

History of
Science and Technology
In Ancient India
— The Beginnings —

with a foreword by
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Admitting this, we have to accept that brick-making according to the application of some definite scale which we come across practically throughout the *Sulva-sutra-s* is indicative of a very ancient tradition, inasmuch as this tradition goes back to the period of the First Urbanization. This, in other words, means that the relation of mathematical calculation with brick-technology has a hoary past.

In view of the large number of brick-types mentioned in the *Sulva* texts each with very specific measurement in terms of the units of linear measures accepted by the texts, it would be a laborious process to try to assess the measurements of the *Sulva* bricks in terms of the scales of the Harappan Culture. Besides, that is not necessary for our main argument, namely that it is not *prima facie* impossible to try to trace the tradition of the application of mathematical calculation to brick technology to the ancient Harappan Culture. This tradition, once accepted, may explain the meticulous care taken by the brick-makers of our *Sulva* texts to be specific or accurate about the measures of the brick-types, a large number of which they had to improvise in order to meet the requirements of the peculiar structures they were asked to execute. Incidentally, this technique of improvising new and newer brick-types, too, could have its roots in the Harappan culture, where, apart from the standardised bricks, we also meet with various other brick-types, like the T-shaped one assumed as needed for covering the drains and the wedge-shaped bricks used for the construction of wells, drains or the grinding floor of the granaries.

But there is another point of considerable interest which may as well be noted in this connection. In spite of various conjectures, the fact remains that we have no definite knowledge of the language of the peoples in the Indus Valley Civilization. It is, therefore, futile to speculate on the possible terminologies used by the Harappan peoples for the units of length measures. In the history of Indian culture, the earliest evidences for such terminologies are to be found in the *Sulva-sutra-s* and *Arthasastra*. In both, the basic unit for length measure is called an *angula*, literally 'the finger'. For the sake of precision, however, the *Arthasastra* defines it as "the maximum width of the middle (part) of the middle finger of a middling man."¹⁵ Whether the unit *angula* of the *Arthasastra* is exactly the same as understood in the *Sulva-sutra-s* may be

open to some discussion, for the *Arthasastra*¹⁶ proposes to measure it in terms of eight *yavamadhya*-s (the width of the middle of eight *yava*-s) whereas the *Baudhayana Sulva-sutra*¹⁷ conceives it in terms of fourteen grains of the *anu* plant (understood by Thibaut as *panicum miliaceum*). But we may note here one point of some interest. According to both the texts¹⁸ the longer unit called *aratni* (loosely translated as 'cubit' by Kangle) is conceived in terms of 24 *angula*-s and it is also the same according to Yallaya's explanation of Aryabhata¹⁹ though the latter uses the word *hasta* instead of *aratni* (literally the length from the elbow to the tip of the little finger). In any case, the fact is that the term *angula* stands for the basic unit of length measure in later literature, inclusive of the Sulva texts and there are at least some hints suggesting correlation between the *angula* of the *Baudhayana Sulva-sutra* and of the *Arthasastra* as well as of much later astronomical works.

Earlier writers like J. F. Fleet²⁰ were satisfied by roughly equating the *angula* to $3\frac{1}{4}$ th of an inch, which makes it 19.499 mm. On the basis of a more meticulous calculation, however, Mainkar equates the length of the *Arthasastra angula* to 17.78 mm. This gives a very interesting clue to correlate the basic unit of later linear measure, viz. the *angula*, to the length measure of the Lothal scale. As Mainkar²¹ puts it :

The author has shown, (in his articles) tracing the development of length and area-measures in India, that the *angula* which is the basic unit of length measures, mentioned in the *Arthasastra*, is 17.78 mm. This value is so nearly equal to the value of ten small graduations of the Lothal scale (1.703×10 mm), that they may be considered as being practically equal. If this is accepted, and Rao agrees with it, the entire series of length-measures specified in the *Arthasastra* falls in a pattern with the Indian scales. The author has shown in his articles mentioned above, that the length-measures used in India throughout later periods were related in some manner or other, with the length-measures specified in the *Arthasastra*. It is,

15. *Arthasastra*, ii. 20.7.

16. *Ibid* ii. 20.5.

17. *Baudh Sul Su*. i. 4.

18. *Arthasastra*, ii. 20. 12; and *Baudh. Sul Su*. i. 16.

19. Shukla and Sarma, *Aryabhataiya*, intro xliii.

20. J. F. Fleet in JRAS, 1912. 233.

therefore, possible to assert that the Indus length-measures had a very profound influence on the length-measures used in India up to a few years back.

S. R. Rao wants to go a step further :²²

It appears that both 'foot' and 'cubit' were treated as units for linear measures. The 'foot' is said to be of 13.2 ins. (33.5 cms.) and the 'cubit' varying between 20.3 and 20.8 ins. (51.5 and 52.8 cms). The houses in Lothal can be measured in terms of complete units of 'foot', e.g. House No. 159 (phase IV A) measures 40×20 units, and warehouse 117×123 units, the unit in each case being 13.2 ins.

But before passing on to see more of the application of mathematics to the brick-structures of the Harappan Culture, we may ask ourselves a simple question. Could it be that the correlation of the *angula* of the later texts inclusive of the *Sulva-s* with the linear measure of the Indus scales be itself an indication that wants us to seek the roots of the *Sulva* mathematics in the mathematical activities in the First Urbanization ?

4. BRICK-TECHNOLOGY AND MATHEMATICS IN FIRST URBANIZATION

While analysing the *Sulva-sutra-s* we were led to the view that the mathematics codified in these texts is inconceivable without the tradition of highly sophisticated brick-technology. The texts give us the impression that this mathematical knowledge was above all the outcome to meet the theoretical requirements of the brick-makers, brick-layers, architects and other technicians, who were required to execute the construction of certain specified forms of brick-structures. At the same time, we were confronted with an apparently anomalous situation. The texts cannot but be placed in a period which, archaeologically speaking, was unaware of any sophisticated brick-technology. Hence we were led to raise the question concerning the possible roots of this mathematics in the mathematical activities of the First Urbanization, one of the most conspicuous features of which had been highly sophisticated brick-technology. But the first point that requires to be established before answering the

21. Mainkar in FIC 147-48.

22. S. R. Rao, LIC 107.