Indian Knowledge System
IIT Kharagpur

INTRODUCTION TO STHAPATYA VASTU & NIRMAN VIDYA AND ARTHASHASTRA
(KS60001)

Indian Traditional Construction System and Practices
Lecture-2

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Climate Sensitive Construction

Clustering of Housing Units

Clusters of huts formed a **Courtyard**

A courtyard being a very **predominant feature** of Indian civic architecture was shared among two to three families depending upon the economic conditions.

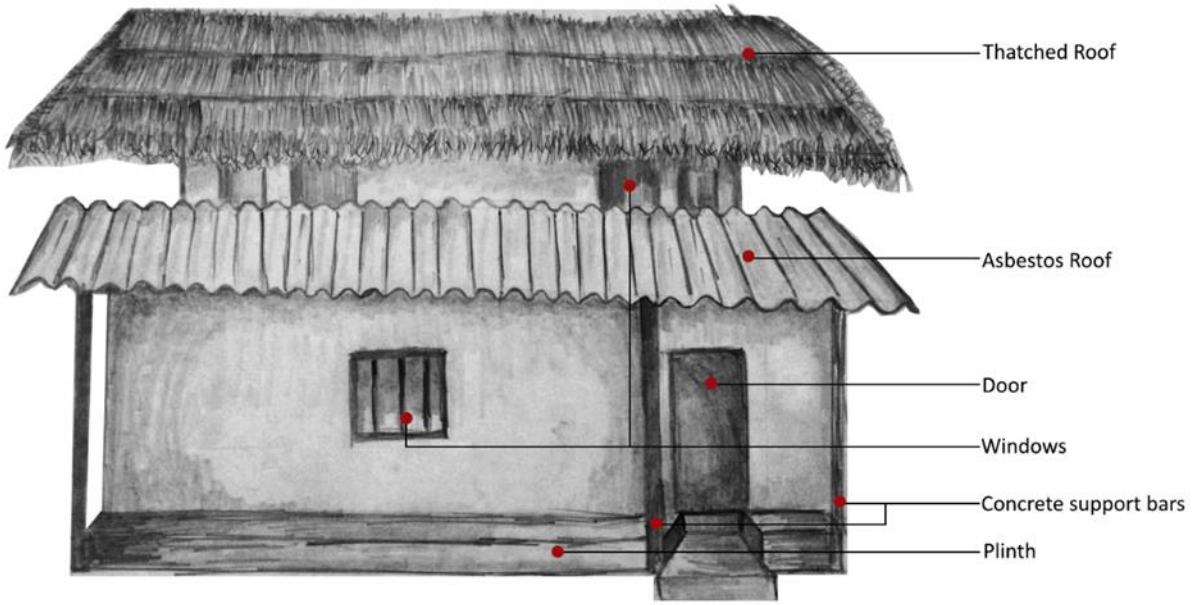
The concept of
Ekshala (courtyard with built spaces on one side),
Dwishala (courtyard with built spaces on two sides or a shared courtyard among two houses),
Trishala and Chatusshala (courtyard that have built spaces on three or four sides or shared by three or four families, respectively) was present.

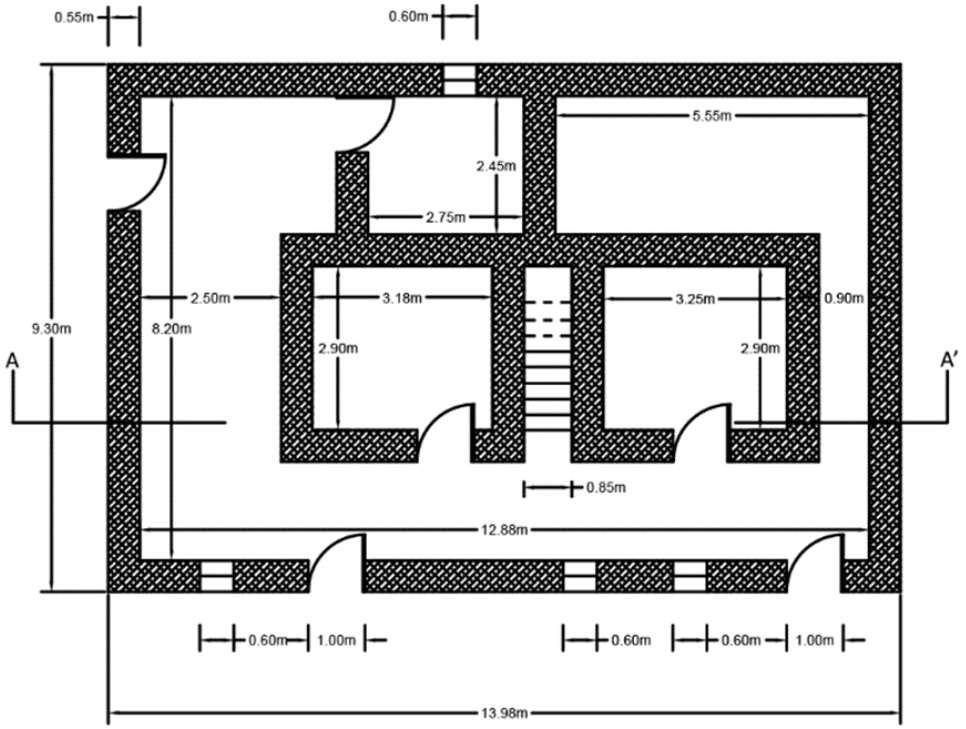
It was the first kind of **Climate Responsive Architecture** concept developed in Indian system

Mud-Bamboo housing of Assam and Bengal

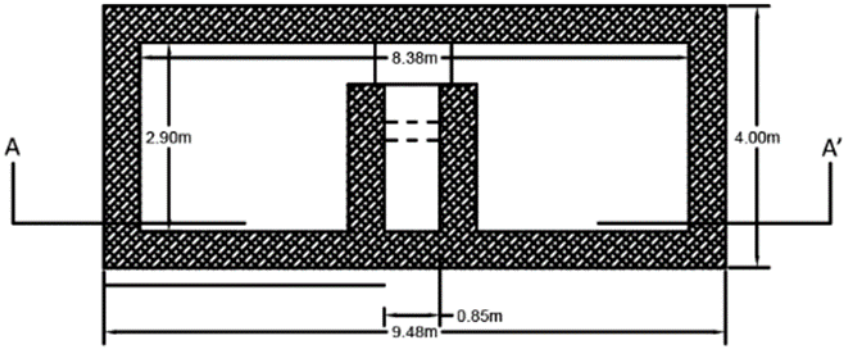
Wall:

- Mud with bamboo reinforcement
- Thickness 300mm, provide sufficient thermal damping
- Square or Rectangular in Plan, Provide Load stability
- Percentage of opening is low





Ground Floor Plan



First Floor Plan

N

Extended Veranda provide

- Shading
- Protection from Rain

Rooms are allocated centrally within a circulatory space,
Provide more flexible option for incremental housing

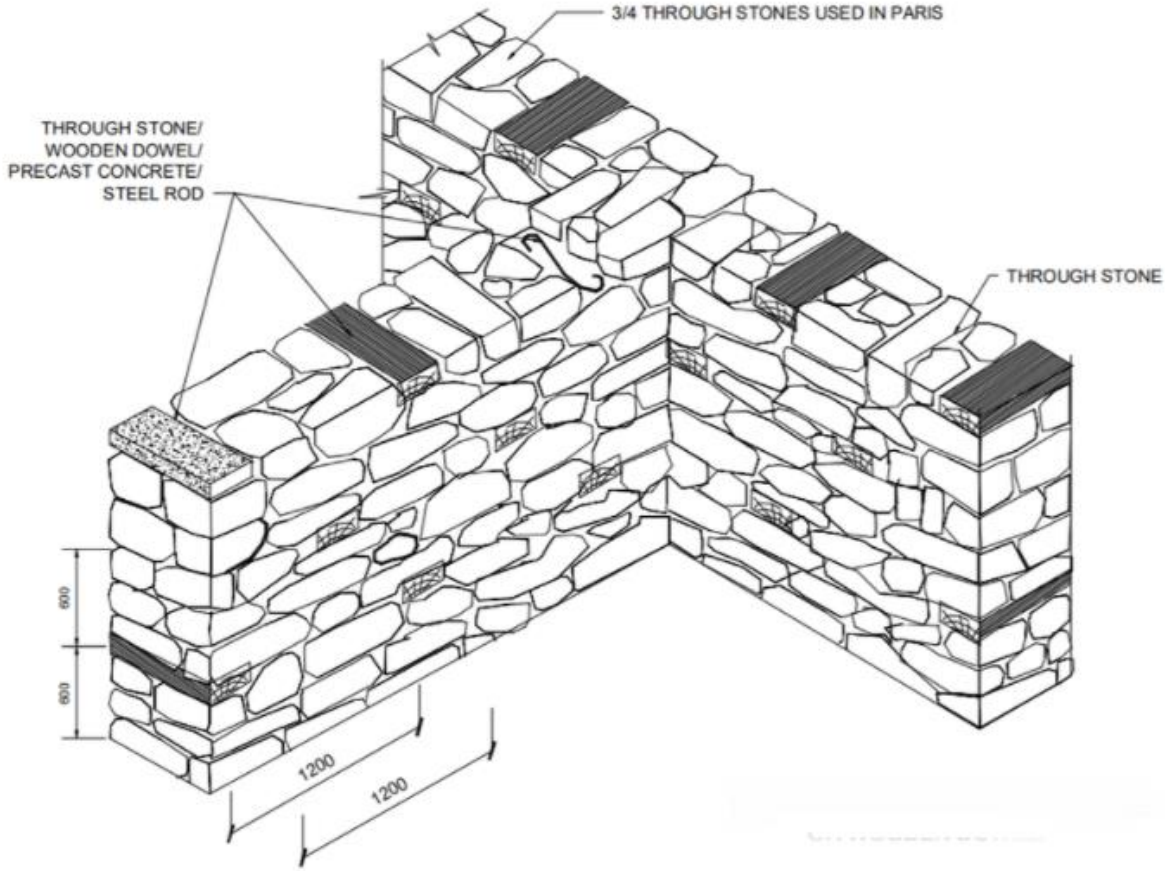
Housing in hilly areas of Himachal Pradesh

Wall:

- Dry stone masonry
- Timber post and beams are placed in locations
- Thickness 250-300mm, provide sufficient thermal storage
- Square or Rectangular in Plan, Provide Load stability
- Percentage of opening is low
- Prone to collapse during heavy earthquakes

The unstable dry stone masonry can be further reinforced with ‘Through Stone’ or ‘Wooden Dowel’

Through Stone: The stone having width 3/4th to full width of wall



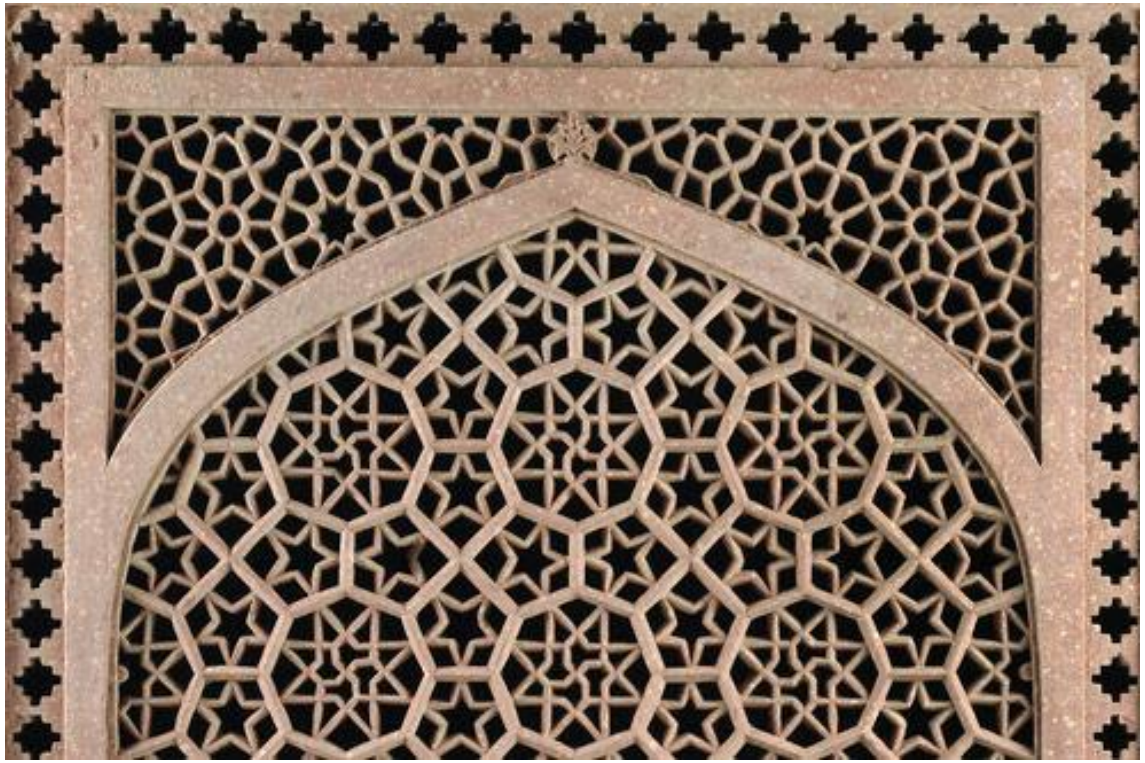
Climate Responsive Housing of Rajasthan

- **Building Orientation:** Maximum exposure should be in North-South to reduce the heat gain
- **Compact Planning:** Minimize the surface area of the building to reduce the heat gain
- **Shading:** Provide shading in East, West and South face of the building.
- **Mutual Shading:** Placing the building blocks closely so that mutual shading is possible

Jharokha and Jali provides the Much needed shading

- **Use High Thermal Mass**: Delay the process of external wall heating
- **Small Opening:** Reduce the direct solar gain and entry of hot air
- **Small Courtyard with High Walls:** Shade provides relatively cool outdoor.
- **Use Long and Deep Verandas and Balcony:** To protect the rooms from direct exposure from heat
- **Plant Vegetation:** Provide shade and psychologically cool atmosphere
- **Light Colour Wall and Roof:** To reflect solar radiation and decrease the heat gain.

Jali works provides the cooling of external hot air through heat exchange process

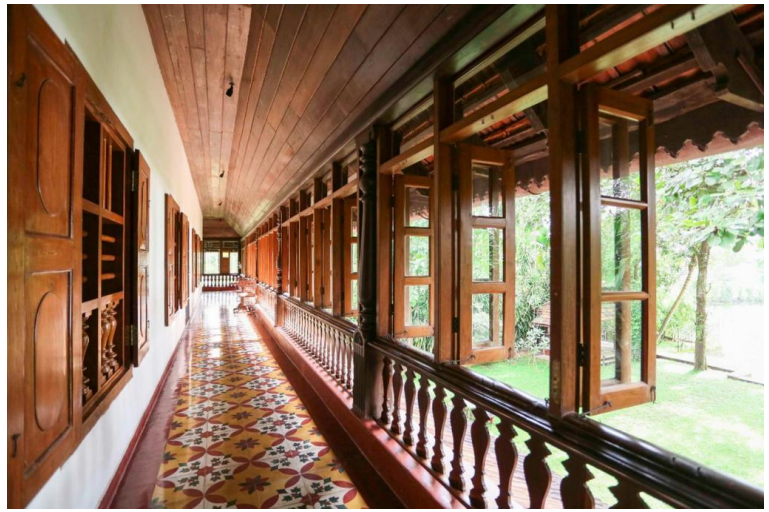


Climate Responsive Housing of Kerala

- **Building Orientation:** Maximum exposure should be in North-South to reduce the heat gain
- **Linear Space Arrangement**: To capture the wind flow in maximum order
- **Open and Segregated Plans:** To provide cross ventilation
- **Semi-open areas:** Provide shading and maximum air circulation
- **Large Courtyards:** To differentiate the air pressure and magnify the natural ventilation
- **Large Openings:** to maximize the ventilation
- **Shading:** Shading of wall and windows reduces direct solar heat gain
- **Plantation in strategic Locations:** To maximize shading and should not block ventilation

Chitoor Kottaram

Royal residence of the ruling family of Cochin



Large and Long Veranda
Maximum Opening (without Mullion in window)

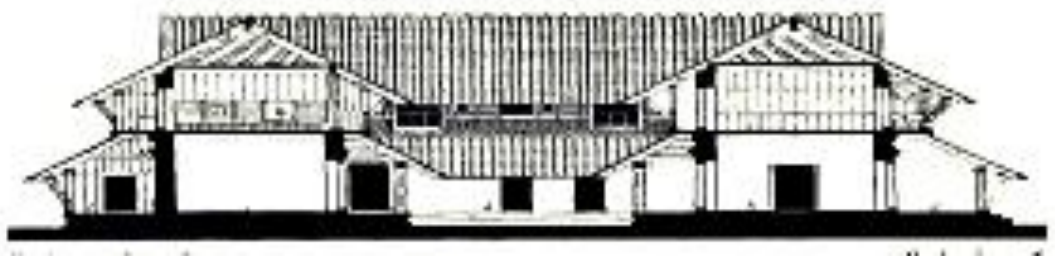
Padmanabhapuram Palace

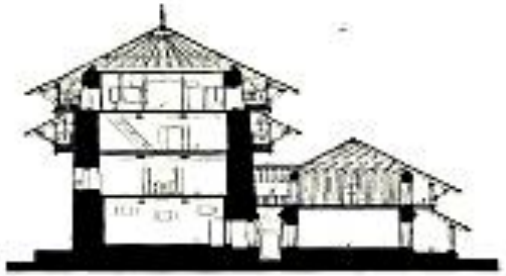
- Padmanabhapuram Palaceis a remarkable **16th Century wood palace** of the erstwhile **Maharajas of Travancore** (1550 to 1750 AD) in the state of **Kerala**.
- The palace was built by Iravi Varma Kulasekhara Perumal, the ruler of Travancore in 1601 AD. It was also called Kalkulam Palace.
- The palace complex, spread around an area of **6.5 acres**
- The Palace **wall** structure is constructed out of **wood with laterite** (locally available building stone).
- The **roof** structure is constructed out of **timber, covered with clay tiles**.

The Palace is having fourteen purposes denoted structures:

1. Poomukam(reception hall)
2. PlamootilKottaram (living quarters)
3. Veppinmoodu Kottaram(living quarters)
4. Thai Kottaram(oldest palace)
5. Uttupura (kitchen and dining hall)
6. Homappura (rituals and prayer hall)
7. UppirikkaMalika (multi-storeyed building)
8. Ayuddhapura (armoury house)
9. Chandravilasam(entertainment hall)
10. IndraVilasam(entertainment hall)
11. NavarathriMandapam(dance hall)
12. LekshmiVilasam (mansion)
13. ThekkeKottaram (palace)
14. Padipura (Entrance porch)

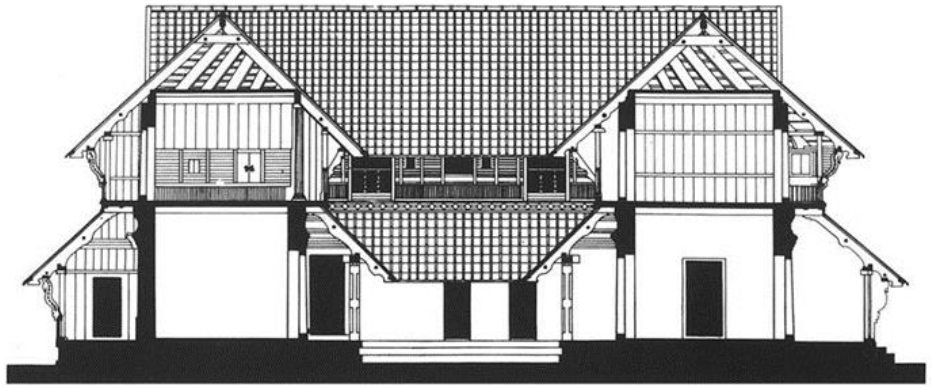
and other smaller ancillary buildings.





Protection from Heavy Rain:

Steep tiled roof forms multi-layered triangular pattern



Features of Taccusastra

- The Palace is an exceptional example of indigenous building techniques and **craftsmanship in wood**, a style unparalleled in the world and based on historic building system, ***Taccusastra*** (the science of carpentry) unique to this region.
- The Palace is a product of the fusion of **traditional building technology, exquisite craftsmanship and superior knowledge of material science**.
- It is a finest example of **climate responsive architecture**.

Natural Ventilation and Daylight

Thai Kottaram:
Built of finely decorated and carved wooden pillars, the structures display the local indigenous style of wood carving.

There is a long corridor bordered with small balconies on the sides called Ambari Mukhappu (bay window).

Courtyards: Cross Ventilation and changing Daylight pattern

Activity Sensitive Construction

DHAJJI DEWARI
Earthquake resistant construction system in Jammu and Kashmir

Dhajji most commonly consists of a braced timber frame in different patterns.

The spaces left between the bracing and/or frames is filled with a thin wall of stone masonry traditionally laid into mud mortar, so as to create a patchwork of small size masonry panels.

Completed walls are plastered in mud mortar.

Dhajji buildings are typically 1-4 storeys tall and the roof may be a flat timber and mud roof, or a pitched roof with timber/metal sheeting

The earthquake resistance of a dhajji building is developed in the following ways.

•The mortar, masonry infill panels quickly crack in-plane thereby absorbing seismic energy through friction against the timber framing, and between the cracks in the fill material. Thus, distributing the earthquake energy evenly.

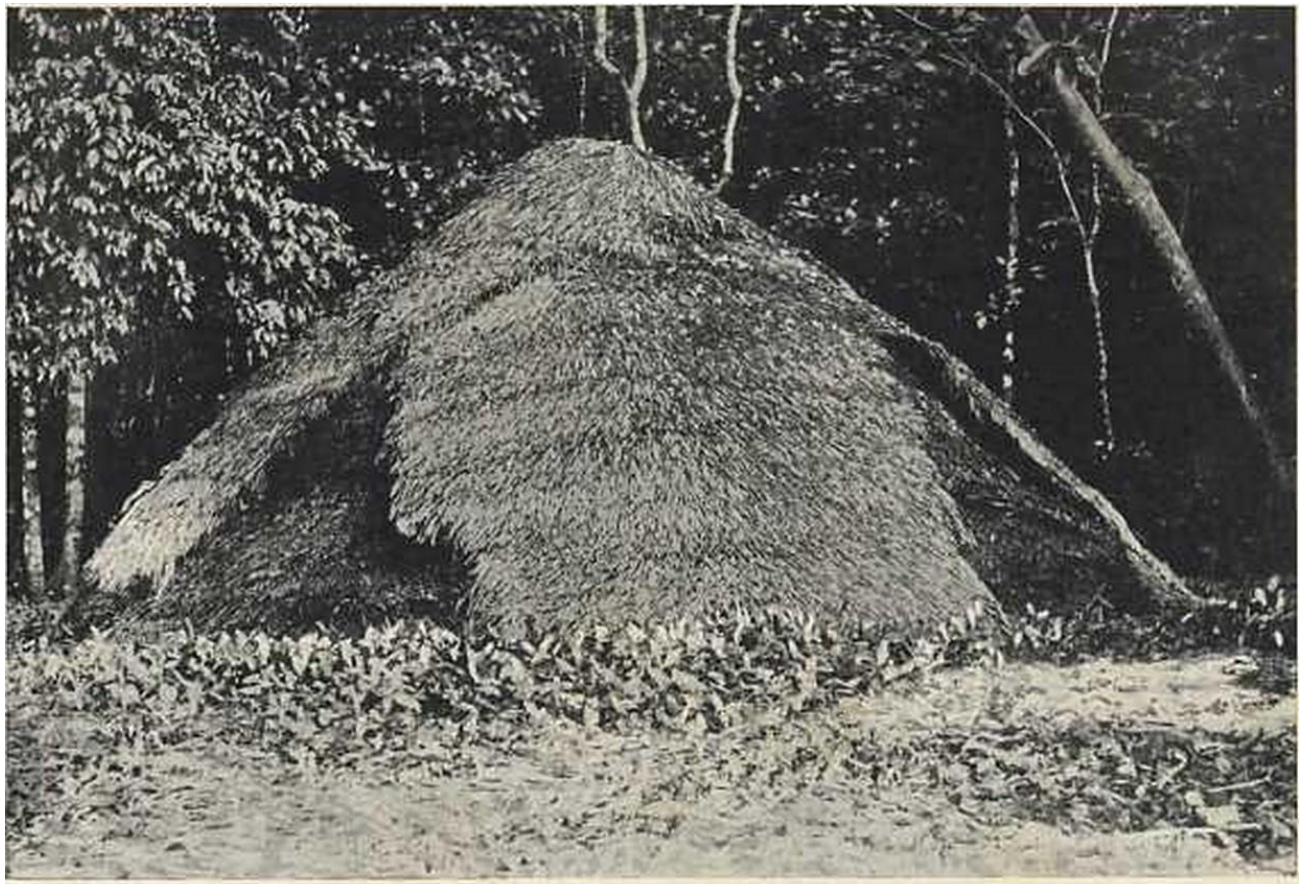
•The timber frame and closely spaced bracing, which essentially remains elastic, prevents large cracks from propagating through the infill walls. Thus, the possibility of out-of-plane collapse of masonry panels is reduced considerably.

•The masonry walls are kept relatively thin. This helps to reduce the mass of the building and therefore the inertial forces that must be resisted during an earthquake.

Traditional Housing at Andaman and Nicobar Islands

Öngé Hut, Little Andaman

The huts are built to the shape of a partially flattened cone.
They are about 13 feet high, and 30 feet in diameter.
They lay a thick mat covering on a framework of light sticks which are supported by upright poles



ÖNGÉ HUT, LITTLE ANDAMAN.

Kar Nicobarese Houses

The circular hut called the ‘ma pati tuhet’ is the principal house of a family.
All the buildings stand on thick piles, about 7 feet high.
The living-houses (pati), are 20 feet in diameter, and 15-20 feet in height from floor to apex.
They are in the shape of something between an inverted basin and a pie-dish, covered with a heavy thatch of lalang grass.
Without windows, the interior is accessed by a ladder of bamboo,

KAR NICOBARESE FAMILY AND DWELLING-HOUSE, WITH LOUNGE BENEATH.

Construction Technology

Early Construction Practices

Sub-structure Construction:

- Construction of the house itself begins first by digging a certain number of holes.
- These post-holes are to have a depth equal to the distance from the ankle to knee.
- The whole base is prepared with compacting mud with gravels

Super Structure Construction:

- Horizontal bamboo sleepers (*Vam-sha*)are then tied with foundation posts
- Incase of higher spans, Full bamboo / tree stem is used as transverse beams
- The size of the central beam (*madhyama vam.sha*). was kept larger in size (or grouped with 2-3 bamboo post).
- Sometimes, two such beams are "attached" to the pillars (*sañjanî*)

Early Construction Practices

Construction of Walls:

- The wall should have thickness equal to **one-sixteenth part of the width** of the room
- If upper part of a wall is heavier than the lower part, or not uniformly made (thicker at some places, thinner at other places)
- Bricks used should be all new or all old, old **bricks should not be mixed** with new ones in the same wall. If some old stock must be consumed, then the new bricks should be used over them.

Early Construction Practices

Construction of Walls:

- The wall on the **North and East** side should be of **less thickness**, and the walls on **South and West** side should be built **thicker**.
- Construction of the wall must be **started at the South-West** corner and work must proceed towards east or towards north in the first phase.
- The construction of walls from **South East towards North** and from **North-West towards East** should be taken up in the **second phase**.
- At every stage during the progress of work, the height of the **wall should be raised gradually**
- **Main building** must be constructed in the **south-west portion** of the plot, leaving more space open on the north and east than on the south and west respectively. Main building constructed in the middle of the plot, symmetrically leaving equal open space on all the four sides is also considered to be good.

Early Construction Practices

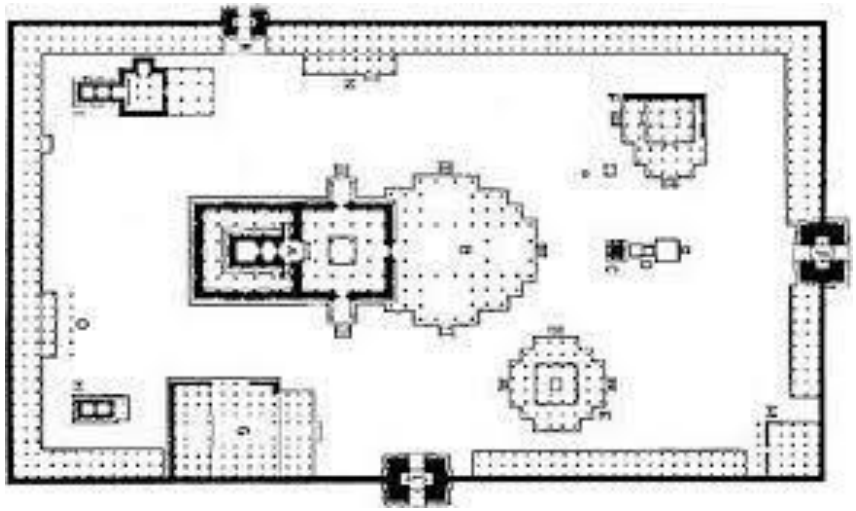
- **Construction of Roof:**
- Roof is constructed in two or three layers
- The array of bamboo provide the supporting base if the roof
- The base was covered with thatch
- Later, the stabilized mud layers are also provided
- The better-off citizens roofed them with planks of wood or tiles, and used unbaked bricks for the walls. To maintain the barrel shape of the roof

Construction Geometry

STHAPATYA VIDYA

VASTU VIDYA

Architecture
Spatial Relation



Knowledge of

- **Geometry and Proportion**
- **Material Property**
- **Technology Application**

NIRMAN VIDYA

Engineering
Construction Practices

VEDIC GEOMETRY

Kalpa

Guiding Principles for Yagna rituals

Srautha Sutras (Rituals)
Sulbha Sutras (Geometry)

Jyothishya

Guiding Principle for the study of Astronomy, Astrophysics and Time computation

Geometry

Trigonometry

Calculus

VEDIC GEOMETRY

Shilpa Shastra

Guiding principle of Temple Architecture, Construction and Sculpting

- Shilpa Shastram
- Maanasara
- Vastu Shastram
- Shilpa Ratna Kosa

Sri Vidya

Guiding principle of warship within the spiritual connection on Yantras

- Complex Geometry
- Proportion

SULBHA SUTRAS

Basically, Sulbha Sutras are the Mathematical Principles and Instructions for the construction of **'Fire Alters'** in the proves of **'Yagnyam'.**

Sulbha = Rope

Sutras = Principles

Sulbha Sutra instructions are based on Two Dimensions Geometric Principles
Sulbha Sutra instructions to construction of fire alters also carry forwarded to the various construction principles:

- ***Foundation Layout***
- ***Construction of wall, pillars***
- ***Construction of roof***

Threthagni: The Three Fire Alters

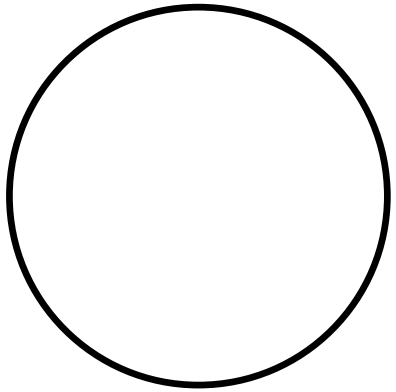
Square: Aha-vaniy-agni
Circular: Gritha-paty-agni
Semi-circular: Dakshina-agni

} Same Area

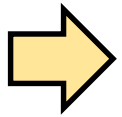
Squaring a Circle

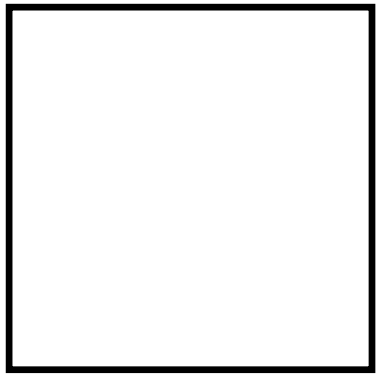
मण्डलं चतुरस्रं चिकीर्षन् विष्कम्भं पञ्चदशभागान्कृत्वा द्वावु-
द्धरेच्छेषः करणी ॥ १४ ॥

- Katyayana Sulba Sutrani, 3.14



Diameter = D



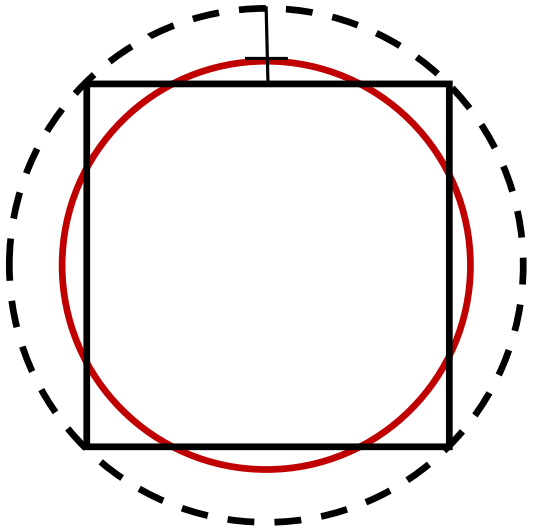


$$Edge = \left(13 \times \frac{D}{15}\right) + \frac{1}{3} \times \left(\frac{D}{15}\right)$$

Circling a Square

चतुरस्रं मण्डलं चिकीर्षन्मध्यादक्षे निपात्य पार्श्वतः परिलिख्य तत्र यदतिरिक्तं भवति, तस्य तृतीयेन सह मण्डलं परिलिखेत्स समाधिः ॥ १३ ॥

- Katyayana Sulba Sutrani, 3.13



Edge = a

$$Radious = \frac{1}{3} \times \left(\frac{a}{\sqrt{2}} - \frac{a}{2} \right) + \frac{a}{2}$$

Thank You