# Analysis of Solar Passive Architecture for Historical Structures in Hot and Dry Climate

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***Abstract*: The research's goal is to find and analyse passive cooling systems used in Historic building architecture. Historical constructions are not only gorgeous, but also functional, realistic, and artistically pleasing, with inspiring details. For the time being, it is critical to include these aspects into modern architecture in order to reduce active energy use in buildings. It is apparent that historical structures have a well-constructed coherent basis based on natural characteristics, climate, local material and intellectual reactions to physical conditions in order to provide comfort and inspirational forms in accordance with the climate. The main issue is to develop cooling solutions that can be used in both olden and modern buildings, with a focus on which techniques and architectural structures can save energy at a high level.This study aims to perform a survey of historical buildings in order to determine how buildings have been ventilated in previous years and what concerns have arisen in the past, as well as to investigate structures that are energy efficient and employ passive cooling techniques. This research will provide various suggestions for building cooling, including how to remove undesired heat from the sun and whether ways are relevant or not.**

***Keywords*: *Solar Passive Architecture, Historical Buildings, Passive Cooling Techniques, Sustainable Buildings***

## INTRODUCTION

Solar passive architecture is the utilisation of solar energy to meet a home's heating and cooling demands while reducing energy usage. It can also be defined as the architectural design of structures whose orientation, shapes, shading, materials, fenestration (door/window openings), and site planning enable the structure to naturally store heat energy from the solar rays, resulting in unaided air movement. The location of the building, the temperature, and the materials used are all taken into account in order to reduce energy use. By utilising free renewable energy, such as solar energy, energy-efficiency measures are applied to lower the building's heating and cooling requirements. Since the dawn of time, mankind has relied on passive solar majors. India's classical architecture bears witness to this. Passive solar techniques are as diverse as architecture itself, and they vary according to climate.

According to the NBC 2005 climatic classification, while India has a wide range of climate classifications, it is mostly a tropical country. The climate is hot, dry, warm, humid, and composite in around 90% of the territory. As a result, climate responsive buildings are built to reduce heat gain while still allowing sufficient lighting into the living space. The following are some of the passive design principles used to maximise building design that limits heat gain while allowing maximum natural light:

1. Optimum orientation
2. Internal space arrangement (thermal buffer zone/buffer spaces)
3. Allocation of building openings
4. Sizing of openings (limitation of window wall ratio and skylight roof ratio)
5. Appropriate shading design (facade shading and fenestration shading)
6. Adequate day lighting (optimum day lighted area and daylight factor)

Solar passive architecture: Legacy from the Past

Historic buildings were designed with many sustainable features responding to climate and site. Because they were designed with excellent craftsmanship and materials that promote a long physical life, heritage buildings benefit from embodied energy. They've been thoughtfully constructed with passive cooling, heating, lighting, ventilation, water harvesting, and storage in mind. Sustainability requires both energy efficiency and water management. Various passive cooling strategies are used in heritage buildings, including thick walls with high thermal mass, high ceilings, courtyards and verandahs, solar shading devices such as jaalis, canopies, still and moving water bodies for evaporative cooling, natural ventilation through wind induced flow to cool the interior, and efficient day lighting and water management systems. Jaali in the wall blocks direct sunlight, reduces glare while allowing enough light in and ensuring a continual flow of air.

Ventilators are vents on the upper end of the ceiling wall or on the top of windows that allow hot air to depart while keeping cooler air within while also allowing light into the room.

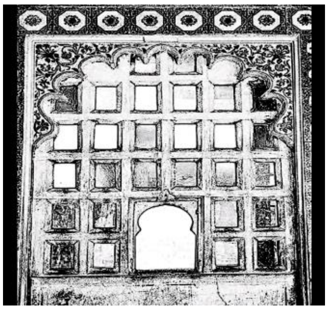

Fig 1: Ventilators

Jaiselmer and jodhpur have dense clustering layout to ensure that the buildings were not directly exposed to the sun.

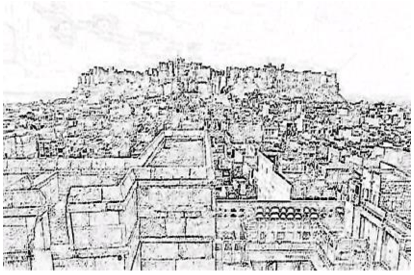

Fig 2: Clustering Layout of Jaiselmer

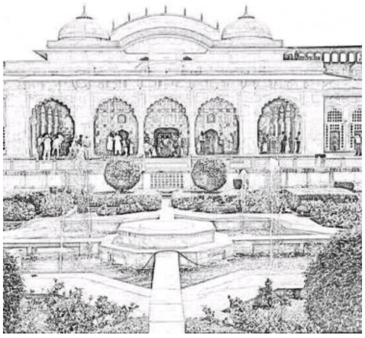

Fig 3: Fountain to improve air quality

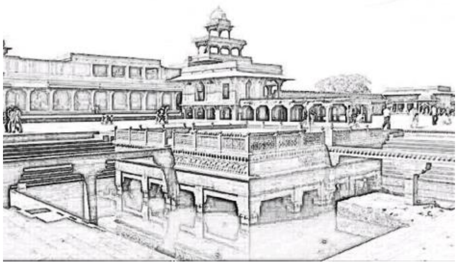

Fig 4: A Water body of Fatehpursikri.

The Taj mahal employs a multitude of passive cooling measures to keep the interiors brightly lit and airy. There are jaalis, a gigantic dome, high-thermal-mass walls, cross ventilation, and the usage of green spaces and water bodies around the built form, among other things. All of these aspects contribute to the building's cooling, which is especially beneficial during the summer months.

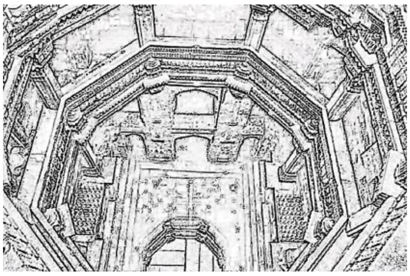

Fig 5: Adalaj Ni Vav famous step well in Ahmedabad.

Hawa Mahal in Jaipur - Natural cooling system

The Hawa Mahal in Jaipur contains 953 jharokhas, or windows, that allow for air flow while also keeping the temperature down. The honeycomb-shaped and ornately carved windows allow breezes to flow through the palace, making it ideal for use as a summer residence. The Hawa Mahal's architecture allows the royal women to enjoy everyday city scenes as well as regal processions without being observed. Small lattice-worked pink windows, balconies, and arched roofs with hanging cornices adorn the mahal. This permits a pleasant breeze to pass through the mahal in the heat, keeping it cool and airy. Despite the enormous number of windows, each one is the size of a peep hole, ensuring that the royal ladies remain hidden from view. According to the scientific venturi effect, these tiny openings allowed air to push through and cool down (where the air squeezed through the tiny holes and cooled the place down). These windows served two purposes: one, to keep the palace cool, and two, to allow the women hidden behind them to observe the world outside while remaining protected.

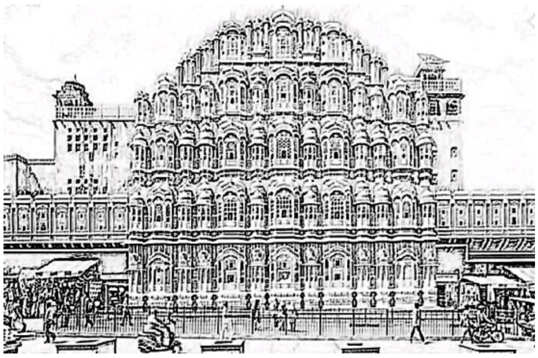

Fig 6: Hawa Mahal in Jaipur

Amber Fort, Jaipur - Water Lifting System

In Amber fort, courtyards, water systems, passive design methods, art, and decorations are all constructed in a very articulate manner, demonstrating hydraulic engineering, architectural integration, and meticulous urban planning. The building's most intricate feature is its underground chambers, which contain many passive design components such as wind tunnels, water walls, ponds, cisterns, thermal mass, and material.

The Amber Palace's major supply of water was the Maota Lake. At Kesar Kyari Garden, water was extracted from the lake and raised to various levels of its mechanism:

STAGE 1: Animals and a number of pulleys and leathern bags were used to raise water from the lake along the eastern front of the Kesar Kyari. Water was collected in storage tanks placed on the terraces overlooking the garden using this method. From there, it was channelled into another storage tank at the bottom of the second stage by a 125-meter-long sectioned clay pipeline.

STAGE 2: This stage is made up of four separate but connected structures built in ascending order. Each structure has its own pulley and rope arrangements made with animals, as well as its own intake cum storage tanks at the bottom. Water is drawn from the lowest storage tank to the next in leathern bags slung over the pulley with the rope. Water was carried up from the first storage tank on the lowest level of Balidan Gate [dhruv gate] to the last one on the first floor. The structures range in height from 10 to 13 metres, implying that the system elevated water to a height of roughly 45 metres in total.

Step 3: A Persian water wheel, or Rehat, is used in the final stage of the lift. This technique, known as 'Sakia in Persian,' seems to have been popular as early as 500BC. It is made composed of a long wooden shaft that rotates on its axis and supplies power to the axle of the drum, which is tied to a rope with a number of earthen buckets. The rope and its linked vessels were pushed elliptically down into and then up through the water in the tank by the spinning drum. The pots were filled with water during the operation and then hauled up the mechanism, decanting their contents into a collection channel at the very top. The water was then circulated around the castle via an earthen pot network.

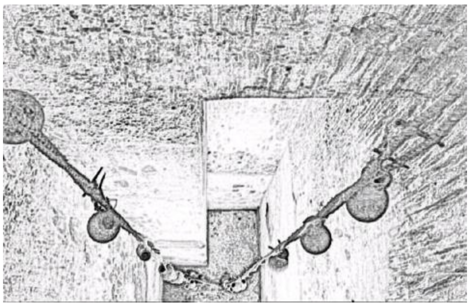

Fig 7: Water Lifting System in Amber fort

Patwon ki haveli, Jaisalmer - is definitely an excellent piece of architecture, located in the heart of the city. It was built in red sandstone between 1800 and 1860 AD and is notable for its magnificent latticework on its stone and wood porticos. It contains a magnificent flat that is impeccably adorned with stunning murals. The beautiful wall murals, intricate yellow sandstone-carved jharokhas or balconies, gateways, and doorways make Patwon Ki Haveli famous. The main doorway is brown, despite the fact that the building is composed of yellow sandstone. It is a lovely Haveli with exquisite latticed havelis and a five-story building front. The following are the building's distinguishing features:

1. Chowk
2. Parsal
3. Choubara/Khadki
4. Zarokaha/Verandah
5. Otala

1. Chowk — a centrally placed open space surrounded by partially covered and/or totally shaded areas. It primarily serves as a source of light and air for the activities taking place in the surrounding. The courtyard also served as microclimate modifiers.

2. Parsal is a somewhat covered space flanked on one side by an open courtyard and totally shaded on the other by Khadki/choubara. Low-intensity light is shadowed in this area. It features both active and passive activities, as well as serving as a transitory space, which is why it is the most dynamic part of the house, situated between the fully shaded rooms and the open courtyard. It gathers light from the courtyard and transports it to the room.

3. Khadki/choubara is a fully shaded space or room with osari (partially shaded area) on one side and either an open or partially shaded area (otala) on the other.

4. Zarokaha/verandah is a shaded, sun-drenched, and breeze-drenched area. A semi-shaded or open area. The verandah, on the other hand, is on the ground floor, while the Zarokaha is on the higher floors. Zarokaha is designed to provide shade to the lower storey while still allowing communication with the street.

5. Otala - The outermost section of the home is known as Otala. Either an open or partially shaded area will suffice. A raised outdoor space linked to each building and usually sheltered from the elements by a verandah or rooms.

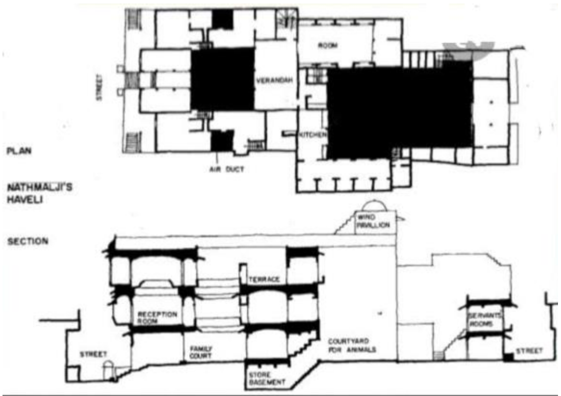


Fig 8: Patwon ki haveli, Jaisalmer

Mandu, Madhya Pradesh

Mandu is a classic example of the mediaeval period's provincial style of art and building. It was 2000 feet above sea level, with no aquifers or ground water, and had to rely on precipitation during the monsoon season. Here you'll find a combination of governmental and residential palaces, pavilions, mosques, reservoirs, and baolis, among other things. All of the structures were meant to be as close to nature as possible, with arched pavilions, light, and airy constructions that did not trap heat that could harm the ecosystem. Locally sourced stone and marble were used. It could be seen as an excellent example of environmental adaptability in architecture. These constructions were designed to collect rainwater. In Mandu, there was excellent water management. Each monsoon has 1200 tanks of various sizes and shapes that are filled of water. Water canals connect wells, step wells, and lakes all throughout the place. If a water crisis arises, Mandu town may be able to meet it with its water reservoir.

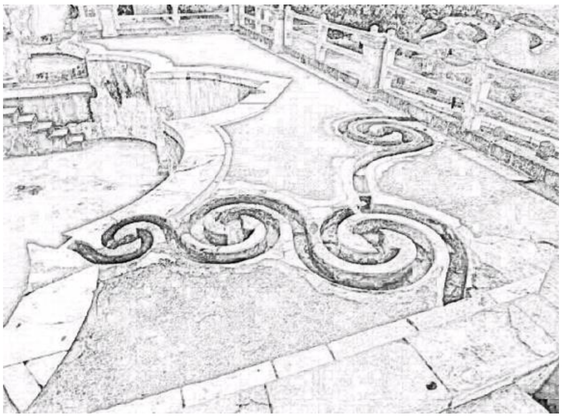

Fig 9: Water management System in Mandu, Madhya Pradesh

Passive Design Key to Sustainable Buildings

Passive approaches take advantage of the surrounding environment to maximise comfort while reducing energy consumption and negative consequences. Passive cooling techniques such as ventilation, window and wall shading systems, natural cross ventilation, trees, water bodies, courtyards and verandas, and thick walls have been found to be particularly helpful in ensuring indoor comfort. To increase sustainability, passive design concepts should be created and used with current modern technology. The combination of evaporative cooling and wind towers has been found to be particularly successful in lowering indoor temperatures. A combination of trombe walls, thermal insulation, and a cool roof could result in significant energy savings.

## CONCLUSION

The findings of this study are based on surveys of Historical structures in hot and dry climates. It revealed some extremely fascinating passive approaches that were employed in old structures but are now out of use and becoming increasingly extinct. It is critical to document these historical structures and to take appropriate measures to conserve these structures, which are an important part of our past. It is impossible to rebuild tangible legacy after it has been gone. If these old but magnificent buildings are refurbished and restored, they can serve as a tourist attraction and generate revenue. The strategies utilised in these Historical structures must be used to modern construction in order to alleviate power shortages and make buildings more durable, sustainable and energy efficient.

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