Construction Time and Regnal Years

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In Honor of Klaus P. Kuhlmann remembering our "good, old days" at Zamalek and Dokki.

Abstract

The building of most of the pyramids of the Old and Middle Kingdom was an enormous task for the royal construction section. The addition of the pyramid temple and other elements of the pyramid complex was less strenuous but more multifaceted and also required careful planning and organising. A study of the work flow involved and the surviving construction dates leads to the conclusion that the construction of the pyramid complex with the valley temple and causeway could have taken seven to ten years, occasionally surpassing the recorded length of the reign of the royal builders. Consequently, several of these projects remained either unfinished or were hurriedly completed by a well-meaning successor. Such complications should be kept in mind for the assessment of the unrecorded length of a reign.

In recent years, several studies have been published on the building technique and the construction time of the Egyptian pyramids, focusing mainly on that of Cheops and, since Rainer Stadelmann's work at the Red Pyramid, also on those of Snofru.[1] These studies address the question of whether the alleged construction time of the pyramids supports a short or long reign of their builders. These calculations generally disregard the support buildings surrounding the pyramid,[2] certainly because their construction seems to be, compared to that of the main pyramid, a piece of cake.

The following closer look at these "pre- and post-pyramid" activities suggests the contrary. The construction of a pyramid complex required during the pre-construction phase careful planning, and included the selection of a favorable building site, considering its connection to local and Tura-limestone quarries and production sites for other materials and equipment.[3] Access roads had to be prepared and boats for the river transport amassed. A great number of skilled workmen had to be gathered and their accommodation and subsistence secured.[4] Some tasks could be carried out by established services,[5] other necessities needed a fresh effort, for example digging the enormous canals and harbor basins like those at Dahshûr and Gîza.[6] Actual construction work started with the excavation and installation of the underground apartments of the

1 See R. Stadelmann, *Beiträge zur Geschichte des Alten Reiches. Die Länge der Regierung des Snofru*, in: *MDAIK* 43, 1987, pp. 229–240 and R. Krauss, *Zur Berechnung der Bauzeit an Snofrus Roter Pyramide*, in: *ZÄS* 125, 1998, pp. 29–37; Idem, *Lifting work and building time at the 4th Dynasty pyramids*, *Papers on Ancient Egypt*, in: *Trabajos de Egiptologia* 12, 2021, pp. 85–111; M. Verner, in: E. Hornung Et al., (eds.), *Ancient Egyptian Chronology*, Leiden/Boston 2006, pp. 124–131.

2 F. Arnold, *Logistik einer Pyramidenbaustelle. Markierungen am Baumaterial der Pyramidenanlagen des Königs Snofru in Dahschur*, in: D. Kurapkat/U. Wulf-Rheid (eds.), *Materialverarbeitung und handwerkliches Wissen im antiken Bauwesen. Internationales Kolloquium in Berlin vom 13.–16. Mai 2016*, Regensburg 2017, pp. 389–398.

3 Comprehensive and in detail, see: Y. Yasuoka, *Untersuchungen zu den Altägyptischen Säulen als Spiegel der Architekturphilosophie der Ägypter*, Hützel 2016, pp. 159–180 (hereafter Y. Yasuoka, *Untersuchungen*).

4 M. Lehner/Z. Hawass, *Giza and the Pyramids*, Chicago 2017, pp. 354–401 (hereafter M. Lehner/Z. Hawass, *Giza*); P. Tallet/M. Lehner, *The Red Sea Scrolls*, London 2021, pp. 214–234, 291–297 (hereafter P. Tallet/M. Lehner, *Red Sea Scrolls*).

5 P. Andrássy, *Builders' Graffiti and Administrative Aspects of Pyramid and Temple Building*, in: R. Preys (ed.), *7. Ägyptologische Tempeltagung. Structuring Religion. Königtum, Staat und Gesellschaft früher Hochkulturen* 3.2, Wiesbaden 2009, pp. 1–16.

6 M. Haase, *Projektziel verfehlt. Wann verlor die Knick-Pyramide ihre ideale Form?* in: *Sokar* 30, 2015, pp. 18–19; D. Arnold, *Transportwege zu Pyramidenbaustellen in Dahschur*, in: *Sokar* 30, 2015, pp. 68–77; G. Marouald, *New Evidence for a Middle Kingdom Harbor Basin at Dahshur?* in: *MDAIK* 69, 2013, pp. 171–178; M. E. Lehner, *On the Waterfront. Canals and Basins in the time of Giza Pyramid Building*, in: *AERAGRAM* 15, 2014, pp. 13–23.

Fig. 1 Pyramid of Senwosret I. Patch stones covering the casing of the west side. (D. Arnold, *The Pyramid of Senwosret I*, in: *MMA Egyptian Expedition* 22, New York 1988, Pl. 93a, Drawing D. Arnold)

pyramid.[7] This task required digging an open trench accessed by a wide, sloping incline.[8] Some of the Fifth and Sixth Dynasty pyramids posed a special challenge because gigantic blocks formed the gable roof of the crypt.[9] Naturally, the underground work had to be completed and the construction trench filled before aboveground building could start.[10] The placing of the first course of pyramid blocks rarely began before the third operating year.[11] The subsequent, actual pyramid building will not be discussed here, since much has been said about this subject already, and we shall return to the site after the pyramid's completion.[12] It seems logical that no construction around the pyramid could be undertaken as long as the pyramid and its surroundings was an active building site covered with accession roads, ramps, stone and brick storages, and entangled by transport activities. After the completion of the main pyramid, its casing was smoothed,[13] damage repaired,[14] the construction ramps removed and the area cleaned from building debris. This concluding work could take months and sometimes even years.[15]

Normally, the valley temple and causeway replaced the landing quay and the transport ramp to the pyramid; both structures could only be launched after the material transport from the river to the pyramid plateau had ceased.[16]

After clearing the site, the construction of the pyramid temple, north chapel, and satellite pyramids could begin. One would expect that the entire construction work of a pyramid temple would have been completed in one continuous process before the interior decoration started. However, one cannot exclude the possibility that the most essential parts of the temple, the offering hall and statue room, were constructed and decorated before the less essential outer parts were built. Neferirkare began a formidable pyramid complex at Abusîr.

7 Detailed information on underground apartments from Unas to Pepi II see A. Labrousse, *L'architecture des pyramides à textes, I-Saqqara-Nord*, in: *BdE* 114.1, Cairo 1996, pp. 24–40, 50–67, 77–107; Idem, *L'architecture des pyramides à textes, I-Saqqara-Nord*, in: *BdE* 114.2, Cairo 1996, figs. 1–4, 8–10, 14–16, 18–20, 29, 36–42, 45–46, 56–57, 70–75, 77–81c, 97, 127–129, pls. III, VIII–XI, XIV, XVI.

8 Underground tunneling was used when stable bedrock was available.

9 F. Monnier, *La construction des grandes vôutes en chevrons de l'Ancien Empire*, in: *GM* 242, 2014, pp. 89–104.

10 King Baka ruled two years and could not complete the work underground. A control note of the 3rd year was found inside the entrance cut of the pyramid of Radjedef, see: M. Valloggia, *Abou Rawash I. Le complex funéraire royal de Rêdjedef*, Cairo 2011, p. 48.

11 F. Arnold, *The Control Notes and Team Marks*, in: *The Metropolitan Museum of Art Egyptian Expedition* 23 (eds.), *The South Cemeteries of Lisht* II, New York 1990, p. 61 [A 2.1], p. 169 [SIII1], p. 174 [Ma 1], p. 175 [Ma 3], p. 176 [Kh 3], p. 177 [Kh 4, 5] (hereafter F. Arnold, *Control Notes*).

12 Latest: M. Verner, *The Pyramids. The Archaeology and History of Egypt's Iconic Monuments*, Cairo/New York 2020, pp. 389–418; M. Lehner/Z. Hawass, *Giza*, pp. 402–461; P. Tallet/M. Lehner, *Red Sea Scrolls*, pp. 212–281; F. Monnier, *L'ère des géantes. Une description détaillée des grandes pyramides d'Égypte*, Paris 2017, pp. 190–235.

13 M. Haase, *Der letzte Schliff. Bemerkungen zur Glättung von Pyramidenverkleidungen*, in: *Sokar* 25, 2012, pp. 18–31 (hereafter M. Haase, *Der letzte Schliff*).

14 In some places, the pyramid casings are peppered with patches, plastered into precisely fitting sockets, see: D. Arnold, *Building in Egypt. Pharaonic Stone Masonry*, New York 1991, pp. 241–243 (hereafter D. Arnold, *Building in Egypt*); Idem, *The Pyramid of Senwosret I*, in: *The Metropolitan Museum of Art Egyptian Expedition* 22 (eds.), *The South Cemeteries of Lisht* I, New York 1988, pl. 93a (hereafter D. Arnold, *Senwosret I*). How did the masons reach their workplace? No putlogs for scaffoldings can be detected.

15 M. Haase, *Der letzte Schliff*, pp. 27–28 calculates two year's work for the smoothing of the Cheops pyramid and the removal of the ramps and 1.5 years for the Khephren pyramid.

16 The only pyramid complex known with a separate access for building material is that of Senwosret III.

Fig. 2 Pyramid of Senwosret III. Sockets for multiple patch stones in the casing. (Photo D. Arnold)

When he died in his 11th regnal year, the offering hall and statue chamber were built and decorated.[17] The outer parts of the complex were only added and redesigned – in brick – by his successors.[18] Related examples for this practice of later periods come to mind.[19] King Seti I reigned for 11 years and completed and decorated only the inner rooms of his mortuary temple at Šayḫ ʿAbd al-Qurna and of his Osiris temple at Abydos. Thus, the inner parts were already functional but the outer parts of the temples were still under construction when his son Ramesses II took over.[20]

The construction of a pyramid temple started with the laying of the temple foundations.[21] Most temples were large and required several foundation courses of heavy limestone slabs. This foundation platform carried the top course of paving slabs. They were rarely formatted and arranged in a regular configuration but stitched together in a lively pattern.[22] This procedure followed the pharaonic principle of saving valuable stone material at the cost of work hours.

As in the architecture of other cultures, the surveyors projected the temple plan onto the pavement.[23]

17 M. Ch. Tetley, *The Reconstructed Chronology of the Egyptian Kings* 1, Onerahi/Whangarei, New Zealand 2017, pp. 319–320 (hereafter M. Ch. Tetley, *Chronology* 1).

18 L. Borchardt, *Das Grabdenkmal des Königs Nefer-ir-ke-Re*, in: *WVDOG* 11, Leipzig 1909, pp. 49–58.

19 This procedure is known from other cultures as well. Frequently, the choir and altar of cathedrals were completed and consecrated before the nave was even begun.

20 P. J. Brand, *The 'Lost' Obelisks and Colossi of Seti I*, in: *JARCE* 34, 1997, pp. 101–114; Idem, *The Monuments of Seti I. Epigraphic, Historical and Art Historical Analysis*, in: *Probleme der Ägyptologie* 16, Leiden 2000, p. 347.

21 D. Arnold, *Building in Egypt*, pp. 109–115; J.-C. Goyon et al., *La construction pharaonique*, Paris 2004, pp. 218–253.

22 For example L. Borchardt, *Das Grabdenkmal des Königs Ne-User-Reʿ*, in: *WVDOG* 7, Leipzig 1907, Plan 28 (hereafter L. Borchardt, *Ne-User-Reʿ*); M. Megahed et al., *Der Pyramidenbezirk des Djedkare-Isesi*, in: *Sokar* 37, 2019, pp. 62–66, figs. 23–31.

23 D. Arnold, *Building in Egypt*, New York 1991, p. 16; W. Müller-Wiener, *Griechisches Bauwesen in der Antike*,

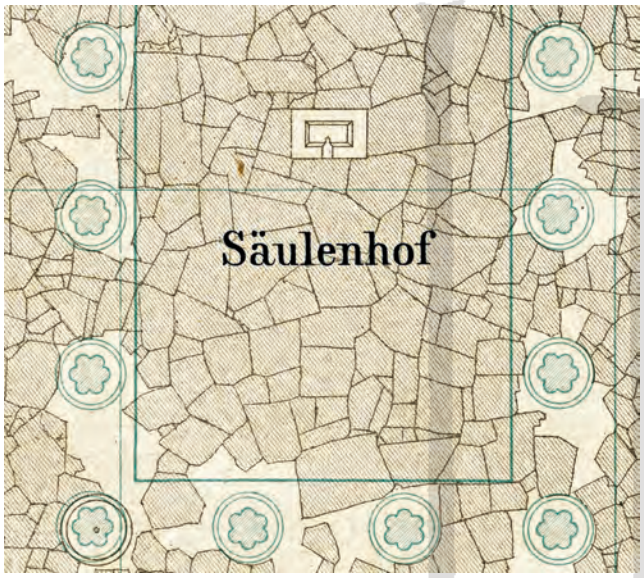

Fig. 3 Pyramid temple of Niuserre. Irregular arrangement of pavement slabs. (L. Borchardt, *Das Grabdenkmal des Königs Ne-User-Reʿ*, in: *WVDOG* 7, Leipzig 1907, Pl. 28, Drawing L. Borchardt)

The plan defined the exact position of all essential elements, also that of the huge false door.[24] Since the temple building certainly proceeded from inside out, placing the false door against the east slope of the pyramid would have been the first major engineering task. From remaining fragments, one can estimate that some had enormous dimensions,[25] the largest weighing nearly 20 metric tons. Their haulage and lifting in place required ample leeway at the foot of the pyramid. The false doors were not the only large objects that had to be introduced before the temple walls could be built. The offering tables and monolithic columns and pillars were so bulky that they were certainly inserted at the beginning of work.[26] The royal statuary could also not pass the narrow doors of the intricately shaped temple.[27] The colossal figures of Userkaf and Senwosret III in the southern cult temples of their pyramid complexes were certainly mounted early.[28]

The columns and pillars surrounding the courts of pyramid temples, standing in the square antechamber and populating the entrance halls of valley temples were not composed from blocks or drums but were monolithic.[29] Their bases were laid together with the pavement and the lowermost course of wall blocks and the column shafts would have been mounted immediately afterwards, before the wall construction started and the spaces were filled up with sand. The monolithic pillars in several temples were sunk into deep, rectangular foundation shafts. The fronts of the pits were slanting, permitting the pillars to slide down in an inclined position.[30] Since the distance between pillars was narrow, the engineers had to carefully plan the succession of their placement. The usage of such foundation pits was later regarded as excessive and abandoned after the Fourth Dynasty.

Greek and Roman engineers mainly used powerful cranes for erecting high, monolithic columns and

München 1988, pp. 34–36 (hereafter W. Müller-Wiener, *Griechisches Bauwesen*); G. Binding, *Planen und Bauen im frühen und hohen Mittelalter nach den Schriftquellen bis 1250*, Darmstadt 2002, p. 81; F. Icher, *Building the Great Cathedrals*, Paris 1998, pp. 96–98.

24 D. Arnold, *Building in Egypt*, pp. 115–119.

25 D. Arnold, *The Pyramid Complex of Amenemhat I at Lisht. The Architecture*, in: *The Metropolitan Museum of Art Egyptian Expedition* 29 (eds.), New York/New Haven/London 2015, pp. 7–10, 41, pls. 15–22 (hereafter D. Arnold, *Amenemhat I*). It was suggested that 40 such false doors adorned the pyramid temples of the Old and Middle Kingdom.

26 Most have disappeared, only those of Amenemhat I and Senwosret I at Lisht have survived, see: J.-É. Gauthier/G. Jéquier, *Fouilles de Licht*, Paris 1896, pp. 22–26, figs. 16–20, pl. 8; D. Arnold, *Senwosret I*, p. 44; D. Arnold, *Amenemhat I*, pp. 42–45, pls. 62–65.

27 The conclusion that royal temple statuary dates to the beginning of the kings' reigns is of importance for their stylistic evaluation.

28 A. Labrousse/P. Lauer, *Les complexes funéraires d'Ouserkaf et de Neferhetepes*, Cairo 2000, pp. 50–51, figs. 50–53, 72, pl. 8.

29 J. P. Phillips, *The Columns of Egypt*, Manchester 2002, pp. 51–63, 278–284 (hereafter J. P. Phillips, *Columns*); M. Verner, *The Columns of Abusir*, in: M. Verner (ed.), *The Old Kingdom art and archaeology. Proceedings of the conference held in Prague, May 31–June 4, 2004*, Prague 2006, pp. 343–355. Monolithic palm columns, most probably from the Old Kingdom, found at Tanis were 10.82 m high. Others at Bubastis measured 6.70 m. But their provenance is uncertain, also D. Arnold, *Hypostyle Halls of the Old and Middle Kingdom?* in: P. Der Manuelian (ed.), *Studies in Honor of William Kelly Simpson*, Boston 1996, p. 40–41, fig. 1.

30 H. Ricke, *Bemerkungen zur Baukunst des Alten Reichs* II, Cairo 1950, pp. 48–53, pl. 2; H. Ricke, *Der Harmachistempel des Chefren in Giseh*, in: *Beiträge zur Ägyptischen Bauforschung und Altertumskunde* 10, Wiesbaden 1970, pp. 20–23. However, V. Maragioglio, refutes this interpretation with the true argument that statues (and pillars!) would not have needed such deep foundation shafts, see: Maragioglio/C. Rinaldi, *L'Architettura delle Piramidi Menfite* V-Testo, Roma 1966, pp. 122–126 (hereafter Maragioglio/C. Rinaldi, *Pyramidi Menfite*); see however M. Lehner/Z. Hawass, *Giza*, pp. 200–201; Y. Yasuoka, *Untersuchungen*, figs. 4.3, 5.21.

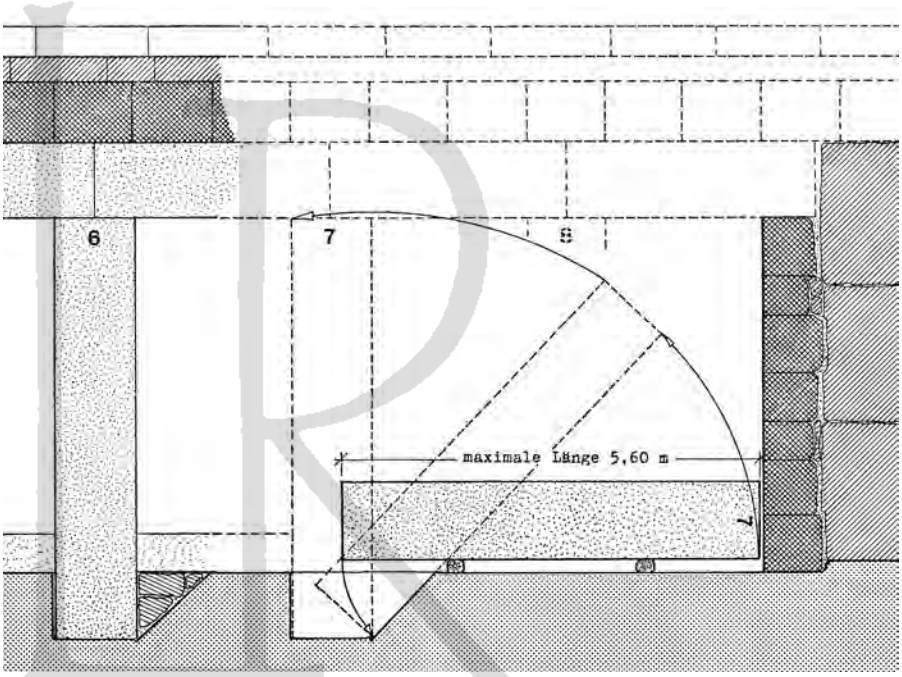

Fig. 4
Harmachis Temple. H. Ricke's suggestion for erecting pillars. (H. Ricke, *Der Harmachistempel des Chefren in Giseh*, *Beiträge zur Ägyptischen Bauforschung und Altertumskunde* 10, p. 21, Fig. 11, Drawing H. Ricke)

other elements.[31] So far, there is no evidence that the pharaonic builders had such tools.

Most researchers of Egyptian technology support the theory that obelisks were pulled up a brick ramp and flipped over into a sand funnel until its foot edge was caught by the groove in the base and the obelisk could be pulled up by ropes.[32] Such voluminous ramps might have been avoided by levering up the upper end of columns (and even obelisks?) in steps until they could be pulled up with the foot edge stemmed against a crossbeam fixed at the base.[33] However, one cannot completely rule out the possibility that the Egyptians had developed a machine similar to another Roman device: pivoting the column attached to a cradle or stretcher from the horizontal into a vertical position.[34] The well-known Unas causeway reliefs show the columns for the temple strapped to a sledge that could have accomplished the procedure.[35]

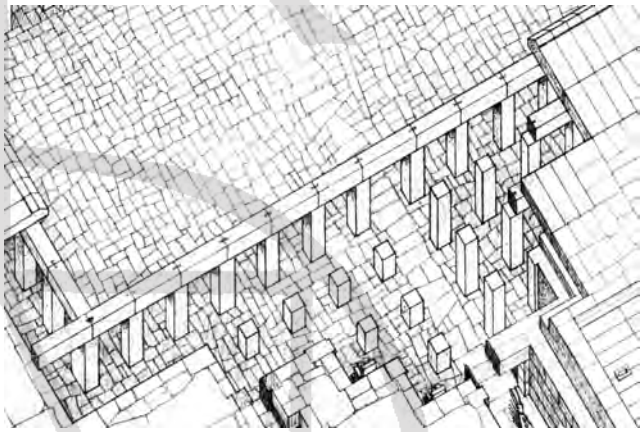

Fig. 5 Pyramid temple of Mycerinus. Limited space for positioning pillars at west side of court. (H. Ricke, *Bemerkungen zur Ägyptischen Baukunst des Alten Reichs* II, Kairo 1950, Pl. 1, Reconstruction H. Ricke)

After the placement of the heavy granite elements, the wall construction could begin, a work that seems easy enough but was actually complex. Moderate-sized blocks could be hand-carried and lifted to great heights on scaffoldings. The uppermost elements like door lintels, architraves and roofing beams were too heavy for that. These blocks do not show U-shaped chan-

31 J.-P. Adam, *Roman Building. Materials and Techniques*, London 1994, pp. 43–51 (hereafter J.-P. Adam, *Roman Building*); R. Taylor, *Roman Builders. A Study in Architectural Process*, Cambridge 2003, pp. 115–132.

32 E.g. J.-C. Goyon/J.-C. Golvin et al., *La construction pharaonique du moyen empire à l'époque gréco-romaine*, Paris 2004, pp. 329–338 (hereafter J.-C. Goyon et al., *La construction pharaonique*); J. P. Phillips, *Columns*, pp. 278–281.

33 R. Engelbach, *The Aswan Obelisk*, Cairo 1922, pp. 35–43; R. Engelbach, *The Problem of the Obelisks*, London 1923, pp. 36–43; L. Borchardt, *Zur Baugeschichte des Amonstempels von Karnak*, in: *Untersuchungen zur Geschichte und Altertumskunde Aegyptens* 5, Leipzig 1905, pp. 15–17.

34 J.-P. Adam, *Roman Building*, p. 47, fig. 98.

35 S. Hassan, *The causeway of Wnis at Sakkara*, in: *ZÄS* 80, 1955, p. 137, fig. 1; J-C. Goyon, *Les navires de transport de la chaussée monumentale d'Ounas*, in: *BIFAO* 69, 1971, pls. 3–6.

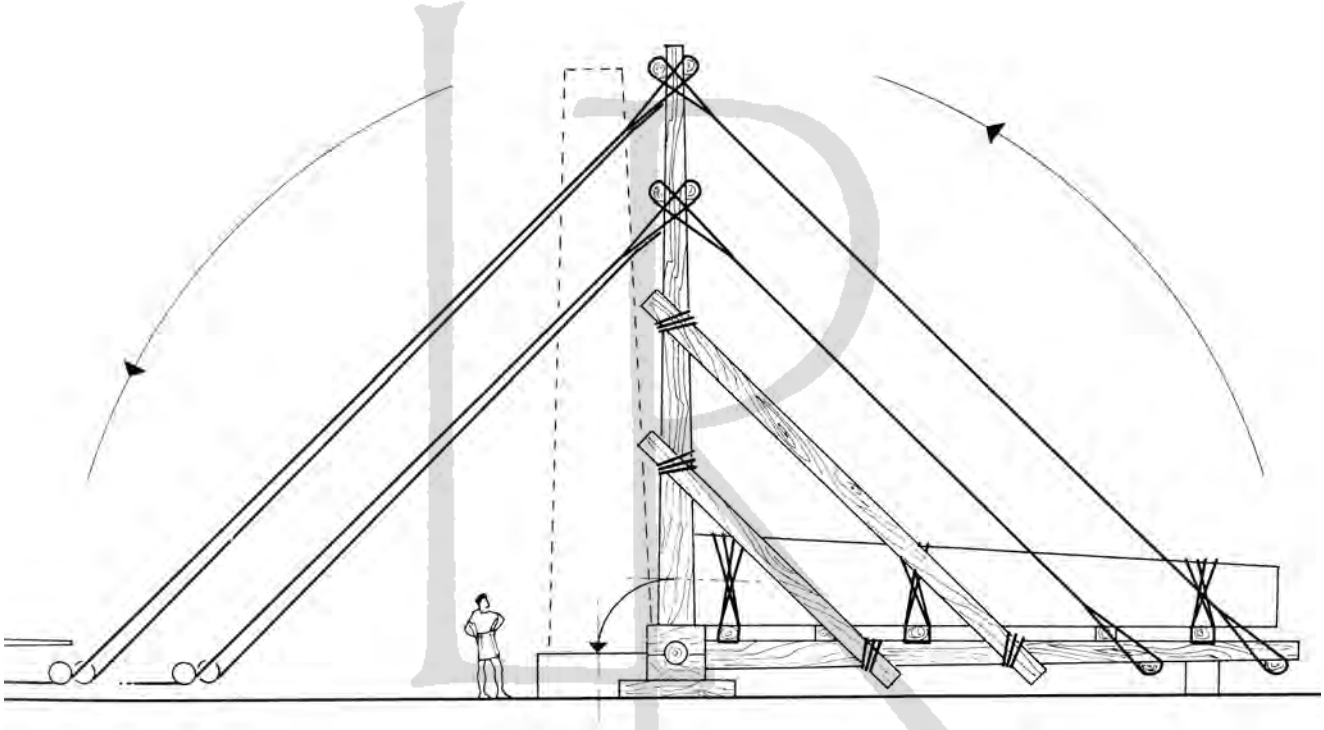

Fig. 6 Reconstruction of Roman device for lifting columns. (J.-P. Adam, *Roman Building. Materials and Techniques*, London 1994, Fig. 98)

nels, frequently appearing in Greek building, which were erected with pulleys and ropes.[36] In Egypt, wall blocks had to be hauled over brick or fieldstone ramps or steps.[37] Ramps had to be wide enough to accommodate the ascending and descending traffic of crews pulling sledges and carrying material. The usage of pulling oxen is thinkable but was probably restricted to special tasks.[38] The ramps would have been raised and enlarged in coordination with the progression of the building, probably over night when transport work was paused. Since the inclination of these ramps was restricted,[39] they were long and could not be used inside temple rooms.[40] One would therefore assume that one major ramp, placed outside the temple walls supplied the entire temple range. The interior spaces of the building were slowly filled with sand that was raised course by course until the roof level was reached.[41] One might add as an interesting detail that the workers stayed inside the workplace during the breaks, and their food was either delivered or brought with them.[42]

The walls were rarely made of massive blocks like in Greek architecture,[43] but consisted of a core of field stones, rubble or rock cased with a coat of dressed blocks or slabs.[44] The casing slabs frequently had the

36 Since no devices for vertical lifting existed, U-shaped rope channels were only used to lower sarcophagus lids or to insert the final key-stone into a pavement.

37 U. Hölscher, *Der erste Pylon von Karnak*, in: *MDAIK* 12, 1943, pp. 142–149; D. Arnold, *Building in Egypt*, pp. 79–101; J.-C. Goyon et al., *La construction pharaonique*, pp. 204–217; M. Haase, *Die megalithische Mauer westlich der Cheops-Pyramide*, in: *Sokar* 20, 2010, pp. 22–29; M. Haase, *Eine Transportrampe am Giza-Plateau?*, in: *Sokar* 21, 2010, pp. 22–29; M. Haase, *Eine Rampe für die Schwertransporte beim Bau der Cheops-Pyramide,* in: *Sokar* 15, 2007, pp. 48–49.

38 H. Köpp-Junk, *Einsatzmöglichkeiten von Schlitten und Rindern beim Pyramidenbau*, in: *Sokar* 25, 2012, pp. 34–35.

39 J.-C. Goyon et al., *La construction pharaonique*, p. 211.

40 However, steeper ramps over short distances have been observed at the Qasr al-Sâgha temple, see: D. Arnold/Do. Arnold, *Der Tempel Qasr el-Sagha*, in: *AV* 27, p. 14, fig. 9 (hereafter D. Arnold/Do. Arnold, *Qasr el-Sagha*).

41 U. Hölscher, *The Mortuary Temple of Ramses III. The Excavation of Medinet Habu*, vol. 4, Chicago 1951, pp. 31–32, figs. 35–37 (hereafter U. Hölscher, *Medinet Habu*).

42 D. Arnold, *Amenemhat I*, p.16.

43 Numerous examples e.g. in: D. Mertens, *Städte und Bauten der Westgriechen*, München 2006.

44 The pyramid and valley temples of Khephren and Mycerinus posed special challenges for the builders, because they consisted partially of grown rock, cased in the lower parts with granite and also included blocks of gigantic dimensions. A Khephren-block weighing 425 tons, see: V. Maragioglio/C. Rinaldi, *Pyramidi Menfite*, p. 66, pl. 11; a Mycerinus-block weighing 220 tons, see: G. A. Reisner, *Mycerinus. The Temples of the Third Pyramid at Giza*, Cambridge 1931, pp. 70, 74–80, pls. 2, 3e, plan 1, 3; also M. Lehner/Z. Hawass, *Giza*, pp. 252–253.

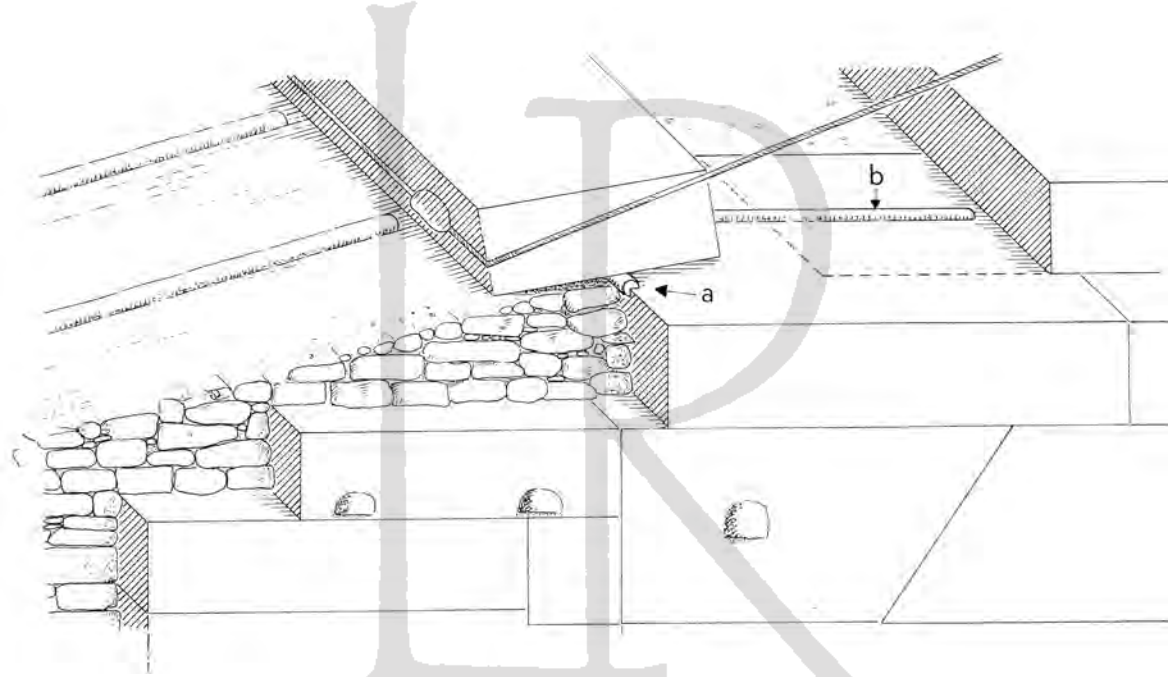

Fig. 7 Qasr al-Sâgha temple. Pulling roof beams to the roof top. (D. Arnold/Do. Arnold, *Der Tempel Qasr el-Sagha*, in: *AV* 27, Fig. 9, Drawing D. Arnold)

Fig. 8
Pyramid of Senwosret III. Casing blocks connected with multiple dove-tail cramps. (Photo D. Arnold)

shape of orthostates, standing upright and being higher than deep.[45] The sizes not being standardized, the blocks had to be adjusted for their specific place. During the positioning, the front of the wall blocks was still in the raw. This condition helped speedy progress because handling the blocks needed less care. After setting the blocks, the stone masons cut the sockets for the dovetail cramps, which connected the stonework.[46]

45 R. Ginouvès, *Dictionnaire méthodique de l'architecture grecque et romaine* 2, Athens/Rome 1992, p. 32, pl. 14. Most of the wall blocks of the Sahure temple are higher than deep, see: figs. 5, 40–41, 77.

46 D. Arnold, *Building in Egypt*, pp. 124–129. Cramps in stressed positions were of bronze, like those in Greek and

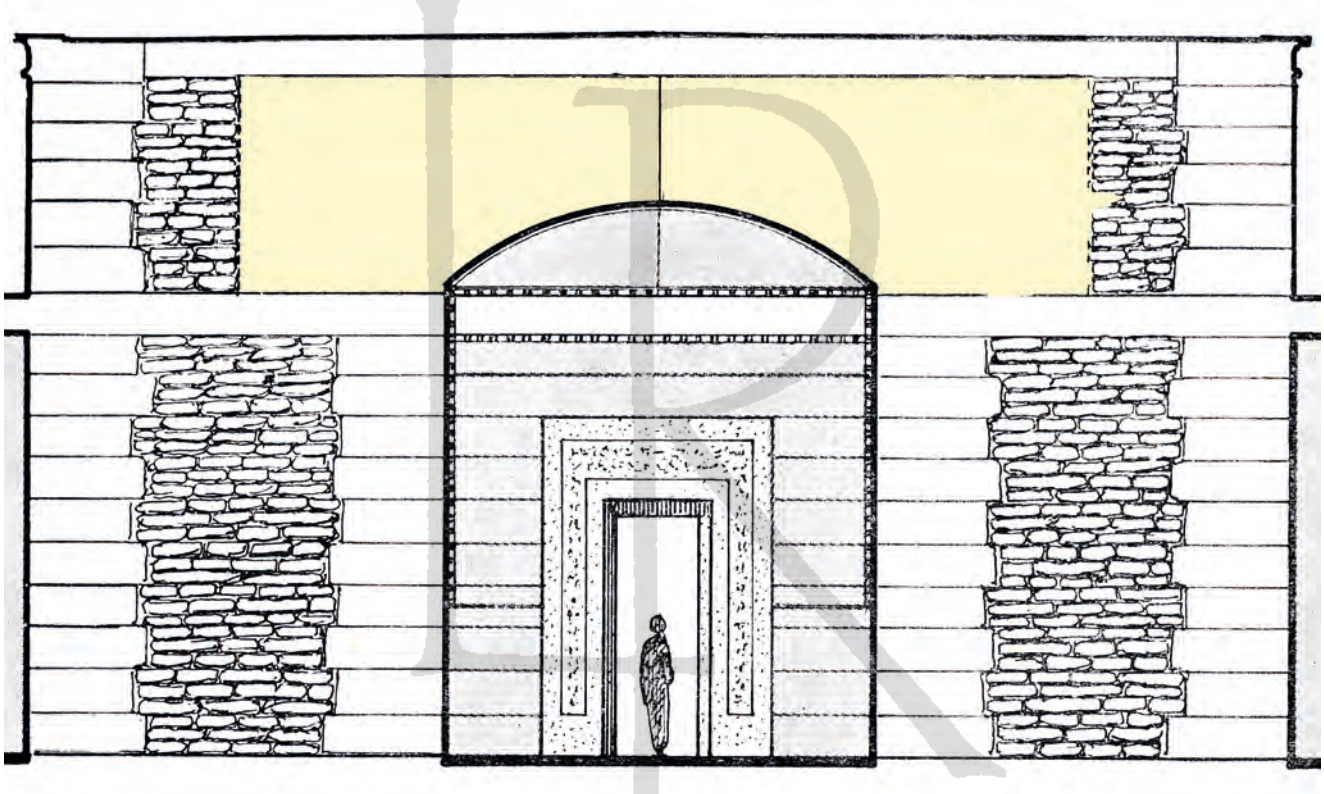

Fig. 9 Pyramid temple of Teti. Reconstructed section of *Per-weru* with juxtaposed 70-ton blocks, center. (J.-Ph. Lauer/J. Leclant, *Le temple haut du complexe funéraire du roi Téti*, in: *BiEtud* 51, Pl. 38, Drawing J.-Ph. Lauer)

The differing heights of the stepped roof terraces and their intricate block arrangement required individually shaped elements and particular supervision of their setting.

The offering hall and *Per-weru* were covered with 5.25-m-long roofing slabs[47] standing upright in two juxtaposed rows of about 15.[48] They weighed 15 tons and had to be pushed together from opposite sides. They were carved round from the underside and decorated with a star pattern. The offering hall of Senwosret III had a vaulted corbel construction, representing a masterwork of early engineering.[49]

For constructing the high-rising, pylon-like corner bastions of the pyramid temples of Djedkara, Unas, Teti, Pepi I and Amenemhat II,[50] additional ramps, certainly rising above the roof level, had to be used. After the conclusion of this complex building program, the sand was removed from the temple interior. The emptying of the rooms had to be well organized, considering the narrow rooms and doors and crooked passages. At the pyramid of Senwosret III, a wide area outside in the south was filled up and levelled with such builders' debris. The ceiling blocks had been installed when the roof could still be reached by ramps. All the work inside the temple was therefore carried out under poor light conditions, slightly improved by small light shafts. Clouded skies and the shadow of the towering pyramid worsened the conditions considerably. It is unknown how the artists compensated for that.

The surface of the walls was still "*en bosse*" and could now be chiseled down. Damaged parts were repaired with patch stones and plaster. Monolithic col-

Roman buildings, see: W. Müller-Wiener, *Griechisches Bauwesen*, pp. 82–86; J.-P. Adam, *Roman Building*, pp. 55–56.

47 L. Borchardt, *Das Grabdenkmal des Königs S'aʾḥu-Reʿ* I, in: Ausgrabungen der DOG in Abusir, 1902–1904, 14. Wissenschaftliche Veröffentlichung der DOG, Leipzig 1910, p. 47 (hereafter L. Borchardt, *S'aʾḥu-Reʿ* I).

48 For example, J.-Ph. Lauer, *Le temple haut du complexe funéraire du roi Téti*, Cairo 1972, pls. 38; D. Arnold, *Senwosret I*, pl. 105; A. Labrousse, *Le temple funéraire du roi Pépy Ier*, in: *MIFAO* 137, Cairo 2019, fig. 97 (hereafter A. Labrousse, *Pépy Ier*).

49 D. Arnold, *The Pyramid Complex of Senwosret III at Dahshur. Architectural Studies*, in: *The Metropolitan Museum of Art Egyptian Expedition* 26 (eds.), New York 2002, fig. 18a (hereafter D. Arnold, *Senwosret III*).

50 A. Labrousse, *Pépy Ier*, pp. 331–333, figs. 22–24.

Fig. 10 Valley temple of Snofru. Damaged south wall with patch stones. (Photo D. Arnold)

umns and pillars had also been erected roughly dressed and needed a finer surface treatment.

After smoothing the walls, the sculptors and painters had a full view of the wall surface and could begin designing, carving and painting the decoration. They could reach the lower parts of the walls, the dado, standing on the floor. The more sophisticated decoration above the dado could only be applied with the help of scaffolding.[51] The artists also needed scaffolding in the center of the rooms for decorating the ceiling. At the very end, the wooden doors of the temple rooms had to be installed. Carpenters inserted the door wings into the threshold and lintel and attached locking devices to the door frames.[52] The pyramid temple of Teti had about 50 such doors!

The completion of the pyramid temple was an important step but did not represent the conclusion of the work in the complex. The construction of the north chapel and the secondary pyramids was probably undertaken concurrently with the pyramid temple but the construction of the enclosure walls, the digging and furnishing of boat pits, the construction of the causeway and the valley temple was still waiting. Some Old Kingdom examples confirm this development.

The Red Sea papyri, recording stone transport from Tura to the Gîza-plateau, are of an enormous historical value and are dated to the 26th to 27th regnal years of Cheops. To that date, the pyramid probably stood finished for several years, but numerous side-projects were still under way — the satellite-pyramid, pyramid temple, boat pits, causeway and finally the valley temple. The papyri seem rather to refer to this extended "post-pyramid" phase of construction work.[53]

51 Round sockets were found in the underground to hold the poles for scaffolding in the temple of Mentuhotep Nebhepetra at ad-Dayr al-Baḥrī, after D. Arnold, *Building in Egypt*, pp. 232–233, figs. 5.21–5.22 and in the hypostyle hall of Madīnat Hābū, see: U. Hölscher, *Medinet Habu*, p. 33, fig. 36; Y. Yasuoka, *Untersuchungen*, p. 8, fig. 0.7. No putlogs are known so far from temple walls or pyramid casing.

52 For example, L. Borchardt, *S'a³ḥu-Reʿ* I, pp. 36–38, 58–60.

53 P. Tallet, *Les papyrus de la Mer Rouge I. Le 'Journal de Merer'*, Cairo 2017, pp. 6–7, pls. 1–2. For the date and destination of the transports see: P. Tallet, *Red Sea Scrolls*, pp. 277–281.