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Comparative Study of Traditional and Contemporary Houses in Abbottabad: Environmental Impact Assessment

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Contents:

Abstract: *The use of new construction materials, active cooling and heating systems, and rising global temperatures are surprisingly harming our environment and are contributing to pollution and the depletion of the ozone layer. The study focuses on several thermal comfort strategies for residential building designs and passive design techniques used in Abbottabad, Pakistan, traditional houses. The research also offers a descriptive examination of a traditional and a modern built house, highlighting the problems caused by the absence of conventional passive design elements in the latter. The research comes to a conclusion and suggests environmental protection measures that modern homes should use in the future.*

Key Words: Comparative Study, Traditional, Environmental Impact Assesment

Introduction

The increasing concern about global warming has been one of the burgeoning problems in the last few years. The Intergovernmental Panel on Climate Change (IPPC) has projected that between 2080 and 2100, average global temperatures would increase by 2.6°C to 4.8°C, as depicted in Figure 1 (Saari, 2013). In addition, temperatures in South Asia (Bhutan, Nepal, India, Pakistan, and South China) are predicted to rise by an average of 2-3 degrees Celsius between 2046 and 2065. In terms of rainy season dates, rains, water shortages, etc., the effects of climate change in Pakistan can also observe.

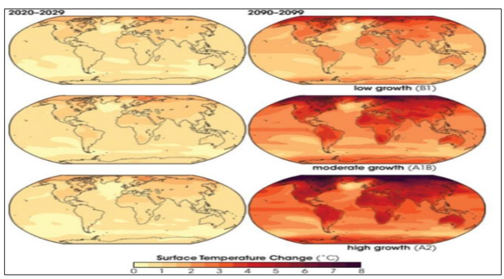

Figure 1: Depicts expected surface temperature variations from 2020 to 2029 and 2090 to 2099, depending on expected population growth (Saari, 2013).

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Buildings are one of the primary contributors to climate change, and their energy consumption contributes significantly to global warming. The building's energy use accounts for almost 40% of the world's overall energy use. In 2015, buildings utilized 2.941 Mtoe (million tons of oil equivalent energy). (Nezhad, 2009) Residential and public-sector energy consumption totalled 2,569 Mtoe, with the residential sector accounting for two-thirds of overall energy consumption. Energy demand in the building sector expects to rise to 5,257 Mtoe in the baseline scenario by 2050, with the residential sector contributing 60% of this increase to 60% (Nezhad, 2009). Also, the primary source of emissions to the atmosphere of greenhouse gases (GHG) and carbon dioxide (CO2) is energy consumption in different sectors (Bahrami, 2008).

Buildings' construction offers an opportunity to help deal with these issues by consumption, considering the current climate change scenario and electricity costs. Building houses for more energy, in this case, efficiency would be very acceptable, and one of the ways is the growing use of passive architecture techniques in modern buildings.

Much of Pakistan's cities lack a correct, well-designed bye-law building code. Abbottabad is a city with more vital by-laws compared to other cities in Pakistan. Even then, it can seem that the gap is enormous. In terms of thermal comfort, current requirements apply. Every standard concerning insulation, airtightness, etc., which helps preserve and achieve thermal comfort, is absent in the bye-laws. During the shifting seasons, this has contributed to the problem of modern buildings getting overheated or cold. Also, it illustrates those excessive quantities of electricity are being used and will continue to maintain warmth inside the structures in the future.

Literature Review

Thermal Comfort

Thermal comfort is a feeling that reflects satisfaction with one's thermal surroundings. Thermal warmth is contextual because it varies from person to person. It is preserved because the heat produced by human metabolism is allowed to dissipate at a pace that keeps the body at a steady temperature. Any extra heat gain or loss creates considerable discomfort. The quantity of heat generated and lost must balance out in order to maintain thermal comfort. One of the most crucial components of living in a house is having the appropriate level of thermal comfort. There is no absolute norm for temperature since people may live and thrive in a variety of conditions, from highly hot to extremely cold. (Darby and White, 2005). It is defined by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard as a mental state signifying satisfaction with the thermal environment. The air temperature, mean radiant temperature, humidity, relative airspeed, and hidden features are among the environmental factors that influence thermal comfort in terms of clothing and activity. By properly integrating these components, a thermally comfortable atmosphere may be created.

It has long been known that factors other than room temperature may impact how hot or cold you feel. Thermal comfort is impacted by six main elements.

- Air Temperature (Real feel of the Air Temperature)
- Radiant temperature (surface temperature in the environment)
- Relative humidity (Percentage of water vapours in the air)
- Air movement (the speed of air at which it comes in contact with the human body)
- Metabolism Rate (the quantity of energy used)
- Insulation in clothing (materials used to keep or lose body heat).

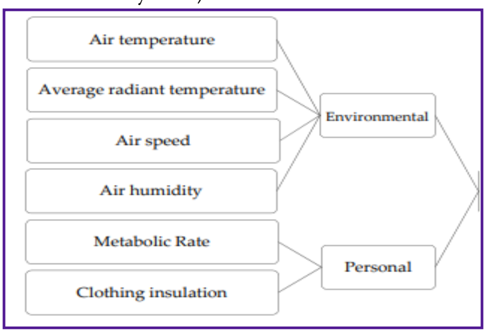


Figure 2: Parameters of thermal comfort for residence design (Parsons, 2003).

Air Flow

Air flow has an impact on the majority of people. As a result, air flow may start to play a big role in thermal comfort. People will feel sleepy and uncomfortable in the presence of stillness or quiet air in artificially created interior environments. Wind speed increases the amount of heat lost without increasing air temperature; however, convective heat loss increases considerably when the air temperature is lower than the skin temperature.

Furthermore, rigorous activity may aid in increasing air circulation (Liping et al., 2007). The calculation of air velocity faces various difficulties due to the irregular flow and trajectory of air. The ideal solution is to maintain a small measuring sphere with steady dimensions and characteristics.

Relative Humidity

Relative humidity (RH) is the amount of moisture carried in the air expressed as a percentage of the actual amount carried at that temperature (Parsons, 2003). Relative humidity is defined as the difference between the mole fraction of water vapour in dry air and the mole fraction in wet air at a given temperature and barometric pressure. Additionally, relative humidity is defined as the difference between the partial pressure or density of water vapour and the saturation pressure or density of air at the same temperature. Heat stress is mostly caused by air humidity, which has minimal bearing on thermal comfort.

Air Temperature

Air temperature is the temperature of the air around a human body (Ta). In addition, the ambient temperature has a big effect on heat exhaustion. It stands for the area of the atmosphere that has an impact on how heat is transferred from the body to the air. The air's temperature changes (Randall, 2005). Humans frequently experience temperature changes, and the limit of heat flow is not necessarily determined by the air temperature that passes over the bulk of the body's surface. Air temperature is not comparable to a dressed body representation and is frequently affected by "border circumstances." And when it's chilly outside, for instance, the body is covered in warmer air. The air temperature is thought to be the most important climatic factor affecting thermal comfort. But there should also be other factors taken into account.

Mean Radiant Temperature

Radiant temperature is the amount of heat that passes unaltered from a body at a higher temperature to a mass at a lower temperature (Tr). The ASHRAE Standard-specified temperature of a hypothetical space or enclosure at which radiant heat transfer from a human body is balanced with that from its surroundings (55-1992). Because the ISO estimates the mean radiant temperature around the human body, spherical globe thermometers that are used to measure heat stress closely resemble the body form of a seated person.

An occupied room's floor, walls, and ceiling may have temperatures that are amazingly close to air temperature. Radiant temperature can occasionally be close to the same as the surrounding air's temperature in both directions. In locations with radiating floors or other types of radiant heating, the average radiant temperature is higher than the air temperature throughout the heating season.

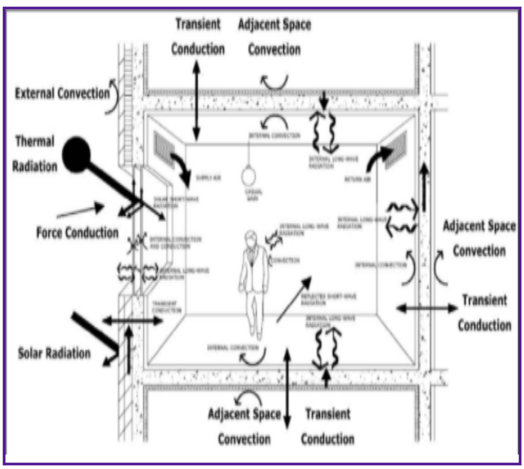


Figure 3: Design elements with the thermal comfort study (Randall, 2005).

Clothing Insulation

Changes in clothing can greatly influence the transfer of heat between both the body and its surroundings. Clothes can act as a heat shield, masking temperature and velocity differences between objects. Clothing functions as an insulator, decreasing heat loss from the body and enhancing endurance and comfort in colder conditions, according to the ASHRAE Standard (55-1992) on covered parts of the body. It is necessary to know about the inhabitants' clothes in order to gauge the area's level of thermal comfort since the thermal resistance of their clothing permits heat to move between the human body and the surroundings.

Metabolic Rate

It is impossible to underestimate the impact of metabolic rate on thermal comfort. The ASHRAE Standard (55-1992) describes metabolism in humans as "the rate of the body's energy production" and is measured in met. Physical activity creates heat, and the more heat we create, the more heat we must lose to keep our core temperature constant to prevent overheating. The metabolic rate is the average rate at which the body generates heat. The metabolic rate is described as met = 58.2 w/m2 and involves all heat cycles in the body induced by chemical reactions.

Passive Design Strategies

Windows

In designing a house, the windows' location may significantly affect heat gain and reduce heat loss. It advises preventing excessive north window areas in the northern hemisphere where Pakistan locates, while relatively more expansive windows on the south or due south face a recommended. Much of the windows are met south in the north part of Europe to get more solar energy.

By adding one or more layers, the insulation characteristics will be improved while the solar gain in windows is reduced. Conversely, windows are a house's weakest thermal connection. As shown in the diagram below, the window frames holding up the glass holding them to the walls typically serve as a thermal bridge connecting the inside and outside. At this moment, the outside environment starts to lose heat. By employing less conductive materials for windows, such as wood and vinyl, thermal bridges can be decreased. On the thermal comfort of the inhabitants, it may have a significant effect.

Currently, the building industry has access to a selection of energy-efficient windows. Its advantages include lowering heat loss, getting rid of draughts, and getting rid of cold spots. Additionally, it enhances the home's noise insulation from the outside. A double-glazed window, compared to a single-glazed window, decreases the amount of heat that escapes via gaps by 50%, according to the Energy Saving Trust (Maslen, 2011).

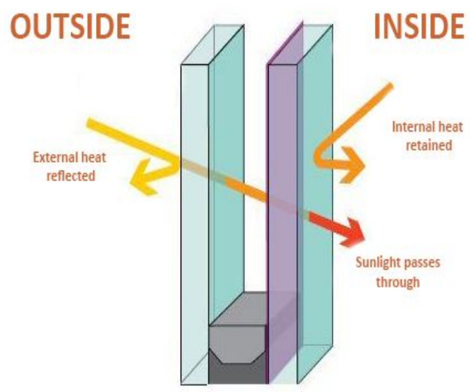


Figure 4: Double Glazed Glass

Thermal Insulation

Thermal insulation increases the envelope's interior surface temperature, directly affecting thermal comfort, according to the Passive Design Toolkit. During the winter, the inner surface temperature must be kept high enough to prevent condensation. Interior rooms are also affected by wall insulation, high-quality doors, and windows, depending on whether the roof is insulated or not. Traditional insulated and uninsulated roof buildings in Cyprus have different heating and cooling demands.

Cross Ventilation

When the internal air speed is twenty-two per cent greater than the speed of air outside, cross ventilation is improved by drilling two or three holes in the same wall. This is the case because one aperture acts as an inlet and the other as an exit (DeKay & Brown, 2013).

Shading Device

Balconies and verandahs with displays link users to the outdoors while also shielding them from environmental extremes such as the scorching sun and rain. Cane screens serve as a curtain in front of walls. The vines' thick vegetation blocks windows in the summer, but they lose their leaves in the winter, letting full light in. Shading devices

One of the most efficient methods of thermal change Comfort in buildings is the use of suitable shading Based on the environment, the place, and the devices Orientation in houses. A well-designed shading operation Device can minimize the heat gain and cooling of buildings—specifications and enhance the house's consistency, natural lighting (Maleki, 2011). The different shading kinds see in the Figure below. Modules are seen in winter and summer—a horizontal overhang efficiency.

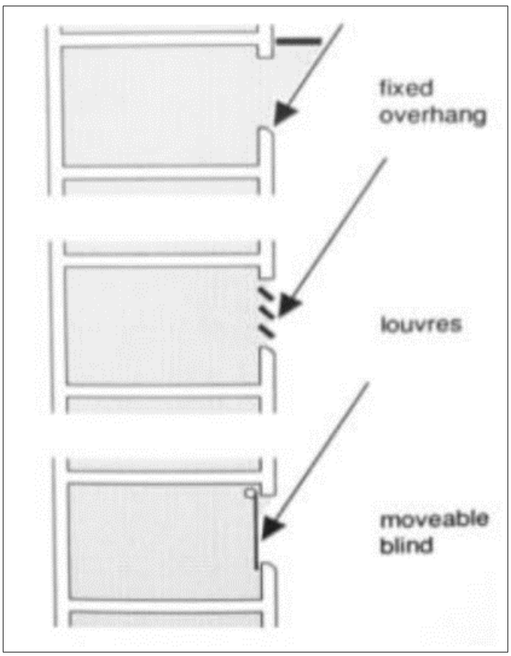


Figure 5: Types of shading devices (Maleki, 2011).

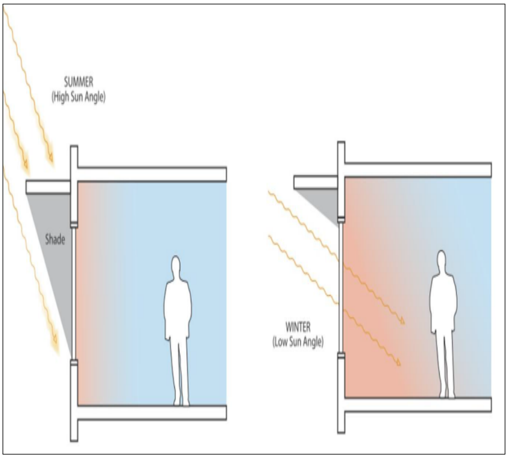


Figure 6: winters and summer performance of a horizontal overhang (Kowk & Grondzik 2011).

A study to evaluate solar passive cooling strategies such as solar shading, insulation, etc., found that when apt solar shading uses, the indoor temperature falls by around 2.5 to 4.5 ° C (Kumar et al., 2005). In the south and west orientations, window shading is essential, particularly in summer, to block the house's excessive sunlight. Blind window shades, for example, can reduce solar radiation gain by 20%, while external devices can cut heat input by up to 80 Percent (Kowk, 2011).

Evaporating Cooling

Evaporation from the residents' two water fountains and ponds cools the air. Inside the home, plants, trees, and vines have leaves that transpire and employ the same cooling process.

Insulation

The internal rooms are insulated and kept at a pleasant temperature thanks to the three-foot thick walls.

Presence of Biophilia

The outside environment is enhanced by a number of trees, potted plants, hanging plants, climbers, floating lilies, and other flowers and fruits. The rustling of trees, the scent of roses, the stroking of the wind, the textures of vegetables, and the visualization of a natural scene affect all human senses. Two fountains in two courtyards, each with its mirror-like tub, breathe life into the h, refresh the spirit, and cool the body.

Building Materials and Construction Techniques

The structure consists of load-bearing walls built with a cavity in the middle using double-leaf random rubble stone masonry. Stone rubble mixed with mortar is used to fill the cavity. The link between the inner and exterior layers of the masonry is made by the mortar infill. These walls have an excellent structural system to withstand gravity loads but lack resistance to lateral loads since the walls at their ends or the roof trusses are not well connected and act as free-standing walls. The walls have minimal tensile capacity because there is no insulation and collapse in a brittle manner. Either at the roof or the plinth level, the columns stand alone without bracing, allowing them to function independently of the other parts of the house. The top is built from corrugated metal sheets laid on these walls and wooden trusses. Since these trusses have no lateral restraints to prevent movement, they do not have diaphragm action when exposed to lateral earthquake forces and may undergo rigid-body translation.

Research Objectives

The research aimed to study the environmental performance impact of both Abbottabad Traditional House and Contemporary Design House.

1. To find out the basic architecture and design strategies for sustainable urban houses.
2. To formulate a detailed conclusion analysis for the user-friendly environmental behaviour of the residential building.

The climate of the Selected Region

Abbottabad has a humid subtropical climate with moderate to warm temperatures in the spring and fall, warm temperatures in June and July, and chilly to mild temperatures in the winter. Mid-summer temperatures can reach as high as 38 °C (100 °F), and they can fall as low as -5 °C (23 °F) during violent viral waves. There are intermittent snowfalls in December and January. Even yet, it is rare, despite the monsoon season, which lasts from July to September, to receive an abundance of precipitation, which occasionally causes flooding in the city's lower-lying areas.

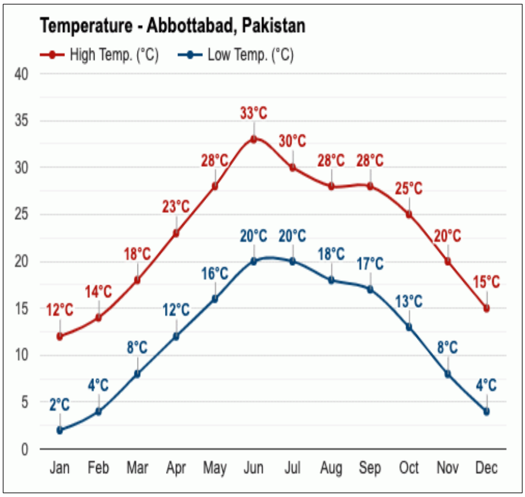


Figure 8: Annual temperature of Abbottabad (Ahmed, N. 2019)

June is the warmest month (33 ° C) (with the highest average temperature). The month with the lowest average temperature is January (12 ° C). The months with the highest low average temperature are June and July (20 ° C). January is the coldest month (2 ° C) (with the lowest average temperature) (Ahmed, N. 2019).

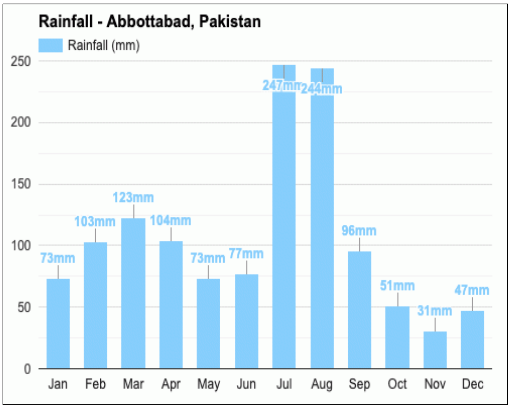


Figure 9: Annual rainfall of Abbottabad (Ahmed, N. 2019)

July (247 mm) is the wettest month (with the highest precipitation). November (31 mm) is the driest month (with the lowest precipitation) (Ahmed, N. 2019).

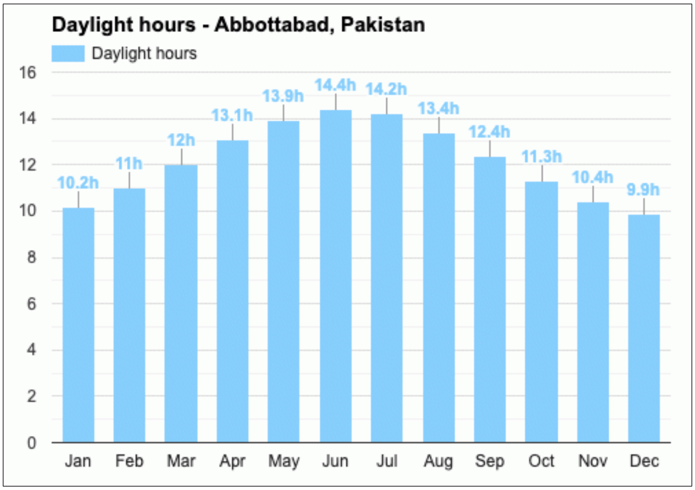


Figure 10: Annual temperature of Abbottabad (Ahmed, N. 2019)

Research Design

Based on the explored literature review, preliminary site visit, and similar research exploration, the following research design evolved. The research was concluded in the following 05 phases

Phase 01 (Literature Review)

In the very initial phase of the research, the basic understanding was built by studying the already published papers, reports, books, case studies and relevant standards.

Phase 02 (Physical Survey)

A personal observation-based exploratory survey was conducted by the researchers to select sample houses of both categories, i.e., contemporary and traditional houses. Photographs and personal notes were recorded. 03 houses from which category was selected for being appropriate for the case study, and then detailed documentation was done for one house of each category. Unstructured interviews were conducted with the residents of the houses regarding thermal performance, and their responses were recorded.

Phase 03 (Data Compilation)

The recorded data was then compiled with the help of software like AutoCAD, Photoshop, Google Earth, Sketch up and MS Excel.

Phase 04 (Comparative Analysis)

Data collected through documentation, observation and interviews of both types of houses were analyzed through comparative analysis

Phase 05 (Conclusion and Recommendations)

Findings were developed with the help of data analysis which led to the conclusions and recommendations of the study

Population, Sample & Sampling Technique

Population

The research exploration population mainly included the traditional and modern house residence in the rapidly growing and developing city Abbottabad. Since the population was huge and scattered at a large scale, sampling was opted to gather an accurate representation.

Sampling Technique & Sample Size

The sampling technique of selecting houses was based on cluster and convenience sampling by considering the design and passive features used in the houses were similar. A total number of six houses were selected (three typical houses of both types, i.e. traditional and contemporary). Further selecting one typical house from each type in Abbottabad to make the research exploration manageable. Brick masonry construction was chosen because only brick masonry construction was accessible in the three marla home category. Still, stone building masonry is available in more than one Kanal house category.

Selected Sample

A total number of 02 houses were selected from the sample population.

1. One traditional house.
2. One modern house.

Data Analysis and Discussion

The thermal comfort and climatic response techniques in Abbottabad City's contemporary and traditional houses were assessed in terms of:

1. Windows, Ventilation and Shading.
2. Water Body and Vegetation.
3. Building (construction) Materials.

A simplified evaluation and comparison of contemporary and historic houses were provided at the conclusion of that study.

Case Study 01: Traditional House

Thermal Comfort Design Strategies

Structures of Abbottabad's traditional architecture were built to resist the harsh weather that constantly surrounded them. The outcome was a successful structure that has withstood the test of time for decades, demonstrating the value of using responsive design techniques for buildings to effectively combat and adapt to their surrounding environment. The following are the main techniques employed in traditional structures:

Location

Traditional courtyard-houses are mostly found in Abbottabad's main city, which may be accessed through a maze of small passageways. The main city's buildings were clustered together to provide shelter from the noon sun. The proportion of street width to building height produced a shaded space from the heat during the hot summer months, allowing people to stroll comfortably and sit on the street.

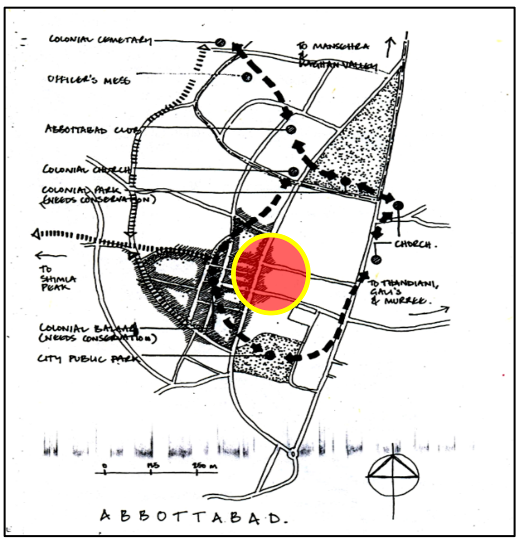


Figure 14: Abbottabad Main Bazar Layout (Walker, & Cary. 2019).

Architecture Design

Figure 15: Traditional House Main Bazar Streets at Present

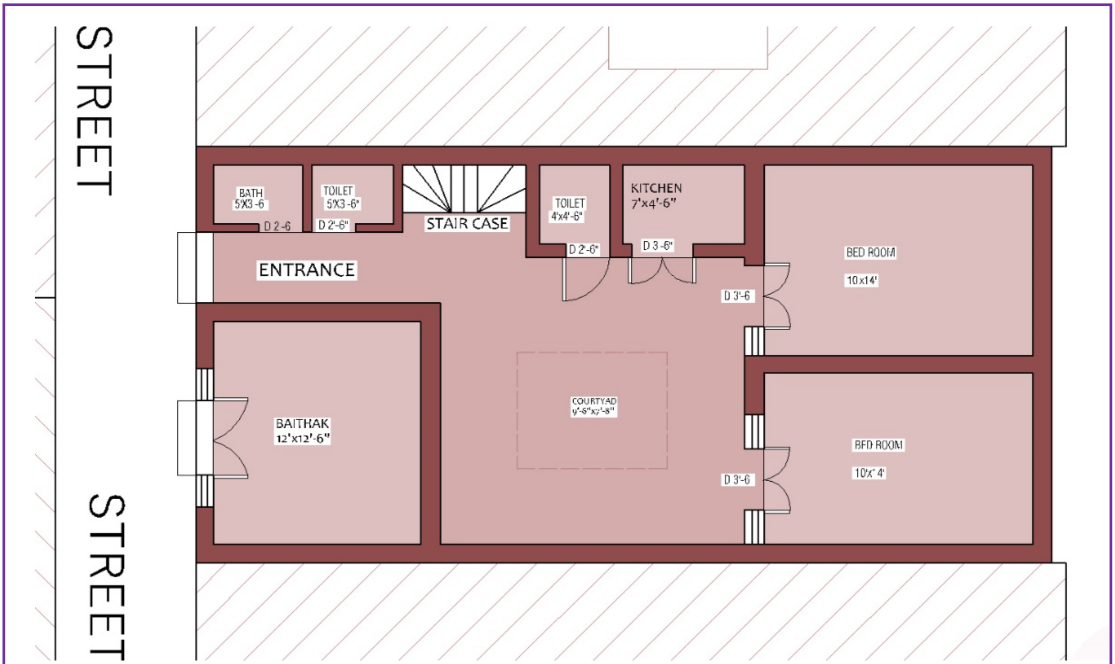


Figure 16: Ground Floor Plan traditional house Abbottabad

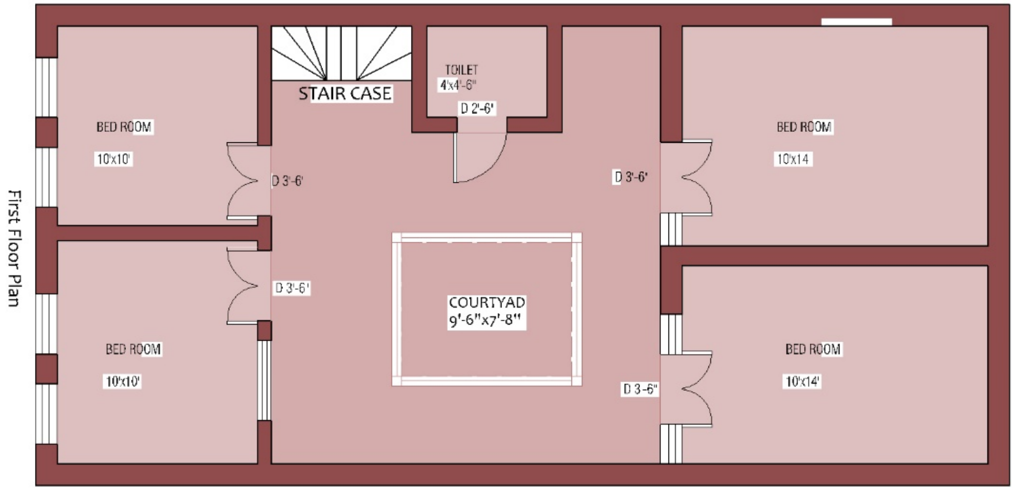


Figure 17: First Floor Plan traditional house Abbottabad

Windows, Ventilation and Shading

The importance of ventilation in changing the dry and hot climate cannot be overstated. Since the courtyard collects cold, dense air at night and supplies cool air to the nearby rooms until late in the day, its climatic response is especially effective. If the places around the courtyard offer additional ventilation alternatives, such as cold corridors and nearby narrow tunnels, the sun's warmth causes the wind to rise and creates cross ventilation. The convection cycle is powered by air flowing through these rooms and out onto the courtyard. Every level has a unique wind scope.

From November to March, the sun heats south-facing rooms more deeply, while from April to October, shading devices can help block the sun's rays. While dwellings are close and introverted on three sides, the outside shading elements on the façade serve little purpose in the Abbottabad residence. The shadings, on the other hand, are found within the home, mostly surrounding the courtyard. The courtyard's atrium and columns provide shade for the apartments that surround it.

Figure 18: Inner courtyard

Figure 19: Geometric Pattern in windows of the gallery

Figure 20: View of the gallery with direct sunlight

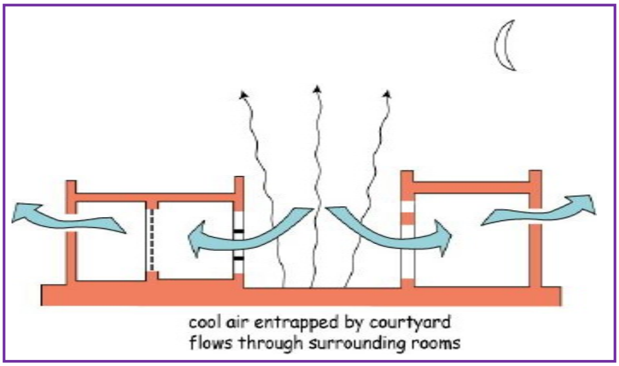


Figure 21: Air flow through courtyards (Aulak rawal, 2018)

Water Body and Vegetation

The heat from the dry, hot air transfers into the small drops of water, cooling the air as it passes through. This encourages water evaporation, which further cools the water. Because water has a significant heat storage capacity, fountains are found in the bulk of Abbottbad's historic buildings. The water has the potential to regulate the ambient air temperature by absorbing heat from the air through evaporation, resulting in a considerable temperature reduction.

Evapotranspiration is an effective technique for vegetation to change the temperature for better circumstances. Transpiration is the cooling effect of evaporation created by a cluster of plants when air flows through or over them. It also offers shade to the home, reducing the amount of direct sunlight. Because all of the windows of Abbottabad's historic buildings face the courtyard, there used to be trees in the courtyard.

Construction (Building Materials)

To protect humans from environmental factors and temperature ranges, building materials and construction methods were developed and put to use. The roof is composed of 8 to 9-inch thick wooden beams that are covered with a layer of mud without polishing. The exterior and interior walls, which range in thickness from 13 to 18 inches, are made of mud, brick, and stone.

Case Study 02: Contemporary Buildings Thermal Comfort Design Strategies

Contemporary residents in Abbottabad are categorized and affected by a combination of architectural styles and designs, such as Architectural styles that is unfamiliar to the area, without taking into account community interaction, unique climatic conditions, and traditional architecture's benefits. This is mostly due to a lack of building by-laws, as well as the knowledge of modern materials and construction methods' thermal efficiency. Because traditional buildings are considered ugly and obsolete, contemporary houses have grown rapidly to meet society and individual requirements for a social success symbol.

Location

Because urban planning rules were adopted from nations that are unconnected to the region's social life and culture, new buildings were developed in Abbottabad and implemented without regard for city features. As a result, the existing home lacked formal codes, resulting in a wide range of styles. The blocks of housing plots are surrounded by streets that are typically structured back-to-back, and the urban planning of the neighbourhood is distinguished by main streets that have a rectilinear grid layout system as well as Secondary Street. Since the roads are designed to let automobiles drive through, they are broad and open, with little shade for the buildings and passengers. The arrangement appears to lack a three-dimensional architectural idea and to take no account of social conventions, environmental circumstances, orientation, economics, urban design, or planning. Some places, however, such as the corners of blocks or houses closer to the main road, have a greater status than others.

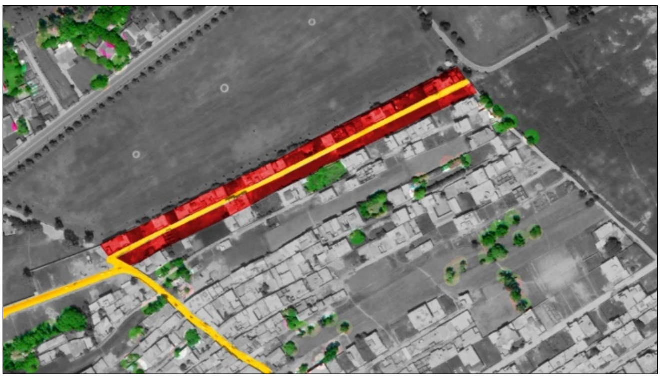


Figure 22: Google Earth Image Thanda Choa Road, Abbottabad

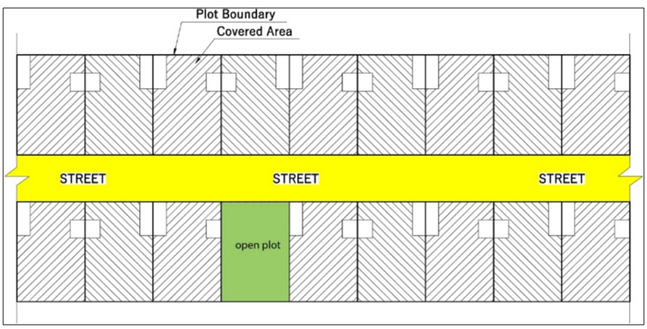


Figure 23: Layout of street houses at Thanda Choa Road, Abbottabad

Architecture Design

The growth in population and urban planning constraints influenced the construction shape and plot area of residential structures, which were categorized into varied sizes with plot sizes of 817.5sft, 1090sft, 1362.5sft, 1907.5sft, 2725sft, and 5450sft for middle-class families. Different design shapes with a front garden, one and two floors, or multi-story were produced as a result of the aforementioned considerations. Due to their close proximity to one another, detached and semi-detached homes do not provide each other with protection from the sun's rays or rain throughout the winter and summer.

Housing orientation is determined by urban planning distribution; environmental factors like wind exposure, sun access, heat transfer and gain from the environment outside are disregarded.

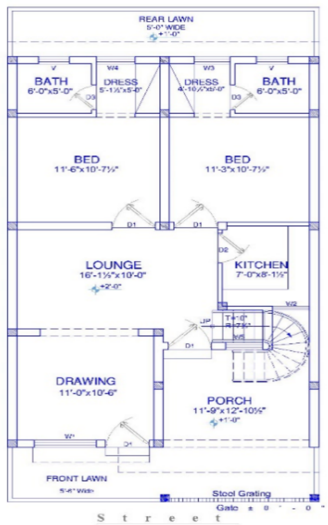


Figure 24: Modern House's Basic Layout (Ground Floor Plan)

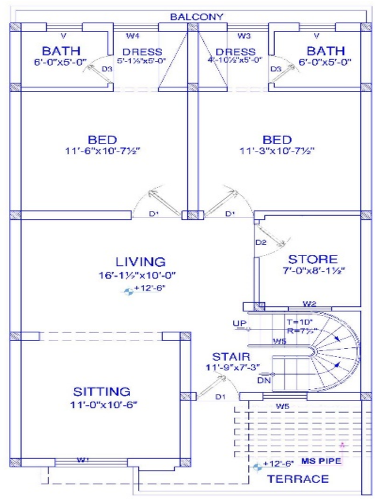


Figure 25: Modern House's Basic Layout (First Floor Plan)

Figure 26: Typical Modern Residence at Thanda Choa Road, Abbottabad

Windows, Ventilation and Shading

The ground level (living, kitchen, and reception) exterior windows facing the street and front yard are huge. Seasonal specialization, environmental variables, or geographic location have no bearing on this. As a result, the house is unable to make use of such windows to promote desired solar heat in the winter while preventing unwanted heat gain in the summer. Choosing the proper window size for a space that will be used all year might be challenging.

Large windows in hot, dry climates can result in heat gain in the summer and heat loss in the winter, necessitating the employment of mechanical equipment (HVAC) to achieve thermal comfort. Exterior windows are slightly shaded by first-floor extending little or large balconies. However, these shading devices are simply there for rainfall defence and aesthetic reasons, with no concern for the solar angle and directions for the summer and winter seasons.

Water Body and Vegetation.

The lawn in a contemporary residence is the result of an urban law that stipulates a distance of 14 feet from the street and with no environmental consideration. The use of the front garden is only for decorative purposes. At the same time, the sun and the wind have completely neglected and cannot be used to cool the internal temperature like the interior patio. Large windows can induce heat gain in the summer and loss in the winter in dry, hot climates, necessitating the installation of mechanical equipment (HVAC) to achieve thermal comfort.

Building (construction) Materials.

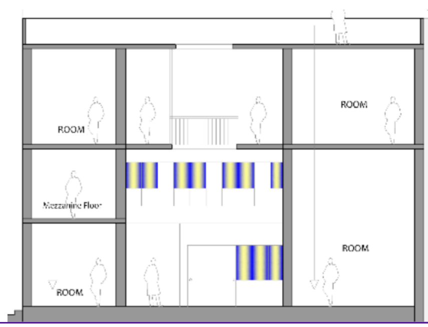
In Abbottabad, the roof of a contemporary residence is built of RCC and concrete blocks. The roof is composed of RCC material with a thickness of approximately 6 inches, sometimes covered with Terrazzo and porcelain tile, and typically left unfinished. The outside and interior walls are composed of 9-inch thick concrete blocks.

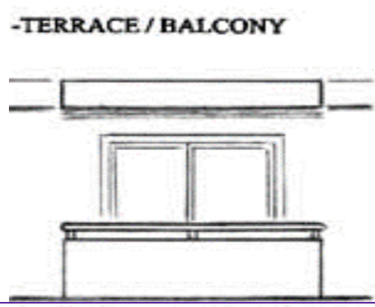
The door and windows are made of wood and aluminium. Floors are covered with tiles and marble. Heavy-duty constructions employ the materials mentioned above.

Evaluation and comparison between traditional build and contemporary build home in Abbottabad

Table 1. Windows, Ventilation and Shading

▪ Windows in the clerestory. ▪ Terraces that are covered. ▪ Natural ventilation and Natural light through Courtyard. ▪ Windows on exterior walls are small, and windows on interior walls are large. Small windows ion upper floors ▪ Windows that are directed toward the courtyard based on the climatic reaction. ▪ • Wall shadowed by connecting with neighbouring dwellings.	▪ Double-glazed windows ▪ Balconies that are not conventional or do not exist. ▪ External and internal windows provide natural ventilation and illumination. ▪ The outside and interior windows are both big. ▪ Windows facing the garden, the street, or the back.





▪ Covered terraces and windows are intended to offer adequate shade in the heat. ▪ The internal windows on the first level face south, while those on the ground floor face north and west to give adequate solar exposure and shade in the winter season and summer season. ▪ Tiny widows on exterior walls provide adequate privacy.	▪ Balcony and windows were not built to give adequate summer shade. ▪ Windows are huge in size and as they are not arranged keeping in consideration the orientation of the building, therefore becomes the reason of overheating in summers and under heating in winters. ▪ NO privacy within the rooms, However, it is appropriate for natural sunlight and ventilation.

Table 2. Water Body and Vegetation

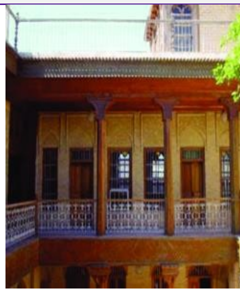
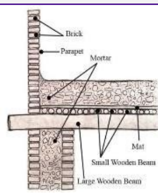
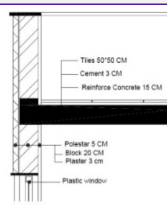
		Traditional House	Contemporary House
Water Body and Vegetation	Comparison	▪ In the courtyard, there is a body of water and greenery. 	▪ Garage and yard in front or back of the house.
	Evaluation	▪ Cooling areas to provide thermal comfort.	▪ For aesthetic reasons.

Table 3. Building Materials.

		Traditional House	Contemporary House
Building Materials	Comparison	▪ Materials obtained on the site of the dwellings or imported from a neighbouring region (wood, mud, and stone). ▪ Walls that support ▪ Loads ▪ 13 to 18 inches thick 	▪ Materials are largely imported or poorly manufactured locally (concrete block and reinforced concrete). ▪ Inadequate or non- ▪ existent insulation ▪ Load-bearing walls and 

	▪ walls	▪ Frames ▪ 9-inch-thick wall
Evaluation	▪ Walls are made up of burnt clay bricks and are thick in sections; therefore, they provide thermal insulation for heat gain from outside and heat loss from inside both in summers and winters.	▪ Walls are made of concrete blocks in thin sections and do not provide any insulation during summers and winters, resulting in heat gain and loss in summers and winters.

Thermally traditional houses are satisfactory all over the year, i.e. summer and winters, while the contemporary houses showed unsatisfactory results during overheating and under heating.

Conclusions

Following were the major conclusion of the research:

In the same environment, a traditional residential building is more thermally comfortable than a contemporary building. The indoor temperature in modern structures is significantly greater, despite the fact that the external temperature in both structures is the same. Modern concrete-based buildings have lower thermal conductivity and thinner roofs and walls, resulting in higher temperature variations as compared to traditional buildings. As a result, it can be stated that the solar passive characteristic employed in traditional buildings may be applied in modern buildings in the future. The courtyard cooling phenomenon that occurs in traditional houses is the source of the significant temperature difference between the indoor and outdoor temperatures of traditional buildings in the summer.

Future Recommendations

1. Landscape planning. Particularly during the hot summer, trees and other plants shade and cool spaces.
2. Open spaces that can be designed include verandas, terraces, balconies, and courtyards.
3. The prevalent wind direction and sun access or orientation should be strongly considered while designing rooms and other living places.
4. Utilizing enough roof and wall thermal insulation, as well as ceilings with adequate heights.
5. Using a simple design and a light colour like white to reflect heat (sun radiation).

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