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Comparative Analysis of the Thermal Performance of a Traditional and a Contemporary House: A Case Study of Abbottabad City

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Abstract: Due to the energy crisis and the high cost of building construction, the thermal efficiency of buildings is a matter of most concern nowadays. Different strategies, including design development, construction materials, and the installation of active systems inside the structures, may be used to address the thermal performance of the buildings. This study examines the thermal efficiency of both traditional and modern homes in Abbottabad, Pakistan, using energy-efficient design principles and construction techniques. Field surveys, interviews, and author analysis were used to collect the data. The case study buildings were chosen from among the city's typical passively cooled and air-conditioned structures. The study came to the conclusion that modern structures can use the solar passive feature used in traditional ones.

Key Words: Energy Crisis, Thermal, Abbottabad, Pakistan, Air Condition, Solar

Introduction

Over the last few decades, buildings' energy consumption in developed and developing countries for building cooling has increased enormously (Pérez-Lombard et al., 2008). The extensive use of mechanical air conditioning for cooling and heating the houses unlike parameters, such as climatic variables, environmental variables that are not subject to human influence, and buildings' thermal behaviour influences. Design factors, which are regulated at the design level, are another type of parameter. An unpleasant indoor environment will arise from not giving enough consideration to a building's thermal behaviour during the early stages of its design. People's local available resources, climate-related and economic capability all impact modern constructions (Laksmi, 2006). By employing simple techniques, the amount of energy used in a building may be reduced. It adopts energy-saving techniques and suitable building

design. Traditional homes were designed by the residents with comfort in mind. (Rumana & Ahmed, 2013). Modern housing criticizes for its lack of response to the local atmosphere (Mehdi, 2017). There are several traditional homes, both primitive and vernacular, that adopt creative techniques to prevent weather extremes and maintain a comfortable indoor climate. (Sangkertadi & Tungka, 2008).

The use of natural materials in construction may improve both health and the environment. (Teddy, 2017). The inner logic of the vernacular precedent uncovers by comparative analysis (Hui, 2019). Thermal comfort can define as when a person in a given atmosphere does not feel cold or warm. Thermal comfort in a living environment is very significant, in addition to good health and elements such as a person's productivity or an occupant (Hensen, 2004). Environmental effects, as well as physical, physiological, and psychological variables,

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have a considerable impact on thermal comfort. Energy efficiency is critical for the residential sector's energy use. However, in most modern residences, the multiple energy conservation techniques remain unknown. A critical factor to consider in the total residential energy consumption is energy consumption for cooling or heating. They use traditional construction processes that presume a reduction in greenhouse gas emissions from building materials, particularly locally available building materials.

The study's most significant addition is that it illustrates the reasons behind the design in terms of indoor thermal comfort rather than following the accepted norm. Understanding the transference of the factors that influence the indoor thermal comfort environment's heredity can be supported by analyzing the interrelationship between success and activity. The goal of this investigation is to determine the cause of the Abbottabad traditional home precedent adaptation's unexplained design process, which is crucial for prospective modern house design inspiration.

Research Objectives

The present research focuses on the thermal efficiency of both Abbottabad's Traditional and Contemporary designed houses and is aimed to:

1. Investigate the design factor of traditional and modern/contemporary designed houses in Abbottabad.
2. Analyze the internal thermal comfort levels of the study area's Traditional/classic and contemporary constructed homes.

Literature Review

Thermal Comfort

A feeling of satisfaction with one's thermal surroundings is referred to as thermal comfort. 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. (De Dear & Brager, 1998) Any

extra heat gain or loss creates considerable discomfort. To preserve thermal comfort, the amount of heat produced must match the amount of heat lost. One of the most important features of living in a house is having the appropriate level of thermal comfort. Individuals can survive and flourish in a wide range of temperature settings, from extremely hot to extremely cold, and there is no ultimate standard. (Alwetaishi, 2016)

Climate in Abbottabad

In the Awash Valley, Abbottabad is located at an elevation of 4,120 feet (1,260 m) between 34 ° 92 'N latitude and 73 ° 13 'E longitude. Abbottabad is the administrative centre of the Abbottabad District and is located in the Hazara province of eastern Khyber Pakhtunkhwa, Pakistan. At an altitude of 1260 meters (4,134 feet), it is approximately 120 kilometres (75 miles) north of Islamabad and Rawalpindi and 150 kilometres (93 miles) east of Peshawar. To the east lies Kashmir.



Figure 1: Location of Abbottabad (Google map 2020)

Historical Content

After Punjab was conquered, the Hazara District's administrative centre was set up in Abbottabad, which holds Major James Abbott's name, in January 1853. From 1849 until 1853, he was the Hazara district's first deputy commissioner. Prior to his return to Britain, Major Abbott is credited with writing the poem "Abbottabad." He describes how much he loves the city and how sad he is to leave it. Around the start of the twentieth century, Abbottabad, which functioned as the

brigade headquarters in the Second Division of the Northern Army Corps, developed into a sizable military cantonment and sanatorium. The garrison consisted of two native mountain cannons, the Border Command (which included the 5th Gurkha Rifles), and four tribal infantry battalions.

Climate

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.

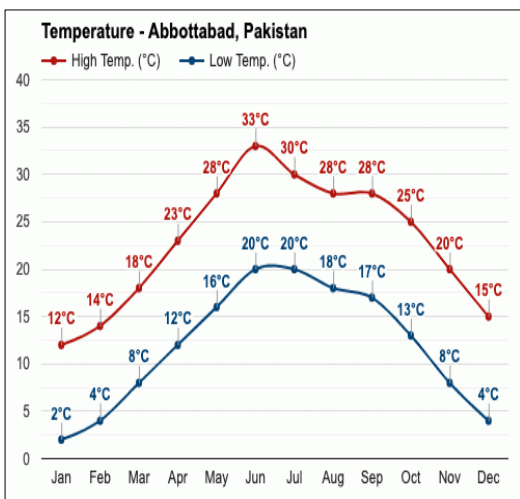


Figure 2: Annual temperature of Abbottabad (Courtesy: [Ahmed, N. 2019](#))

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

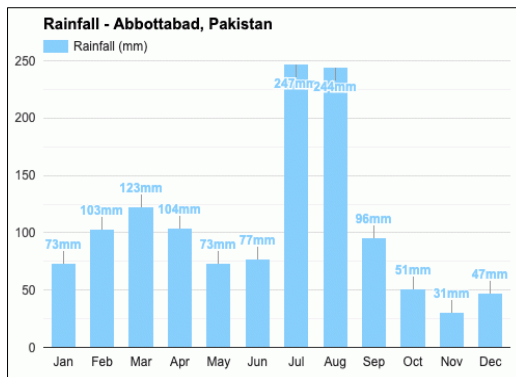


Figure 3: Annual rainfall of Abbottabad (Courtesy: Ahmed, N. 2019)

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).

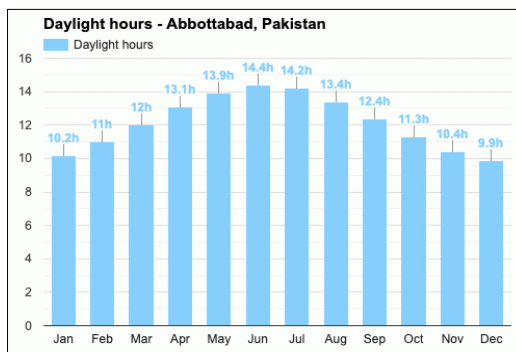


Figure 4: Annual temperature of Abbottabad (Courtesy: [Ahmed, N. 2019](#))

Architecture of Abbottabad

The houses of the Colonial Era were built according to the principles of Colonial Architecture from 1900 to the 1970s.



Figure 5: Colonial houses in Abbottabad

Contemporary designed houses of Abbottabad, built from the 1980s to the 2000s.



Figure 6: Contemporary designed houses in Abbottabad

Contemporary designed houses of Abbottabad, built from the 2000s to the present.



Figure 7: Modern (Contemporary designed houses) of Abbottabad

Abbottabad's architecture has seen three major transformations. From 1900 to 1970, the architecture remained colonial, with fundamental architectural elements such as gable roofs with attics and materials such as stone masonry and wood being mostly employed, with a central courtyard. From 1980 to 2000, the average home design saw significant modifications, such as the transition from a gable roof to an R.C.C roof, the transition from stone to brick masonry, and the transformation of centre courtyards into front verandas. Since the year 2000, the conventional home design has moved to modern architecture, which includes features that were not present in prior eras, such as concentrated circulation with no semi-covered verandas and brick/block masonry.

Methodology

This research aims to analyze Abbottabad's traditional buildings' passive cooling systems in terms of their energy efficiency, occupant thermal comfort, and social acceptability. To categorize various modern building types in Abbottabad according to their design and construction, as well as to evaluate their thermal comfort. The essential data and information were gathered from available literature, personal observation through site visits, interviews with respondents of selected dwellings, and measurement of case-study construction. The case-study building will be chosen from a selection of traditional passively cooled and air-conditioned buildings based on characteristics such as size, layout design, ventilation type, existing operation, and physical condition of the structure.

Finally, recommendations for adapting historic architectural strategies to existing modern buildings that meet people's applicability, compatibility, and actual requirements will be established. It is anticipated that the research will result in successful designs that will maximize energy savings while providing optimal socio-cultural benefits.

The study was conducted among chosen families of Abbottabad locals living in both contemporary and traditional homes. The

research included one traditional house and one modern house. Modern Colonial Period buildings constructed to Colonial Architecture standards would be picked, as would modern dwellings under the age of 20 for the sample.

Problem Formulation

Concerning the research exploration, the problem formulation lies with exploring the comparison of a traditional house and a contemporary house and focusing on its thermal performance. It was critical since research exploration needs to identify the variable under investigation through multiple locations and how the design and spaces within the selected traditional houses can achieve thermal comfort faster and more effectively than modern contemporary. A literature review helped devise a tool-based exploration and defined the action line to ensure that research exploration may be complete. Based on the research objectives and explored literature review concerning the research exploration, the research design evolved to carry out all the significant essential steps to complete the research process.

Research Methodology

The research method is based on exploratory. The analysis of the transformation of Abbottabad city residences from traditional to modern houses was done.

Photography and Drawings.

The drawings of houses were obtained from the owner of the house that included all relevant drawings.

Interview

The unstructured interview was also conducted with the houses' residents to know their time spent in the houses.

Computer Software Program

The software tool AutoCAD and Photoshop was used for documentation of houses.

Research Design

Based on the explored literature review, preliminary site visit, and similar research exploration, the following research design evolved. Following is a list of the significant research and data collection tools used for the multiple research phases and their respective steps:

Table 1. The major tool used in Research Exploration

S. No	Phase	Title	Tool
1	Phase 1	Literature Review	1. Research publications.
			2. Research journals.
			3. Published reports.
			4. Reference books.
			5. Case studies.
			6. Relevant standards.
2	Phase 2	Physical Survey	1. Selection of Sample (containing both types of houses, i.e. contemporary and traditional)
			2. Photographs
			3. Personal Observation
		Selection of Houses.	1. 1. Selection of a total of 6 houses (3 typical houses from

S. No	Phase	Title	Tool
			traditional and 3 typical houses from contemporary houses) from the sample.
			2. Further selecting 1 house from each type for detailed documentation.
		Data collection and documentation from Selected house	Documentation of selected houses. i.e. one house from the traditional house checklist and one from contemp. Checklist Unstructured interview
3	Phase 3	Data compilation	Data was compiled using this software: Autocad, Sketchup, Google Earth, Photoshop, MS Excel
4	Phase 4	Data analysis	Data collected through documentation, observation and interviews of both types of houses were analyzed through comparative analysis
5	Phase 5	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 residences 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). They were 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, but 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 contemporary house.

Data Analysis And Discussion

The thermal comfort and climatic response techniques in Abbottabad City's traditional

and modern homes were analyzed in terms of following

1. Urban Fabric
2. Form and Orientation
3. Occupancy Migration- Plan Arrangement

Case Study 01: Traditional House Thermal Comfort Design Strategies

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

Urban Fabric

The majority of Abbottabad's traditional courtyard-houses are located in the main city, which may be reached via a labyrinth of streets and alleys. The one to two-and-a-half-

metre wide pedestrian alleyways, which had a tree-like layout and approached the main city, was a reasonable, suitable approach to circulation. Due to the large density of nearby buildings, which reduces wind arrays, they are narrow and deep (i.e., alleyways) to provide shade over the road and nearby buildings, decreasing air temperatures and safeguarding the region from dust storms.

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.

Due to ecological site planning, enough amounts of solar radiation and daylight are permitted into each residential unit. During the winter, each dwelling unit will require a reasonably unobstructed southern exposure, and the home design must allow sunlight to penetrate the inside. In order to keep the home unit cool, the greatest angle of the summer sun is avoided

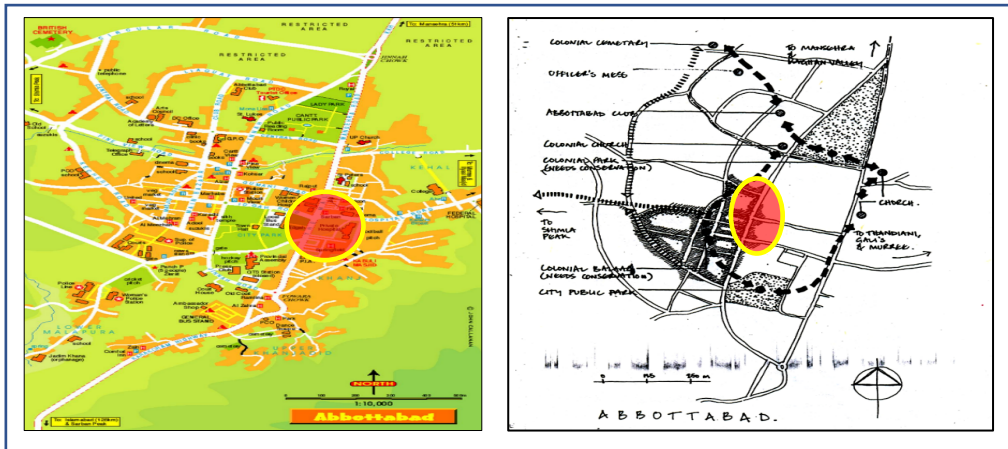


Figure 8: Abbottabad Main Bazar Layout (Walker & Cary, 2019).

Form and Orientation

The building's outside overlay is an essential layer because it impacts and regulates the ideal wind exposure and sun access to manage heat gain and loss through the building.

Traditional Abbottabad residence designs have courtyards as the heart of the

layouts. Typically, courtyards are designed in pure geometric shape, i.e. rectangle or square, centrally designed. Most of the windows on both levels face the courtyard, allowing for natural ventilation and breathing of the structure.

The lowest floor of the majority of buildings is one to one and a half metres below the level of the courtyard. This floor is also simply a few steps up from the patio. The normal ceiling height is from two and a half to three meters, and there are various windows that face outside to the courtyard. To encourage greater cross-ventilation and natural light, the upper level features low windows and a high ceiling.

The position is a valid response to climate, especially if it faces south, which is the main source of solar radiation and may be either pleasant or unpleasant depending on the season. The building's space is planned around the sun route arches that can be seen from the south because Pakistan is in the northern hemisphere. Because of this, all of the summer spaces in native homes are located in the southern section of the courtyard, and every entrance their faces north. On the other hand, winter rooms are often located on the north side.

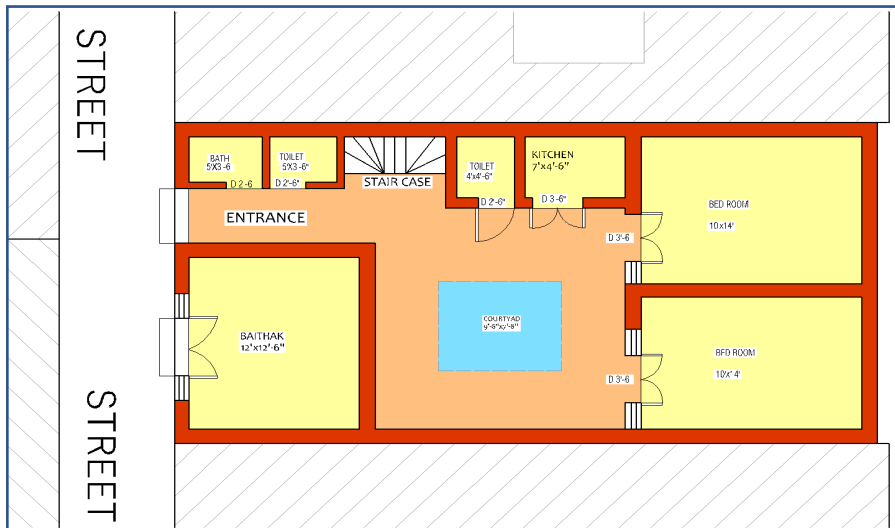


Figure 8: Ground Floor Plan

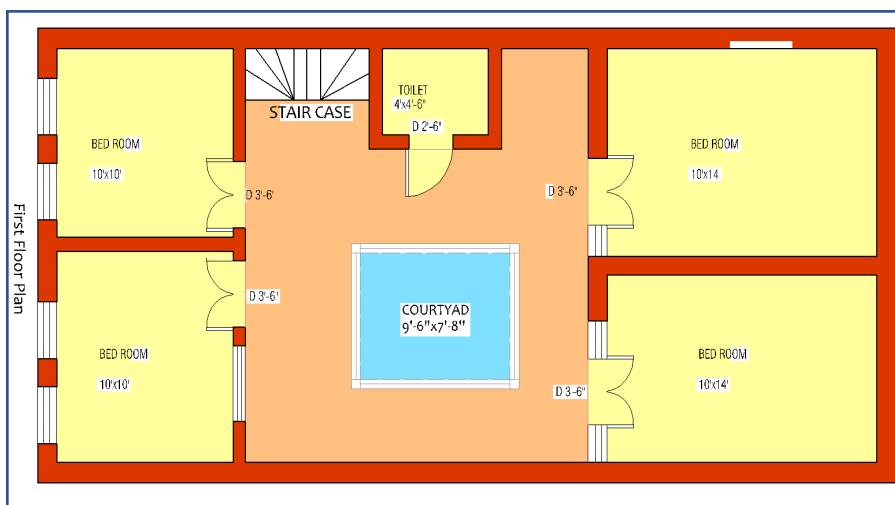


Figure 10: Ground Floor Plan



Figure 9: Section of a Typical House in the Main Bazar Abbottabad



Figure 10: Traditional House C, Main Bazar Streets at Present

Occupancy Migration- Plan Arrangement

Warren and Al-Azzawi state that the function of rooms changes depending on the time of day or season, from the cellar to the attic. In the summer, sleeping twice a night—once on the roof in the early morning and once in the cellar in the afternoon—became the norm. The day was uninterrupted at other times of the year, and the night was spent in a room on the first level. Horizontal migration is a seasonal movement between rooms in Abbottabad homes based on their orientations. To put it another way, people prefer rooms with large south-facing windows and high ceilings to gain solar heat throughout the winter.

The best response to a temperature shift is an upward migration. Because the weather is so hot, the mornings are spent on the ground level, and the afternoons are spent in the semi-basement when the heat becomes intolerable. The roof is used for sleeping at night.

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.

Urban Fabric

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. Streets that are often built back-to-back

surround the dwelling blocks, and the neighbourhood's urban planning is defined by Main Street, which has a rectilinear grid layout system, and 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.

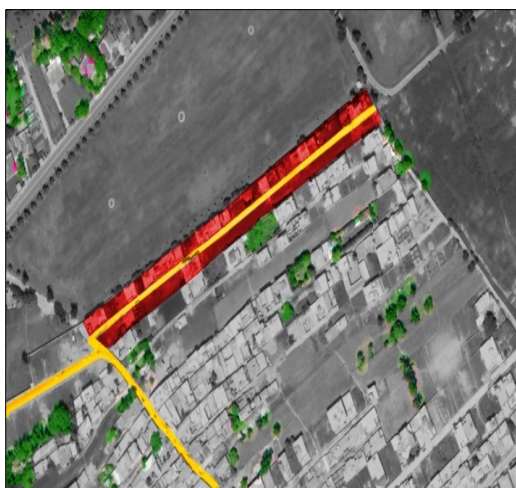


Figure 11: Google Earth Image Thanda Choa Road, Abbottabad

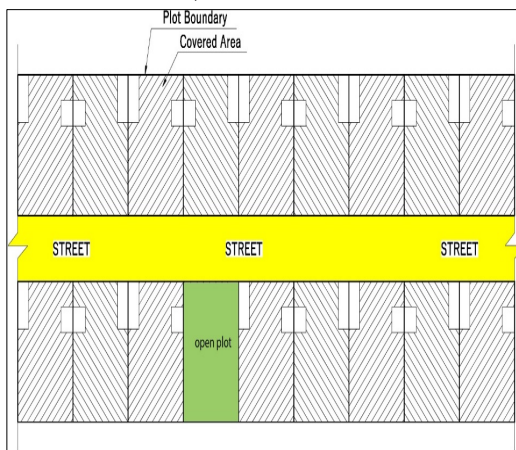


Figure 12: Layout of street houses at Thanda Choa Road, Abbottabad

Form and Orientation

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

forementioned 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.

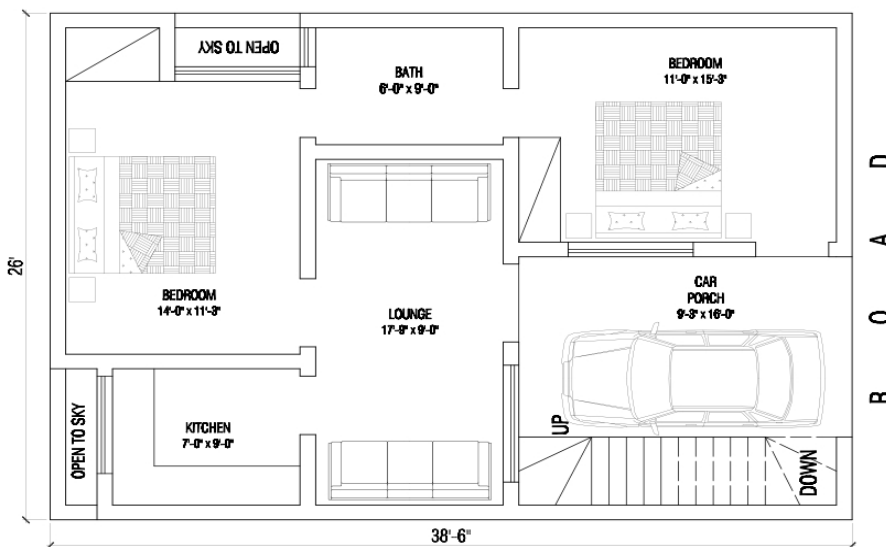


Figure 13: A Modern House's Basic Layout (Ground Floor Plan)

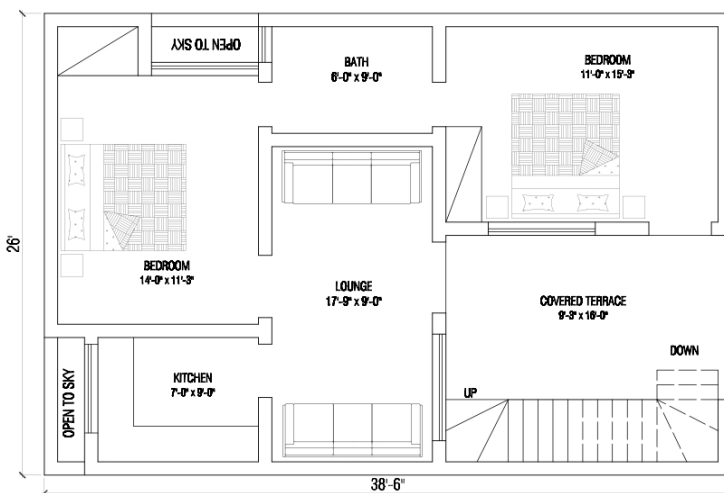


Figure 14: A Modern House's Basic Layout (First Floor Plan)



Figure 15: Elevation of Modern Residence of Mr Fahd Anwar Thanda Choa Road, Abbottabad



Figure 16: Typical Modern Residence of Mr Fahd Anwar Thanda Choa Road, Abbottabad



Occupancy Migration (transition)- Plan Arrangement

Due to the fact that a large number of contemporary homes are made up of detached and semidetached houses, occupants are forced to carry out the tasks in specified locations regardless of seasonal and daily variations in climate conditions. The

majority of the rooms have windows that look out into the street or garden, which makes the space hot in the summer and freezing in the winter. The layout varies, but the ground level often comprises the main living room (Hall), kitchen area in the front home at the entry, and one or two bedrooms in the back, with the other bedrooms on the first floor. These areas are utilized throughout the year.

Traditional and contemporary housing development and comparison

Table 2. Urban Fabric

		Traditional House	Contemporary House
Urban Fabric	urban layout	<p>Communities' houses were grouped together to create shade. Homes were positioned to take advantage of the sun's rays and the direction of the wind</p> 	<p>Large open spaces with minimal shade are characteristic of houses in towns. According to the city planning regulations, the placement of the houses is arbitrary</p> 
	Street network	<p>Streets that are narrow and irregular</p>	<p>Streets that are wide and regular</p>

Streets network of traditional houses are narrow and irregular while they are wide and regular in the case of contemporary houses.

Table 3. Form and Orientation

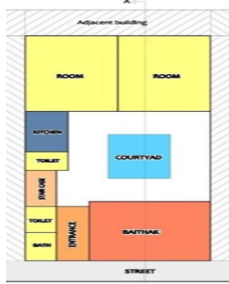
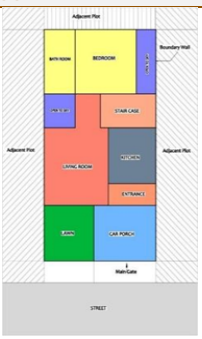
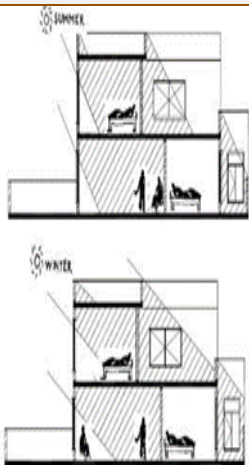
		Traditional House	Contemporary House
Form and Orientation	Comparison	<ol style="list-style-type: none"> 1. A courtyard with an inward gaze. 2. A basic square and rectangular design with a cubic courtyard and equal first and second floors. 3. It has three sides that are surrounded by nearby houses, as well as one exterior elevation. 	<ol style="list-style-type: none"> 1. Looking out the window at the garden or the street 2. Different floor plans, with the ground and First floors not being equal. 3. The majority of homes have two or more elevations
	Evaluation	<p>By cooling the areas during the day and night and reducing the surface area exposed to light and the summer climate, thermal comfort was achieved in both the courtyard and the most basic of plan forms.</p> 	<p>Because the buildings and two or more elevations tend to result in a substantial area of the surface that is exposed to the sun and climate variables, the garden cannot provide thermal comfort for spaces by using an alternative courtyard solution.</p> 

Table 4. Occupancy Migration- Plan Arrangement

		Traditional House	Contemporary House	
Occupancy, Migration and Plan Arrangement	Comparison	<ul style="list-style-type: none"> ▪ A single or two-story building with a modest basement. ▪ Display space based on family size and economic status. ▪ Modifications in residential structures. ▪ Concise design with a courtyard. 	<ul style="list-style-type: none"> ▪ both one or two-story and multi-story buildings ▪ Plot area categorized in accordance with urban planning regulations (no regard for family size or economics). ▪ In residential structures, nothing has changed. ▪ Inadequate planning. ▪ There is no courtyard. The height of the floors 	
	Evaluation	To achieve thermal comfort, use the ground floor during the day in the summer and one floor at night and in the winter.		

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.

The substantial temperature differential between traditional buildings' internal and outdoor spaces in the summer is caused by the courtyard cooling phenomenon, which is common in traditional houses. Modern concrete-based buildings have higher 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.

Future Directions

This research presents design concepts for the near future that might be applied to current and new house projects. Other future options, such as new urban policies and enhanced urban design, might be explored as a starting point. The study approaches followed in this work can be utilized to explore and learn about traditional urban dwellings. It is conceivable to rethink more sustainable dwelling developments by adopting design strategies from the past. Following are the major recommendations of the research study:

1. Landscape design: Particularly during the hot summer months, trees and plants provide shade and cooling for spaces.
2. Courtyards, balconies, terraces, and verandas are examples of semi-open and open areas that may be designed.
3. For the arrangement of rooms and other livable areas, the prevailing wind direction and sun orientation may be considered.

4. Use of sufficient thickness of thermal insulation on the walls and roof, as well as an appropriate height of ceilings, may be incorporated.
5. Reflective paints and colours to decrease heat gain through direct sunlight may be used.

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