

**ANCIENT ARCHITECTURE FROM INDIA CAN BE AN EFFECTIVE
WAY TO REDUCE THE RISING TEMPERATURE OF THE
APARTMENT COMPLEXES IN GURGAON**

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DOI: 10.46609/IJSSER.2022.v07i08.005 URL: <https://doi.org/10.46609/IJSSER.2022.v07i08.005>

Received: 1 August 2022 / Accepted: 10 August 2022 / Published: 30 August 2022

ABSTRACT

The aim of the paper is to tackle climate change, the effects of which can be felt, with increasing magnitude, every passing month. Climate change affects everything on the planet including human beings. Humans have played an instrumental role in their own destruction by aiding the process of climate change, with careless use of our energy resources. With each passing year, Earth faces more and more irreversible damage. To combat this we must initiate and implement action.

The focused goal of the paper is the application of ancient architectural designs as sustainable architecture in Gurgaon, a major satellite city and the second-largest IT hub in India. Urban cities are the biggest problem areas, with limited space, high population, and high energy consumption, therefore making them a mammoth problem. Sustainability is key to tackling climate change which is why the answer to the problem lies in sustainable architecture. Urban cities have an ever-growing need for housing and structures due to the increasing population. Gurgaon faces frequent heat waves, constantly high temperatures, and dust storms. The majority of the buildings rely solely on external cooling devices thereby increasing energy consumption.

The paper reviews different passive cooling mechanisms and procedures that were implemented in ancient buildings and their efficiency while discussing the practicality in applying these mechanisms while building a modern structure. While the literature on the uses and application of ancient architecture to create sustainable, modern buildings is available, one of the prominent gaps is its implementation in urban areas like Gurgaon. This paper seeks to bridge together the scattered research put forth by all the literature to create a solution to the problem. The use of

ventilation, as a cooling mechanism, was seen throughout every structure highlighting its effectiveness in creating cooler structures.

Insulation was used as a way to stall the entry of heat into structures. Building material plays an imperative role in the overall thermal comfort of a structure. Evaporative cooling is one of the simplest and most effective cooling mechanisms ancient designs applied in structures. Excessive energy consumption and pollutants contribute to high temperatures. This paper discusses all these themes.

The simplicity of ancient architecture made it incredibly sustainable. It incorporated passive cooling mechanisms for structures, ensuring thermal comfort and negating any polluting emissions. They had lower electricity/energy consumption, the use of which is directly related to the release of greenhouse gases which is one of the most potent causes of climate change. This paper is a thematic analysis of various researches done on the topic of ancient architecture, and a discussion based on the implementation of the said architecture in modern cities like Gurgaon. The objective of the paper is to present the feasibility of adapting ancient designs into modern structures, in order to create economical and green housing, with the application of passive cooling, by analyzing and identifying patterns in the available literature. It can be a way to curb the rising temperatures of this metropolitan city.

Introduction

Most of India's hottest cities belong to the northern region of the country. Gurgaon is one of the hottest cities India has, which coincidentally also happens to be home to a population of more than a crore. The majority of residents of this city work in high stress workplaces, such is the demand of a metropolitan city, with their homes being their only refuge from their fast paced lives. The problem is that their homes use excessive electricity, increasing their costs, inflating their burden as well as contributing to the problem of the rising temperatures of the city. Gurgaon recently recorded the highest temperatures they have had in years due to which the usage of mechanical cooling devices, primarily air conditioners skyrocketed. Power cuts across the city made it close to impossible to withstand the sweltering heat. On top of that, a very known fact is that 75% of India's electricity is generated using coal, a thermal power plant. Burning fossil fuel releases large amounts of carbon dioxide, a greenhouse gas into the atmosphere. These carbon emissions trap heat and speed up the process of climate change.

While India is trying to break away from using coal, and start using cleaner energy, the fact remains that it is a long drawn process with thousands of livelihoods dependent on the thermal

energy industry. It will take time to find the solution but in the meantime the issue of global warming only escalates. This is why the focus should be on minimizing energy usage. Employing passive cooling techniques, that are recognizable in ancient architecture, in new constructions is an efficient way to go about it.

There are thousands of examples of these techniques that were used in ancient architecture, that have proven to be efficient. Ancient homes were sustainable. Sustainability is the only way humanity will make it to the future. Humans have already been deemed responsible for the extinction of other species but we may very well be the reason for our own too. Talks about the extinction of our species have been underway for decades; if we are not mindful about how we proceed, the speculation may be correct.

Sustainable housing tackles a variety of issues, one of which includes poverty. While it may not eradicate the problem entirely it can alleviate the pitiful living conditions that people face. By using the simple designs of ancient architecture, sustainable houses can be built for such people. The heat, as was stated earlier is a huge problem for these people. With passive cooling techniques, their living costs can be cut down upon, since the buildings themselves will have great thermal comfort, making them energy efficient and economical.

Ventilation, is one of the simplest amongst the techniques and also one of the most efficient. All ancient architecture that was in hotter regions of India employed ventilation as one of the ways used to cool it. Even a strategically placed window can have a wondrous effect on the internal temperature of the buildings. Evaporative cooling, though a seemingly complex name, is one of the simplest and oldest passive techniques to exist. It requires close to no money to implement, the only the required is water. The materials used to construct the building play an even more significant role in providing thermal comfort since they are what will make the building characteristically cool. Painting the house using lighter colors has a great impact on its temperature. The darker the color is the more heat it attracts, so using light and airy colors will result in a home that is just so. Insulation can be as simple as having thicker walls since they delay the entry of heat into the house.

This paper provides insight into the application of these techniques and real-life examples and data that prove that these passive cooling methods are workable. Ancient architecture is the future.

Literature review

The existing literature was reviewed to understand the problem space and the gaps that need to be addressed. As this study brings into conversation dual facets of the application and implementation of ancient Indian architecture to further sustainable development in urban areas of India, it is important to systematically review the literature available. There were minimal studies that incorporated both aspects of the research question. The following section reports the literature that addresses the needs and benefits of the implementation of ancient building design and cooling techniques into modern architecture.

The design analysis carried out by *Kumar et al. (1994)* proposing roof and wall designs that are created using an amalgamation of traditional and modern features is an appropriate place to start. Through their analysis, they argue that ancient architecture in India demonstrates significant innovation in the use of locally available materials and techniques to create buildings that are well fitted to local climatic circumstances. Similarly, a comparative study of thermal comfort in traditional and modern buildings by *Sharma (2019)* concluded that a traditional building had a constant temperature in contrast to a modern building. Solar passive cooling techniques are consistent in ancient architecture and design, as can be seen in the thematic analysis by *Gupta (2017)* who reviewed and investigated some examples of ancient architecture and its building elements from India tracing the respective passive cooling potentials.

The temperatures in ancient buildings are significantly lower than in modern buildings without any external cooling devices, hence making them energy efficient. Sustainability must include consideration of the environmental, economic, and social requirements when designing a building. *Pandit et al. (2019)* observed that natural cooling arrangements provided in ancient buildings have considerable influence on interior thermal comfort. Such arrangements are often not considered when designing new structures. Hence, energy consumption in a modern structure is often greater for the same thermal comfort. According to *ZAGYI (2013)*, the need for air-conditioning devices contributes not only to the growth of municipal & public electricity consumption and emission of pollutants, but it is also responsible for a negative self-generating process: more greenhouse gases are released as a result of air conditioning and our environment becomes warmer. International Energy Agency reported that worldwide buildings consume almost 40% of energy. With a growing population and improvement in living standards, this energy consumption may further increase, thus piling on to climate change. Therefore it is important to design buildings with enhanced thermal comfort and minimum use of fossil fuel-based energy. *SUBRAMANIAN et al. (2017)* sought to provide a solution to the biggest challenge that architects face, which is to design a thermally comfortable living environment with minimum or without the usage of electromechanical devices with their detailed review.

They found the solution to be in ancient design and its features, it offers a good solution to the climatic constraints, allowing natural daylight which results in indirect passive cooling, natural ventilation and openings reduce the dependence on artificial means of cooling leading to energy conservation and is an effective passive cooling technique. Air temperature, air velocity, thermal comfort, and thermal simulation can all be adopted from ancient buildings for creating better thermal comfort in modern buildings with less energy consumption. Ancient architecture can be used to create sustainable, modern buildings and while it may not be in widespread use in the near future the aim should be to publicize the advantages of such design for a cleaner and greener future.

While the literature on the uses and application of ancient architecture to create sustainable, modern buildings is available, one of the prominent gaps is its implementation in urban areas like Gurgaon. An area that is subject to temperatures up to 48 degrees Fahrenheit and frequent heat waves. It is a bustling metropolitan city, with a considerably large population who are subject to dehydration, body ache, fever, and other issues due to the high temperatures. It also means that free space is scarce and makes it hard to execute passive cooling designs.

While not necessarily adding to a “gap,” this study would fit into the growing body of research that aims to understand more about the functionality and feasibility of ancient cooling systems that can be integrated into modern buildings.

Methodology

This paper was written by first beginning the research and looking for papers relevant to the topic. To select the papers that would be used to write this paper, I read through the abstracts and selected them based on how relevant and helpful they were. I then began to do annotated bibliographies of the papers. After this, I decided to do qualitative research instead of quantitative research and chose thematic analysis as my medium of qualitative research. I went through all the papers carefully and tried to find themes. After recognizing my themes I narrowed them down to 5 main themes. I then elaborated on the 5 themes and presented my point of view, to express why I thought ancient architecture from India could be an effective way to reduce the rising temperature of the apartment complexes in Gurgaon.

Findings

1) Ventilation

Ventilation was seen as a way to reduce the temperature in ancient India. The use of ventilation, as a cooling mechanism, was seen throughout every ancient structure highlighting its effectiveness in creating cooler structures. In ZAGYI (2013), it was noted that “One of the newest modern-day adaptations of the formal solutions of the traditional Indo-Islamic architecture serving passive aeration and air cooling is the

educational centre of the 5, the institute playing a leading role in fashion and design training in India which has been dreamed in Manit and Sonali Rastogi's architect studio and was opened in 2008 in Jaipur. The creators have based their architectural conception on the ancient methods of air comfort improvements presented above. Out of them, they gave all their attention to apply jalis to shade and baoris to cool air. The most prevailing detail of the conspicuously closed, introverted compact building situated in an industrial park, approximately 20 km (12.4 mi) far from the centre of the seat of the hot and arid Rajasthan is the perforated pattern metal frame placed around about 1.2 m (3.94 ft) in front of the façade which looks as a modern but less expressive reminiscence of the ancient stone-carved jalis. This structural element provides not only for filtering light rays, but it also serves to enclose a thermal buffer zone around the exterior wall front which delays the heat effect of the solar radiation. The water reservoir being equivalent to a baori has been formed through a several metres step-sided lowering of the ground level.’ Ventilation is quite possibly one of the cheapest and simplest cooling mechanisms that can be incorporated into buildings.

Modern architecture already has provisions for ventilation because it is an essential part of any structure. The focus of the design should be on maximizing the ventilation in a building.

2) Insulation

The purpose of insulation is to delay the entry of heat inside the house and incorporating insulation into modern homes will help achieve greater thermal comfort. *SUBRAMANIAN et al. (2017)* compared the traditional and modern Architecture in Ghana. The temperature measured in traditional indoor varied from 28-35 °C and in modern building it ranged from 31-37 °C. The maximum MRT was found to be 4-5 °C less in traditional building and 3 °C higher in modern building than the corresponding indoor air temperature. In a traditional building the roof was made of the thatch ensuring well ventilated membrane with pores in between. This offers high insulation and allows hot air to escape. The modern house had corrugated metal sheets allowing heat, increasing air temperature and thermal discomfort. Effective passive and natural central system in traditional building provides better thermal comfort than the modern building.’ Insulation is applied in ancient architecture quite frequently, it can be designed differently to

serve either a cooling or heating purpose thus cutting down on our dependence on artificial temperature comforters.

3) Building Material

The materials used to construct a building play an instrumental role in the thermal comfort it can provide. In research from ZAGYI (2013) it was noted that “The right choice of building materials and structural forms improved the air comfort of the inner spaces, too, as they were fitted to the different heat absorption and emission properties and the diurnal temperature fluctuations of the individual house sections on the lower and upper storeys. The thick-walled, flat-fronted ground-floor rooms were massive block-like constructions, usually made of sandstone which slowly admitted the warmth of their environment and were fairly delayed.” The materials used can reduce the temperature of a building without any external assistance. The use of more sustainable material contributes to the thermal comfort of the building as well as a cleaner environment since the sourcing of the material is not from large carbon-emitting factories, as has been noted in Pandit et al (2019) where they stated that “traditional buildings typically use locally sourced materials, whereas the cement and iron used in modern-style buildings are manufactured in large centralized factories. These modern materials have high embodied carbon, which is further increased by the need to transport them long distances to the building site. It should not be overlooked that the very large cement and iron industries constitute a strong vested interest that tends to oppose reversion to traditional building methods.”

4) Evaporative Cooling

Evaporative cooling works on the principle of water evaporation through which the air is cooled down to a comfortable temperature. It is a cooling and ventilation technique that uses water as its refrigerant while radiant cooling cools a floor or ceiling by absorbing the heat radiated from the rest of the room. In Gupta (2017) it was found that the “concept of evaporative cooling is extensively used in ancient architecture, for example, Amber Fort, Rajasthan, India comprises a garden which has been positioned just at the center of the lake to modify the microclimate for comfortable outdoor sitting during summers. Also, this concept can be seen in Red Fort, New Delhi where the entire building has been surrounded by water body and landscaping or by a water garden in Deegh Palace, Bharatpur, India or green area in Imambara, Lucknow. This was done in order to reduce the surrounding temperatures using landscaping. The small spaces were constructed to keep them sheltered from sun by the neighboring buildings. In case of large open spaces, plantation and water pools were used as landscaping element to protect them from the solar gains.”

This cooling technique is easy and economical to implement, in fact, evaporative cooling is one of the oldest passive cooling techniques.

5) Energy Consumption and Pollution

The usage of excessive electrical energy and the introduction of harmful materials into the environment are directly linked. Imprudent energy consumption causes pollution and contributes to high temperatures which can be curbed by implementing passive cooling techniques adapted from ancient architecture. *SUBRAMANIAN et al. (2017)* analyzed the design concepts and architectural interventions of various solar passive cooling techniques. In India, the building sector consumes about 33% of total energy consumed, in which commercial sector needs 8% and residential sector requires 25% to maintain comfortable indoor for thermal comfort is achieved by reducing the rate of heat gains into the building and removing excess heat gained from the building. The important cooling concepts reviewed include solar shading by overhang roof shading, shading by trees and vegetation, induced ventilation by solar chimney, air vents, evaporative cooling, passive downdraft cooling. Theoretical studies have shown that cooling techniques in the building decrease cooling load for about 50% - 70%. Passive cooling is relatively low-cost and offers savings in both capital and operating costs.” Structures with low thermal comfort rely on external cooling mechanisms such as Air conditioners. The use of such devices releases pollutants such as CFC’s into the environment. Little by little this pollution contributes to climate change. The reckless use of electricity to facilitate the running of these devices burns fossil fuel also contributes to the problem. The rampant use of such devices is progressing climate change and thus increasing the temperature.

Without the implementation of energy efficient homes that are self-reliant the problem will only get bigger. Energy consumption will increase and thus the cycle will accelerate climate change. Ancient architecture uses passive cooling and creates homes with thermal comfort thus checking the problem.

Discussion

India has always been renowned for its rich history. The culture of the country is an amalgamation of multiple innovative cultures. Home to one of the Seven Wonders of the World, it's no secret that the architecture of India is famed for its beauty. The ancient architecture of India is hugely diverse due to the influence of so many communities and cultures. The common link that binds them together is the innovation applied in creating them. The buildings of ancient India were built keeping the climatic conditions of the city in mind, since they had no access to any other means of cooling, it was imperative that they create buildings with adequate thermal

comfort. As India developed, people began equipping their homes, offices, etc with external cooling devices for comfort. Architecture soon became more about what looked impressive and due to rapid urbanization, cheap housing was made available to the people. The price of such low costs was the sustainability of the building.

These buildings trap heat and are completely dependent on devices to cool them. Climate change has never been a bigger problem than it is at the moment and the situation only gets graver. Cities like Gurgaon face heat waves summer after summer, with adverse effects on the residents. The solution to the problem lies in the past. Ancient architecture employed various techniques to create structures with thermal comfort, techniques that modern sustainable architecture also uses. Sustainability is always linked to expensive and high costs, when in fact most of the passive cooling techniques used in ancient designs are relatively simple and cost-efficient to implement. The implementation of these techniques will not only help create a sustainable city but also create a new school of modern architecture, a hybrid between ancient and modern. Functionality, modern charm and design, sustainability, and cost-efficiency.

One of the best and simplest passive cooling techniques is natural ventilation. The process of ventilation allows for air to keep moving and avoids stagnation of hot air. It can be implemented in various different ways, as has been shown in many ancient structures.

Ancient architecture offers a good solution to the climatic constraints, allowing natural daylight results in indirect passive cooling, natural ventilation and openings reduces the dependence on artificial means of cooling leading to energy conservation and is an effective passive cooling technique. In research from Gupta (2017), the details of the windows and the openings were taken care of in ancient architecture. Examples included small windows (lesser than 100 mm in diameter) used in Amber fort, India in order to ensure the visibility without letting the light or air in. Openings installed for ventilation purpose were seen in Shahjahanabad, India. These were installed near the floor level and near the roof level in order to let the cool air in from the bottom opening and let the hot air out from the top opening At some places jalis (perforated stone or latticed screen) have been used to maintain privacy, let the air and light enter the building and also allow the visual connectivity from inside to the outside surroundings. Diffused light is allowed to enter the interiors during sunshine hours, and at the same time the interiors are not visible from the outside. For the outside view, a small opening is provided at the eye level of the viewer in sitting position. In the same study it was found that with natural ventilation more than 30 % energy savings may be achieved, the recommended value of air movement is 0.2 m/s for winters and 0.4 m/s for summers. For living rooms, dining areas, mean window to wall ration should be 0.34. The same for bedroom should be 0.27 in high rise buildings. Artificial

mechanical airflow systems should not disturb the natural ventilation and comfortable indoor thermal conditions may be achieved with air movement of 2-3 m/s. Natural ventilation should be the focus of any building design and results in an effective passive cooling technique. This reduces the dependence on artificial means of cooling leading to energy conservation, which is why ventilation is economical to include in the design of a building since the effects of ventilation cut down on energy consumption which directly cuts down cost as well as the impact of energy consumption in general.

SUBRAMANIAN et al. (2017) reviewed passive cooling practices for residential buildings. It was reported that the indoor temperature can be reduced by 6-10 °C by incorporating solar passive cooling techniques such as thermal mass, evaporative cooling and natural ventilation.

This can further enhance the performance of the building. Implementation of cooling strategies adapted from ancient architecture has been documented in *ZAGYI (2013)* One of the newest modern-day adaptations of the formal solutions of the traditional Indo-Islamic architecture serving passive aeration and air cooling is the educational centre of the 5, the institute playing a leading role in fashion and design training in India which has been dreamed in Mani and Sonali Rastogi's architect studio and was opened in 2008 in Jaipur. The creators have based their architectural conception on the ancient methods of air comfort improvements presented above. Out of them, they gave all their attention to apply jalis to shade and baoris to cool air. The most prevailing detail of the conspicuously closed, introverted compact building situated in an industrial park, approximately 20 km (12.4 mi) far from the centre of the seat of the hot and arid Rajasthan is the perforated pattern metal frame placed around about 1.2 m (3.94 ft) in front of the façade which looks as a modern but less expressive reminiscence of the ancient stone-carved jalis. This structural element provides not only for filtering light rays, but it also serves to enclose a thermal buffer zone around the exterior wall front which delays the heat effect of the solar radiation. The water reservoir being equivalent to a baori has been formed through a several metres step-sided lowering of the ground level. Daylighting is a technique that goes hand in hand with ventilation since it efficiently brings natural light into a structure, the natural light can come in through a window or a skylight and in *Sharma (2019)* it was noted that effective ventilation and luminance improve thermal comfort and energy efficiency. Evaporative cooling is a cooling and ventilation technique. An example of it is the cooling sensation felt after perspiration as a form of natural cooling to the body. It is the oldest passive cooling technique and its simplicity places it as one of the best passive cooling techniques. Its implementation can be seen in *Gupta (2017)* Courtyard planning is visible in havelis and forts of Rajasthan, India for cooling effect. Courtyards were the main architectural element used in planning generally integrated with water

bodies, and vegetation and usually open to sky to enhance evaporative cooling, provision of shade and infuse maximum daylight in the buildings. In Shahjahanabad, India, the lower floors are used to spend the hot days while the nights are spent on the terrace taking advantage of the radiative cooling. The rooftops are sprinkled with water for evaporative cooling effect. It was also found that evaporative cooling can reduce indoor temperature by 9.6 °C. In research from *Pandit et al. (2019)* the causes of the significant temperature difference between the inside and outside temperatures of ancient buildings in summer is because of the evaporative cooling phenomenon occurring in mud mortar-based traditional houses. The low thermal conductivity and thinner roof and walls of concrete-based modern-style buildings results in lower temperature differences when compared with traditional buildings. Hence, the features of traditional buildings should be used in modern construction. It was concluded that ancient buildings are more thermally comfortable than modern-style buildings in a similar environment. The evaporative cooling phenomenon is the main cause for significant temperature variation between the inside and outside of ancient buildings.

While much importance is given to evaporative cooling, radiant cooling is also an excellent cooling strategy when used in combination with other techniques. Its counterpart radiant heating has been used for several centuries in other countries. While it is relatively new it can be incorporated into building design working alongside another cooling technique to create a cooler structure. *KARABA et al. (2018)* notes that radiant cooling system is a promising technique, which is suitable for independent control processes of temperature and humidity. The two main benefits of radiant cooling systems include the potential to save energy and the improvement of indoor thermal comfort. Radiant cooling cools a floor or ceiling by absorbing the heat radiated from the rest of the room. When the floor is cooled, it is often referred to as radiant floor cooling; cooling the ceiling is usually done in homes with radiant panels. Various experiments have been conducted using the radiant cooling technique using embedded copper tubes in the concrete slab. It has been noticed that there the water circulated in the embedded tubes had an increase of temperature of 2-5°C during the test. This increase in temperature leads to the extraction of an average of 0.5-1kW/m² out of the concrete slab which would have otherwise caused in the increase of the room temperature. During the test the room temperature was constant at an average temperature of 32°C and the slab temperature was maintained at 34°C. This is a confirmation of the radiant cooling. The effectiveness of the radiant cooling system can be increased by using sub-cooled water.

(KARABA et al., 2018). Insulation is another technique that has been seen in many ancient structures of rural India.

The purpose of insulation is to delay or even curb the entry of heat into a structure. The curbing of heat thereby results in a cooler structure. Insulation need not be an expensive affair, Ancient architecture is about simplicity, and what simpler way than to use locally sourced materials, which are not only sustainable and environment friendly but also pocket friendly. As has been said in *Gupta (2017)* by providing a roof cover from locally available materials like hay, inverted earthen pots, plants, insulation, terracotta tiles etc., indoor temperature may be reduced since roof has the maximum exposed area for solar gains (Kamal, 2012)." Ancient buildings with insulation perform better than modern buildings in terms of thermal comfort without any external assistance. *SUBRAMANIAN et al. (2017)* investigated the traditional and contemporary Architecture of Cyprus. Thermal performance of the traditional, contemporary and solar buildings are discussed related to architectural design, materials, methods and occupancy pattern. In the designed solar house 250mm brick work + 70mm expanded polystyrene was used as insulation mass to exclude thermal bridges.

Two years of hourly monitoring using computer data loggers was carried out. Computer simulation performed using Energy 10 resulted that the solar house (121 kWh/m²) is most energy efficient, followed by traditional house (243 kWh/m²) and finally the contemporary house (368 kWh/m²). Traditional buildings performed thermally better than contemporary buildings due to various solar passive architecture designs like orientation, natural ventilation, thermal mass, landscaping, fenestrations, solar heat gain, thermal insulation, exploitation of spaces – courtyards, solarium, building envelope, which were incorporated in the building. It was concluded that designed solar passive house in Cyprus climate has 100% energy saving potential." While the traditional buildings and the study itself are from another country, it still sets a precedent and proves that insulation is feasible and efficient. Another country that has incorporated insulation into buildings is Thailand. *SUBRAMANIAN et al. (2017)* compared the thermal performance of traditional and contemporary house in Thailand using ECOTECT simulation model. The contemporary structures are constructed with concrete structures, brick walls and plasterboard ceiling with 3cm of insulation and concrete tiles over roof with single glazed windows whereas the traditional Thai houses are constructed with open high pitched roof, windows and walls along with large central terrace. Contemporary houses are not designed in consideration to cooling without mechanical devices and air conditioning. Hence use of artificial microclimates to provide comfortable thermal conditions is unavailable in areas of extreme conditions. This results in high energy consumption contributing to environmental deterioration. The study has concluded that the traditional houses of Thailand provide useful indicators of architectural design responses to climate, particularly in the context of purely passive environmental control.

While on the subject of using locally sourced materials, since we can say that those materials can create insulation that contributes to creating a cooler structure, we can certainly note the importance of the building materials used for the overall construction. The materials used to create a building have a huge impact on the thermal comfort of the structure. In *SUBRAMANIAN et al. (2017)* the building materials and construction techniques towards thermal comfort were studied. Two types of structures- filler slabs with rat trap bond masonry and mud block masonry are analyzed. The data was recorded from 9am to 5pm for the month of June. The data recorded is compared with that of other researchers. It is found that for rat-trap bond building, the temperature ranges from 31.7-32.8 °C and for mud block building it ranges from 33.2-33.8 °C. These readings are very close with the previous study carried out by others. Bioclimatic chart was also used for taking decisions during construction. Here it concludes that the use of 1m/s – 0.4m/s air movement can contribute towards thermal comfort for rat trap bond block." Building materials contributing to the thermal comfort of a building has been discussed by many architects and engineers before. When constructing a structure using locally sourced materials can cut down on the carbon footprint, which is exacerbated when mass-produced materials like, steel and iron and cement are used for construction. There are many sustainable architects that have used bamboo wood to construct an entire home, and while that may not be a local resource in a metropolitan city like Gurgaon it proves that using alternative materials have merit. Inherently cooling materials such as limestone can be used for the structures. In research from *Sharma (2019)* it was found that lime stone which was used in construction of old traditional buildings as raw materials are useful to reduce summer heat gain and winter heat loss, thereby reducing building heating and cooling energy use". The reason why traditional homes and modern homes have varying temperatures boils down to the materials used for construction. Using the right building material reduces our carbon footprint as well as meets the end goal, which is to create energy-efficient homes. *Pandit et al. (2019)* stated that the materials (such as cement and steel) used in modern construction are highly durable but not energy-efficient. A balance between energy efficiency and durability of modern buildings should be sought.

Energy-efficient buildings are the end goal because they curb the carbon emissions and pollution that aggravate climate change. The purpose of using ancient architecture to create cooler apartments in Gurgaon is to help bring down the rising temperature of the city itself. Using passive cooling techniques will create better homes for the people living in them as well as the people living in the city. The benefits of having homes self-reliant when it comes to cooling also include cost efficiency, since the need to use AC's and other such devices is lowered, especially since many cannot even afford such devices. *Pandit et al. (2019)* states that, "According to International Energy Agency, it is reported that worldwide buildings consume almost 40% of

energy. With a growing population and improvement in living standards, this energy consumption may further increase. Therefore it is important to design buildings with enhanced thermal comfort with minimum use of fossil fuel-based energy.”

While this paper does not have any first-hand data, techniques on how to implement these cooling mechanisms in modern architecture have been discussed, and while many other papers have approached the topic of using such methods the question of using a combination of all these passive cooling strategies has not been discussed. This technique, created using a blend of multiple passive cooling methods, can create the ultimate sustainable home.

SUBRAMANIAN et al. (2017) simulated using IES software to assess the building performance by incorporating eight solar passive cooling strategies in UAE. Eight principle passive cooling strategies applied to the case study villa includes louvre shading devices, double glazing, wind catcher and cross ventilation, green roofing, insulation, evaporative cooling via fountain, indirect radiant cooling and light colour coatings with high reflection. In depth analysis revealed the potential of 9% reduction of cooling load on application of these passive cooling strategies. Energy-saving of 23.6% was observed.”

Conclusion

After discussing all these themes, it has been found that the techniques in question are all highly effective in their own rights and so we can conclude that using a combination of the passive cooling techniques, will create a sustainable home with significant thermal comfort.

The benefits can be reaped by everyone, not just people on a budget. Promoting the adaptation of ancient architecture into modern and the implementation of the hybrid model will revolutionize energy usage as well as urban planning. The construction of sustainable housing will usher in a new era of sustainable urban planning and thus become an asset to the battle against climate change. Ventilation, Evaporative cooling, Insulation, and using alternative building materials are simple yet proven to be effective. This model of architecture will be a great aid to the industry as well as the planet.

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