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PASSIVE DESIGN STRATEGIES IN VERNACULAR ARCHITECTURE

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ABSTRACT:

This paper aims to investigate and explore the passive design strategies in Vernacular Architecture. The strategies of passive design by the use of natural characteristics like the sun wind and the natural law of physics to produce a low energy cost, reduced maintenance and superior comfort. Passive design strategies in vernacular buildings has develop in response to prevailing climate of the past, there are numerous of passive design strategies for reduce energy consumption in vernacular buildings. Due to rapid urbanization in India today building are design with complete different to the climate and the material. Now days buildings consume more energy finally it degrade our environment, ecology, renewable resources due to emission of co2 and eco foot print. The main objectives of this paper to establish the passive strategies to resist the growth of international styles and produce an environmentally, culturally, socially at the same time to retain the architectural identify of particular area. In this study passive design strategies will be examined in vernacular buildings to identify the passive design strategies in warm humid climate and hot dry climate. This passive design strategies include layout, orientation, built form, building envelop, thermal zoning, openings, natural ventilation, passive cooling. The undertaken review in this paper identify the passive design strategies in chettinadu houses and havelis, which seeks a better understanding and application of passive design strategies in vernacular architecture features in present architecture. This paper concludes consideration of passive design strategies suitably adopted from vernacular buildings in warm humid climate to integrate them in a present situation in a more comfortable and energy efficient ways.
Keywords: Passive Design Strategies, Vernacular Architecture, Vernacular Settlement, Warm Humid and Hot Dry climate

INTRODUCTION:

The term vernacular architecture is derived from the Latin word vernacular meaning native, domestic it tends to evolve over times it reflect the cultural environmental and historical context. Vernacular Architecture characters are widely varies from region to region due to the changes in climate pattern and different location. This paper discusses about passive design strategies to have been used in vernacular buildings in order to achieve more comfortable in during summer and winter. Passive design strategies has been used by human beings since in the earlier settlement period the people built their home to respond their climate through techniques is called passive design. The passive design strategies are defined by the use of natural characters, like the sun wind and the natural law of physics to produce low energy buildings and its maintains a thermal comfort for users using passive design building forms and thermal performance of a building elements including (architecture, structural, envelop) are carefully considered and optimized for interaction with microclimate The vernacular buildings provides various passive strategies including natural cooling and heating system and are more comfortable in compared to the contemporary buildings in today context.

PASSIVE DESIGN:

Passive design is concept to minimize the energy consumption in buildings and improve the human thermal comfort in buildings. The passive design elements are carefully design and optimized for interaction with local micro climate. The focuses of the passive design fully eliminate the mechanical energy consumption in buildings and providing thermal comfort in all times (summer and winter) periods. Building shape, orientation, and composition can improve occupant comfort. Through properly applying a passive design principle in building we can greatly reduce the energy consumption in buildings.

The four element concept in passive design strategies **FIRE** (Sunlight), **EARTH** (soil), **AIR** (wind or), **WATER** (rain or sea) these essential elements are used in vernacular buildings.

LIGHTING COOLING THERMAL MASS VENTILATION

FIRE WATER EARTH AIR

PASSIVE DESIGN STRATEGIES:

PASSIVE COOLING DESIGN STRATEGIES IN VERNACULAR BUILDINGS

WARM HUMID CLIMATE - CHETTINADU HOUSES,TAMILNADU

HOT DRY CLIMATE - HAVELLIS,RAJASTHAN

QUALITATIVE STUDY:

1. THE STREET AND ORIENTATION OF BUILDINGS

2. SPACE PLANNING

3. THERMAL MASS

4. BUILDING ENVELOP

- WALLS
- FLOOR
- ROOF

5. COURTYARD

6. NATURAL VENTILATION

7. SHADING DEVICES

8. PASSIVE COOLING TECNIQUES

METHODOLOGY:

The research methodology of this study is based on the case study using deductive approach and qualitative analysis of passive design strategies in vernacular buildings. This paper focus case study in vernacular buildings at warm humid climate and hot dry climate, to relate the use of certain passive design strategies to specific local climate condition, examples of different passive strategies were chosen and mapped in vernacular buildings.

Chettinad Houses- Warm Humid Climate

Havelis – Hot Dry Climate

CHETTINAD HOUSES (DESIGN FOR WARM HUMID CLIMATE):

- Provide maximum ventilation and free air movement by large openings.
- Provide maximum shading of direct and diffuse solar radiation.
- Avoid heat storage.
- Use reflective outer surfaces.
- Use ventilated double roofs.
- Use vegetation to moderate the solar impact
-

HAVELIS (DESIGN FOR HOT DRY CLIMATE):

- Provide maximum shading of direct and reflected sun radiation in the hot season.
- Balance the extremes of summer and winter by movable parts.
- Provide ventilation by regulated air movement and small openings.
- Avoid large exposed exterior surfaces.
- Use reflective outer surfaces.
- Balance the extremes of day and night temperatures by adequate thermal storage mass.
- Reduce internal heat production and conduction gain in hot seasons.
- Increase air circulation in humid maritime regions.

CHETTINAD ARCHITECTURE	HAVELIS, JAISALMER (RAJASTHAN)
Chettinadu located in the heart of the Tamilnadu (southindia). Karaikudi is the known capital of chettinadu and having a warm humid climate The chettinadu is a homeland of chettiars (nattu kottai chettairs). A generation belonging to wealthy traders and financiers. The chettinadu well known for 18th century mansions and their palaces, which are rich in cultural heritage art and architecture. The house was constructed following, the traditional science of the architecture(Vasthu Shastra). Chettinadu architecture is characteristic of using large spaces of rooms and courtyard. The locally available materials and decorative elements are imported from the different parts of Asian countries. Imported materials used for construction in chettinadu houses.	Haveli term is used for traditional houses and mansion houses, a Havelis of Jailsalmer date more than 300 years back. These traditional courtyard homes (havelis) are built on the ancient principles of vastu shastra. Havelis, the residence used for rich business man, land lords and zamindhars etc. These havelis a architecture in the combination of Muslims and Rajasthan architecture, richly carved and decorate it says about rich cultural and heritage importance of Jailsalmer. The courtyards are the common feature in havelis consists of two court- yard the outer courtyard for men where inner courtyard was occupied by women's.

STREET AND BUILDING ORIENTATION:

Street Pattern in Chettinad (Warm Humid)

CHETTINAD ARCHITECTURE	HAVELIS, JAISALMER (RAJASTHAN)
Orientation of the building with long axis in the east west direction. Long wall surfaces in the north and south direction. Settlement started off in the north west in a more organic pattern, old traditional houses. As the settlement grew eastward newer houses were constructed along cardinal directions, therefore grid iron pattern. The main settlement is on raised ground and slopes towards the tanks. Water from these tanks are used for domestic purposes. Shorter wall facing in the east and west axis on the southern side of the building the highest sun angle it's easy to limit using horizontal shading devices for windows The traditional vernacular houses are planned in a such a way that they stretch from one street to another street. In chettinadu houses the rooms are placed along a longitudinal axis. Chettinad houses consist of two or more court yards. The houses are oriented in east - west axis the entrance of the houses from the east or west direction the longer side of the building faces the north and south direction less exposed to the direct sunlight to avoid the direct solar radiation from the buildings.	In city of jailsalmer (Rajasthan, Indian) irregular pattern the layout of city is planned against the harsh climate. In jailsalmar streets are design in narrow pattern and shaded from the direct sunlight. The general street orientation is south east to north west axis. Most of the havelis buildings are orientated toward east and west axis longer walls are facing towards north and south direction and shorter walls facing towards east and west direct to avoid the direct solar radiation for examples Nathmalji's havelis. The layout of the town is the first defense against the harsh climate.The streets are Narrow and shaded from the sun. The general street orientation is south east to north West, which is at right angles to the prevailing summer winds. Hot dusty winds are thus kept out of the streets. At many places, buildings overhang the streets on both sides, providing a cool shaded area almost like a tunnel. In some places the buildings actually bridge across the streets. The contiguous construction ensures mutual shading by walls and other elements of the adjoining building. During the years 1750 to 1850 a.d. additions to the town included fortifications around the town and the construction of many beautiful residential buildings called "havelis".

Street Pattern in Jaisalmer (Hot and Dry)

SPACE PLANNING:

CHETTINADU HOUSES:

FRONT (MALE) SECTION OF HOUSE

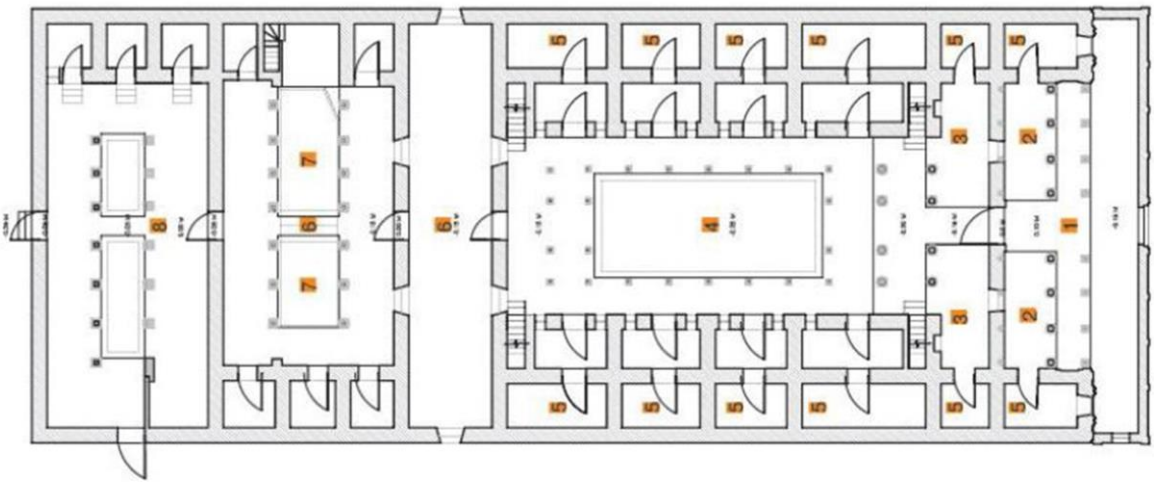
1. Veranda.Central, Ceremonial section of house

2. Hal Vitu or Vitu: First courtyard; literally, “hall house."

3. Tontu: Columns.

4. Melpati, Tinnai: a raised platform on which people sit, usually under the veranda or on either side of the door of the house.

TYPICAL GROUND FLOOR PLAN OF CHETTINAD PALACE



1 Thalvaram 2 Outer Thinnai 3 Inner Thinnai 4 Courtyard 5 Storage Rooms 6 Dining Hall 7 Service Courtyard 8 Backyard 9 Rooms 10 Passage 11 Look out area

5. Valavu: Aisle or Corridor surrounding central courtyard; central section of house including cent- ral courtyard, aisle, and inner and outer rooms; entire house.

6. Ull Arai: Pulli's inner room for puja and storage of dowry items.

7. Veli Arai: Pulli's outer, "conjugal" room. Kirpati: raised sitting platforms in front of each arai (not shown).

BACK (FEMALE) SECTION OF HOUSE

8. Kattu: second courtyard, women's courtyard; where grains are dried, foods are prepared, and water is stored.

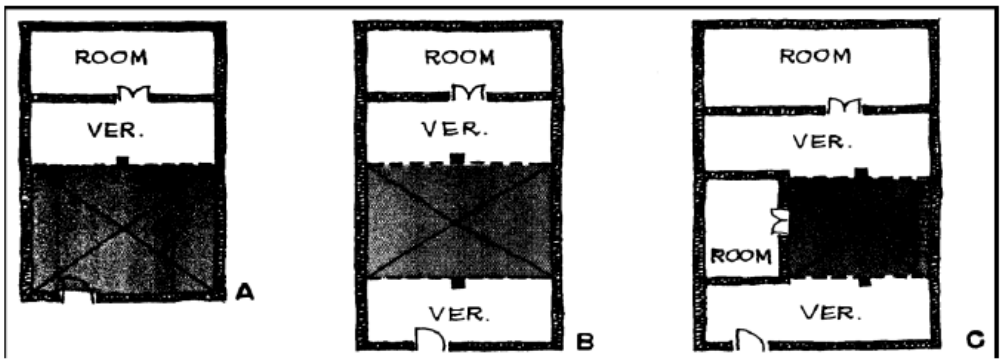
9. Samayal Arai: Kitchen.

10. Kutchin: a small room for women during their menses and for girls during their coming of age ceremony.

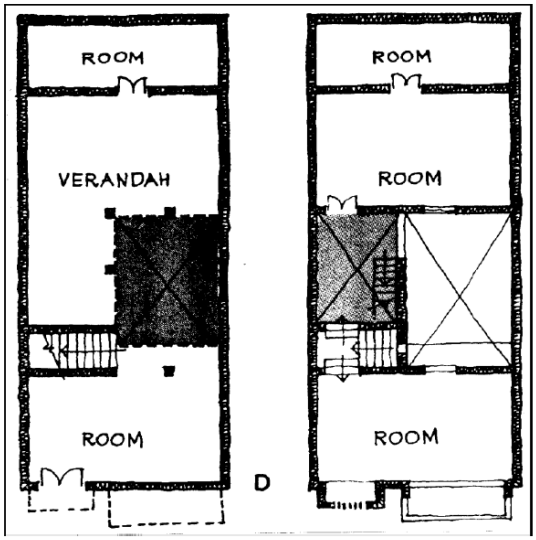
11. Veranda.

12. Pin Kattu: Open garden space with or without wel

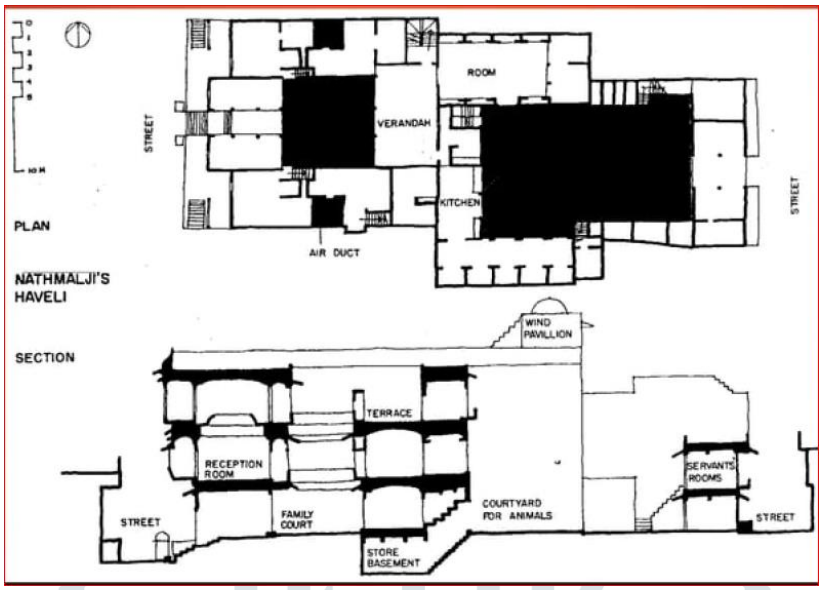
JAISALMER HOUSES, (RAJASTHAN)



Small houses in Jaisalmer



CHETTINAD ARCHITECTURE	HAVELIS, JAISALMER (RAJASTHAN)
The chettinadu houses accommodates space planning are segregated for both men and women. The men occupy the outer verandas and front room and the women occupy the outer kitchen, courtyard and the work around the main courtyard. The most important character of chettinadu houses is that it has a such visual axis which visually connects the all the spaces of the houses. In chettinadu houses comprised of public reception area in front of the street. The houses were built around the central courtyard. The entry of the houses con- sists of outside verandah thinnai for guest. The houses starting with a welcoming spaces called MUHAPPU (living hall). The rooms are planned around the central main courtyard used for marriage ceremonies and religious ritual activities. The small courtyard behind for cooking for the women's to socialize.	In Jailsalmer houses are planned according to the economic and social status there are three types of housing in Jailsalmer city. Most important architecture buildings in jailsalmer havelis (Nath malji havelis) Nathmalji havelis is planned around two courtyards the large courtyard are placed near to the entrance of the havelis the another one small courtyard located on the rare side of the buildings. The front portion of the havelis is three-storey height and rare portion of the havelis is two-storey height. In havelis consist of vertical ducts (courtyard) different sizes it provide light and ventilation through all rooms these openings ensure removal of heat by ventilation. In havelis walls are shaded with projection and balconies to avoid the direct solar heat gain.



Jailsalmer Havelis (Nath Malji Havelis)

THERMAL MASS:

Vernacular building have thick walls these thick wall are design to provide a thermal insulation also theses thick walls of low thermal conductivity material have low transmittance value and it has a longer time lag The rate of heat flow through the surface it depends on the temperature between inner and outer surfaces. Large thermal capacity of the building material its absorbs most of heat during the day time and the internal surfaces remains cool. To reduce the heat transmission through the build- ings the temperature of the outer surfaces are controlled by using shading devices.

BUILDING ENVELOP: The building envelop plays a major role in thermal mass of the building Envelop is a physical separator of interior and exterior spaces it encompasses the walls roofs, floors, fenestrations etc.

CHETTINAD ARCHITECTURE	HAVELIS, JAISALMER (RAJASTHAN)
WALLS The walls had chettinadu plaster Muthuvellai- traditional mix of roots, Yolk, chunnam jaggery, adukka that leaves the surface silken smooth and washable and mirror finished. In chettinadu houses are built with thick external walls. The material used to construct the walls are stone and bricks the external wall thickness in chettinadu houses are construct with 2ft (600mm) thickness and the internal wall thickness is 1'6". The external walls are plastered with lime mortar and the internal wall plaster it gives more thermal comfort inside the house. Lime - binding material Sanghu powder - fitness Egg white - smoothness Karupatti - friction Kadukkai - bonding	WALLS Light yellowish sandstone wall is used for construction in havelis the external wall thickness is 0.45 m In havelis the walls with texture are only 500 mm thickness. The massive wall thickness is 450 mm to 600 mm The wall surfaces are richly decorated with projecting balconies, sun shades and jalli, and each of these build-ing elements is in turn intricately carved. Flat surface of stone walls are also richly decorated with deep carvings. That resulting overall building surface is designed to stay cool even when it is exposed to the sun.

FLOOR AND ROOF The flooring in chettinadu houses flooring with special types of tiles (athangudi tiles), these tiles are manufacture near locally in athangudi village this tiles are handmade tile it consist of raw material like (local mud, sand, white cement, col- our pigment). The thermal property of athangudi tiles are highly conductive its gives the cooling effect inside to the interior spaces. Chettinadu houses are design with three types of roof systems Sloped roof, Sloped roof with a flat roof below (machu). The madras terrace roof: Expansion of sloped roof surrounded the last courtyard near to kitchen spaces. The sloped roof is made up of terracotta tiles are laid in three courses over the wooden batten. This terracotta tiles in roof it consist of three layers are thermally design laid over one above to another with a minute air gap to allow a hot air to escape.	FLOOR AND ROOF In havelis traditional method of roof is laid closely spaced with timber beams are covered with layer of reeds or grass matting with a thick layer of 0.45 to 0.60m earth layer on the top of the roof. The roofs are finished with mud plaster. In recent construction the timber beams are replaced with stone slabs but according to popular belief the wooden ceilings with grass mats stay cooler than stone ceilings. Two types of construction are used for roofs and floors. The traditional method is to lay closely spaced timber beams and cover them with a layer of reed or grass matting and a thick layer (0.45 to 0.60m) of earth on top. Because of the difficulty of finding timber in the desert, in some later houses the timber stone slabs have replaced beams. In all cases the roof and floor are finished only with mud plaster. This presents no problem of water seepage, as there is little rainfall.
WOOD THE THERMAL INSULATIVE MATERIAL The flat roof in these houses made up of timber. It being a high thermal resistive material. The furniture, cupboards, doors, windows, columns roofs, false ceiling and other artifacts in the traditional houses are all made of wood (teak wood) — the climate responsive material having a good thermal resistive property.	STONE THE THERMAL INSULATIVE MATERIAL In Jaisalmer, the walls with texture are only 50mm thick while the massive walls are 450mm to 600mm thick. Finned surfaces - reflective fins, they managed to increase the absorptivity of the absorber and reduce its emissivity. The improved efficiency of the collector was mainly due to the improved heat transfer between the absorber and the incoming air.

COURTYARD:

In hot dry and warm humid climate courtyards located at the centre of the building and it provides a comfortable place for living. The courtyard prevents the internal rooms from the direct solar radiation and hot dusty winds. The courtyard shaded throughout the day. Due to the solar radiation in the courtyard, the air in the courtyard warmer and rises up. To replace the cool air from the ground level.

Courtyard Functions:

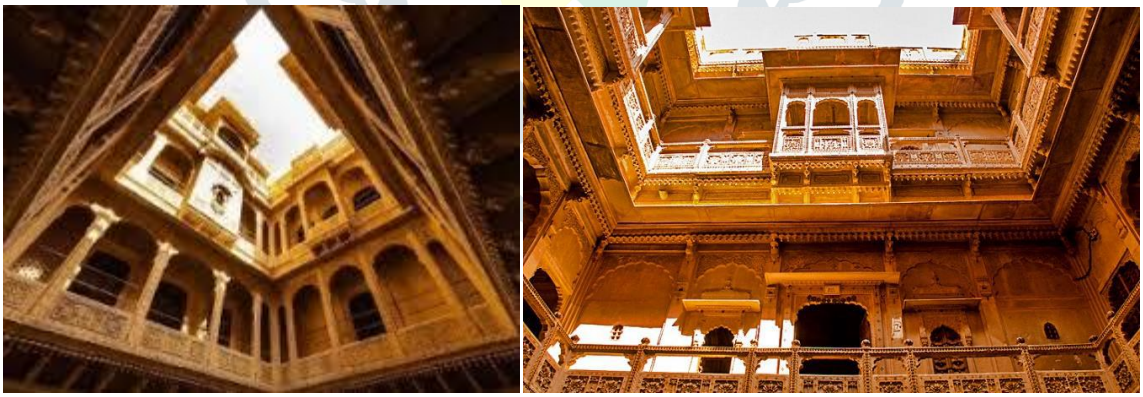
Night: The cool air comes down in the courtyard and it passes through the inside rooms in building.

Afternoon: The sun directly heated the wall that faces to the courtyard the air heats up and goes providing the natural ventilation. The courtyard works as a chimney. The huge massive wall and floors protect from direct soar radiation.

Evening. The air is so hot in evening and the courtyard floor heats creating a nat- ural air flow from the inside rooms that faces to it through the courtyard. The last cool air goes out from the rooms in the evening, but also the shadows are longer and quickly the court is protecting from the solar radiation.

Courtyard in Chettinad Houses

CHETTINAD ARCHITECTURE	HAVELIS, JAISALMER (RAJASTHAN)
In chettinadu houses, living hall mugappu leads to the first main courtyard used for the purpose of marriage ceremonies, religious ritual activities. The Second courtyard opens out immediate after the first courtyard this spaces is used for dinning purpose the second courtyard serves as rest room for the women's who works in the kitchen spaces. In second courtyard roof surfaces are sloped towards an internal courtyard, the cooled airflows through the courtyard and enters the living spaces through the low level openings and leaves through the high level of openings in the chettinadu houses.	In Nathmalji's havelis consist of two courtyard and vertical ducts provides alight and ventilation for all the rooms. While the front courtyards receives sunlight during the summer seasons. The rear courtyard is completely exposed from the direct solar radiation

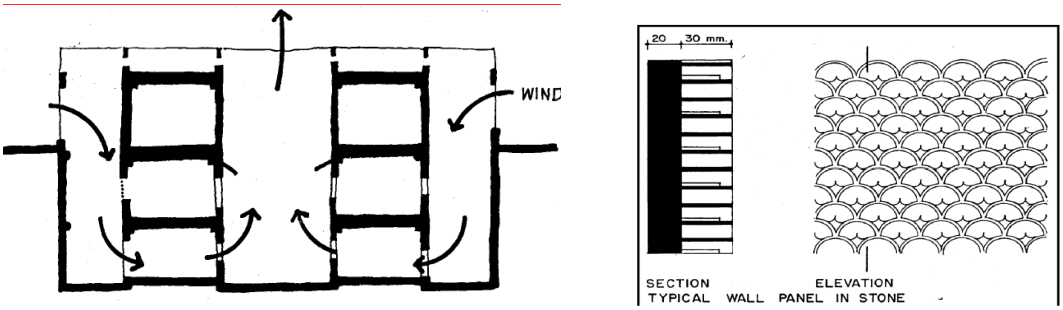


Courtyard in Havelis

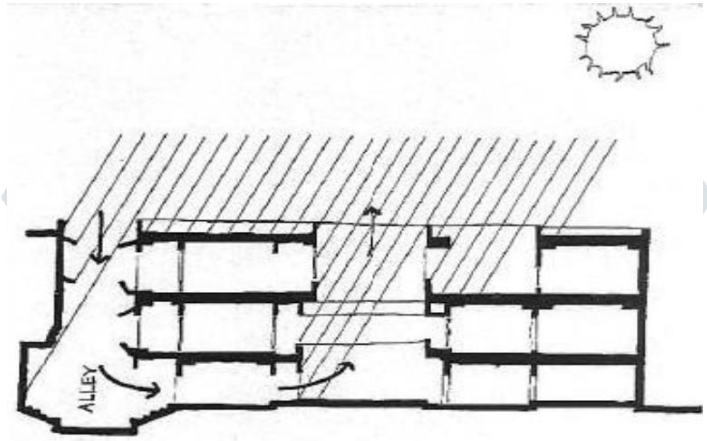
NATURAL VENTILATION:

Natural ventilation plays an important role in vernacular buildings to create a thermally comfortable environment. Natural ventilation is the key factor for the Passive design strategies. The natural ventilation through vernacular building is occurred by wind or the temperature difference between inside and outside. There are several factors which affects the wind flow in the building such as micro climate, size and proportion of windows orientation of building with respect to wind direction.

CHETTINAD ARCHITECTURE	HAVELIS, JAISALMER (RAJASTHAN)
CLEARSTORY In chettinadu houses the openings such as doors and windows in such a way it induces the cross ventilation. The positioning of doors and windows plays an important role in enhancing the passive ventilation in the buildings. The sill levels of windows are kept 1'6" height from floor level to gain the maximum air circulation to the living areas. The doors, windows, clearstory windows all serves as passive cooling elements by providing excellent cross ventilation. The window sill kept at low level (1.6" from the floor level so as to induce better air Circulation inside the building. HORIZONTAL SHADING DEVICES In chettinadu houses horizontal shading devices can be used in north and south side it cuts the direct solar radiation to achieve a minimum heat gain in buildings. In direct day lighting has a benefit of day light access to interior spaces while avoiding a heat gain in buildings. VEGETATION Vegetation plays an important role in vernacular buildings, it reduce solar heat gain and also it cuts the direct solar radiation in buildings. In chettinadu houses PINN KATTU (OPEN GARDEN SPACES) is faces on the west side of building it reduce the air temperature and brings a fresh through the buildings (longitudinal axis) MACHU These Machu are constructed below the sloped roof. The wooden beam that runs though horizontally supports it connected to the rafters and tie member. This re- duces the heat transfer through the roofs acts as an barrier below the sloped roof surface and act as a air trap, this construction technique is considered as a good passive cooling construction technique.	VERTICAL SHAFTS In Jailsalmer Havelis are tightly clustered together it is generally difficult to let wind enters into the houses. It consist of number of interconnected vertical shafts it regulate the air flow through the houses. The courtyard effect is well known and used in almost all hot dry climate. In Havelis consist of simple courtyard, narrow vertical shafts are used to regulate wind blows in to the houses. JAALI WORKS The "Jaali works in Havelis it provide a privacy and it controls the air flow in the buildings and it lower the temperature of the internal spaces, when there is strong solar radiation (sun shine) outside of the building. The internal spaces are not visible from the outside of the buildings by using the jail works diffused sunlight is spread through the interior in havelis. It consists of placing a double skin as the outer layer of the havelis. The outer skin layer can be promoting to let in natural light This double skin acts as a thermal screen of sorts, letting in light, but not heat, In jail works is provided a eye level for viewers sitting on the floor.



Natural Cooling System in Havelis



An Effective Courtyard System in Havelis

PASSIVE COOLING TECNIQUES:

WARM HUMID CLIMATE (CHETTINAD HOUSES)	HOT DRY CLIMATE (HAVELIS, JAISALMER)
• Sun control through orientation • Massive construction for roofs and walls • Courtyard • Cross ventilation through longitudinal axis • Clear storey windows • Machu below the roof it reduced heat transfer • Shading devices	• Dense clustering of buildings. • Sun control through orientation and structural projections. • Cooling of sunlit surfaces by use of fins. • Massive construction for roofs and walls. • Courtyards • Vertical air duct for Ventilation • Wind scoop • Shading devices

CONCLUSION:

The purpose of the study was to determine the main passive design strategies in the field of vernacular architecture and make a comprehensive definition of passive strategies (elements) in the field of vernacular architecture. By incorporating or adopting the passive design principle we can reduce the energy consumption in the building as well as the layout. We can also minimize the load of heating, ventilation and lighting to incorporating the passive techniques.