Two Architects' Sketches
Author(s): Max Hoberman
Source: *Journal of the Society of Architectural Historians*, Vol. 44, No. 4 (Dec., 1985), pp. 380-383
Published by: University of California Press on behalf of the Society of Architectural Historians
Stable URL: http://www.jstor.org/stable/990115
Accessed: 23-10-2015 19:51 UTC

NOTES

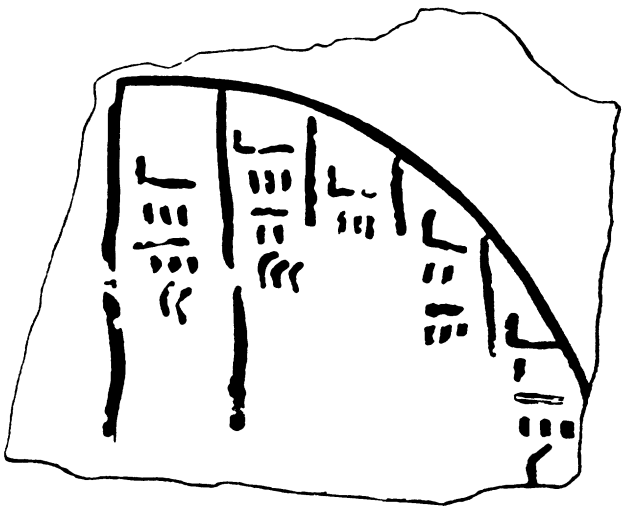


Fig. 1. Architect's diagram, IIIrd Dynasty, 3000–2700 B.C., found April 1925 near Step Pyramid, Saqqara. Red ink on limestone, 15 × 17.5 × 5 cm (Cairo Museum of Antiquities).

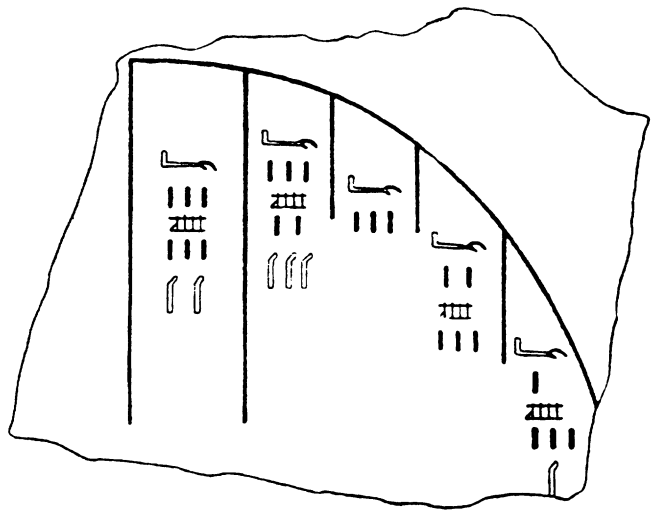


Fig. 2. Transcription of architect's diagram (Cairo Museum of Antiquities).

Two Architects' Sketches

MAX HOBERMAN
Jerusalem

THE ARCHITECT was visiting the building site when a question was raised by the construction foreman concerning the exact curvature for the roof of the small structure being built. To clarify the design, the architect brought out a pen, dipped it in red paint, looked around for a flat stone to write upon and drew on its rough surface a curve representing the ceiling and five equally spaced vertical lines intersecting it. To the right of each line he wrote the height the roof was to be above a horizontal datum in the units used by builders of that time: cubits, palms, and fingers. The plan thus clarified, the foreman finished the job and discarded the stone with the sketch on it, and so it lay for almost 5,000 years until it was uncovered and put on display in a side room of the immense Cairo Museum of Antiquities.[1]

A tracing of this sketch, reduced in size, is shown in Figure 1. The ostracon, measuring 15 × 17.5 × 5 cm, was discovered close by the great Step Pyramid of Neterikhet-Zoser at Saqqara near Cairo, the first massive masonry structure in the world, dating from the IIIrd Dynasty (3000–2700 B.C.), during the excavations of the Egyptian Department of Antiquities there in April 1925. From the paleographic features of the inscription, its proximity when discovered to the great Step Pyramid, and the concurrence of respected opinions,[2] it is considered most likely to date from the era of that first pyramid and so is remarkable, too, in being the earliest known use of rectangular co-ordinates to define a curve. It was published 60 years ago in several research reports[3] and was put on display where I chanced upon it recently and became enthusiastic enough to pursue it further and report upon it here.

A cleaned-up transcription of the tracing shown in Figure 2 will help in describing it. (Note that symmetry around a vertical center line is presumed; only the right half of the curve is shown, a proof that drafting shortcuts were already in use then.)

Starting at the left vertical line and proceeding to the right,

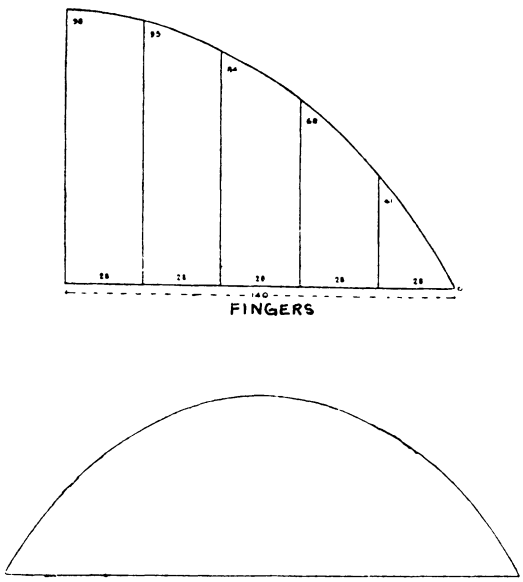
Acknowledgment is made to Dr. Mohamed Saleh, Director of the Cairo Museum of Antiquities, for his kind permission to use the illustrations included in this article.

1. Battiscombe Gunn, "An Architect's Diagram of the Third Dynasty," *Annales du Service des Antiquités de l'Egypte* 26 (1926), 197–202.

2. Ibid.; Alexander Badawy, *Ancient Egyptian Architectural Design,* Berkeley, 1965, 56.

3. B. Gunn, *Journal of Egyptian Archaeology,* 12 (1926), 134, referred to in Gunn, "An Architect's Diagram," p. 200.

JSAH XLIV:380–383. DECEMBER 1985



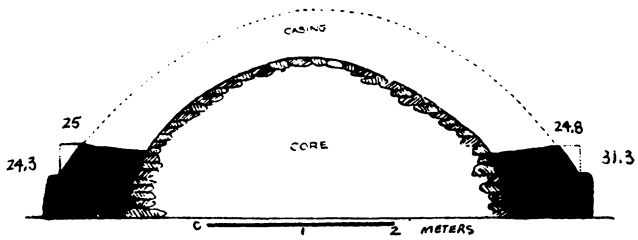


Fig. 3. Reconstructed semicontour of roof (Cairo Museum of Antiquities).

Fig. 4. Full contour of roof (Cairo Museum of Antiquities).

Fig. 5. Building remnant near Step Pyramid (Cairo Museum of Antiquities).

the height above the datum to the intersection with the roof contour is given as:

1. 3 cubits, 3 palms, 2 fingers = 98 fingers
2. 3 cubits, 2 palms, 3 fingers = 95 fingers
3. 3 cubits = 84 fingers
4. 2 cubits, 3 palms = 68 fingers
5. 1 cubit, 3 palms, 1 finger = 41 fingers[4]

The horizontal distances between the vertical lines—the abscissae—are not given; probably a drafting convention of the time specified that they be 1 cubit apart,[5] and with that assumption and the assumption that the roof curve therefore drops to zero at a distance of 1 cubit to the right of the extreme right vertical line, it is possible to draw the roof curve to scale (Fig. 3). The completed contour is shown in Figure 4.

4. One palm = 4 fingers; 1 cubit = 52.5 cm = 7 palms = 28 fingers.
5. See n. 3, above.

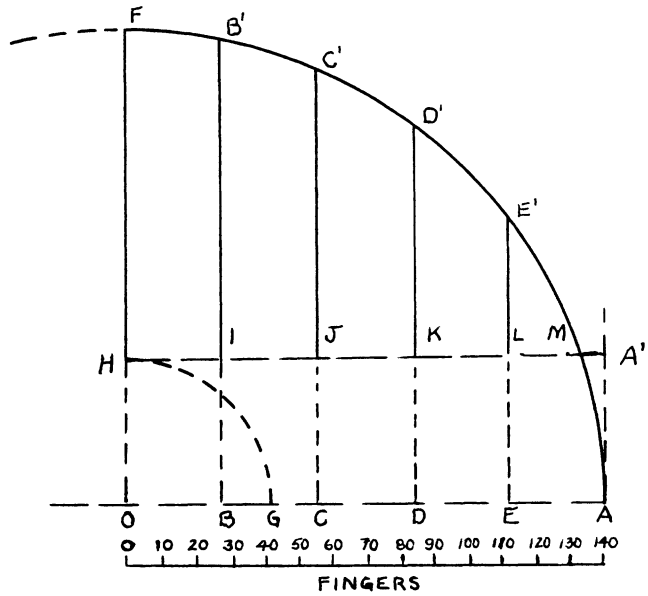


Fig. 6. Assumed semicircular profile (Cairo Museum of Antiquities).

Near where the sketch was found the remains of a saddleback construction was uncovered that suggested to the Egyptologist Cecil M. Firth that the sketch might be a working diagram for building the saddleback to the desired contour.[6] The actual remnant consists of just a core of rubble less than 35 cm high covered with a casing of limestone blocks, but it was possible to project a reasonable shape to the roof from the initial slope of the casing (Fig. 5). Assuming a total diameter of 10 cubits, the casing diameter comes to 525 cm (1 cubit = 52.5 cm). The actual diameter of the saddleback, although not uniform, averages 556.6 cm, a discrepancy of 31 cm. The maximum height of Firth's projected roof contour was 174 cm while the ostracon calls for a height of 3½ cubits, or 184 cm, a discrepancy of less than 10 cm or about 6 percent! This close correlation between sketch and structure, huge by today's standards, is indicative of the accuracy achieved by the putative Pharaoh Zoser's builders, even in structures of minor importance.

But the discrepancies, however small, aroused the interest of another Egyptologist, M. G. Daressy.[7] He remembered a sketch drawn on the wall near the door of the tomb of a much later Pharaoh, Ramesses (Ramses) VI of the XXth Dynasty (about 1100 B.C.), which described the ceiling arch of the tomb and did include a base line, although ordinates were not given as in the Zoser ostracon. By comparison with the actual vault ceiling he had then been clearing, he had determined it as elliptical. Assuming that the use of an elliptically shaped roof was unreasonable so early in Egyptian history as the time of the ostracon

6. Gunn, "An Architect's Diagram."
7. G. Daressy, "Trace d'une voute datant de la IIIe dynastie," *Annales du Service des Antiquités de l'Egypte*, 27 (1927), 157–160.

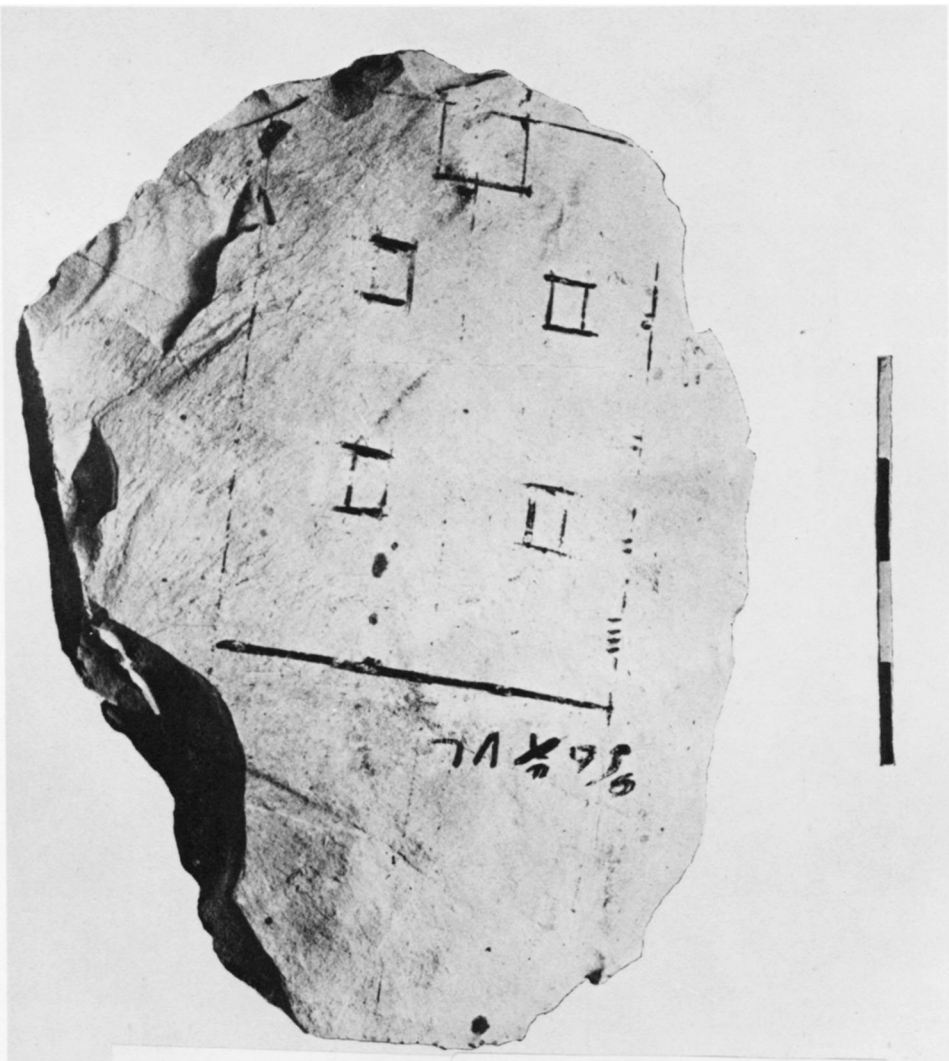


Fig. 7. Architect's floor plan for a rectangular chamber (Cairo Museum of Antiquities).

sketch and that a truncated semicircular cross section was more likely, M. Daressy arrived at the contour shown in Figure 6, concluding that the ceiling curve did *not* drop to zero at 1 cubit to the right of the farthest right vertical line. Assuming the same radius as before, 140 digits or 5 cubits, with 1-cubit spacing along the abscissae at points O, B, C, D, E intersecting a semicircular shaped ceiling arch at points F, B′, C′, D′, E′, and then truncating the semicircle with a horizontal line at H (1½ cubits up, or $\frac{3}{10}$ of the radius), the height of the ceiling arch above this assumed horizontal datum comes remarkably close to the ordinates given on the limestone ostracon, except for section JC′ being 1½ fingers short and section KD′ being 1 finger short. A simpler semicircular dome, too, would seem more reasonable for that primitive time. With only a plumb line and a single small template, the building crew could easily contour the ceiling to a constant curvature as it was being built up. However this theory doesn't explain why the crew would need a set of co-ordinates to specify the ceiling.

In a display case just a few feet away from this remarkable ostracon is another, just as interesting (Fig. 7). This is an architect's floor plan for a rectangular chamber, also drawn in red and found in the Valley of the Kings at the beginning of this century.[8] It measures about 7½ × 10 inches and is probably the sketch of an auxiliary chamber of a royal tomb specifying the locations of four pillars to support the roof. The marks of the center line, made by a taut string dipped in ocher, are still visible today. The columns are shown in cross section, but the door at one end is shown flat as was the custom. No other details are

8. Reginald Engelbach, "An Architect's Project from Thebes," *Annales du Service des Antiquités de l'Egypte,* 27 (1927), 72–75.

shown. Although it seems as if the two right-hand columns were first drawn in square cross section and then reduced to an actual ratio of 2:1½, in fact the draftsman scratched out the superfluous lines with his limestone chip "eraser." Small dimensioning tics are marked on the right and bottom sides of the drawing (those on the bottom are too faint to be seen in the photograph). On the right wall, the space between the lower wall and the lower column is marked with four tics, probably signifying 4 cubits, and the length of the side of the column with two tics. The space between columns is also given with four tics, marked on the bottom but again too faint to be seen in the photo.

The upper right corner of the ostracon has been broken off, with the tics showing the spacing to the upper wall, but this also was probably 4 cubits. Missing too is part of a note in hieratic (cursively written hieroglyphics), which from the context must have read: "Length: cubits 18," but all that remains now is the 8. This too has been scratched out, since the sum of the tics along the side comes to 4 + 2 + 4 + 2 + 4 = 16 cubits and not the conjectured 18 cubits. Spacing for the breadth was also indicated by tics, but these have been scratched out. What can be made out is that the side of the column and the space between the column is 3 or more cubits. (The note in hieratic at the lower right of the floor plan reads: "Breadth: cubits 15.")

The description card in the case with this ostracon gives us a fascinating conjecture of how a routine building problem was solved 3,000 or more years ago, and it is worth quoting:

> It is not without interest to attempt to reconstruct what passed in the mind of the old foreman when he was at work on this plan.
>
> It seems that his instructions were to get up the plan of a chamber 18 cubits by 15 (30′ × 25′) and to have a clear space of 4 cubits about each column.
>
> Taking his string dipped in pigment he "ruled" by eye a center line and the four walls of the proposed chamber and when the lines dried he scratched out what was not required. At first he turned his attention to the width of the chamber and assuming pillars of 2 cubits on a side, he found that he could by no means arrive at a breadth of 15. A solution appears to have struck him which was to make the width of the columns 1½ cubits, thus getting a breadth of 4 + 1½ + 4 + 1½ + 4 = 15. He therefore erased his provisional tics and examined the question of length. Here his difficulty was not so easily overcome. He could get a length of 16 but to obtain 18 meant that his columns had to be 3 × 1½ in section, an unheard of proportion. He therefore erased the number 18, sketched in his columns to the approximate section of 2 × 1½ and then we imagine went off to find out whether a 16 × 15 chamber would do or whether he had to change the spacing.