# THE MODULAR DESIGN OF NEW KINGDOM TOMBS AT SAQQARA*

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## 1. INTRODUCTION

Since 1975, a joint mission of the Egypt Exploration Society and the Leiden Museum of Antiquities has uncovered a number of tombs in the New Kingdom necropolis at Saqqara. So far, these remains have mainly been recorded as individual examples of Egyptian funerary architecture. Comparative studies of these monuments and their Memphite parallels from the Teti Pyramid cemeteries or the site of the Cairo University concession have been rather scanty and have only been devoted to a systematic classification of the various types of ground-plan concerned.[1] Yet such an analytical approach is also very valuable in order to become aware of the underlying patterns which formed the basis for the architectural design of these tombs.[2] Certain repetitive characteristics can be explained as expressing the aesthetic ideals of the architects, which must have been formulated in concrete modular directions. Even though the actual execution by the bricklayers and masons may have been imperfect, a study of details often allows us to reconstruct the underlying precepts.

The ancient Egyptian unit of length was the cubit of roughly 0.523 m. Various authors have asserted that the Egyptian builders preferred whole cubit measurements for the overall inside and outside measurements of their monuments.[3] This leads to the assumption that the original plan of a building was developed with the help of a grid, the squares of which represent a whole number of cubits.[4] Execution of such a modular plan in stonework would inevitably have led to distortions. Since the faces of Egyptian masonry were left rough and dressed afterwards, the resulting finished face is often not measurable to an exactly even unit.[5] This means that in many cases it is not possible any more to obtain an exact assessment of the length of the cubit used for the construction of a specific building. On the other hand, such minor deviations usually do not impede an understanding of the architect's original design: the modular grid was expressed in multiples of the cubit, whereas the final dressing and other inaccuracies led to distortions of no more than a couple of fingers.

* I would like to thank Kenneth J. Frazer and Geoffrey T. Martin for reading a first draft of the present article and for their helpful comments.

[1] K.A. Kitchen, Memphite tomb-chapels in the New Kingdom and later, in: Görg and Pusch 1979, 272-284; J. Málek, The tomb-chapel of Hekamaetre-neheh at northern Saqqara', *SAK* 12 (1985), 43-60; id., The royal butler Hori at northern Saqqâra', *JEA* 74 (1988), 125-136; M.J. Raven, Twenty-five years of work in the New Kingdom necropolis of Saqqara: looking for structure', in: M. Bárta and J. Krejcí 2000, 133-144.

[2] For some preliminary remarks, see already Raven, in: M. Bárta and J. Krejcí 2000, 143.

[3] Clarke and Engelbach 1930, 63; Badawy 1965, 36; Arnold 1991, 7.

[4] Arnold 1991, 7.

[5] Clarke and Engelbach 1930, 64.

The architecture of the New Kingdom tombs at Saqqara presents a special case. Here, the 18th-Dynasty monuments were generally built in mudbrick. The bricklayers did not always follow the architect's instructions, yet an analysis of these tombs is sometimes fairly straightforward because the final dressing of wall-faces did not play any part in their execution. Still, even mudbrick tombs often have certain elements which were revetted in limestone, especially the richer ones. For tombs of the latter category, it is sometimes hard to decide whether one should take the measurements of the brickwork or rather those of the partly extant stone casing. Finally, the local Ramesside monuments were constructed in limestone. A comparison of the two types of monuments can be rather complicated.

The first step towards a study of the architectural design of these New Kingdom tombs is of course a verification of their exact measurements. Here, I have based myself on the excellent plans and sections which the surveyor Kenneth J. Frazer has drawn for the monuments located within the EES-Leiden concession.[6] Additional measurements were taken at my request by his successor Willem Beex during the season 2000 (the second season of the present cooperation between the Leiden Museum and Leiden University in the area) or by myself. Ideally, the other tombs of the period in the Teti Pyramid and Cairo University areas should be included in this comparative analysis, but reliable ground-plans of these monuments are not yet available. I have restricted myself, therefore, to the monuments of Maya, Horemheb, Pay, and Tia. The first three of these were built in mudbrick with limestone revetment, the last one was completely constructed in limestone. The other six tombs so far uncovered by the Anglo-Dutch Expedition are much more irregular or do not survive in such a condition as to be analysed properly. The tomb of Meryneith found by the Leiden Expedition in 2001 was not yet excavated to its full extent when these lines were written.

## 2. The tomb of Maya and Meryt

### 2.1. *Reconstruction of the modular grid*

According to Badawy, the square was the most important element in the design of ancient Egyptian buildings, whereas the basic unity of the constructional diagram of typical cult temples can often be derived from their central sanctuaries.[7] Since the New Kingdom tombs at Saqqara can in fact be understood as private mortuary temples,[8] it is logical to start our analysis with Maya's central chapel (Chapel D, See Figs. 1-2). As executed in mudbrick, this forms indeed an almost perfect square. Its internal measurements amount to 3.35 m east-west by 3.25 m north-south. For the following, I have used a square with sides of 3.30 m as a hypothetical module.[9] If we draw two squares of the same size, one on each side of the central chapel, we find that these define the external west and internal east walls of the side-chapels (C and E),

[6] See, e.g., Martin 1985, pl. 2; Martin 1989, pls. 5, 8 and figs. 8, 12; Martin 1997, pls. 1-2, 5; Martin 2000, pl. 1; G.T. Martin et al., The tomb of Maya and Meryt: preliminary report on the Saqqâra excavations, 1987-8, *JEA* 74 (1988), fig. 1; H.D. Schneider et al., The tomb-complex of Pay and Ra'ia: preliminary report on the Saqqara excavations, 1994 season', *OMRO* 75 (1995), fig. 1.

[7] Badawy 1965, 21.

[8] J. van Dijk, in: Zivie 1988, 43; Van Dijk 1993, 200.

[9] The length of 3.35 m is taken from the plan drawn by Kenneth J. Frazer. Remeasuring by Willem Beex produced a length of 3.54 m instead. However, the walls of the chapel have been extensively restored in the meantime.



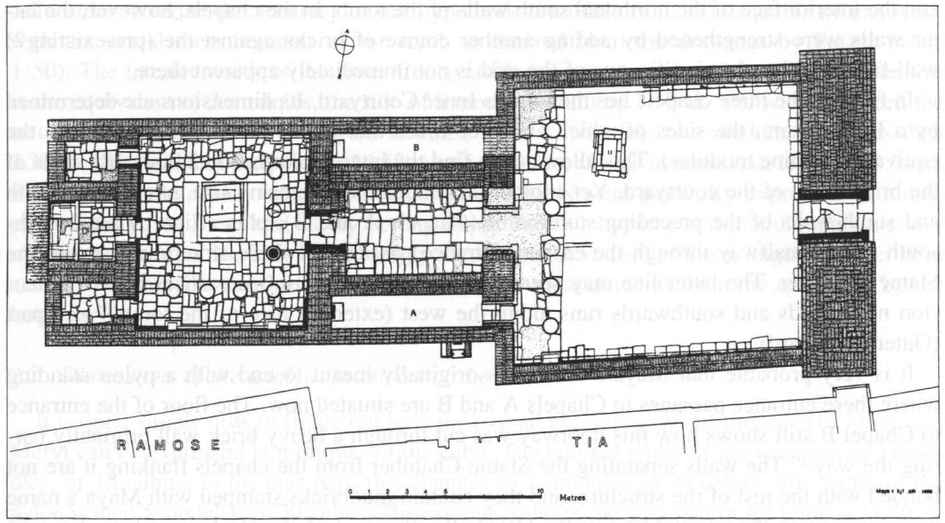


Fig. 1. Tomb of Maya and Meryt, plan of superstructure.

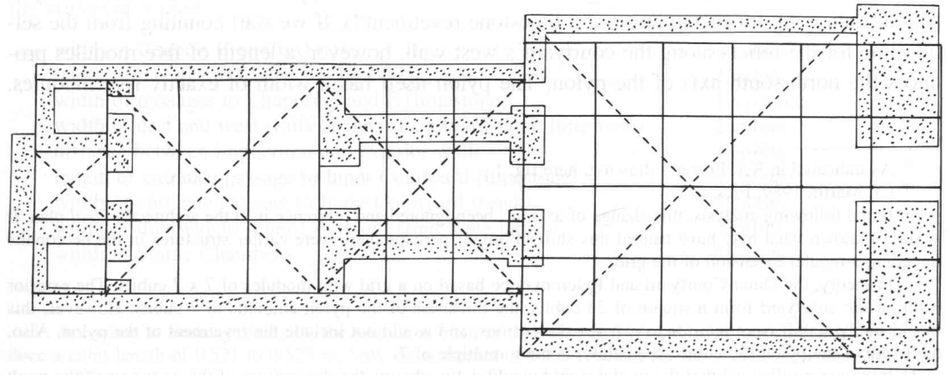

Fig. 2. Tomb of Maya and Meryt, reconstructed grid with correction for the shift in the axis of the east part.

and the interior face of the north and south walls of the tomb. In the chapels, however, the latter walls were strengthened by adding another course of bricks against the (pre-existing?) wall-faces, so that the significance of the grid is not immediately apparent there.

In front of the three chapels lies the tomb's Inner Courtyard. Its dimensions are determined by a large square, the sides of which are three times that of the module (its surface is the equivalent of nine modules). This allows us to find the internal north, south, and east walls of the brick walls of the courtyard. Yet another large square of the same size gives us the north and south walls of the preceding storerooms (Chapels A and B), plus a line running north-south exactly halfway through the eastern entrance passages of these storerooms and of the Statue Chamber. The latter line may seem rather fortuitous, until one realises that its extension northwards and southwards runs along the west (exterior) face of the tomb's east part (Outer Courtyard).

It is very probable that Maya's tomb was originally meant to end with a pylon standing where these entrance passages to Chapels A and B are situated now. The floor of the entrance to Chapel B still shows how this doorway was cut through a heavy brick wall originally barring the way.[10] The walls separating the Statue Chamber from the chapels flanking it are not bonded with the rest of the structure, and they contain mudbricks stamped with Maya's name not occurring in the surrounding walls. Originally, this part of the tomb must have been an open courtyard, and the separations were drawn up later. In other words, the tomb underwent a development similar to that of Horemheb, which must have been under construction simultaneously, and the addition of the Outer Courtyard came as an afterthought.[11] This is also suggested by the slight change of axis between the earlier structure in the west and the later additions in the east, and by the greater width of the latter part.[12]

All this explains that the regular grid which formed the basis for the design of the tomb's western half shows a clear break at the point where the Outer Courtyard abuts it. The external dimensions of the courtyard in question are again based on a large square, but cannot be developed in a logical way from the grid underlying the western part of the tomb.[13] Still, it is undeniable that its interior width, as defined by the setting lines of the limestone wall revetment, is the equivalent of four modules.[14] A length of six modules, counted from the eastern delimitation of the grid of the western half (i.e. from the line running halfway through the entrances to the Chapels A and B and to the Statue Chamber), brings us to the east face of the Pylon of the tomb, or rather just beyond (allowing for the addition of a limestone revetment?). If we start counting from the setting line for the reliefs along the courtyard's west wall, however, a length of five modules produces the north-south axis of the pylon. The pylon itself has a width of exactly five modules.

[10] As indicated in K.J. Frazer's drawing, here fig. 1.

[11] Cf. Martin 1989, Figs. 2-3.

[12] In the following analysis, this change of axis has been ignored and reference is to the architect's *ideal* plan. It is still unknown what may have caused this shift of angle; perhaps there were earlier structures in the necropolis impeding a regular extension of the grid.

[13] In theory, the Outer Courtyard and Pylon may be based on a grid with modules of 7 x 7 cubits. The exterior walls of the courtyard form a square of 28 cubits, the thickness of the pylon amounts to 7 cubits. However, this would imply a shift from *interior* to *exterior* dimensions, and would not include the revetment of the pylon. Also, the width of the pylon (30 cubits, see below) is not a multiple of 7.

[14] It may seem illogical that the modular grid would define the mudbrick structure of the west part of the tomb but the limestone revetment of the east part. Perhaps this likewise reflects a change of ambition, indicating that originally the tomb was planned without revetment whereas the Phase 2 addition took its presence for granted.



In order to refine the accuracy of our hypothetical module of 3.30 m square, we can work with the actual measurements of the tomb as derived from the drawings by Frazer (scale 1:50). The interior width of the Inner Courtyard (within the brickwork) is 9.90 m; since this is the equivalent of 3 modules, the side of a module would be 3.30 m. The width between the setting lines in the Outer Courtyard is 13.21 m or 4 modules; one modular length is then 3.303 m. The width of the pylon is 16.52 m or 5 modules; this gives a modular length of 3.34 m. Reverting to the above remark that architectural grids were generally expressed in multiples of the cubit, there can hardly be any doubt that our hypothetical module amounts to a square of 6 x 6 cubits. This would imply a cubit of 0.551 to 0.554 cm, slightly longer than average but this may be due to inaccuracies in our measurements or in the execution by the builders.[15]

### 2.2. *Dimensions of the tomb as multiples of the cubit*

It is quite simple now to figure out how the overall measurements of the tomb of Maya and Meryt can be expressed in multiples of the cubit. The internal width of the west part is 3 modules, or 18 cubits. In the east part, this changes to 4 modules or 24 cubits. The width of the pylon is then 5 modules, or 30 cubits. The exterior width of the west part of the tomb is 11.50 m, or almost 22 cubits. Wall thicknesses in the tomb are not constant, however, and those of the lateral exterior walls vary between 0.6 and 0.8 m. Probably, this is due to inaccurate work by the bricklayers, and one can assume that the architect reckoned with an ideal thickness of 1 cubit. In that case, the west part of the tomb would have been designed as having a width of 20 cubits. Its length, between the interior rear wall of the central chapel and the *western* jamb of the entrance passage into the present Statue Chamber (then still an open court) would have amounted to a round 40 cubits (7 modules, minus a rough 2 cubits for the west half of the passage). The total length of the tomb, between the interior rear wall of the central chapel and the threshold of the pylon, amounts to 13 modules or 78 cubits. With the thickness of the rear wall of the central chapel, however, it would have resulted in roughly 80 cubits. In other words, the Phase 2 extension doubled the length of the tomb.

Corroboration of our assumption that the layout of the monument was based on multiples of the cubit can be found in the measurement of details. The following estimates are based on the surveyor's plan:

| | |
|---|---|
| width of Chapels C and E (brick) | 4 cubits |
| width of passage to Chapel D (limestone) | 2 cubits |
| width of passages to Chapels C and E (limestone) | 1 ½ cubits |
| width of east and west walls of Inner Courtyard (incl. limestone) | 2 cubits |
| distance between impluvium and exterior walls | 4 cubits |
| length of entrance passage to Inner Courtyard (limestone) | 4 cubits |
| width of entrance passage to Inner Courtyard (brick) | 4 cubits |
| width of doorway to Inner Courtyard (limestone jambs) | 2 cubits |
| width of Statue Chamber | 8 cubits |

[15] According to Badawy 1965, 36, the module is often of the value of 6 1/3 cubits. In our case, this would produce a cubit length of 0.521 to 0.525 m. Still, the multiples of 6 1/3 required for the overall measurements of the tomb of Maya do not always produce a whole number of cubits, which is rather unsatisfactory. Also, a grid based on modules of 6 x 6 cubits seems to have been used for the design of other contemporary tombs at Saqqara; see below. For the possibility that the east part of Maya's tomb was designed with a 7 x 7 cubits module, see above n. 13.

| | |
|---|---|
| width of entrance to Statue Chamber (limestone) | 3 cubits |
| width of Chapels A and B | 3 cubits |
| length of Chapels A and B | 15 cubits |
| width of original pylon (= length of entrance to Chapels A and B) | 4 cubits |
| width of paved portico along west side of Outer Courtyard | 4 cubits |
| width of vestibule between towers of Pylon (limestone) | 3 cubits |
| width of vestibule between towers of Pylon (brick) | 5 cubits |
| length of vestibule between towers of Pylon (limestone) | 6 cubits |

A special case is with the peristyle on the north and south sides of the Inner Courtyard. The distance from the centre-points of the columns to the setting lines of the limestone wall revetment is 1.70 m. The same distance exists between the centre-points of the columns themselves. On the east and west sides of the colonnade, however, a greater intercolumniation of 1.95 was used, with 2.10 m between the pairs of columns astride the axial line. Clearly, these measurements are not simple multiples of a cubit. It is most probable that a number of palms (of about 0.075 m) was added in each case, in order to adjust the intercolumniations to the specific aesthetic and practical needs of each spot. The distances given here seem to be the equivalents of 3 cubits 2 palms, 3 cubits 5 palms, and 4 cubits, respectively. It is a pity that no reliable reconstructions are available to show the entablature of the tomb of Maya and Meryt, since the modular grid may have determined the elevations as well as the ground-plan. This seems to be indicated by the height of 3.30 m of the vestibule between the two towers of the Pylon, which is the equivalent of 6 cubits or one module.

### 2.3. *Analysis of the tomb as a harmonic design*

Designing the tomb on the basis of a modular grid did not only result in a building in which each main element could be expressed as a whole number of cubits. The various parts of the layout were also combined in such a way that the monument became a harmonic system, as Badawy has argued in his book on Egyptian architectural design.[16] This can clearly be seen from the dimensions of the above-mentioned vestibule. With its height and length of a full module and its width of half a module it became a harmonic structure with the proportions of 2:2:1.

Similar relations may have existed for the rest of the monument. Above, it has been demonstrated that the original tomb was laid out as a rectangle of 20 cubits wide by 40 cubits long (without the Phase 1 pylon). This is a ratio of 1:2, which is a well-known favourite in temple design.[17] It can easily be constructed using a 1:4 isosceles triangle, where the height is to the base as 2 to 1. According to Badawy, such a triangle was regarded as the 'pillar' defining any ground-plan.[18] The extension of the tomb in Phase 2 resulted in a length of 80 cubits, whereas the width of the new pylon was designed as 30 cubits. The ensuing ratio is 3:8, which is not one of the classical harmonic proportions and thereby corroborates the assumption that the tomb was not designed as an organic unity. A truly harmonic design would have favoured a pylon width of 40 cubits, but the shift of the tomb's axis already indicates that there was not sufficient space to execute such a grand design.

[16] Badawy 1965, esp. 20-5.
[17] Ib. 23 *sub* 3.
[18] Ib. 23 and 57-8.



## 3. The tomb of Horemheb

### 3.1. *Reconstruction of the modular grid*

The tomb of Horemheb was doubtless constructed simultaneously with that of Maya, and as Overseer of Building Works the latter official may have been responsible for both projects. This means that we can expect that highly similar principles determined its architectural design. In fact, there are both similarities and a number of interesting differences. It can again be demonstrated that the square of the central chapel (D on the plan of Fig. 3; cf. also Fig. 4) served as the basic module of the overall design. Yet here one cannot simply extend the lines of its internal walls in order to generate the architectural grid. Instead, the tomb has an internal width of four complete modules (not three, as for the tomb of Maya), so that the gridline which forms the longitudinal axis of the tomb bisects the central chapel as well. The block of masonry enveloping Chapel D is 2 modules wide, the two flanking squares define the internal faces of the tomb's lateral walls (again these walls have extra width in the chapel area).

The Inner Courtyard of Horemheb is based on a large square, here 4 x 4 modules. Whereas in Maya's tomb only the thickness of the west wall was incorporated in the square in question, here both the east and west walls are part of the square. The resulting courtyard is therefore more conspicuously rectangular than Maya's. The peristyle has a length of exactly two modules and a width of three, with all columns spaced much more regularly than in Maya's peristyle. Three further modules bring us eastwards to the exterior face of the original pylon (Phase 1), now the entrance to the Statue Chamber and its flanking storerooms (Chapels A and B).[19] Yet another square of 4 x 4 modules defines the Outer Courtyard of the Phase 2 project, the east wall of which lay on the same line as the present-day (Phase 3) east colonnade.[20] When the tomb was finally provided with its massive Pylon (Phase 3), this meant an eastward extension of yet another two modules. Thus, the various changes in the plan were always made in accordance with the existing grid, unlike the situation which prevailed in the tomb of Maya where the Phase 2 extension introduced a new grid (although based on the same modular unit).

The tomb of Horemheb was lavishly revetted in limestone. This entails the kind of difficulties discussed in the introduction: should one take the measurements of the mudbrick structure, or rather those of the limestone wall panelling (if extant)? The width of Chapel D (1 module) is 3.20 m between the wall revetment, but measures a full 3.61 m between the mudbrick walls. Assuming that this is again the equivalent of 6 cubits, the variation in the resulting value for one cubit (0.533 to 0.602 m) suggests that the former measurement is in fact correct and that one should concentrate on the stonework. The internal width of the Inner Courtyard (4 modules), as measured within the brickwork, is 13.26 m, that of the Outer Courtyard 13.14 m. This gives a modular length of 3.285 to 3.315 m, and a cubit length of 0.548 to 0.553 m, again rather more than expected. The same measurements taken between the limestone revetment (about 0.20 m thick on average) results in a cubit length of 0.531-0.535 m, which is much more convincing. A measurement along the western exterior wall of Chapel D produces a different outcome: 6.03 m = 2 modules = 12 cubits of 0.503 m each.

[19] Cf. Martin 1989, Fig. 2.
[20] Ib. 13 and Fig. 3.

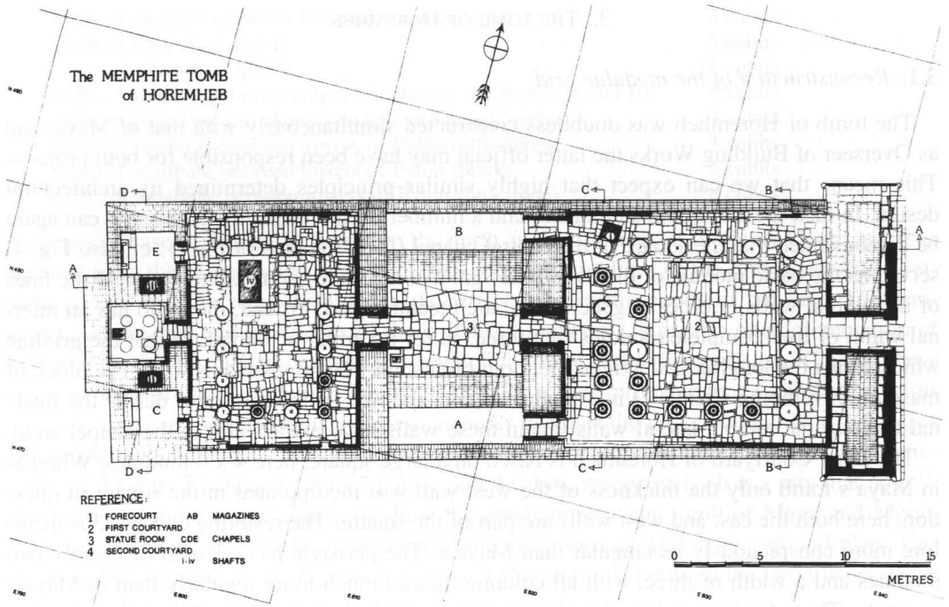


Fig. 3. Tomb of Horemheb, plan of superstructure.

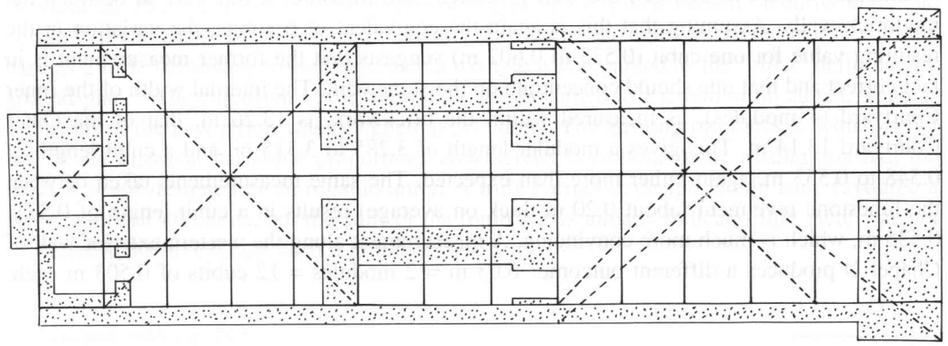

Fig. 4. Tomb of Horemheb, reconstructed grid.



This means that one should not ignore the evidence of the mudbrick structure altogether. The mudbrick Phase 2 extension is said to have measured 12.55 m;[21] this has been seen to be the equivalent of 4 modules, and the resulting length of the cubit would be 0.522 m.

### 3.2. *Dimensions of the tomb as multiples of the cubit*

The internal width of Horemheb's tomb is the equivalent of 24 cubits. During Phase 1, its length amounted to 48 cubits (8 modules, from the internal wall of the central chapel to the east face of the original pylon). This was extended to 72 cubits in Phase 2, and 84 cubits in Phase 3, not counting the 2 cubit projection of Chapel D in the west wall. The width of the Phase 3 Pylon is roughly 17 m,[22] the equivalent of 32 cubits of 0.531 m each. Some other dimensions which may be derived from the surveyor's plans, the final report on the tomb, or from personal measurements are:

| | | |
|---|---|---|
| length of Chapels C and E (brick) | 6 cubits | |
| width of passage to Chapel D (limestone) | 2 cubits | (1.06 m) |
| width of doorway to Chapel D (between jambs) | 1 ½ cubits | (0.85 m) |
| length of passage to Chapel D (incl. jambs) | 3 cubits | (1.56 m) |
| width of east and west walls of Inner Courtyard (incl. limestone) | 3 cubits | |
| distance of colonnade to internal wall faces | 3 cubits | (1.57-1.68 m) |
| width of entrance passage to Inner Courtyard (excl. jambs) | 3 cubits | (1.62 m) |
| width of Statue Chamber | 10 cubits | (5.34 m) |
| length of Statue Chamber and Chapels A-B (incl. entrance) | 20 cubits | (10.76 m) |
| width of entrance to Statue Chamber (excl. jambs) | 3 cubits | (1.56 m) |
| width of Chapels A and B | 4 cubits | |
| thickness of original pylon | 4 cubits | (1.90 m +) |
| thickness of Pylon | 8 cubits | (4.50 m) |
| width of doorway between towers of Pylon (between jambs) | 3 cubits | (1.57 m) |

All this demonstrates that the final dressing of the stone was done very carefully, so that the finished faces are still measurable to an exact unit of length. Frazer has published some detailed measurements of the colonnades and elevations.[23] In the Outer Courtyard, the highest-standing column in the peristyle (Column d) survives to just over half its original height. Owing to the fact that decorated fragments of the upper part of the column, and of neighbouring columns that were used as evidence in the reconstruction, could not always be set contiguous, one against the other, a plus or minus margin of error of 0.05 m should be applied to the column's restored height of 3.23 m, or 6 cubits. The combined heights of the columns and their entablature (no sections of architrave found; only one short section of likely cornice) would have given the Outer Courtyard's peristyle an estimated height of c. 4.20 m, or 8 cubits.

The intercolumniation varies from 2.12 to 2.29 m (4 cubits) on the north and south sides and 1.66 to 1.85 m (3 cubits and 2-4 palms?) on the east and west sides. The height of the Pylon is estimated as 7.5 m, which would be the equivalent of 14 cubits and equals the length of each tower. No limestone roofing slabs that would have connected the peristyle with the outer walls of the courtyard were found. The latter may have stood at c. 3.6 m (about 7 cubits), i.e. the height of the peristyle less the height of its cornice.

[21] Ib. 10, 13.
[22] Ib. 14.
[23] Ib. 18-20 with Figs. 8, 12.

In the Inner Courtyard, the columns were 2.255 m high (4 cubits and 2 palms), with an intercolumniation of 1.82-1.86 m (3 cubits and 4 palms) on the east and west sides, 1.98-2.03 m (3 cubits and 6 palms) on the north and south sides. Again no architrave blocks or roofing slabs connecting the peristyle with the courtyard's outer wall were found. The total height of the elevation around the Inner Courtyard can be estimated as 2.905 m, or 5 cubits and 4 palms.

### 3.3. *Analysis of the tomb as a harmonic design*

Again, harmonic proportions may be recognised in certain parts of the tomb, though its gradual extension seems to have impeded realising ideal proportions for the tomb as a whole. Just as for Maya's monument, the original layout seems to have favoured a width/length ratio of 1:2 (24 x 48 cubits). The same proportions can be seen in the overall proportions of the Statue Chamber including its vestibule (10 x 20 cubits). The Phase 3 Pylon is 8 cubits deep and 32 cubits wide (1: 4), whereas each tower is as wide as it was high (14 cubits, 1:1).

There is an intriguing relationship between the length and width of the Outer Courtyard and the Pylon. Two triangles may be constructed, linking the centre of the impluvium with the outer corners of the old and the new pylons. Both triangles will have the proportions of 8:5 (base:height), a favourite element in Egyptian architectural design and a figure closely related to the golden section.[24] It cannot be proved whether this is merely accidental. If these triangles indeed played a part in the architectural design of the pylon area, then our previous statement that the addition of this element was made in accordance with the existing modular grid would have to be modified.

## 4. The tomb of Pay and Raia

### 4.1. *Reconstruction of the modular grid*

The tomb of Pay was probably constructed at the same time as those of Maya and Horemheb.[25] Both the style of the reliefs and certain details of the inscriptions suggest a date in the reign of Tutankhamun.[26] The east part of the tomb, however, is a later addition by Pay's son and successor Raia (Fig. 5). Both the irregular shape of this addition and the asymmetrical position of its entrance betray that the extension had to respect the presence of earlier structures in the area. In our analysis of the proportions of the monument we shall therefore focus on the western part of the tomb built by Raia's father.

Starting as usual from the proportions of the central chapel (B on the plan), one can again observe how this is an almost perfect square of 3.00 m deep and 2.90 m wide (see Fig. 6). The

[24] Badawy 1965, 33-4. The triangle on the Phase 3 pylon has a base of 32 cubits and a height of 20 cubits, its pendant on the Phase 1 pylon has a base of about 26 cubits (4 modules plus two times the wall thickness; or was it rather regarded as 28 cubits?) and a height of about 16 cubits. The distance between the east faces of the old and the new pylons has been regarded above as the equivalent of 6 modules or 36 cubits.

[25] A full description of the tomb will be found in M.J. Raven et al., *The Tomb of Pay and Raʿia* (in preparation). For preliminary reports, see Schneider, *OMRO* 75 (1995), 13-31; M.J. Raven et al., Preliminary report on the Saqqara excavations, season 1996, *OMRO* 77 (1997), 73-86.

[26] Cf. J. van Dijk, in: Schneider, *OMRO* 75 (1995), 19-20.



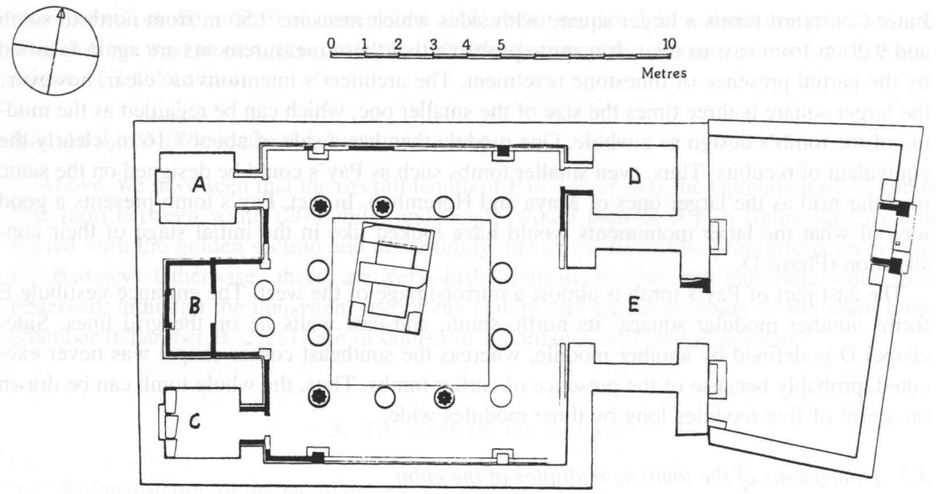


Fig. 5. Tomb of Pay and Raia, plan of superstructure.

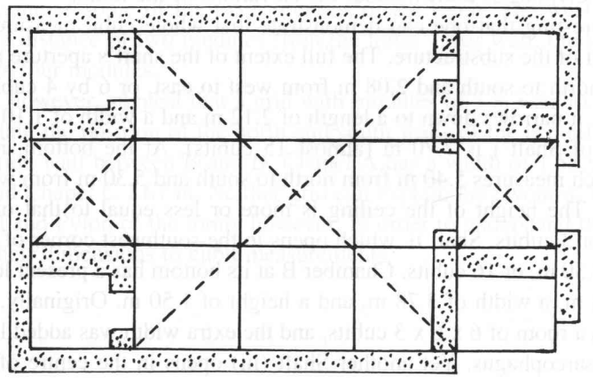

Fig. 6. Tomb of Pay, reconstructed grid with omission of Raia's forecourt.

Inner Courtyard forms a larger square with sides which measure 9.50 m from north to south and 9.20 m from east to west. It is quite probable that these measurements are again falsified by the partial presence of limestone revetment. The architect's intentions are clear, however: the larger square is three times the size of the smaller one, which can be regarded as the module of the tomb's design as a whole. One module then has a side of about 3.16 m, clearly the equivalent of 6 cubits. Thus, even smaller tombs such as Pay's could be designed on the same modular grid as the larger ones of Maya and Horemheb. In fact, Pay's tomb presents a good idea of what the latter monuments would have looked like in the initial stage of their construction (Phase 1).

The east part of Pay's tomb is almost a mirror-image of the west. The entrance vestibule E forms another modular square; its north, south, and east walls lie on the grid lines. Side-chapel D is defined by another module, whereas the southeast corner chapel was never executed, probably because of the presence of earlier tombs. Thus, the whole tomb can be drawn on a grid of five modules long by three modules wide.

### 4.2. *Dimensions of the tomb as multiples of the cubit*

It is very probable that the walls of Pay's tomb were planned to have the ideal width of one cubit. Since the internal width has been seen to equal 3 modules (18 cubits), the exterior width would be the equivalent of 20 cubits. The actual width is about 10.50 m, so that one cubit would be 0.525 m long. The overall length of the tomb is then 5 modules plus 2 cubits for the exterior walls, or 32 cubits altogether. This is close enough to the actual length of 17.00 m (1 cubit = 0.531 m).

The doorways to the chapels A, C and D were doubtless planned to be 2 cubits wide, the wider doorways at either end of the vestibule E were 4 cubits wide. Chapels A and C form almost perfect squares of 4 x 4 cubits. All these proportions refer to the bare brickwork; the application of limestone wall revetment changed the overall effect. Because so many of the limestone architectural elements are now missing, it is very difficult to assess whether these, too, observed fixed rules of proportion. The setting of the colonnade is fairly regular, with an intercolumniation of about 3 cubits and 3 palms and about the same distance to the exterior walls. The distance from the rim of the impluvium to the exterior walls seems to be an exact 4 cubits. Hardly anything is known about the elevations of the tomb.

It is most interesting that one can demonstrate that whole cubit measurements were also used in the layout of the substructure. The full extent of the shaft's aperture at pavement level is 3.10 m from north to south and 2.08 m from west to east, or 6 by 4 cubits. Some 0.30 m deeper, however, it narrows down to a length of 2.12 m and a width of 1.10 m (4 x 2 cubits). The total depth of Shaft i is 7.70 m (almost 15 cubits). At the bottom, it gives access to Chamber A, which measures 5.40 m from north to south and 5.30 m from west to east (about 10 x 10 cubits). The height of the ceiling is more or less equal to that of the doorway to Shaft i: 1.55 m or 3 cubits. Shaft ii, which opens in the southwest corner of the chamber, has a total depth of 8.30 m, or 16 cubits. Chamber B at its bottom has a present length (from north to south) of 3.08 m, a width of 3.78 m, and a height of 1.50 m. Originally, it seems to have been designed as a room of 6 x 6 x 3 cubits, and the extra width was added later for the deposition of Raia's sarcophagus. Yet another Shaft (iii) opens in the centre of the floor of this chamber. The depth of Shaft iii amounts to 5.80 m (11 cubits). It gives access to the deepest



chamber (C) of the tomb. The dimensions of this chamber are 3.48 m from north to south and 3.63 m from west to east. It is quite possible that this irregular chamber was meant to form a square of 7 x 7 cubits.

### 4.3. *Analysis of the tomb as a harmonic design*

Above, we have seen that the overall length of Pay's tomb was the equivalent of 32 cubits. The ratio between width (20 cubits) and length would then be 5:8, a figure directly connected with the golden section and accordingly one of the harmonic proportions recognized by Badawy. Otherwise, there are very little indications that the harmonic rules were observed, although the consistent use of the square and the proportions of the main burial chamber (Chamber B, 2:2:1) are of course in accordance with such a system.

## 5. The tomb of Tia and Tia

### 5.1. *Reconstruction of the modular grid*

The tomb of the Overseer of the Treasury Tia and his like-named wife (sister of Ramesses II) dates to the 19th Dynasty. Its architecture betrays the later date by the characteristic replacement of mudbrick by limestone for the main structure. This means that for this monument there cannot be any doubt about which measurements should be taken, unlike the earlier 18th-Dynasty tombs where there is always the choice between the mudbrick structure and its limestone revetment.

At first sight, the layout of this monument differs considerably from that of its predecessors (Figs. 7-8). There is no square central chapel flanked by two side magazines, and the ratio of central chapel to Inner Courtyard is not the equivalent of 1:3. Still, one can recognize a square element in Antechapel B and Cult Room D, which form in fact one continuous room with an internal partition wall not much different from the central chapels of Dynasty 18.[27] The sides of this square measure about 6.30 m, or about twice the length of the module of the earlier three tombs. The internal width of the tomb is 9.53 m,[28] or about three of these modules. This suggests that the same module of 6 x 6 cubits was in use here. A grid with modules of this size indeed determines some of the main sections of the tomb. The west wall of the Inner Courtyard is at a distance of two modules from the tomb's rear wall, the length of the Inner Courtyard equals four modules.

Other details, however, suggest that a grid with modules of 3 x 3 cubits was used instead. This would explain the position of the north and south walls of the central chapel (B and D) and of the partition wall between B and D. Chapel A has a width of 1.58 m, Chapel D measures 1.65 m, and Chapel C 1.67 m. Neither grid can explain the layout of the pyramid or the Outer Courtyard and Pylon of the tomb, however. In order to understand these elements, one has to convert their dimensions to cubit measurements.

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[27] K.J. Frazer, in Martin 1997, 6.

[28] As far as possible, all measurements in the following paragraphs have been taken from K.J. Frazer, Ib. 3-11.

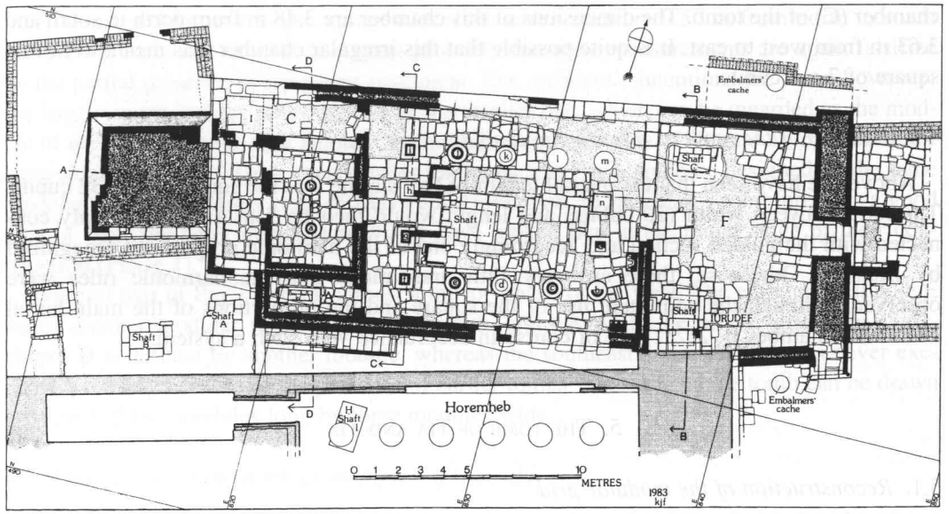


Fig. 7. Tomb of Tia and Tia, plan of superstructure.

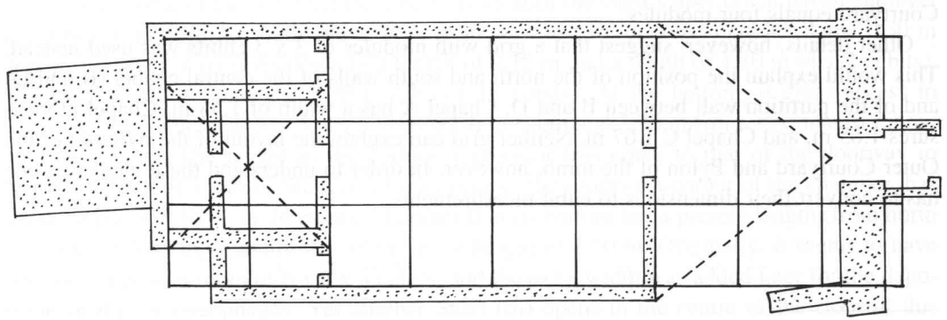

Fig. 8. Tomb of Tia and Tia, reconstructed grid.



5.2. *Dimensions of the tomb as multiples of the cubit*

The pyramid of Tia's tomb measures 5.30 m east-west by 5.41 m north-south, or 10 x 10 cubits. Its estimated height of 6.35 m would be the equivalent of 12 cubits. It should be noted that it is not situated in the tomb's longitudinal axis; this may be due to problems with the foundation in the former Outer Courtyard of the earlier tomb of Ramose. Chapel A measures 3.73 x 1.58 m (7 x 3 cubits), Chapel B 3.60 x 5.12 m (7 x 10 cubits), Chapel C 5.73 x 1.67 m (11 x 3 cubits), and Chapel D 1.65 x 5.10 m (3 x 10 cubits). Chapel I (if it existed) would be 3 x 3 cubits.[29] All interior walls of the monument appear to have been 1 cubit thick, the exterior walls are slightly thicker.[30] Still, the overall width of the monument is almost exactly the equivalent of 20 cubits (10.85 m).

The Outer Courtyard of the tomb measures 7.13 m east-west, less than 14 cubits. Its width was obviously determined by the presence of Horemheb's massive pylon in the south and varies too much to be expressed in a whole cubit measurement. The thickness of Tia's pylon was 1.70 m, or a little over 3 cubits. If we add this measurement to the length of the Outer Courtyard, however, the result of 8.83 m is roughly 16 cubits. The width of the pylon is 11.75 m, or 22 cubits.

On the basis of the above measurements, one can calculate the length of the cubit used by the architects. It varies between 0.51 and 0.557 m, with a mean value of 0.532 m. This compares very well with the standard unit of 0.523 m known from elsewhere and shows how meticulously the architects and the masons worked. It would be possible to refine this calculation by taking the exact measurements of a number of architectural details of the monument. Thus, the width of the entrance through the Pylon and the doorway between the Outer and the Inner Courtyards can be estimated as 2 cubits, the internal width of the Portico G is probably 4 cubits and that of the vestibule between the towers of the Pylon 3 cubits, the external length of the Portico 4 cubits, etc. In the Inner Courtyard, the height of the columns and piers to the top of the abacus is 2.88 m, or exactly 5.5 cubits, and the total elevation including the architraves 3.235 m or 6 cubits.

5.3. *Analysis of the Tomb as a Harmonic Design*

Several measurements of the tomb of Tia and Tia can be interpreted as harmonic proportions. Thus the ratio between the length of the chapel area (12 cubits) and its internal width (18 cubits) may indicate that a 3:4:5 triangle (Plutarch's 'Osiris triangle') was used in its design. According to Badawy, this was a common device in ancient Egypt, used not only for constructing right angles but also for aesthetic reasons.[31] The tomb's pyramid has a side of half the overall width of the tomb (10 cubits as opposed to 20, or a ratio of 1:2).

The distance between the rear wall of the central chapel (D) and the entrance to the Inner Courtyard is 6 modules, or 36 cubits. This is exactly twice the length of the internal width of the monument of 18 cubits, or a ratio of 1:2. In other words, the nucleus of the temple-tomb was again constructed with a 1:4 isosceles triangle.[32] The extension formed by the Outer

[29] And not approximately 2 x 2 m, as stated by Frazer (Ib. 4). The existence of a dividing wall between Chapels C and I is doubtful, however, and C may accordingly have been larger (a full 11 x 3 cubits).
[30] Between 0.46 and 0.55 cm for the inner walls, 0.62-0.75 m for the outer walls, acording to K.J. Frazer (Ib. 9).
[31] Badawy 1965, 23 *sub* 1.
[32] Ib. *sub* 3.

Courtyard, Pylon and Portico had an overall length of 20 cubits, thus marking a square with the tomb's width.

The length (east-west) of the Outer Courtyard (7.13 m) remains puzzling at first sight, because it falls short of 14 cubits. It is quite possible, however, that again a 8:5 triangle was involved in its design.[33] Five eighths of the tomb's external width (10.85 m) make 6.78 m, so that an 8:5 triangle constructed on the east face of the entrance wall to the Inner Courtyard would (almost) have marked the centre of the doorway into the Inner Courtyard (actual distance about 7.00 m). The alternative would be to view this distance as the equivalent of 13 cubits (6.79 m).

## 6. Conclusions

The four funerary monuments analysed here vary in date from the reign of Tutankhamun to that of Ramesses II. The first two must have ranged among the largest temple-tombs of their time, but both of them reached their final extension only after a number of distinct building phases. The third tomb investigated was a more modest construction of the same period and was apparently built in one phase (except for later additions by the owner's son which have been left out of account here). All three were constructed in mudbrick, with wall decoration and architectural details executed in limestone. The fourth tomb, however, was completely designed in limestone and was constructed about half a century after the others.

In spite of all these differences, the layout of these four tombs has been seen to conform to certain common standards. All four have measurements that can be expressed in whole numbers of cubits, not only for the overall dimensions of their ground-plans but also for most of the internal details. Although the evidence is rather limited due to the present ruined state of these monuments, this predilection for whole cubit measurements can also be observed in their elevations. Where fractions of the cubit were used (for instance in the colonnades), these seem to be exact numbers of palms, but this aspect would need further study. The tomb of Pay shows how the preference for whole cubit measures also directed the layout of the substructure, and again this points to further fields of research.

The easiest way of monitoring the correct proportions of a building under construction was of course the application of a modular grid, a procedure rather similar to that observed in sculpture.[34] Above, we have demonstrated that the ground-plans of all four tombs show a predilection for multiples of 6 cubits. Two of them used a square of 6 x 6 cubits to determine the size of the central chapel, always a focal element in Egyptian modular design according to Badawy. This unit was doubled for the two other tombs and tripled or quadrupled for the layout of the courtyards. All this seems to indicate that a modular grid based on units of 6 x 6 cubits was used in the design of the Saqqara New Kingdom tombs. In some cases, however, subdivisions of 2 or 3 cubits may have played a role.

The use of a modular grid inevitably leads to the appearance of simple mathematical relations between the measurements of details. It can be demonstrated that such relations were intentionally selected for the overall proportions of ground-plans and elevations. The recurrence

[33] Ib. 24-5 *sub* 5.

[34] Badawy 1965, 36.



of ratios such as 1:2 or 1:4 is very significant in this respect. Such proportions were understood as expressions of a harmonic system and much sought after by the ancient architects. The Saqqara tombs are no exception in this respect. It is less clear whether the ratio of 8:5 and the related proportionality of the golden section was employed in these monuments, although we have seen three possible cases of its use.

I concede that the above analysis has shown a number of inconsistencies, in that some measurements were taken from the internal wall-faces and others incorporate the thickness of the exterior walls. Also, some proportions acknowledge the thickness of the limestone revetment and others ignore this evidence and focus on the mudbrick structure instead. Still, the reconstruction of the grids and the underlying harmonic concepts does not depend on the exactness of each individual measurement or its imperfect execution by the artisans. It is the sum of these proportions which seems to demonstrate the validity of the reconstructions as a whole. Future fieldwork in the area should take this aspect of the monuments into account and the relevant measurements should be taken before certain details are obliterated by decay or restorations.[35]

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[35] Recent work by Masaki Koiwa of the Waseda University mission at Dahshur has demonstrated the occurrence of similar proportions in the design of the tomb of Pashedu.