Bricks, Sweat and Tears

The Human Investment in Constructing a "Four-room" House

By Douglas R. Clark

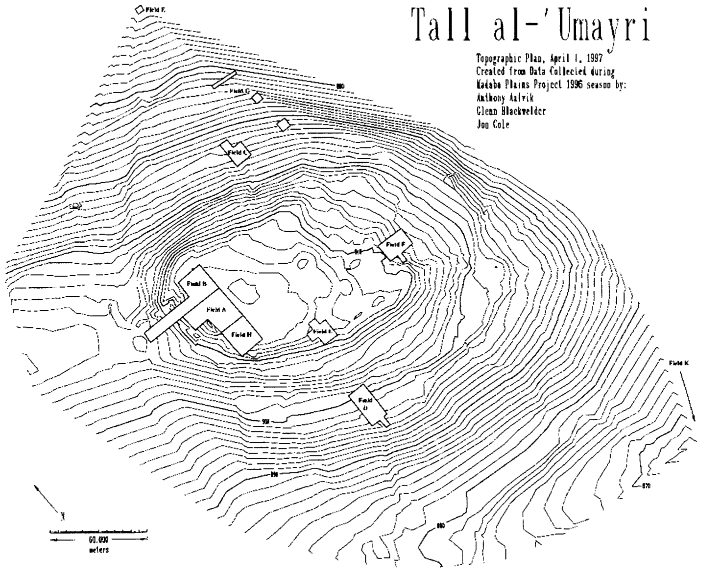
The construction of stone and brick four-room houses in the Iron I southern Levant was extremely labor-intensive, involving a variety of tasks. The collection, preparation, production, transportation and application of earth, stone, wood, lime and clay in the process of building a house required significant time and effort. These requirements were very demanding on villagers whose subsistence-level income forced them to do most of the work themselves, on top of the day-to-day tasks they performed merely to stay alive and feed their families. Building construction was difficult, dangerous and demanding. and theirs was a hard lot. Yet despite their efforts, only remnants of their work remain today. This human investment was essential for their survival and clearly demonstrates the persistence and perseverance, ingenuity and innovation, and strength and stamina of our forebears in this region.

Types of basic housing as illustrated in modern Jordan. Clockwise from top left: a rural home, a cave dwelling, a Bedouin tent and an agricultural villa. The need for permanent living quarters that were protected against the intrusion of natural and human agents was a priority for humans at the advent of agriculture. *By Sali Jo Hand.*

Next to food procurement, the quest for living quarters that were protected against the intrusion of natural and human agents occupied a major portion of the attention of the ancients. The original impetus for early house construction was tied to agricultural pursuits. "Generally, house construction started with the beginning of agriculture; during the hunting and gathering stage of human history, people sought shelter in caves or under cliffs" (Khammash [citing A. E. Knauf] 1986: 9). Natural rock enclosures, fabric tents and open windbreaks probably constituted most housing prior to buildings of wood, stone or clay, since food-procurement strategies based on hunting and gathering and even the herding of sheep and goats did not require permanent housing in the same way that settled farming does. This points to comparatively minimal human investment in house construction prior to the agricultural revolution in the ancient Near East.

Major cycles of intensification and abatement in settlement patterns throughout the history of the southern Levant remind us that human building activity never remained stable or static. Periods of abatement brought more relaxed commitments of time and energy to house and city construction. On the other hand, during times of intense occupation and increased urbanization, as in the Iron Age, construction expanded and took on greater complexity.

While archaeologists have studied the architectural remains of domestic buildings in the ancient Near East for decades, they have seldom considered the human element of the construction process. We know of houses and villages constructed of mudbrick, wood or stone at least back to the sixth and seventh millennia BCE. Jericho is one example, as are Jarmo in Mesopotamia, Beidha in Petra, settlements in Anatolia (such as Çatal Höyük and Hacılar), and Merimde in the western Nile delta, but what can we discover of the building process itself? And what might this tell us not only about building construction in Iron Age Jordan, but about construction across the millennia, from the Pre-pottery Neolithic (ca. 7000 BCE) to modern times? A recently excavated pillared house at Tall al-ʿUmayri, immediately north of the Madaba Plains, gives us an opportunity to examine the human investment in terms of the time and energy expended constructing four-room houses—the typical dwelling—during the early Iron I period.

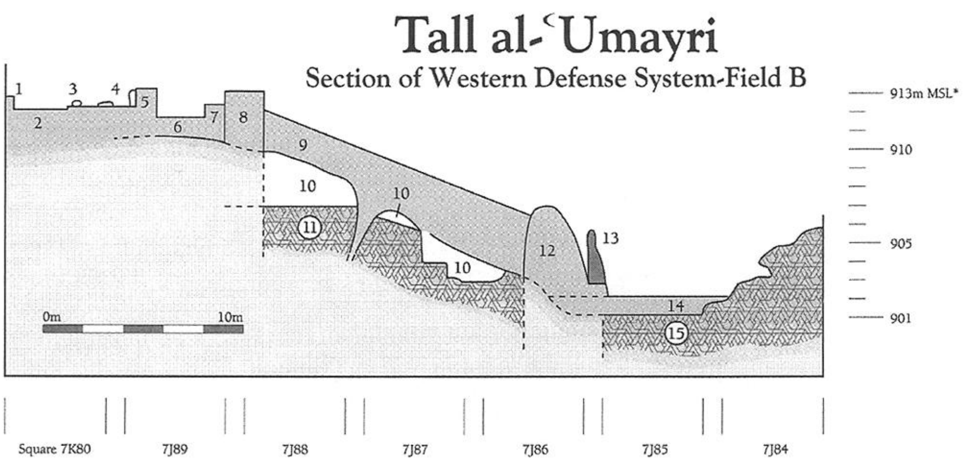


Topographic map of Tall al-ʿUmayri, an Iron I site located south of Amman in Jordan. The excavated area labeled Field B on this plan contained an Iron I period four-room house built of stone.

In antiquity as today, many issues had to be addressed before a house could be built. These include planning and fund-raising, provision for labor, locating, collecting, transporting and preparing materials, preparation of the site, purchase or manufacture of appropriate tools, lifting, leveling and adhering building materials into place, finishing surfaces for pragmatic and aesthetic purposes, maintaining, reusing, and renovating when necessary—all important considerations. Add to these the enduring heat, humidity, long hours, physical debilitations, pests and varying degrees of difficulty and danger inherent in the process, and the complexity of building a home in antiquity becomes even more apparent.

Stone House Construction during Iron I in the Southern Levant

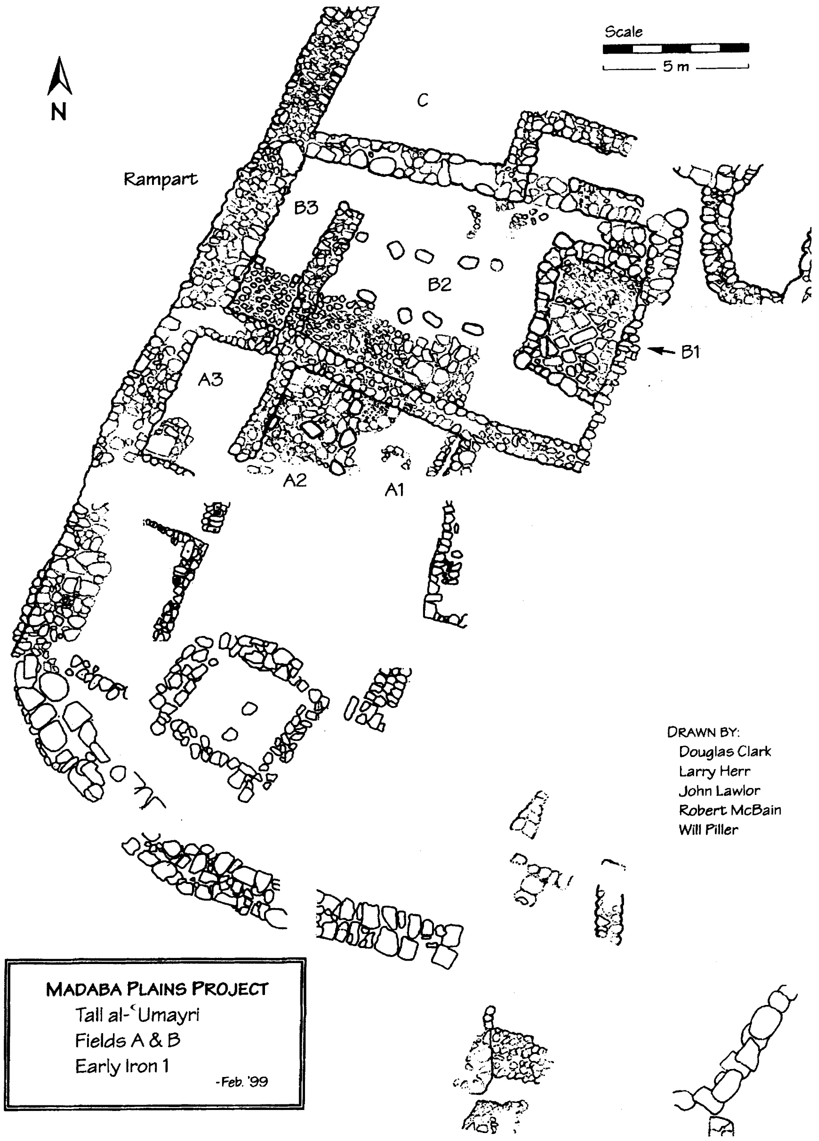
Although we do not have any direct textual descriptions of the building activities or construction design of houses from the Iron I period, archaeologists have focused a good deal of attention on so-called "four-room" or "pillared" houses and small agrarian villages from this period. Their connections with early tribal entities that we traditionally call Ammon, Moab and Israel, have occupied archaeologists and biblical scholars with some intensity of late and will likely continue to do so for some time. A growing consensus suggests that these tribal entities initially settled in small



The western defensive system in Field B at Tall al-ʿUmayri, seen here in section, included a moat, rampart and perimeter wall.

Key to Section of Western Defense System Field B at Tall al-ʿUmayri, Jordan

1 Eastern Wall of Building
2 Beaten-earth surface of food-preparation area
3 One of three post-bases (perpendicular to the section), likely supporting a curtain wall between food-preparation area and cultic room
4 Flat stone (altar?) on pavement facing standing stone against inner "casemate" wall
5 Inner "casemate" wall
6 Beaten-earth surface of "casemate" storeroom
7 Ladder platform for access to upper story
8 Outer "casemate" wall
9 Iron I rampart
10 Middle Bronze rampart (fractured by earthquake)
11 Bedrock
12 Iron I defense/retaining wall
13 Iron II defense/retaining wall
14 Iron I moat base
15 Bedrock beneath Middle Bronze moat base



Architectural plan of early Iron I buildings in Fields A and B at Tall al-ʿUmayri. The broadrooms of the two adjacent houses (Buildings A and B) were integrated into a double-wall defense system.

agricultural villages in the hill country of the southern Levant, often building "four-room" houses and constructing terraces, cisterns, and wine and olive presses.

One might expect the biblical book of Judges, with its accounts of Iron I tribal leaders and activities, to provide some insights into houses and house construction. Unfortunately, while it mentions "house" (*byt*) nearly seventy times, thirty-nine of those being references to domestic buildings or homes, it offers precious little about what these houses must have looked like or what it took to construct one or a small village of them. Normally, the texts simply mention a house or houses in passing. We do read of doors on two occasions, a threshold, and a household shrine. Otherwise, we are totally dependent on archaeological and anthropological resources for answers to our questions about human labor.

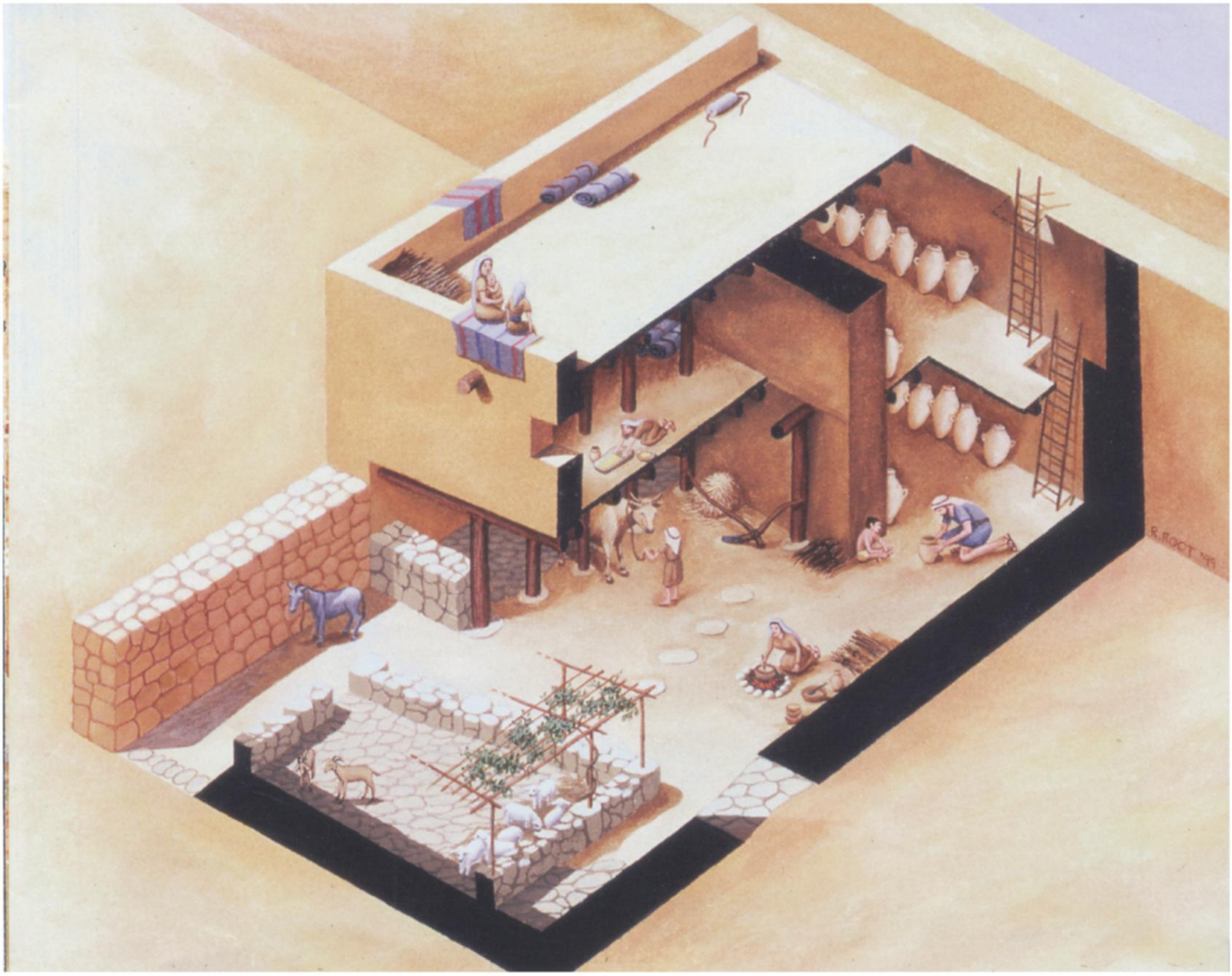
The Iron I four-room houses discovered throughout the hill country typically measured ten to twelve meters long and eight to ten meters wide. The broadroom, extending across the back end of the building, may have been two meters wide and opened into an area containing three long rooms, each separated from the others by a wall or a row of pillars or posts that also supported the ceiling or roof. The two side rooms normally housed animals, leaving the central long room to serve for domestic activities surrounding food preparation and consumption.

This pattern is clear in the best preserved and, likely, one of the earliest examples of this type of house, excavated in Field B at Tall al-ʿUmayri, south of Amman, Jordan (perhaps the Abel-Keramim of Judg 11:33). This late thirteenth/early twelfth-century house (Building B), and others as well that do not follow the four-room plan, was surrounded by an extremely well-defended fortification system, including a moat, rampart and perimeter wall. The builders utilized the broadrooms of the two adjacent houses exposed to this point in excavation (Buildings A and B) as an integrated part of what appears to be a double-wall defense system in places. An external enclosure, perhaps an animal pen, lay in front of building B to the east within an open courtyard.

We have completely excavated both early Iron I buildings and believe that they were two stories over their full extent. This gives us an idea not only of the size of these domestic structures but also the height of the city wall into which they had been constructed. Construction from the ground up would have included flooring, exterior walls, interior walls and dividers, first-story ceiling/second-story floor and the upper story with its own ceiling/roof.

Flooring

The ʿUmayri four-room house featured both beaten-earth and flagstone floors. Although not appearing to demand much by way of human labor, the dirt floors often reveal more attention to composition and installment than one might expect. The fine layers of flooring, some laid contemporaneously and others accumulated over time, show ash and enough clay content to keep the surface smooth and basically level. Of course, the sections of stone flooring were more difficult to install. Large, flat cobbles and small boulders paved one-third of the broadroom and one of the side long-rooms. Laying these stones would have been difficult enough, but before the builders could even begin, the flat stones had to be located and collected, a huge demand of time and effort. During an earthquake around 1200 BCE, after the original construction of the house's stone flooring, the floors experienced some kind of deterioration or damage, necessitating repairs with larger (boulder-size) and more angular flagstones. The residents also renovated and expanded the flooring of the animal pen at that time. Most of the repair stones used in the



An artist's reconstruction of the Field B pillared building (Building B) showing activity on two stories. *Painting by Rhonda Root.*

long room and the animal pen would have required the labor of at least two men to transport and place. The combined weight of the stones used for flooring in the ʿUmayri house was about eight tons.

Exterior Walls

The house's exterior walls were around one meter thick, with the exception of the exterior broadroom wall, which doubled as the outer city wall. This wall measured over two meters thick. The eastern end of the house was almost entirely open on the ground floor, except for a stub wall, one meter high across only the southern long room's end. Perhaps the occupants hung carpets or blankets over the opening during the winter months to ward off the cold. They might also have draped the blankets to the side to allow the sun to shine in during the mornings and to manipulate airflow so the smoke from the hearth would blow outside.

There appears to be little or no foundation to most of these walls, with the result that both the investment of labor and the structural stability of the walls were much reduced. The fieldstones used in the walls' construction range in size from small to large boulders and were transported from surrounding slopes or robbed out of nearby buildings from earlier periods. Cobbles chinked in between the stones served to stabilize the walls. The cumulative weight of the wall stones in the exterior walls was approximately 250 tons (280 tons for the stones in all the walls). These figures speak profoundly of the huge mass of stone being moved and put in place during the construction of a house.

Dr. Raouf Abujaber, landowner at ʿUmayri and a Jordanian historian, believes that it would require two men, a builder and a porter, one long day to construct an unfinished stone wall (one meter wide, two meters high and three meters long). Add another day's labor for two additional men and a donkey if the stone was not already on site. Accounting for the thickness of the broadroom outer wall at ʿUmayri, the extension encompassing the added animal pen, and the height from the ground level up, it would have taken these four men and their donkey approximately one month of concentrated labor to collect stones for and construct the exterior walls of the first story. The project would certainly have taken longer, though, if homeowners did most of the work themselves, since they would have done the work during times free from other tasks required for subsistence (like plowing, planting and harvesting).[1]

The surfaces of exterior walls were also likely plastered to prevent erosion from rainfall, which can be heavy and intense during the winter and early spring. This demanded a significant quantity of lime plaster and included all the labor involved in the manufacture of lime

This section of flooring in the central long-room (B2) of the house at Tall al-ʿUmayri was made of finely layered ash and clay, which kept the floor smooth and level.

After an earthquake in ca. 1200 BCE, the paving in the south long-room of the house (below the right side of the meter stick) had to be repaired.

An animal pen (B1), located in the forecourt of the house, also had a paved floor, and it too required renovation. The animal pen took up most of the eastern courtyard.

The broadroom (B3) and a part of the long-room (B2) of the house at Tall al-ʿUmayri was paved with large, flat cobbles and small boulders. Such paving required considerable time and effort to install.

The pillared four-room house (Building B), seen here after excavations were completed, boasted one-meter-thick walls.

A Byzantine lime kiln found in the region of Tall al-ʿUmayri may provide clues to the production of lime in antiquity.

along with its application and maintenance.

The production of lime was, by all counts, a demanding process. If modern practice and Byzantine lime kilns found in the ʿUmayri region are any guide, workers dug deep circular pits into the ground, lined them with stones, and constructed more stones on top so they extended above ground in a roughly vaulted dome. The depth was typically greater than the diameter and ventilation was achieved through a vent on the windward side. Wood or thistles and weeds, gathered over several days and placed in direct contact with the stone, fueled the fire, which normally burned steadily for three to six days.

In the process of manufacture, limestone is heated to about 900°C, causing its decomposition into quicklime. The lime is then hydrated and mixed with temper such as sand to form an adhesive paste which, when molded and allowed to air-dry, hardens and maintains its shape (Christopherson 1991: 343). To accomplish this process, the ancients paid dearly:

> Although the technology involved in the production of lime plaster is relatively simple, the expense in raw materials and manpower is great. In order to produce 1.00 ton of lime plaster, 1.50 to 2.00 tons of limestone and 2.00 tons of wood are necessary (William Kingery 1988, personal communication). Add to this the manpower involved in building the kiln, collecting the tons of limestone and fuel, firing of the kiln, removing the burned lime, mixing the lime with water and temper, and finally using the plaster in construction. It is obvious that the lime plaster industry was a very labor/energy intensive operation and its product would have been expensive. In fact, the amount of labor involved makes it likely that lime plaster was in some respects a luxury item, especially during the earliest periods of its use. (Christopherson 1991: 344)

While Iron Age builders usually utilized wood for kilns in the Madaba Plains region (common oak was likely the dominant tree at the time [Younker 1989]), one example from Palestine illustrates use of a locally abundant shrub (*Sarcopoterium spinosum*, thorny burnett). It burns hot and rapidly, but from five to seven thousand bundles are required to produce two tons of quicklime (Christopherson 1991: 345). The estimated combined weight of mortar and plaster was about fourteen tons.

Interior Walls

The interior stone walls required the same kind of labor as the exterior ones, although some interior walls were not as thick and some apparently did not reach the ceiling, nor would they require the same degree of maintenance. This is true at ʿUmayri of the animal pen walls, which stood less than one meter high and were built rather sloppily. It is also true of the divider walls between the three long rooms. These comprised five wooden posts each, resting on stone post-bases set into the floor. (Sometimes mangers separated animal from human areas, but if they existed at ʿUmayri, they must have been wooden because nothing remains of them following the massive fire which destroyed the town in

A reconstructed wooden ceiling of a four-room house at Tel Qasile. Twenty-seven tons of wood would have been required to support both floors of the house at Tall al-ʿUmayri!

The second story of the four-room house at ʿUmayri consisted of walls built entirely of large mudbricks, such as this one, tempered with straw and sand.

Making Mudbrick

Brickmaking in Egypt is well illustrated on tomb reliefs and well documented in ethnographic studies. The process was extensive, extremely exhausting and seemingly eternal. It included the following stages: locating, collecting and preparing materials (water, clay, and temper straw was steeped for several days in order to distribute the cellulose uniformly throughout the mud [Goyon 1969: 153]), mixing the materials thoroughly, shaping the bricks in molds, and drying them for a week or so, turning them midway through. Of course they then had to be transported to the construction site. All of this activity took place in the Nile delta where heat, humidity, endless hours of backbreaking, repetitive labor, and insect-borne diseases and other health hazards added to the affliction of the laborers. A modern description of brickmaking captures the process well:

> *"The brickmaker, called* tawwab *in Arabic, searches for a deposit of Nile mud of a suitable consistency for his purpose, and clears as large and flat a space as possible. His assistants dig up the mud and put it into a smallish hole in the ground (*ma'gana *or* makhmara*), where water is added to it until it has the consistency of a very thick paste. The mixing is done with the aid of a cultivator's hoe (*fas *or* turia*), the feet assisting in the operation. If chaff (*tibn*) is available, it is mixed in varying quantities with the mud paste; if there is no tibn the bricks are made without it, but sand is often added with good effect. Having thoroughly mixed up the paste, an assistant takes a round or oval mat (*bursh*) made of strips of palm leaf (*khus*), having handles on either side, and, having dusted it over with fine mud to prevent sticking, he puts as much of the paste on it as he can carry and leaves it beside the brick-maker. The brick maker squats down, holding an oblong wooden mould fitted with a handle of which examples are known in the 12th and the 13th dynasties the mold being of the size of the bricks he wishes to 'strike' (*darab*). Having filled the mold with the mud paste, the brick maker scrapes off the surplus and lifts off the mould, leaving a sticky mud brick, just sufficiently hard to retain its form. He continues 'striking' a series of such bricks, one alongside the other, until all his available space is filled. The bricks must then be left to dry until they are hard enough to be stacked and a new series made. In ancient Egypt the method was identical with that used today, the only difference being that in the old scenes the mud is carried in a pot instead of on a mat." (Clarke and Englebach 1990: 208–9)*

In this 18th Dynasty Egyptian tomb wall painting, the tomb's owner, Rekhmere, is depicted inspecting workmen as they make bricks. On the right, workers construct a pylon from the bricks. On the left, workers fill vases with clay from a pond. *Photos © Erich Lessing; courtesy of Art Resource.*

about 1150 BCE.) In any case, for the posts holding up the second story, the ancient builders needed to locate, fell, transport, trim to size and install the posts.

Ceilings

Large amounts of wood were also required for the beams spanning between walls and posts, for rafters between beams, and for additional ceiling/roof support, as the reconstruction at Tel Qasile demonstrates. This would be true for both stories of the house at ʿUmayri. Atop the wood, workers laid smaller brush and then thick layers of mud, clay or plaster. The total weight of the wood required in this building process was about 27 tons.

Because of potential erosion due to heavy annual storms, maintenance and repair of roofs were particularly important. Normally, householders utilized large stonerollers (approximately one meter long and perhaps thirty centimeters in diameter) to flatten and re-solidify roofs following rainstorms.

Upper Story

The second story of the four-room house at ʿUmayri consisted of walls built entirely of large mudbricks tempered with straw and sand. They demanded the same time and energy as bricks made in Mesopotamia or Egypt, although sources of clay were not as plentiful locally as along the Nile and Euphrates or Tigris Rivers. These were laid with lime mortar and evidently plastered over to form smoothly finished surfaces. Such mortar and plaster were found in large amounts in the destruction debris. Thus, the labor-intensive processes involved in the production of quicklime for mortar and slaked lime for plaster added to the heavy workloads of those involved in this aspect of the construction of domestic buildings.

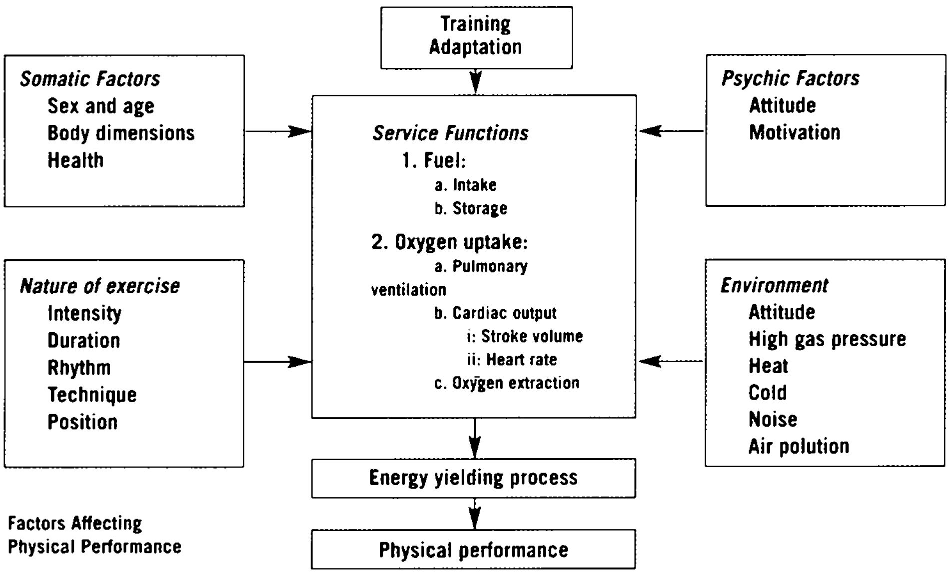
Mesopotamian brick-making with sun-baked mudbricks, while time- and labor-intensive activities, demanded little native talent or skill. Likely every villager was engaged in the practice at one time or another (Moorey 1994: 305). The process involved three major operations: digging out and collecting the raw material, mixing the mud with straw or dung and molding the bricks. Firing, of course, would be added to the job description of laborers in the case of kiln-baked bricks. "The preferred brick manufacturing month was the 'third' (May–June), immediately after the spring rains, when water would be plentiful and the whole summer lay ahead, if necessary, for drying. Chaff or straw was easily available at this time" (Moorey 1994: 304). On the basis of recent calculations, one hundred bricks would require about sixty kilograms of straw or the amount harvested from one eighth of a hectare of barley (Oates 1990: 390). Thus, in addition to collecting available clay, huge amounts of straw were also needed.

The temper and clay were then thoroughly mixed in large puddling basins, from which the combined materials were taken and "shaped, usually two at a time, in a rectangular wooden mould with no top or bottom; and were afterwards left to dry, being turned over from time to time" (Derry and Williams 1961: 158). The total weight of the mudbrick in our house, determined by specific-gravity measurements on estimated mudbrick amounts was approximately 124 tons.

Laborers on the four-room house also raised another roof of similar construction to the one mentioned above for the second story, with the concomitant demands on labor and material. People accessing the upper story (at least in Building A) appear to have constructed and utilized a stone platform supporting a wooden ladder. The total weight of the mud and clay in the two ceiling/floors (one a ceiling/roof) was about fourteen tons.

The Physiology of Human Labor

Assessing the physiological investment of human energy in a task like building a house of stone, wood, plaster and clay requires the expertise of a variety of people in a wide range of disciplines. I lay no claims here beyond mere acquaintance with areas worth further investigation if we are to study and understand this important aspect of human endeavor that



Factors involving the body and the nature of the exercise (on the left), the mind and the environment (on the right), and the functions of fuel and oxygen utilization (center) all contribute to an assessment of energy invested and performance realized in a given task. *From Åstrand and Rodahl (1986: 489, pl. 11-1).*

occupied the time and attention of ancient tribal groups in the hill country of the southern Levant during the Iron I period.

The chart on training adaptation, drawn from one of the standard textbooks in the field on work physiology (Åstrand and Rodahl 1986: 489), demonstrates the range of considerations one must keep in mind. Factors involving the body and the nature of the exercise (on the left), the mind and the environment (on the right), and the functions of fuel and oxygen utilization (center) all contribute to an assessment of energy invested and performance realized.

With the aid of these lines of research into the physiology of human labor, we should be able to calculate more precisely the time and human effort invested in the construction of houses and the nutritional drain and oxygen uptake of builders. From these, we should then be able to say something about dietary needs and aerobic demands. Current measuring technologies allow us to evaluate all kinds of chemical changes during work, heart rate, loads on single muscles or groups of muscles, hormonal responses to stresses and emotional engagement. Energy output estimates derive from monitoring heart rate, time-activity measurements of all types of activities, and assessments of food intake necessary to maintain body weight.

Beyond the basic energy needs for basal metabolism, eating and the necessary expenditures of energy, the body, by the estimates of some physiologists, needs around 2000 kilocalories per day to support hard labor like construction. The expenditure, however, will vary depending on all the factors noted above, internal and environmental.

By comparing what we know archaeologically—the results of human labor and the dietary makeup of the early Iron Age hill-country populations of the southern Levant)—with these data, we may be in a position better to explain human endeavors in antiquity, and particularly, what it took to build a home. Clearly, further study by a cadre of additional specialists awaits our attention.[2]

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Douglas R. Clark was formerly Professor of Biblical Studies and Archaeology at Walla Walla College in Washington State. He is now Executive Director of the American Schools of Oriental Research in Boston, MA. His three decades of excavation in Jordan with the Madaba Plains Project (first Tall Hisban, then, as co-director, Tall al-ʿUmayri) have contributed significantly to this article.

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Notes

1. At the same time, the evidence suggests a fairly hurried attempt to rebuild the city following the earthquake of ca. 1200. And, given the integration of this house into the defenses of the town, the entire population held a stake in this construction at the point on the site most vulnerable to military assault. We should expect this kind of community involvement, given what we know of the kin-based social structure of early Iron Age societies.

2. I would like to thank Walla Walla College for a number of Faculty Research Grants supporting excavations on the Tall al-ʿUmayri four-room house over several seasons. Funds for research also came from the Near and Middle Eastern Research and Training Act and the Council of American Overseas Research Centers for study at the American Center of Oriental Research in Amman, Jordan.

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