BUILDING TECNIQUES OF FORTIFIED STRUCTURES
IN KİNİK HÖYÜK ARCHAEOLOGICAL EXCAVATION (TURKEY)

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Abstract. The archaeological heritage is the result of a phase of the human civilization and, beyond the artistic-monumental values, it is material testimony of the human work and «unlimited» source of knowledge. In this perspective, archaeological excavations at Kınık Höyük, in southern Cappadocia (Turkey) started on initiative of a multidisciplinary team of researchers from the University of Pavia (Italy), the New York University (USA), CNRS (France) and the Universities of Niğde and Erzurum (Turkey). At Kınık Höyük there were found traces of a site that was inhabited for about 4000 years. Among the remains revealed, it is especially important the portion of the citadel walls along the north side of the mound in the centre of the archaeological site, which presents different architectural phases, the last one dating back to the Late Bronze Age (15th-12th c. B.C.E.).
The paper describes part of a multidisciplinary research, still in progress, that aims at developing a study about the operating principle of the architectural elements of the citadel walls and practical and social motivations that undergo the use of this technique and, later, the abandonment of the site and the technologies. However this paper is focused on the investigation of building techniques.
The dry masonry shows some interesting building peculiarities, as the good preserved mud plaster and the presence of wooden fragments in regular hole’s rows, which are visible on the façade. The comparison between the cases mentioned in bibliography and other architectures in pre-classical Anatolia highlights the particularity of the building techniques of the citadel walls in Kınık Höyük. These consideration induced to start a research in order to investigate the Iron Age building technology in this territory, but also with the aim to learn skills for the purpose of planning preservation actions respectful of the historical building features.
INTRODUCTION

Kınık Höyük is in Southern Cappadocia, in the province of Niğde, and its region is characterized by the alluvial plain of Bor-Ereğli, surrounded by mountains. In particular Kınık Höyük is at the foot of Melendiz Dağları, volcanic mountain north of the Bor-Ereğli plain [1]. The region had a strategic importance due to its favourable position on one of the main routes connecting Central Anatolia to the eastern regions (Cilicia, Syria and Mesopotamia), through the passes of the Taurus mountains [2], but also because of the richness in raw materials (gold, silver, tin, iron, obsidian, alabaster, marble) useful for a huge local production [1]. So, the territory is evidently important from a historical, archaeological and geological point of view, but it had been quite unknown – especially about the pre-classical period – until 2006, when the University of Pavia started a series of archaeological surveys [3], followed by the international archaeological excavations of Kınık Höyük in 2011 (University of Pavia, New York University, University of Niğde and Erzurum) [4][5].

Among the mapped archaeological sites of the surveyed area, the peculiar features (dimensions, position, and type of findings) of Kınık Höyük led to assign a key role to it in Southern Cappadocia, at least for the timespan between 1500-150 B.C.E. The mound lies about 1 Km from Bayat village and it is c. 2 Km far from the route connecting Bor and Aksaray, through Altunhisar. Kınık Höyük is c. 20 m high and 180 m in diameter, rising on a squared terrace that is about 300 m wide. The abundance of ceramics surrounding fields proves also the existence of a lower town and, including these fields, the site is 24ha [1][2]. In 2010, magnetic and ground-penetrating radar surveys showed an elliptic stone structure, which encircles the mound, showing traces of a defensive city walls (Figure 1) [6] and in 2011 excavations started. Operations on northern and south-western parts brought to light remains of a portion of the walls [7]. Their features and the good preservation status of the mud plastering motivated a research about its construction techniques. The intention to put in place a preservation programme and a valorisation plan makes further important investigations.

Figure 1: At left: map of Kınık Höyük (A. Savioli). At right: plan of the northern walls remains (L. Davighi).
1 BUILDING TECHNIQUES OF THE CITADEL WALLS IN KİNİK HÖYÜK

1.1 Building technologies of archaeological remains: aims and methods of analysis

Studies about construction technologies grew notably in importance in the field of ancient architecture research and in particular in the area of archaeological excavations. Indeed it is known that materials and building techniques permit to carry out chronological and cultural distinctions like the analysis of other artefacts (e.g. remains of ceramic) [8].

In ancient times, building traditions arose on the empirical experience of craftsmen who, through trial and error, came to the creation of a building element [9]. The craftsman started from the selection of raw materials considered suitable for the intended purpose and therefore he experimented extraction and processing techniques until the production of a "correct" artifact [10]. He wasn’t fully aware of the link between starting elements (raw materials, processing methods, assembling systems, etc.) and final product, he knew only the memory of his sequence of actions: the stabilised sequence became the rule to be followed [11].

Each built environment is a unique and unrepeatable event, especially due to the materials and their use. Indeed building traditions were closely linked to nature of territories and to forms of civilization and of production. Since prehistoric times the development of sedentary ways of life lead to adapt the architecture to territories according to the “principle of least effort”: local raw materials were used in the most profitable method with construction techniques empirically and especially studied. The local origin of technologies brought also to the invention of environment which was created to meet specific climate features and particular cultures, political and economic systems [8][10].

Socio-economic and political challenges influenced the organization of lifestyles and then the architecture, so the building remains may constitute important historical documents. However, in the field of archaeology there is often a lack of information, in part because research interests were focused more on moveable assets, but above all because of the poor preservation status of excavated architectural remains [7].

Restorations of archaeological artefacts are generally difficult and expensive due to the advanced decay of the structures when the interventions are usually put in place. The architectural remains, unlike movable assets, are generally not protected during excavations and, at the end of the activities, if the restoration is still possible, the criticalities are increased compared to the initial situation. Moreover there are damages caused by habitual interventions as the integration of lacunas and the protection of the walls’ tops, which homogenize the construction features and disguise original building techniques as well as stratigraphic relationships between different parts [12].

Therefore the study of construction techniques and the preliminary diagnostic investigations are fundamental for the historical knowledge and for conservation programs which should be planned before decay produces unrecoverable material losses and so the research about construction techniques of city walls at Kınık Höyük is developed in this point of view.

In order to know potentialities of materials, building systems, traditions, used safety measures, it is necessary to find the phases of the construction site and to analyse the individual components of the building system. In fact, particularly with regard to the most ancient excavations, epigraphic documents do not provide deepened information that are able to complete the data of the archeological investigation. In addition, iconography and models of architectures provide symbolic images – maybe imaginary – that give an aleatory idea of construction details, because they are easily subject to subjective interpretations [7], even if in some cases models were used for the material reconstruction of buildings [13].

The research on Kınık Höyük is organized in phases and at first in situ investigations started.
In this phase first samplings were conducted in order to make laboratory diagnosis. In particular, during the 2013 campaign, samples of building materials were collected and preliminary analyses, that are orientative for the next diagnostic campaign, planned for the 2014 excavation activity (paragraph 3).

These investigations are combined with research about construction techniques in neighboring territories and/or coeval cases in Middle East. The presence of traditional building technologies that have endured over time could be significant to understand and to interpret material remains.

1.2 The citadel walls of Kınık Höyük

The excavations of the citadel walls begun in 2011 and they are still ongoing. The activities revealed the remains of a 3.5 m high stone socle that constitutes the base of a city walls. It is hypothesised the presence of a mud brick superstructure on the top of it similarly to other analogous cases, but it does not exist anymore [14]. Under these walls, remains of an earlier citadel walls were uncovered; since the earlier walls adopt a different building technique and it dates to a different period, it will not be considered in this paper.

The actual construction is about 4.5 m wide and it consists of a fill of unshaped river stones (Ø ca 35 cm), retained by an outer 70 cm thick side-wall of unshaped stones, bigger at the base of the structure, possibly for static reasons. The inner face of the walls has still to be uncovered. The central fill has many voids with various dimensions, of the order of tens of centimetres, between the stones. This feature suggests the lack of mortar joints (dry-stone masonry). The described stonework can be defined a rubble masonry.

The central part of the masonry was partially spoiled in antiquity. In the rubble fill of the spoliation trench, few Late Iron Age and Hellenistic pottery fragments were found; this trench was probably used as a quarry for the Hellenistic stone architecture found on the summit of the mound [2].

In a deep trench opened in 2011, archaeologists discovered a portion of the northern façade of the walls, coated with a mud plaster. In 2013 the deep trench was widened to a 4m length, in order to get better information on the building techniques and the construction materials, and also to make some tests for the stabilization of the walls. The investigations showed that the plastering is about 10cm thick and that it is made of mud, tempered with organic inclusions, without lime (macroscopic analyses).

Under the plastering, the masonry consists of stones, mud and timber. Apart for the timber, for which provenience and species are still to be determined, the building materials are locally sourced and have volcanic origin: andesite and basalt stones for the stonework and local earth with volcanic minerals and volcanic glass used as raw material for mud plaster and bricks (par. 3.1). Indeed, geological investigations explain that the territory around the site is characterized by colluvial slopes and alluvial and lacustrine plains; the colluvial slopes are the result of accumulation of andesitic and basaltic rock fragments from near volcanic mountains, the plains are instead composed of flat and carbonate silts [15].

In 2011 some holes were noticed open on the plaster surface (Figure 2). After the opening of a second part of the northern façade in 2013, the surface appeared initially regular, without holes, but the mud plaster, exposed to weathering, eroded in correspondence of voids in the external wall of the masonry. After some days of decaying (powdering), it was clear that the holes are set next to one another (Figure 4), and they form rows of timber, small stones, and mud, placed at ca 0.5m one from the other and spaced out by rows of unshaped stones. In the holes, some decayed timber remains found in 2011 and even more in 2013 likely belonged to
wooden logs embedded in rows into the masonry [2]. In 2013 these were found up to a depth of about 70 cm in the masonry; this is the reason that made us suggesting that 70 cm is the thickness of the stone side-wall.

The function of the log in the masonry is still unclear. Given the short distance between the rows – and due to the defensive function of the masonry – a connection with the scaffolding for the construction of the plaster coating seems unlikely. The posts and mud rows surely provided plasticity to the masonry, but a clear sense of their function, given also the few comparison for this construction technique, requires more analysis and exposition of the fortifications.

The façade was partially hidden by the structure of a rampart (Figure 3), made of rubble and earth and built adjacent to the citadel walls for defensive purpose: the presence of the external glacis prevented war machines approached to the city walls, contributing to the defence of the citadel in case of siege.

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Figure 2: At left: part of the remains of the citadel walls in 2011. At right: a detail of the same façade in 2013.

Figure 4: At left: a particular of the façade in which three rows of holes are visible; the lower one shows the regular position of the holes, next to one another. At right: fragments of wood in a hole of the façade.
1.3 Preliminary dating of the walls of Kınık Höyük

A preliminary dating of the analysed level of the citadel walls is obtained from a relative chronology based on stratigraphic data and an absolute chronology based on radiocarbon analysis on wooden fragment coming from the masonry of the walls. The best indications come from the stratigraphy of the accumulations abutting the northern façade of the walls. Two ramparts were constructed one after the other (Figure 3). The earlier rampart obliterated a level of the fortification and sloped gently from the mud plaster of the walls to the outside; later, in the second phase, the rampart became much steeper and was raised up covering the plastered façade for almost three meters. In one of the earth accumulations forming the second rampart, archaeologists collected approximately 200 diagnostic sherd that can be dated to between the Late Bronze Age (LBA) and the Early Middle Iron Age (ca. 1300-900 B.C.E.) [15]. They offer a terminus post quem for the late rampart and a terminus ante quem for the older rampart and the fortification walls. This relative dating is supported by the radiocarbon analysis on a wooden sample of pole found in the holes of the masonry; the analysis was made at Laboratoire de Mesure du Carbone 14 in Saclay (CNRS, France) and gave a date 3160+/−50 B.C. (15th-14th century B.C.E.). The dating is still tentative and more analyses need to be done: it is nonetheless a clue for dating the construction to the LBA.

1.4 Fortified structures of pre-classical Anatolia

As it was said in the precedent subsection, relative dating indicates that the fortification walls of the citadel of Kınık Höyük was constructed during the LBA. During this period Anatolia was under the hegemony of the Hittite empire [16], whose capital is Hattuša Boğazköy, in North Central Anatolia, some 400 Km north of Kınık Höyük. The region around Kınık, known today as Southern Cappadocia, was at that time either part or at the edge of a province of the Hittite empire named the Lower Land [17]. This region came
under Hittite control at the very early in the history of the Hittite civilization, but was also long contended, in particular with a neighbouring kingdom named Arzawa.

One of the main features characterizing the Hittite hegemony in Anatolia was the construction of fortifications in subjugated towns. A normative text, which is issued by the Hittite king Arnuwanda I (ca. 1400-1380 B.C.E.) and known as the instructions for the governor of the border posts [18], codified construction technique, materials and dimension. The text is unfortunately damaged and some of the technical terms adopted are not deciphered; nonetheless it provides clear evidence of Hittite written instructions for fortifications. The text was copied many times along the last 200 years of history of the Hittite empire, indicating a concrete way in which the architectural technique for the fortifications could have widespread.

Archaeological remains from Hittite Anatolia also support the existence of a standard construction technique for the edification of defensive walls. Fortifications are built as casemate walls, with squared towers or bastions protruding outwards from the outer façade at regular intervals [19]. They had socles of quarry stone masonry, and elevation of mud brick, but possibly also timber and earth fill masonry, as the excavations of the gates at Küşaklı Sarissa recently showed [20]. This type of fortification walls, that derives from Anatolian early second millennium forerunners known from Konya-Karahöyük, and Alışar Höyük, became common in many centres of Central Anatolia, the Upper Euphrates, and Cilicia, as the excavations at Böğazköy, Küşaklı Sarissa, Alaca Höyük [21], Alışar Höyük, but also Mersin [22][23] in the south and Korocenepe and Arslantepe Malattiya [24] in the east indicate.

The citadel walls of Kınık Höyük make use of the same materials as these Hittite fortifications, even though the use of Lesesteine (stone blocks collected on surface or near torrents) and not Bruchsteine (quarry stones) rather recalls a technique in use prior to the Hittite period in Anatolia [23][25]. The height of the stone socle (ca 3.5 m) is unparalleled in most city walls, but the citadel fortifications of Alışar Höyük provide a good parallel [22]. It is worth noting that also those walls are erected against a mound slope. The investigation of the inner face of the Kınık has still to be performed, but the Alışar walls seems indicating that only the outer sidewall was erected with a high stone socle, while the space between the previous slope of the mound and the stone side wall was filled by earth and stones, and only the upper meter of this socle was obtained by adding an inner stone side-wall and a quarry stone core. This upper stone part should serve as platform for the further elevation on mud brick [22].

While the overall conception of the fortification from Alışar Höyük can be similar to that of Kınık Höyük, the technique of alternating posts and stone rows is an unparalleled building technique for fortifications in Anatolia. More in general, the use of timber in fortification walls is very rare [22], and only attested for the timber frame over the stone socles serving as a platform for the mud brick walls, as in later Zincirli Höyük [26].

The best parallel for the use of rows of timber alternated to rows of stones in LBA fortifications is provided by the site of Porsuk-Zeyve Höyük [27]. In the potern corridor of the western fortifications rows of hewed gypsum blocks alternating with rows of large wooden beams are attested. While the materials and technique are slightly different, due to the respective local geology (a cave of gypsum lies beside the site of Zeyve), nonetheless the adoption of timber rows and of timber at all, in LBA fortifications is only found in these two LBA sites of Southern Cappadocia, and let one wonder if they could represent a local construction technique for fortifications. What is evident, at least in the case of Kınık, is that the architectural technique is not the same as the one adopted by Hittite governors of provincial areas, even if the site is in a Hittite region.

The mud plastering of the citadel walls of Kınık is, on the other hand, well known as a typical element of pre-classical fortification walls of Anatolia. Since the mud plastering is very sensitive to weathering, and if not restored decays in few years, in most excavated sites it was
simply not found, or found only on small areas. The state of conservation of the fortification plastering is therefore considered exceptional. Only another case is known, and it is the Early Bronze Age citadel walls of Troy II [23], but these were excavated at the end of the 19th century, and today the plastering is no more preserved. Troy II walls showed that not only the mud-brick elevation, as generally thought, but also the stone socle of the walls was plastered. The citadel of Kınık offer a later 2nd Millennium B.C.E. confirmation technique.

2 PRESERVATION STATUS OF THE CITADEL WALLS’ REMAINS

The deterioration is an evolution of the characteristics of an object in the course of time and it implies a decay of its functionality and a decrease of its value. A slow development is "physiological", but is "pathological" any dangerous acceleration of this evolution [28]. The causes of degradation depend on the combination of external factors and materials properties and two main natural reasons are water and temperature variations. Archaeological excavations pose an immediate problem about the protection of the artefacts that remained under soils, in constant condition of temperature and humidity, for a long time and, once brought to light, are exposed to weathering (rain, strong summer radiation, snow during the winter, etc.). So it makes be important to analyze the conservation status in order to study a preservation plan.

Figure 5: Preservation status of the mud plastering of the northern façade of the citadel walls in 2013.
A phase of more in-depth investigations about the building technologies and the preservation status of masonry started during the 2013 campaign. Kınık Höyük is located on an upland at an altitude of c. 2400 m with hot and dry summers and frigid winters and the alternation of these weather conditions influences even more negatively on the conservation of mud artefacts that were preserved underground. The stonework doesn’t present decay with exception of dust and incoherent deposits carried by the wind. During the surveys, when the surface was cleaned with water, mosses appears in few hours: this proves the presence of biological colonization on the stones. The most fragile element is the mud plaster: due to weathering it is easily attacked by powdering, that cause in few time the total loss of material. During surveys, degradation phenomena of the northern walls portion were macroscopically analysed and classified (Figure 5, Table 1). Preservation status sheets are created referring to the ICOMOS glossary on stone deterioration pattern [29], used also for artificial stone (clay bricks, mud bricks, mortars, plasters, etc.).

Table 1: Example of a preservation status sheet (M03: M=Mud material, 03= identification number).

<table>
<thead>
<tr>
<th>Survey of the preservation status</th>
<th>Kınık Höyük</th>
<th>M03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building:</td>
<td>Citadel walls (revealed portion 2013)</td>
<td></td>
</tr>
<tr>
<td>Building system:</td>
<td>Stone masonry with plastering</td>
<td></td>
</tr>
<tr>
<td>Building element:</td>
<td>Plaster</td>
<td></td>
</tr>
<tr>
<td>Material:</td>
<td>Mud</td>
<td></td>
</tr>
<tr>
<td>Orientation:</td>
<td>North</td>
<td></td>
</tr>
</tbody>
</table>

### Macroscopic survey

<table>
<thead>
<tr>
<th>Degradation pattern:</th>
<th>Powdering (Disintegration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition (ICOMOS, 2008):</td>
<td>Sub-type of “Disintegration” (detachment of single grains or aggregates of grains), term employed for describing granular disintegration of material.</td>
</tr>
<tr>
<td>Relationship with the substrate (ICOMOS, 2008):</td>
<td>It affects only the surface or can occur in depth. Damage generally starts from the surface of the material.</td>
</tr>
<tr>
<td>Surface description:</td>
<td>The surface is much crumbly and some portions are powdered. Grains of plaster are detaching themselves from the substrate.</td>
</tr>
<tr>
<td>Possible causes:</td>
<td>Weathering (wind, rain, excessive solar radiation, etc.). When the structure is under the soil, humidity and thermal conditions are constant, but the changed condition is causing a decay of the mud material.</td>
</tr>
</tbody>
</table>

**Reference**

Drawing: 
Conservation sheet:
3 INVESTIGATION PLAN ON BUILDING MATERIALS

3.1 Preliminary investigation on mud building materials

Introductory investigations were carrying out on mud artefacts and on the local earth at the Department of Earth Science and the Environment of the University of Pavia by prof. Massimo Setti, through X-ray powder diffraction. For the 2013 campaign it was possible to transfer in Italy and analyse a reduce number of plastering samples and the investigation gave only preliminary results, that must support investigations during the next campaign and the activity of sampling of building materials. In particular, the results prove that the mineralogical composition of mud plaster and the composition of local earth are the same, highlighting the probable absence of carbonatic binders (lime). Therefore it was hypothetical that the building materials were obtained with the use of earth present in the site mixed with water.

An interesting result is the almost total absence of clay, usually used for the realization of earth building products, because of its features that gives a particular plasticity, if it is mixed with water, and refractoriness, if dehydrated. The samples show the presence of volcanic minerals, due to the volcanic nature of the territory.

3.2 Planning of analyses for the next archaeological campaigns

As seen previously, the diagnostic analyses are of primary importance for the knowledge of construction technologies. The walls are very often investigated without attention to materials and processing methods, causing not only a superficial cultural-historical knowledge, but also a lacking basis on which it devises preservation activities that often alter the “information potential” of constructions [12].

Therefore the research sets the objective of more deepened diagnostic analyses, based on the results of the preliminary investigation. These introductory analyses on few samples of mud building materials permitted to formulate some preliminary hypotheses about realization and building features.

There is the intention of starting an activity of sampling of building materials, not only mud plaster, but also other artefacts as mud brick masonries and earth of neighbouring areas with the aim to study materials also in comparison themselves.

At the same time, other investigations about the dating, because the first results of the radiocarbon analysis constitute in interesting information. It is intended to take some samples of wood in different holes of the masonry, comparing the results with each other in order to prove or refute results already obtained (subsection 1.3).

4 CONCLUSIONS: TOWARDS A PRESERVATION AND VALORISATION PLAN

The archaeological heritage has an important feature: buildings are not used, but there is the need to preserve memory and to show buildings features, historical cities evolution, past ways of life, etc. So, the most important things in the field of archaeological conservation are to maintain materials and techniques and to guarantee workers and tourists’ safety.

The preservation of archaeological sites is a highly complex, because of the difficulties in safeguarding materials, but also because the funding are few in relation to the great quantity of needs [30]. Furthermore the progress of the degradation development cannot be hopefully considered slow in order to preserve for long time, even if the materials are resistant or placed in favourable environmental conditions. So a long-term conservation should be based on a frequent diagnostic control that allows the application of corrective measures on materials or on surrounding environment [28].
These are the logics of the preventive maintenance planning and this research permits to put
the base for the future creation of a preventive conservation programme for Kınık Höyük.

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