Evaluation of passive technique based on performance in hot and dry climate.

Bachelor of Architecture Research Thesis dissertation

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Submitted By

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Approval

The following study is hereby approved as a creditable work on the subject carried out and presented in the manner, sufficiently satisfactory to warrant its acceptance as a pre-requisite towards the degree of Bachelor of Architecture for which it has been submitted.

It is to be understood that by this approval, the undersigned does not endorse or approve the statements made, opinions expressed or conclusion drawn therein, but approves the study only for the purpose for which it has been submitted and satisfies him/her to the requirements laid down in the academic program.

Thesis Title: Evaluation passive technique based on performance in hot and dry climate.

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Declaration

I, **Ayazali Pathan**, **19bar202**, give an undertaking that this research thesis entitled "**Evaluation passive technique based on performance in hot and dry climate.**" submitted by me, towards partial fulfilment for the Degree of Bachelor of Architecture at Institute of Architecture and Planning, Nirma University, Ahmedabad, contains no material that has been submitted or awarded for any degree or diploma in any university/school/institution to the best of my knowledge.

It is a primary work carried out by me and I give assurance that no attempt of plagiarism has been made. It contains no material that is previously published or written, except where reference has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; I would be responsible.

This research thesis includes findings based on literature review, study of existing scientific papers, other research works, expert interviews, documentation, surveys, discussions and my own interpretations.

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FIGURE

Chapter 01
Introduction

1.1 Abstract

With the exception of the rainy season, summer days in the hot and dry zone are quite hot, with an average high of 41.3 °C, while evenings are pleasant, with an average low of 26.3 °C. Nowadays, the majority of structures are poorly adapted to the environment, necessitating a lot of energy for cooling during temperature extremes. Insufficient surface-to-volume ratios, poor natural ventilation, and the wrong building orientation are additional problems. The physiological comfort, ability to perform both mental and physical labor, health, and leisure have all suffered. Therefore, passive cooling is a beneficial and economical way to control indoor temperature in hot and dry climates. Architects, engineers, and building owners will gain from the knowledge provided by this study, which assesses the efficacy of passive cooling techniques in regulating indoor temperature, in order to design and operate buildings in hot and dry climates. Additionally, a holistic strategy is required to lower energy consumption in the

built environment, as well as the significance of taking passive cooling strategies into account when designing buildings.

Key words: Passive design, Passive cooling technique, hot and dry climate, Indoor Environment, Passive Strategies

1.2 Aim

The purpose of the study is to evaluate passive technique based on how well it performs in a hot, dry environment.

1.3 Objective

- To identify which passive cooling techniques in hot, dry climates are most effective.
- To categories and identify passive technique based on performance.
- To analyze performance of passive techniques with the help pf model, post occupancy in the selected case study

1.4 Research question

1. What is mean by Passive Method
2. How passive method helps
3. Why we are developing passive method?
4. 4. How do passive design strategies affect how well a building performs in terms of thermal comfort in a hot and dry climate?
5. What are the limitations and barriers for implementing passive design techniques in a building (in today's context)?

1.5 Scope and limitations

- The limitation of study is to analysis of passive cooling techniques only.
- The results are specific to hot and dry climates and may not be applicable to other climatic conditions.

Chapter 2

Issue and Background Study

2.1 Introduction

The building structures in these climatic areas are unsuitable for their inhabitants since a sizable number of them are not climate-appropriately planned. By switching from mechanical to passive methods, the amount of energy consumed may be considerably reduced. Passive cooling is necessary in many areas with high ambient temperatures that may not be able to afford the energy usage associated with active cooling solutions.

Many places with high ambient temperatures require passive cooling because active cooling solutions would require too much energy.

Due to their economies' inability to support mechanical air conditioning for the majority of their urban buildings, the residents' comfort and wellbeing are also solely dependent on the building's design and construction. Design that makes use of the local climate to keep the indoor environment at a comfortable temperature is known as passive design.

By using good passive design principles, the need for cooling should be reduced or eliminated. It provides the necessary indoor lighting, ventilation, and cooling through the use of free, renewable energy sources like the sun and wind. As a result, it is also no longer necessary to use mechanical cooling. Buildings can be made more liveable and comfortable by utilising passive cooling because it lowers energy costs, improves indoor air quality, and reduces the temperature difference between inside and outside.

Since the beginning of the earliest times of settlement building, humans have used passive design. Through the use of techniques known as passive design, the settlers built their homes to adapt to their particular climate. The principles of passive design are defined by the utilisation of environmental factors such as the sun, wind, and physical laws to produce low energy costs, minimal maintenance requirements, and superior comfort. In other words, the building doesn't produce or conserve energy through the use of mechanical systems.

According to Mikler et al. (2009), one of the important factors in a passive design approach to decrease building energy consumption and enhance occupant thermal comfort is the relationship between building shape and thermal performance to the local climate.

The following five principles are central to Passive House design and are fundamental to the energy efficiency of buildings, the, and construction.

- **A**irtight construction
- High-performance glazing
- Thermal-bridge-free detailing
- Heat recovery ventilation
- Super insulated envelops

2.2Background

- Since the middle of the 20th century to the present, technological advances have become increasingly visible. Today. This leads to excessive energy consumption due to daily human activity and new infrastructure that requires more energy to function properly. But this is very important. It should be remembered that greenhouse gases, especially carbon dioxide (CO_2), are released into the atmosphere when the energy generated by burning coal, oil or natural gas is used for a variety of everyday tasks in all industries, including construction. with serious consequences for human health. As a result, it's crucial to consider environmental factors when designing any kind of room or building, but especially when it comes to architecture. Due to the expansion of major cities in just 2008, there will inevitably be an increase in GHG emissions. Housing and residential construction's carbon footprint. Appliances, lighting, HVAC (heating, ventilation, and air conditioning) systems, and other equipment accounted for 11% of all direct CO_2 emissions, or 18% of them.
- • India will likely experience severe effects from ongoing climate change due to its 1.2 billion-strong but growing population and reliance on agriculture. India is one of the most vulnerable nations in the world to predicted climate change and a significant emitter of greenhouse gases.
- The country is already feeling the effects of climate change, including water stress, heat waves and drought, severe storms and flooding, and related detrimental effects on health and way of life.
- India's climate is likely to change in a variety of ways given the inherent uncertainties in projections of the global climate.

Chapter 3

Methodology

3.1 Methodology

Introduction:

The methodology used to conduct this study is the main topic of this chapter. In light of this, the study's areas and the justifications for the selection of those areas are discussed.

Area of Research:

This study is based on a number of institutional buildings in an area with a hot and dry climate. Based on their performances, certain buildings were examined to determine which passive techniques were used and how effective they were.

Research Approach:

This study uses a mixed methodology that incorporates both quantitative and qualitative methods, allowing for the analysis of both types of data at the same time.

Throughout the study, the quantitative approach was primarily used. It was offered through various simulations performed on the building design using a programme called Design Builder that simulates buildings. It also included different thermal comfort parameters like heat, temperature, air velocity, relative humidity, etc. The Climate Consultant Software can be used to obtain weather information for the city.

The Qualitative approach was employed through various case studies done on certain buildings by categorizing Passive Techniques that are most used in Hot and Dry region on India, as well as through literature review by categorizing the Passive Techniques that shows certain reduce in temperature.

Data Analysis:

During this research, the data was collected using mixed approach and then data was analysed using simulation software, called Design Builder.

The main parameters of the Simulations carried out on the buildings in this research are: 1) Thermal Comfort & 2) Heat Reduction in a Building.

For simulations, two scenarios were created for the comparison and analysis of a Building Performance:

1) A base case model without using passive techniques.

2) A base case model with using one technique at a time in building for individual heat reduction performance.

The limitations and obstructions that these techniques have are listed so that we can choose the most applicable technique that can be used in a building with the fewest restrictions possible.

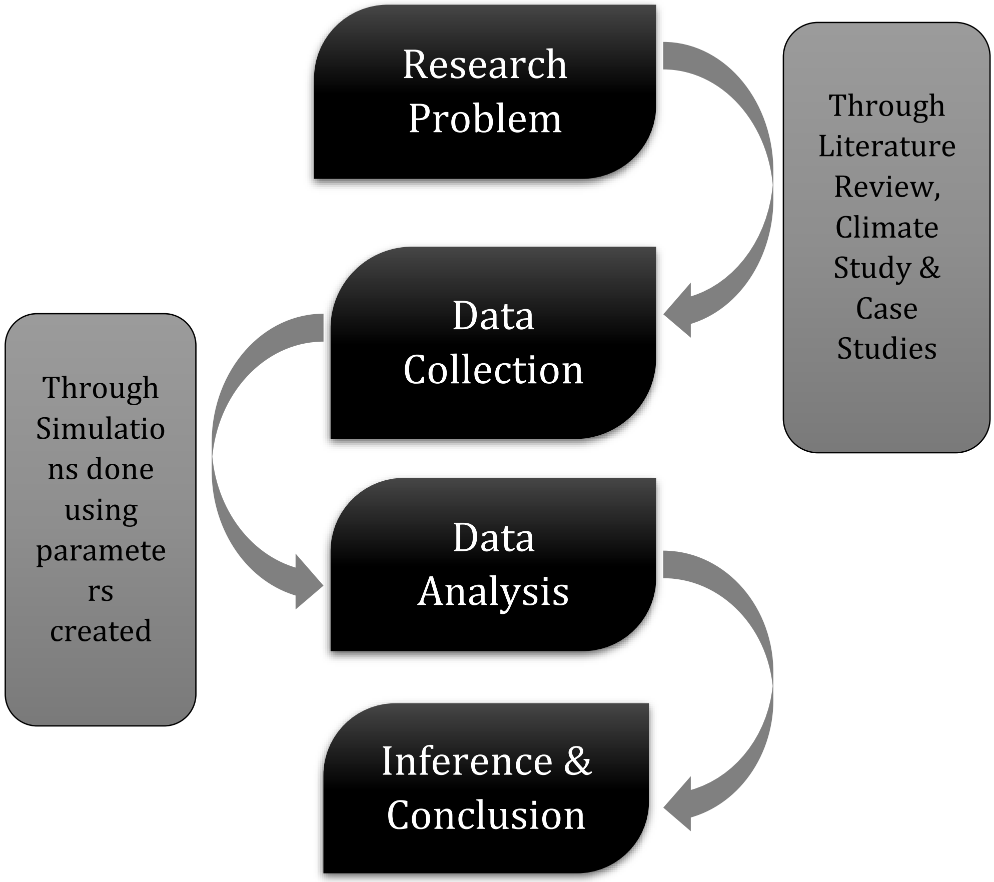


Figure 1 methodology of table

Chapter 4

Literature Review

Introduction:

The Literature review used to conduct this study is the main topic of this chapter. In light of this, the study's areas and the justifications for the selection of those areas are discussed.

History

What is Passive Design

Elements that have an impact on a building's performance during the initial design phase

- Site location
- Site weather

- Microclimate
- Building layout
- Building orientation
- Building form
- Building occupancy type

Climate zone of India

Passive cooling techniques used in hot and dry region

- Heat Dissipation Techniques
  - Heat Gain Prevention Techniques
  - Heat Modification Techniques
  - Induced ventilation techniques
  - Wall systems
  - Terrain
  - Passive design strategies

Reduce temperature table

Secondary case study

4.1 History

Passive structures have been around for a very long time. Ever since humans developed their survival instincts, we have looked for shelter in the comfortable and most affordable buildings. For instance, caves and mud huts are "passive" structures because they consistently maintain a cozy, temperature that is consistently higher in the winter and lower in the summer than the surroundings. For passive structures, the same rules apply. In order to maintain comfort when creating a passive building, use passive design strategies to reduce the need for mechanical heating and cooling.

In order to reduce a building's energy consumption through the use of passive design principles, the Passive House Certification was first known as "Passivhaus" in Germany in the 1990s. Modern passive style homes have been built in the US since the 1940s, experiencing a significant resurgence in the 1970s and continuing into the present day. The creators of Passivhaus established strict guidelines for energy use and came up with limits to building energy use based on the climate in Germany by comprehending the variations in temperature throughout the year.

4.2 Passive Design

Architectural elements that adapt to their environment to maintain a cozy indoor temperature are known as "passive design" features. Depending on where you live, good passive design should minimize or completely eliminate the need for additional heating or cooling, and it frequently requires an occupied space to function. In addition to having low energy costs and greenhouse gas emissions, a passively designed building can ensure lifetime thermal comfort.

- When a building is passively designed, features like orientation, thermal mass, insulation, and glazing cooperate to minimize uncomfortable heat gain and loss while utilizing natural sources of heating and cooling, like the sun and breezes. However, many passive design elements can be added by making small changes or other straightforward house improvements. It is best to use passive design principles when planning or building a new home.

- There are numerous different passive cooling techniques that can be suggested in a hot, dry climate. The use of light- or reflective-colored materials for the building envelope and roof, careful siting and intelligent orientation decisions, appropriate landscaping design, selecting the right glazing for windows or skylights, selecting the right size shading of glass when heat gains are being avoided, and proper window placement and daylight design are all design strategies that lessen the need for mechanical cooling systems.

4.3 Elements that have an impact on a building's performance during the initial design phase

- **Site Location**: Site location refers to the spatial position of an existing or proposed construction or facility.
- **Site Weather**: Site weather is the collecting of meteorological data that is most relevant to a specific location of a proposed or existing development.
- **Micro-climate**: A micro-climate is defined as the climatic conditions of a very tiny or confined region that differ from those of neighboring locations.
- **Building Form**: The overall shape or arrangement of a building as perceived by a viewer in space and time is referred to as its form.
- **Building Layout**: Building layout, often known as floor plan, is the arrangement of physical construction features such as rooms, walls, doors, and windows within a building.
- **Building Orientation**: The position of a structure in relation to the path of the

sun and changes in seasonal wind patterns is known as its orientation.

- **Building Occupancy**: Building occupancy is defined as the use or anticipated use of a building for shelter
- or support of human, animal, or property.

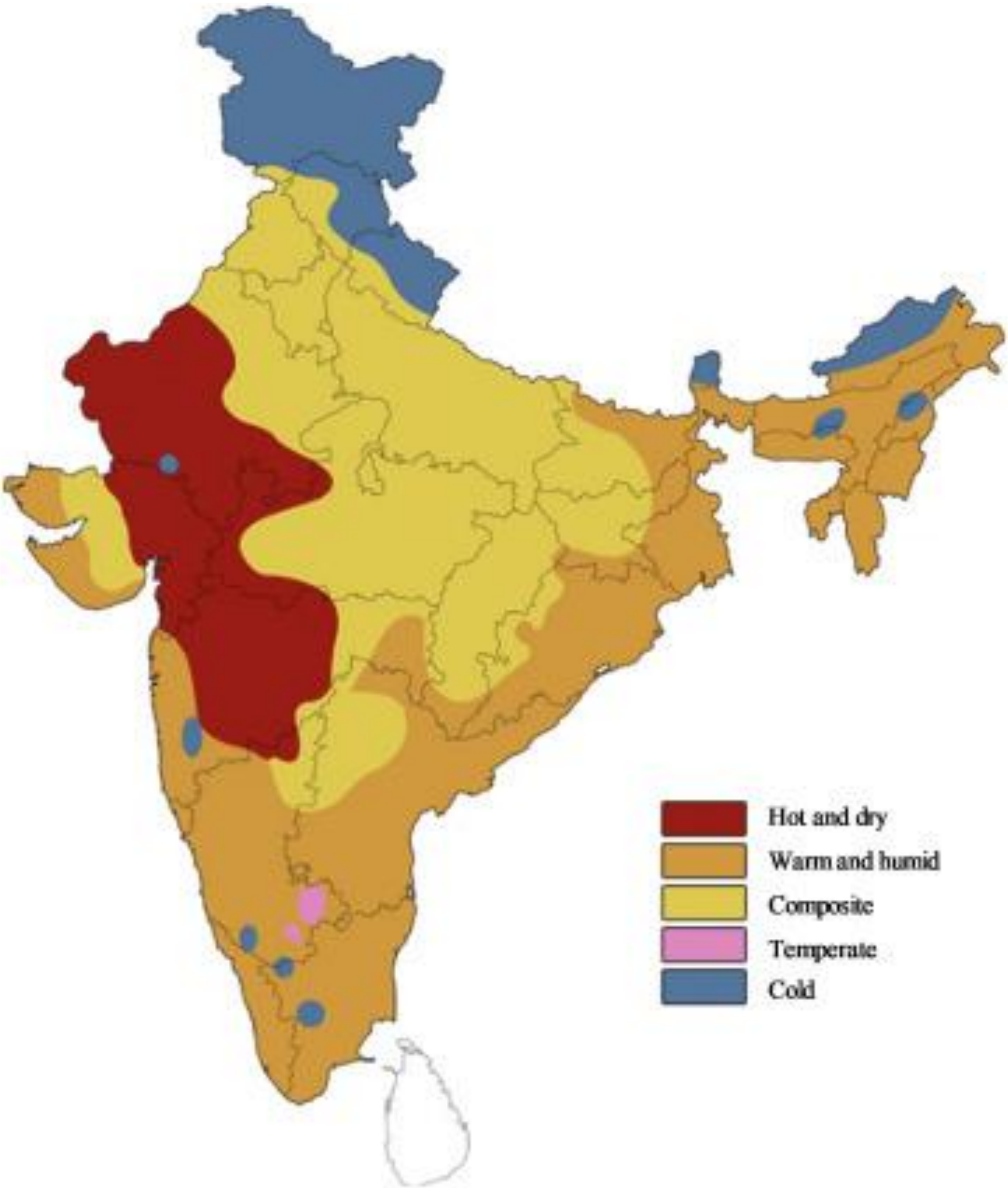


Figure 2 Climate zone of India

4.4 Climate Zones in India

1. Hot and Dry Climate
2. Warm and Humid Climate
3. Composite Climate
4. Temperate/Moderate Climate
5. Cold Climate

4.5 Passive cooling techniques used in hot and dry region

4.5.1 Heat Dissipation Techniques

4.5.1.1 Wind Tower

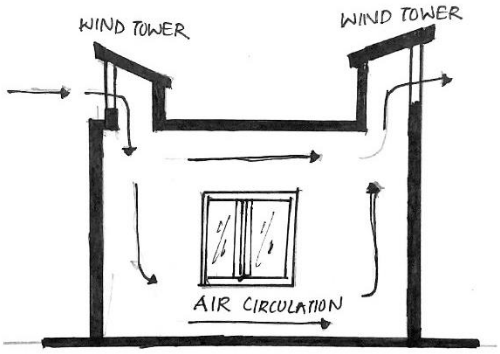


Figure 3 wind tower

On top of buildings, small towers known as wind catchers or wind towers are installed. There are many different sizes and shapes of wind towers. In hot, dry, or humid climates, wind towers have been used for centuries to ventilate and cool buildings. There are still some areas in Egypt and the Middle East where wind towers are in use. By allowing fresh air from the outside to enter the building, wind towers offer a natural ventilation system for dwellings as well as workplaces. Natural wind currents can cool down buildings. The tower's job is to channel cool air into the building through vents or ducts by pulling it down from higher elevations. By using this method, you can significantly cut your need for air conditioning, save money on energy costs, and improve the quality of the air inside your home. Wind towers, which are frequently used in hot, dry climates and are an excellent example of environmentally conscious and sustainable construction design.

Traditional and conventional wind towers can be divided into four main categories.

- Cylindrical wind towers
- One-sided wind towers
- Two-sided wind towers
- Four, six, and eight-sided wind towers

4.5.1.2 Courtyard

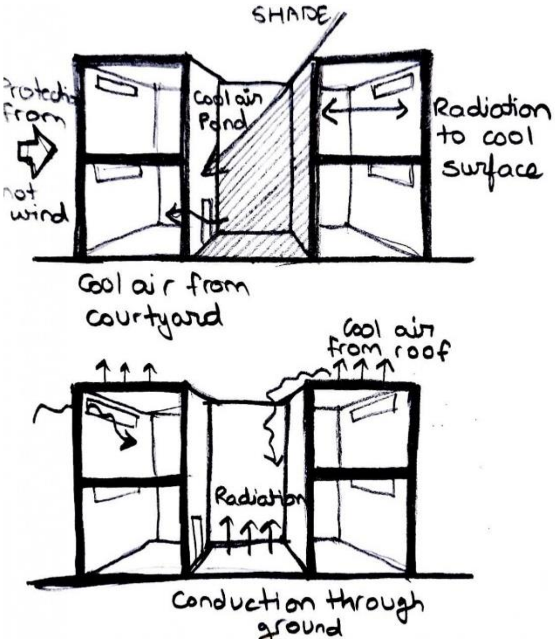


Figure 4 courtyard

The Courtyard Passive Process achieves a passive, thermally comfortable, and energy-efficient environment. The method involves regulating the quantity of sunlight entering the courtyard by using shading components including trees, pergolas, shading screens, and louvres. The following basic assumptions guide the available courtyard building options.

• It was planned for the courtyard structures to face South, East, West, and North, the four main directions.

• The A/V indicators denoting the building form were set to 1 for all alternatives in order to compare the energy consumptions of various courtyard building forms when the effects of various courtyard proportions were taken into account.

• Comparing the various courtyard building types with different floor areas is made possible by varying the building's floor area for each type between 100 and 200 m2 at intervals of 20 m2.

• To compare the alternatives with different courtyard shapes, the courtyard shape factors (W/L) are adjusted between 0.2 and 2 in steps of 0.2.

• Flat roofs cover the one-story, standalone buildings. It is a 4.5 metre tall structure.

4.5.2 Heat Gain Prevention Techniques

4.5.2.1. Vegetation:

In order to increase the thermal comfort and energy efficiency of buildings, vegetation-based passive techniques make use of plants and other vegetation. These methods include, for instance, the following:

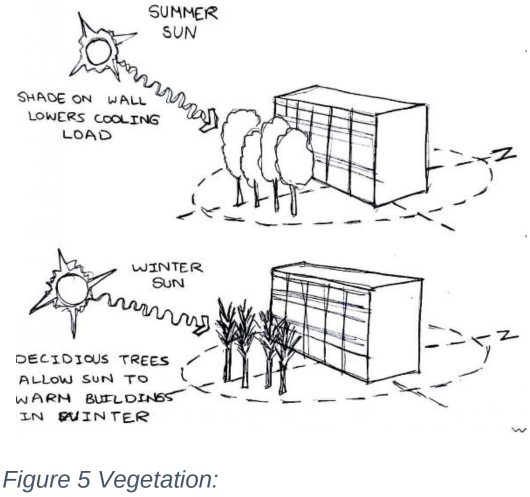


Figure 5 Vegetation:

a) Green roofs: A roof with vegetation and soil on it is referred to as a "green roof." It can aid in improving insulation, lowering summertime heat gain, wintertime heat retention, and summertime heat loss.

b) Living walls: A living wall is a wall covered with plants. It can help to regulate indoor temperature, improve air quality, and reduce noise pollution.

c) Landscaping: Strategic placement of trees and other vegetation around a building can provide shade, reduce wind speeds, and protect against the sun's rays.

In general, vegetation-based passive techniques can increase buildings' energy efficiency, improve the indoor and outdoor environments, and encourage sustainability.

4.5.3 Heat Modification Techniques

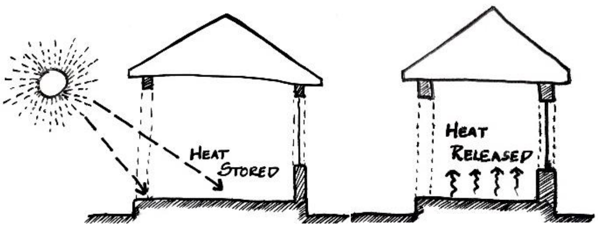


Figure 6 Thermal mass

4.5.3.1 Thermal mass

The ability of a material to absorb heat energy (convectively and radiatively) during a warm period, store it, and then release it during a cool period is referred to as "thermal mass". This lag time could have three important effects.

a) When there are changes in outdoor temperature, the slower response time tends to reduce the fluctuations of the indoor temperature.

b) In comparison to a comparable low-mass building, it uses less energy in hot or cold climates.

c) As energy storage is controlled by the proper sizing of the mass and interaction with the HVAC system, it shifts the building's energy demand to off-peak times.

4.5.4 Induced ventilation techniques

4.5.4.1 Evaporative cooling

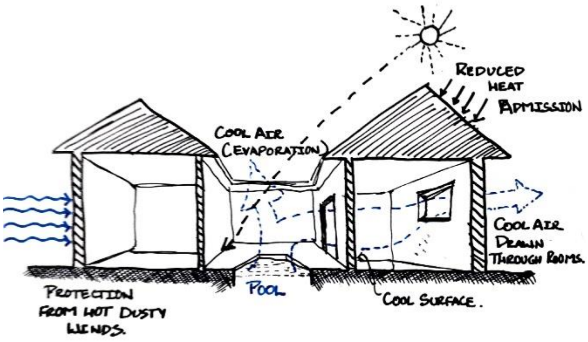


Figure 7 Evaporative cooling

A significant amount of heat is transferred from the air to the water during the evaporative cooling process, which uses water evaporation to cool the air. As a result, the temperature of the air decreases. Evaporative coolers fall under the following categories:

1) Air and water, the working fluids, come into direct contact with one another in direct evaporative coolers.

2) The working fluids in indirect evaporative coolers are separated by a surface or plate.

(3) A system that uses indirect and direct evaporative coolers along with other cooling cycles.

By using the evaporation process to cool the air, evaporative cooling is a passive method. In this method, wet material, such as a soaked cloth or a pool of water, is passed over by hot, dry air, which causes the water to evaporate and cools the air. To provide a sustainable and economical method of cooling, the cooled air is subsequently cycled throughout the building.

4.5.5 Wall Systems

4.5.5.1 Cavity wall

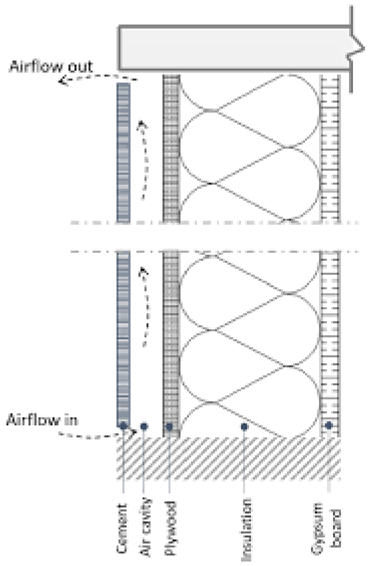


Figure 8 Cavity wall

A cavity wall is constructed of two brick or block leaves: one on the outside and one on the inside, separated by a cavity. The air gap in cavity walls prevents heat from transferring into or out of the building because air conducts heat poorly. Insulating materials are inserted into composite walls' cavities by varying their thickness.

4.5.5.2 Jaali screens

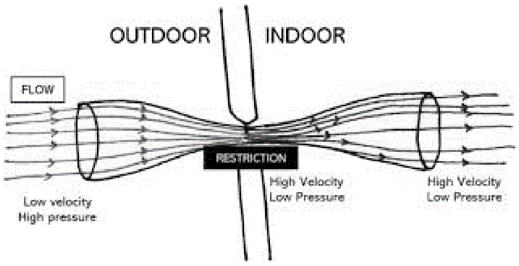


Figure 9 Jaali screen

The word "jaali" refers to a net or fine web. It is a decorative perforated screen that can be found in Islamic, Indo-Islamic, and Indian architecture. It is an eggcrate, a horizontal and vertical shading device, used as a shading device.

It offers shade from the sun's glare and promotes airflow, natural lighting, and ventilation, acting as a passive cooling feature. Architectural methods, fashions, and customs become outmoded when a more workable substitute is found. By adjusting a Jaali's various parameters, one can achieve different levels of thermal comfort.

Fenestrations:

Fenestrations are cut outs made on a surface. In terms of architecture, it is defined as a configuration of openings such as doors and windows on building surfaces like on roof and facade.

Roof Vents:

Essentially, it is a system that permits air to circulate through the attic area through vents installed on the roof, keeping the roofs from overheating.

4.5.6 *Terrain*

4.5.6.1 Earth coupling

The earth coupling theory is based on dissipating waste heat from a building into the earth because the earth's temperature is lower than the outside air temperature. Either a sizable portion of the building that is surrounded by land can be instantly cooled by the earth, or air that has previously circulated below ground to ventilate heat exchangers can be injected.

- Direct Coupling

  When the building is in direct contact with the ground, it functions as a heat sink. The earth can keep things cool when the outside temperature rises, acting as a safety barrier to keep the building safe. Buildings that are earth-sheltered are constructed all over the world to take advantage of the insulation and cooling they offer. As a result, it limits solar infiltration, reducing heat gain.

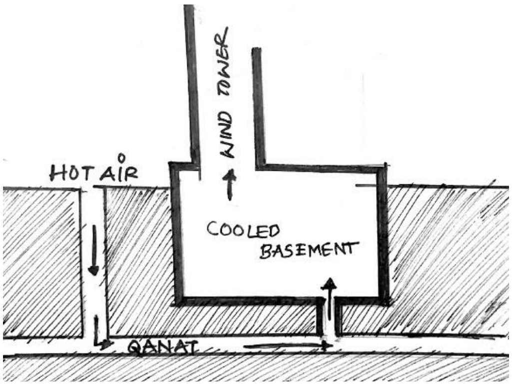


Figure 10 Earth coupling Direct Coupling

- Indirect Coupling

  The building is linked to the earth by the use of earth ducts.

  The buried tubes, which act as earth ducts, give the air supply a way to pass through the ground before entering the building. The local soil in this area cools the supplied air. It is best if the soil temperature is lower than the desired room air temperature to achieve a better cool output temperature. If not, water can be

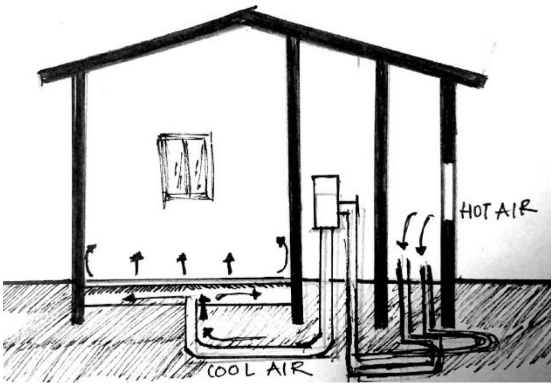


Figure 11 Earth coupling Indirect Coupling

added to the tubes before they are inserted into the structure.

4.5.7Passive Design Strategies

4.5.7.1 Natural Ventilation

Natural ventilation is the most significant form of passive cooling and ventilation. For the air quality and indoor oxygen levels to remain as desired, the building's overall ventilation is crucial. Natural methods have historically provided the necessary ventilation. In the majority of older structures, the permeable floor provides a significant amount of outside air while the windows are left open to meet additional needs. Natural ventilation utilises the ecosystem without the need for automated or mechanical solutions. Natural ventilation depends on natural external factors such as wind, indoor temperature and ambient temperature, and is more economical and environmentally friendly.

a) Single-Sided Ventilation

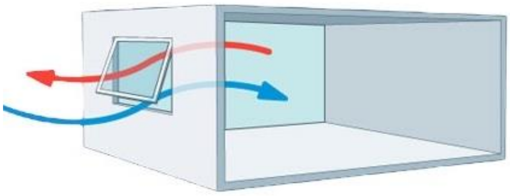


Figure 12 Single-Sided Ventilation

Openings are used on one side of a building for single-sided ventilation. In projects with constrained space, this is used to naturally ventilate a space. When cross ventilation is impossible due to structural or environmental limitations, projects also use single-sided ventilation systems. The least amount of air circulation occurs with this type of ventilation, compared to natural ventilation systems, so keep that in mind.

b) Cross Ventilation

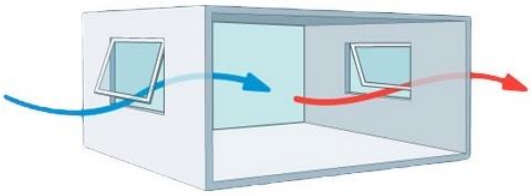


Figure 13 Cross Ventilation

When openings in an arrangement are located on adjacent or opposing walls, air can enter from both sides, circulate through the room, and then exit in the opposite direction. This is known as cross ventilation. Because it continuously recycles the air inside the building, this system is typically installed in structures in climates with higher average temperatures. This lowers the interior temperature.

c) Stack Ventilation

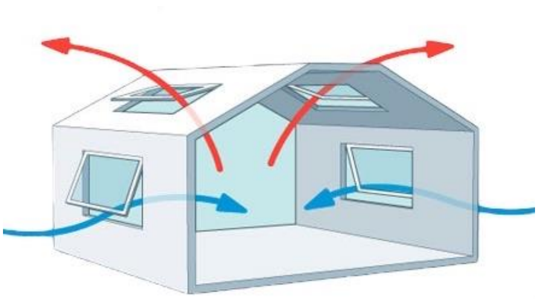


Figure 14 Stack Ventilation

With stack ventilation, outside air is slowly warmed as it contacts heat sources inside the building and is introduced into the building at a low level. As a result of the rise in temperature, the air rises and escapes through the higher-up openings. Stack ventilation is typically more advantageous for tall structures with central atriums, but it can also be helpful in structures where cross ventilation is unable to completely encircle the space. Due to the fact that it needs a warmer interior than exterior temperature to operate properly, this ventilation system might not always be efficient enough to be used alone.

Using passive ventilation for cooling

Buildings should be designed with passive ventilation for cooling in hotter, drier areas. The planning of passive ventilation includes the calculation of air flow rates.

The following factors should be considered when designing a house for passive cooling: •Select a site, orientation, and form that will receive as much exposure to cooling breezes as possible.

• Verify the effectiveness of the building's airflow pathways.

• Select windows that allow for the most airflow and the least unauthorized heat gain.

• Low level horizontal openings should be specified whenever possible because they provide better ventilation than vertical openings (i.e., those that are close to the floor).

Evaporative cooling can be enhanced by airflow rates of up to 1.0 m/s. Uncomfortable conditions typically result from air speeds greater than 1.0 m/s.

4.5.7.2 Daylighting

A passive design strategy that uses natural light to provide illumination for buildings. The goal of daylighting is to reduce the need for artificial lighting and improve the indoor environment by introducing natural light into the building. This can be achieved through various means, including:

a) Skylights: Skylights are roof-mounted windows that allow natural light to enter the building.

b) Clerestory windows: Clerestory windows are high windows located near the roof of a building. They allow light to enter the building while preserving privacy.

c) Light shelves: Light shelves are horizontal surfaces that reflect light into the interior of a building.

4.6 Reduce temperature table

Through literature paper I categories which passive technique give how much reduce in temperature

Technique	Reduce temperature	References
Courtyard	The courtyard has a significant positional influence, which can vary depending on the climatic conditions under which it is constructed	(Bansal, 2018)
	The purpose of the courtyard, its appearance, its aspect ratio, its height, its orientation, its vegetation, its water feature, and its roof and shading structures.	Abdullah Sani Haji Ahmad and Iziq Eafifi Ismail
Earth coupling:	The rooms are generally kept at a constant temperature throughout the year, which is equal to the average annual temperature of 22 to 25 °C.	Yahya Lavafpour, M. Surat
Evaporative cooling	8.5°C to 9.6°C It can reduce the cooling demand by 40%.	(Abbas M. Hassan, 2016)
	The inside temperatures of 29 – 30 °C were recorded	Ilyasu Masaruf magaji,Muhammad sa'adiya
Stack Ventilation	2.7°C	(Emad S. Mushtaha, 2012)
Wind Tower	2.5°C to 5.5°C	(Yasmina Bouchahm, 2011)
Thermal mass	4°C Recommend using small external openings with a 20-40% window to wall ratio.	(Emad S. Mushtaha, 2012)
	The doubly-curved walls screen the interiors from the harsh summer sun and enhance	Hana Abdel

	thermal comfort through reduction of 5-6 °C.	
Wall	2.2°C The use of PCMs in heavy constructions may be substantial, with up to 17% energy savings potential.	(Marwa Dabaich A. E., 2015) (Ali M)
	U-value of 0.77W/mk	Ar. Nikita Gudur,
Land scaping and Vegetation	3°C to 5°C	(Sharma 2016)
	5°C.	Ilyasu Masaruf magaji,Muhammad sa'adiya
	Their investigation into how to plant trees properly to save energy has led them to the conclusion that doing so can cut a home's cooling loads by 10% to 40%.	Nitin bansal and Manit rastogi
Fountain between buildings for Evaporative cooling	In a dry, hot climate with little humidity in the air. In evaporative cooling, water is evaporated using the sensible heat of the air to cool the air, which in turn cools the building's interior.	Nitin bansal and Manit rastogi

Figure 15 Reduce temperature table

4.7 Characteristics of hot and dry region

- Temperatures: Very hot weather in summer and cold in winter
  - Summer- temperatures vary from 40 to 45 deg C
  - Winters – Min temperatures- 5-25 deg C
  - High-temperature difference between Day and Night
  - High Solar Radiation causes glare
  - Hot Winds
- Rainfall: Minimal rainfall
- Groundcover: Dry sandy or rocky ground with less vegetation

- Sky Condition: Cloudless sky

4.8 Hot and Dry Climate region in India

western parts of the country where desert-like conditions exist.

Rajasthan

- Jaipur
- Jaisalmer

Gujarat

- Kutch
- Ahmedabad

Madhya Pradesh

Maharashtra

4.9 Most used passive techniques

Through virtual case study I categories the which passive techniques most used in hot and dry region of India

Institute Building	Built year	Building orientation	Material used	Passive Techniques Incorporated	Outcomes
Ahmedabad University's	2015	North-South	The structure of building is export concrete structure and in facade sand stone screen and glass is used.	Courtyard is in center of building Shaded East facade there is huge shaded terrace In façade there is used **sandstone screens** to filter the sun.	The doubly-curved walls screen the interiors from the harsh summer sun and enhance thermal comfort through reduction of 5-6 °C. Winds are channeled during humid conditions towards the open areas to improve outdoor physiological comfort The towers are spaced apart to

					shade landscaped decks between them, creating at suitable microclimate for outdoor recreation.
Zydus Head quarter Ahmedabad	2020	north-south	doubly curved steel surfaces triangulated glass modules within the Corten steel walls.	**semi open courtyard**, **west facade there is blank wall** with triangulated glass modules	The doubly-curved walls shield the interiors from the glaring summer sun and a 5 to 6 degree temperature reduction. and the towers are spaced apart to create an appropriate amount of shade for the landscaped decks between them.
Tower house Ahmedabad	2015	North-South	Material used in tower house is Bunner block, Concreate wall, glass .	Block jaali near staircase landing **small semi open** courtyard at third floor.	The ventilation in the house can be changed by simply opening the appropriate windows, and there is a semi-open staircase that circulates air throughout the home. The practical slope of a burner block is used because it provides

					both a diffuse, muted light and crucial rain protection. By diffusing light in the stairway, a jaali filter safeguards the privacy of the area at lower levels.
Cept library Ahmedabad	2017	North-South	The exterior layer has a material palette of concrete and wooden louvres, while the internal layers are made of structural steel, concrete, and glass.	In façade there is used **wooden louvers. linear courtyard** provided for light and ventilation in under ground	As a result, the entire structure functions as a teaching tool for the students on the subjects of lighting, ventilation, and temperature control techniques.
Shrujan Campus-Bhujodi Kutch	2004	North-South	Exposed brick and rough kota stone are used for the exterior paving throughout, extending into the courtyard.	This open courtyard, which combines views and movement in its shaded precincts and wind towers on the south and west, contrasts with the protective walled enclosures on	The requirement to provide a thermally stable environment for the exhibits, the programme, the financial situation, and the local climate are all taken into account in the design.

				the heat gain side.	
Living and Learning design center Kutch	2015	East-West	Load bearing structure: exposed concrete stone, lime, and fly ash bricks. Wall finish: natural dolomite lime plaster Roof: china mosaic.	Evaporative cooling Thermal mass Radiant cooling: To insulate the roof. Segregation of service functions, on the heat gain sides. Conical Skylight have maintained built to unbuilt ratio, Use of local materials and resources West and south windows: cutouts are meticulously detailed, allowing the winter sun to warm the interiors while keeping the summer sun out.	To reduce cost and achieve the necessary strength and thermal stability as compared other material Lime and fly ash bricks were made on-site from waste carbide lime slurry, sand and fly ash. A lime mortar was also produced on site. To collect about 7 lac litres of rain yearly, rainwater harvesting tanks were incorporate into the design The architecture aims to minimize thermal benefits by having shaded areas that are naturally cool and can rely on passive cooling to reduce operating costs.

Pearl Academy of Fashion Institute Jaipur	2008	Northwest-Southeast	Concrete, glass, and other locally accessible materials were used to construct the building.	The earthen pots were purchased from nearby potters by the design team. On the site, both the concrete jaalis and other structures were built.	insulation from the heat an old earthen pot on a flat roof. The stepwell section of the building cools the building from within as well as the air entering it, and thanks to evaporative cooling, the underbelly creates a microclimate. Building's interior is given a courtyard. Shading The exterior of the building has a double-skinned façade that is made of the traditional "jaali" of Rajasthan.

Figure 16 Most used passive techniques

CHAPTER 05

CASE STUDIES AND DATA ANALYSIS

5.1 Ahmedabad Climate
5.2Primary case studies.

1. Environmental Sanitation Institute
2. Global Mission School

5.1. Ahmedabad Climate

The Arabian Sea has a significant influence on the climate in Ahmedabad, which is hot and dry. The city's average temperature ranges from 11 degrees to 44 degrees Celsius. The three most significant seasons in Ahmedabad's climate are summer, monsoon, and winter, just like in most other regions of India.

- The first summer in Ahmedabad begins in March and lasts through July. The summers in Ahmedabad are known for being particularly hot and dry. The average minimum temperature is about 23°C, and the maximum temperature is 43°C. So far, the city has seen a maximum temperature of 47°C.
- The monsoon season in Ahmedabad: Around the middle of July, Ahmedabad experiences the south-western monsoons. The climate and weather in Ahmedabad are currently humid.
- Through September, the monsoon season is in effect. The city receives 93.2 cm of rain annually on average. torrential, infrequent rains are a common occurrence during the monsoons.
- A very dry climate characterises Ahmedabad's winters, which last from

November to February. At this time of year, Ahmedabad's weather is pleasant and agreeable, with minimum temperatures averaging around 15°C and maximum temperatures rising to 30°C. In January, the region is subject to chilly northerly winds. The low temperature for the winter in Ahmedabad is five degrees Celsius.

5.*2.1 Environmental Sanitation Institute*

Figure 17 Environmental Sanitation Ins

Building Type: Institute

Began: 2000

Complete: 2004

Structure type: 2 story building

Building orientation: North-East

Site area: 7284 m2

Covered area: 1456 m2

Location: Environmental Sanitation Institute is situation Sughad, West zone in Ahmedabad.

Design by: Yatin Pandya

Indian architect Yatin Pandya runs the business FOOTPRINTS E.A.R.T.H. He is also an academic, a researcher, an activist, and an author.

He has written journals. His works on architecture include "Elements of space making" and "Concepts of space in traditional Indian architecture," both of which have received international publication.

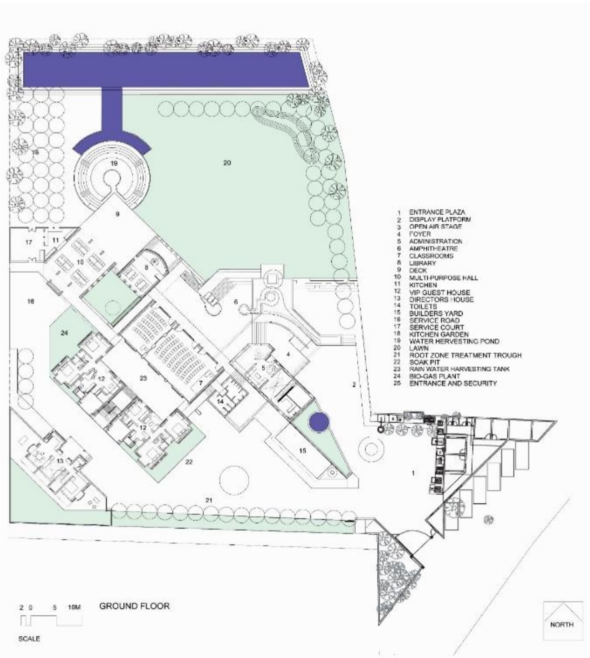


Figure 18 ground floor plan of Environmental Sanitation Institute

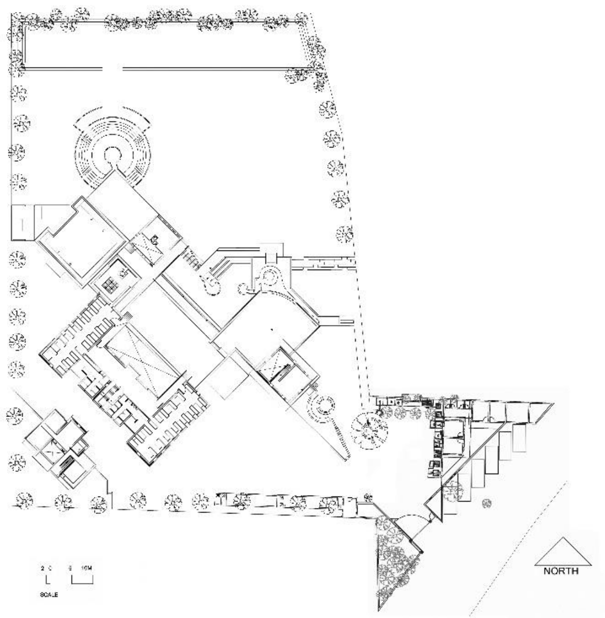


Figure 19 first floor plan of Environmental Sanitation Institute

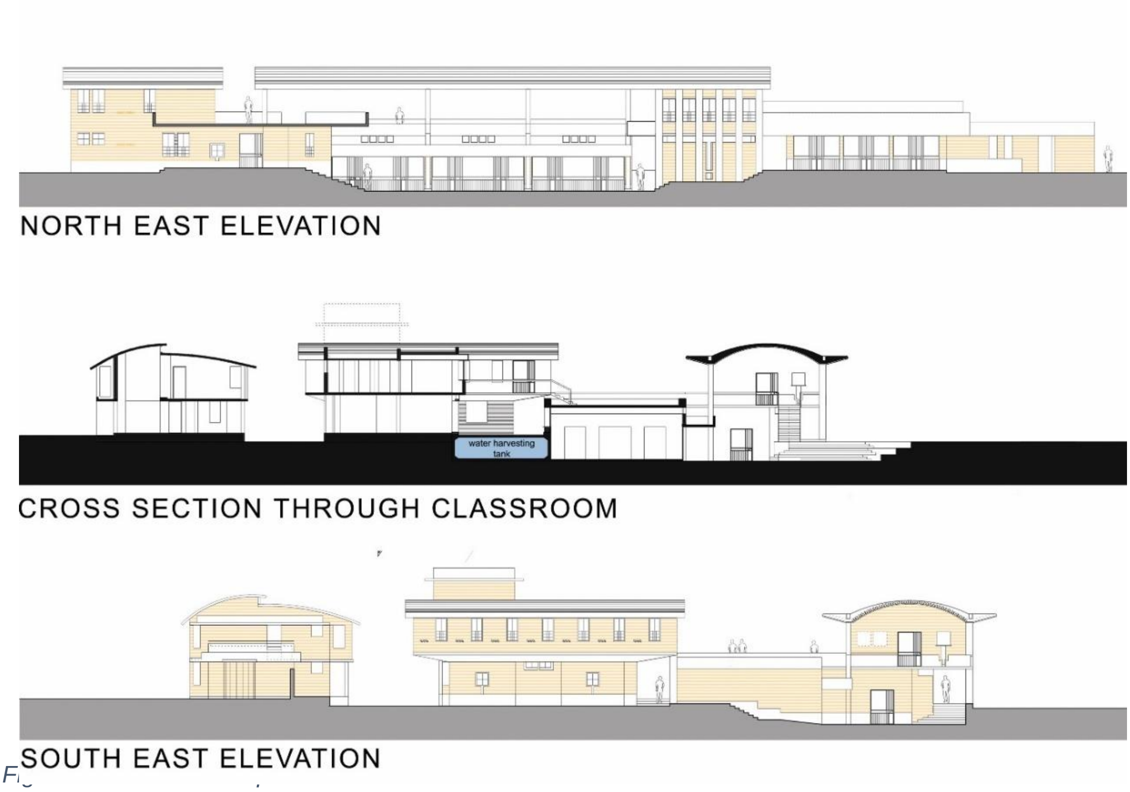


Figure 20 Elevation and Section

Material Used

Flooring: Kota stone

Figure 21: Material Kota stone

- It can absorb and store heat during the day and release it gradually at night due to its high thermal mass, which contributes to the maintenance of a constant indoor temperature.
- This sedimentary rock is composed of fine-grained limestone and is hard, compact, and uniform in cross-section. natural state, and it has a beautiful appearance when sealed.

• To compare with marble is soft and low porosity, non-slippery and less maintenance.

Roof: China Mosaic

Figure 22: Material China Mosaic

- The purpose of the china mosaic terrace is to give the roof a reflective layer that reflects a significant amount of solar radiation that is falling on the roof and then also re-emits the solar energy that was absorbed. The joints between the tiles are then sealed with white cement. Compared to untreated space, the treated space stays about 1 C cooler, and the performance is more or less constant throughout the day.

Brick

Figure 23: Material Brick

- Kota feels rough and leathery in its Structures made of brick have excellent thermal mass. It is known as thermal mass when a dense, heavy substance has the capacity to store heat and gradually release it. The summers are therefore cooler and the winters are warmer. This is a substantial benefit because heating and cooling account for more than 30% of the energy used in buildings.

- Due to its ability to reflect and retain heat, as well as lower energy costs than other building materials, brick is more energy-efficient

Door/Window: Metal + Wood + Glass


Figure 24: Material Metal and Wood

- The door has a strong metal frame for durability and security, and wood louvres for aesthetic appeal and a touch of natural warmth.
- A stylish and practical door made from a combination of metal and wood is created, making it ideal for commercial as well as residential buildings.

Passive Technique used in building

Courtyard

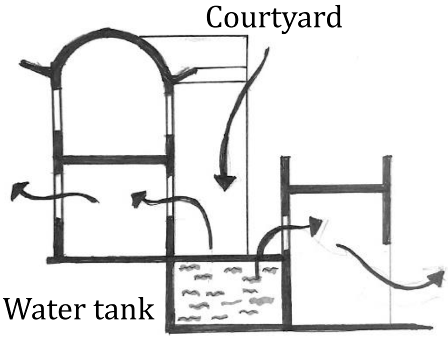


Figure 25 Courtyard 1 section

The courtyard is an effective passive cooling technique used in architecture. It is typically surrounded by buildings, providing shade and reducing direct sunlight exposure.

Additionally, below the courtyard, a water tank is installed, which helps to cool the surrounding air through evaporative cooling, creating a comfortable microclimate within the courtyard. This traditional design approach promotes natural cooling and ventilation, reducing the need for mechanical cooling systems and promoting sustainability in building design.

Inner Courtyard

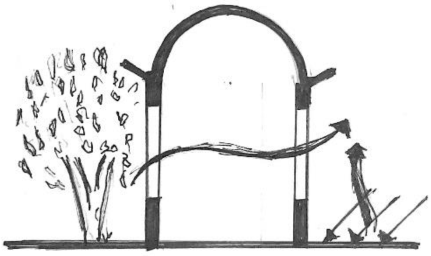


Figure 26 Courtyard 2 section


Figure 27 courtyard 1 view


Figure 28 courtyard 2 view

Cavity Wall

Internal structure wall (9”thick) separated from external curtain wall (4”thick) through ventilated Air Cavity**.**


Figure 30 Cavity Wal Air flow

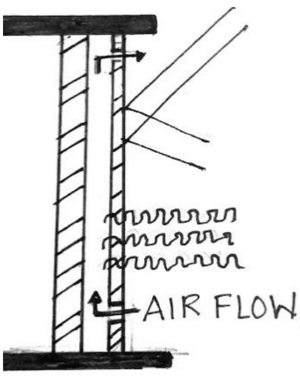


Figure 30 Cavity Wall Air flow section

Insulated Roof

Insulated Roof Thin Ferro-cement shell roof insulation by layers of China mosaic and Vermiculite.

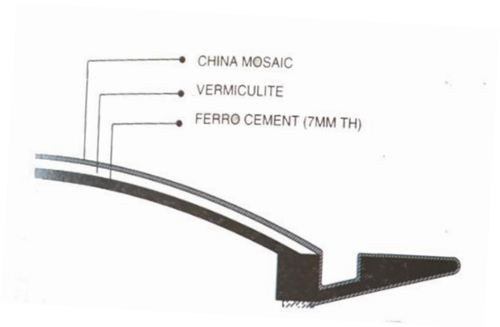


Figure 32 Roof Section

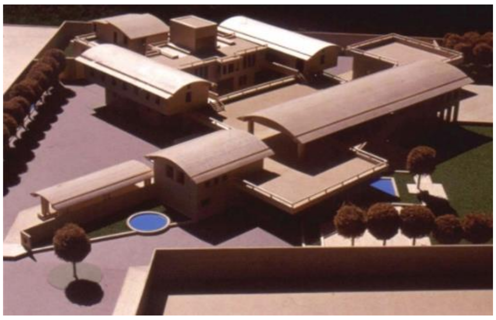


Figure 31 Roof View

Cross Ventilation

Natural ventilation involves using windows and other openings to facilitate the flow of air between indoor and outdoor spaces. When designing ventilation systems, it is important to take into account factors such as the positioning of shading devices, the size and orientation of ventilation openings, and the overall thermal performance of the building envelope.

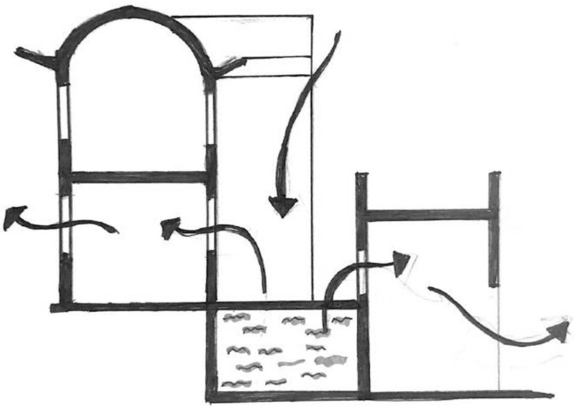


Figure 33 cross ventilation (Rest room)

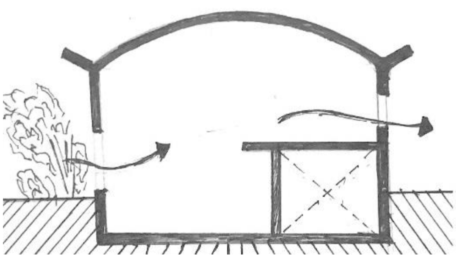
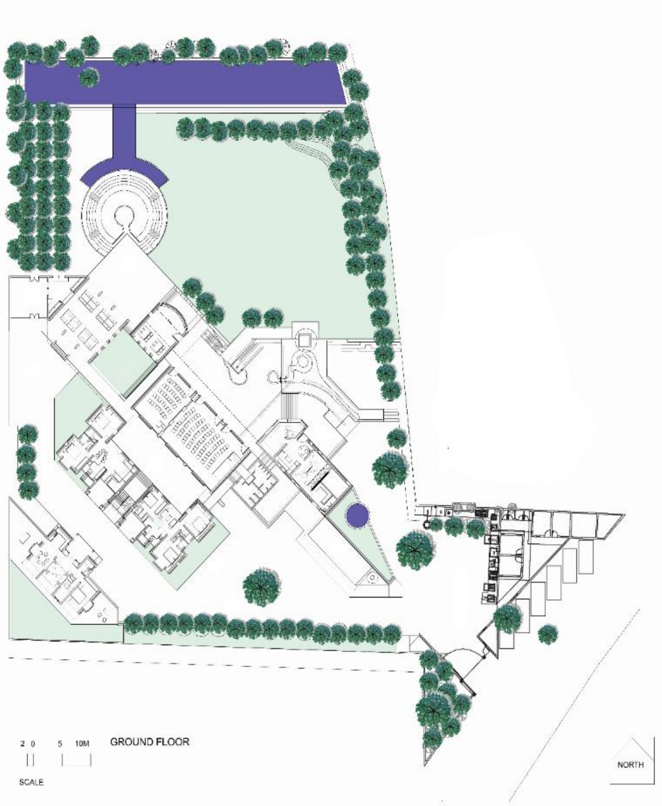


Figure 34 cross ventilation (Library)

Insulated Roof Vegetation and Landscape



Landscaping is the most used element of create architecture and vegetation grows around the building and periphery of site in order to create microclimates and to favour architectural design. It is also the cheapest and most effective way to increase year-round comfort and energy efficiency.

Figure 35 vegetation plan and views

Figure 29 location of testing

	°C	%
01 Outside of building	35.0	41.7
02 Courtyard	33.9	38.7
03 Library	32.0	45.7
04 Office	30.7	45.8
05 Ground floor Rest room	32.6	44.6
06 First floor Restroom	31.2	45.2

Figure 36 reading table from device of ESI

*5.2.2*Global Mission School

Figure 37 Global Mission School

Building Type: Global Mission School

Began: 2010

Complete: 2012

Structure type: 2-3 story building

Building orientation: North

Site area: 21,1511 m2

Covered area: 6962 m2

Location: Global Mission School is situation Sanand, North-West zone of Ahmedabad.

Design by: Yatin Pandya

Indian architect Yatin Pandya runs the business FOOTPRINTS E.A.R.T.H. He is also an academic, a researcher, an activist, and an author.

He has written journals. His works on architecture include "Elements of space making" and "Concepts of space in traditional Indian architecture," both of which have received international publication.

Plan

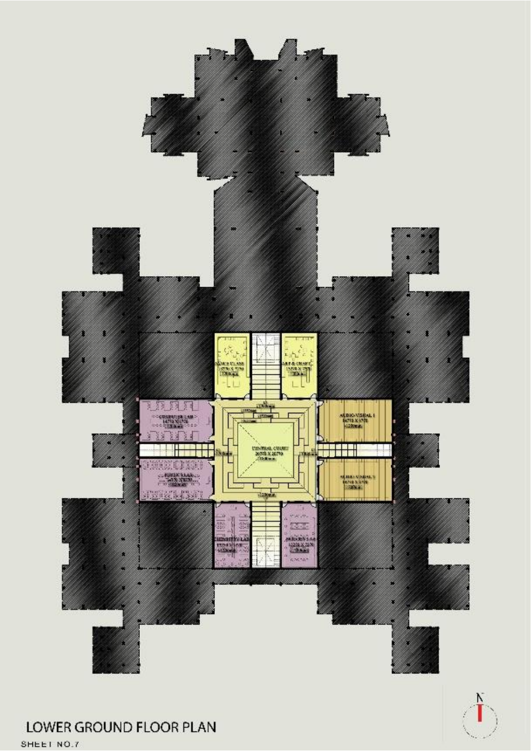


Figure 39 Lower Ground Floor plan

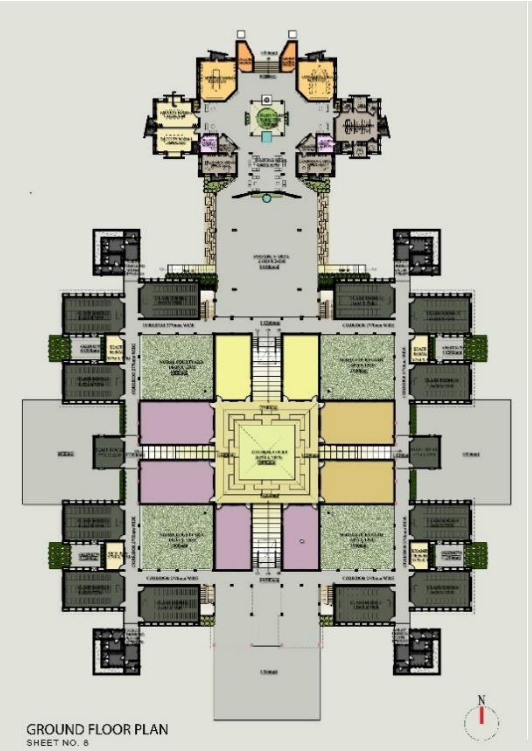


Figure 38 Ground Floor plan

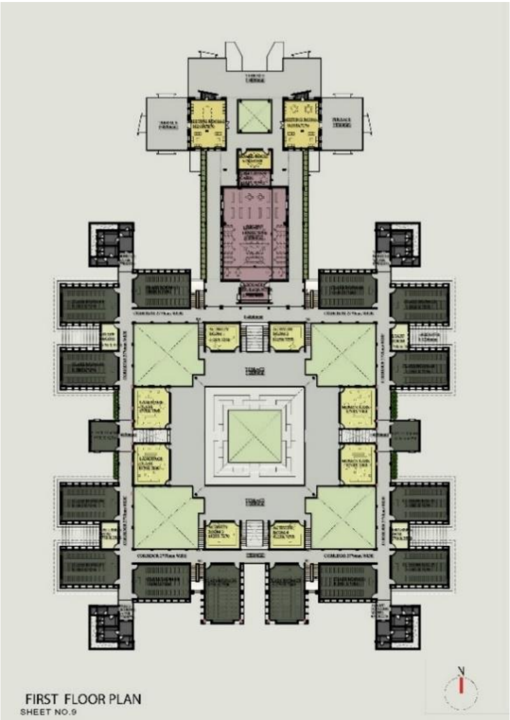


Figure 41 First floor plan

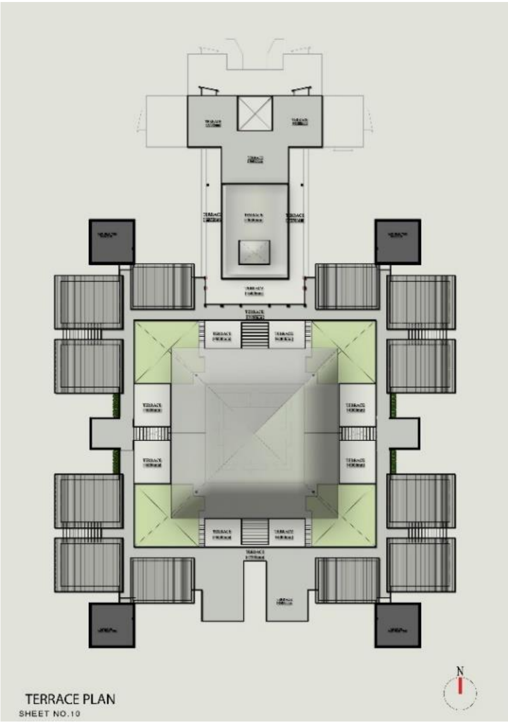


Figure 40 Terrace plan

Material Used

Flooring: (1) Kota stone


Figure 42 Flooring Kota stone

- It can absorb and store heat during the day and release it gradually at night due to its high thermal mass, which contributes to the maintenance of a constant indoor temperature.
- This sedimentary rock is composed of fine-grained limestone and is hard, compact, and uniform in cross-section. Kota feels rough and leathery in its natural state, and it has a beautiful appearance when sealed.
- To compare with marble is soft and low porosity, non-slippery and less maintenance.

(2) Red tile


Figure 43 Flooring Red tile

Red tiles are known for their high solar reflectance, which means they can reflect a significant amount of sunlight, reducing heat absorption and helping to keep the building cooler. Red tiles can also provide a visually appealing and traditional aesthetic, especially in climate.

certain architectural styles or cultural contexts

Roof: China Mosaic

Figure 44 Roof China mosaic

The purpose of the china mosaic terrace is to give the roof a reflective layer that reflects a significant amount of solar radiation that is falling on the roof and then also re-emits the solar energy that was absorbed. The joints between the tiles are then sealed with white cement. Compared to untreated space, the treated space stays about 1 C cooler, and the performance is more or less constant throughout the day.

Wall: **Stone cladding on main facade**

Figure 45 Wall cladding

There are several reasons why cladding, which is the installation of an additional layer of material on the exterior of a building, may be used as a passive technique. Cladding can enhance insulation and reduce heat transfer, helping to improve the building's energy efficiency. It can also protect the underlying wall from weathering and moisture damage, improving durability.

Door/Window: Metal and Glass

Figure 46 Metal-Glass

Metal doors can provide durability, security, and resistance to weathering, while glass doors can allow for natural daylighting, passive solar gain, and visual connectivity to the outdoors.

Passive Technique used in building

Courtyard

Figure 47 Shaded Courtyard

Figure 48 Courtyard

Here courtyard is played with five natural element and reorganize around five placed in each quadrant as well as the center and overlaid with tree shrubbery and water features help create favorable micro climate by diffusing light and providing shade in a hot and dry climate.

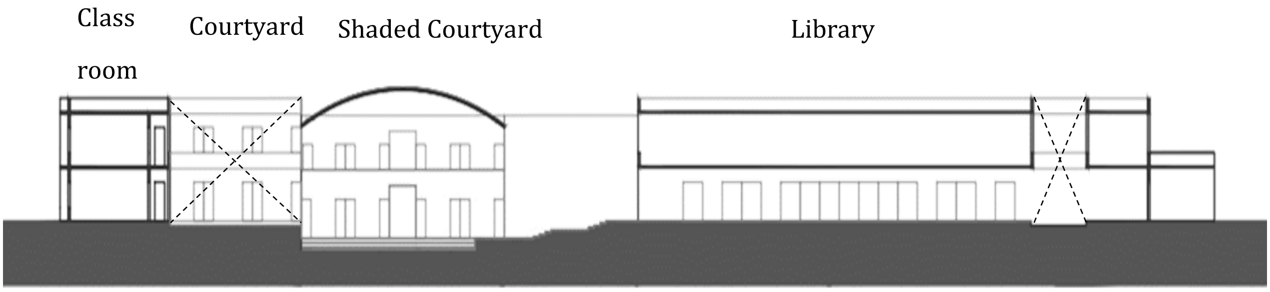


Figure 49 Courtyard Section

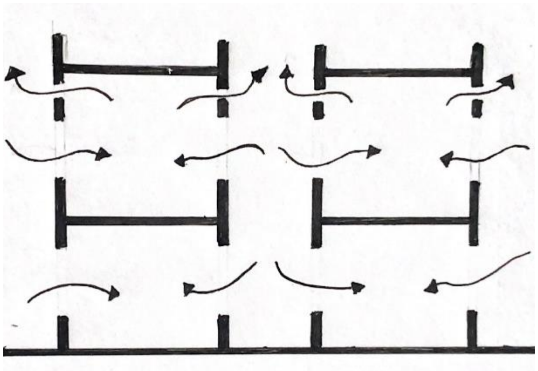


Figure 50 Stack Ventilation section

Stack Ventilation

Stack Ventilation Classrooms organized around courtyards can benefit from ventilation and daylighting. The inclusion of landscaped open spaces, also referred to as "fingers," between two classrooms can encourage cross ventilation and permit fresh air to circulate through the classrooms. This can lessen the reliance on mechanical ventilation systems while also helping to improve indoor air quality. Additionally, the courtyards' natural lighting can improve the learning environment by fostering a sense of connection to nature and obviating the need for artificial lighting during the day.

Vegetation

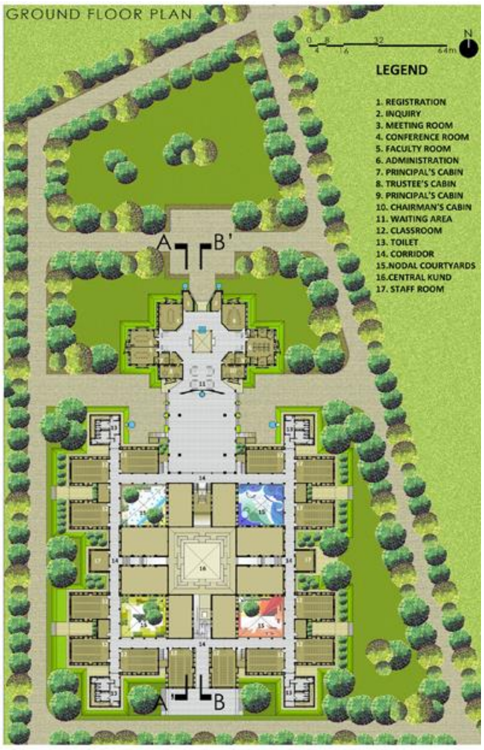


Figure 52 Vegetation plan

Strategic vegetation growth around the building and site periphery can help create microclimates. Trees, shrubs, and other greenery can provide shade, reduce heat island effects, increase humidity, and act as windbreaks. These microclimates can improve comfort for occupants, support biodiversity, and enhance the overall sustainability of the site by reducing energy needs for heating and cooling.

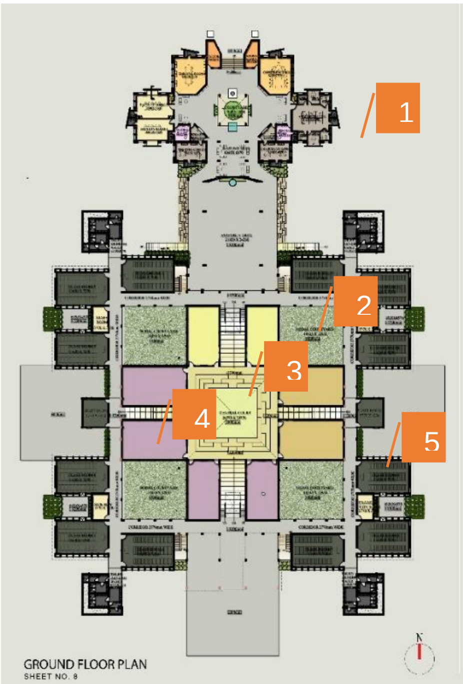


Figure 51 plan for testing

	°C	%
01 Outside of building	33.2	35.4
02 Courtyard	32.1	63.6
03 Courtyard shaded	30.7	40.7
04 lab	30.6	50.6
05 Ground floor classroom	30.0	42.5
06 First floor classroom	30.4	41.8

Figure 53 reading table from device of global mission school

CHAPTER 06

Results and finding

6.1 Environment sanitary institute

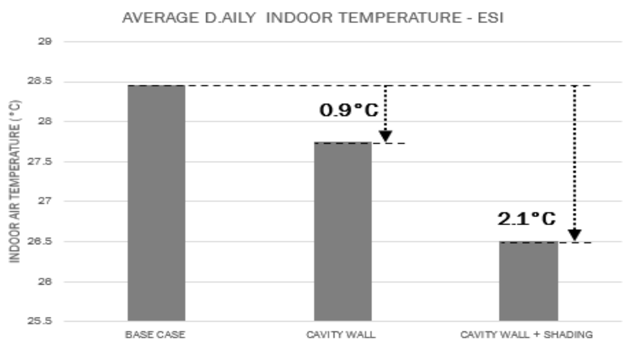


Figure 54 Daily indoor air temperature of ESI

Here we put a model of Environment sanitary institute for simulation for to see with passive technique or without passive technique how is working so first is base case (no passive technique) 29.5°C and then we adding cavity wall so decrease 0.9°C

After that we adding shading so its decrease 1.2°C so total we get 2.1°C less in indoor temperature.

6.2 Global mission school

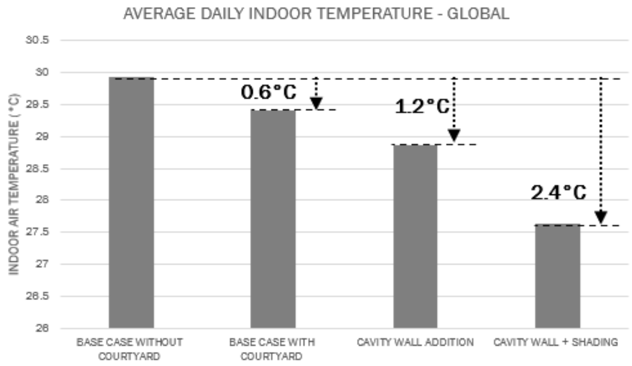


Figure 55 Daily indoor air temperature of Global Mission School

Here we put a model of Global mission school for simulation for to see with passive technique or without passive technique how is working so first is base case (no passive technique) 29.9°C and then we adding courtyard so its decrease 0.6°C

After that we adding cavity wall so its decrease 1.2°C and shading also add its decrease 0.6°C total we get 2.4°C less in indoor temperature.

6.3 Thermal Comfort of both Case study

There are important factors to take into account when evaluating the various parameters that affect thermal comfort. Let's talk about each of them:

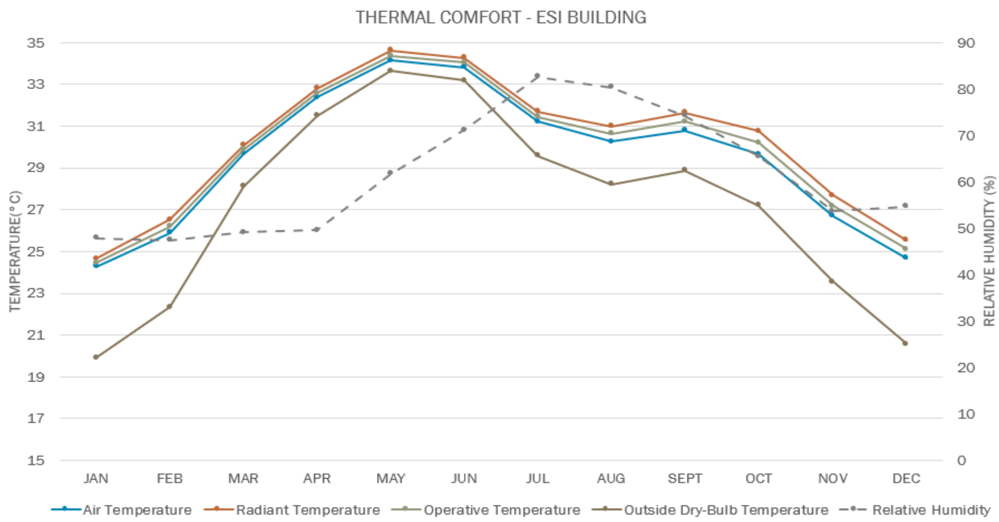


Figure 56 Thermal Comfort of ESI

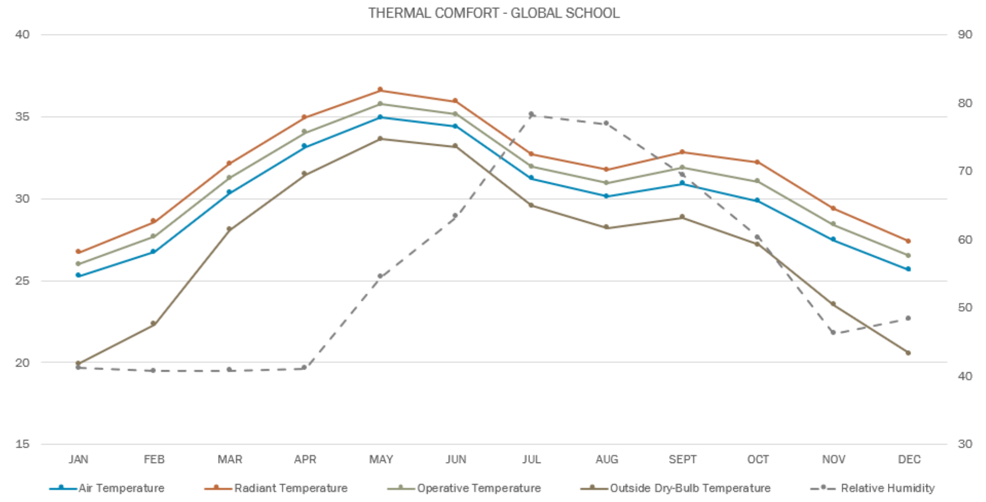


Figure 57 Thermal Comfort of Global Mission School

Measurement of the temperature of the air around people is referred to as "air temperature." Usually, a thermometer is used to measure temperature, which is then expressed in degrees Celsius (°C) or Fahrenheit (°F). Different ranges of temperatures between 20 and 24 degrees Celsius (68 and 75 degrees Fahrenheit) are frequently regarded as comfortable for sedentary activities, depending on the air temperature.

Radiant Temperature: Surfaces that emit and absorb radiant heat, such as walls, floors, and furniture, have an average temperature that is referred to as their "radiant temperature." The heat exchange between people and their environment may be impacted by this temperature. For instance, even if the air is at a comfortable temperature, sitting next to a cold window may be uncomfortable.

Operative Temperature: For the purpose of capturing the complete thermal environment that people encounter, the operative temperature accounts for both the air temperature and the radiant temperature. The formula used depends on the standards or policies being followed and uses a weighted average of these two factors.

Temperature of the ambient air outside the building, away from any direct heat sources or moisture, is referred to as the "outside dry bulb temperature." Understanding the outdoor conditions and how they might affect the thermal comfort indoors is made easier with the aid of this parameter.

Relative humidity is a measurement of how much moisture is actually in the air as opposed to how much moisture the air could hold at a specific temperature. A percentage is used to represent it. People's perceptions of temperature can be influenced by relative humidity because higher humidity can make the air feel warmer due to less evaporative cooling from the skin.

When evaluating thermal comfort in places like the environment sanitary institute, these factors are taken into account collectively. Standards and guidelines like the ASHRAE 55 standard or ISO 7730 provide recommendations on acceptable ranges of these parameters in order in achieving comfortable temperatures and promote wellbeing in various settings. To create a cosy and healthy environment for the occupants, it's crucial to monitor and manage these factors.

6.4 Yearly comparison indoor air temperature of case study

The comparison is only done to see which passive methods work best in a hot, dry climate Here, is existing indoor temperature

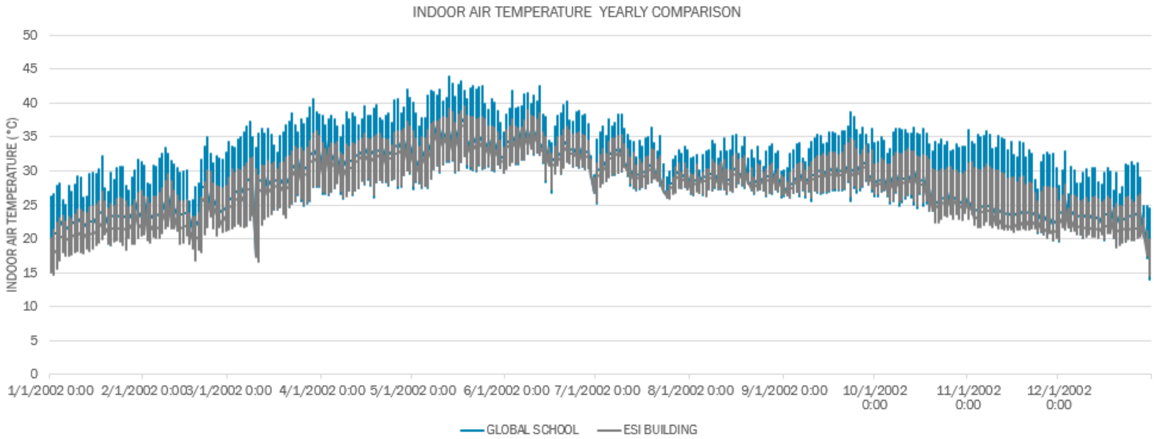


Figure 58 Yearly comparison indoor air temperature of case study

Blue is (global school) higher and grey is (environment sanitary institute) lower

So environment sanitary institute is best performance to compare global mission school

6.5 Inferences

- Environment sanitary institute, to minimize solar radiation, the south and west facade is shaded by dense trees. In Global mission school, the heat gain is reduced by providing overhangs shade of 900 to 1000mm deep and mostly opening are on north and south

- Environment sanitary institute, here the wall thickness is 460mm cavity wall (two brick thick inner and outer wall is one brick and between gap is 150mm). I n Global mission school there wall cladding used in some part of west and east façade
- The heat gain of Environment sanitary institute, with cavity wall, insulated roof and shade is getting 40 to 45 % reducing and in Global mission school there open and semi-open courtyard, wall cladding on some part and shades is getting 35 to 40 % reducing
- To compare both of case study building are well played in level for good ventilation and low consuming energy
- Based on the comparison of the two scenarios discussed above, it can be concluded that the energy

Environment sanitary institute consumption is comparatively lower in a model with passive techniques

- throughout the year. have EPI levels that are 17.5% and 5% lower, respectively, than their base case models.

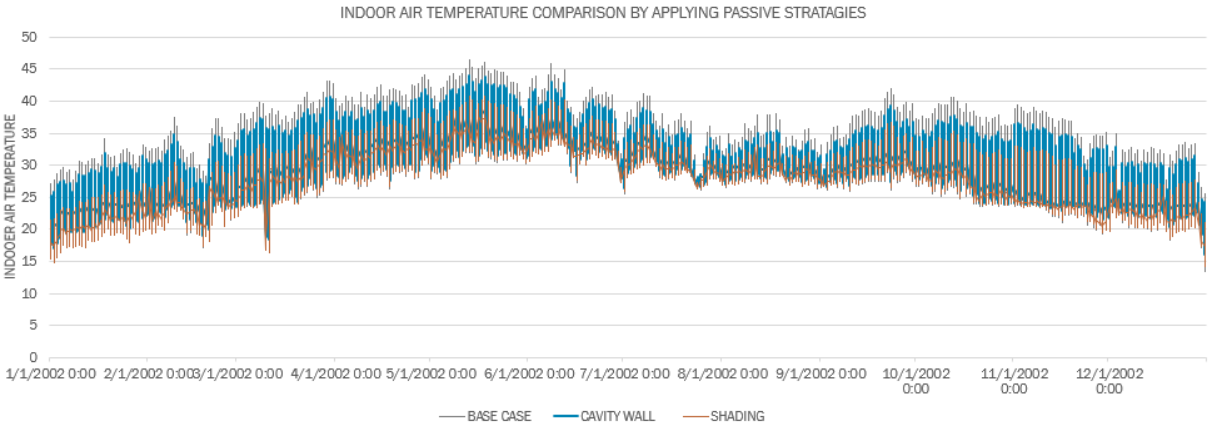
6.6 Percentage (%) temperature reduction on each direction

The table shows the thermal reductions caused by individual passive techniques on different directions of the buildings. Each of these directions have non-identical readings for all the passive methods because these sides are impacted by sun and wind in a different manner.

PASSIVE COMFORT METHOD	CASE STUDY	PERCENTAGE (%) TEMPERATURE REDUCTION ON EACH DIRECTION DUE TO INDIVIDUAL PASSIVE COMFORT METHOD			
		NORTH	SOUTH	EAST	WEST
CAVITY WALL	ESI	1.8	4.8	2.4	3.6
	GLOBAL	1.2	6.4	2.4	2.8
SHADING	ESI	2.6	6.8	4.4	5.6
	GLOBAL	2	8.4	4.8	4.8
THERMAL MASS	ESI	2.2	5.8	3.4	4.6
	GLOBAL	1.6	7.4	3.6	3.8

Figure 59 Percentage (%) temperature reduction on each direction

6.7 Illustrate building



Passive technique analysis in hot and dry region

Here we prove by illustrate building with selected passive technique how much reduction in heat gain

So, we take one building without passive technique then we add Cavity wall after that we add shaded,

Area of building:100sqm

Three stores building

Location: Ahmedabad

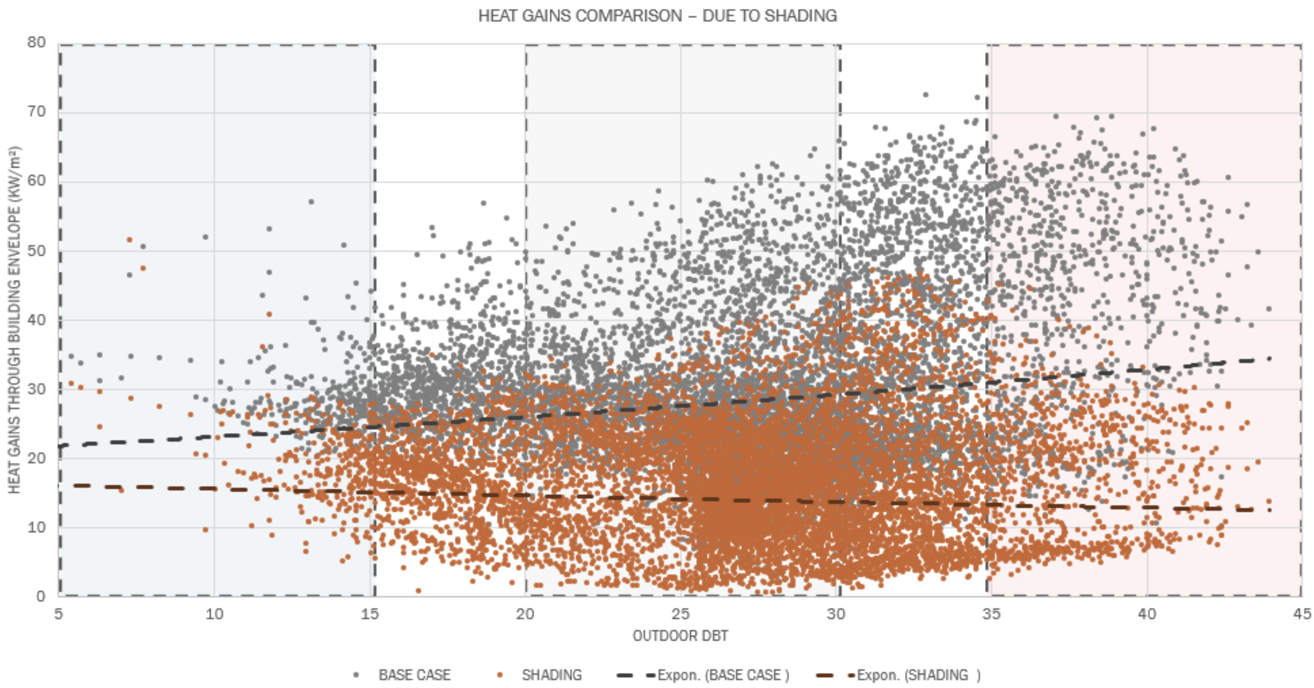


Figure 60 heat gain comparison due to shading

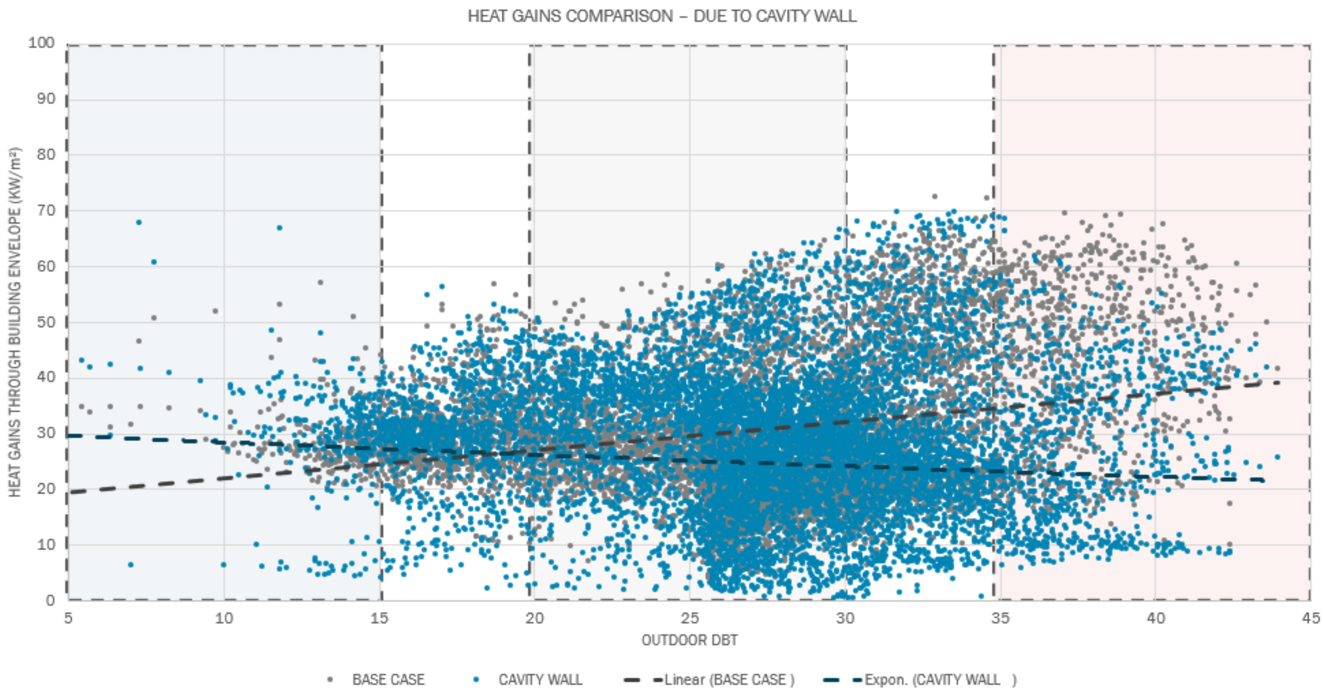


Figure 61 heat gain comparison due to cavity wall

CHAPTER 07

Conclusion

In this research, building envelope design plays a major part in decreasing solar heat gain, which minimises the need for air conditioning and minimises overall energy consumption, the passive cooling design only work if all of the design components can effectively block the heat during the summer and reduced mechanical cooling energy consumption and maintenance of a comfortable indoor environment are the goals of design for passive cooling.

The literature review found that using any one passive technique may significantly affect the temperature of the building's indoor air, so it is important to have a basic understanding of passive design techniques in general, as well as the benefits of using them. According to the table (figure 15), which also reveals that the temperature difference between the inside and outside air is roughly 8.5 to 9.6 degrees Celsius, the cooling demand can be reduced by 40%. With a 4–5°C temperature difference, vegetation and landscape can also flourish in hot, dry climates.

In secondary case studies on various locations to determine the passive strategies that the most well-known structures in those cities use most frequently. A list of the methods for each location is provided below:

- Ahmedabad: The well-known structures there primarily use cavity walls and shaded structures as passive climate control measures.
- Popular buildings in Kutch use passive cooling methods like thermal mass and wind towers to maintain a comfortable indoor temperature.
- Evaporative cooling and earth coupling are frequently used as passive temperature control methods in buildings in Jaipur and Jodhpur.
- Every city employs the same general passive technique, which is the creation of courtyards. These spaces help regulate temperature regardless of the location and are a widely used passive technique.

The table (figure 54,55) simulates the effect on the indoor temperature on the base case model of sites by applying the cavity wall and shading. The temperature reduces by at least 2 degrees C. This difference in the heat reduction was measured using a simulation software called Design Builder.

A promising method for producing naturally ventilated, thermally comfortable spaces is passive design. By comparing the results of the two case studies, it can be said that a passive technique-incorporated model is more thermally comfortable than a conventional material-only model.

The Through illustrates model, which makes use of passive strategies, is not just applicable to hot, dry countries like India. Any area with comparable local and climatic conditions can use it.

By putting these sustainable design principles into practise, it is possible to significantly lessen the need for artificial heating and cooling systems, which reduces the wasteful use of energy and resources. An improvement in a building's overall thermal performance can be achieved by combining different passive techniques.

The result when applying all passive techniques can be assessed in future research by running simulations using weather data sets. It would also help to improve design strategies by giving more precise insights into a building's thermal performance.

It is crucial to remember that each passive technique may not always cause a significant drop in temperature as a result of its addition. Even with the use of all passive strategies, a building's temperature may not drop from 44°C to 40°C. Each technique's effectiveness is influenced by various elements, including the building's orientation and location, the climate in the area, and other design considerations.

Passive techniques' suitability and efficacy in a particular field are greatly influenced by tradition and practise style. Which techniques would work best in each situation can be determined by looking at the orientation and characteristics of the various walls on (figure no 59_North, South, East, and West). The West wall, which receives direct sunlight during the hottest times of the day, may, for instance, contribute significantly more to temperature reduction than the North wall. The depth of the fenestration and the angle of the sun's rays are both responsible for this. Better results can be obtained by using shading techniques on the West and East walls that are properly designed.

Good results were obtained from thermal comfort. It is possible to effectively control the amount of heat absorbed by thermal mass materials without fenestration.

The building's U-value (heat transfer coefficient) is regulated by the thermal mass, which serves as a buffer by absorbing and radiating heat.

Incorporating passive design strategies can improve thermal comfort and natural ventilation in buildings, in conclusion. Even though utilizing all available techniques might not result in a particular temperature drop, doing so can help create a more comfortable indoor climate. Careful examination of the building's orientation, the surrounding climate, and other design elements is necessary for these techniques to work effectively. Future studies that make use of weather data and simulations can offer useful insights for improving passive design strategies.

Figure 62 Testo Meter

Instrument used

Testo Meter

This allows you to carry out quick and easy measurements at places which would otherwise be extremely difficult to reach. There's also a special optional carry case that can hold both your meter and the probes and sensors that make up your individual set.

Figure 63 Temperature measuring range

Feature	Values
Temperature measuring range	0 to 50 °C
Humidity measuring range	0 to +100 %RH (non-condensing)

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