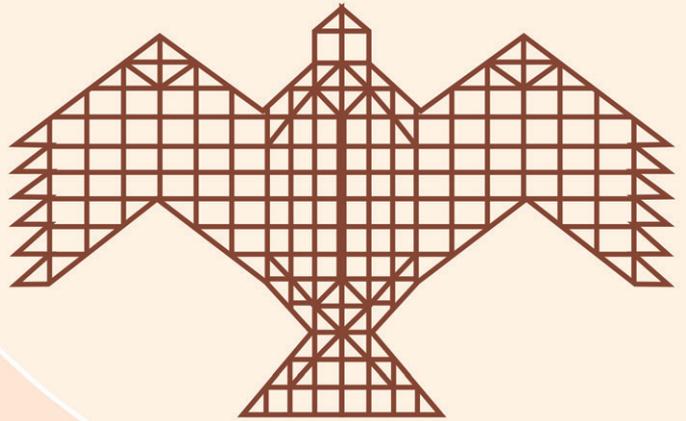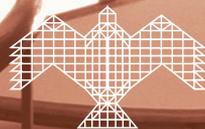Shailaja D. Sharma

Nithin Nagaraj

On the NIAS Logo
by Roddam Narasimha

National Institute of Advanced Studies

Bengaluru, India

ON THE NIAS LOGO
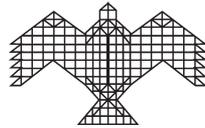## BY RODDAM NARASIMHA

Shailaja D. Sharma
Nithin Nagaraj

School of Humanities

NATIONAL INSTITUTE OF ADVANCED STUDIES

Bengaluru, India

2021

Foreword

I have great pleasure in writing a foreword to this monograph, being the edited, re-arranged and annotated version of the speech delivered by the late Prof. Roddam Narasimha at NIAS on 11th October 2019 on the NIAS logo and its connection with the age-old Śulbasūtrās. The intricate logo that NIAS wears proudly as its badge is a source of endless fascination for all who have seen it and given Prof. Narasimha's deep exploration of the meaning and significance of the logo, we had requested him to speak to the NIAS fraternity on this subject. In retrospect, we see that our request was timely, since we now have with us his testament on the subject, which, for generations of scholars associated with NIAS, will be a reminder of our mission and of all the aspects of our work – its scientific content, its rootedness in our civilizational values and its interdisciplinary nature.

The NIAS logo was born out of the conjunction of great minds. A better fit cannot be thought of for our institution, with its unique mission. I hope that the entire NIAS fraternity will draw inspiration from the rich cultural and scientific information that is encoded in the logo.

Shailesh Nayak
NIAS, Bengaluru
March 31, 2021

Preface

We are honoured to be able to present the speech of the late Prof. Roddam Narasimha on the NIAS logo and the Śulbasūtras.

In editing the speech, we have applied the criterion of minimalism and endeavoured to retain in its entirety the flavour of the spoken word — spoken in the charismatic style of the speaker — in the present text. In re-arranging the material – again, minimally — we have excised some overlaps, combined related parts and incorporated into the relevant sections the important comments made during the Q&A session following the speech. In annotating the speech, alone, have we taken some liberties, and tried to provide as much explanation, reference and cross-citations as we presumed would be welcomed by the readers and approved by the author.

We are grateful to Prof. Shailesh Nayak, Director, NIAS, for entrusting us with the task of making the lore of the NIAS logo, as well as its mathematical, philosophical and epistemological significance, known to the public through this concise publication.

This work has been taken up as a part of the NIAS Mathematical Heritage Initiative, under the aegis of which it is hoped to promote the study and dissemination of the rich mathematical and computational heritage of the Indic civilization. This initiative was conceived during an informal discussion with Prof. Narasimha, after he delivered the 15th Raja Ramanna Lecture on the topic "Algorithms or Axioms? – A View of Indic Mathematics", on 8 January 2020.

Our efforts under this initiative are dedicated to the memory of Prof. Narasimha, who pioneered this work within NIAS and left us a legacy of ideas and ways of working, which shapes our approach to the study of the history of science in India.

<div align="right">

Shailaja D. Sharma
Nithin Nagaraj
NIAS, Bengaluru
March 26, 2021

</div>

On the NIAS Logo

Roddam Narasimha[1]

(Edited, annotated and rearranged by Shailaja D. Sharma and Nithin Nagaraj)

Abstract:

The NIAS logo is an artistic depiction of the geometrical structure of the vedic śyenaciti, one of the specified forms of the platform for vedic sacrifice, which is in the shape of a falcon. The specification of the form of the vedic sacrificial platforms in the śulvasūtras encapsulates the advanced knowledge of Number and Geometry in the vedic period. In particular, a precise rational approximation for $\sqrt{2}$ as well as the Pythagorean theorem are clearly specified in the Baudhāyana śulvasūtra and these are the earliest documented statements on these topics anywhere in the world. The present work draws a connection between the ideas connoted by the NIAS logo and the programme of NIAS as envisioned by its founder, J.R.D. Tata.

Keywords: NIAS logo, *śulvasūtra*, *śyenaciti*, theorem of the hypotenuse, Baudhāyana

---

1   Speech delivered by R. Narasimha, entitled "The NIAS Logo and the *Śulvasūtra*", at an event conceived by Shri V. Siddhartha and held at NIAS on 11 October, 2019. The text of the speech has been edited and slightly rearranged. Explanatory and amplificatory footnotes and additional references have been inserted by the editors.

Introduction

When I came to NIAS in 1997, I noticed the unique logo[2] of NIAS on many of the buildings in the NIAS campus. I then found that the figure was derived from a set of books called the *śulvasūtra*s[3]. The meaning of *śulvasūtra* is as follows: *śulva* is a cord, or a rope or string, and is derived from the root *śulv* which is 'to measure'. That is the important thing — to measure, to create, to mete out and so on. And *sūtra* is a familiar word[4,5], designating rules or instructions, which hold everything together. In this particular case, the reference is to a kind of manual.

The *śulvasūtra* provides a set of rules for measurement using a cord for building the altar (*vedi*), where the (vedic) sacrifice is to be carried out. Therefore, it can be literally translated as a "Manual of the Cord[6]", or a "Handbook of Ritual Geometry". There are two features which dominate the *śulvasūtra*. First, it contains a large number of instructions about the steps for building the required altars. Second, there is a lot of mathematics in it — both geometry and numbers. The *śulvasūtra* is actually a manual, as it is usually translated. It has all the details about how to go about constructing — from selecting the materials to making the tiles of the specific shapes and dimensions that go into the making of the altars such as the one that is depicted in the NIAS logo.

---

2 Shri Balan Nambiar, well-known sculptor and enamellist, was invited by Dr. Raja Ramanna to design a logo for NIAS in 1992/93. In his narration of the sequence of events, Nambiar says that he asked for a week's time to create the logo. He recalled a vedic ritual he had attended in Thrissur district in Kerala in 1976. What fascinated him in the ritual was the use of mathematical principles and precise calculations and measurements. Care was taken that the bricks used for the fire altar were exactly of the sizes calculated as per the vedic injunctions. The bricks were numbered and arranged very systematically layer after layer with appropriate *puja*s and chanting of *mantra*s at each stage. Balan Nambiar constructed the falcon logo based on the design of the vedic altar and showed it to Dr. Raja Ramanna, who presented it to the Trustee Board of which Dr. J.J. Bhabha was the Chairman and it was unanimously passed "without any further discussion". Cf. *The NIAS Logo*, speech by Shri Balan Nambiar, 11 October 2019, NIAS.

3 More commonly written as *śulbasūtra.*

4 The scientific literature of the *vedānga*s was written in *sūtra* or aphoristic style, "a form of expression characterized by great precision, brevity and economy of words, the like of which is not met with in the entire literature of the world" – S.N.Sen & A.K.Bag, *The Sulbasutras*, INSA, New Delhi (1983), p.1.

5 The Vāyupurāṇa provides the following well-known definition of the *sūtra: अल्पाक्षरमसंदिग्धं सारवद्विश्वतोमुखं। अस्तोभमनवद्यं च सूत्रंसूत्रविदोविदुः॥* This means that the *sūtra* is known by the learned to be brief, unambiguous, pithy, universally applicable and free of redundancies.

6 This expression is used, for example, in John D. Barrow, *Pi in the Sky*, Little, Brown and Co. (1992), p. 73.

The cord is for measuring[7], laying out and so on, for the purpose of construction; but it is not strange to us at all, as it is still common in our country. Even now, 3000 years later, there are masons who measure with cords, for constructing a building or a road. It is now beginning to disappear but it is still common.

In order to understand the *śulvasūtra*s, one must see the structure of vedic knowledge. It is well-known that there are four *veda*s, namely, the *Ṛgveda*, *Yajurveda*, *Atharvaveda* and *Sāmaveda,* but there are also *vedāṅga*s. *Vedāṅga*s may be seen as a set of scientific appendices to the *veda*s. In principle, each one of the four *veda*s has some *vedāṅga*s, but the ones that have survived come principally from the *Yajurveda*. There are several *vedāṅga*s even in the *Yajurveda Samhitā* — pertaining to grammar, etymology, astronomy and so on[8]. The *kalpasūtra*s themselves are four, viz. the *śrautasūtra*s, the *śulvasūtra*s, the *gṛhyasūtra*s — which give rules concerning domestic affairs

such as marriage, child-rearing, how to distribute responsibilities and so on, and the *dharmasūtras* — which talk about manners, customs, behavior considered the most appropriate and so on. One can see how much the *veda*s have penetrated into all these subjects which affect our daily lives. Thus, there is a direct connection to the *veda*s in many current practices.

The *śulvasūtra*s, which are our basic object in the present talk, are often taken as part of the *śrauta* literature[9] and they too have a direct connection with vedic knowledge, through these different steps. However the *veda*s themselves hardly ever get quoted or talked about in these works. It is assumed that one knows that it is a *vedāṅga* and that fact determines its scope. There were several *śulvasūtra*s, because there are four *veda*s; but the ones now available are the Baudhāyana and Āpastamba, both from *Kṛṣṇa Yajurveda*, and Kātyāyana and Mānava from *Śukla Yajurveda*[10]. The oldest is the one due to Baudhāyana[11].

---

7   Sen and Bag, *op.cit*. point out that: "among the Egyptians, geometry of surveying was considered to be the science of the rope-stretchers (*harpedonaptae*), who thus appear to be the Egyptian counterpart of the Indian *śulbavids*."

8   The six *vedāṅgas* are *śiksā, kalpa, vyākaraṇa, nirukta, chhandas* and *jyotiṣa*, respectively phonetics, ritual, grammar, etymology, metrics and astronomy.

9   Reference is to *śruti*, i.e. texts (on rituals) related to the *veda*s.

10 The *Kṛṣṇa Yajurveda* and *Śukla Yajurveda* are also sometimes referred to respectively as the Black and the White *Yajurveda*.

11 Baudhāyana's date is placed by Western scholars between 500 and 800 BCE: see Kim Plofker, *Mathematics in India*, Princeton Univ. Press, 2011.

The first Western scholars who made translations of the *śulvasūtra*s and the mathematics in them looked at the algebra and the geometry there and concluded that the date was around 200 BCE. This is the common first Western response to anything which looks very interesting or striking from somewhere else; and one of the things in the *śulvasūtra* (of Baudhāyana) is a theorem which in the West is usually attributed to Pythagoras. For a long time, they could not imagine that this could have been known in India before Pythagoras. More recent research has shown that the theorem has really nothing to do with Pythagoras, although if you say so openly you are likely to be accused of being a "*Hindutva*" extremist. This is now accepted by Western scholars, but somehow in India even now, if somebody says the theorem was known earlier in India, they will probably say, ah, now where does your prejudice come from? But Western scholars agree about it, and it has nothing really to do with "*Hindutva*".

Contents of the śulvasūtra

The *śulvasūtra*s themselves are written in a very business-like tone; the very first sentence[12] says, "The various constructions of sacrificial fires are now given". That first line sets out the objective of the book. Vedic fire altars (*vedī*s) are the main subject of the book. There are two kinds of *vedī*s: *nitya*, which is perpetual and *kāmya* which is usually translated as optional, meaning that it depends on your desire, or where you have a choice. For example, "desiring heaven" comes under the *kāmya* category. It was held that the fire altars should have the characteristics of an animal. It is not clear exactly what the reason for this was. I presume that the principle is that it must have something to do with life, or after-life.

The *śulvasūtra*s describe in astonishing detail the processes to be followed in order to build one of these *vedī*s. The altar represented in the NIAS logo is the *śyenaciti*[13]. *Śyena* is a kind of a falcon and an appropriate choice for those who desire to go to heaven. The falcon is

---

12 Baudhāyana *śulbasūtra {BSS}*, §I.1 i.e. Section 1, line 1: अथेमे अग्निचयाः।

13 There are two categories of falcon-shaped fire altars or *śyenaciti*. The first type has rectilinear (square or rectangular) body, tail and wings. The second set has 'curved' wings and head and spread-out tail. In the latter category, there are two further types of *śyenaciti*, as well as one *citi* each in the form of the *kaṅka* and *alaja* birds.

Śyena is a 'comprehensive term for Falconidae, inclusive of Eagles, Falcons and Hawks', according to: K.N. Dave, Birds in Sanskrit Literature, Motilal Banarsidass, (Revised edition) 2005, p. 199. *Alaja* is the bearded vulture and *kaṅka* is the so-called fishing eagle with sharp talons. All the birds are chosen for their ability to soar high in the sky.

very special bird, and is noted for rising high and flying fast, so *śyenaciti* is the favourite for the people who desire heaven. Here is the translation from the Taittirīya Saṁhitā: "He who desires heaven may construct the falcon shaped altar, for the falcon is the best flyer among the birds. Thus, he (the sacrificer), having become a falcon himself, flies up to the heavenly world." The reference is actually to the female falcon, because it turns out that she has bigger wings than the male[14].
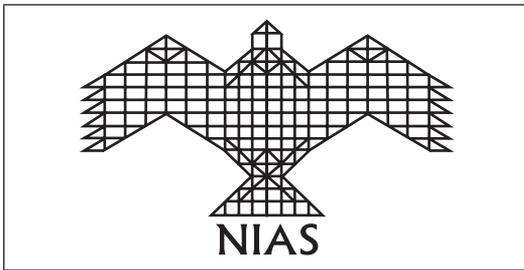

Figure 1: NIAS Logo.

This *śyenaciti* is depicted in the logo of NIAS (see Figure 1).[15] It shows the arrangement of bricks in the form of rectangles, triangles and other polygons. The *śulvasūtra*s give interesting rules about how they are to be combined.[16] There are five layers which make up the altar -- all of them are made from bricks of these shapes, but not of the same size. The bricks in the odd layers, namely, the lowest or the first, the third and the fifth -- are large. The bricks in the second and the fourth layers are small. There are very strict instructions about how the bricks should be made and also how they should be arranged. For example, they have to be so laid that no brick lies on another of the same size and no cleft is formed between the bricks in the upper and lower layers. The bricks should have specified characteristics: for example,

---

14 "As a rule, the female eagle is visibly larger than the male. They are remarkable for the power and stateliness of their flight, which is largely the soaring-in type, i.e. the wings are not flapped but kept outstretched, and the bird appears to float through the air."- Ibid, p. 198.

15 The NIAS logo is an artist's rendition based on the arrangement of bricks in the first of five layers that make up the altar of the type: "falcon shaped fire-altar with curved wings and extended tail" (BSS §11). Such an altar requires 200 bricks of five different shapes in the first layer. The second layer also needs 200 bricks of five different shapes, but requires five additional brick types. There are generally five layers in the altar, odd ones of the first type and even ones of the second. (*See also footnote 30).*

16 Unit conversions are stated at the outset in BSS §1.3. Bag and Sen, op. cit. provide the conversion to modern units as 1 *aṅgula* = ¾ inch (approx.), citing Fleet, J.R., Imaginative Yojanas, J. of the Royal Asiatic Society, p. 229-239, 1912. Using this conversion and taking 16 *aṅgula*s as 1 foot, 1 *puruṣa* = 120 *aṅgula*s = 7.5 ft., i.e., "height of man with lifted arms". Then, total span can be calculated from the brick arrangement as 35.6 ft. or 10.9 m.; area is 7.5 sq. *puruṣa*s, i.e., 421.9 sq. ft. or 39.2 sq. m. Height of altar is "up to the knee" (32 *aṅgula*s or about 1.9 ft in the normal 5-layered construction). Note that all conversions are approximate and intended only to give a sense of the dimensions. The area of the *śyenaciti* is stated to be exactly 7.5 square *puruṣa*s, which is the desired area of such *citi*s, irrespective of shape (see Sen and Bag, p. 181: "A fire altar of size 7½ square *puruṣa*s is the normal construction.") The calculation of the total area is given in BSS §10.4-10.9. Achieving the specified area of the *citi* seems to have been a key requirement of the vedic practice.

they should not be broken or blackened, have scratch marks, etc. Dimensions are given in great detail. The size of the altar is up to the knee. All this shows that they went into a great amount of detail, which, to me, is a sign of good engineering.

I mentioned the theorem of Pythagoras[17]. It is stated in the *śulvasūtra*[18]: the areas of the squares produced separately by the length and breadth of a rectangle together equal the area of the square produced by the diagonal. The *śulvasūtra*s refer to rectangles[19] rather than right-angled triangles here, but it is the same thing, and this is now considered the oldest available statement of the general theorem.

There is no connection between Pythagoras and the theorem. Many people have studied this matter in great detail. In particular, a German scholar spent a lot of time trying to see if there was any connection he could trace between Pythagoras and that theorem and he has been unable to do so. You can read about it in the Stanford Encyclopedia[20] on the internet. Even so, almost every time somebody says something about Pythagoras not being the author, it is immediately criticized in the newspapers the next day[21]. There's no evidence, really, but it is not just an Indian prejudice.

Frits Staal, who had a degree in Sanskrit from Madras and another degree in Sanskrit from England and ended up as a Professor in Berkeley, always called the theorem "Baudhāyana's Theorem"[22] in his books. He never called it after Pythagoras. But in India, we still hesitate to do that much, as we still

---

17 The theorem is nowadays referred to as the "Pythagorean Theorem" rather than "Pythagoras' Theorem" in order to connote subtly the changed view on its authorship.

18 BSS §1.12 दीर्घचतुरश्रस्याक्ष्णया रज्जुः पार्श्वमानी तिर्यग् मानी च यत् पृथग् भूते कुरूतस्तदुभयं करोति ॥ This statement is referred to by modern scholars in India as the भुजाकोटिकर्णन्याय or the "theorem of the sides and diagonal" (of a rectangle) or, briefly, the "theorem of the hypotenuse", or equivalently, "theorem of the diagonal".

19 BSS §1.13 "This is observed in rectangles having sides 3 and 4, 12 and 5, 15 and 8, 7 and 24, 12 and 35, 15 and 36."

20 Stanford Encyclopedia of Philosophy, URL: <https://plato.stanford.edu/entries/pythagoras/>

21 For more context, see: Roddam Narasimha, "The Historic Storm at the Mumbai Science Congress", Guest Editorial, Current Science, Vol. 108, No. 4, 25 Feb 2015 and a newspaper interview on the same subject: URL: <https://bangaloremirror.indiatimes.com/bangalore/others/pythagoras-we-knew-we-fixed-our-noses-too-all-this-is-true-/articleshow/51847359.cms>

22 It may be noted in passing, however, that, within the Indic tradition itself, mathematical and other results are not usually named after individuals. Thus, the reference to the result, in this tradition, is भुजाकोटिकर्णन्याय, as earlier mentioned.

either have doubts or are afraid. Frits Staal and I had somewhat similar tastes in Sanskrit and shared other academic interests and he visited us at NIAS more than once and has lectured here at NIAS on these subjects.

The *śulvasūtra* also gives the calculation of the square root of two[23]. This is the first time that an irrational number has appeared in the world's literature on numbers, in any country or culture. The Greeks did not have such a concept of the irrational; it came much later in Europe. However, in this case, it is implicit in what they do that they understand the irrational nature. For example Baudhāyana gives this approximation[24] for $\sqrt{2}$:

$$\sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3\times4} - \frac{1}{3\times4\times34} \approx 1.4142156$$

The number on the right hand side is correct upto the fifth decimal place. We don't really know how this value was derived, because the author does not state his method; he gives you the results but he does not tell you how he obtained the result. A lot of people have tried to find out how he might have got

the result, or wondered how a result like this, written with a few terms, can be so close to the actual value of $\sqrt{2}$. The expression seems to have a certain structure and several people both abroad and here have tried to see what might be the proof of that relation. Everybody agrees that the proofs are not given in the book but many people think proofs were there in his head and in fact there are three or four ways[25] in which that has been derived from the kind of principles that Baudhāyana might have used.

This is characteristic of Indian work in Mathematics as well as in many other subjects: the proof is for a commentator to present, or some teacher to explain to the student; whereas the *sūtra* itself is very concise. You must remember that these books had to be memorized, therefore, the book should not be longer than absolutely necessary.

Baudhāyana seems to have understood that the expression computed very close to the actual value, but it is not actually the complete accurate result. In order to do

---

23 BSS §2.12: प्रमाणं त्रितीयेन वर्धयेत्तच्चचतुर्थेनात्मचतुस्त्रिंशोनेन। सविशेष:।

24 The qualifier indicating the approximation is सविशेष:

25 One of the derivations, given by Thibaut, G., in his paper "On the Sulbasutra", J. of the Asiatic Society of Bengal, 44, Pt.1, no. 3, 227-75 (1875), and cited by Sen & Bag, is reproduced here: $17^2 - 2 \times 12^2 = 1 \rightarrow$ $\left(17 - \frac{1}{34}\right)^2 \approx 2 \times 12^2 \rightarrow \frac{17 - \frac{1}{34}}{12} \approx \sqrt{2}$. But $17 - \frac{1}{34} = 12 + 4 + 1 - \frac{1}{34}$ and the result follows. "In Baudhayana's selection of units of 12 *aṅgula*=1 *pāda* and 34 *tila* =1 *aṅgula*, Thibaut found justification for the choice of the arbitrary (starting) relation". See Sen & Bag, op.cit., p. 165.

that, he probably was aware that he would have to use more terms. He was aware that it might never be complete, even if he went on[26]. Although they don't give it a special name, the property of irrationality was in the minds of these people. They usually satisfied themselves with the argument that if you have it correct to four figures it is adequate for the purposes of these calculations, or for this application. The same thing happens in geometry too, when they make constructions out of a set of tiles (with dimensions specified upto a level of precision by the choice of units).

I shall go briefly through the contents of the (Baudhāyana) *śulvasūtra*. The text has 21 sections[27]. It starts with the units of measurement: as mentioned earlier, we see a very practical approach, not unlike an engineering textbook. It tells you about the units and so on and goes on to geometrical constructions, such as area-preserving transformations of a square to a rectangle and vice versa. This requires knowledge of irrational numbers or their approximations. There is a section on the diagonal of the rectangle, along with examples of "Pythagorean triples"[28]. There are constructions using circles as well, which in turn assume a suitable approximation for π.

Now let us turn to what is said about the bricks. The instructions specify from what material should they be made, what might be the possible faults, how they should be inspected and so on. The author provides the rules, as for an inspector, to evaluate the quality of the bricks and to reject whatever does not meet the standards.

---

26 The qualifier सविशेष: is suggestive of this.

27 Highlights of the Baudhāyana *śulvasūtra*: §1.1 The various constructions of sacrificial fires; §1.3 Units of measurement; §1.4 Geometrical construction of a square; §1.12 Theorem of the diagonal of a rectangle; §1.13 Examples of "Pythagorean triplets"; §2. Transformation of squares, triangles and circles; §3 Sacrificial ground; §4 Areas of chambers, *vedis*; §5. Enlargement of fire altar; §6. Fire altar possessing characteristics of an animal; §7.1 Injunction on quality of bricks; §8.5 *Śyenaciti*, suitable for one who desires heaven, is like the shadow cast by flying falcon; §9. Another type of *śyenaciti* (square); §10 Another falcon, with curved wings, extended tail; §11. Yet another type of falcon, with curved wings, extended tail; §12 Kite shaped (shaped like *kaṅka* bird) fire altar; §13 Fire altar in the form of an *alaja* bird (bearded vulture); §14 Fire altar in the form of an isosceles triangle (*prauga*); §15 Fire altar in the form of a rhombus (*ubhayata prauga* or with two isosceles triangles); §16 Fire altar in the form of a chariot-wheel (*rathacakra*); §17, 18. Fire altar in the form of a trough (*droṇa*) - rectangular and circular; §19. Funeral pyre (*śmaśānaciti*); §20 Tortoise fire altar (*kūrmaciti*); §21 *Kūrmaciti* with rounded limbs.

28 Triples of positive whole numbers that fit the sides of right-angled triangles. (*See also footnote 19).*

There are several types of *citi* and the construction of each one is described in complete detail. We are particularly interested in the *śyenaciti,* the altar representing the falcon with curved wings and extended tail, which is the one we see in the NIAS logo. There are other types of birds and geometric shapes such as isosceles triangle, rhombus, etc. as well as chariot-wheel, trough, funeral pyre and variations of tortoise (*kūrmaciti*). Thus, there is a large number of distinct fire altars, associated with different sacrificial objectives. The *sūtra*s go through each one in detail[29], describing how many bricks are required, of what shapes, how they should be combined and so on.

Details of the śyenaciti or falcon-shaped altar

Only one half of the *śyenaciti* is shown in Figure 2, but it is quite similar[30] to what we see in the NIAS logo. As far as the head is concerned, there is an alternate, slightly different variant, which is depicted in (b).
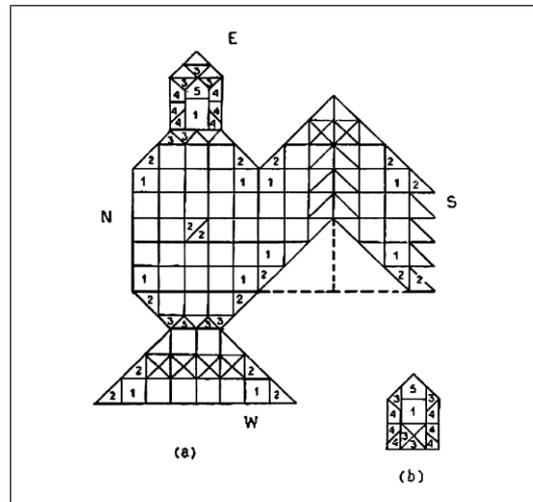

Figure 2: Detailed diagram of *śyenaciti* – falcon with curved wings and extended tail[31]: first layer.

Figure 3 gives the details of the five types of tiles used. You can see square tiles, triangular tiles and others types which are listed[32].

---

29 Instructions are given in each of the *śulbasūtra*s (of Baudhāyana, Āpastamba, Kātyāyana and Mānava) for the different constructions. Each writer presents the instructions in their own way, similar to textbooks written by different authors. See S.N. Sen & A.K. Bag, The Śulbasūtras, INSA, New Delhi, 1983, for a translation of all four, along with detailed commentary. Note, however, that eah *śulbasūtra* is very concise.

30 Note that the NIAS logo is not a replica of the *śyenaciti* and does not preserve its proportions or detailed geometrical structure. Further, some of the details shown in the diagram are not present in the NIAS logo (e.g. head and neck, in the tail and in the corner of the wing).

31 Diagram reproduced with permission from The Śulbasūtras, S.N. Sen & A.K. Bag, INSA, New Delhi, 1983, p.193.

32 One may also note the economy in the design: the tile shapes are all derived from the same basic square tile.
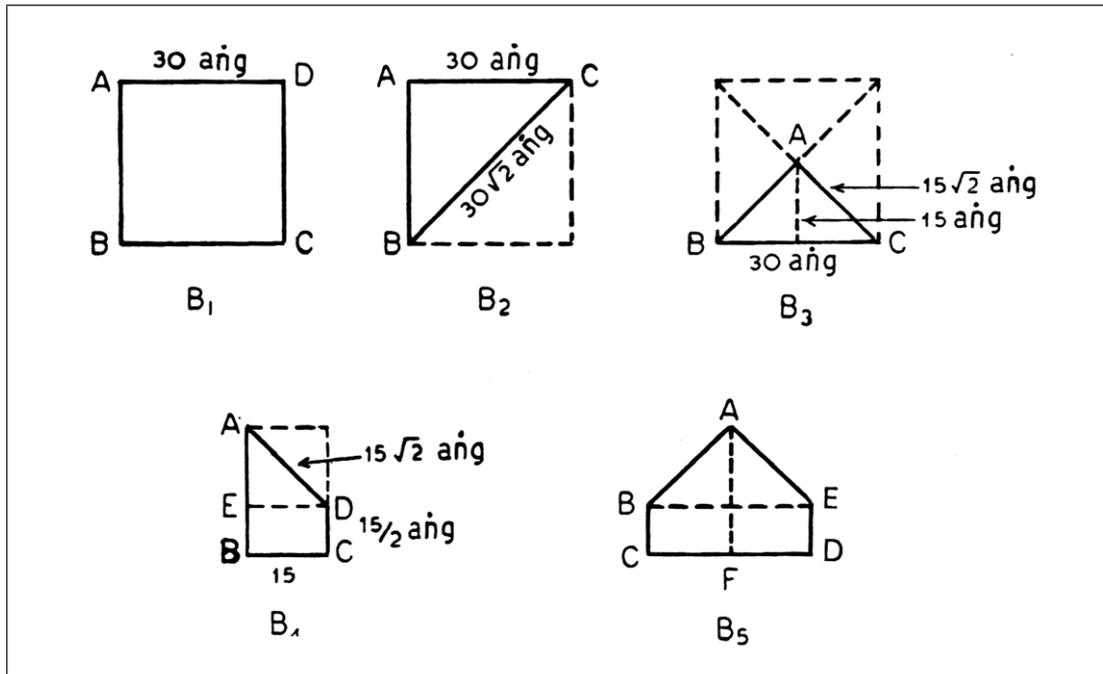
Figure 3: Brick types used in *Śyenaciti*[33].

The five brick types include: i) a square (B_1); ii) an isosceles triangle (B_2) of half the area of the square (B_1); iii) another isosceles triangle (B_3) that is half of B_2; iv) a four-sided brick (B_4) and v) a brick ABCDE (B_5) made up of two B_4 bricks. The square tile has a side of thirty *aṅgula*s (B_1). *Aṅgula* is a word we're familiar with. It is not exactly the same as an inch but it is closely related[34]. In both B_2 and B_3 there is a right-angled isosceles triangle, but of different dimensions. There is the triangle and a little rectangle below it in B_4, and the tile is formed by the rhombus *ABCD*[35].

The entire *citi* can be made with the five shapes depicted above. As mentioned earlier, the rule is that there should be exactly 200 bricks. One can see how many there are: a total of 14 for the head, 46 for the body, 108 for the wings and 32 for the tail and the total is 200. B_4 and B_5 appear only at one place - in the head. It can be seen that the work is thorough.

---

33 Figure reproduced with permission from S.N. Sen & A.K. Bag, INSA, *op. cit.*, p.191.

34 Approx. ¾ of the modern inch.

35 Note that the notation A,B,C,D etc. is not in the *śulvasūtra*.

Part of *citi*	Brick type					Total
	B_1	B_2	B_3	B_4	B_5	
Head	1	-	6	6	1	**14**
Body	30	6	10	-	-	**46**
Wings	30	62	16	-	-	**108**
Tail	8	4	20	-	-	**32**
Total	**69**	**72**	**52**	**6**	**1**	**200**

Table 1[36]**:** Number and types of bricks used in *śyenaciti*.

There is a second level which has smaller bricks and it looks somewhat similar but is not exactly the same. For example, if you look at the head, it is not quite the same as the head of the first level. The second level also has five types of bricks, but these are used in a different way and the difference is clear especially in the head.

The triangles are of the same kind, but their placement is more complex. Tiles in the second layer may not rest exactly on the tiles of the previous layer or share an edge with them. Perhaps they must be closed so that (sacrificial) materials do not leak through.

Figure 5 shows *citi*s that are designed like a chariot wheel and a tortoise – the latter uses six types of bricks but the B_5 brick is two B_4 bricks joined at the longest side. At the very

top there is B_6 and below it on one side B_5 and so on.

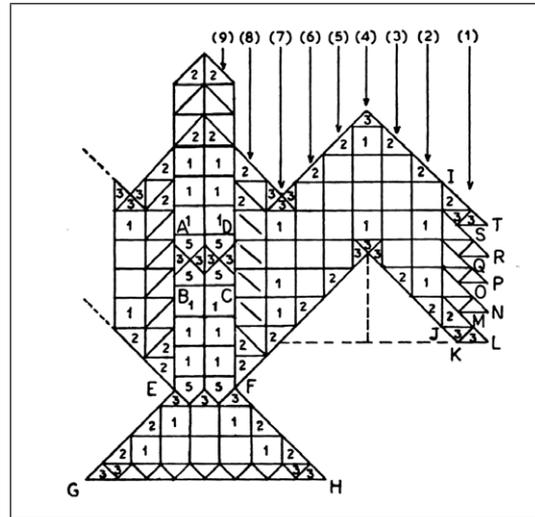**Figure 4**[37]**:** Arrangement of bricks in the second layer.

When I started looking at the *śulvasūtra*s a long time back, I wondered about the level of detail. You see, as far as instructions are concerned, it is very detailed and the tile sizes, for example, are given to you in *aṅgula*s and fractions of *aṅgula*s. It is very precise and akin to engineering instructions. But why did they put so many of these detailed instructions? They do not state the reason. It is a situation where you don't have a design document, but you have the manual for effectively implementing the

---

36 Table reproduced with permission from S.N. Sen & A.K. Bag, INSA, *op. cit.*, p. 194.

37 Figure reproduced with permission from S.N. Sen & A.K. Bag, INSA, *op. cit.*, p. 194.

38 Figures reproduced with permission from S.N. Sen & A.K. Bag, INSA, *op. cit.*, pp. 218, 229.
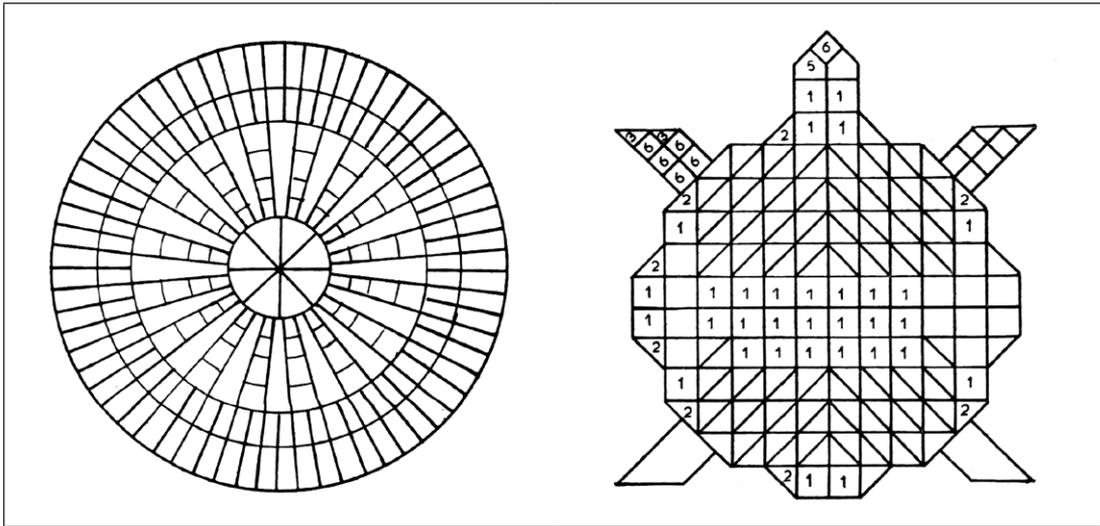
Figure 5[38]: Arrangement of bricks in first layer of *rathacakraciti* and *kūrmaciti.*

design. The ideas that go into it are clear from the sophisticated statements that are made. I have already stated the example of computing the value of $\sqrt{2}$. It is not a simple thing to do, but they very nearly got the right answer.

SOME SCHOLARLY OPINIONS

Quite a few people abroad have looked at this book and in fact it is interesting that it might have been studied more abroad than in India. In India, Sen and Bag[39] made a book about the *śulvasūtra*s and it gives a good translation, which is very useful and I have taken much of my information from there. It goes through all of the *samhitā*s and the four *śulvasūtra*s. Recent opinion in the West is no longer the kind that it was in the last century. For example, here is a view presented in the History of Mathematics Archive of the University of St.Andrews[40]: "Contrary to Euro-centric beliefs, scholars in India have been around for over a period of 4500 years, and that is going quite far back. We can be quite sure about 3500 years, and of course by 4000, there was the Indus Valley Civilization. Thus, scholars in India contributed to some of the greatest mathematical achievements in the history

---

39 S.N. Sen & A.K. Bag, *op. cit*.

40 Ian G. Pearce, University of St. Andrews' History of Mathematics Archive, URL: <https://mathshistory.st-andrews.ac.uk/Projects/Pearce/>

of the subject, and it was the first time that this was being done. This kind of Geometry, and this sort of Algebra and these kinds of numerical methods had not been known. From the earliest numeric civilization of the Indus Valley through to 15th-17th century, Indian scholars conversant in Arithmetic and Algebra, Trigonometry, Geometry and latterly differential calculus, led the world in the field of mathematics. There has been the creation and refinement of the decimal place value system of numeration including zero which all of us know, without which higher mathematics wouldn't have been possible. The Eurocentric ideal is an injustice and, in some cases, a complete fabrication."

This truth is now being realized and people in the West are willing to admit it, but the *śulvasūtra*s are not commonly known. People do know about Āryabhaṭa and Bhāskara and the interesting problems of Līlāvati, but they do not know about the *śulvasūtra*s. The *śulvasūtra*s are perhaps the oldest books on mathematics, or intended to be mathematics, or a kind of applied mathematics. In this particular case, the mathematics was applied to constructing those *citi*s – but, at the same time, it gave birth to a kind of mathematics to which we can relate three thousand years later. And that is a truly remarkable achievement.

Other foreign opinions are similar, for example, the scholar A. Michaels[41] says this about Vedic geometry in his thesis work: "Vedic geometry, though non-axiomatic in character, is provable and indeed proof is implicit in several constructions prescribed in the *śulvasūtra*s, (which are) rich in mathematical content." What he means is that the theorems that they are stating in the *śulvasūtra*s are correct and have been known in Geometry. The *śulvasūtra*s are rich in mathematical content and the results are provable. Later on, not through Pythagoras, but about 200 years later, Euclid did something about this sort of thing.

Not only in the *śulvasūtra*s, but in general in Indian texts, the proofs don't appear alongside the results. If you wanted the proofs, or the arguments, you have to go and hear the commentators rather than the original authors. So I would say that there must have been some kind of argumentation which led to those results, but the details of those arguments are not easy to find out. I think that is partly because there were many results which were already known before writing became well-established. I don't think there was even a script at that time and people had to memorize things, which is something which we have inherited -- we now mug up things even when it may not

---

41 Axel Michaels, Beweisverfahren in der vedischen Sakralgeometrie: Ein Beitrag zur Entstehungsgeschichte von Wissenschaft, (Alt. und new-Indische Studien, 20) xiv+209 pp. Wiesbaden, Franz Steiner Verlag, 1978.

be necessary! But in those times I think it was actually necessary; it was for the *guru*s and the commentators to explain exactly what the author of the original book had in mind.

Thus, the *śulvasūtra*s had an ingenious way of handling conversions in Geometry and conversions in Numbers. There is a relation between the two and they used those relations to build those *citi*s.

CONCLUSION

I have no doubt at all that the *śulvasūtra*s constitute an extraordinary set of books in the history not only of India, but of mankind, because there is no earlier book that comes anywhere close in terms of the results stated. Many of the concepts and views became part of the subject, centuries and sometimes millennia later.

Another interesting fact is that these mathematical works are directly connected with the *veda*s. This is the other side to it. The *veda*s themselves are not mentioned in the books but the connection with the *veda*s, through the *vedāṅga* literature and its sub-components mentioned earlier, is very clear. It reflects vedic philosophy in some sense and therefore it has a connection with vedic thinking in this country. It has a feeling for art, as well. They decided that if somebody had to go to heaven, it would be via something that was beautiful and appropriate and that's

how they chose the falcon. This bird flies fast, casting a shadow. They designed the *citi* in terms of mathematical objects, by looking at the shadow of the falcon.

The *sūtra*s describe, create and use mathematics including geometry, arithmetic and numbers. It is certainly the oldest Indian book on mathematics available; it is the oldest book which states the theorem of the hypotenuse. Its mathematics is applied to meticulously create designs for sacred fire altars with tiles of prescribed shapes and sizes. The books provide criteria for the quality of the bricks, as for quality inspection. Engineering instructions are provided for making the bricks as well as the *citi*s and all the dimensions are given very precisely, as also the number of tiles of various shapes, pertaining to different parts and layers of each type of *citi*.

So, to conclude I would say: with its roots in vedic philosophy, its art in making the altars that capture the spirit of the falcon, its mathematics in giving details of the shape and size of the altar, its meticulous instructions on how bricks should be made and of what material, how the layers should vary in size so that gaps and interstices are ruled out, in its effort to help the soul of a person who desires to go to heaven -- with these and more, this book is at one and the same time extraordinary in terms of its mathematical and engineering merits and also amazing in its connection with the *veda*s. This is

not the kind of vedic mathematics you see in typical books which prescribe ways to solve certain equations, etc. Instead, it has a direct philosophical link. The problems being solved are inspired by the *veda*s: they treat of a variety of human desires, skills, philosophies, art, mathematics, engineering and so on.

Thus, I believe that the *śyenaciti* is a very appropriate logo for NIAS. One thing I found when I came here and looked at the original papers about the principles behind NIAS and the committee that reported to Mr. J.R.D. Tata while he was thinking of this institution was the following: there is no branch of knowledge which will not be considered at this Institute. Of course, it is a relatively small Institute and this doesn't mean that it is going to consider everything; but if there is someone who has something interesting to say from a different branch of knowledge, we will not say that it is not in our scope, or not our concern. If there is something good, it is our concern no matter where the knowledge comes from.
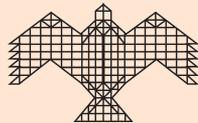
Acknowledgements

Document control sheet

1. **Document No. and Year** : NIAS/HUM/MHI/U/SP/08/2021

2. **Title** : On the NIAS Logo

3. **Type of Document** : Special Publicaiton

4. **No. of Pages and Figures** : 15 + iv pages, 1 table and 5 figures

5. **No. of References** : 41

6. **Authors** : Roddam Narasimha
(Edited, annotated and rearranged by
Shailaja D. Sharma and Nithin Nagaraj)

7. **Originating school** : School of Humanities

8. **Programme** : Mathematical Heritage Initiative

9. **Collaboration** : Nil

10. **Sponsoring Agency** : Nil

11. **Abstract:**

The NIAS logo is an artistic depiction of the geometrical structure of the vedic *śyenaciti*, one of the specified forms of the platform for vedic sacrifice, which is in the shape of a falcon. The specification of the form of the vedic sacrificial platforms in the *śulvasūtra*s encapsulates the advanced knowledge of Number and Geometry in the vedic period. In particular, a precise rational approximation for $\sqrt{2}$ as well as the Pythagorean theorem are clearly specified in the Baudhāyana *śulvasūtra* and these are the earliest documented statements on these topics anywhere in the world. The speech of Roddam Narasimha draws a connection between the ideas connoted by the NIAS logo and the programme of NIAS as envisioned by its founder, J.R.D. Tata.

12. **Keywords:**

NIAS logo, *śulvasūtra, śyenaciti*, theorem of the hypotenuse, Baudhāyana

13. **Security Classification** : Unrestricted

National Institute of Advanced Studies

The National Institute of Advanced Studies (NIAS) was conceived and established in 1988 by the vision and initiative of the late Shri. J.R.D. Tata primarily to nurture a broad base of scholars, managers and leaders to address complex and important challenges faced by society through interdisciplinary approaches. The Institute also engages in advanced multidisciplinary research in the areas of humanities, social sciences, natural sciences and engineering, as well as conflict and security studies.

School of Humanities

National Institute of Advanced Studies
Bengaluru, India