MS-12

GEOMETRY OF MAHĀVEDĪ IN ŚULBASŪTRĀS*

Introduction

Vedas and Vedāngās

Indians have deeply embedded esteem and superlative faith in Vedas and associated literature. **वेदोऽखिलो धर्ममूलम्** । or **सर्वज्ञानमयो हि सः** । are some of the remarks by sages and scholars about the four Vedas. Not only this Bruhadāraṇyaka Upniśada says **अस्य महतो भूतस्य निश्वसितमेतद् यद् ऋग्वेदो यजुर्वेदः सामवेदो ऽथर्वांगिरसः** । i.e. these four Vedas are expiration of the supreme soul.

This Vedic literature mainly includes Samhitās, Brāhmaṇas, Araṇyakās and Upaniśadās. Subject wise this literature is divided into two parts Karmakāṇḍa and Jnyānkaṇḍa i.e. Rites, observances and Knowledge.

The study of Vedāngās as they are called is condition presidency in understanding perfect and flawless meaning of the Vedas. Śikšā, Kalpa, Vyākaraṇa, Nirukta, Chanda, and Jyotiša are the six limbs of the Vedapuruša all written in aphoristic style.

Kalpasūtrās:

Kalpasūtrās and Jyotiša are of paramount importance to understand Vedic rituals. It is said that

कल्पन्ते - समर्थ्यंते यज्ञयागादि प्रयोगाः यत्र इति कल्पः ।

i.e. the scripts in which rites and rituals regarding Yajnās and Yāgās are described are called Kalpasūtrās.

This Kalpasūtra connected to each Vedic Samhitā is further sub-divided into three parts. Śrautasūtra, Dharmasūtra and Gṛhyasūtra. Some scholars consider Śulbasūtra as the forth part while others accept it as the part of Śrautasūtra. Today 13 Śrautasūtrās are available. They are Śānkhāyana and Āśvalāyana Śrautasūtrās of Ṛgveda samhitā; Kātyāyana Śrautasūtrā of Śukla Yajurveda samhitā; Baudhāyana, Āpastambha, Hiraṇyakeśī, Bhāradvāja, Mānava and Vaikhāsana attached to Kṛśṇa Yajurveda samhitā; Maśaka, Lātyāyana, and Dākšāyaṇa attached to Sāmaveda samhitā; and Vaitāna Śrautasūtrā of Atharvaveda samhitā.[1]

Śulbasūtrās:

One would except as many number of Śrautasūtrās equal to samhitās but that is not the case. Similarly Śulbasūtrās available today are much lesser in number than number of

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Śrautasūtrās and samhitās. No Śulbasūtra attached to Ṛgaveda and Atharvaveda samhitā is available today. Only one Śulbasūtra namely Maśaka attached to Sāmaveda samhitā is being referred. One Kātyāyana Śulbasūtra attached to Śrautasūtra of same name of Śukla-Yajurveda Samhitā is available. Four Śulbasūtrās namely Baudhāyana, Āpastambha, Vādhūla, and Hiraṇyakeśī of Taitīrīya Samhitā; two Śulbasūtrās, Mānava and Varāha of Maitrayaṇi Samhitā and one Laugakśī Śulbasūtra of Kāṭhaka kāpiṣṭhala Samhitā all three Samhitās attached to Kṛśṇa Yajurveda are found mentioned.[2]

Out of these nine Śulbasūtrās scholars consider four very important. They are (1) Baudhāyana Śulbasūtra [BSS](2) Āpastambha Śulbasūtra [ASS](3) Kātyāyana Śulbasūtra [KSS] (4) Mānava Śulbasūtra [MSS].

These Śulbasūtrās are not only different in number of verses but also in subject matter. BSS contains 323 verses distributed over 21 chapters; ASS 202 verses, 21 chapters; KSS 67 verses, 6 chapters and MSS 233 verses, 16 chapters.[3]

The very purpose of the Śulbasūtrās is to meet constructional requirements of performing Yajnās and Yāgās. In this connection 17 types of Vedīs (Altars) are found discussed along with their units. Various types of instruments and 16 types of bricks of different shapes and dimensions were used for construction of following Vedīs.[4]

Name of Vedi	Horizontal section
Āhavaniya	Square.
Gārhapatya	Circle or square.
Dakśināgni	Semi circle.
Mahāvedī	Isosceles trapezium.
Sautrāmaṇi Vedī	Isosceles trapezium.
Paitṛki Vedī	Isosceles trapezium.
Prāgvamśa	Rectangle.
Caturasraśyenacit	Bird with square body.
Vakrapakśa vyastapuccha śyena	Bird with bent wings and outspread tail.
Kankacit	Bird.
Alajacit	Bird.
Prauga	Triangle.
Ubhayata Prauga	Rhombus.
Rathackracit	Circle.
Drauṇacit	Trough.
Śmaśanācit	Isosceles trapezium.
Kūrmacit	Tortoise.

Mathematical knowledge in Sulbasūtrās

Following geometrical principles, theorems, constructions, and transformations are found, either unambiguously discussed or can be inferred, in Śulbasūtrās.

Geometrical Constructions:

(1) To draw a line perpendicular to given line or perpendicular bisector.[5]
(2) Construction of all types of triangles.[6]
(3) Construction of Rectangle and rhombus.[7]
(4) Construction of square.[8]
(5) Construction of trapezium.[9]
(6) Construction of circle.
(7) Construction of square equal to sum of two squares.[10]
(8) Construction of square equal to difference of two squares.[11]
(9) Construction for combination of two equal squares.[12]
(10) Construction for enlargement of square.[13]
(11) To divide a line segment into any number of equal parts.
(12) To divide a circle into number of parts by drawing the diameters.[14]

Geometrical Transformations:

Following transformations are explicitly discussed in the Śulbasūtrās.

(1) Transformation of triangle into rectangle or square.[15]
(2) Transformation of rectangle or square into triangle.[16]
(3) Transformation of rectangle into square.[17]
(4) Transformation of square into rectangle.[18]
(5) Transformation of rectangle or square into trapezium.[19]
(6) Transformation of trapezium into square or rectangle.[20]
(7) Transformation of rectangle or square into rhombus.[21]
(8) Transformation of rhombus into square or rectangle.[22]
(9) Transformation of square into circle.[23]
(10) Transformation of circle into square.[24]

Number 3,4,9,and 10 are discussed by majority of Śūlbasūtrās.

Form the list of transformations, constructions and shape of Vedīs it is clear beyond doubt that śulbavid definitely had knowledge of basic properties of plane figures, similarity of triangles, areas of plane figures[25] and volumes of different shapes etc. We enlist some of the propositions without the knowledge of which śulbavid could

to one another.

(11) The perpendicular bisector of the segment is locus of equidistant points from end points of segments.

(12) The tangent of the circle is perpendicular to radius at the point of contact etc.

(13) The circle is locus of points at a constant distance from fixed point.

(14) The area of the isosceles triangle is equal to half the area of the rectangle with sides equal to base and altitude of the triangle.

(15) The figure formed by joining the midpoints of the square is itself a square with half of the area of Original Square.

(16) The corresponding sides of similar figures are proportional.

(17) The areas of similar figures are proportional to square of their sides.

Geometry of Mahāvedī:

Now we discuss geometry of one of the Vedīs discussed in Śulbasūtrās called Mahāvedī, which is simplest among all the vedīs, on following counts. Of Course structure of Mahāvedī is discussed in earlier scripts like Śatapatha Brāhmaṇa and Taittirīya samhitā.

Dimensions of Mahāvedī

BSS says[30] **त्रिंशत्पदानि प्रक्रमा वा पश्चात्तिरश्ची भवति षट्त्रिंशत्प्राची चतुर्विंशतिः पुरस्तात्तिरश्चीति महावेदेर्विज्ञायते। मानयोगस्तस्या व्याख्यातः।**

i.e. unit of dimensions is pada or prakrama. The western side (base) of Mahāvedī measures 30 units, prāchi (altitude or east west line) 36 units, and eastern side (face) 24 units.

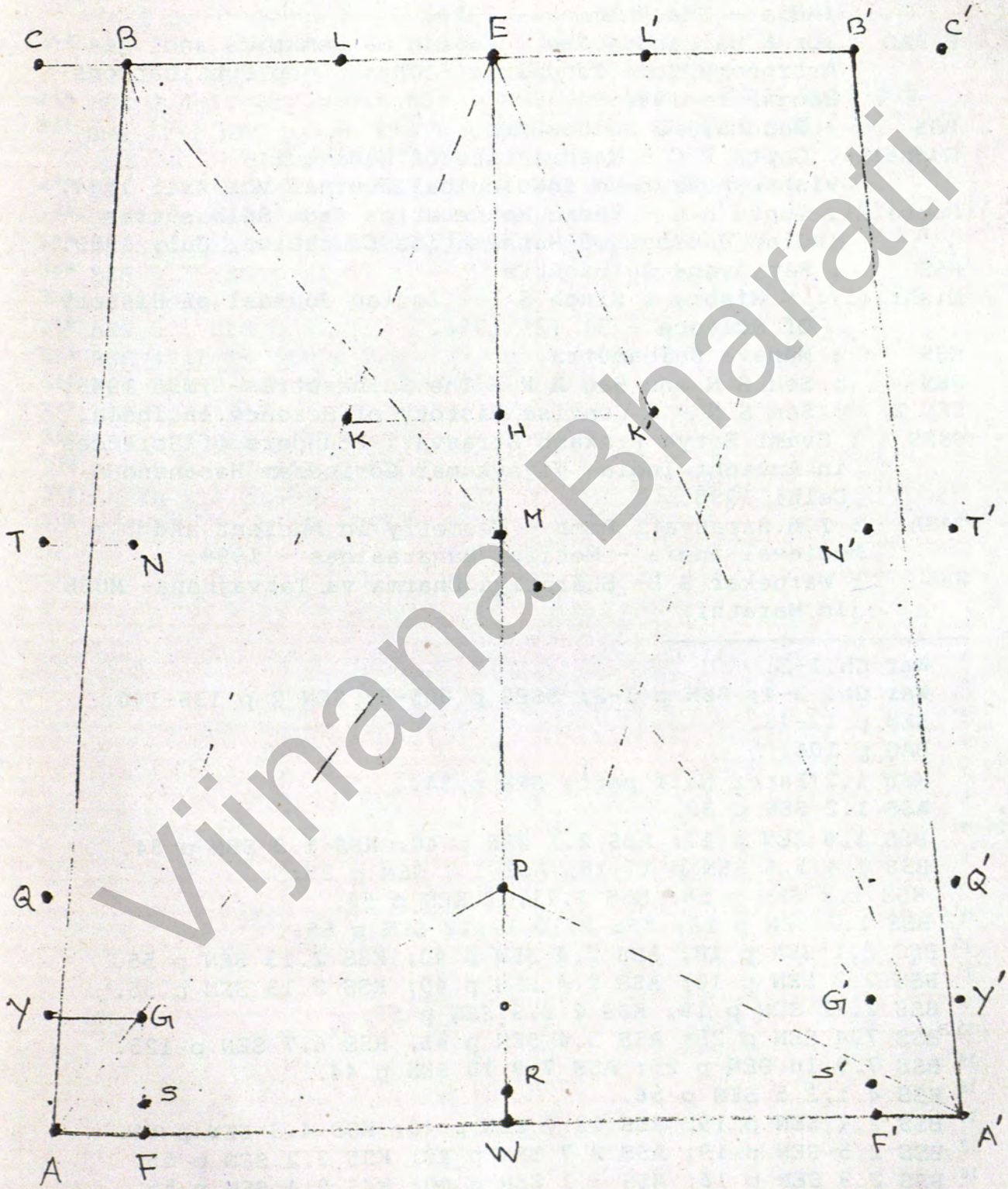
Same measurements are given earlier in Śatapatha Brāhmaṇa and Taittirīya samhitā[31] by name Mahāvedī and later in ASS by name Saumiki Vedī[32]. The phrase "Vijnāyate" here and "Abhyupdiśanti", "iti uktamin" etc at many places in Śulbasūtrās indicates that śulbakārās are quoting what already been said by predecessors. Thus shape of Mahāvedī is isosceles trapezium as shown in figure [1].

Method of Construction of Mahāvedī

The method of construction with the use of ekādaśiṇi Vedī[33] is described in BSS while ASS gives two methods namely ekarajjuvidhi and dvirajjuvidhi[34]. Śatapatha Brāhmaṇa

Fig [1]

1 cm = 2 Units



Following abbreviations are used for writing references.

ASS : Āpastambha Śūlbasūtra.
BAG :Bag A K - Mathematics in Ancient and Medieval India - Chaukhambha - 1979.
B RAO :Dr S Balcandra Rao - Indian mathematics and Astronomy,Some Landmarks - Jnana Deep Publications-Bangalore-1994.
BSS : Baudhāyana Śūlbasūtra.
Gupta(1): Gupta R C - Mathematics of Mahavedi - Vishveshvaranand Indological Journal vol xxii 1984.
Gupta(2): Gupta R C - Vedic Mathematics from Śulbasūtrās - Indian Journal of Mathematics Education, July 1989.
KSS : Kātyāyana Śūlbasūtra.
Mishra(1): V Mishra & Singh S L - Indian Journal of History Of Science - 31 (2) 1996.
MSS : Mānava Śulbasūtra.
SEN : Sen S N and Bag A K - The Śulbasūtrās- INSA 1963.
SEN 2 : Sen S N - A Concise History of Science in India.
SSPS : Svami Satya Prakash Sarasvati-Founders of Sciences in Ancient India- Vijaykumar Govindram Hasanand - Delhi 1995.
TASA : T.A.Sarasvati Amma - Geometry in Ancient and Medieval India - Motilal Banarasidas - 1999.
War : Warnekar S B- Bhāratīya Dharma va Tatvajnāna- MUBB (In Marathi)

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1 War Ch.1-2.
2 War Ch. 3-4; SEN p 1-2; SSPS p 605-8; SEN 2 p 138-140.
3 SEN p 17-73.
4 BAG p 106.
5 KSS 1.2(Later half part) SEN p 54.
6 ASS 1.2 SEN p 39.
7 BSS 1.6 SEN p 17; ASS 2.1 SEN p 40; KSS 1.3 SEN p 54.
8 BSS 1.4,5,6 SEN p 17-18; ASS 1.7 SEN p 39; KSS 1.3 SEN p 54; MSS 1.11,12 SEN p 58.
9 BSS 1.7 SEN p 18; KSS 2.10,11,12 SEN p 55.
10 BSS 2.1 SEN p 18; ASS 2.4 SEN p 40; KSS 2.13 SEN p 55.
11 BSS 2.2 SEN p 18; ASS 2.4 SEN p 40; KSS 2.13 SEN p 55.
12 BSS 2.12 SEN p 19; KSS 2.8,9 SEN p 55.
13 BSS 7.4 SEN p 25; ASS 3.4 SEN p 41; KSS 6.7 SEN p 125.
14 BSS 7.9.10 SEN p 25; ASS 7.9,10 SEN p 44.
15 KSS 4.1,2,5 SEN p 56.
16 BSS 2.7 SEN p 19; ASS 12.7 SEN p 40; KSS 4.3 SEN p 56.
17 BSS 2.5 SEN p 19; ASS 2.7 SEN p 40; KSS 3.2 SEN p 55.
18 BSS 2.3 SEN p 18; ASS 3.1 SEN p 40; KSS 3.4 SEN p 55.

19* BSS 2.6 SEN p 19; ASS 12.4 SEN p 47; KSS 3.2 SEN p 55.
20* ASS 5.7 SEN p 42.
21* BSS 2.8 SEN p 19; ASS 12.8 SEN p 48; KSS 4.4 SEN p 56.
22* ASS 5.7 SEN p 42.
23* BSS 2.9 SEN p 19; ASS 3.2 SEN p 40;
KSS 3.11 SEN p 56; MSS 1.8 (a) SEN p 58.
24* BSS 2.10,11 SEN p 19; ASS 3.3 SEN p 41;
KSS 3.12 SEN p 56; MSS 1.8 (b) SEN p 58.
25* ASS 3.4-10 SEN p 41; KSS 3.5-10 SEN p 55; TASA 2.14 p 51
26* BSS 1.12 SEN p 18; ASS 1.4 SEN p 39; KSS 2.7 SEN p 55
MSS 10.10 SEN p 65; TASA: 2.5 p 16.
27* BSS 1.13 SEN p 18; MSS 11.17 SEN p 67; TASA 2.5 p 16.
28* SEN 2 p 147 - 148.
29* SSPS p 621-630; TASA 2.12,13 p 46-48; RAO 1.4 p 14.
30* BSS 4.3 SEN p 21.
31* SSPS p 611-16.
32* ASS 5.1 SEN p 42.
33* BSS 4.12-14 SEN p 22.
34* ASS 5.1-2 SEN p 42.
35* SSPS p 616-7.
36* ASS 5.7 SEN p 42
37* ASS 5.2-5.7 SEN p 42.
38* GUPTA (1) p 5-9.
39* MISHRA (1) p 161-165.