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Geometry for Gods

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Abstract – **Mathematics and Astronomy was the most prominent aspects of Science in Ancient India. Indians developed mathematics in early period chiefly through life living process like Egyptians. They recorded their findings which are now called as "Sulva Sutras". In this paper, i provide an elaborate introduction about Sulva Sutras and the effect it had in life.**

It is observed that Ancient Mathematicians developed "Sulva Sutras" through various Geometric forms which in turn were used to construct different altars which formed the way of living in early India. This paper considers some of the Geometries used by Ancient Indians and people who constructed them with an application of this process.

Keywords – **Sulva Sutras, Pythagorean Theorem, Geometric Constructions, Doubling the Surface Area, Irrational Number, Paper Sizes.**

I. Introduction

There are many connections that one can make with Geometry and religious rituals offered for Gods. Both are dwelled with Symmetry, Order and Pattern. The most extensive of these connections can be found in Ancient Indian Mathematics produced by three great saints called Baudhayana, Apastamba and Manava. These three produced phenomenal designs of Geometry which in literature are termed as "Sulva Sutras" ("The Books of the Cords"). The Sanskrit name derives from the practice surveyors have of marking out straight lines close to the ground with cords joined by pegs. We still see bricklayers practicing this art, if they want to be sure enough that the wall is straight.

The Sulva Sutras were believed to be written between 800 B.C. and 200 B.C. Sutras refers to formulas or mathematical procedures which provide detailed prescriptions for the geometrical constructions needed to construct ritual altars. The altars were themselves viewed as things with power to change events for better or worse and had to be respected in appropriate ways.

If we glance through the pages of Sulva Sutras, one often find many geometrical results mentioned in Euclid's Elements Book (Which is incidentally the first mathematics book in print to exist) and the most famous Pythagoras Theorem. Thus, we can recognize that Baudhayana and Apastamba who lived much earlier than Euclid, knew Pythagoras Theorem in its full form and applied it effectively in the construction of ritual altars.

Baudhayana Apastamba

The most interesting and geometrically challenging aspect of altar construction was the belief that if things went badly for you, your family, or for your village, then some evil force had begun to dominate your life and you have to take proper measures and follow suitable procedures to overcome it. Depending upon the nature of domination, the ritual rules differ but there existed one common belief in all situations. What is the common belief and how to overcome the domination of evil force and attain peace and harmony?

II. Geometric Constructions

The common belief that Ancient Indians had is that, by increasing the size of altar they pray, they can overcome the destruction caused by evil force. The Sulva Sutras precisely provide this idea of increasing the size of various altars and therefore they provided the means for people to overcome the evil force with the help of Geometry. Hence, like Greeks, earlier Indians considered Geometry to be a subject of highest importance.

Now knowing that increasing the size of the altar would be the proper solution to their problem, they sought ways to describe so. Here increasing the size refers to increasing the surface area and this posed a tricky geometrical problem for the authors of the Sulva Sutras.

The most common type of altar, in the shape of falcon, was made from many small straight-edged bricks of varying shapes. Typical altar building bricks have top surfaces in the shape of a parallelogram, a triangle, or a rectangle with a triangular notch removed.

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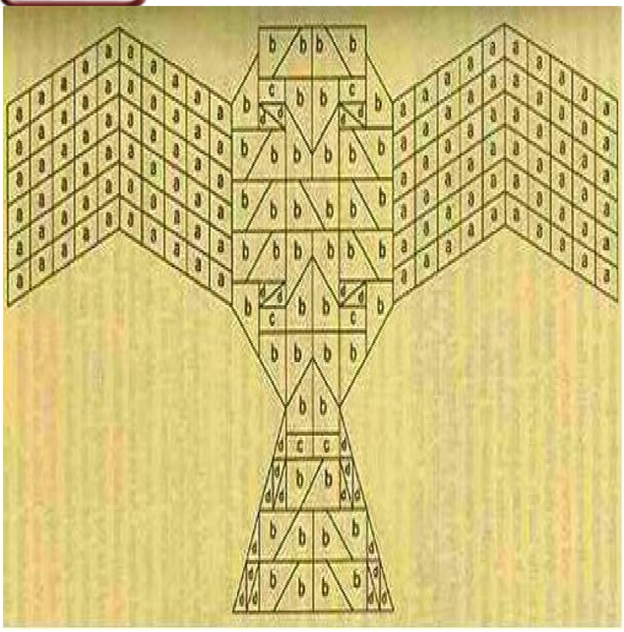


As one can observe from the falcon altar picture, the authors of Sulva Sutras used only four shapes to construct this, namely a, b, c and d. Here shape ‘a’ refers to parallelograms, ‘b’ refers to trapeziums, ‘c’ refers to rectangles and ‘d’ refers to triangles. What a remarkable form is obtained using elementary shapes that we often come across? This is one of the beauties embedded in Sulva Sutras.

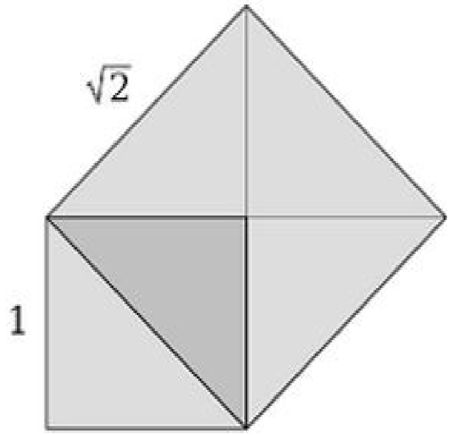
The altar would have been built up in many layers, with about 200 bricks forming each layer in the most important altars. The overall shape had to follow certain stringent conditions as prescribed by the corresponding religious ritual.

We can see that the process of the doubling the surface area of altars like shown above is indeed a difficult task. The Sulva Sutras provide step by step procedures for accomplishing this for straight forward shapes (like doubling the surface area of rectangle, triangle) and showed how to extend them to area-doubling patterns.

As a very simple example, suppose we have a square brick whose sides are each 1 unit and we need to double this. The starting area is 1 x 1 = 1 square unit. In order to increase it to 2 square units of area, there is an easy way and a hard way.

The easy way, of course, is to change the square in to a rectangle whose sides are 1 and 2 units of length so that the area of rectangle = 1 x 2 = 2 square units as desired. But, there is an important property to be noted in this process. Though the area had been doubled, the initial square shape has now become a rectangle. Thus, the area is doubled, but the shape is not preserved.

The hard way, is to keep the shape as it is and still double its area. Is it possible to achieve this? If we keep each side of the square to be $\sqrt{2}$, an irrational number which is approximately 1.414, then the area will become double and the initial square shape would also be a new square, only now it possesses a side length of square root of 2. We can do so, if we measure along the diagonal of a square of side length 1 unit.



Thus, it is possible to double the square by keeping the square shape as it is. Similarly, it is easy to double the rectangle, by just placing another similar rectangle adjacent to it. The little parallelograms in the wings of the falcon (marked as ‘a’) which make a large parallelogram form a block of 30, can easily be doubled. If you imagine straightening one out in to a rectangle, then its area is just the base-length times its height. Doubling it is no harder than doubling a rectangle.

Another shape that can be seen down the centre line of the falcon (marked as ‘b’) is a trapezium, in which two sides are parallel and other two sides are non-parallel. But again, it is easy to double this shape keeping the shape as it is, since it comprises of two triangles and one rectangle i.e. two shapes of ‘d’ and one shape of ‘c’. Thus knowing the way of doubling these rectilinear shapes, ancient Indian mathematicians could find a way out to double a given altar efficiently.

III. Irrationals

While developing the idea of doubling process of various structures and forms, the ancient Indians had an ingenious way of computing many irrational numbers to high accuracy which agrees to modern values to at least four to five places. Here are few examples for such accomplishments.

One of the pioneer of Sulva Sutras, Apastamba, gave the following formula to compute $\sqrt{2}$ to five decimal places of accuracy.

$$\sqrt{2} \approx 1 + \frac{1}{3} + \frac{1}{3 \times 4} - \frac{1}{3 \times 4 \times 34}$$

One of the great Mathematician and Astronomer of ancient India, named Aryabhata I gave an elegant formula for determining the most important real number in mathematics namely π .

In particular, in his book Aryabhateeya, he mention a small verse (sutra similar to today’s formula) that π is ratio of the circumference of 62832 units divided by 20000 units of a circle. That is, $\pi = \frac{62832}{20000} = 3.1416$. This value of is accurate up to four decimal places. Thus, through elementary methods, ancient Indians explored the unknown Transcendental numbers through ingenious ways.

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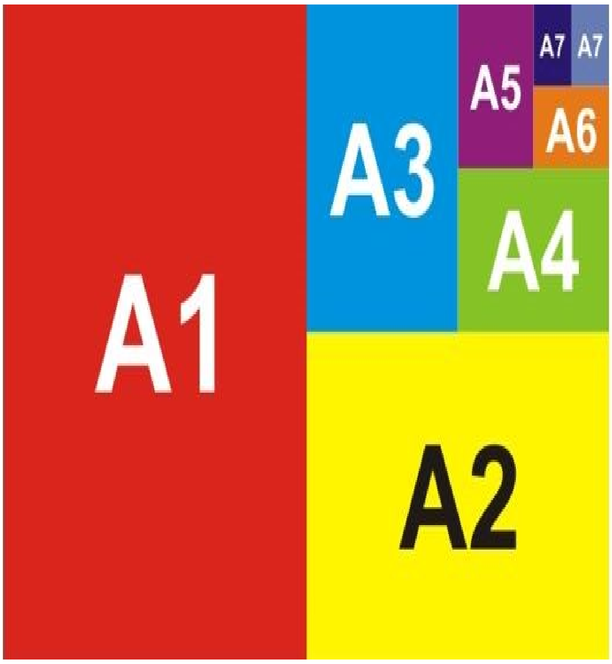
IV. Application

The process of doubling a given square, for example, finds applications in modern day A sized paper. To be precise, an A3 sized paper is double of A4 sized paper and an A4 sized paper is double of A5 sized paper. We start with A0 paper and consider exactly half its size to get A1 paper and continue the same process until we need the desired size. Thus observing the Geometric property of doubling leads to several applications like paper sizes and in certain construction purposes. No wonder, Ancient Indians did paved way for this also.



V. Conclusion

Though, it is not completely clear as to why our ancestors chose to double the altars, say instead of cubing it (as earlier Greeks did), or expanding it to some other ratio, these geometric rules of construction certainly assert that our ancient Indians are clever in Geometry and they used its properties efficiently to satisfy their life needs and also satisfy the need of the supreme power. What else is needed? and who said Geometry is not needed in our life? Learn Sulva Sutras to enjoy Geometry and thereby make yourself happy.

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