

Mechanical Engineering in Ancient Egypt, Part 52: Mud-Bricks Industry

Galal Ali Hassaan

Emeritus Professor, Department of Mechanical design & Production,
Faculty of Engineering, Cairo University, Egypt
galalhassaan@gmail.com

Abstract— The production of mud-bricks in ancient Egypt is investigated. Applications of mud-bricks structures are presented in different aspects of the daily life of the ancient Egyptian society. Characteristics and manufacturing technique of Egyptian mud-bricks are outlined.

Index Terms— Mechanical engineering history, ancient Egypt, mud-bricks industry.

I. INTRODUCTION

Mud-bricks represented the cheapest structural material in the Egyptian ancient society used by all classes of them in building their houses and business structures such as granary stores, slaughter houses, cattle stables, weaving workshops and house-gardens.

Marsh (1885) in his book about ancient crude-brick construction stated that in the oldest Egyptian civilization, there were extensive use of bricks for building purposes [1]. Mognin (1994) in his research paper about ancient solutions for future sustainability stated that sun dried mud-brick for home construction may be the first human made building material developed, and the word 'adobe' originated from the Egyptian word 'thobe' meaning mud-brick [2]. Wegner (1999) in his paper about excavating the residence of an Egyptian Mayer announced that the Mayer building at Abydos was a rectangular building of 52 by 80 meters and floors were of mud-bricks originally plastered and decorated [3]. Nicholson and Shaw (Editors, 2000) in their book about ancient Egyptian material and technology studied the inorganic materials in ancient Egypt including mud-brick architecture. The presented brick data from three buildings, the relative properties of clay, silt and sand in samples of bricks and soil from Amarna and East Karnak, sample brick sizes from Early Dynastic, Middle Kingdom and Late Period, laying of bricks, niched brickwork in 1st and 2nd Dynasties, brick vaults and domes in 1st, 4th and 19th Dynasties [4].

Klemm and Klemm (2001) in their paper about the building stones of ancient Egypt stated that building stones and clay-rich Nile mud were ancient Egyptians main raw construction materials [5]. Bard (2007) in her book about the archaeology of Egypt assigned a chapter-section about building materials and declared that during the Dynastic times most people including the King lived in mud-brick houses. She stated that mud was mixed with chaff to make it stronger and the mud-bricks provided excellent insulation for buildings [6]. Capaldi (2011) in her paper about mud-brick

construction outlined that sun-baked bricks produced using the same methods as the Egyptians without straw had a strength from 4 to 5 N/cm², whereas bricks containing straw had a 7 to 9 N/cm² strength. She stated that during the Predynastic Period, the average mud-brick was 24x12 cm, while in the Old Kingdom it was 42x21 cm with length/width ratio of 2:1 [7].

El-Gohery (2012) studied the mineralogical composition and granulometric distribution of mud-bricks of an ancient granary located in Edva of Sohag. He defined the physical properties of ancient mud-bricks such as density, porosity, water absorption and shrinkage [8]. Rossi (2012) in her chapter about building materials and technology in Pharaonic Egypt declared that ancient Egyptian architecture was mainly built of mud brick and stone and mud bricks were used from earliest period to construct houses, palaces, granaries, magazines, workshops, forts enclosure walls, temples and tombs. She stated that stone was the main building material of most important temples and tombs from Old Kingdom onwards [9]. El-Derby and El-Yamani (2016) investigated two case studies of 'adobe' (mud-bricks) vaulted storerooms dated to the 13th century BC from Seti I temple at Abydos and the Ramesseum temple at West Thebes. They presented different brick designs used by ancient Egyptians in vaults construction including curved-sides bricks from the 4th Dynasty, interlocking-edges bricks from the 6th Dynasty and perpendicular sides bricks from the 15th Dynasty [10].

Negmeldin (2016) in his paper about types of ceilings and its decorations at ancient Egyptian architecture stated that it was agreed to call the residential architecture as the mud-brick architecture. He stated also that during the 1st and 2nd Dynasties, the Kings were buried at a rectangular tomb made of mud-bricks and called 'mastaba' [11]. Hassaan (2016) in his investigation of the mechanical engineering in ancient Egypt through the study of the textile industry presented a weaving workshop from the Middle Kingdom [12]. Malandra (2017) studied the dwellings in ancient Egypt and stated that they were made of mud-bricks. He outlined that some houses had only one brick wall thickness while larger houses had two or three blocks wall thickness [13]. Hassaan (2017) studied how the ancient Egyptians authorized the existence of fly, bee and scorpion insects in their society through figurines and statuettes. The fly and bee insects were related closely to their life and housing structures [14].

II. ANCIENT MUD-BRICKS SPECIFICATIONS

The ancient Egyptian mud-bricks specifications are as follows:

- Materials: The main raw material in mud-bricks is the Nile mud and a plant straw mixed with each other using Nile water [15].
- Specifications:
 - Dimensions [16]:
During Middle Kingdom: 300 x 150 x 75 mm
During New Kingdom up to Late Period: 400 x 200 x 150 mm
 - Strength [17]:
Without straw: 0.588 N/mm²
With straw: 1.961 N/mm²

This means that the genius ancient Egyptians modified the contents of the mud-bricks through the addition of plant straw to the original mud to increase the brick strength to three times its original value without straw. This invention resulted in the construction of building structures lived for thousands of years.

III. MODELS OF MUD-BRICK MAKERS

The ancient Egyptians as pioneers in the administration sciences registered the industry of mud-bricks through the production of some models of the workers of this important industry and put them inside some of their tombs. Here are some of such models:

- The first example is a wooden 560 mm length model of men making mud-bricks found in Tomb 10 at Deir el-Bersha from the Middle Kingdom (2050-1650 BC) in display in the Museum of Fine Arts at Boston and shown in Fig.1 [18]. It is clear that some unit are missing from the model due to bad excavation or bad transportation. The two workers on the back side of the model-base are carrying a pole. They may be carrying the raw materials and water required for the mud-brick industry (the basket or sack is missing). The worker on the back of the model is preparing the paste using a hoe which is also missing from the model. The worker in the front is producing the mud-brick by molding the stuff in a wooden mold (not shown).



Fig.1 Brick making model from Middle Kingdom [18].

- The second example is a 327 mm length and 121 mm

width wooden funerary model of brick makers from Bani Hasan during the 12th Dynasty (1991-1802 BC) in display in the British Museum and shown in Fig.2 [19]. The model comprised three figurines: one holding the hoe and preparing the mud-straw paste, the second is holding the wooden mold and molding the mud-bricks and the third is most probably a supervisor guiding the mud-brick production process.



Fig.2 Brick making model from 12th Dynasty [19].

IV. MODELS OF MUD-BRICK STRUCTURES

The ancient Egyptians used mud-brick in building different structures for specific purposes. The authorized such applications through models made of various materials as will be presented in the following examples:

- The first example is a house model found in a tomb from the First Intermediate Period of ancient Egypt (2100 BC) in display in the Royal Ontario Museum of Canada and shown in Fig.3 [20]. The model represents a one story ancient Egyptian house having a ramp in its entrance to avoid Nile-flood effects, a courtyard with short walls from sides and entrance and staircase to the building roof which has a short wall and a conical front structure.



Fig.3 House model from 2100 BC [20].

- The second example is a 402 x 370 x 160 mm pottery model of a house from the 12th Dynasty (1981-1802 BC) in display in the Metropolitan Museum of Art at New York and shown in Fig.4 [21]. This is an innovative design of a villa set more than 3800 years

ago. It has a semielliptical shape surrounding a one story house with door in the front and two windows beside each other. There is a wide courtyard in front of the house with door leading to a ramp leading to the house roof. The left walls of the courtyard has an increasing level with the ramp to reach the roof where there is (may be a local granary on the house roof).



Fig.4 Pottery house model from 12th Dynasty [21].

- The third example is a 271 x 340 x 275 mm clay model of a house from Deir Rifa of Egypt produced during the 12th Dynasty (1981-1802 BC) in display in the Metropolitan Museum of Art and shown in Fig.5 [22]. This model represents a two-stories house with columns in each story carrying the roof. This model has no courtyard and no windows. The structure to the right of the first store may be a staircase.



Fig.5 Clay house model from 12th Dynasty [22].

- The fourth example is a 380 x 310 x 180 mm wooden model of a granary found at Asyut of Egypt produced the Middle Kingdom (2030-1850 BC) in display in the Metropolitan Museum of Art and shown in Fig.6 [23]. This is a special design for ancient Egyptian granaries consisting of a single short story with outside door, two storage compartments each having a separate door, a staircase leading to the roof of the storage compartments where a scribe is setting recording all the operations of the granary and a setting overseer supervising the whole process (top technology in management and process operation).



Fig.6 Wooden granary model from Middle Kingdom [23].

- The fifth example is an 844 x 425 x 395 mm painted wooden porch and garden from the early reign of Amenemhat I, the first King of the 12th Dynasty (1981-1975 BC) found in the tomb of Meketre in display in the Metropolitan Museum of Art and shown in Fig.7 [24]. The model reflects the passion of the ancient Egyptians with agriculture and planting ornamental trees. It consisted of two compartments: small compartment as a porch (may be to set in or store all requirements of the garden) and an open-air garden with projection area about three time the porch. The two compartments were isolated by columns may be to prevent everybody to get into the garden and destroy the plants.

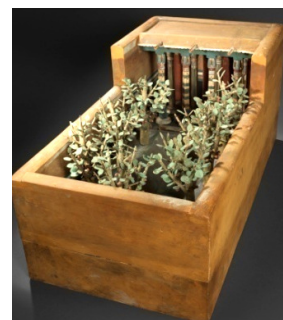


Fig.7 Wooden porch and garden model from 12th Dynasty [24].

- The sixth example is a 768 x 585 x 585 mm painted wooden slaughter house from the tomb of Meketre in display in the Metropolitan Museum of Art and shown in Fig.8 [25]. This is an open-air structure for animal slaughtering. There are two side bars and one lateral cord. They are used to hang to hang items related to the slaughtered animal as depicted in the zoomed image of Fig.8. The model depicts three closed compartments each with a door to keep the animals inside them during the slaughtering process. This is very modernized approach not to harm the animals by seeing the slaughter animal. In the left side of the house there is a staircase leading to the

roof of the three compartments for use as spare area for food storage, recording the slaughtering process by scribed or administration supervisions by overseers.



Fig.8 Wooden slaughter house model from the 12th Dynasty [25].

- The seventh example is a 725 x 570 x 285 mm model of a cattle stable from the tomb of Meketre in display in the Metropolitan Museum of Art and shown in Fig.9 [26]. It consists of two compartments. The first compartment has an outside door and houses the operating staff of the stable. The second compartment includes only some cattle with internal door between the two compartments near its end. The cattle are feeding from a longitudinal tray without disturbance from any operator.



Fig.9 Wooden cattle stable model from the 12th Dynasty [26].

- The eighth example is a 930 x 520 x 260 mm painted wood carpentry workshop model from the tomb of Meketre of the 12th Dynasty in display in the Egyptian Museum at Cairo and shown in Fig.10 [27]. This wonderful model simulates an open-air carpentry workshop consisting of a single compartment with an external door in the right front corner of the structure and a sun umbrella of about one-third the length of the workshop. The model shows some workers setting beside a tool-box where all the carpentry tools are set in specific positions, one worker is cutting a piece of wood in the centre of the workshop, two bordered areas comprising workers doing specific carpentry jobs and a group in the back left corner performing a specific carpentry

operation. This is the administration and organization which we miss now. I hope the recent generations can learn from those great people who build the most wonderful civilization in the old times.



Fig.10 Wooden carpentry workshop model from the 12th Dynasty [27].

- The ninth example is a 930 x 420 x 250 mm painted wood model of a weaving workshop from the tomb of Meketre in display in the Egyptian Museum at Cairo and shown in Fig.11 [28], [29]. The model simulates a weaving workshop consisting of a single open-air compartment with sun-umbrella roofing from both sides of the workshop. The model depicts a whole ladies staff working in preparing the yarns and weaving on two looms (one of them is not shown in the view of Fig.11. The door of the workshop may be located in the front right hand side.



Fig.11 Wooden weaving workshop model from the 12th Dynasty [28], [29].

- The tenth example is a 1.73 x 0.72 x 0.55 m painted wooden model for a cattle counting compound from the tomb of Meketre of the 12th Dynasty in display in the Egyptian Museum at Cairo and shown in Fig.12 [30]. The compound model is consisted of an L-shaped base with a shrine supported by four

columns where the cattle overseer sets with a team of four scribes counting the number of cattles driven by a number of workers in front of the shrine. Such activities registered by such models depicts some of the answers about the achievement of the ancient Egyptian civilization and glory.



Fig.12 Wooden cattle counting model from the 12th Dynasty [30].

V. MUD-BRICKS PRODUCTION

The ancient Egyptians as their well authorized tradition authorized the production of mud-bricks through colored scenes found in some tombs specially in the tomb of Vizier Rekhmire of the 18th Dynasty. A wonderful scene about mud-bricks production is shown in Fig.13 [16]. According to this scene, the procedure for mud-brick production during the 18th Dynasty was as follows:

1. The Nile clay and plant strew are transferred to the mud-brick production site.
2. The stuff is mixed will using hoes (two workers are shown doing this job).
3. Transferring the water required to prepare the paste from a water pool using buckets (two workers are shown doing this job).



Fig.13 Scene for mud-brick production from the 18th Dynasty [16].

4. Preparing the mud-paste by mixing the stuff with water and mixing well using the hoes.
5. Moving the paste to two locations where bricks are molded (three workers are doing this job).
6. Molding the paste in brick-molds in parallel rows (two workers are doing this work).
7. Leaving the mud-bricks to be dried naturally by son and air in an open atmosphere.
8. Collecting the dried mud-bricks in stacks well organized and adjusted in position using the hoe.
9. Now, the mud-bricks are ready to be transferred to the building locations or for sale.
10. The dried bricks are transferred by porters.
11. The whole process are performed under complete

supervision using qualified overseers (one overseer setting in the top left-hand corner of the working site and holding a stick).

VI. CONCLUSION

- The production of mud-bricks in ancient Egypt was investigated.
Some of the specifications of the mud-bricks produced by the ancient Egyptians were outlined, mainly: materials, dimensions and strength.
- The ancient Egyptians used plant strew to increase the strength of the bricks by about three times.
- They produced wooden models authorizing the production of mud-bricks in ancient Egypt and put them as funerary objects in some of the tombs of the Middle Kingdom.
- They authorized also their use of mud-bricks in building various structures for different purposes through the production of funerary models.
- This covered dwelling houses, granaries, gardens, slaughter houses, cattle stables, carpentry workshops and cattle counting compounds.
- They used pottery, clay and wood in building such models with outstanding physical simulation designs.
- They registered the mud-brick industry using painted tomb scenes reflecting the mud-bricks production.
- The mud-bricks production procedure in ancient Egypt was presented in a colored scene from the tomb of Vizier Rekhmire of the 18th Dynasty.

REFERENCES

- [1] R. Marsh, "Ancient crude-brick construction and its influence on the Doric style", *The American Journal of Archaeology and of the History of the Fine Arts*, vol.1, issue 1, pp.46-53, 1885.
- [2] M. Moguin, "Ancient solutions for future sustainability: building with adobe, rammed earth and mud", *Sustainable Construction*, pp.543-552, November 1994.
- [3] J. Wegner, "Excavating the residence of an ancient Egyptian Mayor", *Expedition*, vol.41, issue 3, 5 pages, November 1999.
- [4] P. Nicholson and I. Shaw (Editors), "Ancient Egyptian materials and technology", *Cambridge University Press*, 2000.
- [5] D. Klemm and R. Klemm, "The building stnes of ancient Egypt – a gift of its geology", *African Earth Sciences*, vol.33, pp.631-642, 2001.
- [6] K. Bard, "An introduction to the archaeology of ancient egypt", *Blackwell Publishing*, 2007.
- [7] X. Capaldi, "Ancient Egyptian mud-brick construction: Materials, technology and applications for modern man", *Egypt Unit, Research Paper – Draft 2*, April 2011, <https://dataplasamid.wordpress.com/2011/04/08/ancient-egypti-an-mud-brick-construction-materials-technology-and-implications-for-modern-man/>
- [8] M. El-Gohary, "The contrivance of new mud bricks for restoring and preserving the Edfa ancient granary-Sohag, egypt", *International Journal of Conservation Science*, vol.3, issue 2, pp.67-78, 2012.
- [9] C. Rossi, "Building materials and techniques, Pharaonic Egypt", in "The encyclopedia of the ancient history", *John Wiley and Sons*, 2012.
- [10] A. El-Derby and A. El-Yamani, "The adobe barrel vaulted structures in ancient Egypt: A study of two case studies for

- conservation purposes", *Mediterranean Archaeology and Archaeometry*, vol.16, issue 1, pp.295-315, 2016.
- [11] M. Negmeldin, "Types of ceiling and its decorations at ancient Egyptian architecture", *Proceedings of the 4th International Conference*, Mukogawa Women's University, Nishinomiya, Japan pp.21-24, July 16-18, 2016.
- [12] G. A. Hassaan, "Mechanical Engineering in ancient Egypt, Part XIX: Textile industry", *International Journal of Advanced Research in Management, Architecture, Technology and Engineering*, vol.2, issue 12, pp.11-20, 2016.
- [13] O. Malandra, "Dwellings in ancient Egypt", <http://classroom.synonym.com/dwellings-ancient-egypt-18728.html>, 2017.
- [14] G. A. Hassaan, "Mechanical Engineering in ancient Egypt, Part 48: Statuettes of fly, bee and scorpion", *International Journal of Advanced Research in Management, Architecture, Technology and Engineering*, vol.3, issue 5, pp.50-55, 2017.
- [15] Global Egyptian Museum, "Mud-bricks", <http://www.globalegyptianmuseum.org/glossary.aspx?id=250>
- [16] Reshafim, "Building in ancient Egypt", <http://www.reshafim.org.il/ad/egypt/building/>, 2011.
- [17] Study Jesus, "Egyptian mud bricks", http://www.studyjesus.com/Religion_Library/Biblical_Essays/026_Egyptian_Mud_Bricks.htm
- [18] Museum of Fine Arts, "Model of men making bricks", <http://www.mfa.org/collections/object/model-of-men-making-bricks-143822>, 2017.
- [19] British Museum, "Painted wooden model group", http://www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=119427&partId=1
- [20] Quatr, "Egyptian houses", <http://quatr.us/egypt/architecture/houses.htm>, 2017.
- [21] Metropolitan Museum, "Model of a house", http://www.metmuseum.org/exhibitions/view?exhibitionId=%7B36BFD863-BD71-4D58-B1B2-F3F865084DBB%7D&oid=591337&pkgids=331&pg=7&rpp=20&pos=135&ft=*, 2017.
- [22] Metropolitan Museum, "Model of a house", http://www.metmuseum.org/exhibitions/view?exhibitionId=%7B36BFD863-BD71-4D58-B1B2-F3F865084DBB%7D&oid=591373&pkgids=331&pg=3&rpp=60&pos=134&ft=*, 2017.
- [23] Metropolitan Museum, "A model of a granary with scribe and overseer", <http://www.metmuseum.org/art/collection/search/555954>, 2017.
- [24] Metropolitan Museum, "Model of a porch and garden", <http://www.metmuseum.org/art/collection/search/544256?rpp=30&pg=2&ft=garden&pos=51>, 2017
- [25] Metropolitan Museum, "Model of a slaughter house", <http://www.metmuseum.org/art/collection/search/544257>, 2017.
- [26] Metropolitan Museum, "Model of a cattle stable from the tomb of Meketre", <http://metmuseum.org/art/collection/search/544254?rpp=20&pg=1&ft=model&pos=17>, 2017.
- [27] Tour Egypt, "Model of a carpentry workshop", <http://www.touregypt.net/featurestories/picture04252003.htm>, 2017.
- [28] D. Korel, "Model of a weaving workshop from the tomb of Meketre", <https://www.pinterest.com/pin/491877590526491303/>
- [29] A. El-Shehawy, "The Egyptian Museum in Cairo: A walk through the alleys of ancient Egypt", Farid Atiya Press, p.136, 2005.
- [30] A. El-Shehawy, p.137, 2005.

BIOGRAPHY



Galal Ali Hassaan:

- Emeritus Professor of System Dynamics and Automatic Control.
- Has got his B.Sc. and M.Sc. from Cairo University in 1970 and 1974.
- Has got his Ph.D. in 1979 from Bradford University, UK under the supervision of Late Prof. John Parnaby.
- Now with the Faculty of Engineering, Cairo University, EGYPT.
- Research on Automatic Control, Mechanical Vibrations, Mechanism Synthesis and History of Mechanical Engineering.
- Published more than 220 research papers in international journals and conferences.
- Author of books on Experimental Systems Control, Experimental Vibrations and Evolution of Mechanical Engineering.
- Chief Editor of the International Journal of Computer Techniques.
- Member of the Editorial Board of a number of International Journals including IJARMATE.
- Reviewer in some international journals.