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On the Relevance of Earthen Supports Material Characterisation: Case Study Nako in Western Himalayas, India

Maria Gruber1 and Gabriela Krist1

1 University of Applied Arts, Conservation Department, Austria, maria.gruber@uni-ak.ac.at, kons-rest@uni-ak.ac.at

Abstract Since 2004 the Conservation Department of the University of Applied Arts Vienna has been active in saving Tibetan cultural heritage of Nako in Western Himalayas, North India. Main goals are the conservation, study, and long-term preservation of the Buddhist temple complex interior decorations dating back to the 12th century. The research project Scientific Study of the Artwork at Nako, India, addresses the polychrome surfaces of the significant decorative elements that are executed on earthen supports. First of all, the research on adobe, earthen joint and rendering mortars, clay from sculptures, and local soils used for traditional building practice considerably contributes to the conservation of the mural paintings and sculptures of the temples. Furthermore, the analyses on material characterisations of the earthen supports represent an attempt to contribute to the material culture of earthen building practice, its past and tradition until present.

1 Introduction

Situated at 3,600 m above sea level in the Western Himalayas, North India, the small village of Nako houses a rare example of an early Tibetan Buddhist temple originating from the 11th to 12th centuries (See Fig. 1). The four earthen temple buildings are built as a windowless single-storey construction capped with a flat roof. The building foundations are made of stones onto which are built walls composed of adobe, joined, rendered, and plastered with earthen mortars; the roofs are constructed over wooden beams and columns which are insulated with earth. Nondescript from the outside, the temples’ 12th century and later interior decorations, today partly overworked and over painted, bear witness to the outstanding art and cultural history of Western Tibet: including valuable mural
Due to natural disasters, climate change, and centuries of inconsistent maintenance, the earthen buildings have shown alarming signs of damage and deterioration. Thus, in 2002 the multinational and interdisciplinary Nako Research and Preservation Project (NRPP) [1] funded by the World Monuments Fund (WMF), was initiated to save and preserve the endangered ensemble. Evolving from its participation within the NRPP, the Conservation Department of the University of Applied Arts, Vienna, together with its Indian project partners, has been active in the research and preservation of the rich cultural village heritage from 2004 to date [2]. The main tasks have been the conservation of the temple interiors and their scientific examination, the establishment of a village museum, the preservation of the local Thangka collection and the establishment of workshops for the village and lama community.

A comprehensive three-year programme on the temples’ interior decorated surfaces, the Scientific Study of the Artwork at Nako, India funded by the Austrian Science Fund (FWF project no. L335-N19) has focused on the basic research of the materiality and technology of the earthen supports and paintings as well as their decay and deterioration. A key goal of the study was to develop appropriate conservation treatments for the interior decorations which could be gradually implemented into a conservation programme.

Research on the earthen supports leading to the reproduction of support specimens addressed the four temples’ architectural structures which consisted of adobe, joint and rendering mortars, clay from the sculptures and local soils [3-9]. The work was based on previous studies related to the temples’ earthen structures including architectural surveys [10, 11], the examination of mural paintings [12].
and ceiling panels [13] and the study of plasters and earthen conservation materials [14]. Since the architecture of the Western Himalayan earthen temples has rarely been studied from the material point of view, the study of clay for conservation purposes in the Ladakh region is particularly noteworthy [15].

2 Materials and Methods

2.1 Research Scope

Conservation, preservation, and long-term maintenance of the temples’ interiors pose a wide scope for study of the earthen supports. Material composition, structure, mechanical and physical properties were investigated to characterise the supports and soils. Field work and analytical examinations, including standard and non-standardized tests, have been applied.

Besides its priority to conservation, this research has strongly contributed to the understanding of earthen material culture and its traditions for this particular region. Earthen architecture often, as in Nako, presents anonymous architecture that usually lacks written records regarding building dates, architects, craftsmen or building practices; the earthen temples themselves are the only historical and material sources to address simple questions such as “Who built the temples? When? and How?”. Well aware that these questions could not be answered unambiguously through materials characterisation, this paper attempts to interpret and discuss the study results in regards to the following key questions: how were the earthen supports of the four temples made? What was the technology of their preparation? And, is the building know-how from the past still relevant in recent traditional earthen building practice?

2.1.1 Field work

Field work consisted of a historic structure survey of the supports, the documentation of the different building materials used and technologies applied and an assessment of the structural damages, deterioration processes and their possible causes and environmental monitoring. On-site survey was documented with photographs, descriptions, and digital mapping [16]. On-site measurements were applied to assess the supports’ surface resistance, conductivity, temperature and moisture content [17]. Sampling was performed not on intact wall surfaces but on areas with damage to the architectural fabric that required conservation treatment.

Local soils used as raw materials for still-existing traditional earthen building practices were identified and sampled. Recent building techniques known and applied by craftsmen in Nako were studied and documented [18].
2.1.2 Analytical work

Selected samples of adobe, joint mortars, plasters, local soils used for traditional building practice, and reproduced support specimens were investigated. Thin sections were studied using optical microscopy in normal and polarized light. Particle size distributions were examined using the standard sieving method. Mineralogical compositions and clay mineralogical compositions on fractions < 2 µm were analysed with X-ray diffraction, supported by differential thermal analyses and carbonate determination according to Scheibler; these were quantified through X-ray fluorescence analysis. Loss of moisture and loss of ignition were assessed, as well as the total carbon content through combustion in oxygen and by using infrared detection. Contents of vegetal fibres were determined with the standard sieving method. The salt content of the soils was analysed through ion-chromatography. Soil-mechanical parameters of local soils such as Atterberg and shrinkage limits were investigated as well as critical shear strengths which were determined through direct shear tests. Analyses on bulk and true density, water vapour adsorption isotherms, water vapour permeability, water uptake, porosity through Hg-porosimetry and optical microscopy combined with digital image analyses and compressive and bending strength analysis are in process.

3 Results and Discussion

3.1 How were the earthen supports of the temples made?

3.1.1 Local soils

Local soils used as raw earthen materials for application in recent building practices are called Thawa, Tua and Sassa and differ in source, texture, material composition, quality, and resultant use. These materials are also seen to be used in the earthen temples of Western Tibet. The abundant Thawa is a commonly-used, rather coarse aggregate, brown in colour, poor in clay and consisting of around 30% quartz, 50% feldspar, and 11% sheet silicates. Tua is found on one site at Nako, the fine-grained soil is of a whitish brown colour and is utilized as a binder for mortars; 25% of the minerals are of quartz, around 30% sheet silicates, and nearly 40% calcite. The clay minerals of Thawa and Tua are similar, in the main consisting of mica/illite and chlorite. Sassa is an inhomogeneous material; it is fine grained and the clay-rich components are of a greenish white colour and are especially used for waterproofing applications. Sassa comprises of around 50% quartz and feldspars, 35% sheet silicates, and almost 20% calcite and dolomite,
and is seen to contain mostly swelling clay minerals of mixed-layer types (all
given in mass %).

3.1.2 The manufacture of adobe

Adobes from all four temples show a very similar material composition,
structure and block measures. Unlike joint and rendering mortars, the materiality
and technology of adobe manufacturing was not altered during the construction of
the temple complex. As the temples feature 60 to 110 cm thick walls, a high
amount of pre-fabricated adobe blocks was needed; manufacturing of adobe
demanded a quick and efficient, mass-production method. From analyses of
particle size and mineralogical composition, simple unsieved Thawa, without any
vegetal fibres, mixed with Tua was considered the best material to use. Thawa
could be easily taken from the construction site and used immediately without any
preparation. The adobes were cast into wooden moulds, compressed by hand,
turned out and then left to be sun-dried. Adobe blocks of all the four temples
measure c. 10 x 21 x 42 cm, which is in accordance with the typical block size for
the early building period in Western Tibet until the 15th century [19]. Due to the
mainly Thawa composition, plasticity indices of adobes are low at 7 mass %,
critical shear strengths are at a high friction angle of 36°, and there are no salts
present due to the raw materials used.

3.1.3 The manufacturing of joint and rendering mortars

Joint mortars can be easily distinguished from those used in renders since the
former contain no vegetal fibres, are of a special reddish colour, and are rather
coarse in texture. Mineralogical compositions of the joint mortars vary, containing
different rations of Tua and Thawa, from 1:4 to 1:5; occasionally they can contain
pure Thawa.

The first decoration phase of all four temples used two different mortars for the
plastering: a coarser and a finer one. These two mortars do not differ in
mineralogical composition, but in grain size distribution and by the addition of
vegetal fibres (See Fig. 2). All coarse plasters are made of Tua and sieved Thawa
mixtures in varying ratios of 1:4 and 1:5 and contain vegetal fibres; often thick
barley straw cut into 3-7 cm long pieces. This mortar preparation technique
corresponds to that used in traditional Tibetan architecture [20]. Fine mortars of
three of the temples again show the use of the Tua and sieved Thawa mixtures in
ratios of 1:4 to 1:5, with rather thin barley straw in 1 cm lengths added to the mix.
In the fourth temple no vegetal fibres were added into the fine plaster which
contained a higher admixture of Tua. The modification of mortars with organic
substances such as animal dung and animal glue needs further investigation.
3.1.4 Application of adobe, joint and rendering mortars

All the temple walls are constructed only of adobe over a foundation of stone, with the exception of one of the buildings that is built up to half the walls’ height with stone. The stone and adobe are joined with mortars; joint mortars are laid horizontally between the single rows of adobe, each joint measures c.2 cm. Flat stones have been found inserted into the joints, possibly to serve as anchors for the adjacent renderings.
The plasters of the first decoration phase in all the temples were applied in a two-layer system to level the walls and provide support for the paintings which consist of glue-bound paint layers over a ground gypsum support layer. In secondary decoration phases, only one plaster layer was applied to support the paintings. For the first phase’s two-layer system, a coarse mortar was applied as a lower plaster, with its thickness (from 1-7cm) being dependent upon the evenness of the adobe walls to which it was applied. The upper plaster layer, without any further anchoring, consists of a finer mortar applied in a much thinner layer from 0.2 to 1 cm thick. The lower plaster layer had a rough surface and was presumably planed with wood whereas the surface of the upper plaster layer was finely smoothed, probably with stone, to prepare a truly perfect ground for the elaborate murals (See Fig. 3).

3.2 Are the temple-building skills from the past relevant in recent building traditions?

Growing tourism in Nako has caused an increase in prosperity for the villagers and a rising need for new hotels, shops and restaurants. Many of these buildings are built with cement-based materials and bricks, which are considered modern. However, there are village authorities and private house builders whose concern for village authenticity results in the continuation of the use of traditional earthen building techniques. Local masons still know how to use local soils, Thawa, Tua and Sassa, for different building applications. Earthen rendering and roofing techniques are applied today, but instead of adobe, stones are used for the building of structures. Also the vernacular architecture in the nucleus of this historical village is mainly composed of stone built-houses with wood, plaster and earthen roofs.

Surprisingly the mixture of Tua and Thawa (1:4) that was found to be used for the temples’ earthen supports continues to be used in Nako for making plasters; proving that the traditional knowledge of the past is still being used today.

4 Conclusion

This research programme, focussed on the Nako temple interior decorations, opened up the tremendous possibility to study the earthen supports that are usually neglected, or at least not very extensively studied. Similarly, the earthen building materials and techniques used in Nako would probably have never been under investigation if they had not served to support the highly significant polychrome mural paintings and sculptural decorations that the site is famed for.

Through studying the earthen supports and local soils it was possible to define their main components and to characterise their main material parameters; such parameters led to an understanding of the supports’ materiality, technology, and
susceptibility to decay and deterioration and has therefore contributed to the field of earthen material culture studies in the Western Himalayas.

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6 References