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SCIENTIFIC APPROACHES OF ANCIENT INDIAN RACES

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ABSTRACT

We have reached at the present configuration of our structure through a lot of revolution. Similarly our cultural development had to assume different types of knowledge from the Nature and human brains had segregated it by intelligence gained time to time. In this paper the ways of cultural development have been tried to be estimated on mathematical view point to terminate towards the Indian context.

Key Words: Aryāns, Drāviḍiāns, Sulba, Rajju, Veda

Text

Geologists sub-divided the ages of the earth with respect to development of life as (House, 1968):

- Azoic*: When there was no life on the earth.
- Palaeozoic*: When life first appeared in the form of *invertebrates* such as sea-weeds, sponges, jelly-fish and later fish, reptiles, birds with gigantic trees and forests which ultimately transformed into coal by different disasters.
- Mesozoic*: Middle life.
- Cenozoic*: Recent life during which different types of mammals evolved and of them best mammal is man.

Another form of division in details is:

Era	Years ago	Period	Characterized by
Archæozoic ¹	5,000,000,000 – 1,500,000,000	Precambrian	Earth's crust formed and unicellular organisms.
Proterozoic	1,500,000,000 – 600,000,000	-----	Bacteria, algae, fungi, primitive multicellular organisms.
Palaeozoic	600,000,000 – 500,000,000	Cambrian	Marine invertebrates.
	500,000,000 – 440,000,000	Ordovician	Conodonts, ostracods, algae, sea-weeds.
	440,000,000 – 400,000,000	Silurian	Air-breathing animals.
	400,000,000 – 350,000,000	Devonian	Dominance of fishes, advent of amphibians and ammonites.
	350,000,000 – 300,000,000	Mississippian	Carboniferous ²
	300,000,000 – 270,000,000	Pennsylvanian	
	270,000,000 – 220,000,000	Permian	
Mesozoic	220,000,000 – 180,000,000	Triassic	Volcanic activity, marine reptiles, dinosaurs.
	180,000,000 – 135,000,000	Jurassic	Dinosaurs, conifers.
	135,000,000 – 70,000,000	Cretaceous	Extinction of giant reptiles, advent of modern insects, flowering plants.
Cenozoic	70,000,000 – 60,000,000	Palaeogene	Palaeocene: Advent of birds, mammals.
	60,000,000 – 40,000,000		Eocene: Presence of modern mammals.
	40,000,000 – 25,000,000		Oligocene: Sober-toothed cats.
	25,000,000 – 10,000,000		Miocene: Grazing mammals.
	10,000,000 – 1,000,000	Neocene	Pliocene: Growth of mountains, increase in size and number of mammals, gradual cooling of climates.
	1,000,000 – 10,000	Quaternary	Pleistocene: Widespread glacial ice.
	10,000 – present	Recent	Development of man.

¹Archæo from Greek means *primitive* + Greek

²It indicates coal producing period.

³It is early part of Cenozoic era.

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According to archaeological discoveries we can divide the races of primitive man in *Palaeolithic*⁴ age i.e. Old Stone Age and *Neolithic*⁵ age i.e. New Stone Age.

About 2 million years ago there existed a creature looked like MAN named as *Australopithecus*⁶. But as per Archaeologists ancestors of modern man were *Neanderthal*⁷ man. They were existed in the area of Europe and Western & Central Asia for very long period from 300000 - 50000 BCE. They were biologically marked as *Pithecanthropus*⁸. Of course it has been identified that apelike man was in the beginning Quaternary period and order of classifications and existence periodswere considered as (a) *Pithecanthropus*⁹ (Java), (b) *Sinanthropus*¹⁰ (China), (c) *Heidelberg man*¹¹ (Germany).

Race types classified with reference of two main standards. These are (Nesturkh, 1984):

1. The *Cephalic Index* / *Cranial Index* i.e. the proportion of the maximum breadth¹² of the skull to its maximum length¹³. The *dolichocephalic* / *dolichocranic* begins with the index being 75% and below whereas the higher index points to the *brachycephalic* / *brachycranial* type.

Index		Scientific Term	Appearance	Structure	Found in
Male	Female				
< 75.9%	< 75%	Dolichocephalic / Dolichocranic	Long-headed	Elliptical or Ellipsoid	Australians aborigines & Native South Africans
76% - 81%	75% - 83%	Mesaticephalic / Mesocephalic / Mesocranic	Medium-headed	Oval	Europeans & Chinese
> 81.1%	> 83%	Brachycephalic / Brachycranial	Short-headed	Pentagonal	Mongolians & Āndāmān Islanders

2. The *Nasal Index*¹⁴ is the proportion of the breadth¹⁵ of the nose to its height¹⁶. Narrow-nosed¹⁷ types show index to be below 70%, medium nose¹⁸ and broad-nosed¹⁹ types show to be 85% - 100%.

3. For Index, formula is = $\text{Breadth} \times 100 \div \text{Length or Height}$.

⁴Palaois = old, lithos = stone

⁵Neo = new, lithos = stone

⁶They were called *Australopithecine*, a primitive of extinct genus of Pleistocenemainly found in South Africa [Greek: *austrāl* – Southern & *pīthēcus* – Ape].

⁷The name was given after Neanderthal Valley of Germany, near Düsseldorf, where evidence of such man was first found.

⁸It indicated primitive man group and were known as member of extinct genus apelike man.

⁹It is *Pithecanthropus erectus* and was of the Pleistocene [Greek: *pleīsto(s)* – much, *koinós* – recent] {Early part of Quaternary or one part of Neocene period} epoch of Java [Greek: *pīthēk(os)* – ape & *ánthrōpus* – man].

¹⁰*Sino* – China & *ánthrōpus* – man: Actual name of this race is *Sinanthropus Pekinensis* fossil of man was first found in a cave of Peking, China.

¹¹The primitive man of the early Pleistocene age reconstructed from a human lower jaw near Heidelberg, Germany.

¹²measured above the ears

¹³measured from the *glabella* to the posterior *occiput*

¹⁴ $\text{Nasal Index} = \frac{\text{Nasal breadth}}{\text{Nasal height}} \times 100 = \frac{\text{Inter Alar Distance (IAD)}}{\text{Upper facial height (UFH)}} \times 100$. The measurements were taken while subjects were sitting on chair or bench in a relaxed condition and head in the Frankfurt position.

¹⁵Nasal breadth is inter alar distance (IAD) measured at right angle to the nasal height from alar to alar.

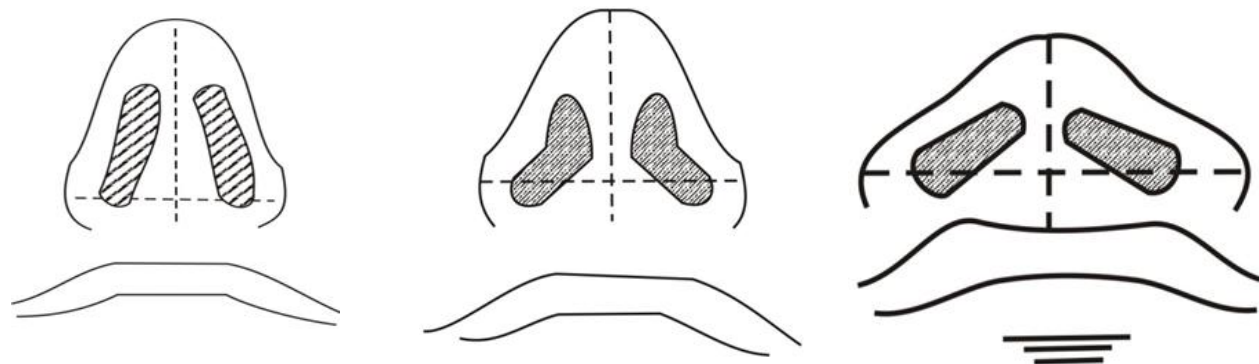
¹⁶Nasal height is Upper Facial Height (UFH) was measured from nasion (the point where inter-nasal suture meets the frontal bone) to nasospinale (mean point between lowest points on the aperture's lowest border).

¹⁷*leptorrhine*

¹⁸*mesorrhine*

¹⁹*platyrrhine*

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Narrow-nose = Leptorrhine

Medium nose = Mesorrhine

Broad nose = Platyrrhine

The earliest period of human civilization is called *Palaeolithic* age. When man used stone chips in rude form. Then the *Neolithic* age came when we find evolution of improved stone implementation with ground, grooved and polished accompanied with the use of pottery etc.

Great Race	Race	Archaeological Divisions
Negroloid (Equatorial) Cephalic Index < 75% Broad nosed	Negroid (African)	- South African as <i>Bushman</i> - Central African as <i>Pygmies</i> - Sudanese as <i>Negro</i> - East African as <i>Ethiopian</i>
	Australoid (Oceanian)	- Andamanese as <i>Negritos</i> - Melanesian - Australian as <i>Tribe</i> - Kurilise as <i>Inu</i> - Srilankān-jond as <i>Veddy</i> - South Indian as <i>Drāviḍiāns</i> - Middle Eastman - Mediterranean as <i>Bolcan</i> - Inhabitants of coast of Atlanto-Black Sea - East European - Atlantoian as <i>Baltic</i> - Inhabitants of coast of Baltic Sea
Europioid (Eurasian) Cephalic Index lies between 75% - 81% Narrow nosed	South-European (Indian - Mediterranean)	
	North European (Atlantic – Baltic)	
Mongoloid (Asio-American) Cephalic Index > 81% Medium nosed	North Mongoloid (Atlato-Baltic)	- Urālian - Siberian(<i>Baikāl</i>) - Middle Asian - Sumerian - East Asian
	South Mongoloid (Asia – Pacific Ocean)	- South Asian - Polynesian - North American - Central American - Patagonian
	American (American Red Indian)	

Negroloid belongs to *Palaeolithic* age and *Australoid*, *Mongoloid*, *Europioid* belong to *Neolithic* age.

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Palaeolithic remains are rare in India but some were in the Deccan i.e. in the southern part of India which is geologically the oldest part of India as it is considered to be the part of *Gondwanā*²⁰. Then by earthquakes, volcanic eruptions, atmospheric and climatic changes there happened raise of floor of Euro-Asian ocean²¹ to form *Himālayās* in the north part of India²². It has been established from sediments of Sea-fossils on the rocks. These things are found in *laterite*²³ beds and *ossiferous* gravels at the south of 25° north latitude and made of generally of *quartzite*. So, Palaeolithic men are also called Quartzite men²⁴ whereas Neolithians spread all over India. From Sanskrit text we find that southern zone of this continent, separated from the rest by the *Himālayās*, was the land of the sons of *Bharata* i.e. *Bhāratvarṣa* or India. *Bhāratvarṣa* alone was 9,000 *yojanas*²⁵ across and whole *Jambudīpa*²⁶ is 33,000 *yojanas*²⁷.

Nearly one hundred thousand years ago *Neanderthal* used to live in the area under Asia adjacent to Africa and scattered parts of Europe. They sub-divided into two wings:

1. South-West division.
2. North-East

Due to obstruction of the *Himālayās* and the *Hindukus* mountain range South-West division transformed into *Europoid* and *Negroid* whereas North-East division turned into *Mongoloid* and thereby sub-divided into smaller races. The migration of subdivisions in India may be expressed as:

Negroloid	Inhabitants of Africa. Some of their ancestors live in Āndāmān as Kādār. In Cochin and Trivendrum as Palāyān. In Assam as Nāgā.
Proto-Australoid	A part of the race Australoid. In India they exist as Kol, Bhil and Mundā.
Mongoloid	Sub-divided to stay in Chitagong-hill of Assam and others in Sikkim and Bhutān.
Mediterranean	Known as Drāviḍiāns in India and recognised as Tāmil, Telegu, Kannāḍā and Malayalām.
Alpine, Denarik, Armenoid	Migrated from Middle Asia; lives in Bengal, Orissa, Gujrāt.
Nordic	They were Aryāns – migrated from German, England, Holland and France.

The earliest people who lived in India are considered to be of *Negrito* race whose traces are still found in Āndāmān, South India among *Kādārs*, *Urālis*. Bow is the product of the *Negritoculture*.

After them *Proto-Australoids* were in India and their races are considered to be the aborigines of India as Indians are mainly of *Platyrrhine* and dark skinned. They introduced *Neolithic* culture through *Mundās*, *Kols*, *Bhils*, *Kurumbās*, *Savārās*, *Hos*, *Kowās* and *Juangs*.

The Mongolians are found in Khāssi hills, Malay Peninsula, Nicobar Islands and among the races of the *Boḍos* of Cooch-Bihar, the *Garhwāls* and the *Gāros* of Western hills.

Of the earliest people *Mondās*, *Mon-Khmer* gave the earliest oral languages in India.

We observe that the source of Indian culture among these people. They invented the process of cultivation and to make different animals as pets. They count by the multiple of 20. Oceanic Negritos of Āndāmān have numbers to them limited to ‘one’ and ‘two’ but they can count to ‘ten’ by the following process (Bunt, 1976):

²⁰ Combined parts of South Africa through Australia as far as South America determined on the basis of identifications of fossils of animals and vegetables in these areas.

²¹ Tethys

²² Barend first suggested that *Man and the Himālayās arose simultaneously towards the end of Miocene period* i. e. over a million years ago.

²³ This soil layer is rich in iron & aluminium oxides found in tropical and subtropical regions under humid climate.

²⁴ Some of them lived near Madras city, Ongole in Guntur, Cuddapah and Narmadā valley.

²⁵ Nearly 81,000 miles or 13,7,500 K.M.

²⁶ Southern continent, on which human beings dwell, had a Jambu (rose-apple) as its distinctive tree and it was therefore called Jambudīpa.

²⁷ 2, 97,000 miles or 5,05,000 K.M.

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“the nose is tapped with finger tips of either hands, beginning with one of the little fingers tip of either hand, by saying *úbatul* (one), *ikpôr* (two) and then repeating with each successive tap with word *anká* (means ‘this’). When the second hand is finished, the two hands are brought together to signify 5 + 5 and then *ardiru* (all) is spoken”. The formations of structures of weapons used by them were based on geometrical concept.

In Indus Valley civilization we found that the weight measuring devices were:

1. For small measurements: 1, 2, 4, 8, 16, 32, 64 – multiples of 2 were used and devices were in Geometric Progression.
2. For big measurements: 160, 200, 640, 1600 were used. $160 \times 4 \times 1 = 640$; $200 \times 4 \times 2 = 1600$ i.e. from first weight, third found by multiple of 4 and 1 for first and from second to fourth has been found by multiple of 4 & 2 where 2 indicated second weight device.

Ancestors of Mediterranean are i.e. *Drāviḍiāns*²⁸, who lived in South India, built the temples with the use of geometry and trigonometry and temples are like pyramids. The utensils they used were of geometrical shape.

They had knowledge of boat-building, thread making and garments making from pre-historic period. So, our Pandits (Scholars) expressed that “*Aryāns*²⁹ learnt worshipping with geometric forms of Vedis from *Drāviḍiāns*”. It is fact that we have acquired ‘Rules of our society’ from *Aryāns* but the use of metals and building of temples (*Mandiras*) had been migrated to *Aryāns* from *Drāviḍiāns*.

In Vedic literature we find the use of geometry on formation of sacrificial altars³⁰ i.e. *Yajña* place.

1. *Gārhapatya Yajña Vedi* – Circular.
2. *Āhavānīya Yajña Vedi* – Square.
3. *Dakṣiṇāgni Yajña Vedi* – Semi Circular

These *Vedis* have proper meaning with social co-relation as example: *Gārhapatya*³¹ *Yajña Vedi* was considered to be circular to recognize the ‘womb’ i.e. *Sṛṣṭi* and *Āhavānīya*³² *Yajña Vedi* is square to recall all the good wishes and ideas from all the four sides. The *Dakṣiṇāgni Yajña Vedi*³³ is semi-circular,

²⁸The *Drāviḍiāns* descend mostly from the first wave of people who left East Africa (Ethiopiā, Somālia) around 65,000 to 70,000 years ago some are of *Australoid* origin. Their maternal lineages belong to haplogroup M (In human genetics mitochondrial DNA is Haplogroup M. It is considered native outside of Africa are descendants of either haplogroup M. The geographical distributions of M and N are associated with discussions concerning out of Africa migrations and the subsequent colonisation of the rest of the world). Member of one of the aboriginal races of India (pushed south by Caucasians and now mixed with them). Italian Professor of Stanford University and eminent geneticist Luigi Luca Cavalli-Sforza in his work of 1980s classified Indians as being genetically Caucasian. Cavalli-Sforza theorised that Indians are about three times closer to West Europeans than to East Asians. More recently, other geneticists, such as Lynn B. Jorde and Stephen P. Wooding, demonstrated that South Indians are genetic intermediaries between Europeans and East Asians. *Drāviḍiāns* can also be recognised as inhabitants of Southern part of *Bindhya Parbatmālā* i.e. mountain-range. The term *Sindhu* was metamorphosed into *Hindu*, and history reveals that the Indus Valley civilization is of the *Drāviḍiāns*. Hence the term ‘Hindu’ refers to the *Drāviḍiāns* alone is Indian, since they are the original inhabitants of India. Hindu = Indian = *Drāviḍiān*. It has been accepted that *Sindhu* Valley civilisation were best on *Drāviḍiān* culture as it has been derived from the later *Drāviḍiān* language that scripts of that period tally and it has also been proved *Sindhu* culture was long before the *Aryāns* came to India.

²⁹*Aryāns* are inhabitants of Northern part of *Bindhya Parbatmālā* and are migrated people.

³⁰ There were three types sacrificial *Yajña* (1) *Īṣṭi Yajña* – sacrifice with fruit performed in every *Darśa* i.e. New-Moon & *Paurṇamāsa* i.e. Full-Moon; (2) *Paśu Yajña* – animal sacrifice such as *Nirūdhapaśubandha* performed once in a year in rainy season – as of the animals give birth of young ones in summer; (3) *Soma Yajña* – it is very big and expensive with all sorts of sacrifices – it is performed in a family of Vedic Hindus – once in three generations.

³¹ It means house (*grha*) building on the Earth. This is also signified as *womb of vedi* and Gods begat this *Vedi*. After sunset sin (*pāpa*) is eliminated by sacrifices for the betterment of house-holders; so, this altar is placed in the west as Sun sets in the west.

³² It means towards the sky. After bringing fire from *Gārhapatya Vedi* to *Āhavānīya Vedi* it appears to be free from all sins therefore it is at east-side for the beginning of fresh morning.

³³ It is used mainly for offerings to the forefathers after being free from sin (sacrifices on *Gārhapatya Yajña Vedi*) and being fresh (sacrificing to *Āhavānīya Yajña Vedi*). It is semi-circular as it is one-half of *Gārhapatya* i.e. *Grha* or members of the family who are living and offering sacrifices to expired predecessors who are missing other half i.e. other half of the circular *vedi* is not showing. It is kept towards south as we believe that death of a person ultimately vanishes or disappear at ocean.

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situated in the south and used for certain rituals. It is semi-circular as some members of a family have been exhausted or lost and they considered being the respected half. The *Gārhapatya Yajña Vedis* to be placed in the west of the offering ground. Fire is taken from the *Gārhapatya* and kindled in the remaining two fires. This idea was considered as everything would go ahead after creation or attempt to create i.e. *Sṛṣṭi*. *Gārhapatya*, *Āhavānīya* and *Dakṣiṇāgni* and collectively called the *tretāgni* and are three primary vedis and *Nitya-agni* i.e. daily offerings.

In Rg Veda we find concepts of *Gārhapatya Vedi* by following Ślokas:

मण्डल-१, सूक्त-१५, श्लोक-१२: गार्हपत्येन संत्य ऋतुना यज्ञनीरसि । देवान्देवयते यज ॥

Mandala-1, Sūkta-15, Śloka-12: Gārhapatyena saṁtya ṛtunā yajñanīrisa | Devāndevayate yaja ॥

मण्डल-६, सूक्त-१५, श्लोक-१९: वयमु त्वा गृहपते जनानामग्ने अकर्म समिधा बृहत्तम् ।

अस्थूरि नो गार्हपत्यानि सन्तु तिग्मेन नस्तेजसा सं शिशाधि ॥

Mandala-6, Sūkta-15, Śloka-19: Vayamu tva gr̥hapate janānāmagne akarma smidha bṛhattama |

Asthuri no garhapatyani santu tigmena nastejasā saṁ sisādhi ॥

मण्डल-१०, सूक्त-७५, श्लोक-२७: इह प्रियं प्रजया ते समृध्य तामस्मिन् गृहे गार्हपत्याय जागृहि ।

एना पत्या तन्वं सं सृजस्वाधा जिब्री विदथमा वदाथः ॥

Mandala-10, Sūkta-85, Śloka-27: Iha priyaṁ prajāra te smṛdhyā tāmasmin gr̥he gārhapatyāya jāgr̥hi |

Enā patyā tanvaṁ saṁ sṛjasvādhā jibrī vidathamā vadāthah ॥

In Śatapatha Brāhmaṇa we find a Śloka VII/1/1/37:

व्याममात्रो भवति। व्याममात्रो वै पुरुषः, पुरुषः प्रजापतिरग्निरात्मसम्मितान्तद्वोनिकरोति परिमण्डला भवति,

परिमण्डलाहियोनिरथो ह्ययं वै लोको गार्हपत्यः परिमरिमण्डलं ह उ अयं लोकः ॥ [श्लोक ७/१/१/३७]

Vyāmamātro bhavati | Vyāmamātro vai puruṣaḥ, puruṣaḥ prajāpatiragnirātmasammitān tavyoniṁ karoti parimaṇḍalā bhavati, parimaṇḍalā hi yoniratho hayaṁvai loko gārhapatyah parimaṇḍalaṁ ha u lokaḥ ॥ [Śloka VII/1/1/37]

It has been in English that: *It (the gārhapatya fire or altar) measures a fathom (vyāma) (in diameter), for man is a fathom high, and man is Prajāpati (the lord of generation), and Prajāpati is Agni: he thus makes the womb of equal size to his (Agni's) body. It is circular (Parimaṇḍala), for the womb is circular and moreover the gārhapatya is the (terrestrial) world and would doubtless be circular.*

The area of each Yajña Vedi was of equal in area and equal to one square vyāma (1 vyāma = 120 aṁgulis = 1 puruṣa = nearly 6 ft.). So they have the idea (a) to construct of a square on a given line, (b) to circle a square and vice versa. The measurement of the Fire-altar (Vedi) by Bamboo-rod was as early as *Taittirīya Samhitā*³⁴ and also reappeared in almost all early *Samhitās* and *Brāhmaṇas*. The device of measurement gradually replaced by cord (*rajju*) and was introduced at the time of *Śatapatha Brāhmaṇa*³⁵. The method of construction was also applied in *Kātyāyana*³⁶ and the construction is in *Mānava Śulba*³⁷ where technical term used was *pañcāṁgi* (five-joint) as it has five (*pañca*) joints (*aṁgi*) i.e. two ties and three marks.

³⁴ It was written nearly 3000 BCE. The Śloka was in V/2/5/1.

³⁵ It was written nearly 2000 BCE. The Śloka was in X/2/3/8.

³⁶ It was written nearly 300 BCE. The Śloka was in XVI/8/1-20.

³⁷ It was written nearly 500 BCE.

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Structural Arrangement of Vedis

A. To construct a square with a given side (Dutta, 1991; Pradip Kumar Majumder, 2005):

a) Baudhāyana Śulba sūtra³⁸ gave:

Caturśraṃ cikīrṣanyāvaccikīrṣettāvatīm rajjumbhayataḥ pāsāṃ kṛtvā madhye lakṣaṇaṃ karoti lekhamālikhya | Tasyā madhye śamku nihanyāttasminpāsau pratimucya lakṣaṇena maṇḍalaṃ parilikhet | Viṣkambhāstayoḥ śamku nihanyāt | Pūrvasminpāsāṃ pratimucya pāsena maṇḍalaṃ parilikhet | Evamaparasmimste yatra sameyātāṃ tena dvitīyāṃ viṣkambhamāyicchet | Viṣkambhāntayor | Śamku nihanyāt | Pūrvasminpāsau pratimucya lakṣaṇena maṇḍalaṃ parilikhet | Evaṃ dakṣiṇata evaṃ paścādevamuttarateṣāṃ ye hantyaḥ saṃsargāstaccaturśraṃ sampadyate | (I/22-28)

चतुरस्रं चिकीर्षन्यावच्चिकीर्षेत्तावतीं रज्जुमुभयतः पाशां कृत्वा मध्ये लक्षणं करोति लेखामालिख्य। तस्यामध्ये शङ्कुनिहन्त्या तस्मिन्पाशौ प्रतिमुच्य लक्षणेन मण्डलं परिलिखेत्। विष्कम्भास्तयोः शङ्कुनिहन्त्यात्। पूर्वस्मिन्पाशं प्रतिमुच्य पाशेन मण्डलं परिलिखेत्। एवमपरस्मिन्पाशे त्रयमेयातां तेन द्वितीयां विष्कम्भमायच्छेत्। विष्कम्भान्तयोः शङ्कुनिहन्त्यात्। पूर्वस्मिन्पाशौ प्रतिमुच्य लक्षणेन मण्डलं परिलिखेत्। एवं दक्षिणत एवं पश्चादेव मुत्तरतेस्तेषां येऽन्त्याः संसर्गास्तच्चतुरस्रं संपद्यते। (१/२२-२८)

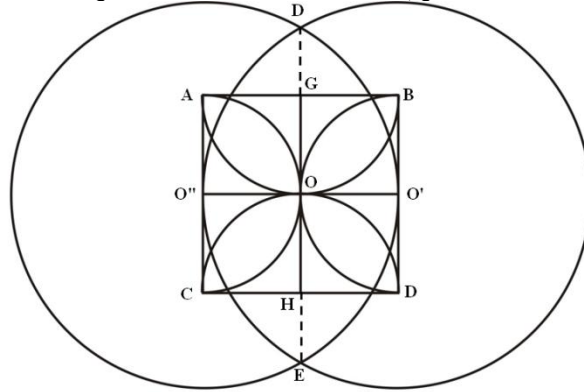


Figure 1:

Two circles are with radius $O'O'' = AB =$ given side of the square. Line joining the points of intersection of two circles subdivide AB at G. $AG = GB = CH = HD$. ABCD is the square.

³⁸It was written nearly 1000 BCE.

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It may be expressed in English as: “If you wish to construct a square, take cord (rajju) as long as its side is desired to be make a tie at both ends and a mark at the middle. Then having drawn a line (east to west) of the desired length, fix a pole at its middle. Fasten the two ties at this pole and describe a circle with the mark. Now fix poles at the both ends of the diameter (running east to west). Having fastened one tie at the eastern pole, describe a circle with the other tie. Describe a similar circle about the western pole. On joining the points of intersection of the circles, the second (i.e. north to south) diameter will be found. Fix two poles at the extremities of this diameter. Now, having fastened both ties at the eastern pole, describe a circle with the mark. Similarly describe circles about the southern, western and northern poles. The exterior points of intersection of these circles will determine square”(Figure1).

b) Athāparam | Pramāṇād dviguṇām rajjumubhayataḥ pāśaṁ kṛtvā madhye lakṣaṇaṁ karoti | Sa prācyarthaḥ | Aparasinnardhe caturrbhāgone lakṣaṇaṁ karoti | Tannyamchanam | Ardhehaṁ sārtham | Prsthācāntayoḥ pāśau pratimucya nyachnena dakṣiṇāpāymadhyārdhena śroṇyaṁ sānniharet | (I/29-35)

अथापरम्।प्रमाणाद्विगुणारज्जमुभयतःपाशांकृत्वामध्येलक्षणंकरोति।सप्राच्यर्थः।अपरसिन्नर्धेचतुर्भागेनेलक्षणांकरोति।तन्यच्छ
नम्।अर्धेहंसार्थम्।पृष्ठाचान्तयोःपाशौप्रतिमुच्यन्यच्छनेनदक्षिणापायम्यार्धेनश्रोण्यांसान्निहरेत्(१/२९-३५)

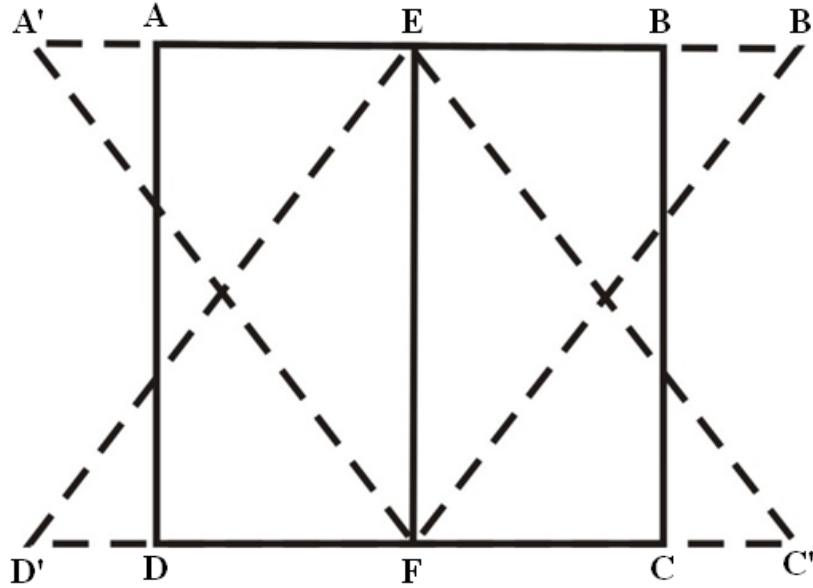


Figure 2:

$EF = a = \text{given side}$; $AE = EB = DF = FC = \frac{a}{2}$; $A'E = EB' = D'F = FC' = \frac{3a}{4}$; $ED' = EC' = FA' = FB' = \frac{5a}{4}$.
ABCD is a square.

It may be expressed in English as: “Take a cord two times the measure of the given side of the square; make a tie at both ends and a mark at the middle. With one half of this cord, measure the east to west (breadth) of the square. In the other half, make a mark at a distance (from the western end) less by its one-fourth. Let this mark be called ‘nyañchana’. Make another mark at the middle of that half for the purpose of (determining) the eastern corners. Having fastened the two ties at the two extremities of the east to west breadth, stretch the cord towards the south by the ‘nyañchana’³⁹ mark. Thus the two eastern and two western corners of the square should be constructed by the middle mark of the other half of the cord(Figure2).

c) Āpastamba Śulba sutra stated:

³⁹It is a point towards half of half-length of the given side = one-fourth of side.

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Yāvadāyāmaṃ pramāṇam | Tadardhamabhyasyāparasmiṃstṛīṭye ṣaḍabhāgone lakṣaṇam karoti | Prṣṭhāntayorantau niyamy lakṣaṇena dakṣiṇāpāyamyā nimittam karoti | Evamuttarato viparyastetaratammaṃ sa smādhiḥ | Tannimitto nirhāso vivṛddhirvā | (I/2-6)

यावादायामंप्रमाणम्।तदर्धमभ्यस्यापरस्मिंस्तृतीयेषड्भागोनेलक्षणंकरोति।पृष्ठान्तयोरन्तौनयम्यलक्षणेनदक्षिणापायम्यनिमित्तंकरोति।एवमुत्तरतोविपर्यस्तेतरतन्मःससमाधिः।(१/२-६)

It may transform into English as: “Add to a cord as long as the given side its half and make a mark at a distance (from the other end of the added portion) less by its sixth part. Fasten the ends of the (increased) cord at the extremities of the east west line and stretch it towards the south having taken by the mark and put a sign at the point reached by it. Do similarity on the north and again on both sides after interchanging the ends of the cord. This is the construction(Figure3).

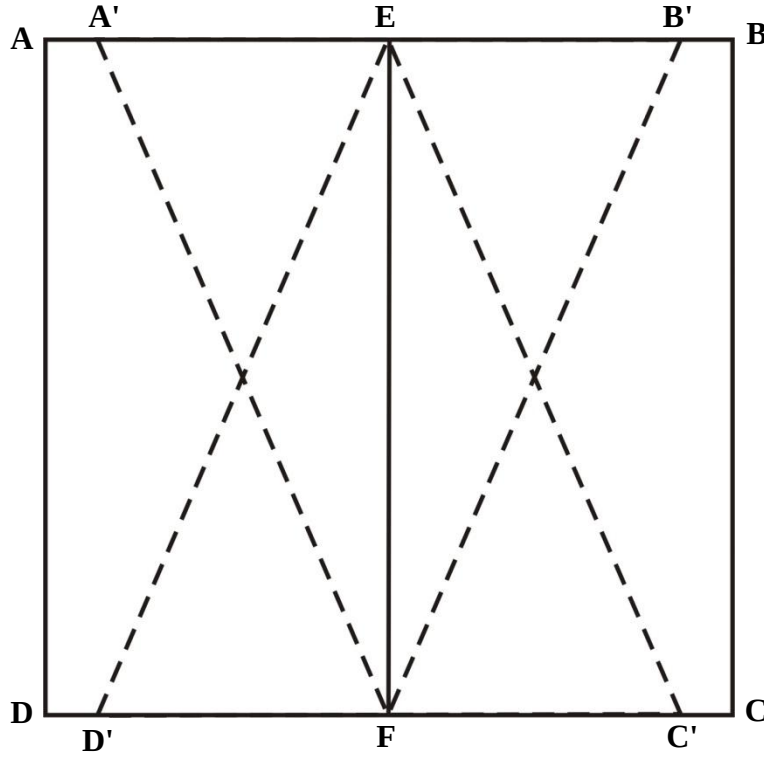


Figure3:

$EF = a$ = given side; $AE = EB = DF = FC = \frac{a}{2}$; $A'E = EB' = D'F = FC' = \frac{5a}{12}$; $ED' = EC' = FA' = FB' = \frac{13a}{12}$.
ABCD is a square.

d) Athāparam | Pramāṇamātrīm rajjumubhayataḥ pāśām karoti | Madhye lakṣaṇamardha mdhyamayośca prṣṭhāyām rajjumāyamyā pāśayorlakṣṇedhiti śamkuṃ nihatyō pāśuntayoh pāśau pratimucya madhyamena lakṣaṇena dkṣiṇāpāyamyā śamkuṃ nimittam karoti | Madhyame pāśau pratimucya uparyupri nimittam madhyamena lakṣaṇena dakṣiṇāpāramyā śamkuṃ nihanti | Tasmin pāśam pratimucya pūrvasminnitam madhyamena lakṣaṇena dakṣiṇamamsamāyacchet | Unmucya pūrvasmādaparasmina pratimucya madhyamenaiva lakṣaṇena dakṣiṇām śronimāyacchet | Evamuttarau śronyamsau | (I/15-21)

अथापरम्।प्रमाणमात्रीरज्जुमुभयतःपाशांकरोति।मध्येलक्षणमर्धमध्यमयोश्चपृष्ठायांरज्जुमायम्यपाशयोर्लक्षणेधितिशङ्कुनिह
त्योपाशन्तयोःपाशौप्रतिमुच्यमध्यमेनलक्षणेनदक्षिणापायम्यशङ्कुनिमित्तंकरोति।मध्यमेपाशौप्रतिमुच्यउपर्युपरिनिमित्तमध्य

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मेनलक्षणेनदक्षिणापायम्यशङ्कुनिहन्ति।तस्मिन्पाशंप्रतिमुच्यपूर्वस्मिन्नितमध्यमेनलक्षणेनदक्षिणमंसमायच्छेत्।उन्मुच्यपूर्वस्मादपरस्मिन्प्रतिमुच्यमध्यमेनैवलक्षणेनदक्षिणांश्रणिमायच्छेत्।एवमुत्तरौश्रोण्यंसौ॥(१/१५-२१)

It can be transformed to English as: “Take a cord as long as the measure (to be given to the side of the square); make a tie at both ends and a mark at the middle of itself and of its two halves. Stretch out this cord along the east-west line and fix poles at the three points. Then having fastened the ties at the two poles of outer marks, stretch the cord towards the south having taken it by the middle mark and makes a point there. Now fasten both the ties at the middle pole and stretch the cord towards the south by the middle mark over this point and fix a pole at the place reached. Fasten one tie at this pole, another tie at the easternmost pole, and stretch out the cord having taken it by the middle mark; thus will be obtained the south-eastern corner of the square (required). Then freeing the tie from the easternmost pole, fasten it to the westernmost pole and again stretch the cord by the middle mark; thus the south-western corner will be determined. Similarly can be determined the north-eastern and north-western corners of the square(Figure 4).

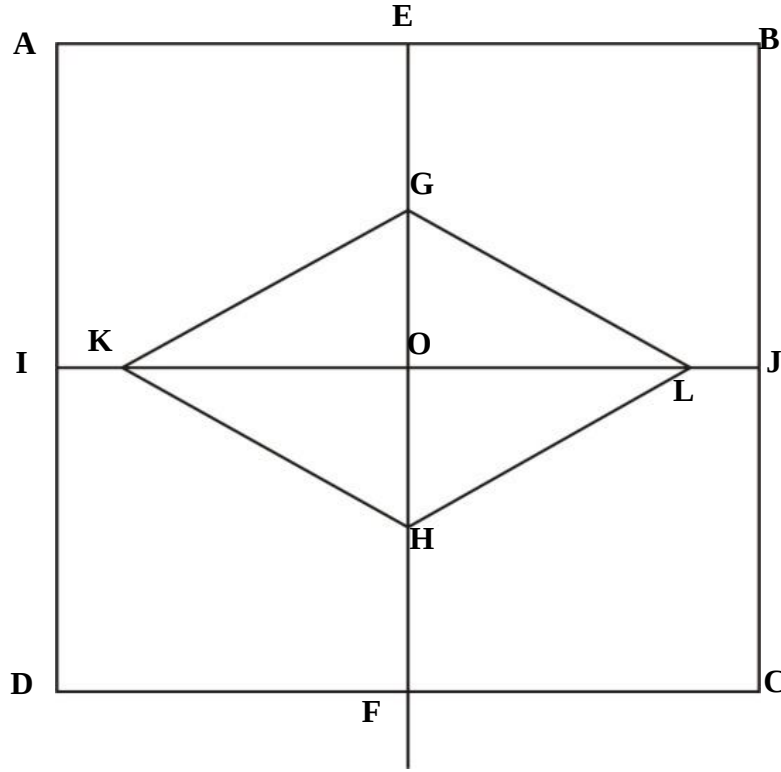


Figure 4:

$AB = a =$ given side; $AE = EB = DF = FC = IO = OJ = EG = FH = \frac{a}{2}$; $IK = JL = \frac{a}{4}$; $OK = OL = \frac{3a}{4}$. ABCD is a square.

e) Yāvānyajamāna ūrdhvavāhustāvadantarāle venościdre karoti madhye tṛtīyam | Apareṇa yupāvaṭadeśamanuprṣṭham veṇum nidhāya chidreṣu śaṁkunihatya unmucyāparābhyām dakṣiṇā prākparilikhedāntāta, unmut | Unmucya pūrvasmāda parasmīnapratimucya dakṣiṇā pratyakaparilikhedāntāt | (VIII/23-25)

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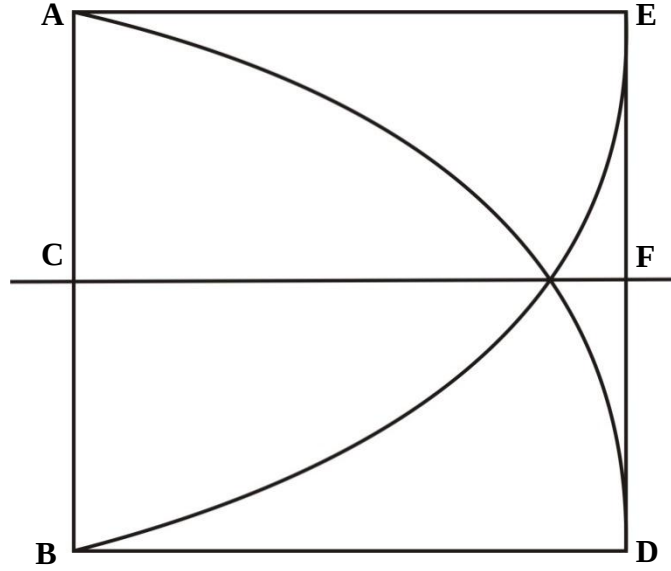


Figure 5:

$AB = a =$ given side; $AC = CB = EF = FC = \frac{a}{2}$; BE and AD are quadrant of circle with radius AB. P is point of intersection of arcs. CP is produced to F such that $CF = AB$. EFD joined. ABDF is a square.

यावान्यजमान ऊर्ध्वबाहुस्तावदन्तरालेवेनोश्चिद्रेकरोतिमध्येतृतीयम्।अपरेणयुपावटदेशमनुपृष्ठवेणुनिधायस्त्रिद्रेषुशङ्कुनिहत्य उन्मुच्यापराभ्यांदक्षिणाप्राक्परिलिखेदान्तात्, उन्मुत्। उन्मुच्यपूर्वस्मादपरस्मिन्प्रतिमुच्यदक्षिणाप्रत्यक्परिलिखेदान्तात्। (८/ २३-२५)

It may be translated as: “In a bamboo-rod, make two holes (A, B) as much apart as the height of the sacrifice with uplifted arms and a third hole (C) mid-way between them. Place the bamboo-rod on the east to west line and fix poles in the holes (beginning) from the western extremity of the sacrificial place. Then freeing the two poles (C, B) on the west, describe a circle (by rotating the bamboo) south-east wise by the hole at the (opposite) end. Then unloosening the eastern hole and fixing the hole in the west (in its original position), describe another circle south-west wise by the hole at the opposite end. Now release the bamboo (completely); fix again an extreme hole at the middle pole (C); place it towards the south over the point of intersection of the two circles and fix a pole at the point (F) reached by the outer most hole. Then fix at this pole the middle hole of the bamboo and having laid it along the extreme outer edges of the two circles, fix two poles (E, D) at the two outermost holes. It (the figure thus described, ABDE) is a square (having a side)(Figure5).

B. (i) To transform a square into a circle(Dutta, 1991; Pradip Kumar Majumder, 2005):

a) Maharṣi Baudhāyana said:

Carurasraṃ maṇḍalaṃ cikīrṣannaḥśanayārdha madhyāt prācīmabhyāpātavedyadatiśiṣyate tasya saha tritīyena maṇḍalaṃ parilikhet | (I/58)

चतुरस्रमण्डलंचिकीर्षन्नयार्धमध्यात्प्राचीमभ्यापातवेद्यदतिशिष्यते तस्य सह तृतीयेन मण्डलं परिलिखेत्। (१/५८)

It may be translated as:

“If you wish to circle a square, draw half of its diagonal about the centre towards the east-west line; then describe a circle together with the on-third of that which lies outside (the square)”.

b) Same comment was given by Āpastamba as:

Caturasraṃ maṇḍalaṃ cikīrṣanmadhyāt kotyāṃ nipātakhet | Pārśataḥ parikṛṣyātīśayatrīyena sahamāṇḍalaṃ parilikhet | Sānityā maṇḍalam | Yāvaddhīyate tāvadāgantu | (III / 2, 3, 4, 5)

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चतुरस्रमण्डलं चिकीर्षन् मध्यात्कोट्यानि पातयेत्। पार्श्वतः परिकृष्याति शयतृतीयेन सह मण्डलं परिलिखेत्। सानित्यामण्डलम्। यावद्द्वीयते तावदागन्तु। (३/२, ३, ४, ५)

Here by the words: सानित्यामण्डलम्। यावद्द्वीयते तावदागन्तु। i.e. Sānityā maṇḍalam | Yāvaddhīyete tāvadāgantu | indicated that areas are exact to each other.

c) Kātyāyana said:

Caturasraṁ maṇḍalaṁ cikirṣandadhyādāmanipāja pārśvataḥ pariliyā yadatiriktāṁ bhavati tasya tritīyena saha maṇḍalaṁ parilikhetāṁ sa samādhīḥ | (III/13)

चतुरस्रमण्डलं चिकीर्षन् मध्यादामनिपाजपार्श्वतः परिलियायदतिरिक्तं भवति तस्य तृतीयेन सह मण्डलं परिलिखेत् स समाधिः। (३/१३)

d) Mānava in his Śulba sutra said:

Madhyāt koti pramāṇena maṇḍalam parilikhet atirikta tribhāgena sarvaṁ tu saha maṇḍalam | Caturāstre kṣṇayā rajjumadhyataḥ saṁnipātayet | Parilekhā ta darddhenārddha maṇḍalameva tat | (I/8)

मध्यात्कोटिप्रमाणेन मण्डलम् परिलिखेत् अतिरिक्तत्रिभागेन सर्वतु सह मण्डलम्। चतुरश्रेक्ष्णयारज्जुमध्यतः संनिपातयेत्। परिलेखात् दर्द्धेनार्द्धमण्डलमेव तत्। (१/८)

(ii) To transform a circle into a square:

a) Mahārṣi Baudhāyana said:

Maṇḍalaṁ caturrasraṁ cikirṣanviṣkambhamacetā bhāgāmkṛtvābhāgāmakonaṁ trisadhā vibhajyāṣṭaṁ viśatibhāgānuddhared bhāgasya ca ṣaṣṭamaṣṭabhāgonam | (I/58)

मण्डलं चतुरस्रं चिकीर्षन् विष्कम्भमचेता भागां कृत्वा भागामकोनत्रिंशधा विभज्याष्टविंशति भागानुद्धरेद्भगस्य षष्ठमष्टभागो नम्। (१/५९)

It can be expressed in English as:

“If you wish to square a circle, divide its diameter into eight parts; then divide one part into twenty-nine parts and leave out twenty-eight of these; and also the sixth part (of the preceding sub-division) less the eighth part (of the last)”.

b) Apī vā pañcadaśabhāgān kṛtvā dvābuddharetadeṣānitvā caturrasra karaṇī | (I/60)

अपि वा पञ्चदशभागान् कृत्वा द्वाबुद्धरेतदेषानित्या चतुरस्र करणी। (१/६०)

In English it appears as:

“You divide the diameter of the circle into fifteen parts, leave out two of its parts; you find the side of the square”.

c) Same idea was expressed in Āpastamba Śulba sutra as:

Maṇḍalaṁ caturasraṁ cikirṣana viṣkambhaṁ pañcadaśa bhāgāna kṛtvā dvābuddharet trayodaśaraśiṣyānte sā nityā caturasraṁ | (VI/8)

मण्डलं चतुरस्रं चिकीर्षन् विष्कम्भं पञ्चदशभागान् कृत्वा द्वाबुद्धरेत् त्रयोदशरशिष्यान्ते सानित्या चतुरस्रम्। (६/७)



Survey Rope of Egypt 2000

Research Article

Maṇḍalaṃ caturaśraṃ cikīrṣana viṣkasta pañcadaśa bhāgāna kṛtvā dvābuddhareccheṣṭa karaṇī | (III/12)

मण्डलंचतुरस्रंचिकीर्षनविष्कस्तपञ्चदशभागानकृत्वाद्वाबुद्धरेच्छेषःकरणौ।(३/१२)

The applied geometry in ancient Hindus was known as *Śulba*.

In Sanskrit *śulba* and *rajju* have identical significance as rope or as cord and it was used to measure. As the word *śulba* derived from *śulb* or *śulv* means 'to measure'. Thus we can present four types of identification of the word *śulba* or *rajju* (Dutta, 1991).

1. Mensuration – the act of measuring.
2. Line or surface – the result obtained by measuring.
3. A measure – the instrument of measuring.
4. Geometry – the art of measuring.

In ancient Hindu literature we find three kinds of measuring – linear, superficial and voluminal with *rajju*. We find that there is a fundamental difference on conceptual attitude of geometry in India and in Greece. Indians, mainly, learnt mensuration for their practical use which were mainly existed in Egypt and we find unicultural progress between these two countries whereas Greeks were intended to express different geometric problems by arguments based on geometric structures and configurations. For example we see in ancient India people used 1 *Rajju* = 10 *Danda* = 40 *Hātsor Hastas or cubits* = 960 *aṅgulis* = 10 *puruṣa* = 60 ft. = 18.3 m. (Pradip Kumar Majumder, 2005) for survey of lands. The rope (*rajju*) was sometimes called *patina* (that which is laid out) because measurements were made by lying (*pātā*) on the ground.

Mathematics, particularly geometry, played a crucial role on the Indus Valley civilization about 3000 B.C. and was used for (Majumder, 1994):

- Arrangement of cities in the form of rectangular, square land areas; drains in the form of rectangular parallelepiped and metalled road of same width.
- Use of ornaments depicted with valuable stones was of geometrical arrangement.
- Utensils of geometrical shapes.
- Weapons with even and uneven geometric forms.
- Furniture like beds, tools etc. were built by the use of geometry.

From the different Archaeological discoveries we came to know that inhabitants of *Mahenjodāro* and *Harappā* were very much acquainted with profound knowledge of geometry such as:

- ✓ Idea of value of π (pi) as they could form circular plane to erect granary.
- ✓ Idea of *Pythagoras* theorem as they made right angled triangular bricks and could cut the bricks in the form of right angled triangle.
- ✓ Idea of parallel lines to construct roads.

CONCLUSION

We should be very much proud of our country as it contains such a rich civilization from the pre-historic period. And going through the above context we must go for thinking of the intension of those people who were inhabitants of India.

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