown is insignificant since it is derived from calibration curve for concrete. Higher value of Standard deviation show wide variation in quality at the points of observation. UPV results in Amar Singh ki Chhatri show quality of the material used in the structure. For obvious reasons velocity is higher in direct method as compared to indirect method. Microscopic examination is critical to observe decay in stone and mortar for exposed and unexposed surfaces. Appropriate techniques should be used for condition assessment or health monitoring. Limitations and assumptions should be well taken care of.

Preservation of Heritage buildings is quite different from new construction. Conservation needs initial study of present structure in detail and the stages it has passed in past. Performing trials can be highly sensitive. The burning demand of today's civilizations is to carry out renovation & conservation of these enormous structures. For that identifying the damage, development of damage, any immediate risk needing consideration and environmental effect is essential. Modern science has opened up scope by newest tools. Today strong need is to have a compromise between Measurable, Qualitative and Ancient analysis for restoration of historic building and a model range is required to be developed giving due weightage to all variables for the value of separate structure. Data gathering has vital role to play for conservation and requires very detailed and scientific participation. Existing fabric has to be restored; new one should be compatible and in similarity with minimum interference to the old one. Heritage has always involved tourism nationally as well as internationally consolidation local and national economy. Heritage may be considered as Monuments, Sites, Buildings, Artifacts, Cultural Landscape and Imperceptible Heritage .Religious, Art Antiquity and Architecture, Scientific and Technical, Nationalist, Domestic, Economic and Development, Re-creational and Humanistic are its paradigms.

Various international agencies autonomously, under UN cover and national agencies, regional authorities and NGO**S** are working in this field. There is need of active coordination of all these administrative and executive agencies so that uniformity in policy of upkeep is formed. Under the same cover techniques should be idealised for utilities on regional bases and by facility to be provided to all concern interested in matter via information-technology.

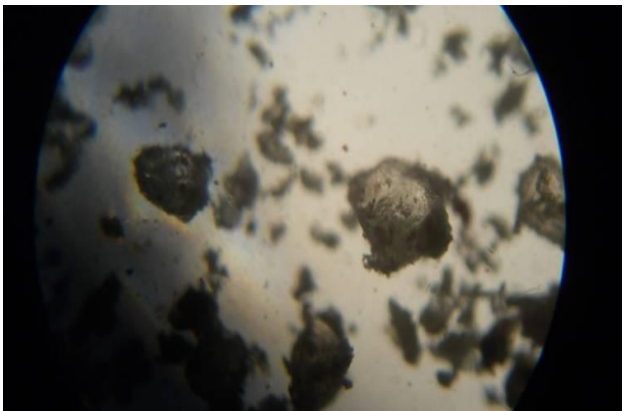

Photo 1: Microscopic Exam stone/ exposed/5x/ sample rao udai singh 463

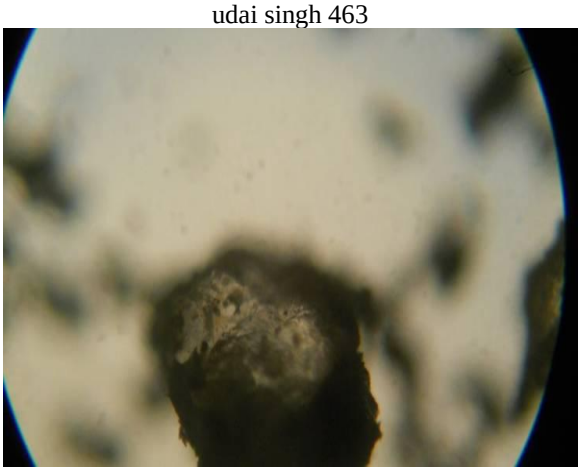

Photo 2: Microscopic Exam decay of stone, exposed/10x sample rao udai singh 461

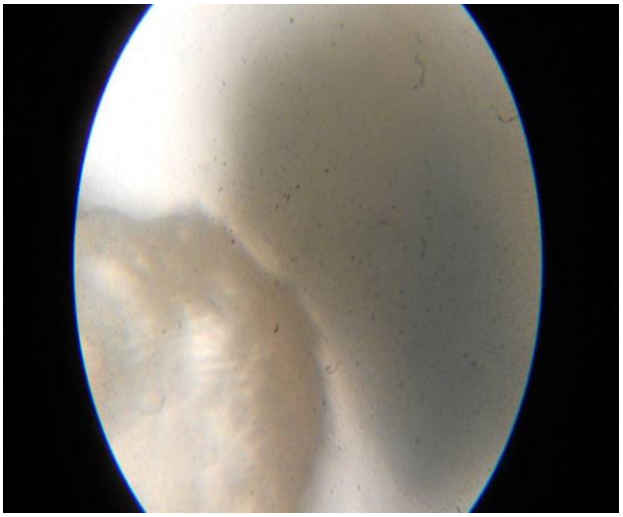

Photo 3: Microscopic Exam decay of stone, exposed/40x/ sample rao udai singh 457

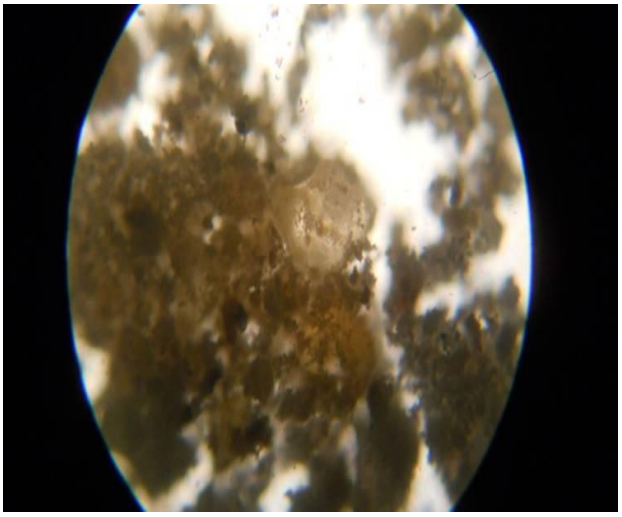

Photo 4: Microscopic exam mortar/ exposed/10x/ sample rao udai singh 472

Photo 5: Stone Cylinder tested in Compression

Photo 10: UPV Test Jodhpur A&M Office

Photo 9: UPV Test on stone A. Singh Chhatri

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