THE STABILIZATION, CONSERVATION AND PRESENTATION OF MONUMENTAL MUD-BRICK ARCHITECTURE: THE SHUNET EL ZABIB IN EGYPT

Anthony Crosby

Theme 3: Documentation, Conservation and Management of Archaeological Sites
Keywords: Decay, stabilization, presentation

Abstract

The Shuneh is a large mud-brick structure in Abydos, Egypt constructed for the funeral of Khasekhemwy, the fifth Pharaoh of the 2nd Dynasty. It consists of two parallel walls that enclose an area approximately 60 meters by 110 meters. The inner, or enclosure wall, is 5 meters wide at the base, and the battered walls originally rose to a height of approximately 14 meters. Portions of the inner wall remain at a height of 11 meters. Approximately 7 million earth bricks were used in the construction.

The overall conservation project is to stabilize the structural geometry of the Shuneh, conserve the remaining fabric, which consists of architectural elements such as pilasters, doorways, and original finishes, and present the Shuneh as a ruin that evokes the character that has evolved over 4,700 years. The primary factors of decay are wind erosion, animal and insect infestation, and the intervention of man, who utilized the large mud-brick walls as a Coptic community in the first centuries of the first millennium CE, resulting in the partial collapse of some of the walls.

The major stabilization consists of restoring or repairing portions of walls that contribute to the structural integrity, rebuilding foundations that have been undercut, reattaching plasters, pilasters and other features, and capping the tops of walls, all with mud bricks made on site.

1. INTRODUCTION

The conservation of the Shunet el Zebib is an initiative of the Institute of Fine Arts, New York University, as part of the University of Pennsylvania Museum – Yale University – Institute of Fine Arts, New York University Expedition to Abydos, David O'Connor, Co-Director, Matthew Adams, Associate Director/Field Director. Major support for the project has been provided by the American Research Center in Egypt (ARCE), using funds provided by the United States Agency for International Development (USAID) and administered through its Egyptian Antiquities Project (EAP), Egyptian Antiquities Conservation (EAC), and Antiquities Endowment Fund (AEF) grant programs. Additional support has been provided by the World Monuments Fund and Egypt's Supreme Council of Antiquities (Crosby, 2000).

The conservation of the Shunet el Zabib (or Shuneh, if mentioned by itself) began in 2000, with a site visit by a team of architects, a structural engineer, and the assistant project director. The purpose of the site visit was to collect information about the conditions and the values of the Shuneh for a comprehensive conditions-assessment report, which would lead to treatment plans for the conservation of the structure. The conditions-assessment report identified the overall conditions, including the major problems that were causing deterioration and loss. The reports also documented the primary character-defining features of the Shuneh that were to be preserved. Generally, these characteristics are the overall geometry and the color and texture of the exposed mud bricks. The site features, such as the large sand embankments, and architectural details, like plaster and pilasters, are other important characteristics that are to be protected. Reports resulting from the site visit emphasized that the Shuneh is a ruin and it is to be preserved as such. The subsequent development of the treatment specifications one year later was designed to protect these characteristics (Crosby, 2000, pp. 4-12).

The large mud-brick enclosure at north Abydos known today as the Shunet el Zebib was built near the end of the 2nd Dynasty (ca. 2750 BCE) to serve as a cultic enclosure for King Khasekhemwy, last king of the dynasty. It represents half of a two-part funerary complex, the other consisting of his underground tomb, located some 1.5 km to the south of the enclosure at a part of the site known as Umm el-Qa'ab. The enclosure was the last and largest of a series of royal cult enclosures at Abydos that, insofar as presently available evidence indicates, begins at the start of the 1st Dynasty, corresponding to a dramatic increase in scale in royal tomb construction at Umm el-Qa'ab. All the kings of the 1st Dynasty, as well as the last two of the 2nd, were entombed at Abydos, and it appears that each also built a corresponding enclosure. Given that the royal tombs were underground features located in the desert relatively far from ancient habitation, and that for the most part they do not seem to have been marked above ground by any large-scale built feature other than possibly a tumulus of sand and gravel, the Abydos enclosures, situated on a low desert terrace near and overlooking the ancient town of Abydos, probably should be seen as representing the primary monumental statement of royal presence and power for each king (O'Connor, Adams, Remsen and Crosby, 2006).

Fig.1 Shunet el Zabib, the funerary enclosure of Khasekhemwy from the north, with mud brick walls 11 meter high (credits: Anthony Crosby, 2001)

2. DESCRIPTION, CONTEXT AND CONSERVATION ISSUES

2.1 Physical description of the site and structure

The Shunet el Zabib is located 10 kilometers west of the Nile and 2 kilometers from the western edge of the Nile Valley. It consists of two parallel mud-brick walls that enclose an area about the size of a football field, or approximately 110 meters by 60 meters. The interior walls are the largest being 5 meters wide at the base and some are still 11 meters high. It is estimated that these interior, or enclosure walls, were approximately 12 to 13 meters high originally. The exterior or perimeter walls were smaller being approximately 3 meters thick and perhaps about two-thirds as high as the enclosure walls, or approximately 6 meters high. Both the enclosure and perimeter walls were battered, or tapered from the base of the wall to the top. There were four entrances into the enclosure, the northeast and the southeast ones being the most significant. Niches, defined by pilasters, were constructed on the exterior surfaces of the enclosure walls, those on the east being slightly more complicated than those of the north, south and west. The entire surfaces were plastered with gray clay and finished with a thin coat of white gypsum plaster.

The original construction of the Shuneh was consistent and appears to have been the result of one building episode. Mud bricks were laid on a bed of sand, probably compacted, and the walls constructed to a height of approximately one meter at which point, a layer of reed was placed; this may have been for the purpose of adding a minimal amount of horizontal reinforcement. The layer of vegetable matter was also placed to terminate a leveling course. The construction continued for another 1 to 1.5 meters at which point another leveling course was defined by another layer of reeds, which were not woven but placed loosely on bedding mortar. The process continued until the top of the wall was reached. The walls are battered at an angle of approximately 2 degrees and the coursing of the interior and exterior wall surfaces is alternating headers and stretchers with header courses beyond the surface mud brick. The bricks are relatively small, 27 cm by 13 cm by 9 cm, which is common for this early period (Spencer, n.d, p.5).

2.2 Conditions of the microenvironment

The average annual precipitation is less than 25 mm. Mud rills formed by a rain in 1996 remain on wall surfaces indicating the lack of subsequent rainwater sufficient to erode the rills. No measurable rain has occurred during our work seasons. The average high daily temperature during the summer months of May through August is approximately 42° C, but extremes can be considerably higher. Daily highs of greater than 50° C were experienced while working on site and mud-brick wall surface temperatures of 60° have been recorded. The area is a relatively low risk for seismic activity.

The relative humidity during site work in the spring averages approximately 25-35% for the daily temperature highs and 60-65% for the daily lows. The relative humidity corresponds to the daily temperature gradients; hence, the absolute moisture content of the air during this time of year does not vary significantly. Prevailing winds from the north off the Mediterranean are relatively cooler than the hot and dry winds from the south and west. Winds speeds above 6 - 10 meters per second are not uncommon and can reduce work efficiency during cooler temperatures. Wind speeds of 10-20 meters per second can cause work to be shut down because of blowing sand and unsafe scaffolding.

Presently, the water table is approximately 6 meters below the existing grade, as measured in the well at the Dig House. Without having access to hydrological information it is impossible to predict the corresponding current water-table level at the Shunet, although there is certainly no evidence of a significantly higher water-table level at the site. However, an increase in irrigation could possible result in a higher water table in the future. To actually affect the lower walls of the Shunet, the water table would have to be within a meter of the existing ground level and that is not probable.

In order to accommodate the battering of the walls and also to level courses, several conventions were employed. Bricks were often laid perfectly flat, but at an angle to the wall plane, reducing the overall horizontal dimension, Header bricks were also laid vertically or at an angle between horizontal and vertical for the purposes of leveling; this is a practice often found in Egyptian brickwork (Spencer, n.d, p.114).

2.3 Factors resulting in decay

The most significant problems were the large losses of wall sections that put the adjacent walls at risk. In some cases, the construction of the Coptic cells resulted in the removal of as much of 3.5 meters of a 5-meter thick wall. The cells eventually collapsed and additional loss of mud-brick walls occurred. Large sections of mud bricks adjacent to all of the four entrances had collapsed, leaving the adjacent walls free standing with only the northwest corner intact. Wind, rain erosion and insects had also caused significant loss, the latter resulting in holes and small voids in the walls, some of which are as deep as two meters. Animals often enlarged the holes, as well as creating their own. Large animals, such as jackals and foxes, have made dens in the walls, significantly undercutting them to a depth as much as 3 meters.

In addition to these external or extrinsic causes that results in loss and deterioration, there were also intrinsic problems. The original mud bricks were made with chopped straw and other organic matter, such as manure, which served as a food source for insects and fungi. After nearly 5,000 years, most of the organic material had been eaten, leaving a substantive amount of the mud bricks significantly weakened. The other intrinsic problem was that of the actual brick-laying pattern, which used only header courses, or bricks laid perpendicular to the wall axis for the majority of the mass masonry. Because the bricks of the Shuneh are relatively small, it is impossible to lay the bricks as header courses without having many joints lining up vertically, or "stacked" in such a large structure. This results in weak points that can develop into a vertical structural crack as stresses develop.

Fig.2 Large sandbag buttresses were constructed in 2001 to support the east enclosure wall (credits: Anthony Crosby, 2006)

3. INTERVENTION

3.1 Emergency stabilization

The first stabilization action was the construction of large sandbag buttresses along the interior of the east enclosure wall in 2001. This entire wall section is much lower than the other enclosure walls, but had been severely undercut by animals and 19th-century invasive archeological excavations. Many sections of this wall were in immediate danger of additional loss. One large structural crack was identified as characteristic of the failure pattern of the entire wall, and it was cleaned and repaired with mud mortar and horizontal reinforcement.

In addition to emergency stabilization for the Shuneh, issues often arise that require emergency bracing and shoring during archeological excavations. Specifications have been prepared for these emergencies utilizing site scaffolding.

3.2 Conservation priorities

The conservation-implementation phase actually began in the spring of 2004, continued with a second field season in the fall of that same year and continued with three additional conservation seasons. Site work was delayed after the spring of 2006 season and did not resume until spring 2009. The sixth field season in 2009 was followed by a seventh in spring 2010 and an eight in 2012.

Conservation interventions during the first several seasons concentrated on some of the highest priorities that had been identified in earlier reports. The highest priorities included the infilling of a large missing portion of the north wall, the construction of a mud-brick "buttress" at the east end of the north wall, the initial stabilization of two collapsed Coptic cells in the west wall, the stabilization of the south end of the west wall, and the infilling of the holes and voids that had been caused by insects and animals. Part of the first season also consisted of working out many logistical and technical details of the site work. The mud bricks are manufactured near the Shuneh and are transported the several hundred meters to the actual work site, as they are needed. Each new mud brick is stamped with the project identification 'PYIFA'. The mud bricks are made with only natural sand and soil, as is the mortar, and include no additives. The selection of a suitable material for horizontal reinforcement and for the attachment of new masonry to the existing Shuneh masonry was made and implemented in areas where reinforcement was required. The material selected is a high-density polyethylene (HDPE) in the form of an open grid.

Fig.3 The west enclosure wall showing the completion of the stabilization of two collapsed areas where Coptic cells existed (credits: Anthony Crosby, 2006)

Fig.4 East enclosure wall showing the process of constructing the mud-brick foundation system (credits: Anthony Crosby, 2010)

Because of the structural problems, it was impossible to leave features of the Coptic cells, such as the plastered walls and floors, exposed. They were protected before the cells were completely infilled by placing a separation layer of clean sand. If the infill is ever removed, the features of the cells can be recovered. Where necessary, the existing plasters in the cells were stabilized prior to covering them.

3.3 Details of conservation interventions

The Shuneh conservation work consisted of 1) filling holes and voids; 2) reconstructing missing portions to stabilize existing walls; 3) constructing missing features such as doorways; 4) capping all walls; and 5) conserving surface features.

During the process of planning the interventions, original Shuneh mud bricks and the available soil for new mud bricks and mud mortar were analyzed (Harrison, Amione-Martin, and Keift, 2005). In addition, testing was done on site to determine the strength of the mud bricks utilizing field techniques and compared with the specific analysis and with the actual overburden of new masonry. The strength of the original mud bricks was estimated to be low, but the masonry system with much stronger mud mortar appeared capable of supporting the overburden of the new masonry (Crosby, 2005, pp. 26-28).

3.3.1 Small holes and voids

Filling small holes and voids are primarily not structural, but are an important part of the project. Insects and birds have created and then expanded the holes, and filling them discourages but does not completely stop damage. These holes and voids are filled with mud bricks, replicating the adjacent coursing patterns and wall texture.

3.3.2. Structural stabilization

Structural stabilization generally addresses two conditions – tall unsupported walls, the unsupported ends of which separate over time from the wall mass, and large cavities in walls that leave upper portions of walls unsupported. At every unsupported end wall, large structural cracks were documented, often a series of vertical through-wall cracks, becoming less severe the farther away from the end. To provide stability, a portion of the adjacent missing wall is reconstructed as a buttress.

The most severe conditions of unsupported upper walls has resulted from the construction of the Coptic cells and their eventual collapse and the loss of foundation sand from the east enclosure wall from mid-19th-century archeological excavations. These conditions have required the greater interventions in the form of replacing much of the loss materials from the Coptic-cell collapse and the construction of a mud-brick foundation system along the interior of the east enclosure wall.

The large collapsed areas were partially reconstructed with mud bricks following the same coursing as the original. The reconstruction of a collapsed Coptic cell was not completed flush to the existing wall, but recessed to indicate that a cultural feature existed. Geogrid was used as horizontal reinforcement at the approximate same vertical spacing as the original reed mats.

Mid 19th century excavations extended along the east wall were approximately 3 meters deep – they were never backfilled. Sand began to move from under the wall into the trench, and the lower mud bricks followed the sand into the excavation trench. A new foundation is being constructed to provide the missing support for the east wall. It extends out from the original wall plane approximately 1 meter and extends 1 meter below the original base of the wall. The new sections are completed between the sandbag buttresses, and once completed, the buttresses are removed and the two sections are connected with a continuation of the foundation.

Fig.5 Aluminum wedges attached to stainless-steel cables used to attach geogrid to mud brick walls (credits: Anthony Crosby, 2010)

Fig.6 Comparison of mud-brick protective cap and existing wall top (credits: Anthony Crosby, 2005)

An important addition to the original field procedures was the development of a system to mechanically tie the new mud bricks to the existing original Shuneh bricks. In areas where the new mud bricks are entirely under compressive loads, no mechanical ties are necessary. However, areas where the repair is relatively thin, or where there may be some tension stresses between the old and the new, a system of mechanical ties is required. In all cases, regardless of the anticipated loading, the new bricks are 'keyed' into the coursing of the existing masonry to improve structural integrity.

Initially, a system was developed utilizing stainless-steel threaded rods, toggles and eyebolts to attach the geogrid to the wall mass. Holes were drilled into the historic masonry and the rods with toggles were inserted into the holes. When pulling the rods, the toggles opened and locked into place. The eyebolts on the exposed ends were then attached to the geogrid. While it provided the attachment necessary, it was time consuming and required the direct supervision of the conservation architect. Between seasons three and four, another more efficient and effective system was selected.

The new mechanical ties are similar, but much simpler in design and installation. They consist of aluminum wedges attached to stainless-steel cables. Holes are drilled and the aluminum wedges are driven into the historic mud bricks. Tension is put on the cables and the aluminum wedges are set perpendicular to the axis of the drilled holes, locking them in place. The cables are then attached to the geogrid. These proved effective as they can be installed with minimal supervision and provide adequate pull strength of > 140 kilos.

3.3.3 Protection of tops of walls

It is estimated that the tops of the walls, unaffected by more traumatic loss, have eroded approximately 3 meters, vertically, over the 4,700-year life of the structure. The upper most exposed mud bricks are friable and will continue to erode, albeit, extremely slowly, because of the lack of significant rainfall. While a lower priority than the reconstruction of missing structural elements, capping using unstabilized mud bricks is one of the important treatment interventions. The tops of the walls are prepared by removing loose, friable materials and new mud bricks are placed in the general contours of the existing walls. The contouring of the cap and the distribution of additional loose soil result in a character that evokes the character of the pre-treated wall tops.

The important structural stabilization of the walls at the original gateways into the Shuneh presented an important presentation issue. The missing mud-brick sections had to be rebuilt to support failing end walls and the decision was made to include an opening into the Shuneh through the new masonry. After much deliberation a decision to partially restore the west gateway to its historic appearance was made. The existing footprint of the gate was known from archeological evidence and additional research to determine the appropriate height and other details was undertaken. The results from the combination of research and physical evidence is a gate opening approximately 3 meters high with exposed beams and lintels; the proportions are based on the royal cubit. The wall surfaces immediately adjacent to the opening are restored to their original plane, but immediately blend to the color, texture and wall planes of the existing mud-brick masonry of the Shuneh.

3.3.4 Plaster stabilization

During the process of excavating areas that needed to be structurally evaluated, original plasters were often exposed and required conservation treatments prior to the backfilling of the excavated areas. The extent of the conservation intervention included reattachment of completely detached plasters, injecting mud grouts to provide additional support for partially detached plasters, and applying mud beads at exposed edges. We have also completed a partial survey of existing plasters, identifying the extent of the plaster and their conditions. This is important work that will continue in future seasons.

3.4 Summary of conservation interventions

At the completion of the 2010 fifth conservation-implementation season, over 400,000 mud bricks have been laid. This is approximately 65% of the estimated total to complete the major structural stabilization. More importantly, the construction details have all been worked out, presentation issues have all been resolved, and the masons and laborers are thoroughly trained and completely capable of executing most of the conservation treatments. In addition, the presentation solutions have been developed and incorporated into the conservation specifications with the completion of the partial restoration of the west gate. In future seasons, the work will continue with the stabilization of the remaining tall walls, the filling of voids and the stabilization of the other gateways. Eventually, all of the walls will be capped with a sacrificial layer of mud bricks. The sacrificial bricks will ultimately erode, but in the meantime the original bricks beneath will be protected.

Fig.7 The west enclosure wall from the north after completion of the west gateway stabilization and restoration (credits: Anthony Crosby, 2010)

During the process, much has been learned about original construction practices and materials. While the entire structure was plastered and finished with a thin gypsum plaster, some color was also used as splashes and drips of terra-cotta color paint have been identified. No structural wood remained in the Shuneh, but wood would have originally supported the opening of the gateways. Structural wood has been embedded in the mass masonry at other sites, but this practice did not exist in the Shuneh (Nicholson and Shaw, p. 89). However, tamarisk wood has been found in walls of the Shuneh that was used for scaffolding. Tamarisk wood is mentioned in ancient Egyptian texts, but not specifically for this purpose (Nicholson and Shaw, 2000, p. 345).

4. CONCLUSION

The conservation approach that has guided the project from the beginning is to protect the existing Shuneh as a ruin, while structurally stabilizing endangered masonry elements, reducing or mitigating the causes of decay, and evoking the basic characteristics of the structure and the immediate site. Presentation issues are important to the overall goals and no actions are undertaken without considering the overall effect on the character of the structure.

The conservation methods have remained basically the same as originally designed, but some important modifications have been made and these changes are incorporated into the conservation specifications at the end of each field season. Some of the important changes are specific to material use and some simplify the original specifications to reflect the reality of local site conditions. The same crew of masons have worked on the project from the first season in 2004, having come to the project with sound masonry skills, and have learned how to incorporate those skills on the often specific requirements of conservation. They are skilled at their profession, sensitive to specific issues, adept problem-solvers, and self-directed. No task is too difficult and no challenge is too great.

We recognize that conditions can change, which will require future changes to the treatment approaches. Just as the specifications have evolved during the project, some modifications in the future will be necessary to respond to conditions, new threats, and new conservation treatments materials and approaches. One example is an increased threat by birds that has developed during the project. Birds have increased on the site and the damage they cause will continue to increase as more grain crops are grown in the immediate area.

Birds roost and lay eggs in cracks and small holes in the Shuneh and they feed in the fields. As more food is available, the population will continue to grow. Presently there is no existing long-term solution to this problem. Small holes that provide nesting are being filled, but more will be excavated by the birds on a continuing basis.

References

Crosby, A. (2000). *Conservation Report No. 1, Shunet el Zabib*. Cairo, Egypt: Egyptian Antiquities Project, American Research Center in Egypt (ARCE).

Crosby, A. (2005). Appendix 1 Strength of Original Mud brick and Pressure of Overburden. *Documentation and Conservation of Pharaoh Khasekhemwy's Funerary Monument at Abydos, Report #7*. New York, USA: Institute of Fine Arts, New York University, prepared for Egyptian Antiquities Project, American Research Center in Egypt (ARCE).

Harrison, J., Amione-Martin, C., & Keift, T. (2005). *Analysis of Mud brick, Mortar and Soil Samples from Abydos, Egypt*. Socorro, USA: New Mexico Institute of Mining and Technology.

Nicholson, P. & Shaw, I. (2000). *Ancient Egyptian Materials and Technology*. Cambridge, UK: Cambridge University Press.

O'Connor, D. & Adams, M. (2005). *Documentation and Conservation of Pharaoh Khasekhemwy's Funerary Monument at Abydos, Report #7*. New York, USA: Institute of Fine Arts, New York University, prepared for Egyptian Antiquities Project, American Research Center in Egypt (ARCE).

O'Connor, D., Adams, M., Remsen, W., & Crosby, A. (2006). Documentation and Conservation of Pharaoh Khasekhemwy's Funerary Monument at Abydos. *Annual report to Egyptian Antiquities Project*. Cairo, Egypt: American Research Center in Egypt (ARCE).

Spencer, A.J. (n.d.) *Brick Architecture in Ancient Egypt*. Warminster, Wilts, UK: Aris and Phillips Ltd.