Building Assyrian society: the case of the Tell Sabi Abyad Dunnu
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V. Constructing the *Dunnu*

For a good understanding of excavated architecture, we need to approach it from both an archaeological (depositional, post-depositional and stratigraphic) perspective as from an architectural (material, constructional) perspective. This chapter focusses on the second by discussing the architecture of the *Dunnu* from the point of view of construction materials and methods. This starts from an overview of construction practices in West Asian historical cultures, and general mud brick construction methods. The archaeological evidence it considered both in its own local context and the wider context of construction practices. The archaeological data from the *Dunnu* as found in the field documentation is used in a detailed re-analysis. All the standing interpretations, were verified in this way, often leading to new, improved interpretations.

Analysing the structural and material properties of the architecture, forms the basis for the reconstruction of remains. The final aim is to understand the degree of deliberation that went into the construction of the *Dunnu*. This ultimately helps to answer the question of the interaction with the built environment and the intentions of the builders.

V.1 The social and cultural context of construction

V.1.1 The nature of architecture

Architecture is the outcome of a complex interplay of natural and cultural factors (Figure 39). The climate and geology determine the presence of building materials. The climate, against which people seek protection, also determines the choice of materials how they are put them together to make a building. The choice of building materials, then again influences architectural form as is has certain structural possibilities and limitations. At the same time other factors interact with these, such as social structure, social process, cultural values and ideas, and individual choice. Furthermore, construction may also be a response to certain more sudden changes in social, political and military circumstances. All these aspects come together in construction and architecture and should be considered relevant in its study. Construction and architecture are deeply embedded parts of a society, but have been as far as we know, always been recognized from the point of view of ancient society as a class distinct from other elements of their world. Building was incredibly important and the act of building as well as the building itself also had symbolic meaning. This was also true in ancient Mesopotamia.

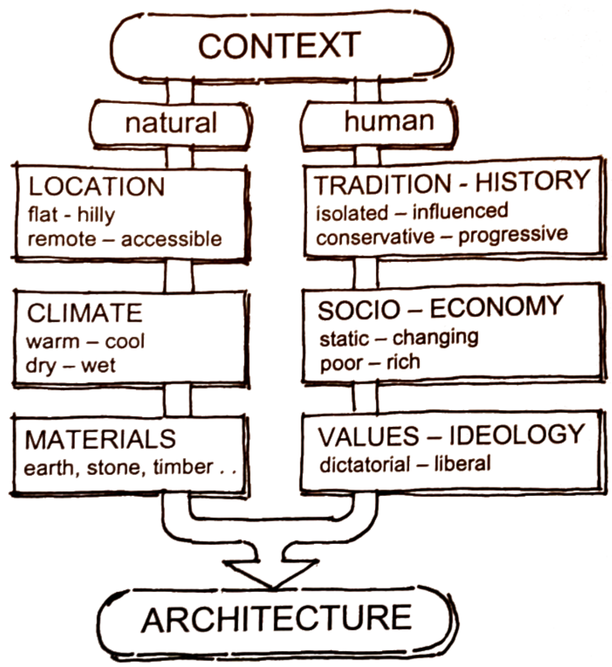

Figure 39. Model of architecture by Friedrich Ragette (after Ragette, 2003, p. 10).

V.1.2 The place of mud brick architecture in ancient Mesopotamia

Although expelled to the fringes of modern society, mud brick construction was in much of human history a significant element of the architectural, social and cultural realities. Today, mud brick construction is often romanticised, considered a heritage building tradition that requires protection, or as a type of "architecture for the poor" (i.e. Fathy, 1976). But in the pre-modern world, it was everyone's building material, applied in the construction of simple houses until the king's bedroom. Therefore, the mud brick can be considered one of the cornerstones of society. Kings were depicted carrying loam baskets and builder's tools, and at the third month (our May/June) was named the month of the king's brick-mould, when brick production rose high (Salonen, 1972, p. 10). Earth was omnipresent and a fact of life taken for granted.

The manufacture and acquisition of mud brick and other building materials was thus of prime importance, a significant part of the economy and a business that needed the attention of the king and high administrators alike. Everything was meticulously managed and administrated. Besides the archaeologically very visible parts such as mud brick production and construction, the organization of the timber and reed industries, closely related to construction, was equally important. Furthermore, it involved the acquisition and production of auxiliary construction materials such as lime, gypsum, bitumen and fired brick. From the perspective of the present, these are traditional, low-tech construction materials. But that assessment fails to appreciate the fact that these are all activities that require specialist knowledge, and a significant amount of labour investment (Moorey, 1994).

V.1.3 The profession of master builder

Ancient Mesopotamian society had specialised master builders. These were responsible for state architecture, but – at least in the cities – were also hired by private house owners to repair or build houses. At least by the time of Hammurabi (18th century BCE), there were laws regarding safe and sound construction of houses (laws §228-§233). These laws give the impression that house construction was left to professionals, and that these were supposed to deliver quality, and were held accountable. The Sumerian word for builder is *šidim* and appears in texts starting in the early third millennium (Neumann, 1996). Neumann translates *šidim* as master builder, and assigned to the *šidim* a high level of specialization, professional education and high social status. But the *šidim* found in the Ur III (21st century BCE) Garšana texts discussed by Heimpel (Heimpel, 2009, pp. 47–48) seem of more common background, and in fact most builders here are slaves. However, that does not disqualify them for receiving some form of training.

In later periods, we know for sure that there is a ranking of builders, which is reflected in the fact that there are different words for them. Perhaps we see some specialisation of tasks. In official texts of the Middle Assyrian empire we find the professions of *etinnu*, master builder, and *šalimpāju*, probably architect or engineer (Jakob, 2002, pp. 453–465). Again, the suggestion is given of a highly specialised professional. Although for the second there is little proof of its actual activities, Jakob argues it is reasonable to assume this individual was involved with the design of the plan, decided on dimensions and performed the necessary calculations while the former managed the practical execution of the work. Nevertheless, much overlap existed between the activities of the two professions. Salonen (1972, p. 11) interprets the existence of different words in Neo-Assyrian sources as the presence of a hierarchy between lower master builders (e/*itinnu*) and supreme master builders (*šitimgallu* or *šitimmāhu*).

That there were builders of different kind and social status is clear, even if they were referred to with the same word. For example, as opposed to other builders, the builders of Garšana seem not to be involved with the planning and surveying at all. They are purely executers of the work. The suggestion of the aforementioned Jakob, that the builders may have been a kind of engineer as well does not seem to correspond to the evidence from mathematical texts, which suggest that preparing of 'engineering' work (e.g. surveying, calculating labour and materials) are specialised task that scribes do, who learned to do this in scribal schools (Robson, 2002).

It is interesting to see how the builders at Garšana had different social status. Besides builders that were part of the possession of the household[35] (which therefore had three fulltime builders at its disposal), there were builders that came from elsewhere, probably also slaves. Apparently, they did not like the work too much, because several of them were registered as runaways. Other builders still were hired. Although this all suggests that builders were in lesser high regard than Neumann proposes, the builders had nevertheless important roles to play in the workforce, since they were the ones doing the actual construction. They were assisted by the many common workers that were part of this workforce as well, who had such tasks as moulding bricks, carrying building materials and handing mortar, plaster and bricks to the builders.

V.1.4 Who built the *Dunnu*?

Builders do not occur on the preserved payrolls of the *Dunnu.* For initial construction, master builders had to be brought in. Interesting in this respect is the mentioning of 14 Elamite master builders at Tell Chuera in this period (Jakob, 2002, pp. 458–459; Brown, 2013, p. 109). Such people fell under the command of the king of Hanigalbat (see II.8). They travelled for almost 1000 km and brought their building practices with them. It is likely that the *Dunnu* was not built by local builders, but by builders that could have come from anywhere.

V.2 Building materials in mud brick architecture

This section introduces the characteristics, acquisition and procurement of common building materials associated with mud brick architecture. In a later section (V.4), the specific evidence for building materials used in the *Dunnu* is dealt with.

V.2.1 Loam, water and straw

The base material of mud brick architecture is loam. Loam is a mixture of mineral elements consisting of clay, silt, and sand. The proportions in which these elements occur in a deposit determines the suitability for use in mud brick manufacture. Nevertheless, the range for an ‘acceptable’ mixture is quite large (McHenry, 1984; Houben and Guillaud, 1994). Clay is the main binding agent, while sand give the brick compressive strength and prevents shrinkage. A surplus of clay may cause shrinkage and cracking while too much sand creates a brittle brick. It is interesting to note that the proportion of sand that is suggested to be ideal for mud bricks (at least 30%), is much higher than found in most loam samples from river deposits analysed by Sauvage (1998, p. 18). This means that not all river deposits are automatically suitable: either good deposits must be actively searched for, or sand must be mixed in. Water is required in great quantities

[35] Garšana was the possession of the household of an important general.

to be able to properly mix and soak the ingredients, which also determines that mud brick manufacture must take place near a water source. Last, a vegetal binder, often chopped straw or chaff is added to the mix to reinforce the brick mechanically and chemically.[36] To chemically improve the building material, loam may be left to rot for a one or two days (Wulff, 1966; Salonen, 1972, p. 72). Bacterial activity causes the excretion of lactic acid, which may be responsible for improved structural properties of the loam when dried. However, it may also be used immediately after preparation. Precise loam procurement practices vary significantly between regions and historical epochs.

In addition to the brick, loam is also the main ingredient for other construction materials: mortar, plaster, wattle-and-daub and pisé (beaten earth). The proportional quantities of the materials, sand, clay, water and straw/chaff, varies according to application (Figure 40). The significance of this for building practices is reflected by the ancient naming and classification of many different types of loam-based construction materials.

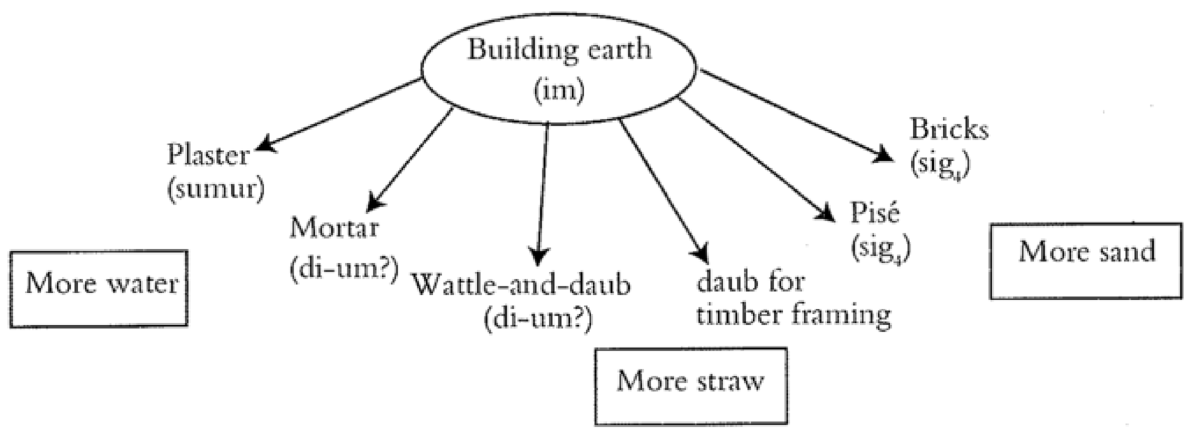

Figure 40. Different terms found in the Garšana texts, hypothetically connected to different mixes of loam (after Sauvage, 2015, fig. 4)

V.2.2 Wood and reed

Besides the base material of loam, water and straw, other materials are used in the domain of mud brick construction. Among these are wood, reed, stone, baked brick, lime, gypsum, and bitumen. Regional availability of these have strongly impacted building traditions. In dry Mesopotamia, timber is relatively scarce so it is used were most necessary in construction: for the roofs and often for door posts and window

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[36] Fibre decomposition products may act as a chemical binder, or ‘biopolymer’. There are other organic compounds known to be added to loam as a kind of biopolymer such urine, dung or blood (Winkler, 1956; Eires, Camões and Jalali, 2013).

frames. Commonly used tree species are poplar, willow and palm. Although the latter is not ideal due to its softness, it is common to see them being used even for roof construction. Reed, which grows abundantly on the riverbanks include *Phragmites australis*, or common reed, and *Arundo donax* or Giant cane. Reeds are used to create fences, doors, partition walls and in roof construction. In combination with loam, it is used in the Mesopotamian version of wattle-and-daub. Although rarely preserved, such walls must have played quite a big role in the partitioning of architectural and exterior space.

Figure 41. A rare example of a partition wall made of reed and loam unearthed at Nuzi by Starr (after Starr, 1939, Plate 24B).

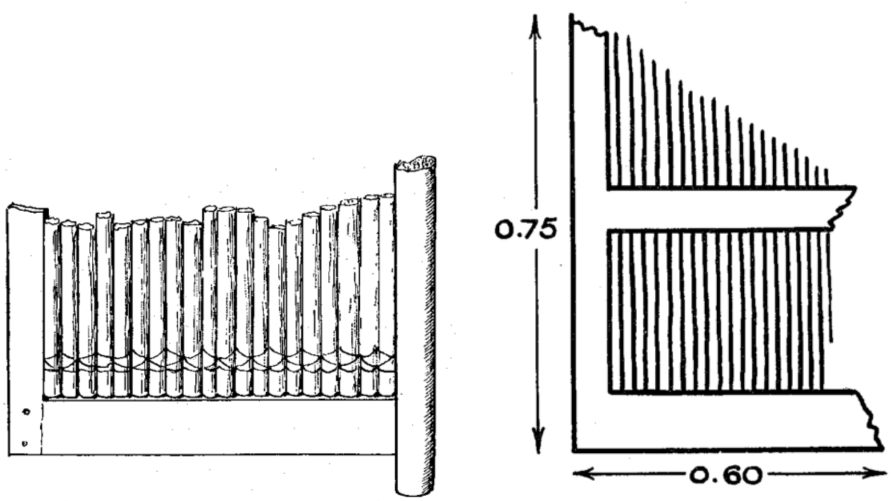


Figure 42. Reed panel doors found in Ur. Left: example found in the Nin-subur chapel of Old babylonian Ur (Woolley, Mallowan and Mitchell, 1976). Right: example found in Kassite Ur (15th-12th centuries BC). It belonged to an internal doorway between rooms (after Woolley, 1965, fig. 2).

V.2.3 Stone

The use of stone in mud brick construction shows significant regional differences. It plays a relatively unimportant role in the architecture of lowland Mesopotamia. It may be occasionally applied in base courses of walls, to form a barrier against water in the same way that baked brick is locally used to this end. However, most of the time no stone is used in wall construction. It has some limited additional use, in the form of pebbles to reinforce floors and to manufacture pivots for turning door posts.

V.2.4 Gypsum and lime

Gypsum and lime are both used to reinforce loam plasters, bricks or mortar, or to create hard floors. Both limestone and gypsum rock need to be burned, or heated. To turn limestone into quicklime (calcium oxide – CaO) constant heating is required for three to four days at temperatures around 900 ˚C, a chemical process called calcination. It is then hydrated by mixing it with water. The calcium hydroxide thus formed can be used in lime plaster and applied in construction. Reacting with CO2 in the air, the calcium hydroxide turns back into the extremely hard material calcium carbonate, or limestone. Gypsum rock on the other hand just needs to be heated to about 120 ˚C for a period of at least an hour. The purpose of the heating is to drive off chemically bound water.[37] It can then be used directly. Lime and gypsum are usually mixed with sand, straw, pebbles, pieces of limestone before or during application. The production of gypsum is much more fuel and labour efficient and easier than lime, which was a significant factor in ancient building practice. To produce a ton of quicklime, an estimated 1.8 tons of limestone rock and two tons of wood is required (Kingery, Vandiver and Prickett, 1988). Another disadvantage of the lime production process is that special care must be taken when working with quicklime as it is caustic and reacts with water, causing heat and forming a danger for skin and respiratory systems. In return for a higher and more specialised labour input and the expense of more resources, lime offers superior water resistance and durability. In villages in the Middle East, production of both gypsum and lime takes place on a small scale, often using limestone or gypsum rich deposits rather than quarrying the rock directly (Horne, 1994, p. 137; Moorey, 1994, p. 330; Pütt, 2005, p. 247). It is uncertain to which degree recent village material procurement practices are representative for ancient practices, as the scale of production may differ significantly.

Bitumen or natural asphalt has been used extensively in the past as waterproofing agent, adhesive, and to make sculpture and jewellery (Connan, 1999, pp. 34–38). It was frequently used to waterproof objects like reed baskets and boats. In construction it was used in mortars and plasters to increase the strength and

[37] Burned on this temperature for an hour and 'plaster of Paris' is formed. Burning longer results in the removal of more water and the formation of anhydrite, which makes slightly stronger plasters.

durability of the material, and to seal walls and floors in areas of water-use. Bitumen was generally not used in pure form, but used to fabricate a compound material: it was mixed together with sand, lime/gypsum and organic materials like straw, rushes, leaves and reeds. Archaeological samples contain typically no more than 30% bitumen, the rest being made up by the mineral or organic component (Connan, 1999, p. 39). When used as mortar, bitumen is mixed with much sand and straw just like loam mortar.

V.2.5 Baked brick

For the largest part of Mesopotamian (pre)history, baked brick saw relatively limited use, which may be attributed to the fuel expenses needed for firing (Moorey, 1994, p. 306). For brick production, scove kilns were probably used (Moorey, 1994, p. 306). A scove kiln is made of piles of stacked bricks with some space between them, which serve as firing tunnels, and covered with loam. Firing occurs inside the stack at the bottom. In the Ur III Garšana archives a kiln is mentioned that probably is a scove kiln, as the activities related to it seem to indicate a high stacked structure (Heimpel, 2009, p. 185). Such kilns are quite inefficient, so no high temperatures can be reached, which explains why many bricks found archaeologically are not very hard baked. Also, baking occurs very unevenly, with the result that those bricks close to the fire are likely to become over fired, while those on the outside are often under fired (Woolley, Mallowan and Mitchell, 1976). Archaeologically observed bricks are generally of poor quality, and estimates are that they are often not fired to higher temperatures than 600 ˚C, which classifies them as half-baked. Matson (1985) estimates a firing range of 800-900 ˚C based on his study of relatively hard baked Neo-Babylonian bricks, which is a range of temperature in which clays just start to vitrify, and a ceramic material is produced.

Baked brick would have been an expense, due to the need for fuel to produce them, and are therefore somewhat of a status material. It is most frequently used on those areas which were in contact with water, and as pavements for courtyards. However, in dense urban environments, conditions rose where baked brick was used more extensively. Although the picture is far from clear, it seems that baked brick sees increased usage in the architecture of Southern Mesopotamia during the Middle Bronze Age (Miglus, 1999, p. 85), and later also in Northern Mesopotamia.

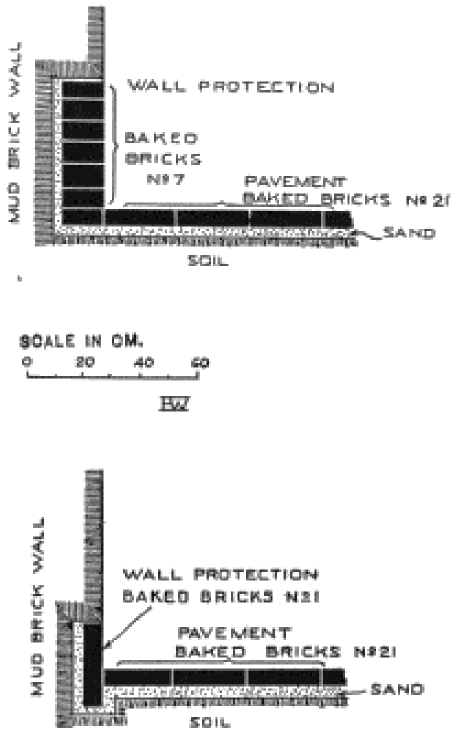


Figure 43. Tile floor construction and two methods of wall protection in house of Shilwi-Teshub in Nuzi (after Starr, 1939, plan 37A).

V.3 Building principles of mud brick architecture

This section introduces common construction techniques and methods known in antiquity, specifically the mud brick building methods used in Bronze Age Mesopotamia and the Levant. In a later section (V.5), evidence for techniques and methods found at the *Dunnu* will be dealt with.

V.3.1 Surveying and planning

There is ample evidence for the careful planning of construction, and calculation of labour and material costs. Well-known are the examples of building plans inscribed on tablets, known from various periods in Mesopotamian history (Heinrich and Seidl, 1967; Wiseman, 1972). Heinrich & Seidl (1967, p. 45) consider it unlikely that these represent actual building designs. On them we find commonly represented the dimensions of walls, and in some cases the name or function of certain rooms. It is therefore believed that these may have been used in legal contracts or measuring exercises. What they do tell us is that the basic unit of measurement used for buildings is the *kuš* or cubit, approximately 50 centimetres. Most walls are strictly dimensioned as whole numbers of *kuš* in length on these building plans, only for the longer walls fractions are used as well. It may therefore be possible to deduct the length of a *kuš* from archaeological building plans, or perhaps rather establish whether it was used. With this methodology the use of the *kuš* has been suggested on sites pre-dating the earliest drawn plans such as mid-4th millennium Habuba Kabira, where spaces had been dimensioned using a base unit of approximately 49 centimetres (Frank, 1975). Babylonian mathematical texts bear much evidence of surveying (Robson, 1996). Curiously, these texts are almost all exercises for learning the trade, and little in the form of calculations for real buildings have preserved. Nevertheless, they give us information about what kind of units that were used, how totals of materials were calculated, and how labour was calculated. We know thus that bricks are counted in groups of 720, or the brick-šar[38]. As different brick types have different total volumes in a šar of 720, the exercises train the students to convert these brick-šar's in volume-šar's in order to accurately calculate the number of bricks used in a wall of certain given dimensions. Especially interesting are the coefficients or standard work rates used to estimate labour time. These include work rates for digging canals, razing buildings, carrying bricks, water, reed etc, making bricks, building walls and so forth. These allow us to compute labour investment the same way as it was done in the ancient past. This may in fact be more accurate than currently common approaches that use potentially unrepresentative and unreliable ethnographic accounts (i.e. Burke, 2008; Richardson, 2015).

Figure 44. Nanna handing a measuring rod and a line partly on a coil to king Ur-Nammu on the Ur-Nammu stela. These were the basic instruments to mark the outline of a building.

[38] The *šar* is used for surface units (1 *šar* = 36 m^2), volume units (1 *šar* = 18 m^2), and brick numbers (1 *šar* = 720 bricks *of any size*).

V.3.2 The mud brick production *chaîne opératoire*

Nowhere in the ancient world, the series of activities involved in mud brick construction has been more beautifully illustrated than on a famous Egyptian painting, found on the wall of a chapel constructed in the memory of a vizier named Rekhmire (Figure 45). It shows in detail the activities of the brick makers, carriers and builders. Water is collected from a pond, and carried on large vessels on the shoulder to the heaps of loam where other workers mix it using hoes. From there it is carried in baskets to the brick makers, which are shown with their brick molds for single bricks. A stack of finished bricks is visible as well, from where carriers get the bricks and transport it using a shoulder pole to the construction site. Also mortar is carried. At the end, builders are busy constructing. One is shown laying bricks, another probably adding mortar. The entire process is followed by the controlling eyes of overseers with small sticks in the hand.

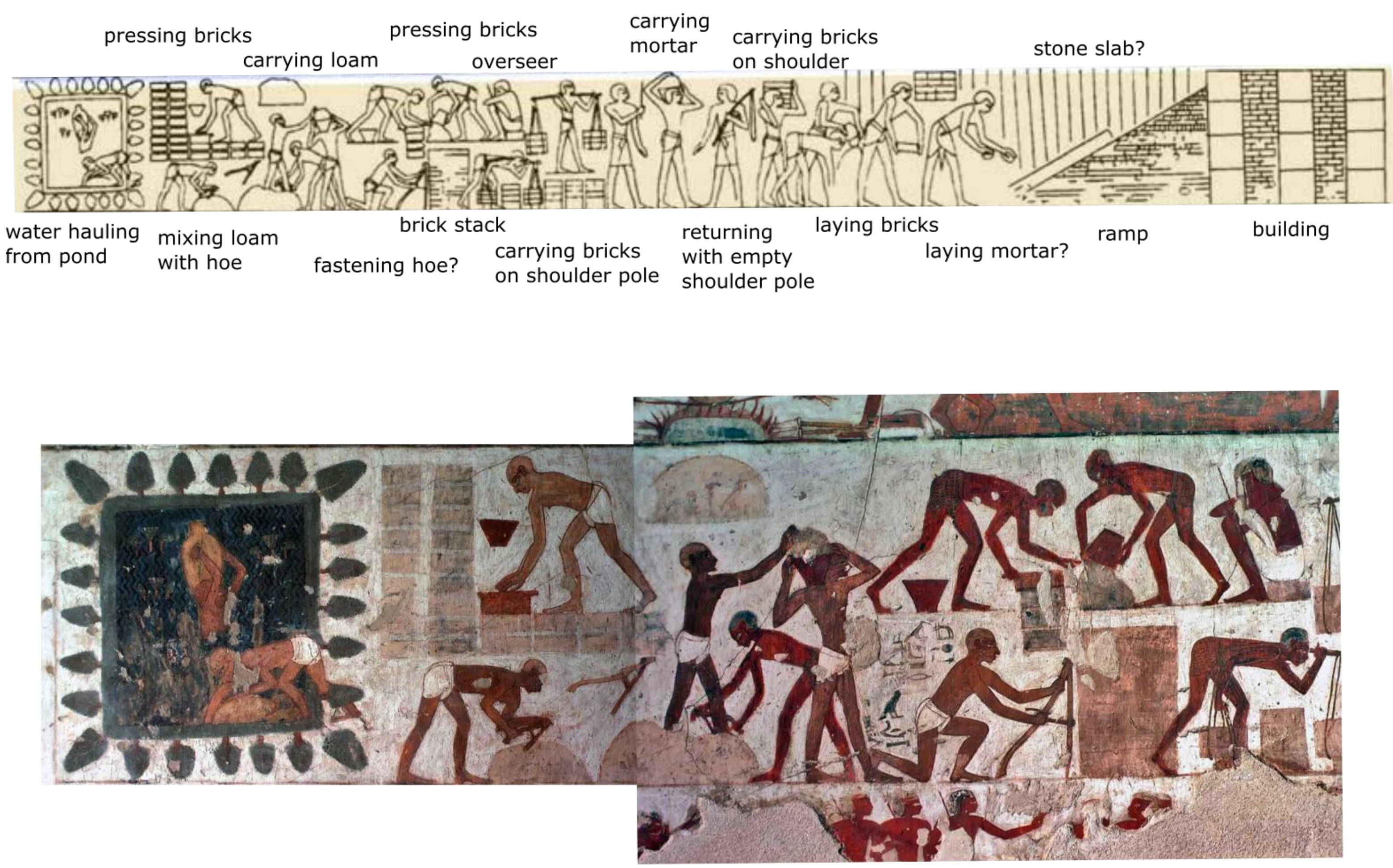


Figure 45. Painting in the chapel of Rekhmire showing brick molders, carriers and builders. Late 15th century BCE (after www.osirisnet.net/tombes/nobles/rekhmire100/e_rekhmire100_07.htm with annotations made by author).

Not all steps in the process are represented. For example, there is no straw being cut or added to the loam and water mix. Neither are the later stages of the building process shown: the plastering and the construction of the roofs. Also excluded is the acquisition and procurement of the other building materials: reed and wood for example, which must have been integral part of the entire undertaking.

In ancient Mesopotamia, mud bricks were preferably made just after the spring rain, during the ‘month of the king’s brick-mould’. The summer is therefore ‘the building season’. But bricks were probably being produced during the entirety of the hot season, responding to the fluctuating demands of construction works, as happens today.

V.3.3 Transport and lifting

Transportation of building materials must have been done mostly by humans. It is remarkable that so little use was made of donkeys or mules. At least, not in the Ur III and Old Babylonian mathematical texts concerning labour rates, which usually assume human based transport (Robson, 1999), nor in the wealth of cuneiform labour texts from Garšana (Heimpel, 2009), animal transport plays a large role. However, for the Neo-Assyrian empire, donkey-transport is well attested for as it is referred to in the Assyrian State Archives.

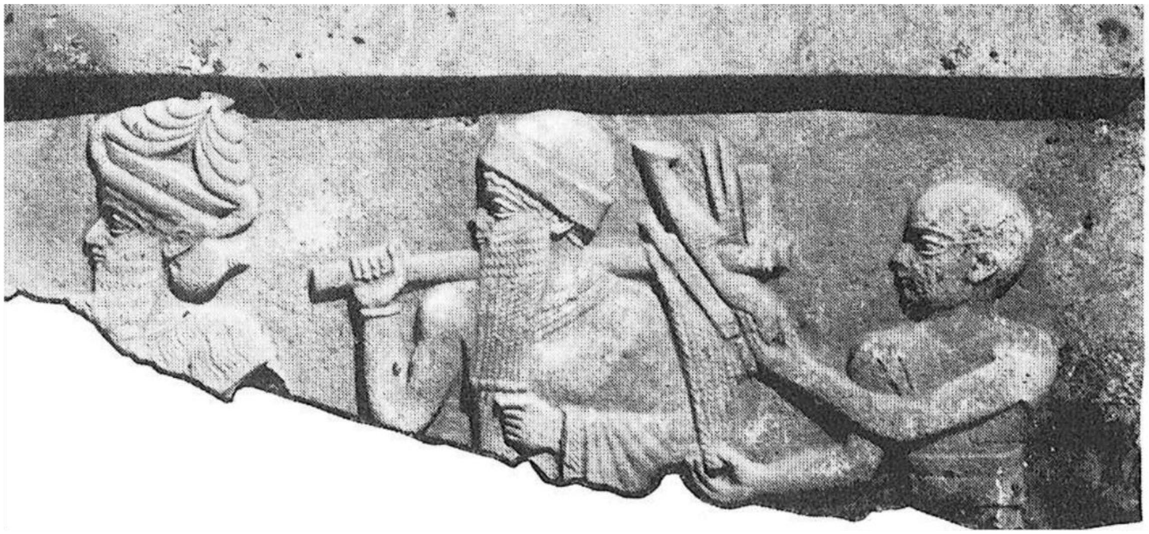
Materials were sometimes transported in carts. The two-wheeled human powered cart, is referred to in texts and depicted on Neo-Assyrian reliefs (Salonen, 1972, p. 107), but this may not be representative of the earlier periods. Shorter distance transport of bricks was done by means of the shoulder pole shown on Rekhmire’s painting, which is also known from Sumerian and Akkadian cuneiform texts (Salonen, 1972, p. 112). Taking a regular brick size from Egypt – which is smaller than the Mespotamian one, the weight of the mud bricks the workers carry on the shoulder pole must have been around 23 kg. This is close to the weight of one large Northern Mesopotamian mud brick, and not coincidentally the standard mud brick carriage rate for a worker in the Babylonian mathematical texts. The consistency reflects the weight a human being can reasonably carry over some distance, and implies a significant degree of accuracy for the Rekhmire tomb painting. However, since a single brick cannot be balanced on a shoulder pole, it is likely that brick carriers in Mesopotamia carried them in baskets on their heads, the way they also carried loam (figure 47), or on the shoulder.

Bulk transport of building materials over longer distances was common. Boats or rafts were used to transport bricks and wood over rivers and canals. The larger irrigation canals were probably important for the transportation infrastructure, and the many smaller canals could have been used as well to get the building materials quite near to where they are needed. The Garšana texts give ample evidence of bulk transport of construction materials over water. Boat towing was also done by people.

The transport of large heavy objects is also clear thanks to depictions of it. Sledges on rollers were used to transport heavy objects such as is famously illustrated on a relief from Senecharibs palace in Nineveh. For this sort of task, ropes were used to stabilize, and to pull the massive object. Extra force was used to push the object by means of massive beams as lever. The entire contraption rolled on beams. The one other construction problem that must have strained the technical capabilities of people using mainly ropes and poles, was to lift heavy beams that were used to cover large rooms. As such heavy items can easily cause damage to the loam walls, it seems not practical to push and drag them over the walls. They must have lifted them and laid them in the right position from above. One possible way is that they used an upsized version of the shadoof, the counter weighted water hauling device, which is also proposed as lifting device for heavy stones in ancient Egypt (Molyneaux, 2006).

V.3.4 Tools

The tools shown on Rekhmire's chapel painting are various sizes of hoes, the brick mold, carrying basket and shoulder pole. Miniatures and full-size copies of such tools have been found in Egyptian tombs as burial gifts, and they look exactly as depicted. The hoes are wooden hoes and consist of two parts: the handle and the blade. The blade is removable so it can be replaced when it breaks. It is fastened by means of rope, fixed behind a right-angled bulge found on the handle. It is probable that the man sitting next the brick stack is fastening his hoe, seemingly using the stack to push the blade against to increase the tension in the hoe (Figure 45). Comparing this to the only Mesopotamian depiction of construction works, there are some interesting differences.



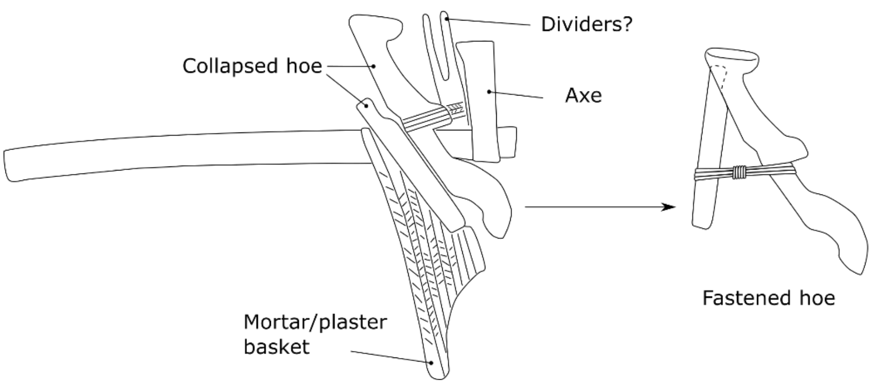


Figure 46. King Ur-Nammu with tools of construction. Below the interpretation of the tools depicted on the relief by the author (photo on top after Woolley, 1974, PL. 42d).

The only Mesopotamian depiction comes from the reign of Ur-Nammu, king of Ur in the 22nd century BCE, who has depicted himself as a builder on a stela that is appropriately named Ur-Nammu's stela (Woolley, 1974, chap. XII) (Figure 46). Assisted by a servant, he seems to carry five items on his back. No single scholar has identified exactly the same set of tools, which is in some cases due to a misnomer or misidentification (Salonen, 1972, tafel XIV.2; Woolley, 1974, p. 77; Moorey, 1994, p. 303). In my view, the most likely interpretation of what we see, is a collapsed hoe of the small type used for mixing loam on the Rekhmire painting. The object hanging underneath the typically shaped handle, is most likely the blade (and not a wooden trowel). The rope for fastening the blade is wound around the bulge on the handle. When fastened, it will sit below this bulging part. The large tool that he carries on his shoulder is an axe. Such an axe would have been used for razing walls and cutting ground, roots and digging. Razing the walls of standing buildings is a common task preceding associated construction work, just like levelling and digging (Heimpel, 2009, pp. 230, 240). There can be no doubt about the wickerwork basket, used to carry bricks and raw material in. It is also depicted on another, heavily reconstructed, part of the Ur-Nammu stela, where we see workers carry buckets of mortar on their heads up a ladder (Figure 47). The Rekhmire painting shows workers carrying the baskets on their shoulder. The only tool whose identification is not completely certain, is the forked object behind the axe. It has rope wound around its base.[39] It may indeed be a pair of dividers as suggested by Woolley and Moorey, although the fact that it seems to be rigidly fixed with a rope argues against this hypothesis. It is hard to see how this would work as an easily adjustable divider. Woolley and perhaps Salonen suggested it to be the forking end of a fork-hoe, but such tools are not known from antiquity. It is furthermore unclear how a forked hoe would be of use to a builder, neither is the way it is depicted very convincing. A curious absentee is the brick mold, which on other occasions was important enough to have month named after. One would expect it to have some symbolical status and therefore represented. Perhaps it is left out because moulding bricks is a separate task from building, done by regular workers.

Salonen (1972) mentions still various other tools used in construction that he identified in the cuneiform sources. He enlarges the toolset with a spade, which was apparently for scooping loam into the mould, and dig out the loam pit. This would have been associated with the brick moulder, not the builder. The spade is not used by the workers on the Rekhmire painting, nor is the spade commonly used today in mud brick manufacture. Salonen also finds mention of straw cutters, which is interesting since we were still lacking this essential tool. Other objects used in the building crafts is a specific type of bucket for pouring water (which may refer to a pottery vessel as seen on the Rekhmire painting), a large basket for carrying clay, and a large bitumen sealed basket for carrying loam.

[39] Not visible on the photograph published by Woolley, but clearly visible on higher resolution images found on the internet. Also Moorey (1994, fig. 19) includes a line drawing which shows this rope.

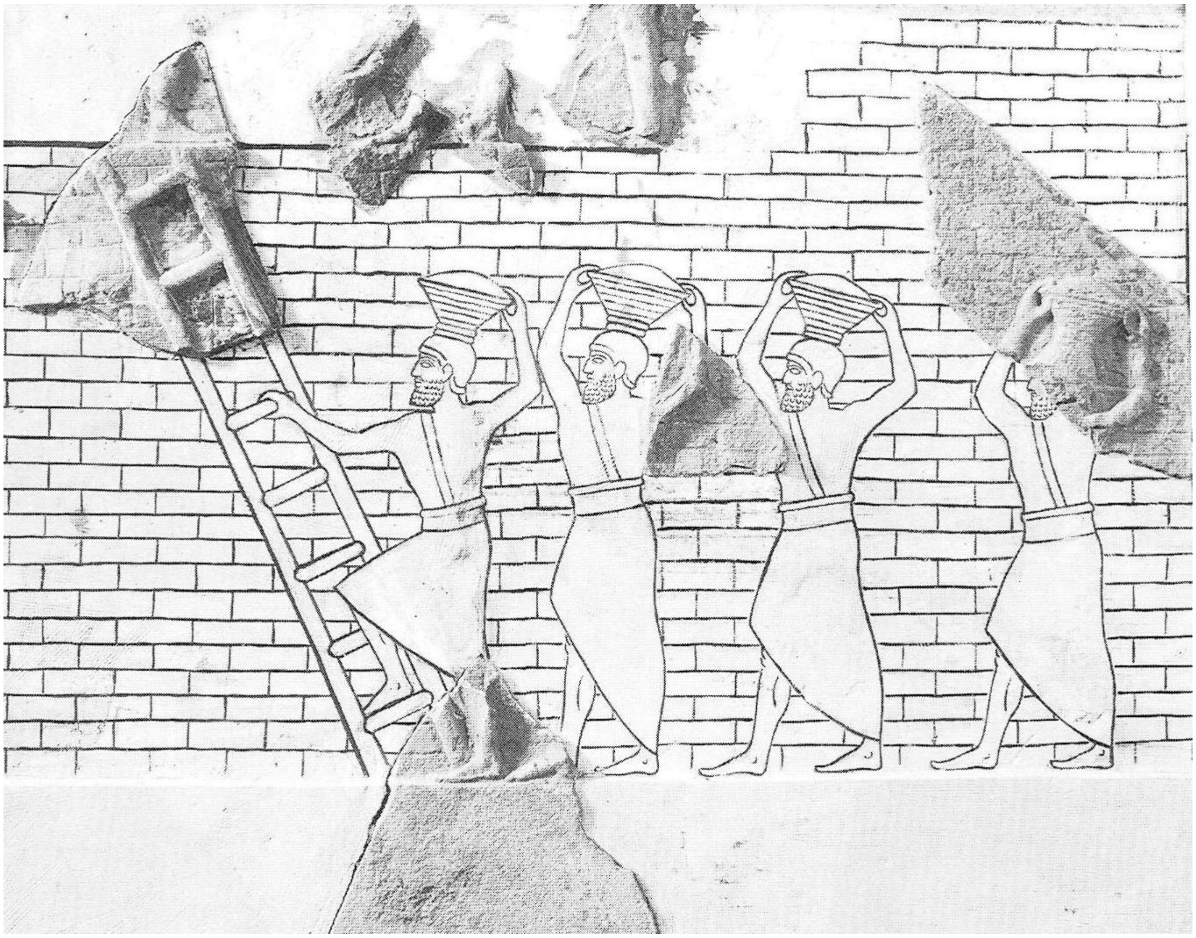


Figure 47. Part of the 3rd register on the obverse side of the Ur-Nammu stela. It is heavily reconstructed, but the subject seems clear: workers walking with baskets of loam mortar in front of a large wall (after Woolley, 1974).

V.3.5 Scaffolding

With masonry structures, one expects that scaffolding is used. But there is very little evidence that this existed or used frequently. Some would attribute this to the general scarcity of wood, which is also proposed as an explanation for the use of vaulting techniques that can be executed without the need for timber support also known as centring (Oates, 1990). However, simple scaffolding does not require that much wood when using a system with beams and planks that is moved while going upwards. Characteristic 'putlog holes' would be the remaining evidence of this type of scaffolding and indeed such evidence has been found in some walls of the bronze age palace in Mari (Margueron, 2004) (Figure 48). But putlog holes are not often found in excavations, but that may be due to difficulty of detection in the absence of specifically targeted archaeological investigations. But there is another explanation, and that is that builders stood on walls while doing masonry work. The walls, at least 50 cm thick, would allow for such a way of construction. From personal experience in mud brick construction, walls are easily constructed by standing on a wall even if it is only 36-38 cm wide (1,5 brick) (Figure 49). Also Heimpel (2009, p. 254) supports this theory as no scaffold was ever used in the construction of the Garšana compound. In fact, no Sumerian word for 'scaffold' is known to him at all. It therefore seems that generally, ladders were used to climb on top of walls and construction took place right under the feet of the builders (Figure 47).

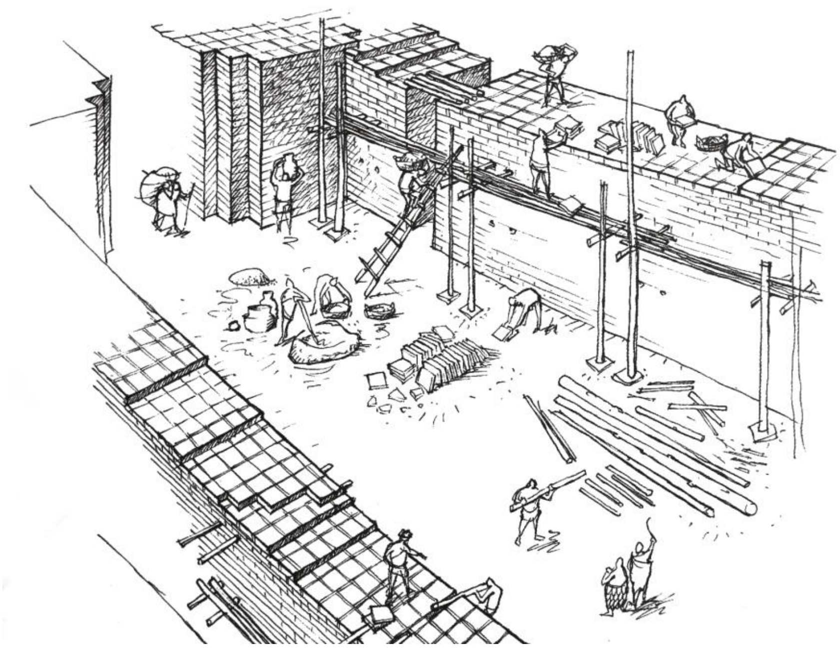


Figure 48. Reconstruction of scaffolding in Mari based on the discovery of putlog holes in the wall (after Margueron, 2004, fig. 204).

Figure 49. Bricking up a wall while standing on top of it. No scaffolding needed. Scaffolding was however regularly used on this project. This approach developed by coincidence while looking for an efficient way to finish the last part of the wall without having to adjust the scaffolding. Photo made by author during a loam construction workshop near Agdz, Morocco.

V.3.6 Foundation methods

Construction starts with preparing the ground. Foundation techniques vary, but in general the builder's approach towards foundation is very pragmatic, which is true for ancient times as well as in more recent traditional practices (Aurenche, 1981, p. 103; Gasche and Birschmeier, 1981, pp. 15–17; Dunham, 1982; Ragette, 2003, p. 29). One important observation is the general absence of deeply dug foundations. Moreover, foundations are rarely wider than the walls due to the already broad dimensions of mud brick walls, which gives these walls an inherent stability (see V.5.3). Foundation trenches are rare, but if soil conditions require, earth is dug out until stable earth is found. In densely populated settlements, preexisting walls are often used as the foundation for the next generation house (Figure 17). The main concern of the (ancient) builder was that the wall stood on a flush surface, to minimize the chances of wall shift or sag. As construction often takes place on sloped or irregular terrain, level ground is the minimum requirement for construction. Not surprisingly, various forms of ground levelling are the most common method of foundation (Loud and Altman, 1938, p. 18; Gasche and Birschmeier, 1981; Dunham, 1982). On sloped terrain, terracing is the most common form of levelling. Levelling might involve the construction of mud brick platforms, but excavated terraces are more common. Terraces can be constructed for individual walls, or for entire buildings, or parts of the settlement. The activity usually involves both removal and addition of soil.

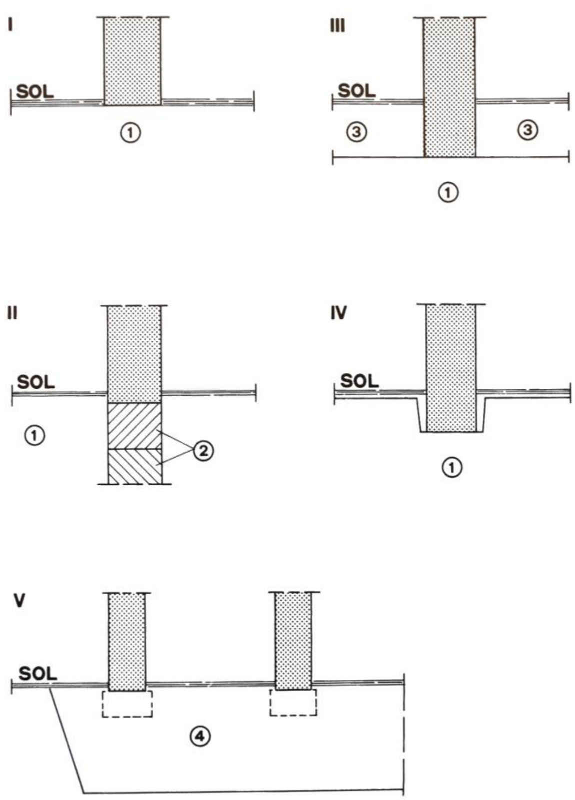


Figure 50. Common foundation practices found in the archaeology of Mesopotamian mud brick architecture. I. On surface. II. On previous walls. III. On surface, then soil dumped against wall. IV. Shallow trench. V. On sand or gravel (used occasionally for monumental architecture) (after Gasche and Birschmeier, 1981, fig. 4).

V.3.7 Wall construction

In mud brick construction, running bonds are most common. Since brickwork is generally covered by a loam render, there is no incentive to apply elaborate and decorative brick bonding patterns. Variations of brick bonding techniques have been observed in monumental architecture, but the reasons are functional and related to effectivity and efficiency (Oates, 1990; Sauvage, 1998; Wright, 2009). When the main brick unit is square (i.e. 30x30 cm or 40x40 cm), as is the case in most Bronze Age architecture, there is no difference between headers and stretchers. This therefore requires a different approach to bonding than in cases where rectangular bricks (i.e. 10x20 cm) are the base unit. With square bricks, rectangular 'half bricks' are applied to attain the required offset at the beginning of a brick course, or to construct walls with half brick widths or a multiplication of this (i.e. 1.5, 2.5 brick width etc.). If halves are used in the latter fashion, quarter bats are required again for proper offsetting at the beginning of a brick course. So that means that at least 3 types of brick are needed if the base brick unit is square: squares, halves, and quarter bats.

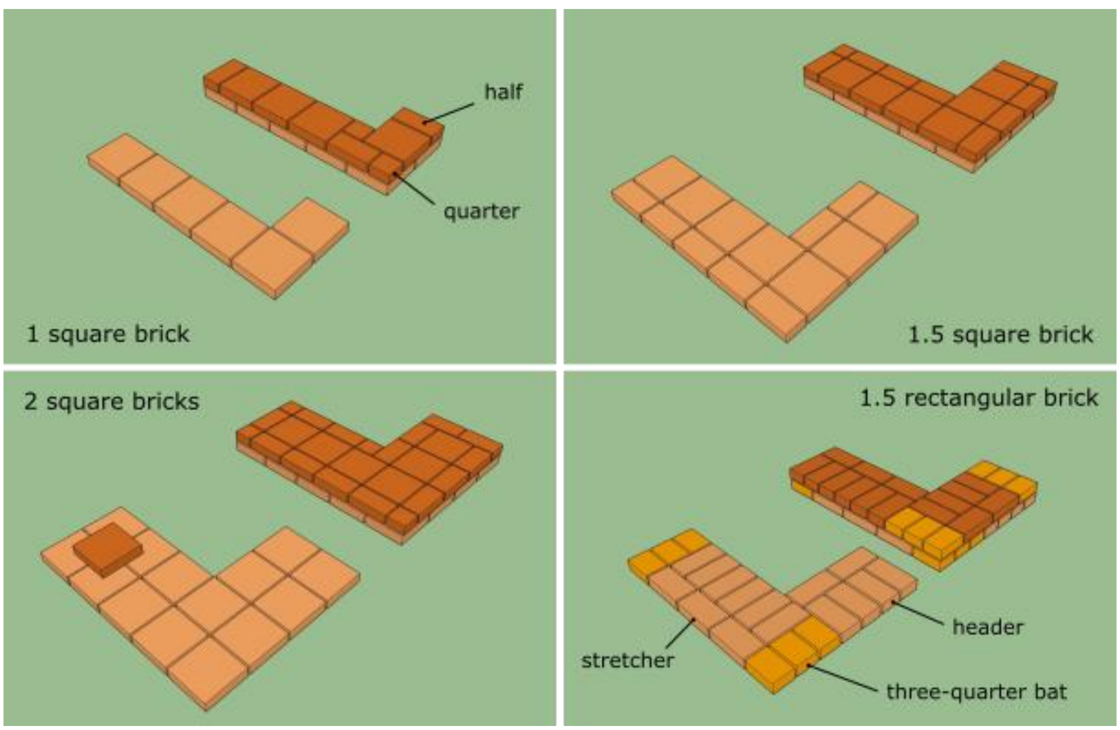


Figure 51. Illustration of some common bonding patterns with the square brick as base. For comparison, a common brick bond for rectangular bricks is illustrated on the bottom right.

Walls that are load bearing or important for the stability of the entire structure, must be bonded at the corners or at T-junctions. Different corner bonding patterns are possible. Various corner/junction bonding patterns found in the *Dunnu* of tell sabi abyad will be discussed later. The corner/junction bonding pattern applied appears to be determined by the width of the wall: i.e. a 1 brick width wall requires a different approach than a 1.5 brick width wall. The wider the wall, the more potential variations in corner/junction bonding are possible. Moreover, to create a sufficiently strong connection, it is not required to bind every brick layer, but some may be skipped.

The width of walls is proportional to the size of the base brick unit. Generally, the minimum width is therefore equivalent to the size of a single brick, e.g. 30-40 cm, although half brick walls are possible for light constructions such as enclosures. On average, single floor houses of traditionally constructed houses have wall thicknesses of 40 to 60 cm, and about 80-100 cm if there is a second floor[40], but if more building types are included, wall widths vary immensely. This is for a large part a consequence of the height or size of the building, as a minimum wall 'slenderness' has to be observed to maintain a certain stability (Yeomans, 2009, p. 84) (Table 5). It has been claimed that mud brick walls are often "unnecessarily" wide (Heinrich and Seidl, 1967, p. 5; Wright, 2000, p. 40).[41] However, considering the general practice of constructing directly on levelled ground without advanced foundation methods, wall stability is probably attained by constructing on a wide base. Another factor is that ancient builders stayed on the safe-side, and probably constructed 'earthquake proof' (Table 5). Last, a wider wall at the top also helps to better distribute the weight of the heavy mud terrace roof and prevents damage caused by beam sagging (Figure 55). The reasons for the dimensioning of walls is therefore a combination of structural necessity and safety. Suggesting that walls were unnecessarily wide disregards the pragmatic and rational approach to construction by the ancient builder. This means that we can read differences in wall width as a rough reflection of differences in wall height, taking into account the possibility of intermediate floors and their influence on the stability of walls.[42] If the distance to intermediate floors or ceilings is high, thicker walls are required to attain the same wall stability.

Another important factor contributing to building stability is interior wall or space configuration (McHenry, 1984, p. 84). Interior walls at regular intervals, supporting the exterior walls, creates a much stronger structure than very long uninterrupted stretches of wall. Enclosure and fortification walls naturally suffer

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[40] Some examples of traditional village architecture wall widths: Gazira, Northern Syria: 35-50 cm for regular walls, 60-70 cm for 'stronger' walls (Pütt, 2005), Tauran, Iran 70-90 cm (Horne, 1994), Aliabad, Iran: 50 cm for single floor, 100 cm for two floors (Kramer, 1982).

[41] It must be said, they refer to monumental architecture: palaces, large residences and temples. Heinrich and Seidl (1968) have suggested that this is because the thickness of walls plays a symbolic role in monumental architecture.

[42] The slenderness of walls is offset by the presence of rigid floor frames at higher levels. The floors used in traditional mud brick constructions are in many cases not completely rigid, as the beams are placed on the walls without binding them. This type of floor will have some effect on the stability of the walls, but not the same as a completely rigid frame.

from this problem, and are therefore constructed very wide, with buttresses, or deviate from the straight line by building sections with corners.

Wall thickness (cm)	Slenderness aspect ratio (thickness:height)		
	8	10	15
	Max wall height (m)		
30	2.40	3.00	4.50
40	3.20	4.00	6.00
60	4.80	6.00	9.00
100	8.00	10.00	15.00

Table 5. Maximum wall heights (in meters). These are common aspect ratios applied in loam construction nowadays. A slenderness ratio of 8 (left) is advised for earthquake prone regions. A ratio of 10 is generally considered safe (middle), while a ratio of 15 reflects the maximum, only to be used on solid soil, and in conjunction with well-designed foundations and masonry of good quality (after McHenry, 1984, table 13.1).

V.3.8 Flat roof construction

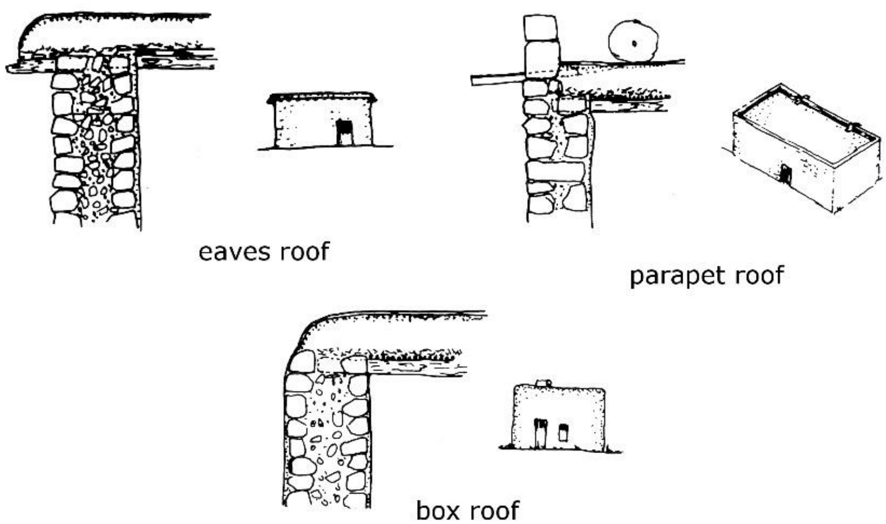


Figure 52. Three common roof types: eaves roof, parapet roof and box roof. The examples show dry stone walls, but the principle of loam terrace roof construction is the same (after Wright, 1985, fig. 363).

Although roofs are seldom found archaeologically, archaeologists commonly make the assumption that roof construction in the ancient Western Asia differed not from traditional practices found today (Delougaz, 1940, p. 133; McCown, 1967, p. 37; Moorey, 1994, p. 355). The roof type found throughout the Middle East, North Africa and far into the Asian continent is the loam terrace roof. This type of roofing is still used in modern village houses in the Western Asia today (Krafeld-Daugherty 1994, 166-172), and is the most common in traditional Northern Syrian roof constructions (Pütt, 2005, p. 243). There are three main forms of this roof: the eaves roof, the box roof and the parapet roof (Figure 52). Generally, the box roof is found in the driest areas, alongside various vaulted roof types (see V.3.9). The eaves roof is used in areas with slightly more rainfall, which is also evident from its distribution in Northern Syria (Pütt, 2005, p. 243). The parapet roof has a raised edge of up to 0.5 meter high (Aurenche, 1981, p. 154). Its occurrence is related to use rather than climate: in some areas it indicates the roof is used for sleeping, giving privacy and protection (Pütt, 2005, p. 246). In addition, more generally, it forms a safe barrier for people and things to fall off, allowing for other secondary uses of the roof. It also helps in controlling the flow of rainwater, channelling it to specific locations with discharge spouts. Control over the flow rainwater may explain its common occurrence in urban environments. Looking at roof construction and specific buildup in more detail, the degree of variation is very large with local building traditions playing an important role.[43]

All flat loam terrace roofs are a layered construction applying a various plant or loam based building materials. The structural support is formed by the timber frame, for which two options are common in traditional practices in Northern Syria (Daker, 1984; Pütt, 2005, p. 249). The first is to simply lay a number of beams across the width of a space. The second is to use one long central beam and place rafters covering the space from this beam to the wall. Although the difference may seem trivial, this is a significantly cheaper option than the former as it requires one single long and heavy timber and a larger number of smaller ones (Pütt, 2005, p. 249). In either case, across these beams or rafters, smaller timbers or purlins are placed. These are in turn superimposed by matting, straw or reeds, or even bushes of twigs or grasses are used. Finally, several layers of loam of coarse and fine consistency, are dumped and distributed on the structure, and compacted. A waterproof surface can be obtained by mechanical compression (rolling) and by using lime plaster or bitumen enriched plaster for the outer coat. The proportion of the roof construction made up by loam or by other materials differs quite significantly. The roofs documented by Pütt (2005, p. 244) contain a thick layer of straw, and relatively thin layers of loam. In a certain variation of the eaves roof, the thick layer of straw forms a roof that is dome like in appearance, which is up to 1.5 m thick in the middle. Adding thick layers of straw will increase the insulation value of a roof, while it may also create a lighter, putting less strain on the beams and walls.

The roof beams carry the entire weight of the roof, which is considerable at about 500-600 kg per m^2 roof, if the structure has a high proportion of loam. This weight is a main factor in roof and wall decay, as it causes sagging and edge pressure on locations where the beams are supported by the wall (Figure 55). In

[43] See for instance the documented roof construction types for Anatolia by Dalokay (1966) or for North Syria by Pütt (2005, p. 244).

some cases, wall plates are used, wooden planks or round timbers running over the top of the wall to support and distribute the weight of the beams. However, this is not standard practice. Thicker walls also help in distributing the weight of the roof better.

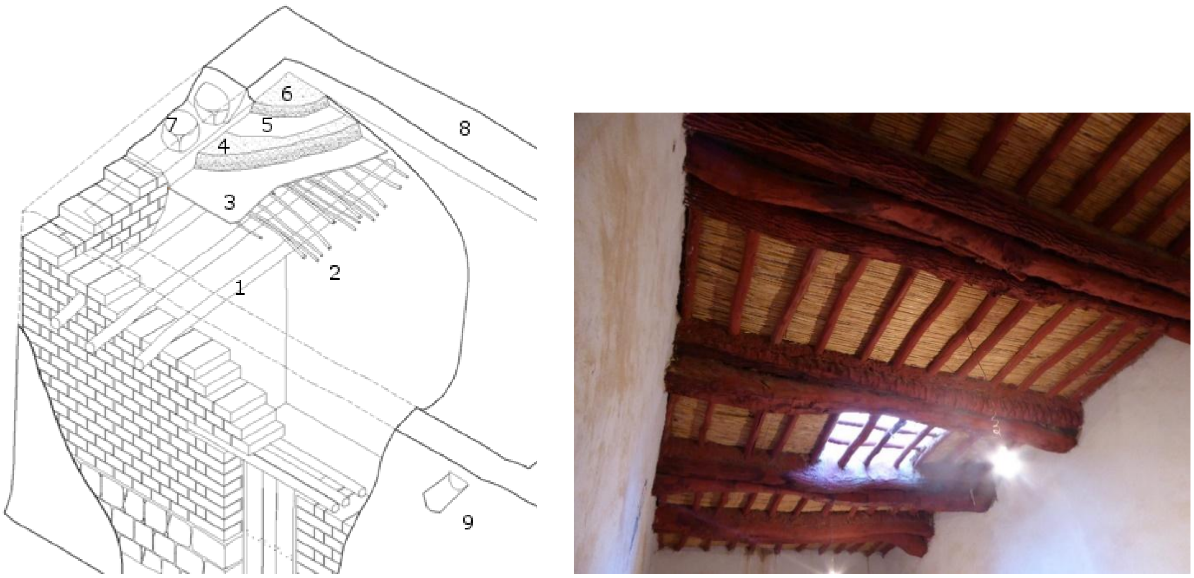


Figure 53. Roof construction methods. Left: common roof construction of houses in northern Syria. 1. Joists of poplar. 2. Purlins of brushwood. 3. Matting. 4-6. Layers of loam mortar with plastic sheet in between. Final layers mixed with dung or very fine clay to increase waterproofing. 7. Stone reinforcement. 8. Low parapet. 9. Water discharge. (after Dipasquale, Onnis and Paglini, 2009, fig. 63). Right: roof construction for a room with a larger span. The joint beams are a combination of trunks of date palm and tamarisk. It is a construction method that can be used when strength is required, but proper timber is not available. Top floor in a fortified building in south-eastern Morocco (photo by author).

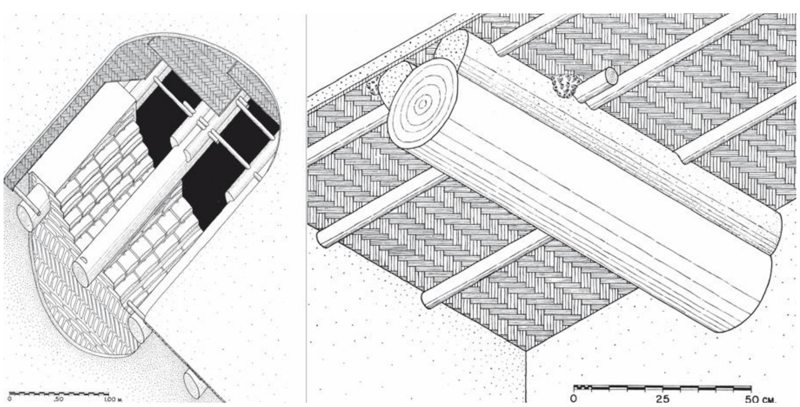


Figure 54. Khafajah/Ancient Tutub, 3rd millennium. Reconstructed roof based on charred beams and imprints in burned clay. It is curious that Delougaz chose to depict woven reed mats instead of a plain reed cover, because as far as his reports show, of these actual evidence was found in imprints, not of the herring-bone pattern mats. Diameters of beams and rafter could be determined exactly (after Delougaz, 1940, p. 133).

During the 20th century the most common tree species used for roof construction were poplar and date palm. In wooded areas of Anatolia, there would be more options, but in the drier low-land, poplar and palm are the types of timber that are more readily available (also see V.2.2). Larger trees were imported from far distances, but these would only have been used in monumental and state architecture mainly.

The variables important for timber roof construction are span, beam diameter, wood quality, interspacing, and wall thickness (Figure 55). The ancient builder had to assess these variables, and relied for this on expert knowledge. The thinner the beam, the closer they had to be put together, and the more beams would be needed. Conversely, when increasing the size of the room, either the beam-spacing had to be reduced or the beam thickness to increase, to be able to carry the weight of the roof.

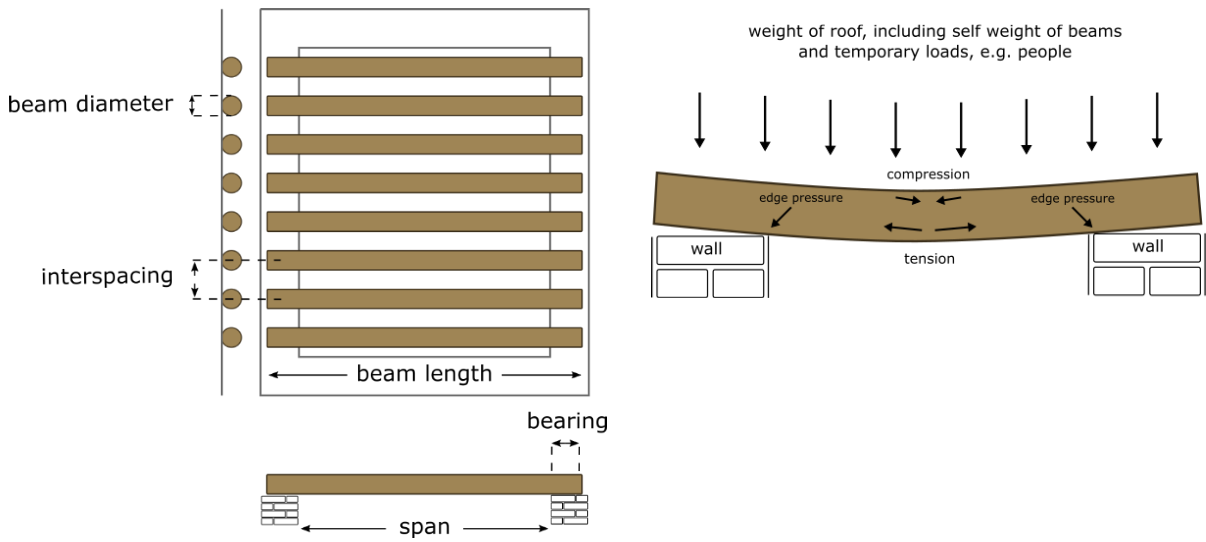
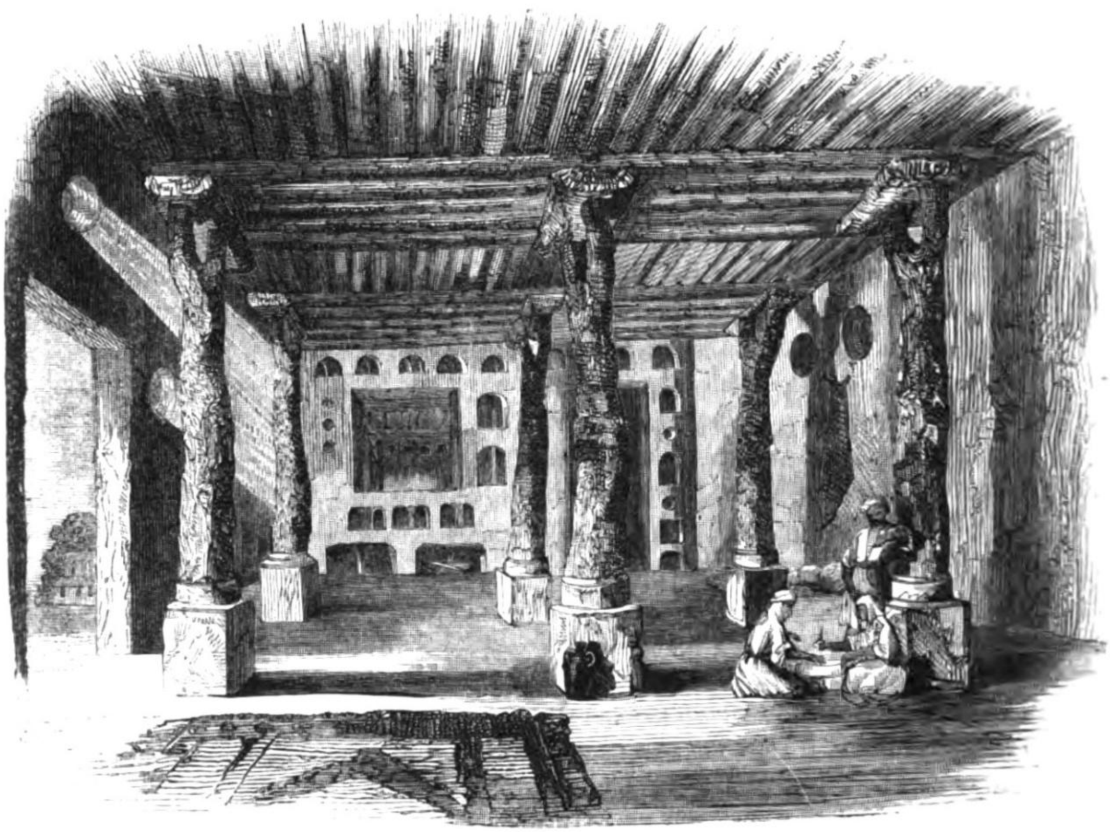


Figure 55. Left: variables important to roof construction. Right: forces acting in a horizontal beam structure.

Generally poplar beam diameters range from 15 to 25 cm (Dalokay 1969, 37; Margueron 1992, 89) although the use of beams with diameters below 15 cm have also been reported.[44] With such small diameters, they need to be placed very close together: Reuther (1910, 99) observed that town houses in Basrah and Baghdad had poplar beams only 10-12 cm in diameter, placed 5 to 10 cm apart. Other ethno-archaeologically attested placement distances gathered from the literature go up to 1 meter.[45] On average the interspacing seems to be around 30 to 70 cm.

[44] E.g. Krafeld-Daugherty (1994, 170) states that trees are usually judges to be of sufficient thickness when they had reached 12 to 15 cm in diameter.
[45] See for example Krafeld Daugherty (1994, p. 167) who cites several sources in which the beam spacing ranges from 30 to 70 cm, and Aurenche et al. (1997, p. 81), who report 20-30 cm interspacing between beams of traditional houses at Cafer Huyuk, Turkey. Reuther (1910, p. 99) states that the town and city houses in southern Mesopotamia have roofs and floors of poplar beams spaced only 5-10 cm from each other. Also Woolley and Mallowan (1976, 161) report that the beams were laid “at intervals not much greater than the diameter of the poles”.

Various ethnoarchaeological studies agree that no more than 3 to 3,5 meter is usually spanned with either poplar or palm (Hall, McBride and Riddell, 1973; Koyunlu, 1982; Friedl and Loeffler, 1994; Krafeld-Daugherty, 1994).[46] Covering larger spaces than this normally requires the use of columns or wooden supports, or to import different species of trees. In villages in Turkey and Syria, the use of wooden posts to support the roof beams is common. But no spans larger than 6 m have been observed (Krafeld-Daugherty, 1994, p. 167). However, in arid non-mountainous Northern Syria the use of wood is more constrained due to the limitations of the environment (Pütt, 2005), and wooden posts are not recorded to have been used in this way. According to Moorey's overview of wood use in ancient Mesopotamia (Moorey, 1994, p. 355) the use of timber for columns was a highland phenomenon until the Achaemenid period, but he cites relatively little evidence.



Interior of a Yezidi House at Bukra, in the Sinjar.

Figure 56.Drawing of the inside of a Yezidi house by 19th century archaeologist Austen Henry Layard. A lot of wood was used for the roof, supported by heavy timbers on stone bases. The plentiful use of beams is perhaps not just an demonstration of affluence, but considering the size of the room, could be a structural requirement as well (after Layard, 1882, p. 214).

[46] The total length of the beams needs to be another 80 cm or more longer.

The most valuable part of houses has until recent times always been the roof beams, which is shown by texts recording the transfer of houses to new owners (Stone, 1981, p. 20). It also explains why roof beams are often removed and re-used.

The flat faced loam terrace roof is not the only type of roof commonly found. Looking specifically at traditional architecture in Northern Syria, saddle roofs are in fact quite common as well, as are domed, or part-domed structures (Pütt, 2005; Mecca and Dipasquale, 2009). The domed houses are a very old phenomenon and are even recorded on a Neo-Assyrian relief. The domed roofs are usually associated with the driest and timber-scarcest regions. Some of these houses are round structures with the dome starting at the wall base. But some are found on rectangular wall structures, which would be less apparent, archaeologically.

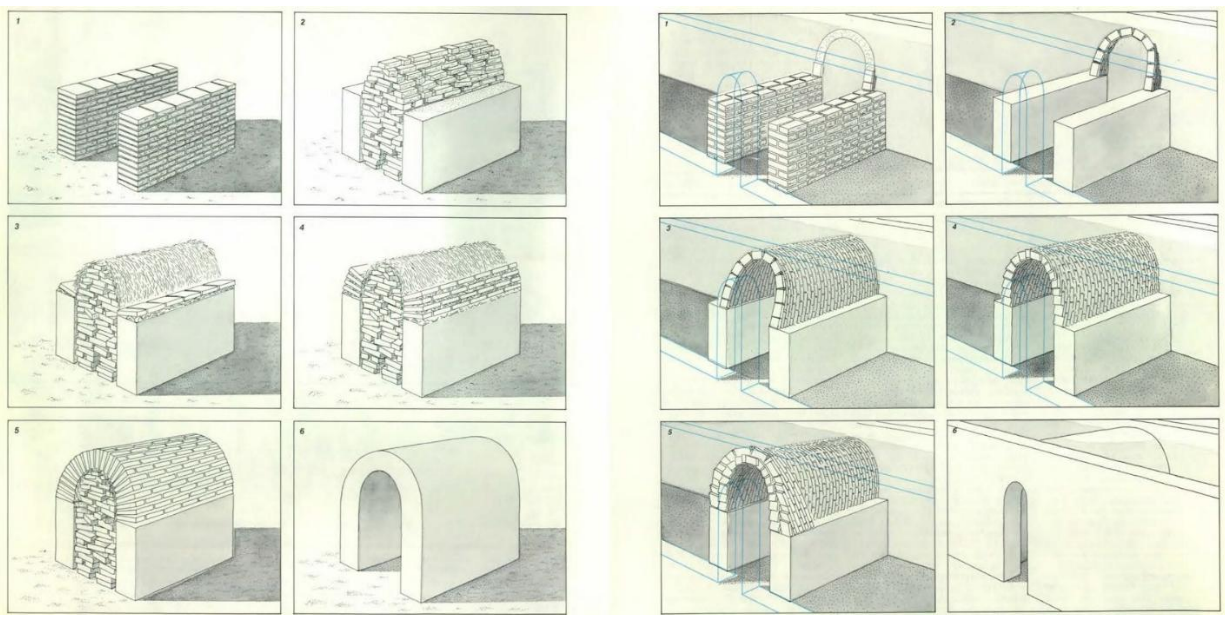


Figure 57. The execution of the two most used vaulting methods used during the Bronze Age in the ancient Western Asia (after Van Beek, 1987, pp. 84–85). Left: radial vaulting using a rubble fill as centring. Right: Pitched-brick vaulting, which requires no centring but relies on a back support of a wall.

V.3.9 Vaulting

As an alternative to timber based lintels and roofs, vaulting techniques were commonly applied to span rooms, doors and windows, long before the famous examples of Roman and Byzantine architecture (Besenval, 1984; Oates, 1990). Aside from ceilings and doorways, it is also employed in stairway construction. Two of the most common vaulting techniques are radial vaulting and pitched brick vaulting (Figure 57). The first requires centring, or support, during construction of the individual archivolts. The centring can be made of timber, or a rubble fill that is removed when the vault is set. Perhaps the most common technique is pitched brick vaulting, which does not require centring during construction. The archivolts are constructed against a wall on one side and at an angle just so the bricks do not slide or fall.

When dry, it has similar structural performance as a radial vault. The structural limit of mud brick masonry vaults with a single archivolt is about 4 meters. To better distribute the downwards forces, multiple archivolts can be employed, but this also requires more massive walls. Hence, when a structure is expected to carry great weights or large spans are needed, for instance with city gates, multiple archivolts are common. A famous example is the completely preserved mud brick city gate of Tel Dan, Israel (Frances, 2013). Recognizing arches and vaults in archaeological context is not as easy as it seems. Collapsed vaults resemble general mud brick collapse, as vaults often disintegrate gradually or fragment completely on hitting the ground.

V.4 Building materials used in the *Dunnu*

In this section, we will look at the building materials available to the builders of the *Dunnu.* It is based on both an environmental analysis and data available from the documentation of the excavation. It should be emphasized, that very little in terms of specific sampling and analysis of building materials has occurred. Therefore, many important questions cannot be answered. The main purpose of this section lies therefore in painting the general picture of the material and physical bounds that the builders of the *Dunnu* had to deal with.

V.4.1 Loams in the Balikh valley

The Balikh valley depoits are suitable for mud brick production are found on the recent and older river terraces formed by alluviation. These loamy alluvial deposits contain varying amounts of pebbles, gravel, sand, silt and clay. Outside these river terraces deposits are very shallow and consist of the weathering products of the bedrock, mostly limestone and gypsum. These have no use in mud brick production, which is thus confined to the river terraces. The deposits of the Balikh river terraces contain relatively little sand (on average 10-30%), although large variation is recorded in geographical distribution and sample depth (Mulders, 1969, table 30.1-30.10). Thus, deposits with the advised minimum of 30% sand are available, but must be looked for.

The proportions of different types of clay minerals is also of some importance to the fabrication of bricks, mortar and plaster. Clays are classified as either expanding or non-expanding. Expansive clays swell if a large amount when water is added, and shrink proportionally when drying out. Too much of these clays may cause mud bricks or plaster to crack. On the other hand, these clays are also the stronger binders. Without them, the material is weaker. The clay minerals occurring in highest amounts in soils of the Balikh valley are illite and palygorskite (Mulders, 1969, table 20), which are both non-expansive. The fraction of expansive clays is generally negligible. However, higher amounts of expansive clays such as montmorillonite are found locally as well. Again, this suggests that the best soils for construction must be searched for. Another possibility is that they are taken from preexisting mounds.

A last interesting fact about the Balikh valley is that due to the vicinity of calcareous bed rock the deposits contain high amounts of calcium carbonate. In theory this is good, because it may act as a binding agent, cementing particles together when dissolved and hardened on drying out.[47] However, due to changing relative humidity of the air and bricks, calcium carbonate and other salts may travel to the exterior of the brick and form encrustations that will flake and damage the wall (Bruno *et al.*, 1969). It is unclear whether the high amounts of calcium carbonate are therefore advantageous to loam constructions in this region.

V.4.2 Loams in the *Dunnu*

Unfortunately, none of the *Dunnu's* mud bricks or loam renders and plasters were analysed so at present it is impossible to compare their mineralogical composition with the soils of the Balikh. Therefore, we do not know whether specific loams were selected for construction. It is clear however that the Neolithic tell was quarried for loam as is suggested by the fact that prehistoric sherds that were occasionally found in Bronze Age mud bricks. The fosse that was dug out probably provided a large volume of the raw building material, although volume calculations show it was sufficient only for a part of the initial construction works.

A little more can be said about the loam used for the mud bricks of the *Dunnu*. The texture and colour of the mud bricks in many walls were documented during excavation, although not systematically and based on subjective descriptions. It does however show that a variety of mud brick textures and colours was present, possibly indicative of various loam sources (Figure 58). A notable difference has been observed between reddish brown mud bricks, often of a crumbly composition, and greyish mud bricks, often harder and compact and just plain brown mud bricks. The use of mud bricks of differing consistency and colour is a commonly observed archaeological phenomenon (Oates, 1990, p. 489; Sauvage, 1998, p. 18). In the ancient sources as well, two different names for two classes of mud brick are used: those of good (*ukurrum*) and of bad quality (*zarinnum*) (Sauvage, 1998, p. 18). Oates reports on builders saying that grey earth coming from former settlement earth produces stronger bricks than 'fresh' earth from the fields. The reason

[47] Calcium carbonate dissolves in water enriched with carbon dioxide, forming calcium bicarbonate. Hence, the degree to which it dissolves depends on the presence of carbon dioxide, which is generally higher in rainwater than in ground water.

is that ashy occupation material is a source of carbonates and able to act as a binder (Wright, 1985, p. 382; Miller Rosen, 1986, p. 75).[48]

The presence of the use of bricks of multiple colours is a common archaeological observation. It is probably a conscious decision to mix bricks of different stacks and sources. Some have suggested a symbolical meaning related to the performance of construction (Love, 2013b). However, a structural explanation may also be proposed. In that case, if bricks were of variable quality, a more or less equal distribution of the weaker and the stronger ones would be logical. The common occurrence and use of bricks of different quality has also been suggested by some ancient sources, which refer to ordering certain quantities of good and of lesser quality bricks (Sauvage, 1998, p. 18).

[48] If this is correct, then Sauvage (1998, p. 18) suggestion that bricks described in the texts as bad quality were produced from 'archaeological earth' and the good ones of newly acquired earth cannot be correct, and it should be the reverse.

Figure 58. Brick colour, texture and size of the two largest buildings. No colour means no data. Light brown: brown crumbly brick. Darker brown: brown medium compact brick. Dark brown: compact brown. Grey brown: brown and grey compact bricks. Brown with red stripes: greyish brown compact and reddish brown crumbly bricks.

Red loams are found in bricks throughout the *Dunnu*, but a couple of examples stand out because of their specific application. Interestingly, the walls of one of the most prominent building on the site, the large residence, are made of interchanging courses of reddish brown and greyish brown bricks (Figure 59). As for all these cases, a functional explanation is likely, but a symbolical one should not be excluded. Hypothetically, the act of combining the old and the new earth seems quite susceptible to attachment of symbolic meaning.

Another significant amount of reddish-brown loams was used in walls that were part of a reconfiguration in the south eastern corner of the *Dunnu*. However, different than from the walls of the residence, these were completely built out of red earth, probably from one source. Therefore, no deliberate choice was made to combine the red with the grey type of mud bricks. Since this reconfiguration took place in a phase while the *Dunnu* was used actively, perhaps it simply reflects the fact that they had moved the production of these bricks out to the plain in order to not interfere with the daily activities of the *Dunnu*.

Figure 59. The use of interchanging courses of crumbly reddish brown and denser brownish grey mud bricks in the residence. 'Interchanging courses' may be a slight exaggeration of reality. It was not applied this neatly in all walls of the residence, and even this photo of the 'best example' shows quite some randomization in the placement of mud bricks of different colours.

V.4.3 Bricks

The walls of the Assyrian *Dunnu* are made of large quadrangular mud bricks of a type that had already been a standard size for a long time: they are already used in Akkadian architecture of the late 3rd millennium and seem to have become a regional standard around this time or a little later (Sauvage, 1998, p. 157). These are large and heavy units of construction, measuring about 40 cm x 40 cm x 10 cm and weighing about 22.5 kg each, a size and weight that can only be handled by one person if using two hands. Bricks in later periods (Achaemenid or today) are usually half this size or even smaller, allowing easier or single-handed handling. Based on this average size, the *Dunnu* brick can be classified as a ‘type 10 brick’ in Powell’s brick types, for which a standard size of 39.8 x 39.8 x 8.3 cm is given (Powell, 1987). However, the *Dunnu* brick clearly is thicker on average and shows considerable variation in length and width dimensions.

The brick sizes of the *Dunnu* were not measured systematically and no reliable statistical or exact locational information for them is available. Measured examples taken from the day notes and field drawings show a remarkable range from 34^2 to 42^2 cm, suggesting no strict standard sized moulds were used. In a relatively neatly constructed building like the residence this variation of sizes is a little lower (38^2 to 42^2) then in the neighbouring central building (34^2 to 40^2) (Figure 58). This variation is not solely the result of various building phases using different bricks, but occurs often in one and the same wall of one building phase.

V.4.4 Straw

Although the straw content in the mud bricks of the *Dunnu* has not been subjected to closer study, the perceived amount of straw imprints found in mud bricks during excavation is low (Brüning, pers. Comm.). This would be in accordance with the use of rational amounts of straw applied to improve structural performance of a brick (chapter 3). Straw supply is dependent on local availability. Agricultural fields growing barley and wheat are a precondition for large amounts of straw. If these were not present prior to the founding of the *Dunnu*, they must have been acquired from further away, which has quite some implications for the cost of construction. Considering the historical context of conquest and population decline in the preceding period, it is possible that the builders of the first *Dunnu* had a hard time finding enough straw supply.

V.4.5 Wood

Charred wood remains have been found throughout the *Dunnu.* The excavated charred wood is generally very fragmented, and pieces that preserve the entire diameter of the original timber show that these were not part of larger beams. The few measured pieces are only 5 to 8 cm in diameter. The common practice of removing roof beams after abandonment, possibly even when partly burned, may be the reason for the absence of evidence.

The charred wood remains have been sampled and botanically analysed by Fantone (pers. comm.). Although some of the analysed wood samples may have been used as fuel, it seems a fair assumption that a large amount of charred wood found in the burnt layer originated from roofs or upper floor constructions. This is moreover supported by the fact that much wood is found in the collapse deposits. The analysis shows the predominance of poplar/willow and ash. Regarding the latter, this must have been the narrow-leaved ash, possibly a variation called syriaca. Like willow and poplar, this is a tree common to riparian habitats, and requires wet soil. The absence of imported species mirrors the observations made at Middle Assyrian Tall Šēḫ Ḥamad (Frey, Jagiella and Kürschner, 1991).

Although timber transport over long distance was common in antiquity, even for species like poplar, the location of the *Dunnu* is not particularly favourable for long distance transports over water. One of the main sources of the Balikh is just 25 km north. Another branch leads towards Harran in modern day Turkey, which hardly flows any water today as it is used for agriculture. However, in theory, it may have been possible to seasonally transport trees from highland Turkey. Nevertheless, it seems more reasonable to assume that these trees were felled locally. As has been described in chapter 1, parts of the Balikh valley were a marshy area during long periods of its history. Even if some of it was drained and used for agriculture, it is likely that riverine and marsh forests still existed in the Bronze Age. The identification of the species based on the charred wood samples seems to confirm that.

Figure 60. Identified wood species based on analysed charcoal found in the Dunnu. Left: poplar/willow. Right: relative quantities of fraxinus against willow/poplar (figures produced by Federica Fantone).

V.4.6 Reed

Reed must have been acquired from nearby as well. The Balikh riverbanks and marshland are an obvious source for reed, but it could also have been harvested from the banks of drainage and irrigation channels, where it would have grown plentifully.

Evidence for the use of reed stalks, primarily for roofing, has been found in the *Dunnu* of Tell Sabi Abyad. Although it is regularly mentioned by excavators, the only saved and photographed specimen of reed imprint from a roof is from a Neolithic context. Reed imprints are mostly found in the debris that fell into a room, so we may assume that these belonged to roofing material. No evidence for woven structures has been recorded. Archaeobotanical analysis being absent, the species of reed or constructional features could not be determined. No evidence has been found for the use of reed as structural reinforcement of walls, a feature occasionally found in mud brick architecture.

V.4.7 White plaster

The Tell Sabi Abyad field notes frequently use ‘white’, ‘brownish white’ or various other descriptors for whitish plastered walls or floors. In the reports they are commonly referred to as ‘lime’ based floors and wall plasters, but in theory they could be gypsum based instead. Without chemical analysis it is not possible to distinguish between lime or gypsum plasters (Moorey, 1994). Because of the high occurrence of gypsum deposits in the surroundings of the *Dunnu*, it is possible that the floor and wall coatings were gypsum based. The differences in manufacturing process and their consequences on material cost have been noted above (V.2.4).

The material is applied in outside spaces as well as in inside spaces. The evidence is summarised in figure 61 - figure 63.

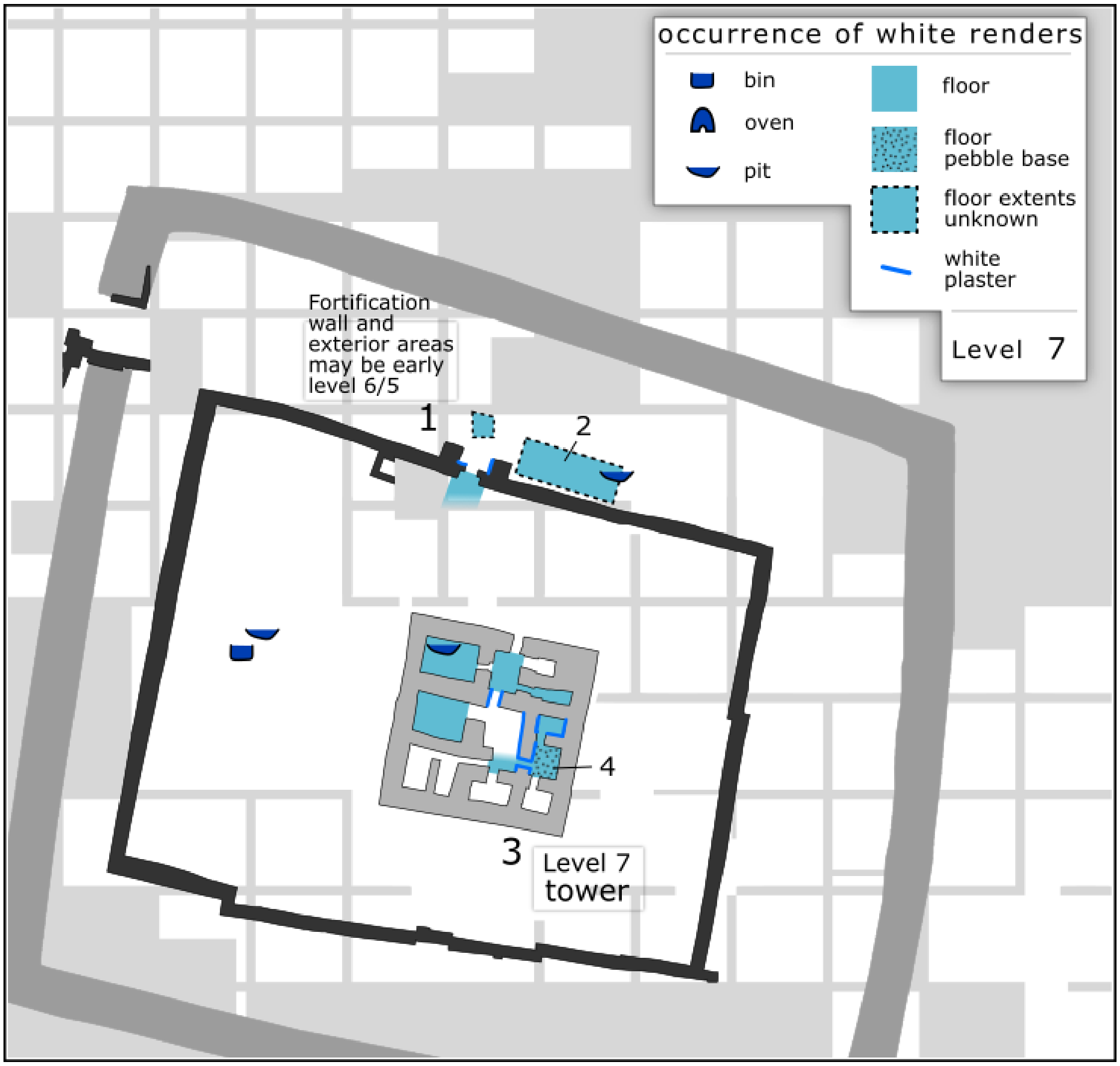


Figure 61. Level 7/early level 5/6 evidence for white renders in the Dunnu.

Figure 62. Early level 6/5 evidence for white renders in the Dunnu.

Figure 63. Late level 6/5. Evidence for white renders in the Dunnu. For some areas indicated on the figure, already rendered in early level 6/5, it is uncertain whether the white render was maintained also in late level 6/5.

Both floors and wall plasters are in some cases described as a thin layer (3-5 mm) on top of a loam plaster, and at other times as a thicker layer entirely made up of a 'limey' material (1.5-3 cm). This may suggest that pure lime/gypsum plasters as well as lime/gypsum enriched loams were used.

Alternatively, the thickness may have been the result of multiple plaster coats. However, in most cases no multiple coats of plaster were recognized, but there are a few exceptions (see next).

A special treatment was given to room 5 of the residence, were a 3 cm thick pinkish-white to pinkish-orange-white plaster was found. Perhaps these are traces of pigmented plaster. The plaster was applied in multiple layers (**7**).

A few floors are described as cobbles or stones embedded in white plaster. Some are in the heavy-duty areas referred to above. Another is found in level 7 phase room 6 of the tower, which use is unclear and somewhat enigmatic due to various other special finds (**4**).

There is a pattern in the spatial and diachronic distribution of white plasters. White plasters have been used on walls and floors in the core of the settlement within the confines of the perimeter wall, as well as in the extramural area. But most white plastered spaces are found in the northern half of the intramural *Dunnu*, likely related to the fact that representative spaces are found here (see also below). White plastered walls and features are not only found during the most ‘prosperous’ period of the *Dunnu* proper. They are also very common during the later ‘domestic’ period (levels 4, 3 and 2, not depicted).

The evidence indicates that the area around the new front gate, walls as well as ground surface, was whitewashed, possibly in correspondence with age-old practices related to doorways (**5**). The same held probably true for the old gate (**1**). Multiple whitish floors found below the floors of room 1 in L08 and rooms 1 and 2 in L09 probably belong to the phase of the old gate (**2**), rather than being old floors of the buildings they were excavated in (as suggested by the documentation regarding this area). Their elevation and the fact that the area around the new gate was completely plastered as well, makes this conclusion plausible. Also the front part of the residence and great court bear traces of white plaster (**6**). Since white wall plasters are a relatively rare phenomenon in the *Dunnu*, it is hard to ignore the suggestion that this must relate to the special status or representative functions of the main gates and façade of the residence.

Large parts of the tower, including the floors showed traces of a white plaster in the buildings earliest phase, e.g. the level 7 phase which is considered pre-Assyrian. On some later walls also traces of white plaster appeared, but the white plastered floors do not return in later ‘Assyrian’ phases (**3**). It may suggest a function difference between the earliest and later phases of the tower.

On various places, white plaster is clearly related to ‘heavy duty’ use of the area, such as the cooking area in level 5 where both walls and floors were plastered white (**8**). White plaster was used in the construction of the bathroom floor in I07, and in the bathroom of M08. In the first it was the only waterproofing material, while in the second it was applied over a layer of bitumen. A small share of all ovens and bins were lined with a white plaster on the inside, suggesting purposeful functional use of white plasters in the construction of certain fixed features.

V.4.8 Bitumen

In the *Dunnu* bitumen is primarily found in the bathrooms. These are areas of intensified water-contact and places where some degree of hygiene was required (Figure 64, Figure 65). It was used as mortar between the fired bricks of the floor and plinth, and as a coat of bitumen plaster to cover the entire surface. The precise composition, e.g. additives such as sand or vegetal matter, is unknown. Interestingly, not in all bathrooms it was applied the same way. In the bathroom in M08 it was applied over a coat of gypsum/lime plaster. The bathrooms in the residence only use bitumen, and no white plaster is recorded. However, not *all* bathrooms were constructed using bitumen. For the bathroom in I07 only a very hard white (lime?) plaster was used. Why for some bathrooms bitumen was used while for others it was not, is unclear. It could have been a matter of availability, and/or related to the status of the people using the bathroom.

Figure 64. Early level 6/5. Occurrence of bitumen in the Dunnu.

Figure 65. Example of the use of bitumen as mortar between the baked tiles of the bathroom in square M08.

Large deposits of bitumen are found near Hit on the middle Euphrates, but also near Qalat Shergat (Assur) and Kirkuk. This means the Assyrians had good access to resources, but the concentration of this resource often meant that it had to be transported over long distances. The nearest natural deposit to Tell Sabi Abyad is Samsat (Roman Samosata) in present day Turkey, about 120 km north on the upper Euphrates (Connan, 1999).

Without chemical analysis it is impossible to determine the source for the bitumen in the *Dunnu* was, but the choice is narrowed down to two plausible scenarios. It was either traded with the closest source, e.g. Samsat, which was probably outside Assyrian territorial influence, or it was brought all the way from the homeland near Assur. Considering the small amounts used, it appears to have been a relatively scarce resource. If we assume that the purpose-built private bathrooms were not used by everyone, the targeted use of bitumen here suggests it was a rather valuable material in this context.

V.4.9 Stone

The use of stone in the mud brick architecture of the ancient Western Asia is limited, especially on the planes and river valleys. This also regards the Assyrian *Dunnu* of Tell Sabi Abyad. Stone played an insignificant role in construction, even though great quantities of limestone are available close by.

Stone is used to a very limited degree in floors, sometimes embedded in a white floor plaster. In a few cases it seems to have been applied as foundation layer below loam floors. Its function may have been to reinforce and stabilize the floor in intensive use areas. In loam floors, a layer of pebbles could also have served to improve drainage or create a less slippery surface under wet conditions. There are very few other architectural elements made of stone. The sockets for door posts can be made of stone. Evidence has only been found for bottom pivot stones. In traditional construction in the Western Asia, upper door post sockets can be made of a large oblong stone, embedded deep in the wall on one side, and pierced on the other side to catch the door post. Since not a single such object has been found, it is likely that the upper ends of doorposts moved in wooden sockets, or forked branches. Large stones are occasionally used as steps or thresholds. No hewn stones were found.

V.4.10 Baked brick or tiles

Baked brick or tile floors are found in the courtyards and bathrooms of the *Dunnu*, corresponding to the common application of this material in this period and region. The square tiles are smaller than the mud bricks, on average around 33*33 cm. In one case in the north-eastern corner of the great courtyard, the use of over-fired tiles was reported, which suggests that this otherwise relatively elaborate floor did not have to conform to the highest standards. The over-firing of such tiles are a common feature and is related to the manufacturing process. As noted in the general discussion of building materials in this chapter, such tiles were probably fired in a scove kiln, which produces many over-fired and under-fired bricks.

The tiles were most likely produced locally. However, no direct evidence for this process in the form of wasters, unbaked specimens, or storage near a kiln has been found. The scove kiln leaves hardly any structural traces, as it is completely dismantled to get the bricks out. The evidence on site suggests that the large updraught kilns found here seem to have been used for pottery production. They could nevertheless in theory have been used for tile baking at an earlier stage, although this seems unlikely because of their limited capacity.

It is likely that most tiles were produced at one point in time, when the large courtyard and the residence were built. Together these form about 80% of the total fired tile surface area in use at this point in time. It is possible that later incidences of baked brick, such as the floor of a bathroom in L11 contained re-used tiles. Re-use must have occurred, since only part of the tiles of the large courtyard have been found in-situ. That the original floor covered a larger surface, is clear from the occasional brick or imprint of brick found on the edge of an otherwise brick-less area. A pile of broken bricks was found on the side of the courtyard, and throughout the *Dunnu* other small piles have been found, as well as some tile surfaces. It is very likely that these piles and later surfaces all contain tiles from the older dismantled floors, primarily the large courtyard.

The baked tile pavements are an interesting floor type. In the *Dunnu* such pavements are restricted to bathrooms and two large spaces. This matches very well with what we know in general about the range of application of such pavements in the Middle and Late Bronze Age. Examples are Old Babylonian Ur (Woolley, Mallowan and Mitchell, 1976), the Middle Bronze Age residence at Bakr Awa (Miglus *et al.*, 2013), and Middle Assyrian houses in Nuzi (Starr, 1939, p. 44). Within the Mitanni/Hittite sphere of influence the same picture arises at sites such as Tell Fakhar (Khalesi, 1977), the palace at Tell Taban (Numoto, 2008), the Mitanni palace at Tell Brak (Oates, Oates and McDonald, 1998), and the palaces of Tell Atchana (Woolley, 1955) and Zincirli (Luschan, 1893). In all cases tile, pavements are found in private courtyards in houses, in large (semi)public courtyards in front of the main building in monumental architecture, and universally in bathrooms. Tile pavements are more rarely also found in a food production area, 'kitchens', such as in the palace of Tell Brak or in the middle bronze age residence at Bakr Awa (Miglus *et al.*, 2013). In Ur, it is interesting to note that in private houses tile pavements were occasionally found in the 'principal room'. Hence, although it is not restricted to exterior spaces, such pavements are strongly connected to public and representative spaces, that were often unroofed courts and courtyards.

V.5 Construction methods and techniques in the *Dunnu*

V.5.1 Dimensioning

The base unit for dimensioning buildings most likely was the *kuš* or cubit, or about 50 cm (V.3.1). The precise length of a *kuš* differs across regions and time periods. Variations in base unit length between different buildings could therefore be interesting as they give new information about the different building fases and the origin of their respective builders. Theoretically, the unit length used by the builders in the past can be reconstructed by laying out a grid with 50 by 50 cm squares over a site plan, then scaling it until a whole number of squares fit the excavated spaces. In practice it is hard to acquire reliable results when this method is applied on the *Dunnu* due to the strong post-depositional deformations of wall structures. In addition, there is no consistent documentation of the position of the wall bases, which would be a more reliable measure as opposed to the top of the wall that is usually drawn on the plans. The result is that reliable grid sizes are hard to establish. Notwithstanding these caveats, a grid size of 47.34 cm gives a reasonable fit for various wall-to-wall distances in the residence and tower, and various other buildings integrated in the fortification wall.

Figure 66. Two slightly different grid sizes projected over part of the residence.

V.5.2 Foundations and wall bases

Foundation methods in the *Dunnu* reflect the basic practices seen in traditional mud brick architecture (Figure 50). It is important to emphasize that generally, no use was made of trench foundations, one exception aside. Although trench foundations are occasionally referred to in the day reports of the excavation, the evidence is scanty and suggests that these were not applied consistently by the builders of the *Dunnu*. The features referred to in the reports are generally local cuts, possibly to level a slope or bump. The main concern of the ancient builder was to create level construction surfaces to ensure wall stability. The absence of trench foundations may be related to the large dimensions of walls in general, which increases their stability. The effect of this practice is that floors and walls are often founded on nearly the same level. Divergence between wall base and floor base level does however occur because of various more shallow techniques to level ground and micro terracing, to enable construction on the sloping surface of the tell. Levelling ground can also be attained by dumping deposits on a surface. In the case of the large rooms of the residence, it has been observed that this occurred after the construction of a wall. Beyond adding to our understanding of construction, these practices are also important to consider in reconstructing building phases, as they complicate stratigraphic relations. For instance, different walls, or even parts of walls of the same building may not have matching foundation levels. Stepped foundations are common, and this state of matter should not be wrongly interpreted as phased construction.

No other special treatments of the bottom of walls was found. No stone plinths or damp courses are used, apart from tile plinths in bathrooms. Thus one may assume that the effects of capillary water or rain was not a great concern to the builders of the *Dunnu*. More recent traditional construction practices in the area also do not apply stone wall bases.

In the following some archaeological evidence regarding foundations is discussed in more detail.

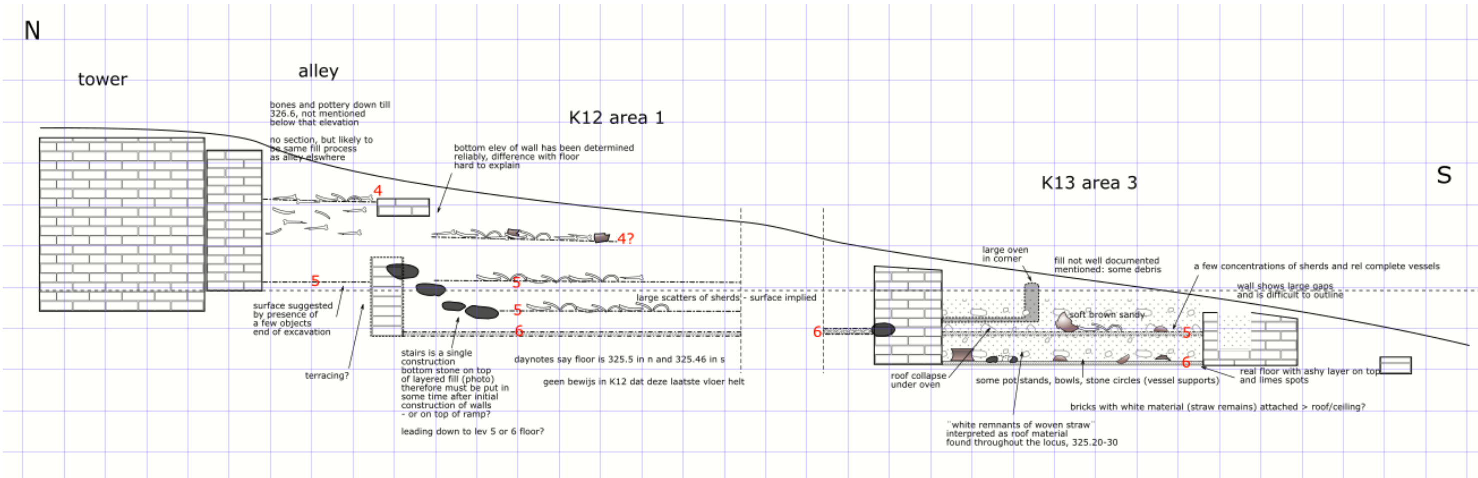


Figure 67. Deposit sequence graph of area south of tower showing the terraced nature of the architecture.

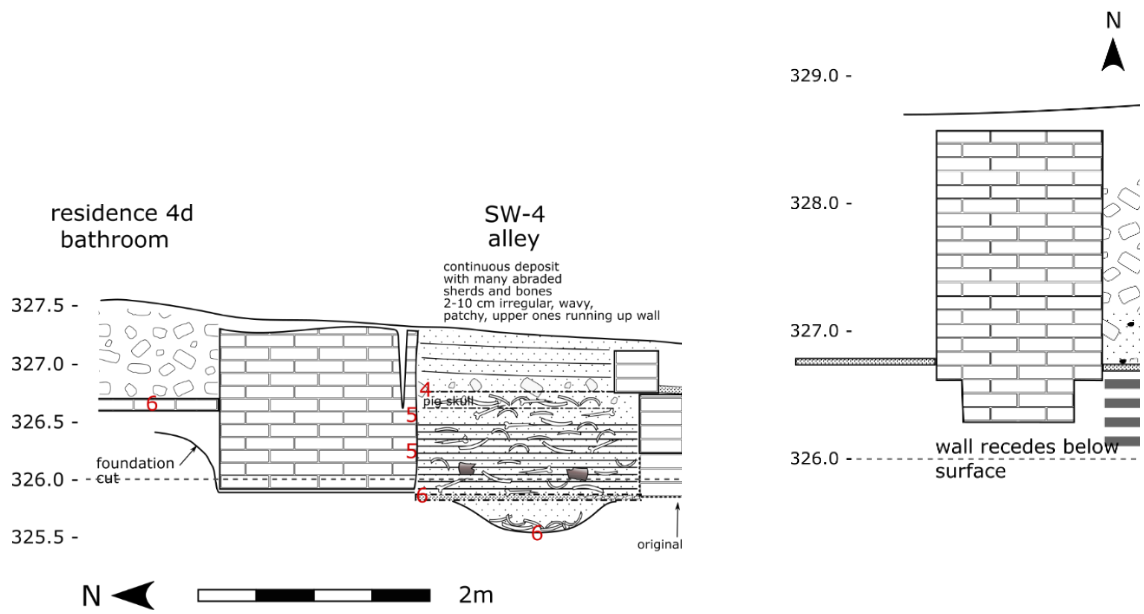


Figure 68. Left: southern exterior wall of the residence, showing the foundation cut, and the stratigraphic relation with the deposits in the alley along the back side of the building. Right: the receding foundation of the long eastern north-south wall of room 2.

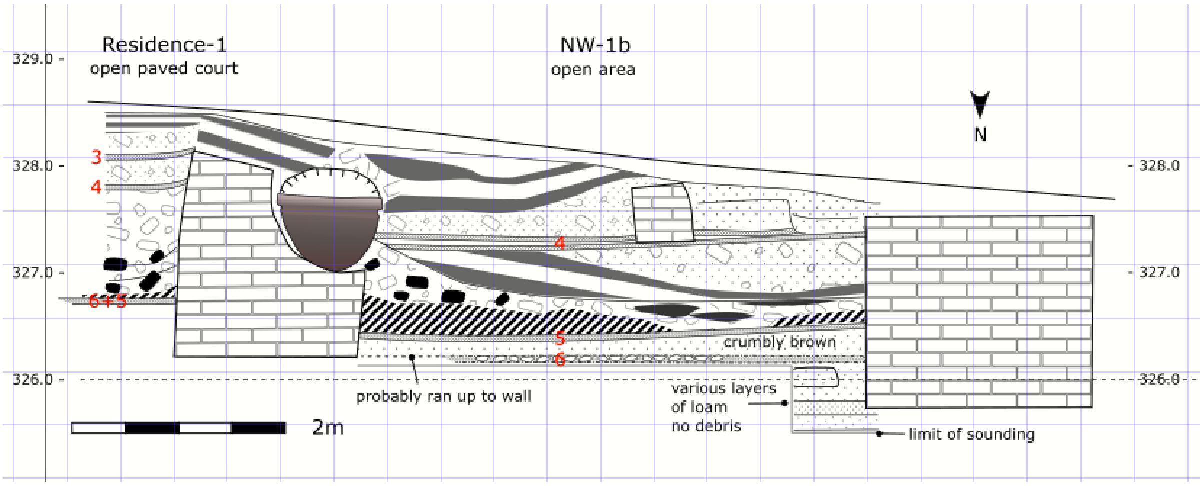


Figure 69. Deposit sequence graph of area between western wall of residence and western fortification wall.

Terracing is an effective manner of locally levelling ground for construction on a sloped surface such as a tell. It is evidenced on a number of places. It is most clear in the southern and south-eastern sides of the *Dunnu*, where the original tell surface was steepest (Figure 68). Terracing is also implied by the construction of long walls, such as the fortification wall, and the walls of larger buildings such as the residence and the tower, whose wall bases are stepped. In the southern *Dunnu* we find three terraces: one for the fortification wall and associated heavy walled buildings, one for the lighter walled architecture, and one for the southern walls of the two large central buildings. The southern walls of the residence and the tower seem to have acted as retaining walls at the same time as giving support to the roof of these buildings (Figure 68, Figure 67). It seems that in these cases, terracing causes a difference in foundation heights between the heavy walled structures attached to the fortification wall, and the lighter architecture that was built against it. The elevation difference ranges from 15 to 50 cm between the foundation of the heavy walled architecture and the floors of the light-walled architecture. It quite plausible that earth was brought in to create level floors, causing the stratigraphic difference. In this area, there is some evidence for a phase preceding the light architecture, hence the terrace is partly built up by previous occupation layers that have caused the rise in elevation relative to the heavy walled architecture.

Another case of terraced construction is found in the area east of the tower. The same pattern occurs where three terraces are implied by the construction heights of the tower, the light walled architecture, and the fortification wall and connected buildings. However, in a second construction phase, the area was modified completely. The terraces were removed by filling up the lower parts, those located directly alongside the interior of the fortification wall, with great quantities of debris. It is possible that this was done out of convenience, as it was an easy way to dispose of the demolition debris that was created by thorough renovations.

Last, we have evidence of terracing in the construction of the residence and western fortification wall (Figure 69). In a trial trench crossing this space a thick layer of loam was found to be deposited against the fortification wall. Again, it is plausible that this was a backfill layer, deposited after construction of the fortification wall and the residence in order to level the sloping ground between the two buildings (Figure 71). This interpretation suggests that the residence and the western fortification wall were probably part of a single building project.

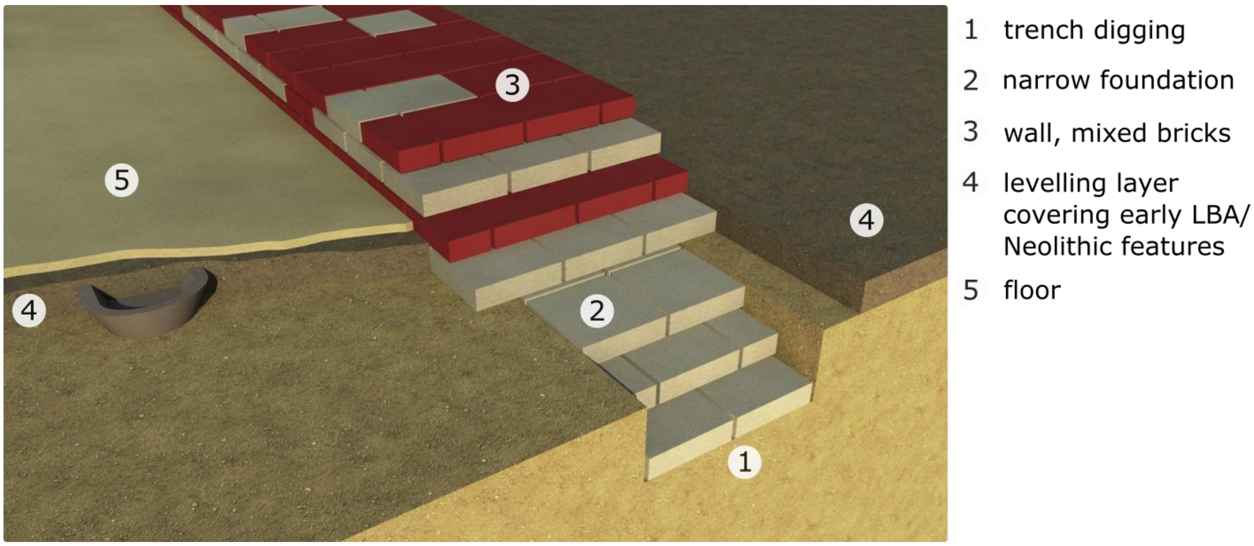


Figure 70. Interpretation of excavation data for interior load bearing north-south walls of residence. Showing the receding foundation, and dumping of soil as levelling layer.

As said, there is not much evidence for foundation trenches, apart from in one building, the residence. The residence forms a special case in the foundation methods used in the *Dunnu*, underlining the special status of this building. As mentioned above, its exterior walls were constructed on small terraces especially made for them, carved out in the slope. A trench foundation method appears to have been used for its two long load bearing interior walls, the only walls for which we have good evidence of a trench foundation, cutting into previous LBA exterior use surfaces (Figure 70). As opposed to common foundation types for brick masonry walls, the wall constructed in this trench is in fact *less* wide than its superstructure. This suggests that the main function of the trench wall was not to distribute the downward forces of the building more evenly to the subsoil. There are two possible other locations where such foundations have been found in the *Dunnu*: in the tower, and below the fortification wall in room in the north-eastern corner of the *Dunnu*. Since the archaeological excavation rarely extended underneath the walls, it might have been a more common foundation technique for heavy architecture. In the tower, the receding foundation was taken in the reports as the evidence of an older construction phase of the wall rather than a foundation type. The evidence for the oldest building phase in this part of the tower – as opposed to the northern part – is however too scanty for definite conclusions. Because of the partial excavation, we can also still not entirely exclude the possibility that the foundation wall in this trench was of a previous building.

Another typical feature of the foundation of the residence are the raised floors (Figure 70). After construction of the main walls, a levelling layer was deposited inside the building. Due to the size of the building, it covered a significant portion of the irregular surface of the tell, requiring the addition of this layer. Although many buildings show such a raised floor built on top of a backfill or demolition deposit, this always concerns a secondary construction phase. In the case of the residence on the other hand, the levelling layer was part of its original construction.

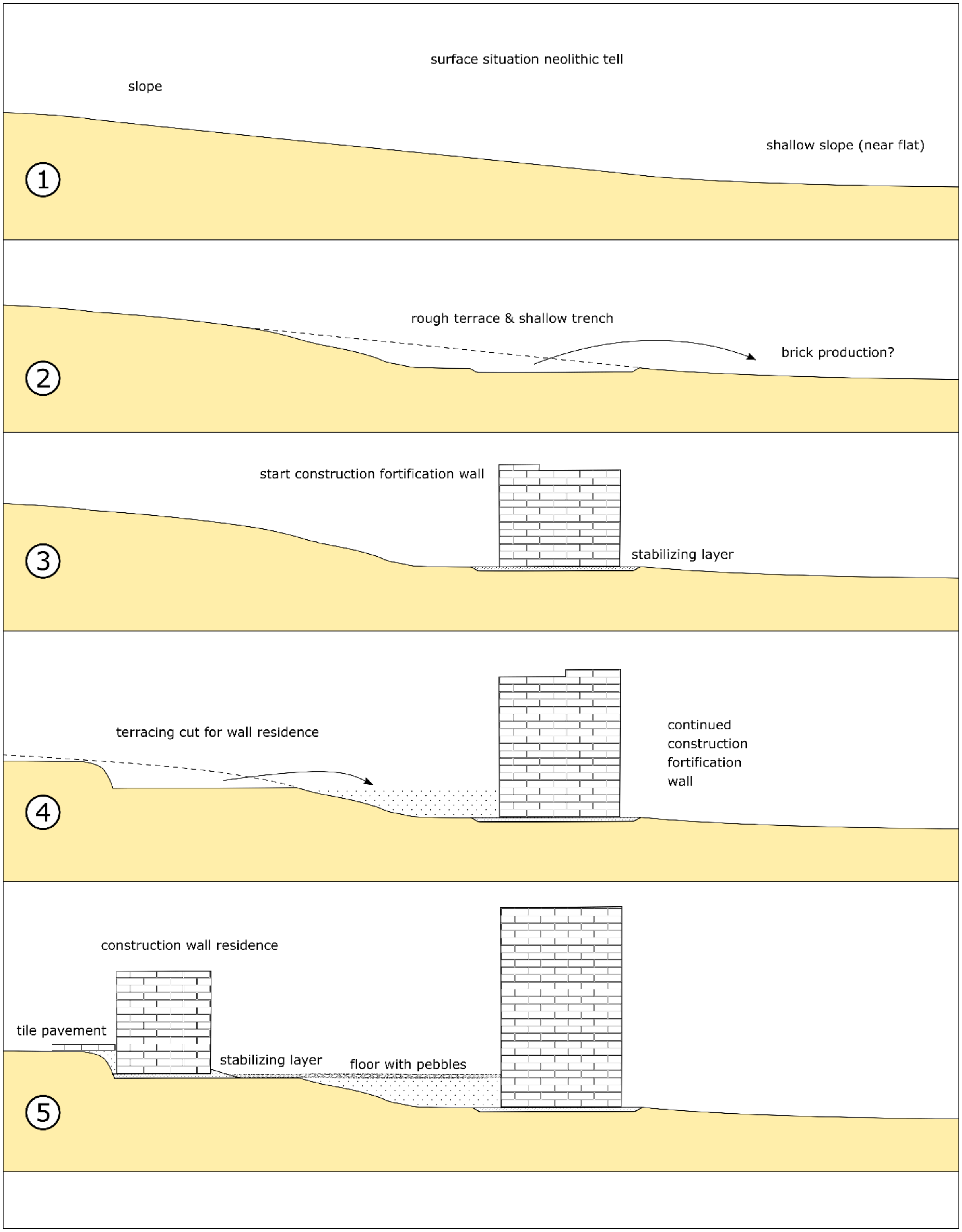


Figure 71. Proposal for the order of construction of the western fortification wall and residence.

A common foundation practice in ancient construction was to prepare the construction surface with deposits of ash enriched soils, which is aimed at soil consolidation (Wright, 1985, p. 382; Miller Rosen, 1986, p.

75). This may have been observed in a section across the northern fortification wall in L08/M08 (Figure 89). Also visible on this section is that the fortification wall (Q2 on the figure) seems to cut another layer (4 on the figure), which may indicate that soil was removed prior to construction. This was followed by a stabilizing layer of ash, and then a wall. But it is just as likely that the layer indicated with 4 was not cut by the wall, but deposited against it to level the construction surface for walls K/Q3. The ambiguous interpretation of this section results in opposite hypotheses regarding order of construction events, and have a major impact on our understanding of settlement development.

Finally, the practice to use mud bricks to create construction terraces or platforms may also have been used locally at the *Dunnu*, but the situation is quite unclear. In square L08 two superimposed mud brick 'floors' were found underneath the building just discussed (space NE-2b). They do not seem to be part of an interior floor, but seem to have been used as an outside surface. The structure is also quite fragmentary, and it is possible that these were used in a levelling layer that in part filled an older (fortification?) structure of which the remains were found underneath the eastern wall of building NE-2.

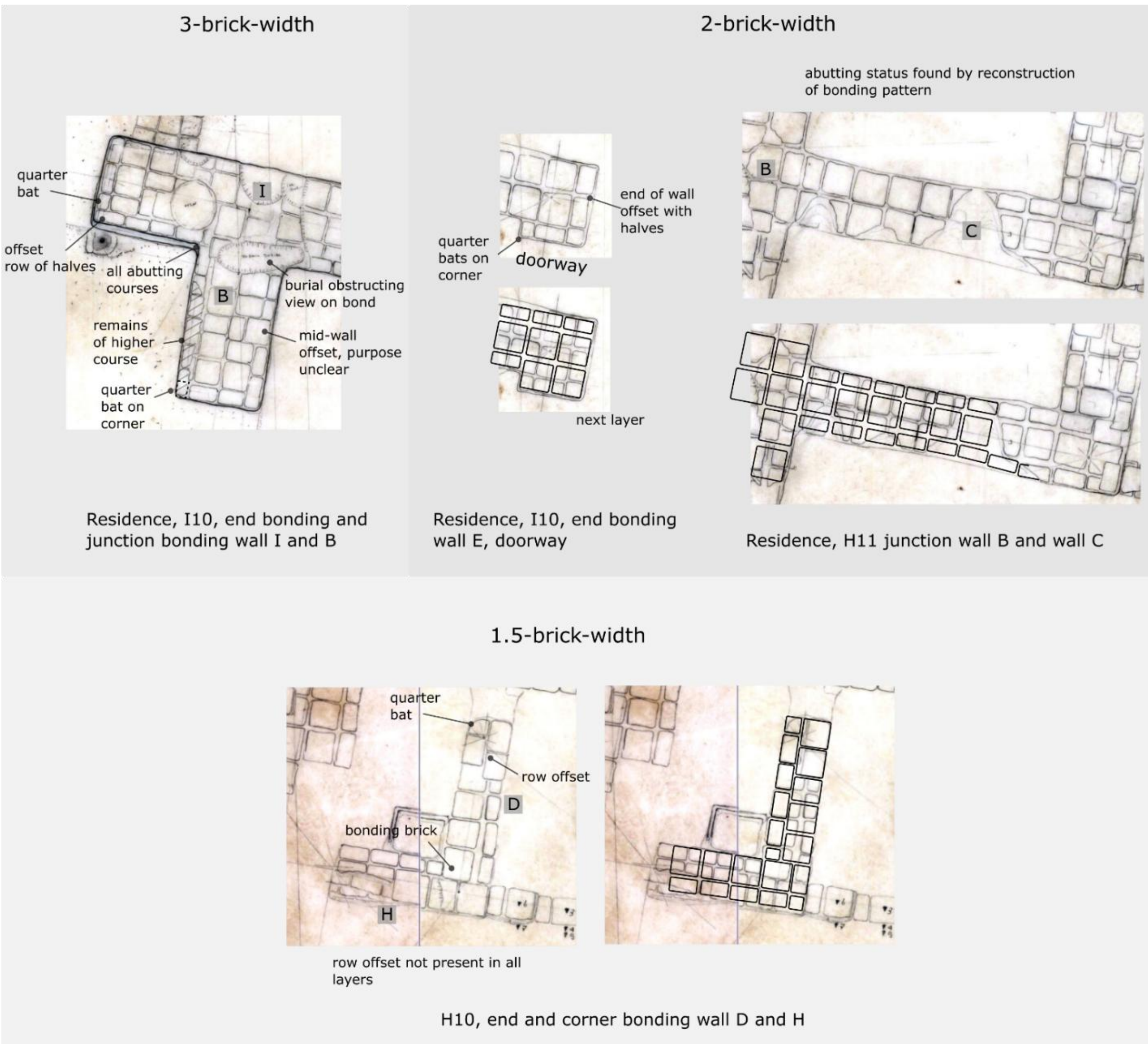
V.5.3 Wall construction

Wall construction in the *Dunnu* may be characterized as straightforward and highly functional. The walls of the *Dunnu* are made of large quadrangular mud bricks of a type that had already been a standard size for a long time: they are used in Akkadian architecture of the late 3rd millennium and seem to have become a regional standard around this time or a little later (Sauvage, 1998, p. 157). These are large and heavy units of construction, measuring about 40 cm x 40 cm x 10 cm and weighing about 22.5 kg each, a size and weight that can only be handled by one person if using two hands. Measured examples taken from the day notes show a range from 34^2 to 42^2 cm, suggesting no standard sized brick moulds were used. However, we should take into account the inaccuracy involved in measuring archaeological bricks, variable shrinking rates, and post-depositional factors.

Figure 72. Plan of the Dunnu *with all mud bricks drawn.*

V.5.3.1 Brick bonding patterns

Bricks are laid universally in running bonds. As noted earlier in this chapter, square brick masonry has no headers and stretchers. As a consequence of this, and of the variable wall-width there is quite some variation in bonding patterns, revealing the craft and training of the builders. To create the offset required for bonding, halves and quarter bats are used at the edge and end of walls. Walls are between 0.5 and 8 bricks in width. For each width, a different bond pattern is required, and applied with skill at the *Dunnu*. For instance, whole brick width walls (1, 2, 3 etc.), every other course, two rows of halves must be used to create an offset. With walls of a size that already includes a half (1.5, 2.5), every course has one row of halves, but the location of the row switches to ensure the vertical bond. Occasionally, quarter bricks are found to be used at the end of a row of halves, or to fill up a hole in a corner bond. The wider the wall, the larger the range of possible solutions for brick bonding, and interestingly some variation in practice may be observed here. For instance, in some larger walls, rows of halves are sometimes found in the core of the wall, while in others, rows of halves are only used on the exterior face of walls. Unfortunately, as the bonding patterns of walls have not been documented systematically layer by layer, it is impossible to make more detailed observations or draw further conclusions.



Residence, I10, end bonding and junction bonding wall I and B

Residence, I10, end bonding wall E, doorway

Residence, H11 junction wall B and wall C

H10, end and corner bonding wall D and H

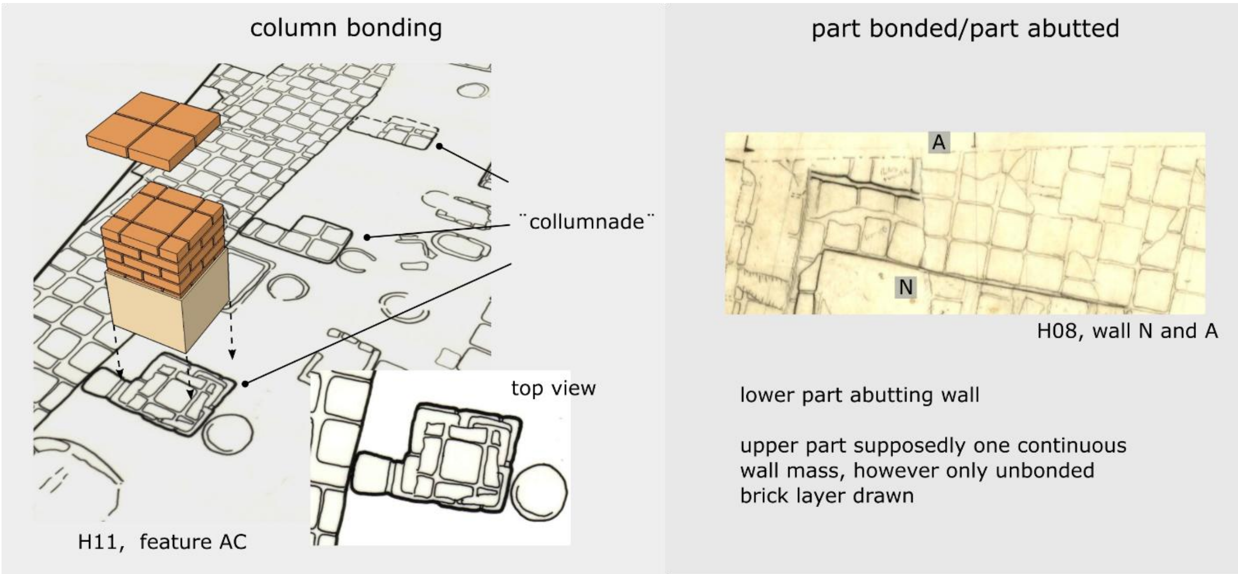


Figure 73. Brick bonding patterns documented in the Dunnu

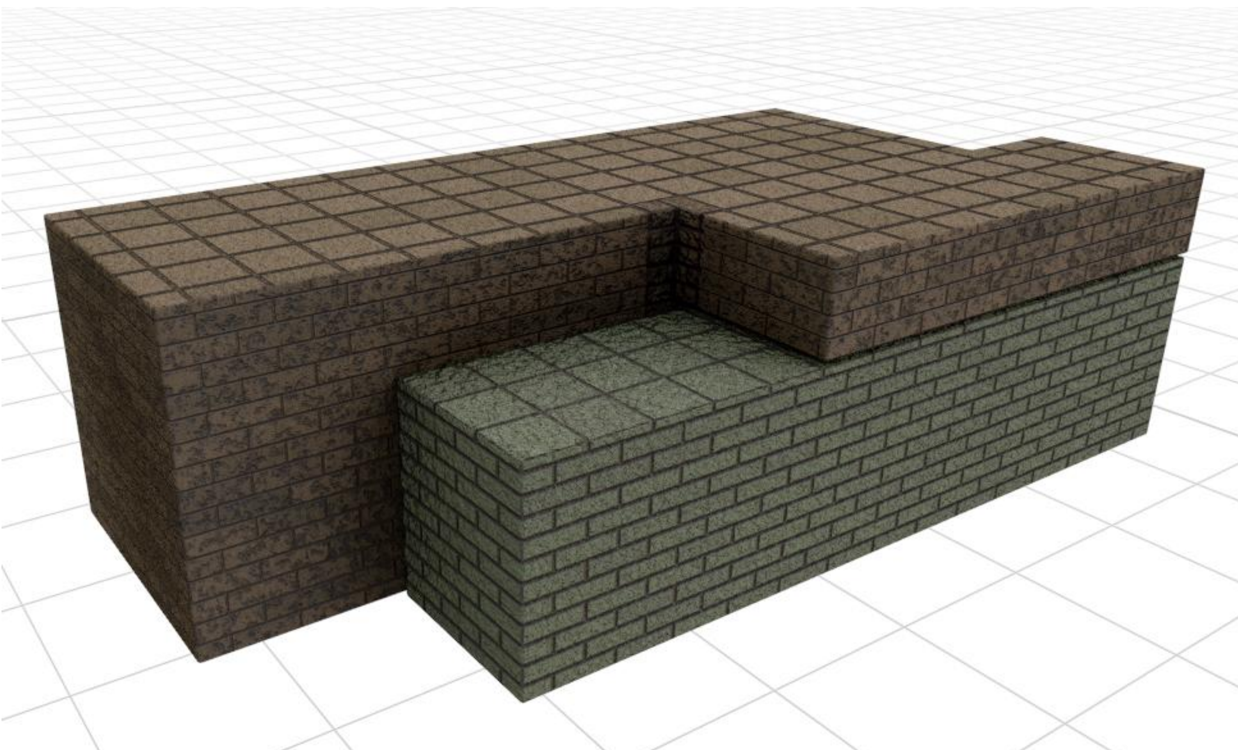


Figure 74. Example of a wall abutted in the lower section, while bonded higher up.

V.5.3.2 Brick variability within walls

As discussed above in the section on building materials (V.4.2 and V.4.3), mud bricks used in walls are not all the same. A large variability in terms of mud brick sizes has been noted (Figure 58). A large building like the tower applies mud bricks of a larger range in sizes than the residence, which is interesting and may be related to the different construction histories and functions of these buildings. Another source of variability is mud brick material, or loam source. It appears that different sections of wall of the tower were constructed using bricks made of slightly different loams. In one cross-section of the fortification wall, various layers of bricks with different material characteristics have been noted (Figure 75). The cause of this variability is uncertain: they could be either indicative of differences in construction phases but may also relate to building logistics. In the latter case, different batches of bricks from different sources have been applied in the building. Especially large structures such as the fortifications or the tower can be expected to have been built with a range of bricks sourced from different loams, and/or from brick production teams with different regional backgrounds. The difficulty in determining the cause of these observed patterns in masonry variability is an important source of uncertainty with regard to the reconstruction of building phases.

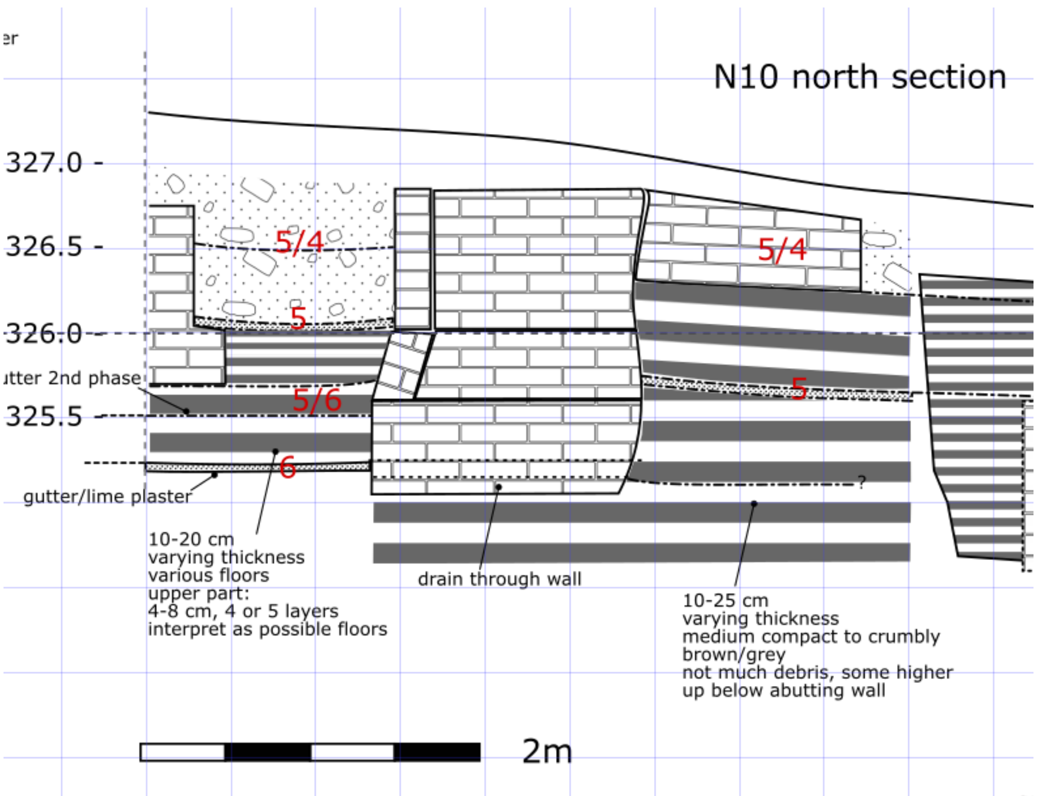


Figure 75. Deposit pattern graph of area around eastern fortification wall, square N10.

In another case, variations in brick material reflect deliberate choices in the patterned application of building material. The intermittent courses of red and brown bricks, as seen in the residence (Figure 59) and walls of the large courtyard (Figure 84) is clearly a constructional decision made by the builders. Although it is not completely clear what the function of this feature is, the pattern appears to be limited to the area of the *Dunnu* that was most strongly involved in the communication of political and social status. However, as the bricks themselves were not visible, and the pattern was too irregularly executed to have any decorative function, it was most likely related to a structural consideration. Possibly "wall quality", or the fact that these walls were to be plastered with red coloured loam plasters and renders played a role. The latter, somewhat speculative, hypothesis is suggested by the fact that only the lower, red plastered, part of the courtyard walls also had intermittent courses of red and brown bricks (Figure 84). But it could be that the red bricks provided better bonding surface for plasters. However, an alternative explanation for this material distinction is that the upper part of the wall belongs to a renovation phase during which this part of the *Dunnu* was partially demolished and build up again. But this also is not an unproblematic hypothesis (see V.6 Modification and repair).

V.5.3.3 Vertically narrowing walls

Builders may apply the principle of vertical width reduction in order to optimise space and structural functioning of a building. In such cases, the width of a wall decreases either gradually or incrementally with the height of the wall. This enhances wall stability, lessens wall weight, reduces the amount of building materials and increases space size on upper floors. The decrease of width often initiates at the second-floor level, and therefore rarely preserve archaeologically. Although the technique is often seen used in large structures such as fortifications and buildings with over two floors, it is uncertain whether this technique has been applied in the *Dunnu*, as wall height preservation is never sufficient.

At one location only could decreasing wall widths be identified. In space NE-3b, both the northern and southern wall have stepped interior faces (Figure 23, Figure 76). The northern wall, the interior face of the old fortification wall, is set back only once, while the southern wall has two shorter steps. The excavation documentation refers to these as 'wall phases', implying a near complete demolition and rebuilding of these walls. Although possible, it is stratigraphically and practically unlikely. An old, blocked doorway cuts both "steps" and since this blocking appears stratigraphically earlier than these supposed building phases[49], it would imply that a blocked doorway was rebuild during these renovation phases. There is in other words no justification to rebuild an unused doorway, implying these steps should be considered integral part of the original wall construction. An alternative option is that the wall was intentionally reduced in width without demolition and rebuilding, but simply by excavating it vertically to set it back some decimetres. The fact that these width reductions align with the floor levels in this room, may imply a correlation with such different kind of 'building' phases. Trying to find the logic behind such choices, it is possible that the northern wall of this space, which also is the old fortification wall, could be reduced in width as its defensive

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[49] Assuming the rebuilding phases are associated with the higher floor levels.

function had been lost. This reduction of wall width, allowed for some increase of floor surface of the room inside. Whether the minor reductions in width seen in the southern wall can have the same reasoning applied to them is however questionable. The possibility that we are dealing with exposed and damaged wall surfaces, difficult to recognize in excavation may also play a role in the creation of this pattern.

Summarising, the evidence for a building method in which wall width reduces with the increasing height of the wall, is limited.

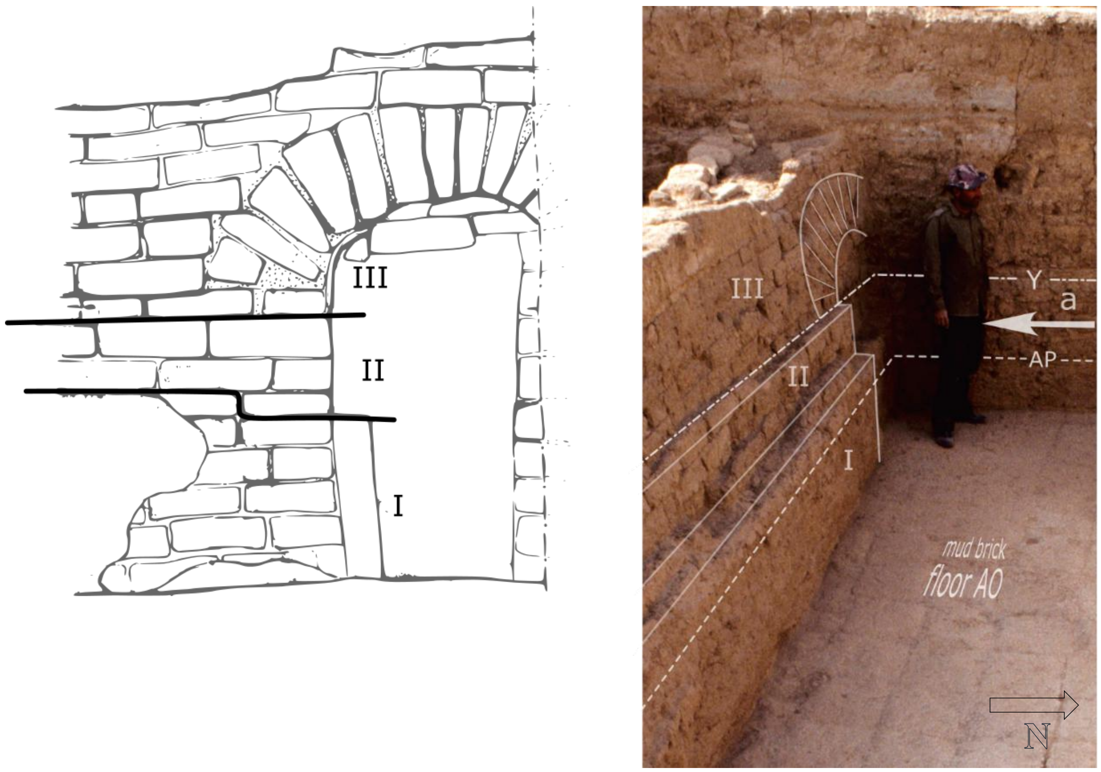
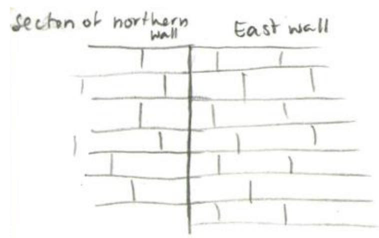


Figure 76. Doorway AJ and wall I, in space NE-3b in M09 with layers of offsetting brickwork.

V.5.3.4 Corners and T-junctions

At the meeting of two load bearing walls in a corner, a corner bond is needed. In a few cases with larger buildings, interior walls are also bonded to the exterior walls at T-junctions. Bonding at corners and T-junctions is often applied only every other brick layer. This makes using the plan drawings for establishing the presence of a bond unreliable, since generally only the visible course is documented. Although wall relationships are required to be filled in on the feature forms, this has not always been done. There are also possible cases where unique bonding patterns are overlooked by excavators unfamiliar with the potential variability of mud brick building techniques. An example is the way the long interior walls of the residence are bonded to the exterior walls (Figure 78, Figure 79). These are load bearing walls, and one would thus expect solid T-bonding with the northern and southern exterior walls. However, bonding is attained using just one brick every course. This brick may switch locations within the course, or stay in the same place (Figure 79). The use of a single brick as bonding brick makes it difficult to recognize bonding when looked at the wall interface from the side, which gives the wrong impression that the wall is abutted (Figure 78).

Figure 77. Wall relationships found in the Dunnu



Sketch in day notes I10 10/09/2001, claiming walls I and B are abutted.

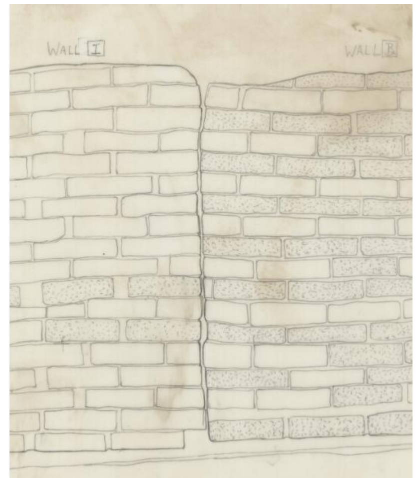


Figure 78. Abutted or bonded? All documentation of the connection of these walls suggests they were abutted. The top was disturbed by a grave, and the other side was not investigated with the same rigour. The mirroring set of walls across the central room however suggest that bonding was done by just one brick on one side of the wall (Figure 79).

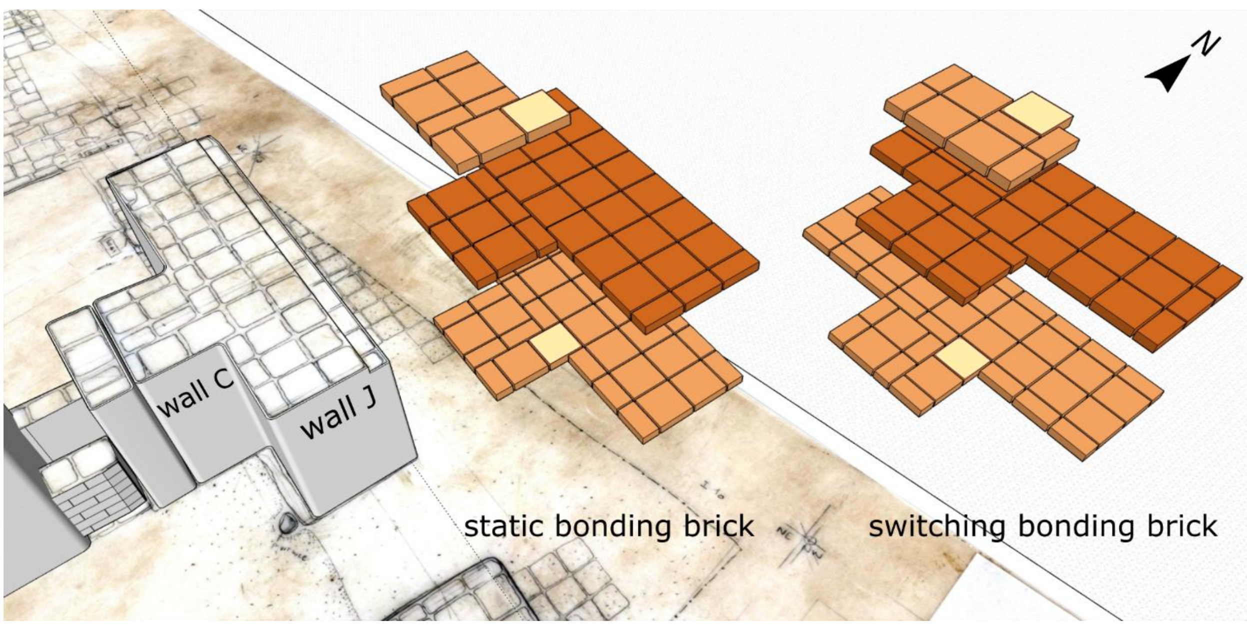


Figure 79. Hypothetical reconstruction of the T-junction bonding of walls C and J of the residence, suggesting two alternative patterns. In the first hypothesis a static bonding brick is used, e.g. the bonding brick returns on the same location every other course. In the alternative hypothesis, a switching bonding brick is applied, which switches between two locations. In the above examples the bonding brick returns every other course, while it is equally possible that each course had a bonding brick.

Not all T-junctions are bonded. Although such "abutments" are in the archaeological field documentation generally interpreted as reflection of a chronological difference between two walls. However, the real reason for walls not to be bonded is probably structural: these walls did not need to be structurally reinforced. This may often indeed be the case with walls that have been put in later to quickly partition a space for instance. However, the internal partition walls of the residence, build at the same time as its exterior walls, are also not bonded to the main structure. Their sole function was the subdivision of and probably played no role in carrying the roof structure. There are other walls in the *Dunnu* however, that appear to be unbonded T-junctions, while some of them appear to have carried a roof after all. In all cases this involves lighter architecture. There are some abutting T-junctions of walls constructed in the open space west of the residence (NW-1a), in between the heavy fortification walls and the residence. The row of lighter structures in the south, constructed against a heavier building that was integrated with the fortifications, also appear to be abutted T-junctions (Figure 80). It is interesting, as this must be viewed as a structural weakness, especially for the covered structures. The structural bonds have unfortunately not been explicitly confirmed in the wall documentation forms, but can only be derived from the plan drawings, which is an unreliable source. However, even if an abutment is certain, it is theoretically possible that these walls were abutted at their lower courses, while bonded higher up at a level that has not been preserved.

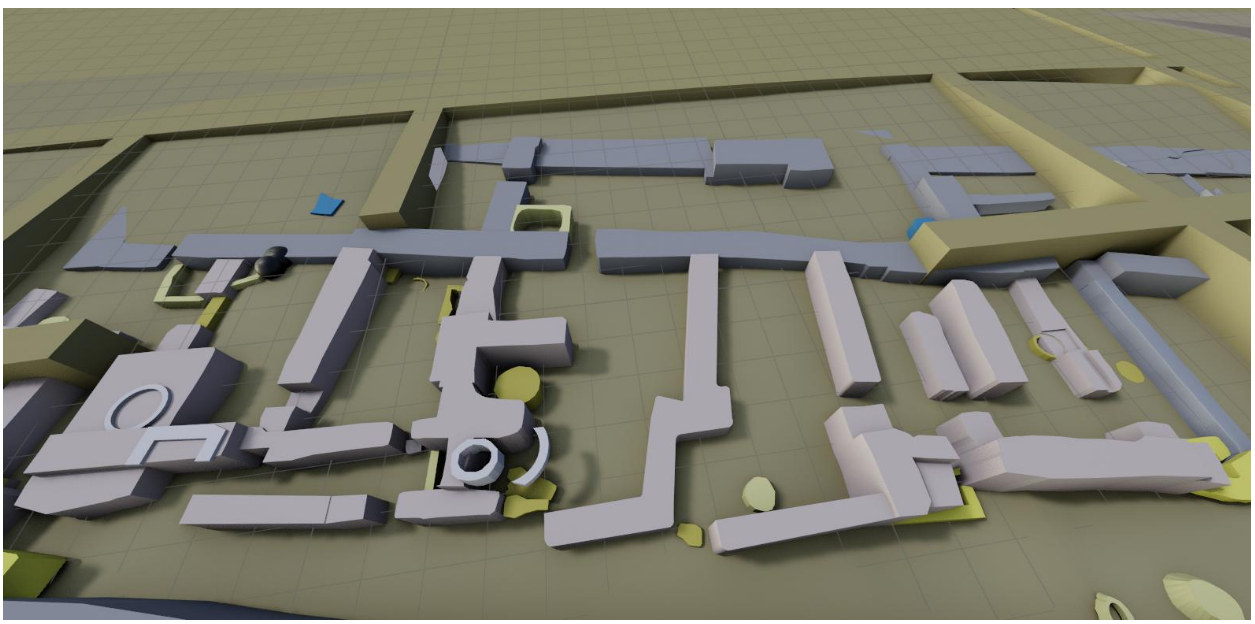


Figure 80. Series of T-junctions that are probably abutting in the southern Dunnu.

V.5.3.5 (Roof) load bearing walls and non-load bearing walls

Load bearing walls are walls that carry the weight of the structure including roof loads and upper floors. Often, the exterior walls of a structure are its load bearing walls, while the interior partition walls are not. The main load that the mud brick buildings of Tell Sabi Abyad had to carry is heavy roof deck made out of timber and loam. As we are dealing with flat terrace roofs, most these forces are directed downwards, rather than laterally as is the case with pitched roof and vaulted constructions. Nonetheless, locally, other vectors act on the top of the walls as a result of bending the roof beams, classified as edge pressure. The differences in structural function are often reflected by differences in wall width. In buildings in the *Dunnu*, roof bearing exterior walls are constructed wider than interior partition walls, or non-roof bearing walls such as the short sides of buildings or rooms. This shows that the builders of the *Dunnu* were well aware of these, and used this knowledge to optimally economise the use of building materials. To secure the construction, load bearing walls are always fixed by means of corner bonding to other load bearing or non-load bearing exterior walls. Interior walls not bonded to the main structure may be classified as non-load bearing partition walls, although technically their presence may also be used as intermediate support of roof beams. In the example of the residence, the main roof structure was probably carried by the long walls. The interior long walls are therefore both wide, and bonded to the exterior walls of the building. The interior partition walls on the other hand, used to create separate rooms, were not all bonded to the main structure, which implies they did not play an important structural role in carrying the roof.

V.5.3.6 Abutment

There are two general types of wall abutment: parallel and perpendicular. Parallel abutting walls are constructed along the length of an existing wall. Perpendicular abutting walls are T-junctions, and have been discussed above at V.5.3.3. Parallel abutments generally indicate a structural separation between two buildings, constructed in sequence. Some other parallel abutments may have served to reinforce an existing building. With regards to the former, there are several of them documented in the *Dunnu* (Figure 81). Examples are the two long and narrow structures identified as staircases (spaces SE-6 and NE-5), which possess long walls entirely abutted to the exterior of the fortification wall. Others are the residence's eastern exterior long wall, and the long walls of the building appended to the north (NE-2). The constructional pattern these walls share is that they are thinner than the other exterior walls of the same structure. This indicates that the builders took the presence heavy architecture into account and adjusted the width of the abutting walls of new buildings accordingly. Although these walls had to carry the same vertical load as their sibling walls in the same structure, the additional support they received ensured they did not require the same width needed for wall stability as freestanding walls. This building practice reflects the rational and economising choices of the builder.

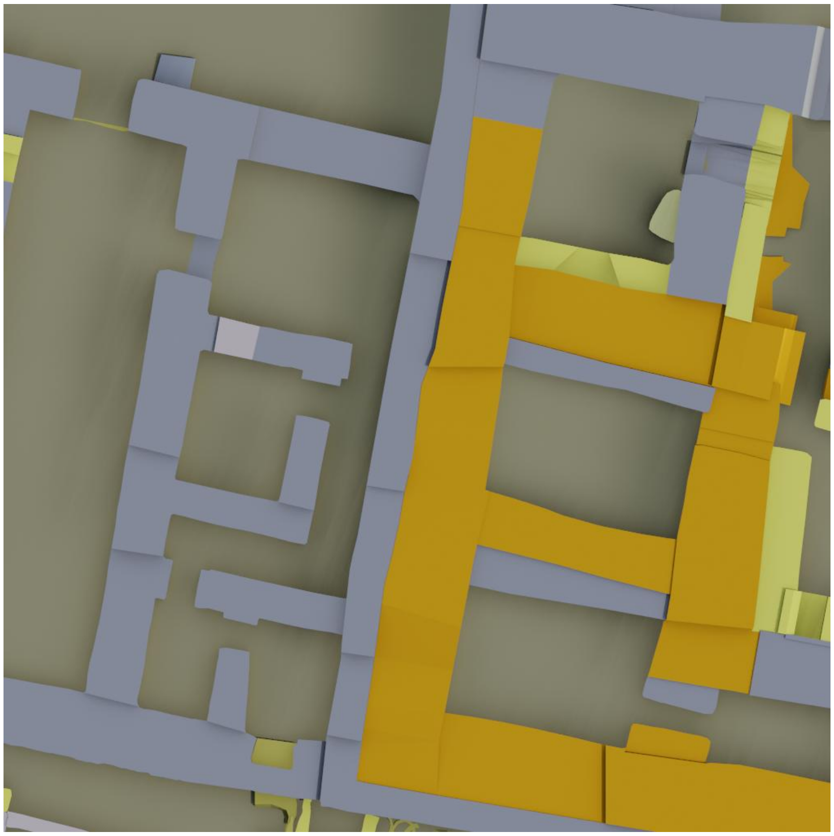


Figure 81. Examples of parallel abutments in the Dunnu. In the middle the long parallel abutment that structurally separates the two central buildings. On the right some parallel abutments on interior spaces in the tower. Orange = level 7, blue and yellow = levels 6/5.

Other parallel abutments may have served to reinforce an existing wall or building. These are mostly found in and around the tower. Other locations are at several segments of fortification wall, and in the elongated space behind the postern gate (SE-2d). In case of the tower, the entire building is uniformly reinforced both on the interior and exterior, which seems to indicate a large structural modification, such as the addition of a floor on top. Examples from ethnoarchitectural case studies support this interpretation (see Figure 19 and VI.5.2). In the excavation documentation and various publications, it has been suggested that these modifications to the tower reflect a renovation in response to the dilapidated state of the building. However, with walls already this thick and heavy, the question is what kind of structural support such a thin encasement would offer. A renovation of a dilapidated building would have more likely looked like wall surface reconstruction with floor and roof replacement, and possibly localised structural support by means of buttressing, rather than a structural reinforcement in all sections of the building, interior and exterior. If the building would have showed signs of sagging or leaning, buttressing it with strategically placed buttresses are the preferred solution. In the case of space SE-2d, and room 5 of the tower, the construction of an abutment may even indicate the roofing of a previously unroofed space. If true, these are good examples of archaeological traces on ground level that tell something about the building on higher levels.

V.5.3.7 Buttresses

Both buttresses and abutments are forms of structural wall reinforcement that may be part of original construction or added later during works aiming at repair or building modification. Buttresses are structural reinforcements perpendicular to the wall. They may be part of the original construction to support long and slender walls, or constructed later as a preservation measure to prop up tilting or bulging walls. In the *Dunnu* such structures are rare, only found as part of the structural reinforcement of the main gates, and next to the front gate of the tower (Figure 82). It is uncertain whether this latter buttress indicates a late fix to a structural issue, or was part of a structural reinforcement plan related to the addition of height to this building. In the excavation documentation, features are frequently named buttress, but these are misnomers. Features classified as buttress in the archaeological documentation are in reality short walls, and part of door jambs.

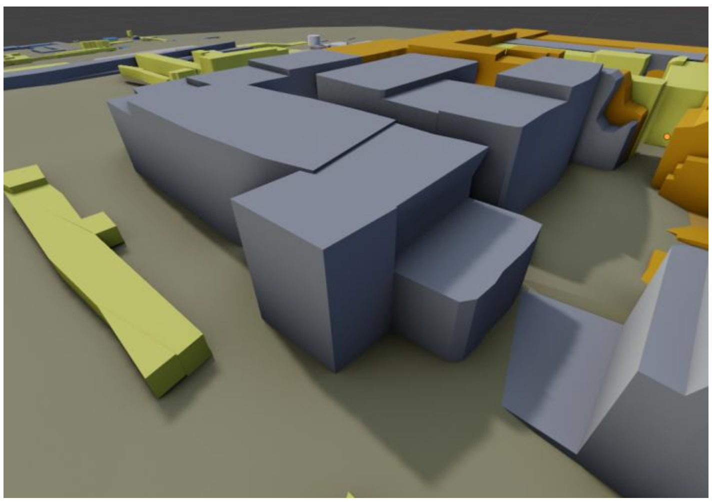


Figure 82. Buttress at the front gate of the tower.

V.5.3.8 Layered or complex construction

In some cases of wall construction in the *Dunnu*, a type of constructional layering has been documented (Figure 85-Figure 88). These are characterised by transitions of brick material or bonding type within the same wall, or blocks of multiple, separate walls joined in construction. These wall complexes are remarkable as they appear to have been constructed as separate abutments near the base, but are integrated as bonded structures higher up. This raises questions regarding their manner of construction, their function, and the temporal relations of these walls.

Figure 83. Areas with layered or complex wall construction discussed in the text.

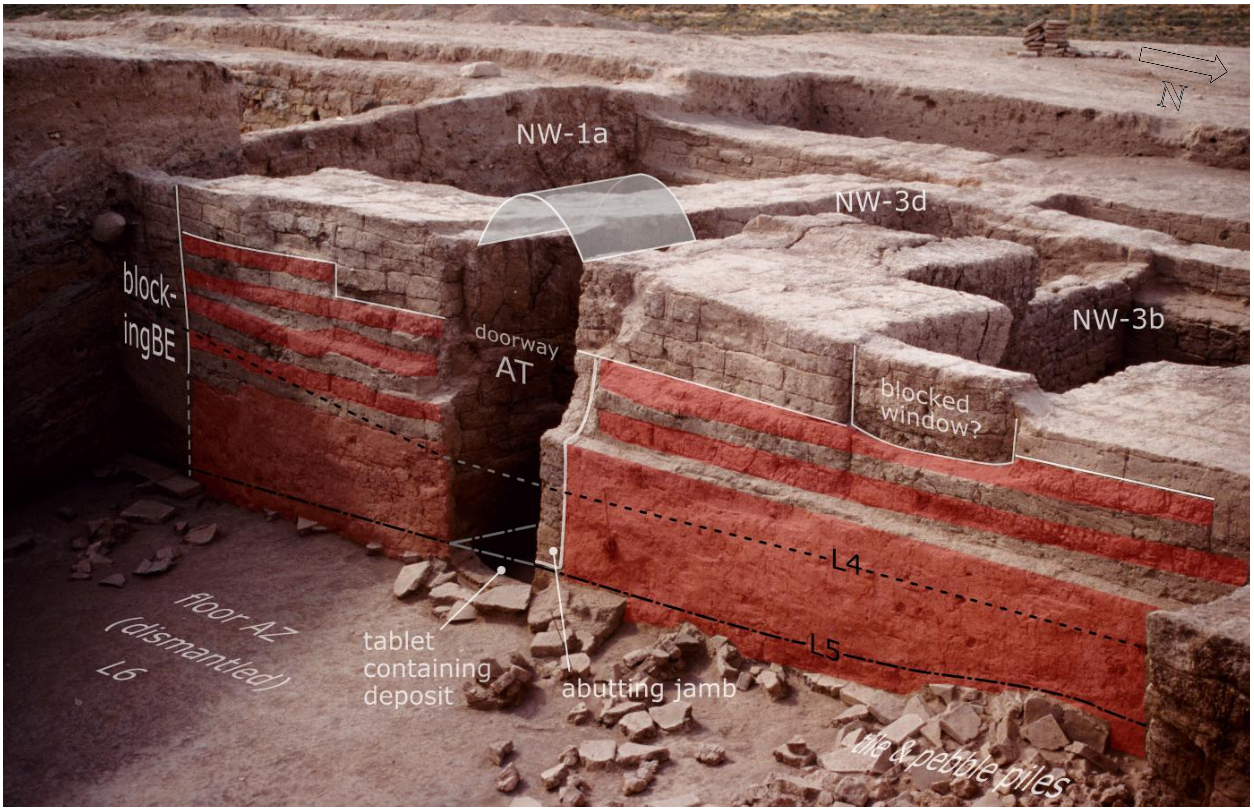


Figure 84. Western wall of large courtyard, NW space 2a, viewing southwest. White lines indicate distinct sections of brickwork. Lines and colouring based on field sketches and day note descriptions of square I08. The red plaster was pigmented, the red bricks are made of reddish soil.

The cases of layered construction complexes are part of or near to the fortifications, which suggests a relation with fortification building practices. The cases will be discussed here in more detail. The first case is found in the north-western corner of the *Dunnu*. The corner appears to have a layered wall construction. This is noticeable on the western wall of the large courtyard, which is constructed with characteristic layers of red and brown bricks in the lower part, but with uniform brown bricks above (Figure 84). But also elsewhere a layering in construction in noticeable, which is not distinguished on the basis of brick material, but on the basis of a difference between abutted and bonded construction (Figure 85-Figure 87). This also includes the massive block of brickwork north of spaces NW-3a and NW-3b, which is unusual both in form and weight. In general, the entire corner is constructed in a way that near the base of walls, these are separate, abutted constructions, but higher up, the entire structure is joined by wall bonding. The obvious interpretation as to the cause of this pattern of horizontal and vertical complexity is phasing, but some observations may give some cause for doubt. In the case that phasing caused the layered wall construction, the consequence is that at some point in time, the walls in this area were taken down to just about 1 to 1.5 meter above founding level, and rebuilt afterwards, integrating previously abutted walls. Considering the size and height of these walls, being part of the fortifications, this was a considerable effort for which the justification is so far unclear. Theoretically, modifications to the spatial structure are a valid reason for demolition and rebuilding, but nothing was changed to the spatial structure of the cluster of rooms NW-3. Nor were any modifications made to the support structure, which could potentially imply changes to the higher building levels. Of course, the construction of the large block of wall north of NW-3 could have somehow structurally justified the demolition of bordering architecture. However, this block is not well understood in terms of stratigraphic belonging[50] and architectural function, which makes any hypothesis based on it problematic. There is another explanation possible for the observed layered pattern, which relates to the logistics of construction and building planning. Construction of the fortification wall may have started a little earlier than the internal structures of NW-3. Only after construction at the internal structures had caught up with the level of the fortifications, the wall bonds were created and continued to be bricked up as joined structures. Starting construction with the fortifications, then adding internal structures while the fortifications are still under construction, finds its parallel in the sequencing of construction works at Garšana (Heimpel, 2009).

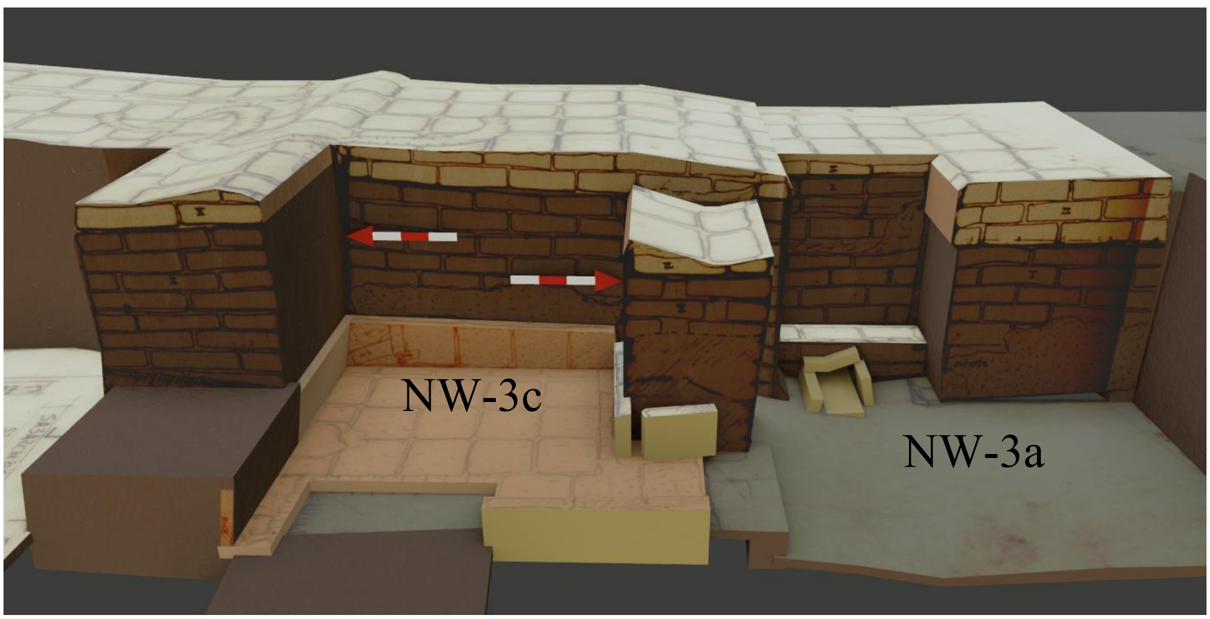


Figure 85. Walls of spaces NW-3c and NW-3a. Lower part abutting against, higher part bonded to fortification wall. Arrows indicating abutting joint lines.

[50] From the archaeological documentation it appears joined with the western fortification wall, but in the plan phase drawings produced by the project was built over an older phase of the fortification wall.

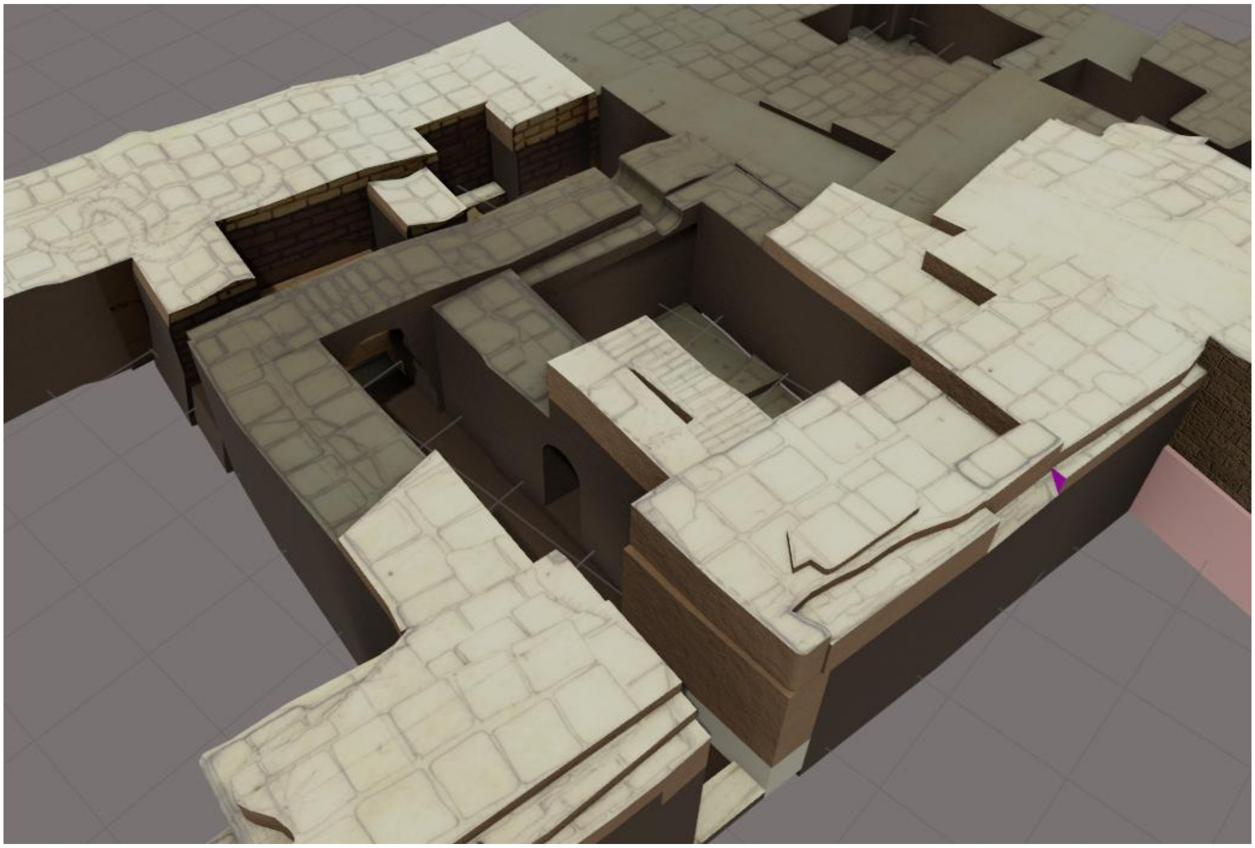


Figure 86. Layered differences in masonry material and structural characteristics, indicative of either a renovation phase, or logistics of construction. North-western corner, building NW-3.

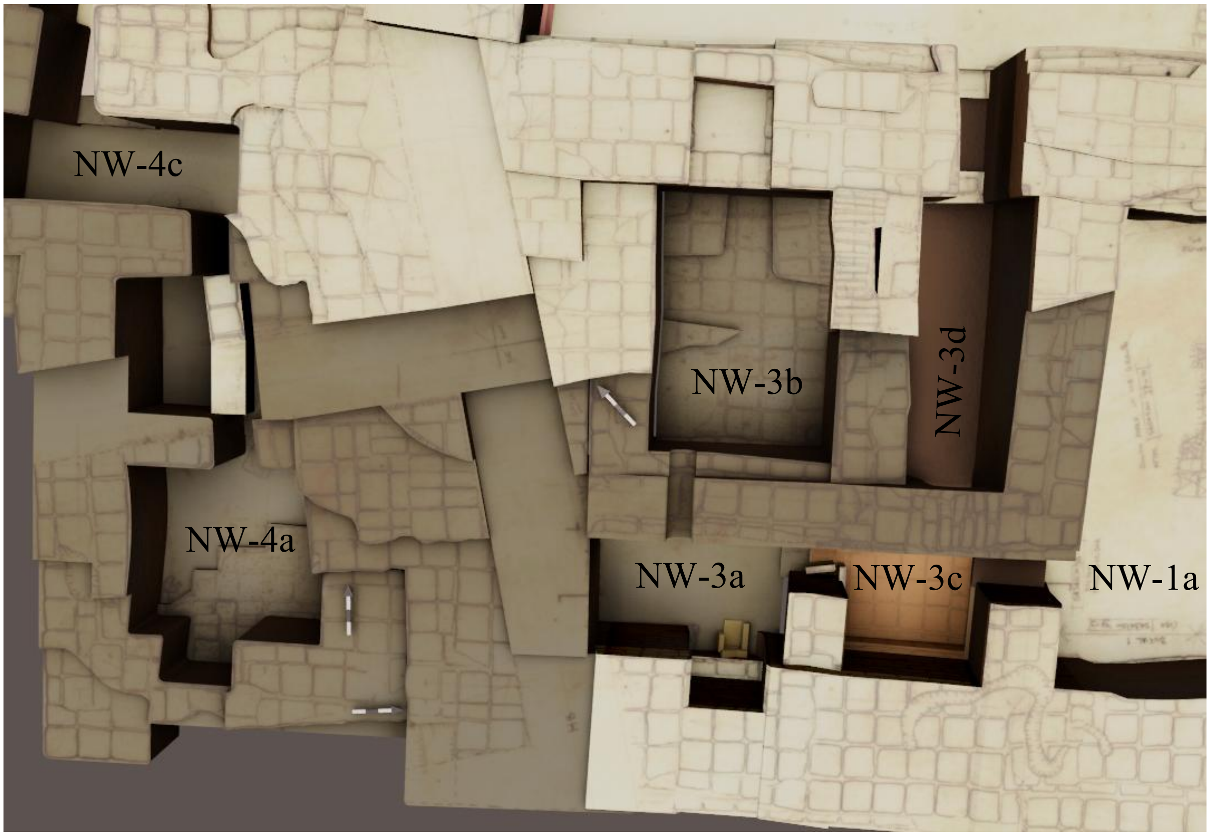


Figure 87. 3D plan of north-western corner of Dunnu, characterised by a massive masonry block. Below a certain level, walls are abutting, while in higher segments, they are bonded. This corresponds to the height of the renovation of the western wall of the main courtyard (Figure 84). Arrows point at abutting seam lines.

Another case of complex and layered wall construction is found in the central northern part of the *Dunnu*, where the new northern fortification wall is built against a double-roomed building (NE-2a/2b) (Figure 88-Figure 89). The two walls are abutting, but the top layer that was preserved for just one or two brick layers, clearly shows that higher up, the walls are joined into one. The cross-section through these walls, indicates that these walls are indeed of a different construction phase (Figure 89). Therefore, the bonding must have been created at a later stage. The section does in fact indicate the fortification wall was constructed before the two-roomed building (possible surface levels indicated on Figure 89). As seen on the section, there was an earlier wall underneath that building (roman numeral I), that is contemporary with other fragments of older thick walls and possibly mud brick surfaces found in the direct vicinity. These remains may have been part of the original fortification system, a hypothesis discussed in more detail later.

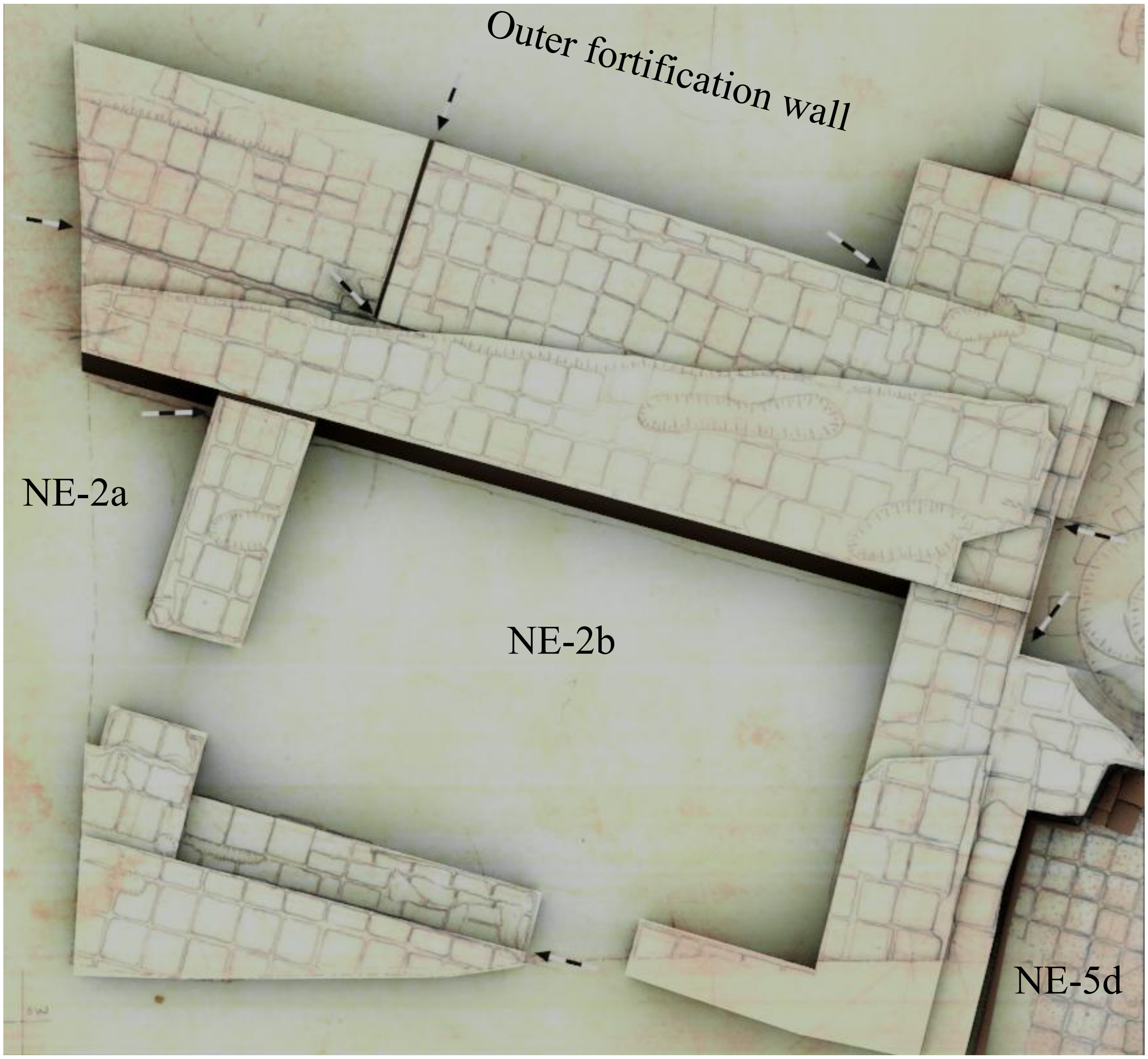


Figure 88. Plan of building NE-2 and northern fortification wall. The arrows point at confirmed abutments. The upper courses of the building and the fortification wall are bonded, while the lower courses are abutting. There is no evidence that this was also the case with the building's south wall. See also Figure 89.

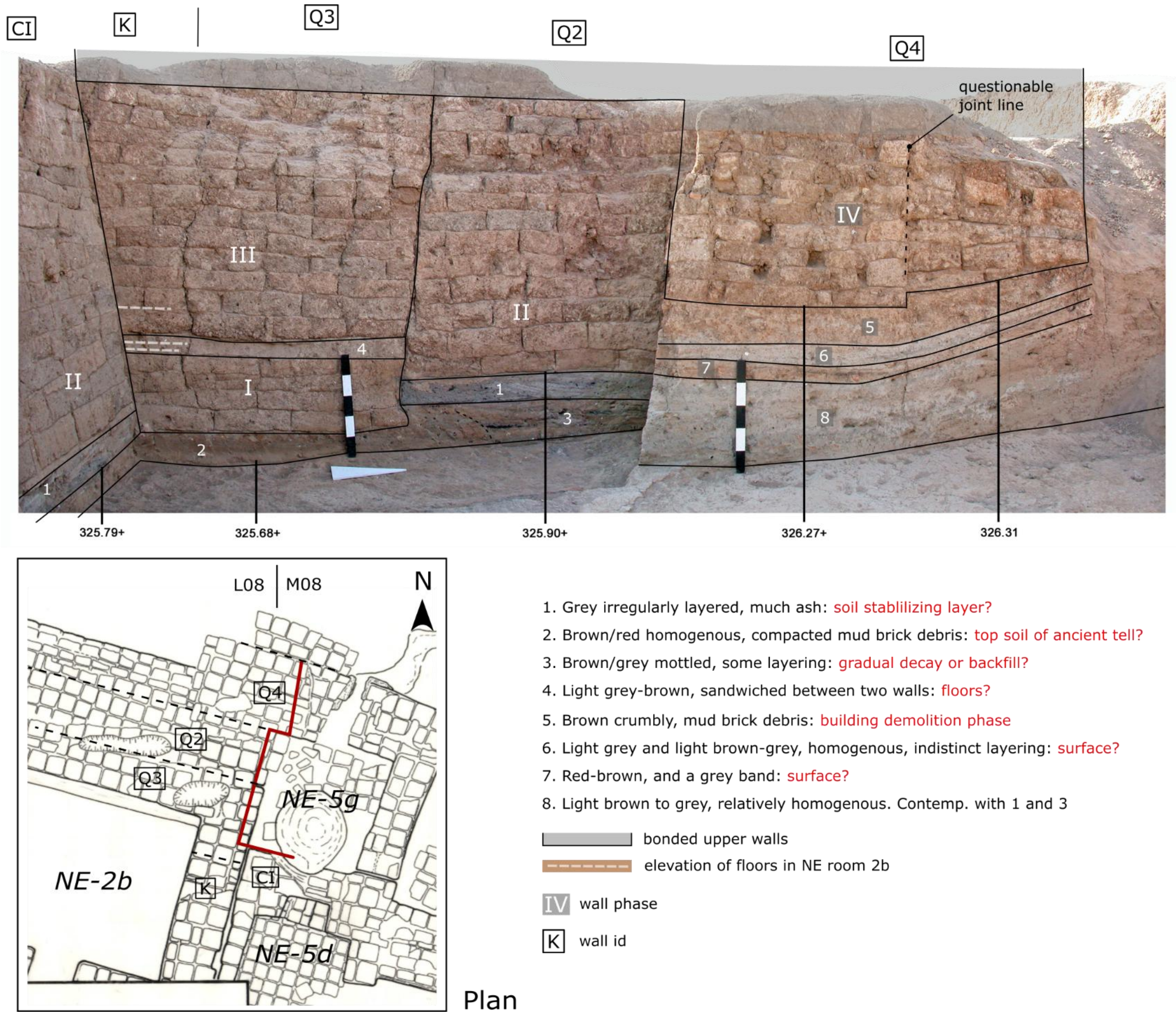


Figure 89. Cross-section of a sequence of walls that are separate walls at the bottom, but appear to be joined into a bonded structure in the upper courses. See also Figure 88.

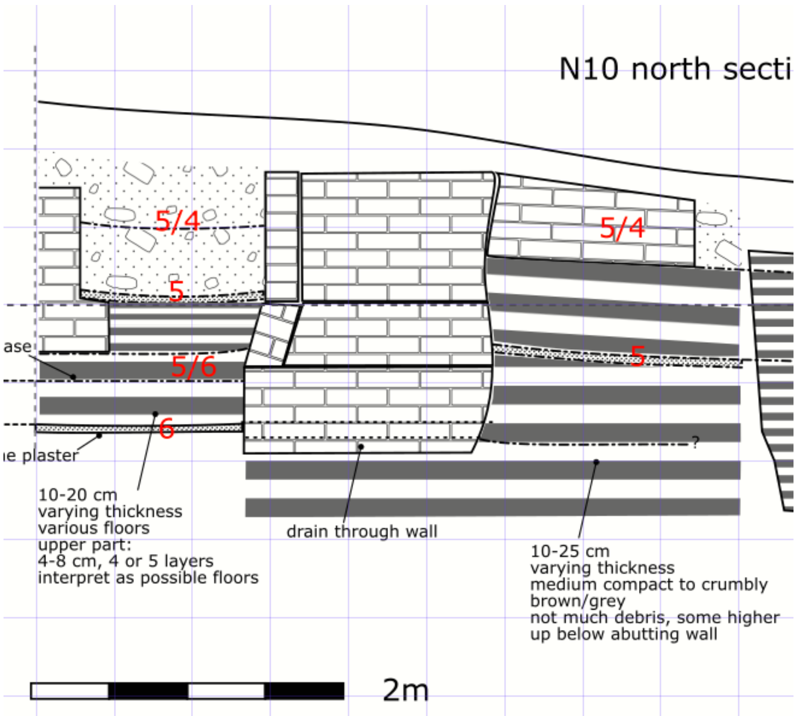


Figure 90. Deposit sequence graph of section through eastern fortification wall in N10. Black lines demarcate layers or columns of mud bricks with similar compactness.

Additional cases of complex layering and transitions in brickwork are found in the eastern fortification wall in M12 and N10. In a section of the fortification seen in square N10 (Figure 90) there are multiple horizontal and vertical layers of brickwork distinguished based on colour, consistency, and bonding. Again, the question may be posed whether this indicates rebuilding phases, or simply different batches of bricks used in the construction of the fortification wall. The latter seems the more obvious, but it cannot be proven with certainty. In a section of fortification wall in M12 (Figure 91) these are just two brick layers of different consistency and colour, but an apparent cutoff levelling of the lower bricklayer does seem to indicate a rebuilding. Interestingly, the space using this wall also has a rebuilding phase in the wall on its opposite side (Figure 92-Figure 93). The space itself contained a significant amount of mud brick rubble, top surface levelled, implying that indeed at this case, it appears that a larger renovation had taken place. During this renovation, the fortification wall may have been demolished and rebuild. As a new elongated space on the exterior of the fortification wall was also constructed, which has here been plausible identified as a stairway. The demolition and rebuilding also appears to be related to increased access restriction of the area. The spatial structure and access pattern of the architecture was modified significantly (VI.12), justifying the thoroughness of the demolition and rebuilding activities.

Figure 91. Two noticeably different brick layers in the eastern fortification wall on top of each other. Based on the excavation notes and photos it is unclear whether bin AE abuts both wall layers, or just the lower one. There is no evidence for a floor associated with the level of the joint line, although one has been postulated by the excavators.

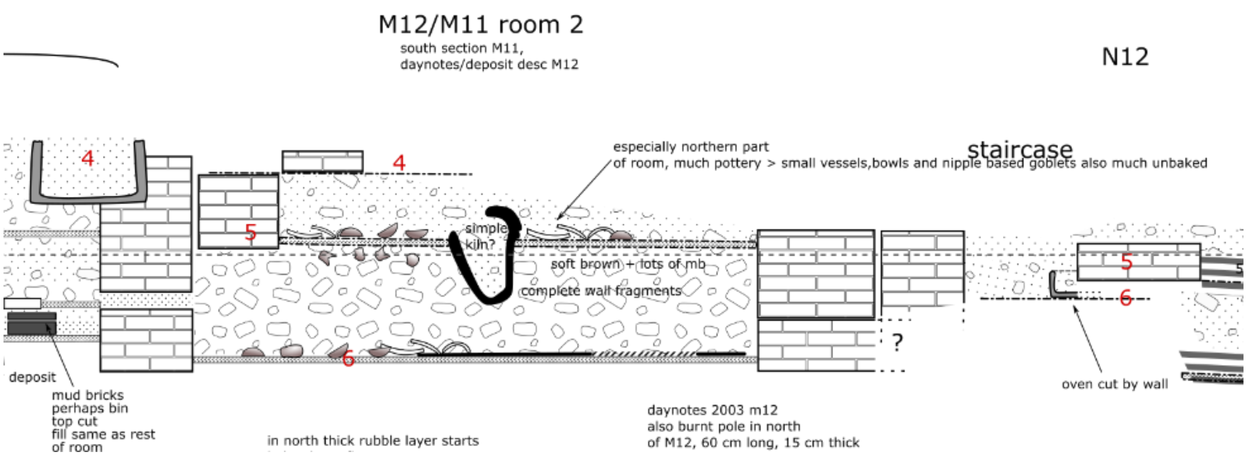


Figure 92. Deposit pattern diagram of buildings in L12 and M12, in the SE sector. The construction phases are separated by rubble deposits. On the right the layered construction of the fortification wall, illustrated on Figure 91. On the left the apparently mirroring pattern on the other side of the space, also shown on Figure 93.

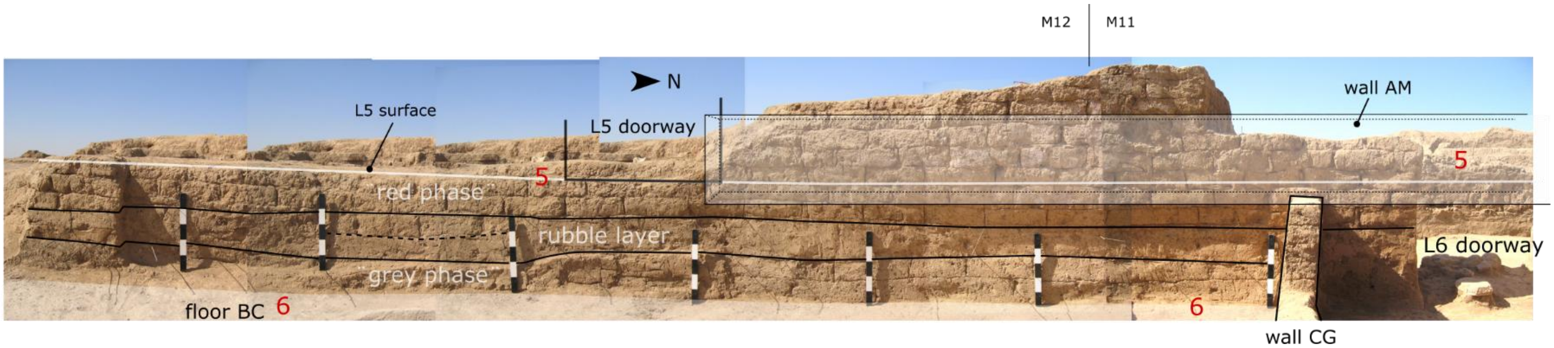


Figure 93. Wall B/C in M12/M11, showing the same dual-phase construction separated by a rubble layer.

V.5.3.9 Wall finishing

Most walls were finished with a layer of loam render (interior faces) or plaster (exterior faces). The exact compositions and way of application has not been investigated in detail during excavation. Some additional details are available, but a systematic analysis is not possible. A lot of walls in the western part of the *Dunnu*, including the fortification wall near the main gates and the front walls of the residence were plastered with a calciferous material (Figure 62). Since no chemical analysis was performed, it cannot be established whether it was lime or gypsum based, although lime has been assumed by the excavators. The main court was finished with a plaster mixed with a red pigment. In this area, an underlayer with grooves was used, probably to improve attachment of the final outer layer. An underlayer with a dotted pattern probably created by inserting a stick in the wet plaster was found in a single room in the residence. The size and depth of these holes make them less useful for plaster adhesion (they would take up a significant amount of material), so it seems that something else was fixed to the wall here. The hypothesis that their use was decorative seems unlikely since no apparent effort was made to create a coherent pattern with the holes.

Figure 94. Grooved loam plaster, most likely a base layer for the application of a fine red pigmented plaster.

V.5.4 Vaults & arches

The excavated remains of the Assyrian *Dunnu* bears evidence of six arched doorways, one window-like opening, the remains of a vaulted corridor and one vaulted staircase. The difference between 'arch' and 'vault' is arbitrary here since these constructions above doorways are in fact all short vaults. None of the arched doorways is constructed as a single arch and the method of construction does not differ from the longer vaults.

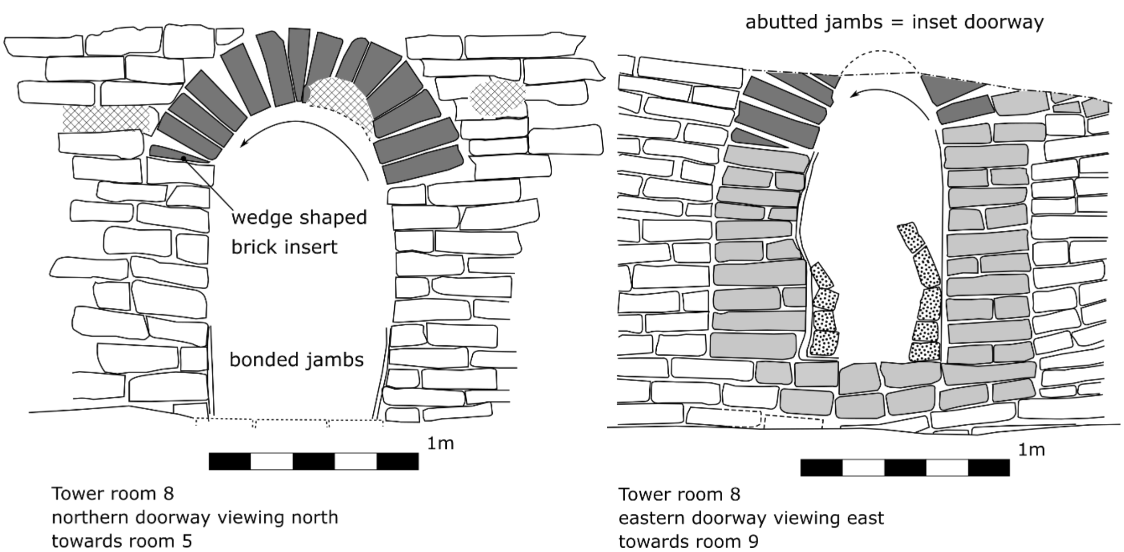


Figure 95. Two vaulted doorways in the tower. The one on the left with bonded jambs is part of the original wall construction, while the one on the right with the abutting jambs is probably a later modification.

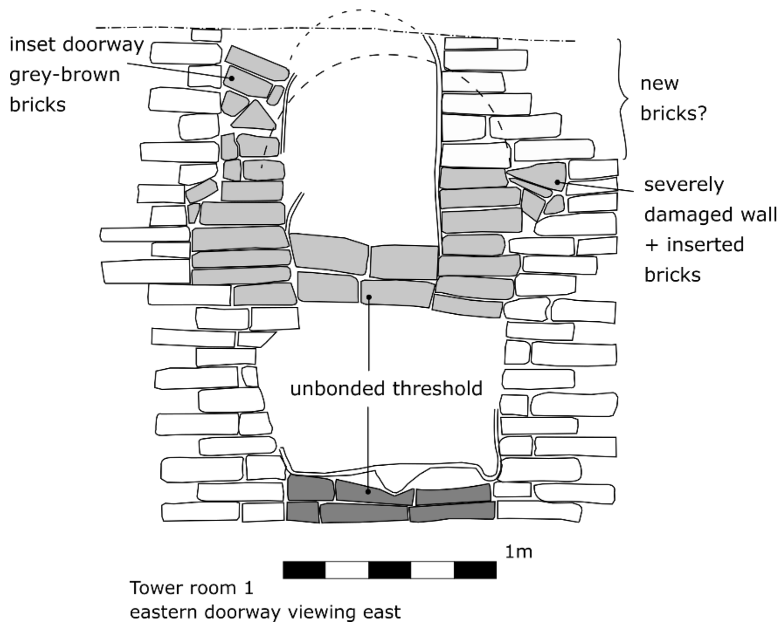


Figure 96. Younger smaller doorway set in older larger doorway.

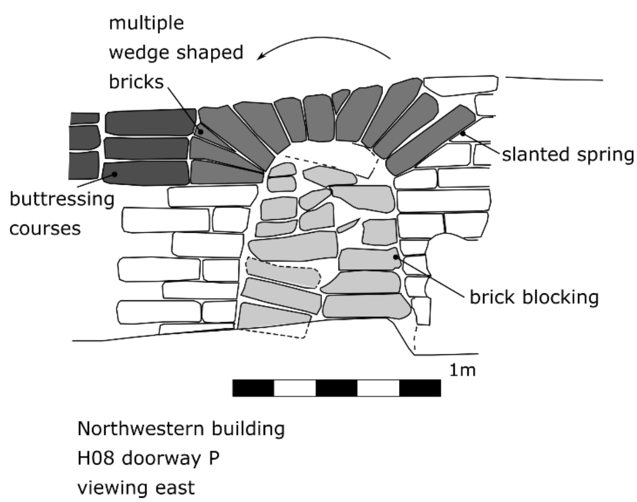


Figure 97. Vaulted doorway in building NW-3, showing a more elaborate construction practice as regards to the use of multiple wedge-shaped bricks, and a slanted spring base on one side.

All vaults are small radial vaults with the bricks laid in a running bond. The bonding pattern depends on the length of the vault, and it appears that bricks especially produced for vaulting have been used. Bricks with a length of 1/1, ½ or 1/3 of the base unit have been observed. The 1/3 base unit is not seen in regular wall construction. Typical of most of these vaults is the use of a single wedge-shaped brick on one side on the spring of the vault. It is unclear what this means in terms of construction: if these wedge-shaped bricks were inserted from the exterior to fill up a gap, the vaults were constructed before the wall that covered them. It also seems to indicate a directionality in the construction as only one side of the arch contains wedge shaped bricks. Perhaps the vaults were constructed starting from one side, and ending on the other, rather than starting on both sides and meeting in the middle. This is only possible if there is enough support during construction, such as a rubble fill that was removed later. Indeed, from a construction historical point of view, this is the most likely (Van Beek, 1987).

The vault of the doorway of building NW-3 diverges significantly from the others in construction manner (Figure 97). There is no special structural need for using this different method, so it seems that here we see the hand of a builder that learnt the trade from a different tradition. The possible chronological differentiation between this building and the tower, which would also imply a different builder being responsible, underscores this observation.

Figure 98. Remains of vault of corridor space NW-3d, "Tammitte's office". On the left the part that covered the doorway, which was lower thus better preserved. It applies wholes and 1/3-size bricks. The row of mud bricks placed on their side in the room directly to the north, may also indicate the pitched brick vaulting technique was used.

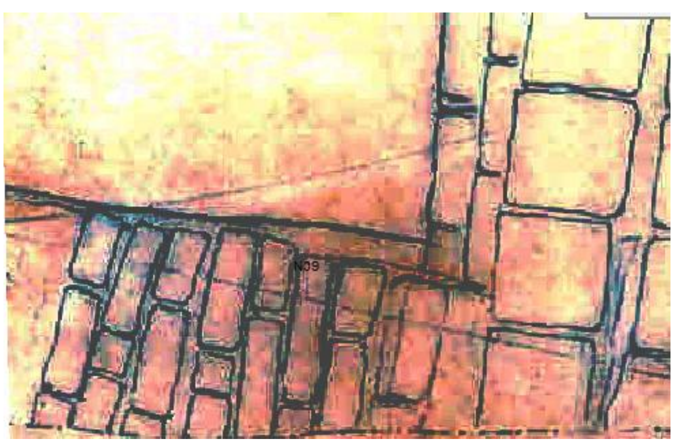


Figure 99. Vault above doorway of space NE-7. A running bond using, whole, 1/3-size and 2/3-size bricks.

Two vaults are found used for larger structures. One was found in the staircase in the north-western corner of the tower (Figure 100). This staircase is characterised by a massive central spill wall, which prime function was to resist and transfer the cumulative weight of the vaulted steps. Various parallels can be found for such staircases (see below). The vault itself was probably a stepped construction, not much unlike that the great temple at Tell al Rimah. Only a small part of the vault was recovered and documented. With the running bond applied, it would be interesting to know how they solved the problem of connecting the individual segments of the vault.

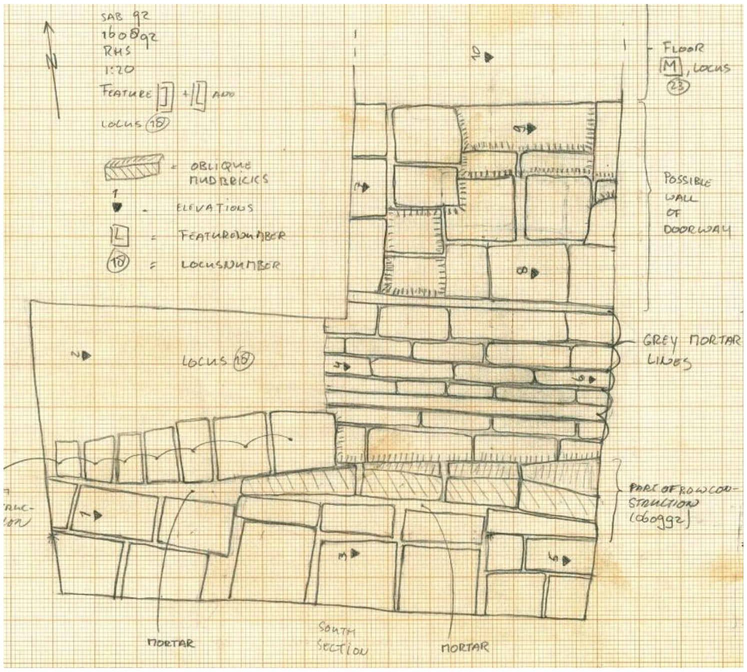


Figure 100. Sketch of the top view of the vault of the staircase in the tower, space tower 3.

A last place where a vault has been found is covering a corridor in square H08, in the building called ‘the office’. Again, its manner of construction was not documented in detail, but plan drawings and sections clearly show a bonded vault. The crack pattern of the walls along the length of this corridor also indicate an inwards shift of the wall caused by the removal of the vault.

The use of a vaulted construction in the staircase, as well as in the corridor suggests that vaults were likely present in more places where narrow spaces had to be spanned.

V.5.5 Floors

Most floors are of the rammed earth type, or simply trampled by regular usage, while fewer are whitewashed or plastered. For the occurrence of white floors see the discussion of the use of white plasters under V.4.7. Loam floors are often described in the excavation documentation as covered with many ‘lime spots’, suggesting perhaps a loam/lime mix or a disappeared wash. But such spots are also part of the general loam matrix found throughout the settlement, so it is hard to say what such spots represent.

Figure 101. Floor/surface material types.

Few floors are made of fired brick tiles. Such floors are found in the courtyards and bathrooms of the *Dunnu* (also see V.4.10). Some surfaces in the *Dunnu* are covered with sherds and/or pebbles, which seems to be intentional, and associates in one case with the presence of water channels leading to it suggesting these could function to improve drainage.

Floors have unfortunately not been recorded in sufficient detail to be able to describe their precise construction. In some spaces many thin layers on top of each other have been observed, and interpreted as series of floors. However, the genesis of some of such deposits may be of (natural) sedimentary origin, formed in an open area. In others, their formation is less clear from the recorded material and context (see IV.3.1).

V.5.6 Doorways

Doorways in general terms are simply gaps in the wall starting at floor level, and with a certain limited height. The variation in doorway construction is seen in the bonding pattern on the sides, the door jambs, and the way the superstructure is supported. Of the door itself usually nothing remains, although many door sockets have been recovered indicating the use of rigid panels connected to a pole that was fixed in a top and bottom socket. In terms of superstructure, there were originally probably two main types of doorways, those with flat timber lintels, and those with vaulted or arched lintels. Clearly, of very few doorways the top parts have been preserved, so it is impossible to say something about absolute or relative numbers of occurrence. And only brick vaulted doorways preserve due to their material a superior structural strength. However, it is likely that vaulted doorways and passages are preferred for most of the heavier architecture with walls two mud bricks wide and wider (e.g. approx. 80cm).

The standard doorway is completely integrated in the wall, meaning that its jambs form no separate construction (Figure 95, left). Of the 8 complete or near complete examples, all have an arched lintel (see V.5.4). Nonetheless, it is likely that many doorways, especially in lighter architecture, had a timber based lintel construction.

Of the timber door construction itself nothing is preserved. It is likely that no doorframes were used. Most doorways would have used the pole-and-socket contraption to swivel to door. In this construction method, a doorframe is not required to attach the hinges.

V.5.6.1 Lintel construction

The only evidence we have for lintel construction are the preserved vaults or arches. We know from various archaeological examples that vaults or arches were not only used for smaller doorways, but also for tall ones and for city gates (see V.3.9). The top of the doorways leading out of room 2 of the tower for instance were not preserved, but their estimated height would be similar to the high and slender vaulted doorways documented in Tell al Rimah. These were 2 to 2.40 m in height. More such examples can be found. The northern Syrian vernacular building tradition documented in the 20th century, shows a preference for the horizontal wooden lintel even though wood is limitedly available (Pütt, 2005, figs. 297–298). It is quite likely that flat wooden lintels were also applied in the *Dunnu* in the lighter structures. The gateways were most likely arched as well, since all preserved examples of ancient Western Asian gates, and most iconographic evidence indicates the same. Nevertheless, one can find examples of gates in traditional construction that possess large wooden lintels (Hallet and Samizay, 1980; King, 1998). The two gates found at the *Dunnu* are flanked by large protruding jambs. This is a common feature of gates, and also these often support an arch. This construction practice monumentalizes the gate while keeping the actual entrance passage itself relatively small and controllable (see VI.11.7).

V.5.6.2 Doorways with abutted jambs

A few doorways have separately constructed jambs (for instance Figure 95, right). In the excavation reports such doors are assumed later constructions. To construct these, first a larger hole than the actual doorway opening must have been cut, and then the jambs that carry the arch are constructed inside the hole. Unexplained in this interpretation is that how the load of the of the upper wall is diverted to prevent collapse while the doorway was under construction. Also, in the illustrated example, the placement of the wedge-shaped brick used to close the arch on the left side must have been inserted while the abutting wall was not yet at this height. This would suggest either a larger part of the wall was demolished than indicated on the drawings, or that the abutted jamb method was part of the original construction. Which hypothesis is correct, significantly influences the reconstruction of the architectural development of this building in this case.

There are several doorways with an abutting jamb on just one side. This feature has a clear spatial patterning, as it is solely found in the architecture surrounding the main court and the residence. Examples are the doorway from the main courtyard to building NW-3 (Figure 84) and from the central hall of the residence into room 3a (Figure 123). The function of this feature is not entirely certain. In the excavation documentation this feature is often referred to as a 'narrowing' of a doorway, implying it was always added in a secondary phase of a doorway. Indeed, its abutment to standing architecture, and in one case its clear stratigraphic placement in a new soil 'layer' would suggest its part of architectural phasing on not of original design. However, we should not rule out the possibility that its function was more structural in nature, related to the renovation of the upper structure of doorway. However, it is currently hard to imagine what constructional procedures would exactly be helped with a single new jamb. The fact that these door features seem to be limited to the area of the large court and residence, may in the end suggest a relation with the functional shift of this area in the latest phases of the *Dunnu*. This was a shift away from the representational and administrative functions to manufacture and subsistence related activities.

In two cases, a single pillar of bricks is found abutted to on one side of the doorway rather than a full jamb (Figure 102). This feature is only found in the residence, at the main access gate into its court, and at a doorway leading from the court to the main room of the western apartment block. The former has an abutting jamb, of the kind discussed above, on its eastern side, and a brick pillar on the north-western corner. Right behind the brick pillar we find the pivot hole for a door post, suggesting the brick pillar may be a reinforcement of the gate's rotating system.

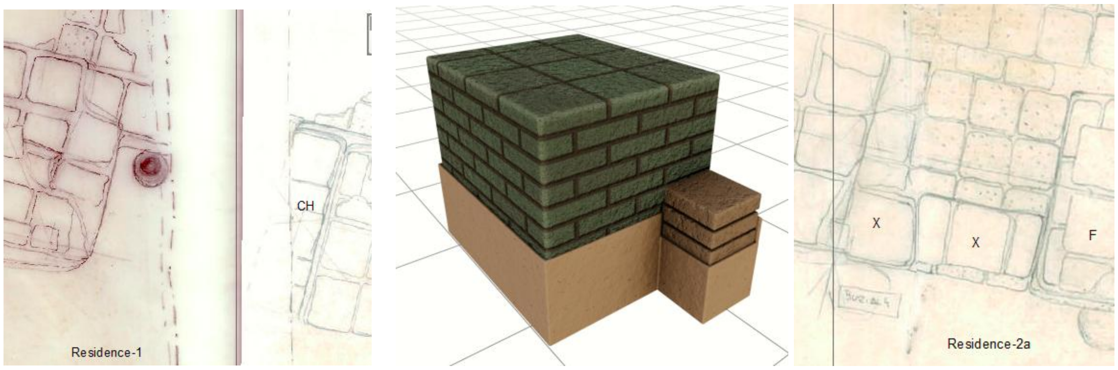


Figure 102. Doorways in the residence with constructions inside them. Left and centre: passage from main court to inner court, Right: from the inner court to room 2a. It has a brick pillar, integrated with the plaster of the main wall, and a separate small wall blocking. The latter does not seem to have blocked the full height of the passage.

V.5.6.3 Thresholds

In many cases the passage has no observable threshold, and the floor simply continues into the next room. Occasionally doorways are found to have a constructed threshold. Some doorway passages are completely enveloped by a wall, with a threshold being formed by the lower courses of the wall. Such a construction has been found at two small doorways in room 2a of the residence, and possibly at some doorways in the tower, and one in the north-eastern corner of the *Dunnu*. It seems that the explanation for such a construction is that the walls have been dug in, with the floor level above the base levels of the walls, hence the doorway needed to be constructed slightly higher up. The suggestion that such doorways have been cut through later, as sometimes suggested by the excavators, does not seem to hold.[51] Other doorways have separately constructed thresholds made of mud brick, and occasionally of fired brick tiles. These are clearly put in after the construction of the wall. In such cases, the purpose of the threshold might be to form a firm lower ledge to be able to close of a space properly with a door. In two cases, at the older main gate, and the gate into the central room of the residence, the threshold is a ledge cut into the loam or plaster floor. These clearly functioned to stop a door. Additionally, the purpose of the build in brick thresholds can be to keep out dust and dirt from the outside. Hence, the presence of a threshold might be related to a certain special use of a room that either required it to be able to close it off properly or the keep it clean or both.

There are also a few thresholds or steps made of unworked fieldstones, it seems that in these cases, found in the southern *Dunnu*, function to bridge a difference in elevation.

[51] Regarding the small western doorway in room 2a of the residence, the excavators have assumed that this is a later doorway, cut into the wall. I have found no evidence for this statement. In fact, all the drawings and descriptions and the fact that a northern doorway mirrors the construction method, suggest the opposite: that this exit was part of the original design of the building.

V.5.6.4 Door post sockets

The door post sockets that were found, suggest that doors were present at many passages in the *Dunnu*. No upper sockets were found, so we must assume these were made of planks with a hole, or forked branches. Lower door sockets come in three types:

1. Simple holes in the ground, may be plastered and reinforced with pot sherds.
2. Lime stone or discarded grinding slab or mortar with a circular depression
3. Pits with at the bottom a pivot stone (made like no 2), and reinforced with cobbles, rocks and fired brick.

Type 1 sockets are found least often, which may also be attributed to the fact that they preserve less well and are hard to find. They are basically post holes, and indiscernible from regular post holes if not found near a corner of a doorway. Most sockets found in the *Dunnu* belong to type 2. They are usually placed on top of the floor, which means that these doors are relatively lightly constructed. Perhaps important to note is that these are easily dislodged, thus not so safe. Their main function thus must have been to divide space, and allow people privacy. In this light, type 3 would be the door socket for heavier and more secure doors. These are found subsurface, and when they are reported in excavation, it is likely that the surface they belonged to is already dug away. This has caused some confusion in the reports regarding the surface the door socket associates with. The only heavily constructed door sockets are found at the new main gate, the residence (both front gate, as entrance to main hall), the old tower entrance, the entrance to room 1 of the tower, and the entrance to the long building in L09 (space NE-3a).

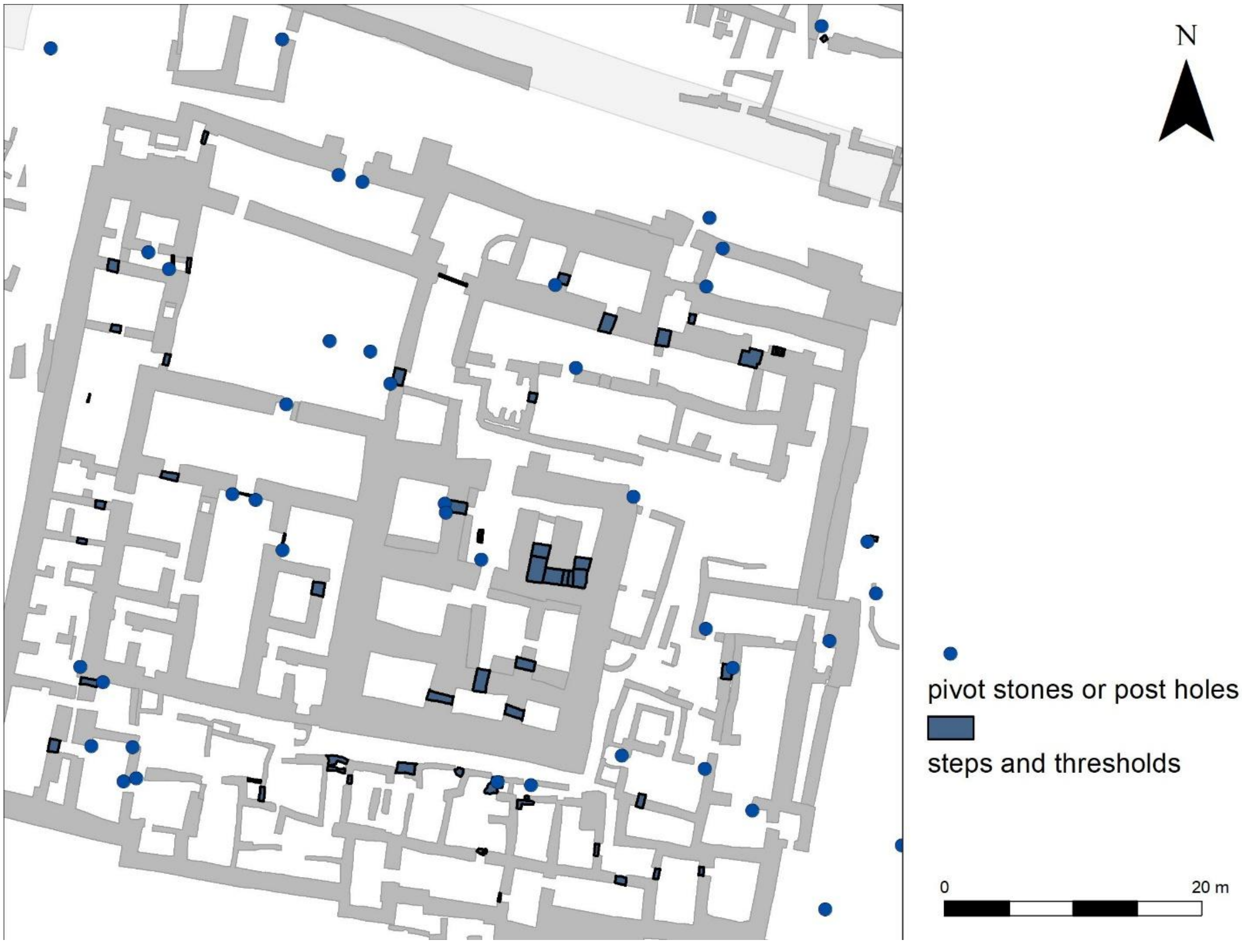


Figure 103. Location of pivot stones, post holes and thresholds/steps, level 6/5.

V.5.6.5 Doorway width

The width of doorways is indicative of their use. In the *Dunnu* doorways vary considerably in width, from 40 cm to 1.63 m (Figure 104). The calculated average of over 116 measured doorways is 79.5 cm. About 42% of doorways fall in the 70 to 86 cm range. With all the inaccuracies involved with measuring mud brick doorways, we may suggest the standard doorway width dimension was 80 cm, or perhaps more accurately: exactly two mud bricks. Those falling outside this range may thus have a special purpose: to allow passage of larger than human sized objects. This may be animals, or people with large loads possibly on carts.

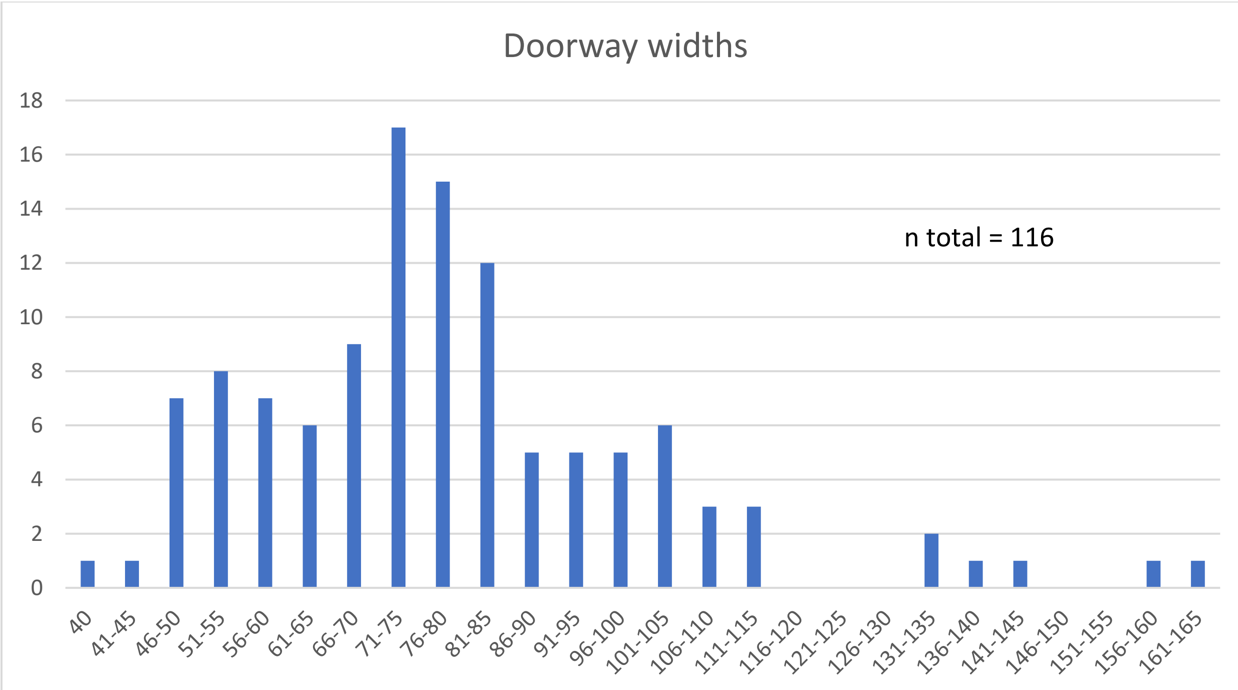


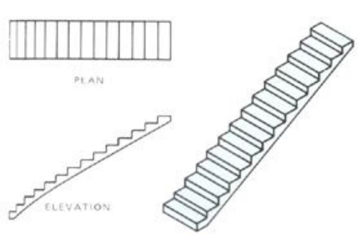
Figure 104. Chart of doorway widths in the Dunnu. Only doorways which width can be determined have been included.

V.5.7 Staircases

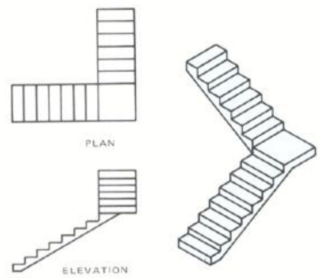
There is evidence for staircases in the archaeology of the *Dunnu*. Before turning to the archaeological evidence, traditional staircase construction methods are discussed to identify the possible variety of staircases that may have been originally present in the *Dunnu*, but did not preserve.

V.5.7.1 Staircase types and construction methods

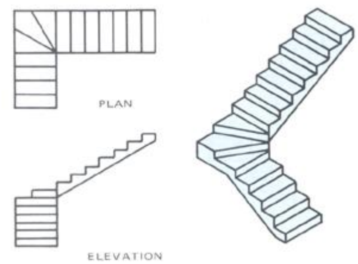
In terms of architectural form and construction material traditional staircase construction varies considerably. With regards to form, staircases can be straight, L-shaped, U-shaped or 360 degree revolving. Stairwells, rooms specially created for staircases, may be constructed while in other instances, no dedicated rooms are created for them, and stairs are built against the interior or exterior walls of buildings. Significantly for archaeology, staircase construction material and method influence their chance of preservation. Staircases may be largely timber constructions, largely mud brick constructions, or a combination of materials (Figure 106-Figure 108). Structurally, any staircase consists of two parts: the supporting structure, and the steps. Supporting structures can be timber based, solid masonry, or vaulted. Combinations are possible too. A very common staircase type found both archaeologically and in recent traditional construction is a block of mud brick masonry supporting straight timbers, bridging the gap to the next floor (Figure 109-Figure 111). The mud brick steps are put on top of these timbers. Slightly more advanced are staircases which employ a vaulted mud brick construction to bridge this gap and support the steps. In such cases, the archaeological signature is also different as there will be a second supporting point or pillar at the far end of the staircase receiving the other end of the vault or arch. Completely vaulted constructions are also possible, with a raising vault constructed across a narrow space to support the steps (Figure 109, middle). In this case, heavy supporting walls on both sides are required to anchor the raising vault. Even if the vaulted structure has collapsed, these supporting walls may still identified archaeologically. These vaulted or timber-based construction methods consequently create an empty space underneath the staircase, which may subsequently be used in various ways, hence playing a supporting role in the functioning of a building. Due to its greater chances of preservation, stairs built of massive masonry are most commonly found in archaeological contexts (Figure 109, top). Often such staircases are part of infrastructural works in a settlement, or just part of the base structure of a larger staircase. However, even if steps cannot be identified many staircases may be recognized just by their surrounding structure, the stairwell. In these cases, the steps have long gone, decayed, and collapsed, but the walls supporting them preserve (Figure 107). Such spaces may be identified based on their shape and access structure. Staircases are generally found in narrow, elongated spaces with a single access point. In the case of revolving stairs, these spaces may be arranged in a square or rectangular shape.



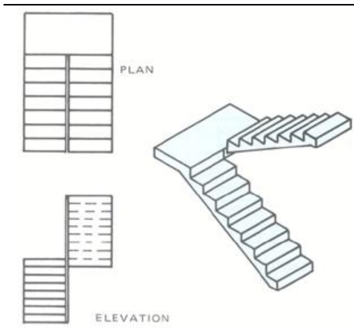
Straight running stair



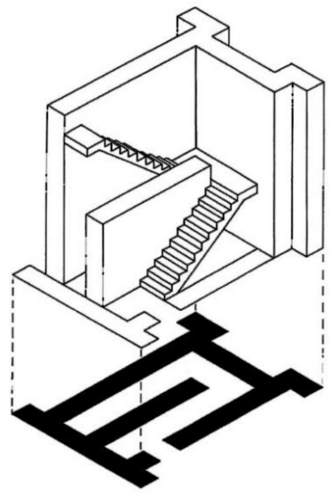
2a. L-shape stair with half-way landing



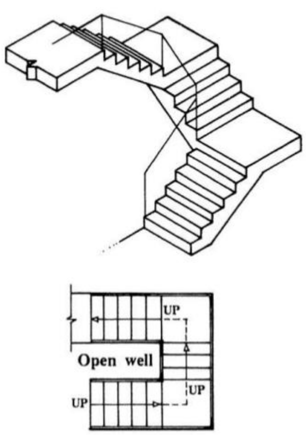
2b. L-shape stair with winders



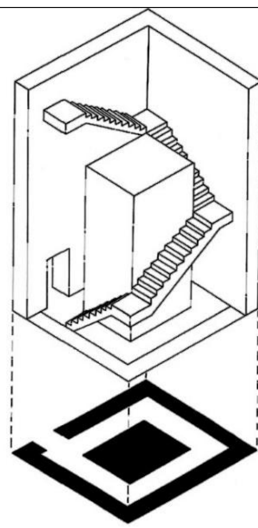
3a. U-shaped or dog legged stair



3b. U-shaped with spine-wall (after Margueron, 1999b).

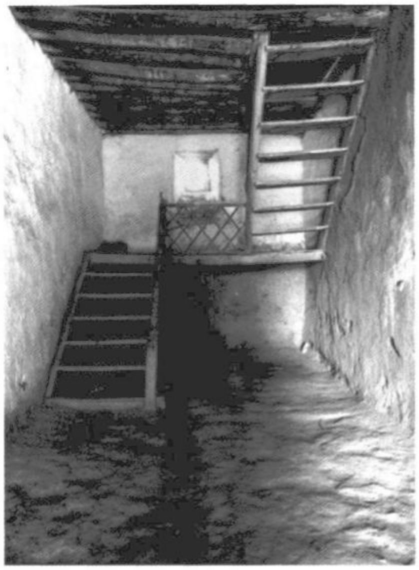


4a. Open well with two quarter space landings



4b. Revolving stair with square spine-wall (after Margueron, 1999b).

Figure 105. Staircase morphological types.



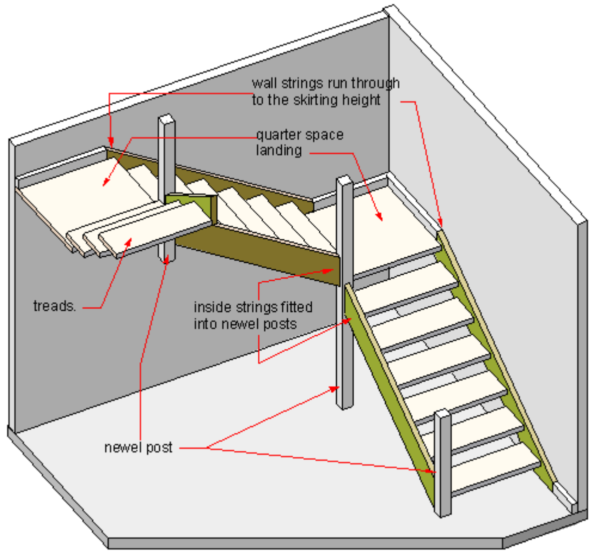


Figure 106. Timber stairs. Left: stairs in a house in Cafer Hüyük, Turkey. These U-shaped stairs are supported by a landing made of large beams embedded in the wall (after Aurenche *et al.*, 1997, fig. 4.13)*. Right: a common type of wooden stair construction. It uses so called newels, or vertical posts, to suspend the entire structure (drawing by Bill Bradley).*

Figure 107. Ruined staircase in Morocco. The mud bricks of the steps have weathered to an unrecognizable degree. The wooden base construction still holds and protects the empty space under the stairs, but when it gives way the stairway would only be recognizable by the walls of the stairwell (photo by author).

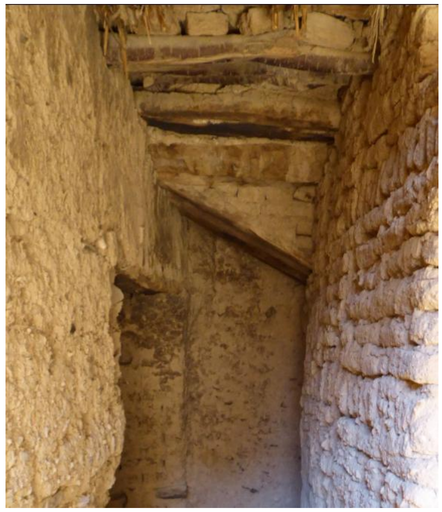
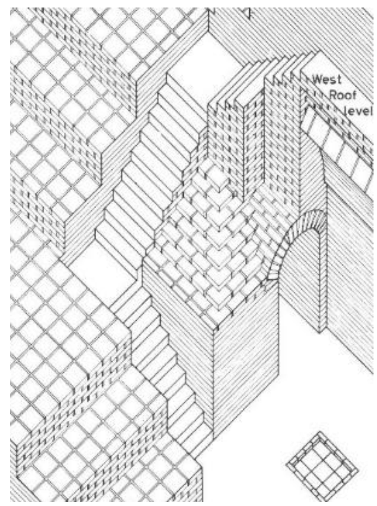



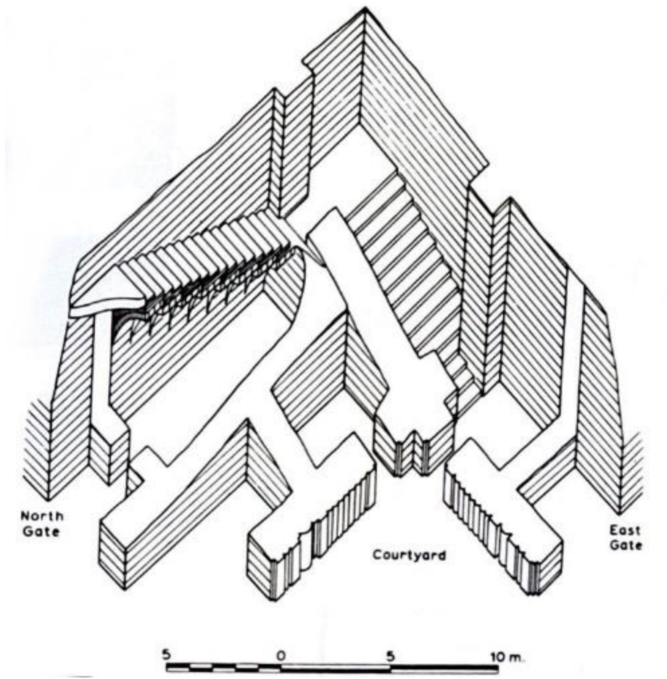
Figure 108. An example of a stair with mud brick spine wall in a ruinous house in Morocco. Like in Figure 49, the mud brick steps are put on a palm trunk base. The mud bricks have now degenerated to a precarious loam slide which the author climbed up to roof (photos by author).

Mud brick stairs plastered with loam plaster in the Red House of Tall Šēḫ Ḥamad

Baked brick stairs in old Babylonian Ur, unplastered. Each step is three bricks high

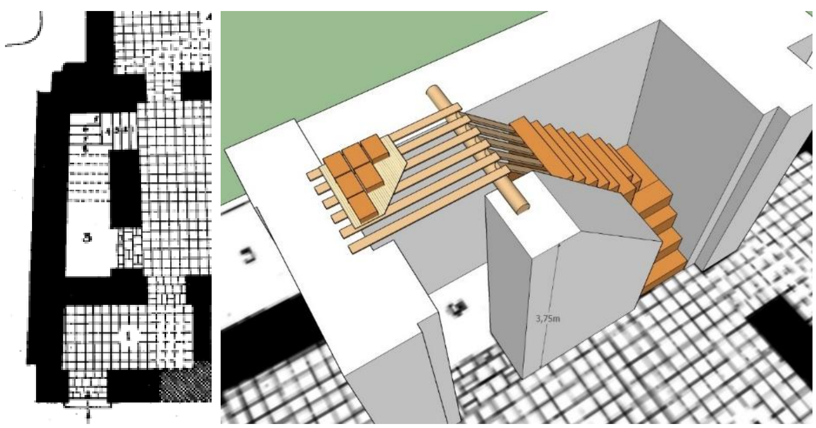


Reconstructed stairs in the Mittani palace of Tell Brak, running over vaulted corridor.

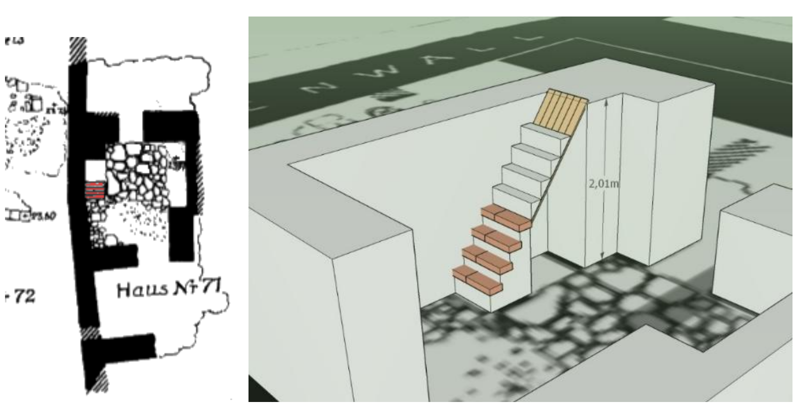


Staircase of the "Great temple" at Tell al Rimah (1800 BC). Arches are constructed on incremental elevations to form the base for the steps of the staircase. Note that the first flight is not vaulted but consists of a solid block of masonry (Oates 1990, fig.5).

Small stairs in a house in Nippur. The single half arch is a remarkably slender construction (after McCown, 1967, Plate 48B).



Staircase of the house at No. 2 quiet street in Ur. Left: plan drawing by Woolley. Right: reconstruction based on one of Woolley's suggestions. The reconstruction would lead to floor on 3.75 m. above ground level.



Evidence for stairs in house 71 in Assur (after Preusser, 1954, Pl. 25). Right: reconstruction, which leads up to an elevation of 2 m.

Figure 109. Examples of archaeological staircases.

Figure 110. A stair with a solid base and retaining wall of masonry and a timber superstructure under construction in Morocco. It was constructed in just over one day by a master builder and (unexperienced) assistant (photos by author).

Figure 111. A variation on stair construction from Egypt. Here, just two beams form the support of the stairs, while a strong layer of reed stem mats support the mud brick steps (after Correas-Amador, 2011, p. 16).

V.5.7.2 Staircases in the Dunnu

There are good indications for the presence of a number of stairs or staircases in the *Dunnu*, even if only in one case steps have been recovered. There are two types of large staircases: the heavy revolving staircase of the tower, and two long straight staircase that were used to access the fortification wall. Although of the latter type no steps have been preserved, the shape and location of these spaces leave no better alternative explanations. There are also indications for smaller staircases used to get to the roof or second floor of other buildings.

Already introduced in the discussion of vaulting, a heavy revolving staircase has been found in the north-eastern corner of the large central building (room 3). The staircase has two construction phases, one belonging to the original building, the other to the renovated and expanded building. In the later phase, it is rectangular in plan, and has a massive spill wall which anchored a vaulted construction that supported the steps. Parts of this vault has been recovered in excavation. The steps did not start directly after the entrance passage at the stairwell, which was located in the north-western corner. Instead, steps only start in the south-eastern corner, which means that one had to pass through a cornered corridor before the ascend started. This curious situation probably stemmed from the earlier phase, during which the staircase was smaller. We must therefore assume that they kept parts of the earlier phase of the staircase, and created an extension that mainly affected the higher levels. Although the extent and form of the original staircase is quite uncertain, it must have been smaller. If the step height and length remained the same between the phases, the later, larger staircase would have allowed for a much higher rise, and therefore implies that storey height was increased.

The width of the passage and the steps is 1.20 m-1.25 m, which implies that two people could easily pass each other, indicating it could be used as a two-way stairway.

Figure 112. The heavy revolving staircase of the central building. Left: the remains of the steps. Right: the vaulted construction that supported the steps (photo's by the Sabi Abyad excavation project).

The steps of this staircase were built on a vaulted structure. Unfortunately, the precise manner of construction is not disclosed by the excavation notes, as the original documentation drawings suggest this feature was not understood correctly. Besides the poorly documented remains of the vault, the heavy spill wall necessarily implies the use of vaulting. It seems however likely that we are dealing with a rising vault, possibly similar to those found at the great temple of Tell Al Rimah (Figure 109). In this case, each pair of steps had one supporting arch in this case. Alternatively, a diagonally rising vault may have been used, although no archaeological examples dating to the Bronze Age exist that suggest that staircase vaults were constructed in this way.

The length and height of the steps is not entirely certain. The excavation notes give variable step length of 35 cm to nearly two meters. Some of these steps show a 40 cm rise. Both the variable length and the substantial rise (beyond comfortable use) indicate that some steps may not have survived or were accidently missed during excavation. Steps such as these are however hard to recover, as their surface will almost certainly have suffered severely from erosion, like the top of any wall. In VI.5.7 it is inferred that more likely, the staircase had steps with a 40 cm tread and 20 cm riser. This results in a very comfortable incline, which may be explained by the possible use of this staircase as cargo lift. In section VI.5.7 the details of the reconstruction of this staircase and the related storey heights are discussed.

On two locations (buildings NE-5 and SE-6) in the *Dunnu* we find long and narrow spaces attached to the exterior of the earliest fortification wall. These spaces lead to dead ends and would be impractical for storage as a main function. No other good use for them can be thought of than to consider them as remains of staircases, even if no steps have been found. The original steps would have decayed and collapsed, or in one case intentionally removed during a renovation. This could mean that it originally housed a timber support structure for the steps. But even if the steps had a vaulted mud brick support, this may have collapsed or simply decayed earlier than the surrounding walls, which have a greater volume and therefore take longer to erode away. There are other structural similarities between the two cases that indicate that we are dealing with similar structures. First, both have a length of almost 10 meters, which suggests that stairs built within them would rise to a similar height. This is expected, as they would both lead up to the top of the wall. They are also of similar width, with measurement varying between 80 cm to 105 cm, which approximates the width of doorways. The most characteristic feature of each is that they were constructed by adding a narrow 1.5 brick width wall to an already existing wall, in both cases the exterior face of the fortification wall. This is another indication, the spaces were used as stairwells, as this abutting wall would not have been necessary were these spaces just intended to be long corridors. However, such a wall would make the construction of steps much easier and more reliable. Where this wall is preserved high enough, at the north-eastern staircase, no clear indication can be found that steps were attached. If the steps were originally vaulted, the spring of the vaults should be visible embedded in the wall.[52] As this is not the case, it seems that the alternative hypothesis, a timber-based support for the steps, gains additional ground.

Looking closer at the plan of the *Dunnu*, more possible candidates for staircases appear. On a few locations we find narrow spaces attached to a building, and open on one short side. It is very hard to think of a functional use for these other than as stairs. The light single brick walls indicate that if they supported steps,

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[52] This is not entirely certain as no good photographic documentation or elevation drawings of this wall exists.

these steps had a timber base construction rather than a vaulted construction. Note that the particular type of stair construction found in the *Dunnu* (if interpreted correctly) is not represented by the ethnographic examples of traditional construction. In more recent traditional building, we often see the type with a massive brick base, and slanted timbers on top of which the steps were constructed (see pervious chapter).

Figure 113. Possible location of staircase in building SW-6.

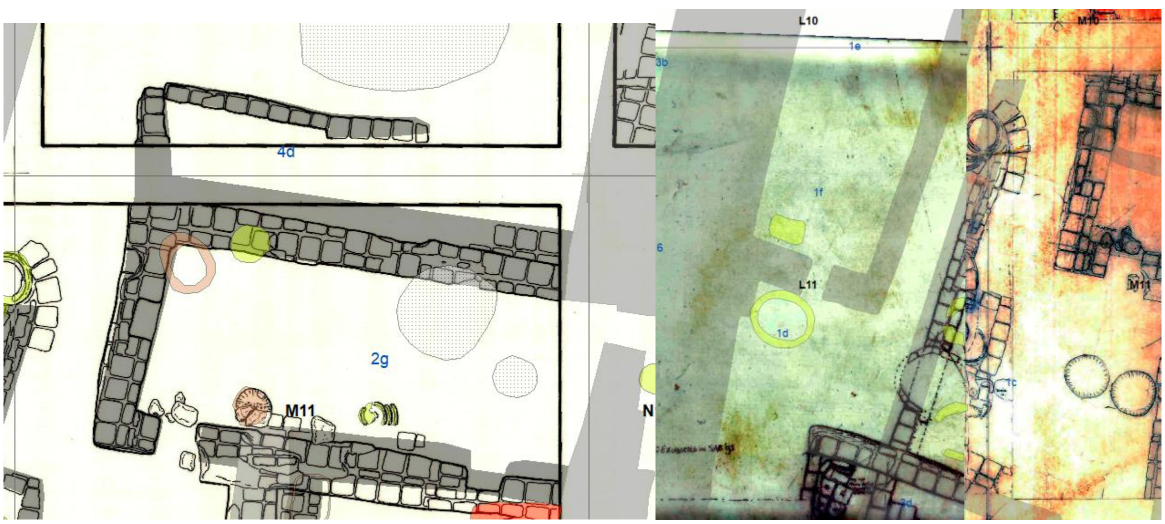

Figure 114. Two potential locations for staircases, judging from the elongated nature of the space. Left: north side of building SE-2. Right: In between building SE-1 and a separate stretch of wall without further apparent function.

One of the two more likely cases is found attached to the north of building SW-6 (Figure 113). Another is found attached to the north of building SE-2 (Figure 114: left). Just to the west of the former, we find another potential candidate for a staircase against the eastern side of building SE-1. This case is however less certain. A narrow, elongated space is found here between the building and a single wall that seems otherwise to have no clear function. However, it does seem that if here was a staircase, it would belong to the earlier phase of the *Dunnu*, since in later phases it was derelict and partly demolished.[53] Moreover, in the later phase, the presence of a staircase on this location would also block circulation. There are further architectural features that may indicate the presence of staircases in the eastern and norther extramural sectors. As the level of preservation is bad in these areas, these hypothetical staircases are less certain. But there are currently no good alternatives for the reconstruction of elongated narrow dead ending structures to the side of buildings.

A last case that should be discussed is found in the south-western corner of the *Dunnu* (Figure 115). The architectural situation is hard to understand here, but the observed irregularities require an explanation. Here, the parallel walls of space SW-2a and SW-2c are constructed with some spacing between them. The walls are of unequal thickness, and show irregular features, which may be caused by very limited preservation and post depositional movement. One hypothesis is that they might be remains of an earlier fortification wall that ran over this line prior to the construction of the residence, which required expansion of the fortification wall. Another interpretation, and perhaps not necessarily excluding the previous, is that we see the remains of a staircase. Perhaps this staircase ran in two directions from room SW-2b: one to the south towards the fortification wall, and one to the north towards the residence. However, for this stair to reach the top of the wall, more space is needed. Instead of two stairs running in different directions, it is possible that it represents one long stair with an access at the south-western corner of the residence. The length of this potential staircase, 9.2 m, would be near in length to the other staircases that reached up to the fortification wall, therefore possibly reflecting a pattern. The structural type, with a massive block of brick at the lower end of the stair, and a lighter, floating steps construction based on timber higher up, has been discussed earlier as common approach to stair construction (Figure 109-Figure 110).

[53] Its original base was however preserved by demolition debris and sediment deposits.

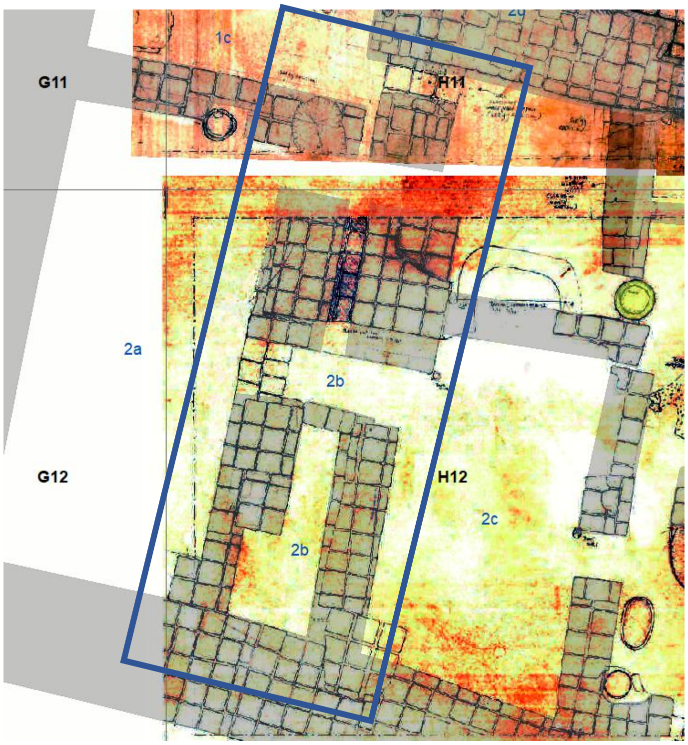

Figure 115. Unusual structural features (framed) possibly indicating the presence of staircases in the south-western corner of the Dunnu.

V.5.8 Roofs & intermediate floors

Although pieces of burnt timber are frequently found in the *Dunnu* (see also Figure 135), there is no direct evidence for large quantities of heavy timbers that one would expect if a roof collapses. Recognizable fragments of what seem to be poles of some sort are always relatively small: the few measured pieces are 20 to 60 cm in length and 5 to 8 cm in diameter. It seems a fair assumption that most of the pieces were part of the roof or ceiling as this it is in the roofs where the largest volume of wood is present. As discussed above (see V.4.5), some of the carbonized wood has been sampled and analysed, which shows that the major wood species are poplar, ash or willow.

One remarkable fire-preserved deposit may be roof collapse. It is found for example, in room 6b in the south-western sector (see Figure 34). The room fill contained large quantities of orange burnt loam, charred grain, and burnt bricks, almost immediately after the surface was scraped off at the start of excavating this area. Moreover, excavators reported repeatedly and independently of each other large slabs of burnt loam, in one case described as a slab of loam with a finely layered structure. Pottery in room SW 6b was found in relatively complete state, standing in situ, but with crushed tops. The most likely interpretation for this situation is that the fire baked large parts of the roof deck, which then came down, crushing the pottery inside the room. Like elsewhere no preserved remains of roof beams are found in this context. It is remarkable that the characteristic imprints of poles or reed were found nowhere in these slabs of burnt loam.[54]

V.6 Modification and repair

An important question is how the *Dunnu* changed over time as result of building modification. Like other construction practices, modification is part of the builder's repertoire of techniques and follow certain conventions as well as pragmatic decision making. Modifications to architecture often include entire or partial demolition, and therefore leaves a trace in the stratigraphic record surrounding the architecture. Deposits such as these were discussed in the previous chapter. A classification of different types of possible modification is given under IV.2.3. Here we will discuss the evidence for modification as seen in the preserved architecture of the *Dunnu.*

V.6.1 Evidence for modifications

Evidence for modifications is both found in the wall structure itself, and the deposits found inside buildings. Concerning the walls, there are two types of evidence: the structural relation between walls, i.e. bonded or abutted, and material transitions within walls, i.e. a change of brick type, or a different grout. The evidence found in between the walls mainly concern fills that include demolition debris or other types of intentional filling in order to raise the level of a building or roof. Large scale modifications requiring partial or entire demolition of a building will naturally be more visible in the archaeological evidence than repair related to regular maintenance.

[54] It is possible that this was overlooked by the excavators, as the slabs were just found and described in sections. Additionally, it is possible that their fragile state would not have allowed easy observation of the bottom part where one expects the imprints of poles or reed.

Evidence type	Options	Caveats
Structural relations between walls	Bonded	May equally be indicative of phasing, as of type of construction method.
	Abutted	
Deposits between walls	Mud brick wall debris	Cause of deposit may be hard to establish: natural causes or human, partial or complete building replacement.
	Levelling layer	
Wall material characteristics	Brick colour	Differences may instead be indicative of certain constructional choices or coincidences.
	Brick size	
	Bonding type	
Stratigraphic relations	In the same layer/on the same surface	Constructions on the same surface are not always contemporaneous. Layer differences may be caused by different foundation practices (levelling).
	In a different layer	

Table 6. Types of evidence used to determine building modification.

All the evidence is ambiguous to some degree, as observed situations or patterns might have different possible causes besides a modification activity. As a base rule of thumb in archaeology, bonded walls are often considered contemporaneous, while abutting walls would be constructed in chronological sequence. Abutments are logical when one considers the practice of constructing one building against the next, to expand the complex with a new structure. Walls belonging to the same structure, build at one point in time, are logically bonded to each other. However, the choice for walls to be bonded or abutted is more a decision based on structural requirements, than an accidental side effect of chronological building modifications. So, if structurally required, walls may be bonded even if they are chronologically separated. On the other hand, abutting walls may be opted for if there is no structural necessity to create a bond with other parts of the building. A good example of this are the interior partition walls of the residence, which were built abutted to the main load bearing walls.

Transitions in the material characteristics of brickwork, or in bonding occur frequently in the *Dunnu*, and may be indicative of modification activities. However, it is often unclear whether the transition reflects a change in building method or material that occurred during construction, or whether it reflects phased modifications. For instance, a change in brick material, primarily indicated by colour or consistency, may reflect a demolition and rebuilding phase of a wall. The very same pattern may be attributed to the use of different bricks from a different origin within the same construction. Especially with very large constructions, such as the fortification wall, this could have occurred easily, as large volumes of brick are required, and production batches can be depleted before the top of the wall is reached. Therefore, situations like documented in one section of the fortification wall as illustrated on Figure 90, may very well be the result of various production batches being used in the construction of this wall.

The clearest evidence for modification is usually found in cases where there is a clear stratigraphic separation between building phases. New walls are constructed on top of deposits that postdate the construction of a building. These deposits have been described in detail in the previous chapter.

V.6.2 Horizontal modifications: addition and partition

Addition involves constructing completely new buildings, or extensions to the exterior of already standing structures. Partition involves the creation of spatial separations in already standing structures. Examples of additions are the construction of the residence against the west wall of the earlier tower, and the new structures to the exterior of the fortification wall. That the residence is a later, added, structure, is clear from various indications. There is a clear stratigraphic relation between this building and the one it was built against, the tower. There were deposits of building and habitation accumulation outside the tower that occurred prior to the construction of the residence. The builders also took the former structure into account by applying a lower wall width on the side of the residence supported by the central building.

This also underscores the importance of stability over carrying capacity as main structural argument for the width of walls that builders applied. These are all examples of the long side of buildings being placed adjacent to already standing structures. An abutting long wall is still necessary as it needs to carry the roof beams. In cases where the short side of a building is appended to standing structures, no such wall is needed. This is demonstrated by the 1/1.5 brick wide wall structures that are added in the south to the heavier architecture integrated with the fortifications. The other type of new structures that may be added to standing structures are partition walls. These may be hard to stratigraphically differentiate in the case of interior spaces where hardly any deposition occurs. However, when observing cases in the *Dunnu*, this is quite a rare phenomenon. The few partitions that are added to the interior of large indoor or outdoor spaces, most likely postdate the main *Dunnu* phase, as they correspond to evidence of use that are inconsistent with the original functions of the architecture. Partitions are interesting pieces of evidence, as they indicate changes of function. The use of a space has evidently changed, which required the partitions to be put in place. There are also cases where partitions have been removed. The two only documented examples are found in two spaces in the tower (space 6 and 7). The survival of material evidence of these removed partitions is due to the use of demolition debris as levelling layers inside these rooms. Like the addition of partitions, their removal point to an important functional shift in the uses of this building.

V.6.3 Vertical modifications

Vertical expansion involves adding or removing height to a building. Archaeological detection of such modifications is hard since it usually occurred above preserved levels. Nonetheless, there are types of indirect evidence that may indicate such modifications. The first is the widening of walls. The addition of a floor would require reinforcement of walls on ground level. Such practices have been recorded in ethnoarchaeological studies of domestic architecture (Figure 19). Widening of walls has been observed on various locations in the *Dunnu*. In some cases, this may indicate the addition of height to a building, while in others it may be evidence of the roofing of a formerly open area. A difficulty with this type of evidence is however that widening may also be indicative of a reinforcing effort to counteract structural failure, rather than a change of building height. In none of the cases it is possible to completely exclude this possibility, but contextual evidence makes it possible to increase the likelihood of being evidence of a vertical modification.

The most interesting case is the tower (Figure 116). The widening of these walls on the interior as well as on the exterior is very hard to explain otherwise than to indicate an increase in building height. The architectural changes also accompany a change in mode of deposition in the central rooms (2 and 5), from gradual rise to a fixed floor level (Figure 139). These phenomena may have a shared cause: a roofing construction that was built over formerly open areas. The curtain wall added to its exterior and those added to the interior walls, are hard to explain otherwise than indicating the addition of building height. In favour of the height increase is also the enlargement of the staircase, which would in fact imply an increase in height for the individual floors, not necessarily the addition of new ones on top. The reinforcements of the tower have always been understood by the excavators as part of a renovation program to restore a decayed building. However, the placement of reinforcing walls seems more strategic, and aimed at reinforcing the entire structure to better withstand increased vertical loads. Also, the demolition of the northern exterior wall (while other walls are left untouched), its rebuilding on a new location, and the consequent increase of the size of the staircase has the appearance of a very specific constructional aim.

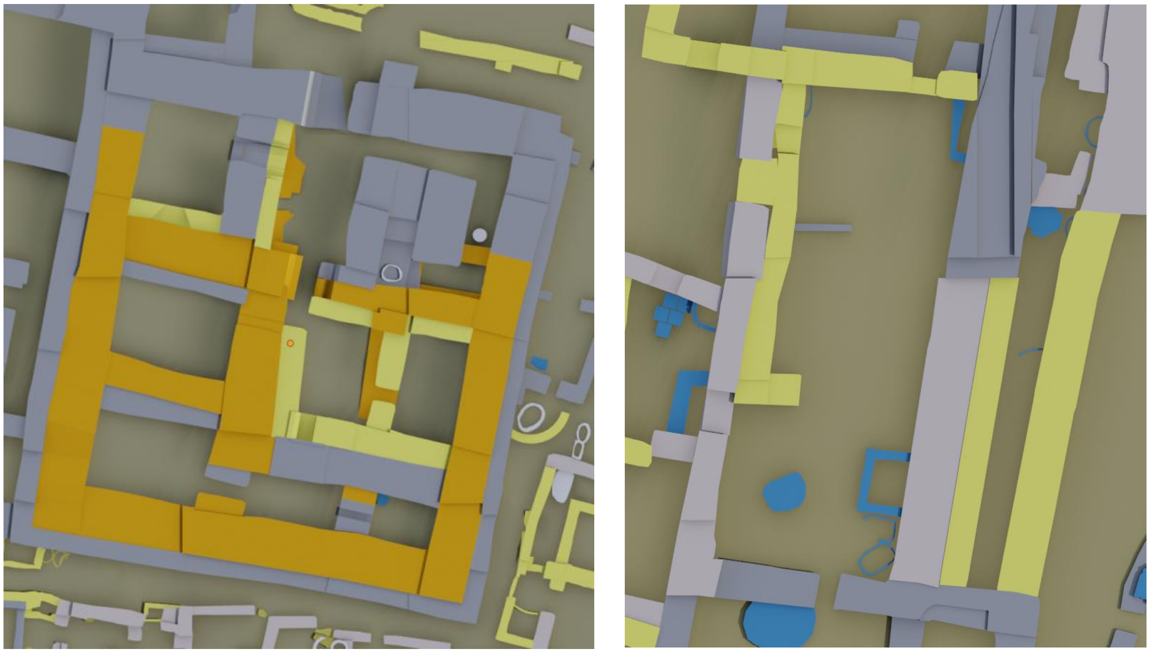

Figure 116. Widening of walls in the Dunnu related to structural modification on higher levels of the architecture. Left: the tower. Right: near the postern gate, buildings SE-3 and SE-6.

A wall width increase has also been attested on the western wall of space SE-3 (Figure 116, right). A new wall was constructed abutting an older wall, that itself was kept standing as well, effectively doubling the width of the wall. The main function of this wall was to create a separation between inner and outer *Dunnu* as it closed off the large open space behind the postern gate. The effect of the wall widening, is a decrease in space width, bringing it into roofing range. It therefore seems possible that the widening reflects the construction of a roof over a previously unroofed area. The proposed roof construction does not occur in isolation, as the addition of this wall correlates with a significant modification to the architecture in this general area.

Other cases of wall widening mainly concern the fortifications. On a few locations heavy abutments are constructed. Since these are targeting just small sections of the fortifications, these should not be considered as evidence for a general increase in fortification height. The walls do effectively increase the surface area on top of the wall, which may be related to the reason for their construction. On the other hand, structural reinforcement as a means of repair may very well be the cause.

Reduction of wall width has been observed in just one case, in space NE-3b (Figure 76). Here, walls are reduced in width, effectively increasing the surface area inside the space. It is interesting that the fortification wall is also involved in this reduction. At this moment in time, the fortification wall had lost its defensive function in this area. To justify the effort, there must have been a functional or structural architectural reason to do so. One possible interpretation is that the reduction of width may be indicative of a reduction of height of this wall as well.

V.6.4 Demolition and rebuilding

This type of modification concerns the (near) complete removal and replacement of buildings. Generally, with this practice, the stumps of previous walls are left covered underneath the debris produced by the demolition practices. This deposit is subsequently levelled and used for a new phase. There is evidence for demolition and rebuilding in the *Dunnu* in distinct areas (Figure 117). In these cases, older versions of buildings have been replaced by more recent ones, generally of a different type or form. These modifications are not part of common building repair and maintenance, but they imply a functional change of the architecture, and the *Dunnu* in general.

There is a difference between buildings that are completely raised and replaced by something else, or buildings that are partially demolished and modified. The tower is an example of the latter practice (Figure 117, no. 1). The northern exterior wall and attached interior parts are demolished, and rebuild on a different location, with the effect of expanding the building. As argued elsewhere, it is possible that this is related to the enlargement of the staircase, requiring the northern wall to be moved. Also, around the interior in rooms 5 and 6, demolition and rebuilding of some walls occurs. However, in the remainder of the building, the old walls are left standing, indicating continuity of the building in general.

In all other cases, complete buildings are demolished in order to make place for a new structure. In the area of the postern gate (Figure 117, no. 2), the access structure is reorganised with this modification, implying the demolition and rebuilding was motivated by a rethinking of the spatial functions of the *Dunnu* in this area. Another case is the expansion of the fortifications in the north-eastern corner (Figure 117, no. 3), which occurred at the expense of some extramural architecture of the old gate phase. The motivation for this expansion remains unclear. Since the rooms at ground floor are not very accessible, nor does the material evidence suggest any role of importance, it seems likely that the modification offered defensive advantages, and/or was related to the addition of new functions for which the upper floor was used. A similar case may have occurred in front of the new gate, which appears to have been demolished to make space for this new structure (Figure 117, no.5). Lastly, the large-scale demolition of all extramural architecture in the eastern *Dunnu* (Figure 117, no. 4) is of another nature, since it covered all the buildings of what seems to have been the pottery district. Although there are some indications of rebuilding, it seems that this took place to a limited degree. However, archaeological preservation due to surface erosion may have biased the picture here. Nonetheless, the architectural modifications again imply an important functional shift in the *Dunnu*.

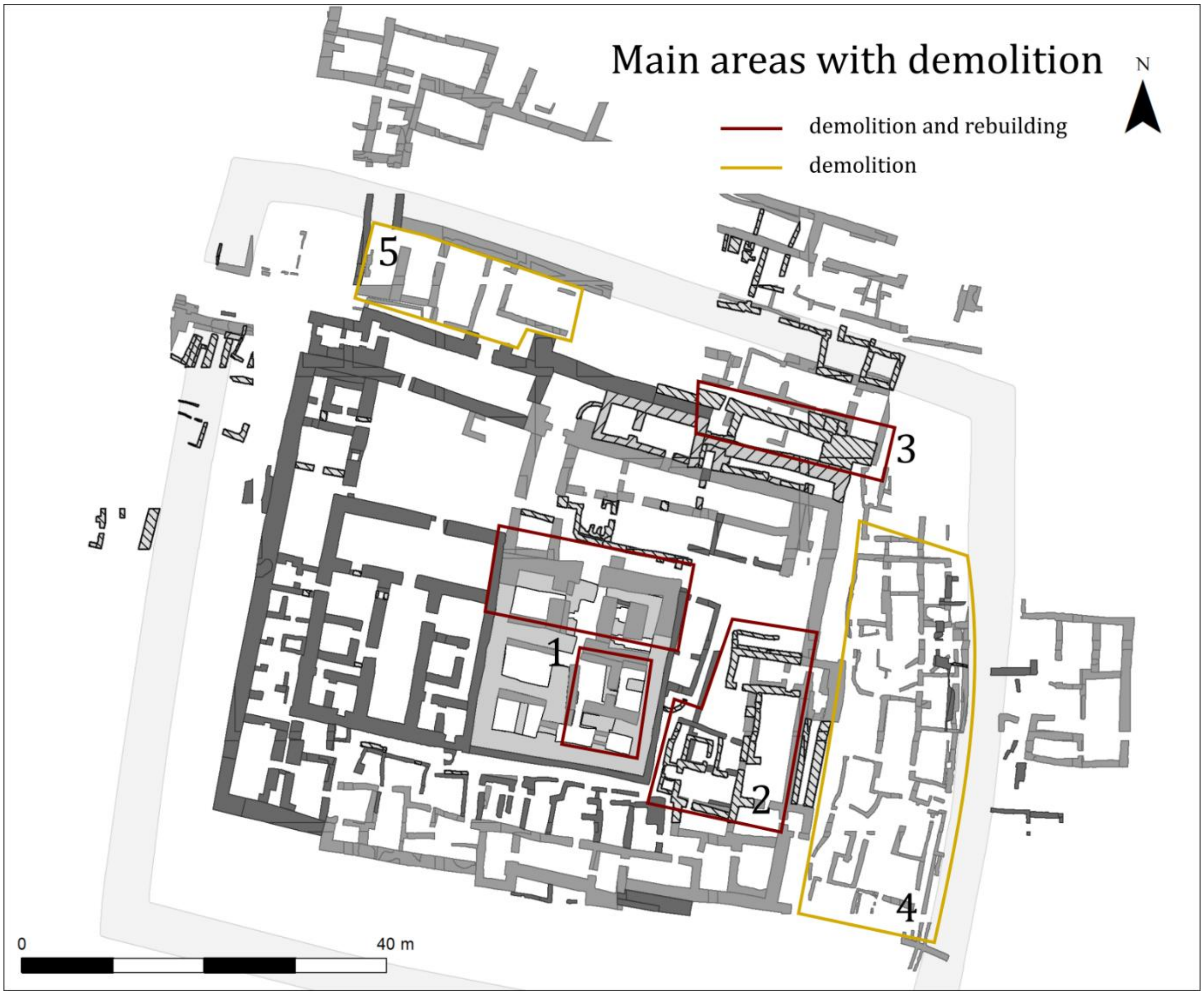

Figure 117. Primary areas of demolition and rebuilding.

The transitions in brickwork that can be observed in various structures in the *Dunnu* may be taken as additional evidence for demolition and rebuilding. However, as argued above, the meaning of this evidence is ambiguous. It is not clear whether such transitions indicate a true rebuilding phase, or simply reflect differences of used construction materials and methods within a single construction. Which one chooses has large repercussions on the reconstructions of the *Dunnu*. As most brick transitions have been observed in the fortification wall, this would suggest that the large parts of the enceinte would have been demolished and rebuild on the same location at least once.

V.6.5 Doorway modification: blocking and opening

Doorways form a separate class of evidence for architectural change. New doorways may be created by removing bricks from a wall to create a gap, or existing doorways may be blocked with bricks, rubble fill and plaster. Doorways may also be enlarged or reduced in size. The archaeological identification of doorway modification is not always easy, as certain building methods may create a wrong impression of modification. Again, we are limited by the amount of specific comparative information that can be found in the literature about traditional construction methods, to properly assess many situations in the *Dunnu*.

Figure 118. Plan showing various types of doorway modification.

The cutting of an opening for a new doorway in existing walls may be recognized in several ways. The first is that the end-bonding of the jambs may show unusual brick sizes, supposedly created by the cut at an odd location. Also, the cutting activity may have caused an irregular face of the door jamb. Both are problematic in terms of archaeological detection, as the sides of doorways are often damaged by erosion and building collapse. A second characteristic is the presence of a bonded threshold. In buildings of the *Dunnu*, generally, the bottom of doorways possesses no threshold, and are flush with the floor surface. The presence of a bonded threshold may therefore indicate the remains of a once uninterrupted wall. In such a case, the doorway may have been cut above foundation level due to the raising of floor levels. We can however not completely rely on this characteristic, as bonded thresholds may be part of the original construction and therefore do not always indicate such a doorway was cut later. A few examples can be drawn from the data of the *Dunnu,* for instance, various internal doorways in the residence clearly possess a bonded threshold which must have been part of the original construction. However, a small exterior doorway present on the north-western side of the residence has been interpreted in the excavation reports as a later, cut doorway, while there is no good evidence to exclude the possibility that it was part of the original construction of this building just as well. There are some interesting repercussions in terms of the spatial functioning of the *Dunnu,* and the hypothetical functional role of certain areas, as a result of how one views the construction of this doorway, that will be discussed later. On the other hand, unbonded thresholds, that were thus constructed after the creation of the doorway, may indicate the doorway was cut at a later point in time. However, it may also be indicative of an approach to construction that involved putting in the threshold last.

The presence of abutting door jambs are another indication of a doorway that was constructed later. In general, in doorways in the *Dunnu*, door jambs are structurally integrated with the main wall construction (Figure 95, left). In a few cases, jambs appear as separate constructions. This may indicate the doorways was a later construction. The separate jambs indicate a reduction of width of the doorway, while their structural function is the support of a new arched lintel. Therefore, it is possible that such newly constructed jambs had indicate the use of an arched lintel also in places where the lintel did not preserve. There are several of such cases found in the construction of the tower (Figure 95, right). The modification of these doorways on ground level implies a significant construction effort as the heavy superstructure would have needed to be supported during construction, while a short tunnel had to be made into the 2 meters thick walls. It remains a question how it was done. It is possible that the doorway was not cut at once, but step by step, followed by a segment of the vault, to minimise the chance of collapse. However, these vaults are not made of separate archivolts, but are entirely bonded brick structures. With this type of vaulting, it would be constructionally more logical if the vault was constructed lengthwise layer by layer, tilting each next brick layer somewhat more inwards. However, this approach would require a rubble fill and space on top for the builder to move and lay bricks. This would imply, that to build it, either the entire wall on top has to be demolished until the highest floor, or the gap had to be temporarily supported by heavy timbers in order to prevent wall collapse. The thoroughness of such modification would however fit in the general picture we get from the evidence of renovating this building.

In one case, a reduction in doorway size is indicated by the construction of a new doorway inside the gap of an old one (Figure 119). The construction of new jambs, abutted to the older wall is also clear from this example. It seems likely that the new doorway was constructed at the place of the vault of the old doorway, implying the latter had collapsed or was demolished. The new doorway is however associated with a very late use-phase of the *Dunnu* structures, which post-dates the primary phase of our interest.

The construction of low walls, reminiscent of benches, inside a doorway may be mistaken for the construction of new jambs in one case. The passage from the large gate room of the new gate towards the paved court, contains such low walls (Figure 120). Although it is possible that the upper side of these walls was destroyed, it seems more likely that they never were much higher. If they were constructed with the intention of creating new door jambs, chances are they would have been plastered to form one whole with the older existing courtyard wall, as is the case in other examples from the *Dunnu*. The absence of plaster and the fact their short ends are somewhat retracted from the face of the main wall, suggest these structures sat behind large doors. For other constructions inside doorways that have a different structural purpose than a door jamb, see V.5.6.

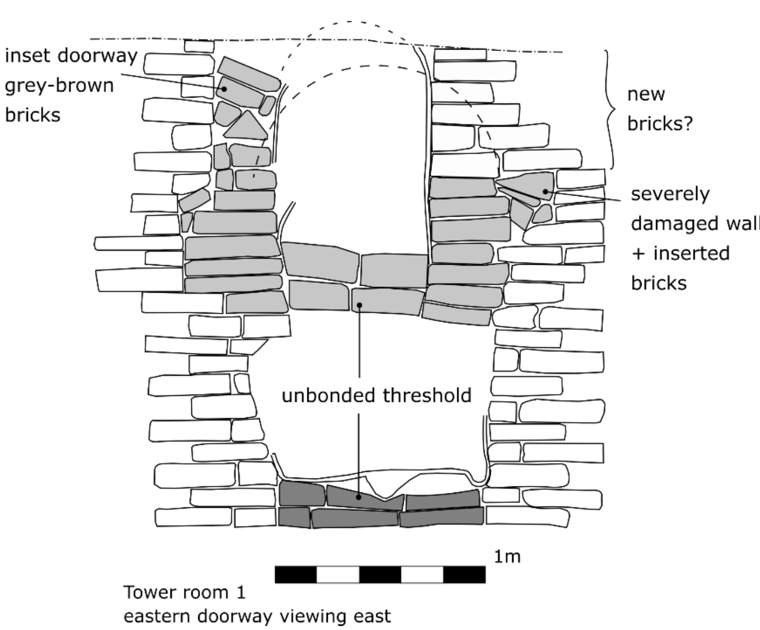

Figure 119. Doorway from room 1 to 2 in the tower. The best example of a doorway with two phases of which the second phase doorway is not bonded to the original walls. Both doorways, even the first doorway, have unbonded thresholds. The second doorway dates however to the secondary settlement phase during which the tower was partly in ruins.

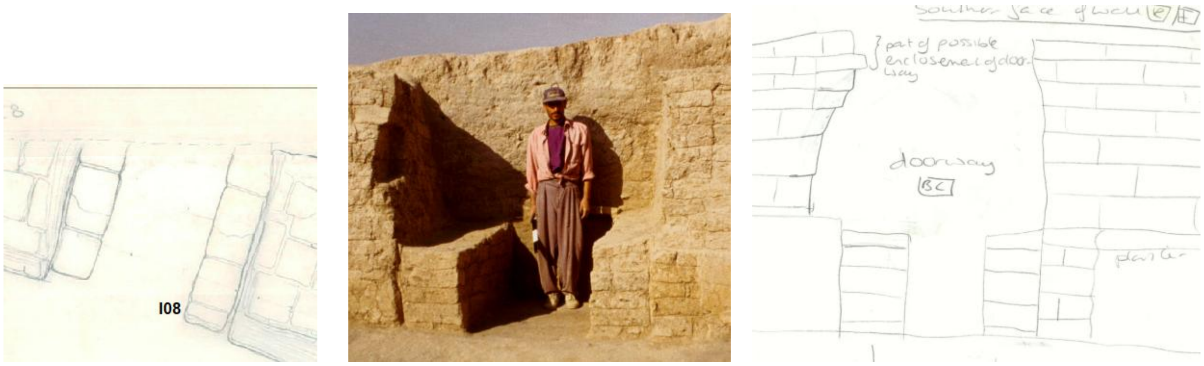

Figure 120. Gate to main court with benches.

Figure 121. Different threshold constructions in the Dunnu. 1: full width of wall, bonded with jambs. An example of a neatly constructed one in the residence. 2: Consisting of two baked tiles with some space between, probably a gutter for drainage of the main court. 3: Bricks on their sides applied on both ends of a doorway, which functioned as small retaining walls for a loam fill in the middle. 4: two bricks without special features.

Opposite to doorway creation, a number of doorways have been blocked. The construction of these blockings varies. The neatest blockings are those that fill the entire depth and height of the opening, and are covered with the same render as the wall itself. This is clearly done with the intention of continued use of a space in the same manner, requiring a neat finish on the walls. The best example is found in room 4a in the residence, where a doorway has been found in the southern wall. The reason for this blocking is unclear. Access between these two rooms is also possible around the corner, so it almost seems that a doorway here was a mistake in the original planning of this building. Then there are blockings that are less neatly constructed: single width walls of simple brick stacks, often not completely covering the entire height of a passage. Some of these features referred to as ‘blockings’ in the excavation documentation are so low, that they could easily be stepped over. However, it is possible that blockings, due to their feeble construction, may often not have preserved to their original height. In a few cases archaeological context clearly indicates a raising of floor level, which went hand in hand with the raising of a threshold inside a doorway.

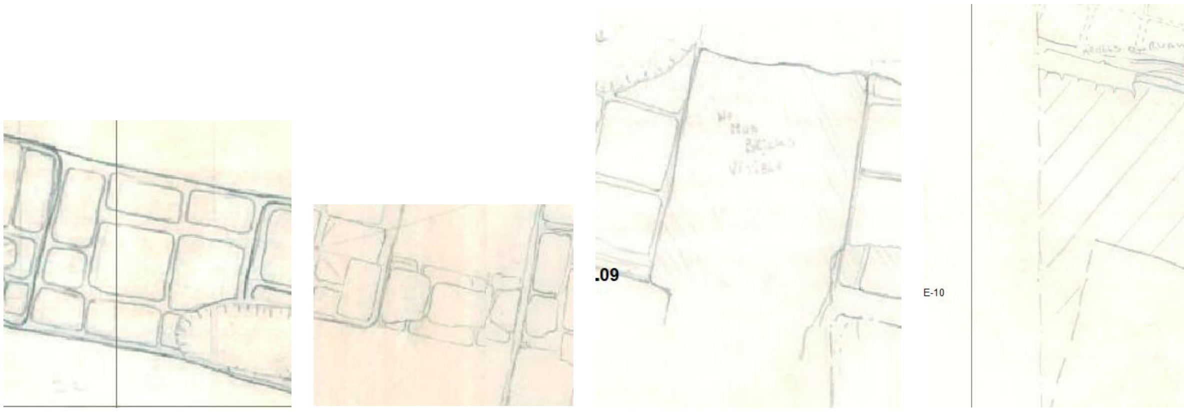

Figure 122. Doorway blocking in the Dunnu. 1: neatly constructed and integrated blocking in the residence. 2: hastily constructed blocking in the residence. 3 & 4: rubble fill with a later constructed wall blocking one side of the entrance.

Building NE-3 is another building that was significantly modified over time, which included doorway modification (Figure 122: 3 & 4). Different from other regular blockings constructed with brick, is that rubble blockings were constructed. Also different is that the blockings are clearly associated with the construction of new walls perpendicular to them. Doorway blocking here is thus motivated by functional repurposing of the building, or area in general.

In other cases, it seems that the blocking also served a new additional purpose besides blocking an entrance. Various interesting structures have thus been created inside doorways. In a few cases, some kind of windows appear to have been made by low walls inside doorways. Two of such structures were constructed in room 2a of the residence. The most curious blocking feature is one found in another doorway from and towards the main court (Figure 125). It appears to consist of four different structural parts, whose function has never really been clarified.[55] It is possible that it was a phased construction, with several different modifications applied to this doorway.

[55] Due to its stepped construction, it was identified by the excavators as possible stairs. But this seems quite unlikely since the three steps do not lead up to the original height of the wall, and there is no place for additional steps in this design that reach to a sufficient height. The steps are also of an unusual and inconvenient height.

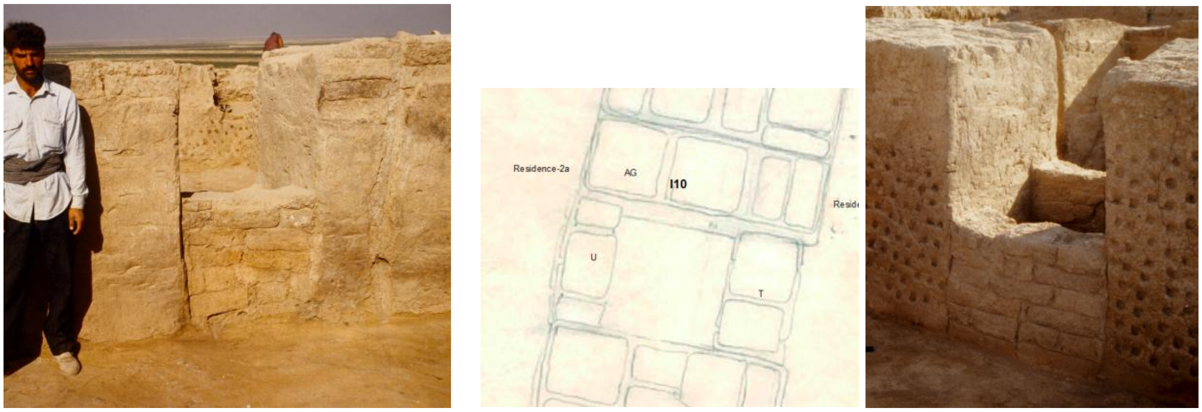

Figure 123. Construction inside a doorway in the residence. Jamb AG appears to have been constructed before walls U and T and is integrated with the main structure.

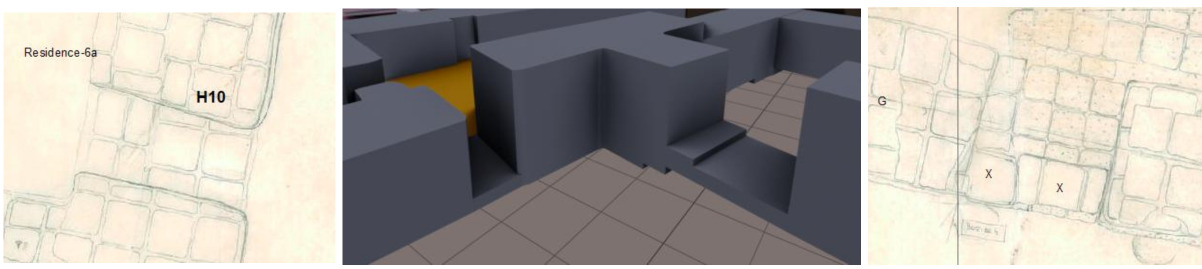

Figure 124. The western and northern doorway into one of the main rooms of the residence (2a). Both doorways have two courses of mud brick wall underneath the doorway.

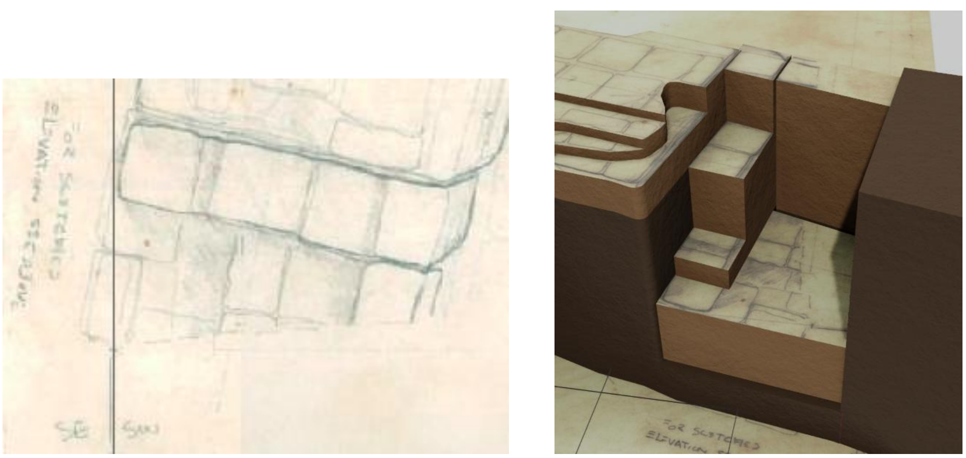

Figure 125. Feature AG in space NW-1.

In terms of phasing, stratigraphic evidence is often hard to assess, because no sedimentary stratigraphy was given the chance to develop prior to the placement of many blockings. Hence, they are placed on the original floors of the *Dunnu*, but there are indications that some of them post-date the main *Dunnu* phase. However, there is a marked difference between the north-western sector and eastern and southern sectors of the *Dunnu*. In the north-western sector and the residence, many doorway openings, blockings or structures inside doorways must be placed in a phase of transition after the end of the main *Dunnu*. Even though stratigraphic evidence is difficult to assess in several cases, the effect they have on the functioning of buildings such as the residence clearly indicates that they were not part of the original construction. Therefore, many of these openings and blockings most likely reflect a phase that the residence was no longer used as such. The openings and blockings of doorways in the tower, the north-western sector and south-eastern sector can generally be associated with wholesale renovations of buildings in these sectors, pointing at functional change prior to the final days of the *Dunnu*. The small blockings seen in the southern *Dunnu* on the other hand are part of continuous use and can in some cases be related to issues with drainage directions and sedimentation in the narrow alley at the back. This alley collected all water and erosive sediments from the two massive central buildings (see VI.7).

V.6.6 Repair

Common maintenance activities in mud brick architecture involve replastering walls and replacing roofs. As has been discussed, regular wall plaster repair is important for the long-term survival of mud brick architecture and commonly takes place annually or biannually. Interior and exterior maintenance is different in nature and frequency. Roofs similarly have to be replastered and compacted to maintain waterproofness. Replastering leaves relatively few archaeological traces, although layers of plaster should be visible on close inspection. Also, old plasters will end up at the bottom of the wall as a result of weathering and erosion and therefore leave recognizable traces. Unfortunately, neither type of evidence has been systematically documented, and it is therefore hard to say something about wall plaster maintenance practices in the *Dunnu*.

Roofs also require occasionally wholesale replacement. Although this practice has been recorded in ethno-archaeological studies, variations in frequency between climatic regions or cultural zones of construction practices are not well documented. Roof replacement, which involves demolition and replacement of roof beams, theoretically leaves a layer of debris inside a building. This layer may either be cleaned out or compacted into a new floor, which would result in a recognizable archaeological feature. Again, such building practices are not well documented, and it is therefore unknown what archaeological traces roof replacement really leaves. In the *Dunnu*, occasionally thin layers of rubble are found within a building. Although possible, this evidence does not allow us to link such deposits to roof replacement or any renovation in the upper sections of a building. It should however be considered as valid alternative to the interpretation that such rubble deposits are caused by abandonment and subsequent decay, a statement often found in the field documentation and some publications about the archaeology of the *Dunnu*.

Repair may also involve the structural reinforcement of buildings, using buttresses and abutments. Buttresses and abutments are not by definition indicative of repair related reinforcement, and as such their structural context has to be assessed very carefully. Again, abutments and buttresses are also used when a building modified and requires reinforcement, such as when another floor is added. In these cases, repair is not the aim, and such reinforcement cannot be used as evidence for the structural condition of a building at a point in time.

V.6.7 Brickwork transitions as evidence for modification

In paragraph V.5.3.8 the phenomenon of layered or complex wall construction was discussed. Although the explanation of these patterns is uncertain, one possibility is that it is indicative of wall renovations or architectural modification. An alternative one offered here is that during wall construction, at some point a transition was made to a different brick or a different bonding method, thus mainly reflecting the logistics of construction. In one case were a cross section of the fortification wall revealed multiple layers of bricks of different material characteristics near to each other, the latter seems like a plausible explanation. In the case of the south-eastern corner, a clear cut may be observed in the brickwork, corresponding to other evidence of an extensive remodelling of the *Dunnu* architecture in this zone. Therefore, the simple dual layering is probably indicative of one modification phase. In the north-western corner of the *Dunnu*, the evidence is less straightforward. Although on first sight is appears as a very likely a case of demolition and rebuilding that can also be correlated with debris and levelling deposits found inside the buildings. However, some of the evidence is confusing or inconsistent. For instance the preservation of certain partition walls in this rebuilding phase seems unnecessary, considering the new function of all of the spaces. The question is, why put the effort into rebuilding an entire building during a renovation phase, and not change its spatial layout more suited to new functions?

The answer has a significant impact on our model of settlement development. If these are interpreted as wall renovations, this implies that large segments of the fortification wall were taken down to 0.5 to 1.5 meters above ground level, and entirely rebuild. This would affect a large part of the northwestern corner, a segment at the centre point of the northern fortifications, and a large part of the eastern fortification wall (for details see: V.5.3.8). Although no such layered complexes were documented in the southern *Dunnu* this does not mean it does not occur here. However, wall preservation is simply not high enough in this area to be able to tell. Rebuilding 6-meter-high fortifications is a labour-intensive project, so there must have been good reason to undertake them. In this case, either the fortifications had structural defects, or there had been historical events that required a significant redesign in the functioning of the fortifications or the *Dunnu* as a whole.

V.7 Conclusion

The evidence discussed in this chapter shows that the *Dunnu* was constructed by people familiar with the building craft. Analysing architecture from the perspective of construction methods, it becomes clear that the builders of the *Dunnu* were well aware of structural performance of loam architecture and applied a certain degree of pragmatic efficiency in their work. In their practice, rational choices were made regarding construction methods and architectural function. Although this may seem an obvious conclusion, this is not a feature often highlighted when discussing ancient architecture because there is a tendency to emphasize the symbolic and cultural aspects of buildings. This is not to say that architecture could not have symbolical meanings, or that its form was not motivated by an abstract idea. However, this is to say that given this ideological context, architecture's physical part primarily reflects technical attempts to counter the problems of gravity, the weather and the limitations of the available building materials.

The pragmatic approach of the mud brick builder of the *Dunnu* and the observed repertoire of techniques also help us create a more comprehensive model of the complete buildings and their functions, which will be the focus of the next chapter.