

**THE TRADITIONAL COURTYARD HOUSE OF LAHORE: AN ANALYSIS WITH
RESPECT TO DEEP BEAUTY AND SUSTAINABILITY**

by

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Abstract

Sustainability is essential for survival on this planet but only focusing on the green aspects is not a comprehensive solution. The idea of Deep Beauty provides a more thorough and complete framework that is the answer to the sustainability problem of today. This framework is comprised of three levels: functional, typological and archetypal. These three levels combined, look at a building in terms of its functionality, its relevance to its region and the universal beauty that it must possess to exist long term. The union of aesthetics with function is what can save the planet.

For this research, the focus of study is the traditional residential architecture of the city of Lahore, Pakistan, a city with a rich cultural background. Throughout history, Lahore has seen many transformations with respect to its architecture. Its architectural history can be traced back to the Indus Valley Civilization in the 3rd millennium BC, to a predominance of Buddhism, to a prevalence of Hinduism transformed further by the advent of Islam, the arrival of the British and the founding of the independent state of Pakistan. Currently, the housing trends are continuing to become more and more westernized in a pattern that is not fit for the region because of their inability to provide comfortable living environments and life-enriching spaces.

In order to provide better housing solutions for the future, it is important that we look back at examples that have passed the test of time. This report discusses the present day and traditional housing trends of Lahore. With the purpose of improving the current residential designs, an analysis of a traditional house of Lahore has been performed to learn how it meets the criteria of Deep Beauty and sustainability. The results from this analysis provide design strategies that can be incorporated into present day houses to achieve sustainability. Based on these conclusions, a more sustainable design has been proposed for the modern house.

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Dedication

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Preface

Being a resident of the city of Lahore, Pakistan and practicing the design of residential architecture in the city for two years, it became evident to me that the current housing trends in the city are unable to provide worthwhile living environments. The reliance on machines in a region undergoing an energy crisis, the westernization of architecture in a city with a rich cultural background and the lack of aesthetics are all reasons that make current houses unfit for this region. As a designer, I seek to find solutions that will enhance our residences and make them sustainable.

Sustainability is not only about green strategies. Aesthetics is an important factor when it comes to survival. I was introduced to the framework of Deep Beauty in Professor Gary Coates's seminar on that topic last year. This framework consists of three levels: functional, typological and archetypal. It not only studies a building from one angle but deals with sustainability in a comprehensive manner. I believe this holistic approach is the answer to sustainability issues of our era.

The important question here is how to design a building that is sustainable and fulfills the criteria of Deep Beauty. For this purpose, the housing trends of the present and the past have been discussed. Later, to highlight specific design strategies, I analyze a traditional house of Lahore that has proved its sustainability by surviving all these years. The analysis is performed based on a rubric developed to operationalize the Deep Beauty framework. The results emphasize the successes and failures of the house and provide design solutions that architects, designers and clients can incorporate in future residences. These strategies will help enhance living spaces and make them more livable, lovable and thus, sustainable.

Structure of Report

The first chapter introduces the project and justifies its significance. In addition to that it explains the Deep Beauty framework and its importance for sustainable living. The second chapter gives background information about the current and traditional residential architecture of the city. The chapter begins with the introduction of the city of Lahore and moves on to explain housing on all three levels of Deep Beauty.

The study methods are explained in the third chapter where a brief description of the sample house, known as the ‘Barood Khana Haveli’ is given. A rubric has been developed to operationalize the Deep Beauty framework. This rubric is described along with the tools that have been used for assessment.

Chapter four includes the analysis of the sample house. The conclusions from this analysis are summarized in the fifth chapter. The last chapter summarizes the report and concludes the results of this analysis. Specific design strategies have been identified that the traditional sample house follows. A preliminary design is proposed for the modern house by incorporating these strategies that make it sustainable. Later, the chapter explains what future directions this research can take.

Chapter 1 - Introduction

Building sustainable living spaces is a goal that countries all across the globe are seeking to achieve. Pakistan is a developing country whose architecture is taking inspiration from the western developed world. Ironically, the answer to a sustainable future does not lie elsewhere but within the tradition and culture of the region.

Significance

Pakistan's energy infrastructure is not fully developed, inadequate and mismanaged (Haq & Hussain, 2008). The data from the Economic Survey of Pakistan, 2009-2010 shows that during the last ten years the gross energy demand has exceeded the population growth rate; energy use has increased at 4.95% per year and the population has grown by less than 2.26%. Of the total electricity produced, 42.15% is consumed by the residential sector (Hub, 2010).

Present day housing design has become more and more dependent on artificial means to create a comfortable interior environment. According to the Consumers Rights Commission of Pakistan (CRCP) survey, the two major electrical end using categories are lighting and space cooling in the domestic sector of Pakistan (Jan & Mutalib, 2013). Even though the energy demand has increased during the past decade, neither the public nor private sectors have made any attempts to install new generation capacity. The demand exceeds the supply and therefore load-shedding through power shutdown is commonly observed (Haq & Hussain, 2008).

Since generating more energy is becoming increasingly difficult for Pakistan, another approach is to decrease the demand for energy. When spaces and places are shaped more intelligently so that reliance on machines is minimized, large amounts of energy can be saved.

Energy use can be cut significantly if buildings channel heat and air naturally without using electricity (Hosey, 2012).

Along with the energy crisis, the use of machines has deprived us of our connection with the outside world. Smart design can bring back a sense of the sacred and feelings of delight. Air-conditioning has almost brought an end to our cultural rituals and habits. Climate plays little role in how we design our homes, communities and lives because any space anywhere can be tempered artificially to achieve indoor comfort. A consistent indoor environment cuts us from the outside world and brings in no social, cultural or aesthetic richness to a place (Hosey, 2012). The indoor environments are isolated, cutting off our connection with nature. On the other hand, buildings that are partially or completely naturally ventilated give their users the ability to tolerate a wider range of temperatures. Users also value their control over the environment through actions like opening a window and dressing according to the weather (O'Neill, 2003).

The increasing globalization and advancement in science and technology have caused us to move away from our traditional architecture. A standardization of built environments results in lack of cultural and regional identity. The use of same building methods, materials and styles globally, challenges our ability to achieve sustainable living (Eldemery, 2009). It is evident by looking at the modern day residential architecture of Pakistan how designs have evolved over time. We are leaving the richness of tradition behind and adopting a more energy-intensive western style of architecture. The houses, now being built, are losing their relevance to their region.

Analysis in this research is an attempt to learn from the past, understand the present and design for a better future. R. Lewcock (1988) emphasizes this approach when he says:

“At any given time the man-made world is inevitably the measure we use to determine the direction of change. Whatever we may think of it, the world around us

provides the basis for decisions about the future. We are keenly aware of its deficiencies, but not always so aware of its strengths. From time to time it is wise to pause and consider whether what we might be losing when we change something. The corollary to this is to look back to see whether what we lost yesterday might, with little effort, be regained” (pp. v-vi).

Framework of Deep Beauty

Gary J. Coates, 2014, defines Deep Beauty. He says:

“Deep Beauty exists in a realm beyond mere aesthetics. Deep Beauty is rooted in an ecological ethos and a spiritual worldview. Deep Beauty respects and reveals the interconnectedness and unity of all life and the irreducible mystery within which everything exists. Deep Beauty heals and restores balance, harmony and equanimity to both self and world. To create Deep Beauty in whatever we make and do is an act of love, because only that which is loved is beautiful.”

Sustainability is generally associated exclusively with carbon emissions and energy efficiency. Green buildings are concerned with cost and performance but ignore an important criteria for evaluating design i.e. aesthetics. Conventionally it is thought that beauty and sustainability do not go together and that they need to be balanced as if one has to be comprised in order to achieve the other. At the start of the environmental movement, sustainability was meant to combine ethics with aesthetics but over time ethics have replaced aesthetics. Criteria for quality design and environmental performance are not the same and so ‘great buildings’ are thought to be different from ‘green buildings’ (Hosey, 2012).

Most designers are interested in incorporating invisible green strategies rather than the visible ones that affect form, shape and looks because that approach to design allows them more freedom to play with their artistic sense. Nature gives us many examples where survival is dependent on the shape and the look of a living organism like the colors of birds, tastes of fruits and scents of plants. The same idea also affects design – form affects function and appearance influences survival. The life of many things is contingent upon how desirable they are. If something is made to endure, it must also be made lovable. We become emotionally attached to

and care more about things that we regard as beautiful. We have a preference for using and preserving things that are attractive and pleasing (Hosey, 2012). Lance Hosey, 2012, says *“Aesthetic attraction is not a superficial concern-it’s an environmental imperative. Beauty could save the planet.”*

The chances of the survival of something that is functional and beautiful are much greater than something that is one or the other. It can be said that in order to make architecture sustainable, it is essential that it must also be beautiful and ‘Deep Beauty’ is the way towards it. The framework of Deep Beauty is not only restricted to ecological science but expands the thinking of a designer from functionality to regionalism and deeper meanings of architecture. It provides a complete and holistic approach to think about the built environment. The framework is comprised of three interconnected levels of design: functional, typological and archetypal.

Functional level

“The Functional Level includes design for all the pragmatic needs of the building’s users. Truly functional buildings are also artfully integrated with their sites and respond simply and appropriately to available sun, wind and light. Such buildings, which are always no bigger than they need to be, are necessarily energy efficient, and make maximum use of healthy and locally available building materials. Biomimicry, as a functionalist approach to biophilic design, is included in this level. Everything associated with the technological and functional aspects of ecologically and humanly sustainable design is included in this first, and necessary level of sustainable design.” – Gary J. Coates, 2014

The house is not only a structure. It is an institution that is built for multifaceted purposes. Building a house is a cultural phenomenon and so the form and organization of a house depend on

its cultural setting. The function of the house is more than a utilitarian idea and serves a greater purpose than only providing shelter. Since shelter is a secondary purpose of the house, its definite role is to create an environment that best suits the way of life of people. The house acts as a social unit of space (Rapoport, 1969).

Biomimicry is a discipline that entails learning strategies and designs from nature that have proven to be successful for so many years. In the past, architects have taken inspiration from various acts performed in nature and implemented them into works of architecture. Such architects who follow biomimicry believe that when designs are guided by nature, architecture becomes more life-like (Benyus, 2008).

Nature can be mimicked for two purposes: it is possible to mimic forms found in nature to design a building's appearance, like a Corinthian column with curling leaves, or to mimic nature to solve a functional challenge, like flexibility, insulation and energy production etc. Biomimicry is a design process which is focused on functionality and seeks solutions from organisms and ecosystems that are the best performers of that function. Examples of biomimicry can be seen in the design of building structures, forms, day lighting systems, natural ventilation strategies, sounds, colors and landscapes as well as urban design (Benyus, 2008).

In order to achieve sustainability, it is essential that our communities are able to support themselves in the same way that wild spaces are self-sufficient. If our society worked in an automatic way, producing for itself, maintaining itself and remaining in equilibrium with its surroundings, it would be a true imitation of nature (Benyus, 2008). Following in the footsteps of living creatures, it is possible to develop cities and houses that function as competent ecosystems. Biomimicry has the potential to lead the way towards sustainability.

Typological level

“The Typological Level involves the adaptation of bioregional building traditions and historically situated building types in the design of contemporary buildings that are capable of evoking a sense of connection with history, community, nature and place. Rather than merely replicating historical forms, buildings functioning at this level enter critically into a conversation with the past in order to create something that is both familiar and yet somehow always fresh and new. At this level of design, culturally based meanings are continuously created and deeply rooted building traditions are continually given new life. Buildings at this level also embody the principles of biophilic design, connecting building users to elemental nature and to the patterns, rhythms and forms of the natural world, thereby fulfilling our intrinsic need to be connected to the regenerative processes of life.” – Gary J. Coates, 2014

Categorizing observations according to similar characteristics and recurring principles is an important component of cognitive process. Humans perceive and communicate by forming standards and systemizing patterns. In this context, architectural typologies consider the varying requirement profiles of building types and spatial systems. Typologies deal on different levels: at the urban level, typologies deal with blocks, row or detached houses and at the building level, it can include residential houses, theaters and industrial plants etc. Floor plan typologies are defined by the circulation system that connects individual rooms. Even though the room itself behaves as a single functional space, different floor plans create different building types like patio houses, apartment houses (Pfeifer & Brauneck, 2007), courtyard houses and so on.

Typological examination begins with the reduction of shapes to basic geometries but it is much more than that. Typological order ranges from construction details to socio-political

interrelations thus, characterizing many appearances of the built environment. Examining typology involves a dialogue within history to discuss the generation of ‘new’ from the ‘old’. Types are transformed over time due to changes in user requirements, scale, context, or other mechanisms (Pfeifer & Brauneck, 2007). The remarkable thing about typology is that it is generative. Two forms can be of the same type but can appear and be constructed entirely differently. Therefore, studying a typology does not result in a repetition but a transformation (Polyzoides, Sherwood, & Tice, 1992).

It is a universal fact that the greatest architectural examples in history are awe-inspiring. These models have more to offer than beauty - they provide lessons that teach us design principles. Architectural types, like courtyard houses, that have passed the test of time, are important examples that have set high levels of excellence (Kelbaugh, 2002). Douglas S. Kelbaugh, 2002, explains the human attitude towards change that is too radical or too familiar. He says:

“Humphrey postulates that what is both stimulating and legible is imagery that ‘rhymes’ with other familiar images, whether across space or over time. To ‘rhyme,’ images must be neither too similar nor too dissimilar. In the former case, the human tends to lose interest too easily and in the latter case to become confused and discouraged too easily.”

It is important that architecture must be fresh but it should also relate to the past. The immeasurable materials, techniques and design attitudes that are present today, have given designers too many options. This lack of limits and boundaries has minimized regional differences and resulted in a chaos. Compared to other products like cars, clothing and machines, architecture has the greatest potential to depict a region. Since architecture is not generally mass-produced, it is difficult to turn it into a commodity. It is specific and unique to its site and can oppose

standardization. Architecture can develop from the local characteristics of the region like climate, building materials, construction methods, architectural types and culture. Designers and clients have to change their selfish attitudes if visual harmony, contextualism and historical connection is to be seen in urban spaces (Kelbaugh, 2002).

Important lessons of beauty, sustainability and vitality can be learnt from nature. The biological and ecological systems can serve as inspiration for design. Green buildings operating only at the Functional Level of Deep Beauty are able to cater well for concepts like day lighting, use of local materials, reducing energy costs and lower environmental impact. Subsequently, the next step is to design life-enriching, healing architecture that is nurturing and stimulates well-being. In other words, our way forward is a biophilic response (Cramer & Browning, 2008).

An approach to creating a biophilic environment is integrating plants, animals and water into the built environment. Throughout the world in history, biophilic elements like domestic gardens, ponds, fountains and garden courtyards are evident. In present day buildings, elements like green terraces, landscaped atria and aquariums contribute to bringing nature into the built environment. Photographs and paintings of natural landscape are other ways of incorporating biophilia. Research has shown greater productivity in office workers, less recovery time for patients (Cramer & Browning, 2008) and better performance of students in schools that were exposed to biophilic elements. Biophilic design has proven to be a way of enhancing the energy-centric model of sustainability. Research has confirmed the positive impacts of biophilia on our physical and psychological health as well as our brain development (Louv, 2008). Communities, houses, schools, hospitals, offices and other indoor and outdoor spaces can be sustained using biophilic design strategies.

Archetypal level

“The Archetypal Level involves the use of archetypal building elements, patterns and forms that are most typically found in the world’s sacred architecture. Buildings at this level speak in the natural language of space, which is rooted in the pre-verbal meanings of embodied experience: up and down, right and left, front and back, inside and outside, near and far, darkness and light, rough and smooth, warm and cool, the horizontal and vertical, the center and periphery. The archetypal and biologically-rooted polarities of prospect and refuge, complexity and simplicity, enticement and peril are structured in ways that deepen and harmonize the apparent psychophysical opposites of lived experience. Often such buildings are shaped to higher levels of formal order by use of the universal tradition of qualitative number and sacred geometry. The archetypal level is the deepest layer of meaning and metaphoric signification in architecture. Buildings that reach this level lead users back through layers of consciousness and time from the outer surface of the waking mind to the depths of what Carl Jung calls the collective unconscious and beyond, to the edge of the luminous ground of being itself.” Gary J. Coates, 2014

Men and women in traditional sacred societies see the universe as an emanation from the One, and believe that humans and nature have the common characteristic of structure and proportion that can be quantified through mathematics. Every creation of man and nature are forms that can be observed through mathematical laws of geometry, similitude and symmetry. The beauty of a snow crystal depends as greatly on its geometry as on its capacity to reflect a more complex order. All shapes, lines and surfaces are set in accordance with the proportions that are found in nature and exhibit perfect systems of beauty. Based on an impartial foundation, detached from the

personal tastes of a person, a beauty is reached that is universal, general, and eternal (Ardalan, Bakhtiar, & Haider, 1973).

Grant Hildebrand (2008) has identified five survival-advantageous characteristics: prospect and refuge; complex order; peril; and enticement. Designing these characteristics into our buildings increases the likelihood of creating deeply rewarding spaces. Humans have a tendency to process sensory information and categorize it into some form of order. We find appeal in sensory materials that are ordered but also complex at the same time. Order alone becomes monotonous and complexity alone results in a mess. Hildebrand combines these two characteristics and calls them 'complex order' (Hildebrand, 2008).

Shelter is a necessity for humans to protect themselves from climate and other threats. Jay Appleton has referred to this characteristic as 'refuge' (Appleton, 1996). At the same time, we also need vast open spaces. Prospect is spread out and lit while refuge is narrow and dark. Both cannot be present in one space but they must be contiguous. We should be able to examine the prospect from the refuge and flee to the refuge from the prospect. Prospect and refuge spaces can also be created in indoor environments (Hildebrand, 2008). Interior spaces that are small and dark act as refuge while large and bright halls behave as prospect. The prospect and refuge cannot be established in a building with constant ceiling heights and same amount of light. Though day lighting is essential for human well-being, dark spaces are also important as our retreat and place for recovery, sleep and meditation (Hildebrand, 2008).

Stephen Kaplan concluded from his research that we also have a preference for scenes that present mystery (Kaplan, 1987). We have a desire to discover, in safety, what the obscured has to offer. It is important to note that during this process of discovery, we like to move from the dark into the light, where we can assess the dangers of the place before entering, rather than from the

light into the dark, where other dangers or creatures in the dark are able to see us first. Hildebrand calls this characteristic ‘enticement’. Enticement only exposes part of the information and leaves the rest to be discovered. Architectural spaces can be designed incorporating enticement or a pattern or sequence of several enticements (Hildebrand, 2008).

We enjoy settings that let us experience thrill, where we experience fear with pleasure. Hildebrand calls this characteristic ‘peril’. In situations of peril, we face real dangers but we have the ability to control the risks. This controlled confrontation gives us pleasure. In architecture, tall buildings, extended balconies and transparent bridges are examples that provide such experiences (Hildebrand, 2008).

These five characteristics given by Hildebrand have the potential to make buildings meaningful and give us pleasure by offering experiences that are similar to those of a natural setting. The long term worth of design is impractical without attracting all the senses. If design is unable to inspire, it will be discarded rather than sustained (Hosey, 2012).

Karsten Harries 1993, in *‘Thoughts on a Non-Arbitrary Architecture’*, argues that to make a genuine dwelling, it is important to use natural symbols. These symbols make a language of space that is derived from the existence of human beings. The human body provides a sense of proximity through a set of coordinates: up and down, left and right, front and back (Harries, 1993). Karsten Harries 1993, gives an example to explain how all of these coordinates have their own significance. *“Up, for example, has a very different significance from down. We cannot simply turn a building upside down or rotate it; but we can design buildings to look as if they could be inverted or rotated rather easily. The curtain wall invites such a look of invertibility... Think of the gabled roof, its presence seems to resist inversion.”* (pg.53)

Similarly, vertical and horizontal, inside and outside, dark and light all have different meanings (Harries, 1993). The horizontal and vertical can be called natural symbols because they belong to experiences of human beings in nature, like standing up and lying down. A slab, line or plane represents the horizontal which ties a building and the earth together. The horizontal can symbolize comfort or an unlimited openness but it can also indicate death, sleep and rest. On the other hand, the vertical is assertive and requires effort to stand. It has the ability to accentuate a space and connects the above and below, the earth and the sky. It possesses the power to gather people around a center that forms an axis mundi. Tall vertical structures endorse human pride and can be associated with masculinity (Harries, 1988).

The natural symbols of light and dark refer to a light that changes according to the time of the day and year and moves us from light to darkness. The reference here is not made to any artificial light but to the sun. This natural language is absent in modern buildings as artificial lighting has discouraged our dependency on sunlight (Harries, 1988). Inside and outside relates to the idea of refuge and prospect. As explained earlier, the inside is a refuge which can be perceived as shelter and a prison. The outside is a prospect which can be threatening but also provide a sense of openness and freedom. Harries (1998), discusses the symbol of a center. Every enclosed space has a center. Squares and monuments can form centers of cities and neighborhoods that serve a communal purpose. Sacred structures represent centers that have symbolic significance (Harries, 1988).

Assumptions made by science have reduced things to just objects and eliminated their potential to speak. Natural symbols are a way that our body perceives our surroundings. Thinking about this natural language while designing has the potential to produce non-arbitrary architecture that is universal.

Chapter 2 - Housing in Lahore

City of Lahore

Location

Lahore lies between 31°15'—31°45' N and 74°01'—74°39' E. It is surrounded by the Sheikhupora District on the north and the west, by Wagah on the east, and by Kasur District on the south. The Ravi River flows on the northwest side of Lahore. The city has a total land area of 404km² (Walled City of Lahore Authority, WCLA.2014).



Figure 2.1 Location of Lahore (Google Maps.2015a)

Historical Context

Throughout history, Lahore has been through instability, tranquility, cultural celebrations, invasions and destructions. In the eleventh century, Lahore became a metropolis and has continued

to be an important city ever since. Lahore reached its glory during the Mughal era which lasted from the year 1521 till 1752. The Sikh Rule lasted for fifty years beginning from 1798 to 1848 after which the British ruled the city for 99 years. At the end of the British rule, Pakistan was founded and Lahore became its second largest city and cultural capital (Walled City of Lahore Authority, WCLA.2014).

All the important works of architecture in Lahore, including haveli(s) (regional name for courtyard houses), were built during the Mughal era. When the British took over, they disregarded the Walled City of Lahore and built a new Lahore towards the southern side. The Walled City is home to many cultural traditions. Buildings, mosques and a complex network of streets along with music, food and dance depict the cultural richness of the place (Walled City of Lahore Authority, WCLA.2014).

Climate

Lahore has a hot semi-arid climate (Köppen climate classification BSh). Summers are long and extremely hot, and winters are dry and warm. The area also experiences a monsoon and dust storms. The monsoon season lasts from June to August and brings heavy rainfall to the city. The highest and lowest temperature recorded are 48.3 °C (118.9 °F) in 1944 and -1.1 °C (30 °F) in 1967. In 2008, the city received the highest rainfall of 221 mm (8.7 in) (Walled City of Lahore Authority, 2014).

The following climatic data has been acquired from the software Ecotect.

Month	Avg Temp (°C)	Sol.Rad (Wh/m ²)	RH 9am (%)	RH 3pm (%)	Avg. Rainfall (mm)
Jan	22.2	4828	60	41	23

Feb	24.6	4911	25	16	29
March	28.9	6014	49	40	41
April	33.2	7220	29	21	20
May	35.0	9144	32	19	22
June	30.3	8743	61	46	36
July	27.4	6662	68	61	202
August	26.4	5907	73	66	164
September	28.3	6709	59	48	61
October	26.8	8738	56	44	12
November	23.9	7672	49	43	4
December	21.5	6674	53	41	14

Table 2.1 Monthly average temperature, solar radiation, relative humidity and average rainfall of Lahore, Pakistan

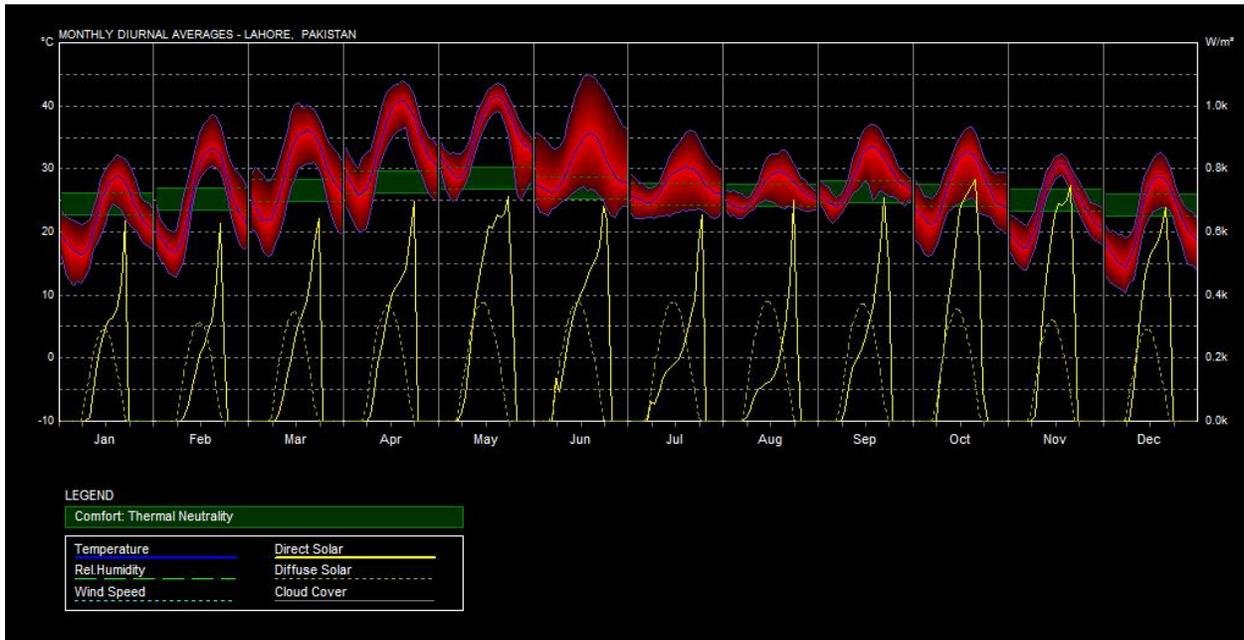


Figure 2.2 Monthly Diurnal Averages

This diagram shows that the temperature remains above the comfort zone in the months of April, May June and below the comfort zone in November, December and January.

Solar Path and Solar Radiation

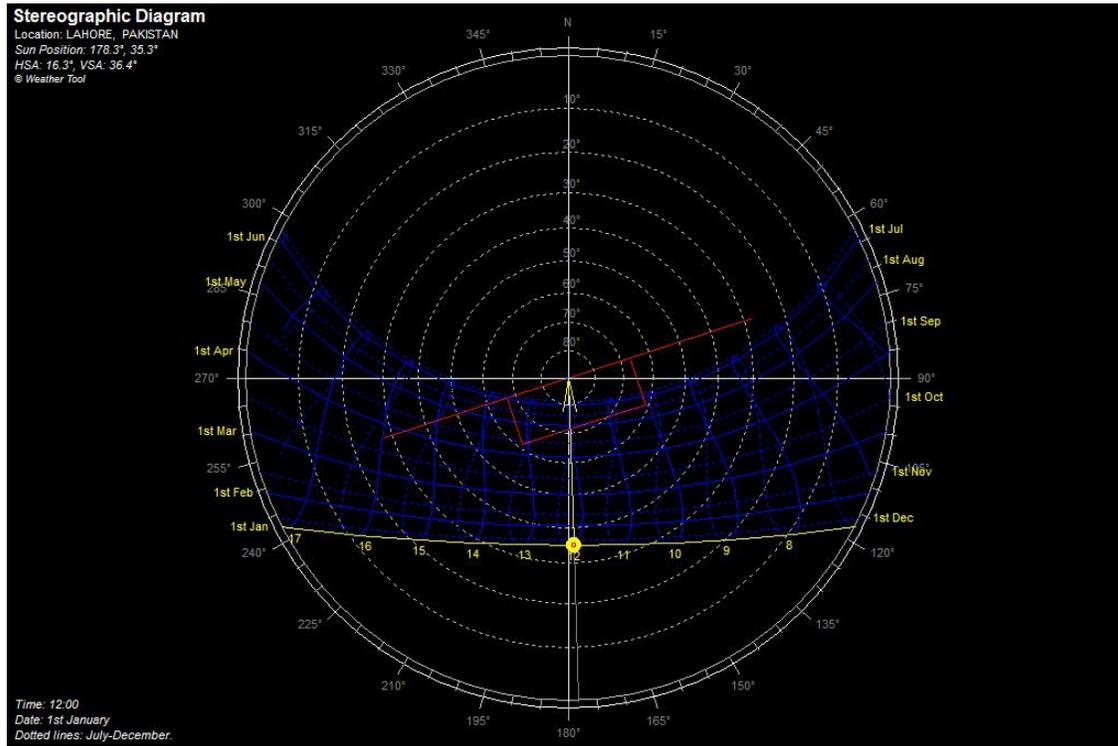


Figure 2.3 Solar Path

The building in the center is placed at the optimum orientation of 162.5 degrees. More sun is available on the south side with the longest sun path in June and July and the shortest sun path in December and January.

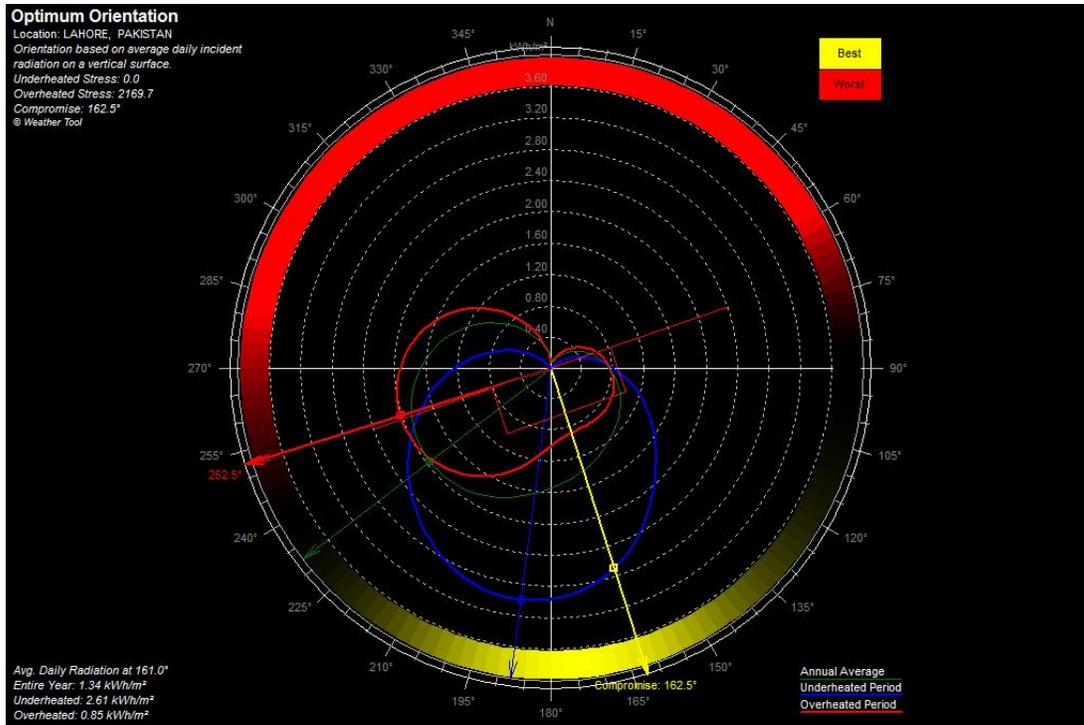


Figure 2.4 Optimum Orientation.

Ecotect analysis recommends the optimum orientation of 162.5 degrees and the worst orientation of 252.5 degrees.

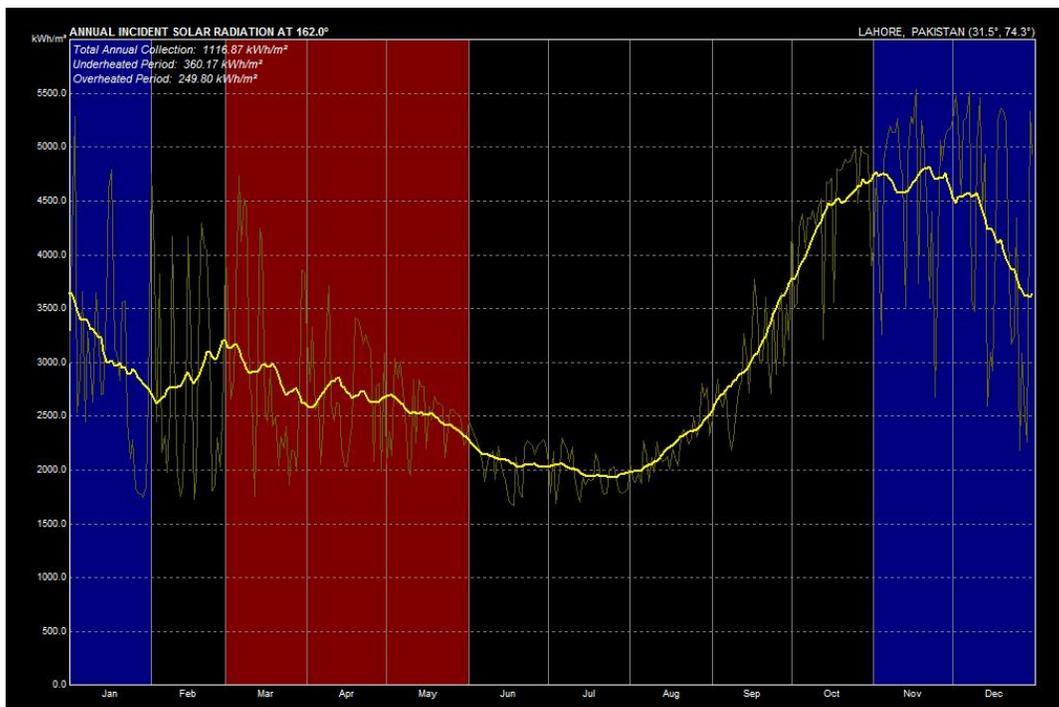


Figure 2.5 Annual Incident Solar Radiation at 162 degrees.

At the optimum orientation, the building receives maximum solar radiation during the coldest months and less solar radiation during the hottest months.

Passive Design Analysis

This analysis is run using six passive design strategies: Passive solar heating; thermal mass, exposed mass + night purge ventilation, natural ventilation, direct evaporative cooling and indirect evaporative cooling. From the analysis, it can be concluded that exposed mass + night purge ventilation, natural ventilation and indirect evaporative cooling are the most effective strategies that are useful most of the year. Passive solar heating and direct evaporative cooling are the least beneficial. The following figures show the complete analysis.

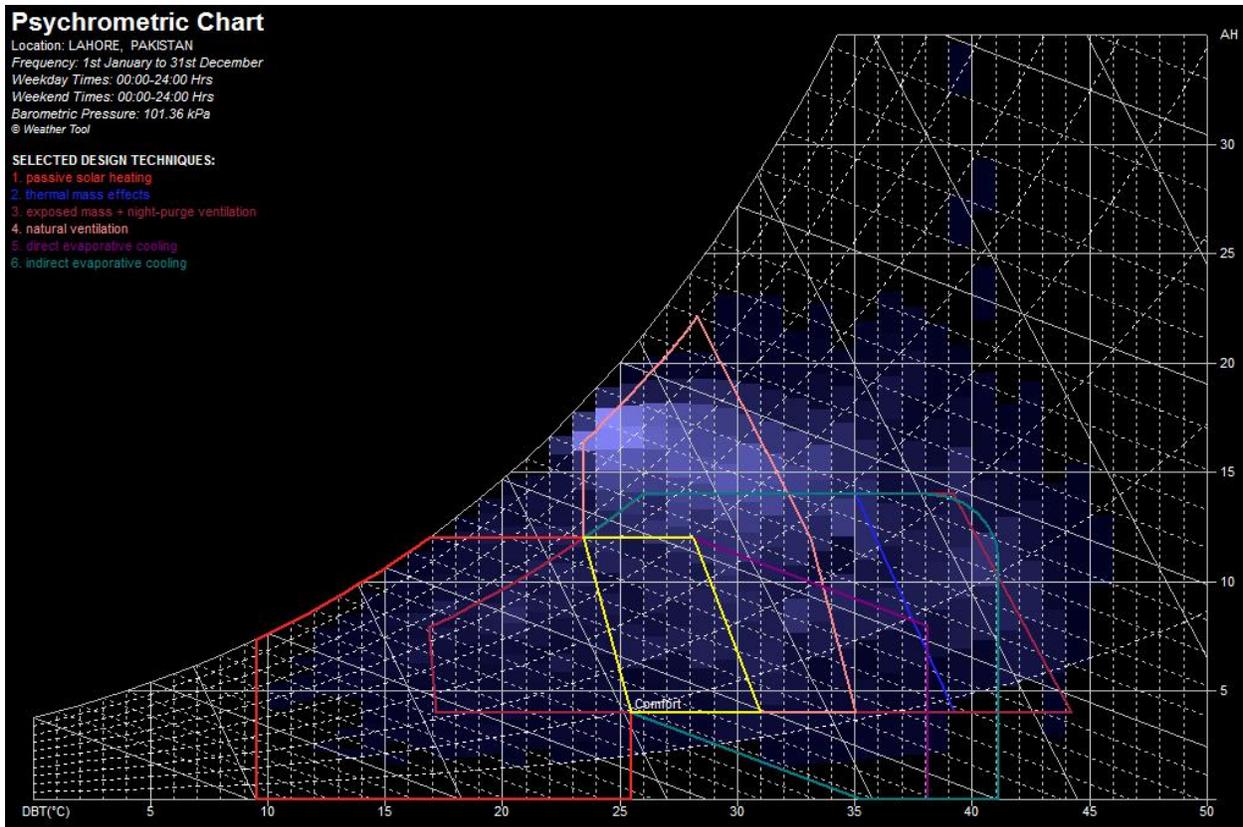


Figure 2.6 Psychrometric Chart with Passive Design Strategies.



Figure 2.7 Passive Solar Heating Effects

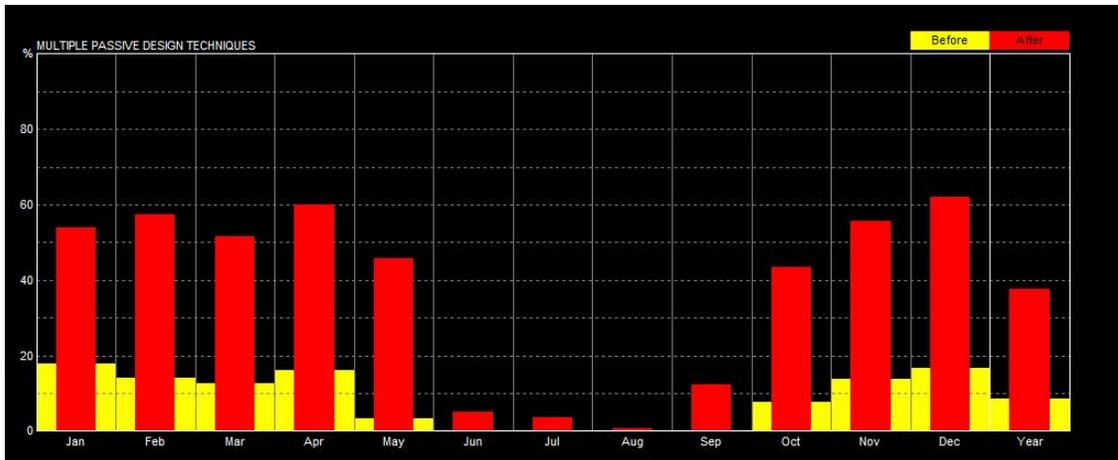


Figure 2.8 Thermal Mass Effects

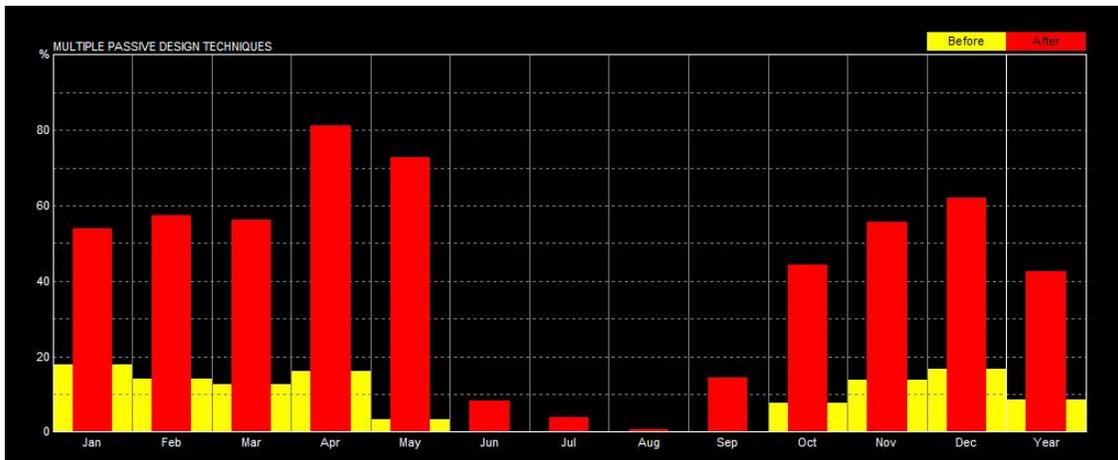


Figure 2.9 Exposed Mass + Night Purge Ventilation Effects

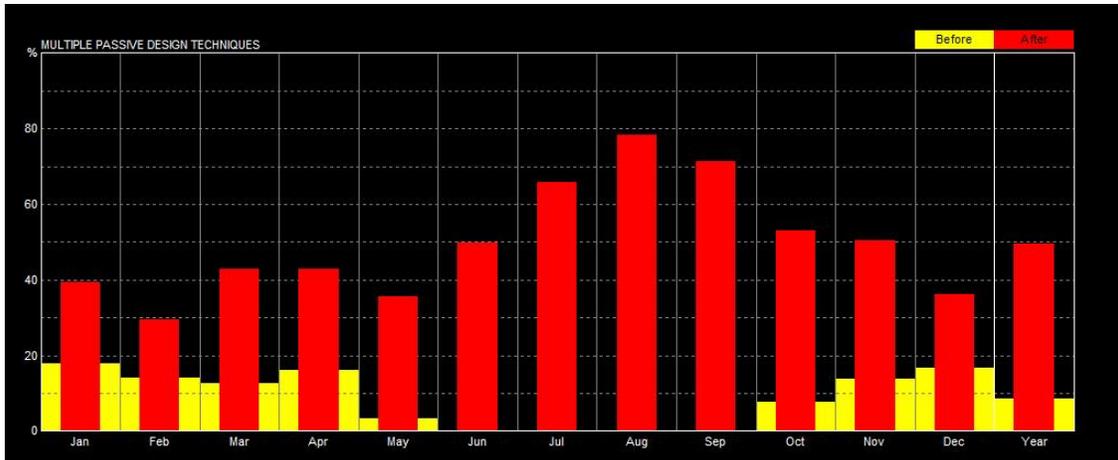


Figure 2.10 Natural Ventilation Effects

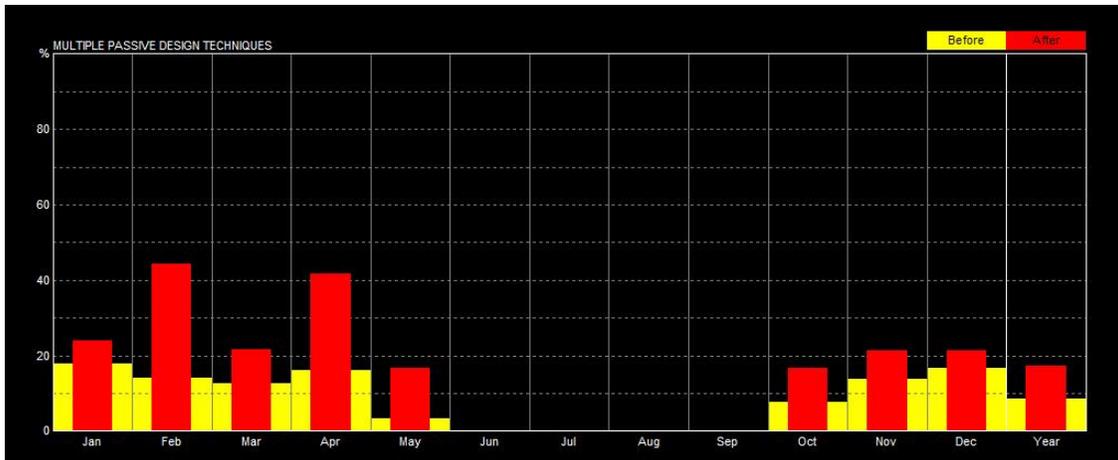


Figure 2.11 Direct Evaporative Cooling Effects

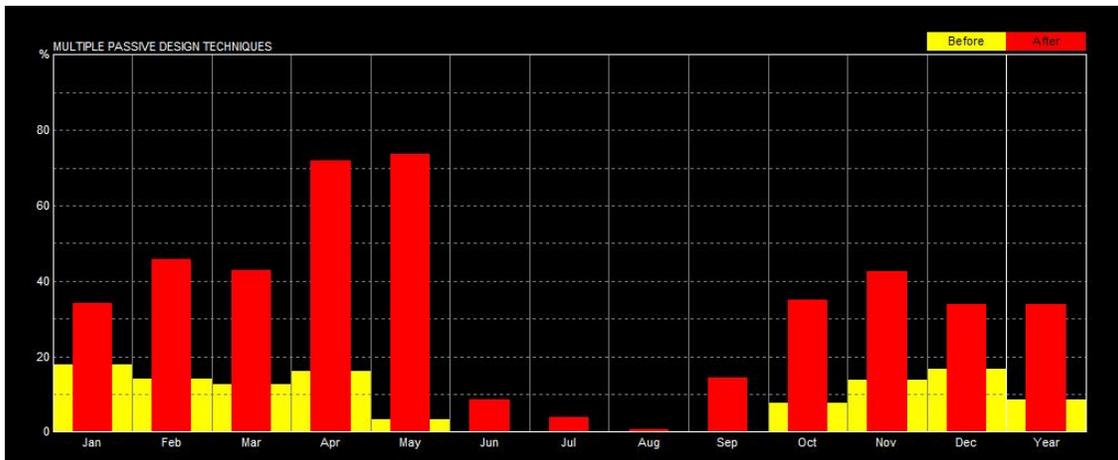


Figure 2.12 Indirect Evaporative Cooling Effects

Wind Data

The wind blows for maximum hours from the west direction at a speed of 10 to 20 km/h.

The winds are mostly high in temperature from 20 °C to 35 °C and an average humidity of 55 %.

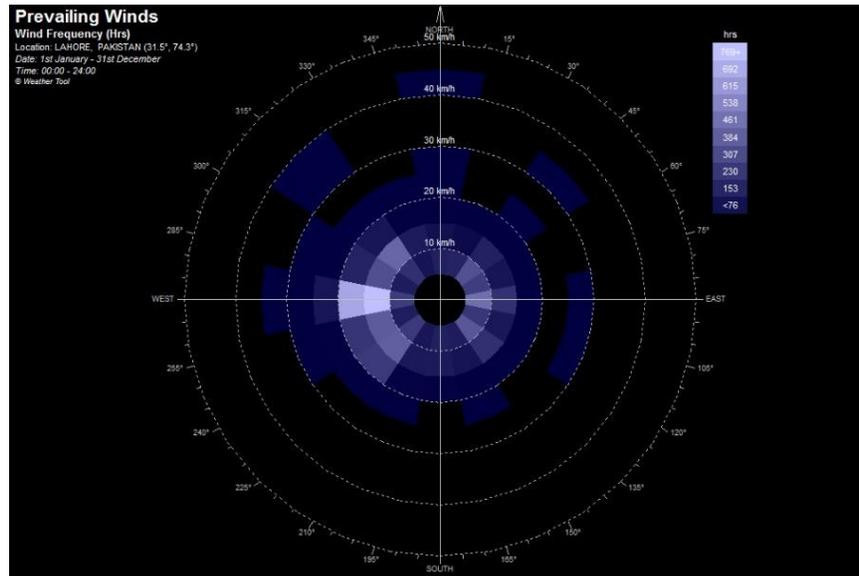


Figure 2.13 Wind Frequency

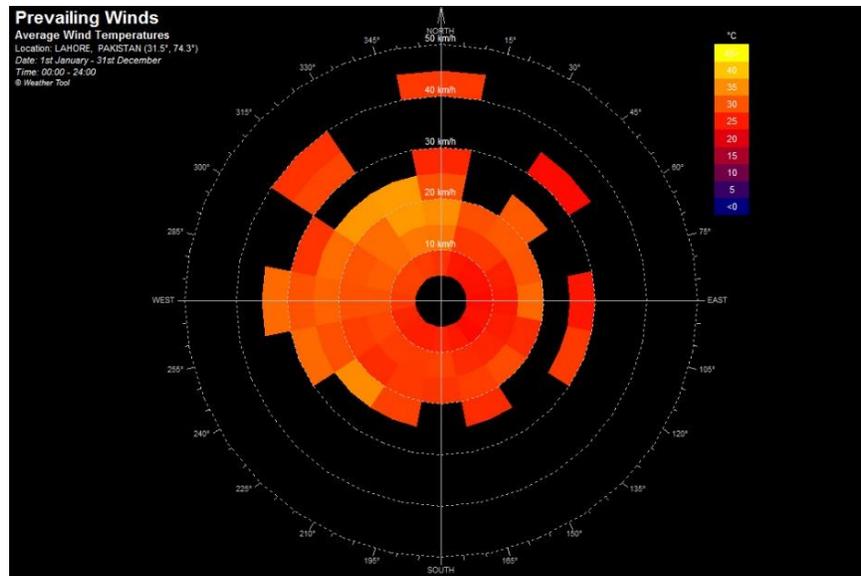


Figure 2.14 Average Wind Temperature

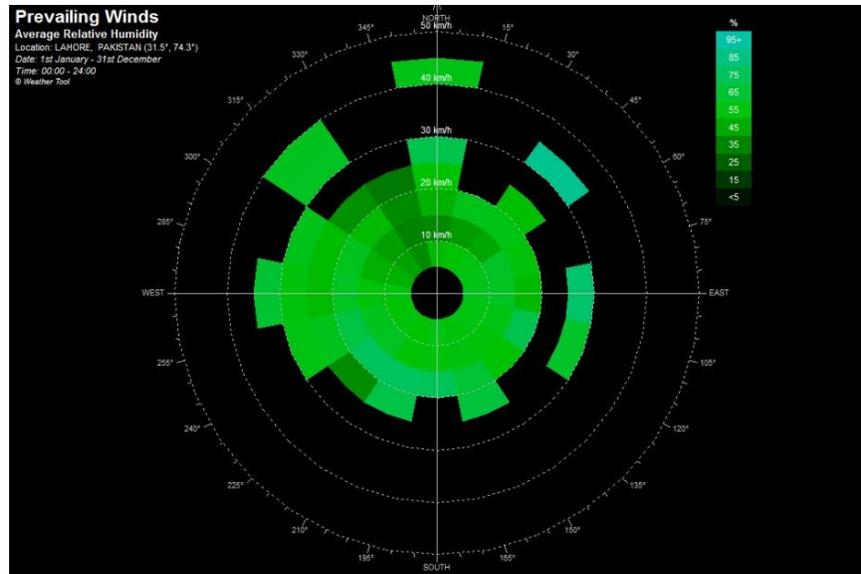


Figure 2.15 Average Relative Humidity

Present Day Houses of Lahore

The housing developments for middle class families offer houses on plot sizes of 2250sft, 2700sft, 3150sft, 4500sft, 6750sft, 9000sft (Fig. 2.19). Some housing developments build all the residences first and then sell them, some sell the plot first and then build a dwelling for the buyer and others only sell the land and leave it up to the purchasers to design and build their house. Every housing development has its own set of by laws regarding the design and construction of the house e.g. the amount of area that can be covered, the height of the building and the width of open spaces on all sides, and so on.

Functional Level

Orientation of Buildings

The relationship of sun, wind and light with the building is not usually considered while designing of housing developments or houses as independent units. An example is the plan of one

of the famous housing developments known as the Lake City shown below. The division of the plots is done in such a way that all the houses have variable orientations.

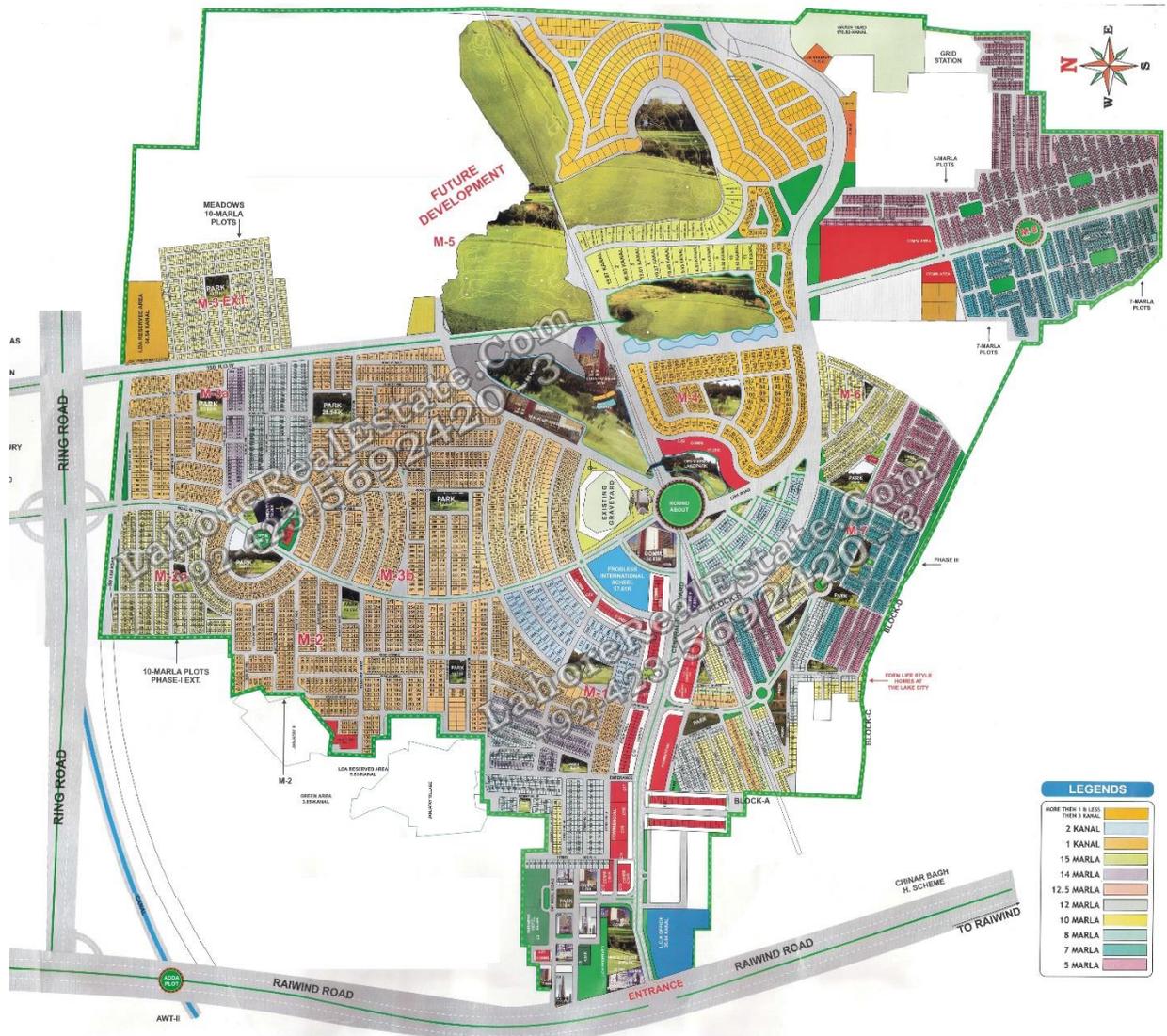


Figure 2.16 Plan of the Lake City Housing Development in Lahore
(Lahore Real Estate.2014)

Building Materials and Construction Techniques

The British replaced the ‘Lakhauri’ brick with a standard 9 by 4.5 by 3 inch brick (Cooper & Dawson, 1998) that is currently used in Pakistan. Brick walls and cement mortar form the load bearing wall structure for residences. The ceilings are made of reinforced concrete slabs that are

fabricated on-site. Pre-fabricated slabs are common for commercial buildings but not for residential ones. At times, the main entrance of the house has a solid wood door but to reduce the cost, flush doors made of plywood are installed with a metal frame throughout the house. Aluminum sliding windows are common because they are easier to maintain. Flooring materials vary from space to space. The car porch is covered with concrete tough pavers. The interior flooring materials include tiles, marble, solid wood and laminated wood. Rugs and carpets are used for decoration. Bathrooms and kitchen almost always have tile work with a huge variety of colors and designs of tiles available in the market. Brick tiles are used on the roof.

Family Structure

Due to the joint family system, the households in Pakistan are large. On average the household size is considered as 6.9 persons per house in urban settings (Pakistan Demographic and Health Survey 2006-2007.2008). The family usually consists of two grandparents, two couples and their children. Two to three servants also work around the house which are sometimes provided accommodation in the residence.

Social Setup

Grandparents do not work and stay inside the house. They usually have a servant assigned to help them with their chores. Their sons go out for work while the women usually remain inside as housewives. The trend of working women is slowly penetrating into the society as the economic situation is making it difficult to meet the expenses. In case the wife works, the younger children are left at home with the servants and the grandparents while the older ones are sent to school.

Comfort

The placement of houses close to each form narrow passages in between them. In this way, the buildings are able to shade each other from the sides and the back while the front is mostly left exposed to the sun. Horizontal shades and pergolas block the harsh sunlight from entering through the windows and provide cooler areas on the terraces and the lawn for sitting.

To provide heat insulation some techniques are coming into practice but are not common yet. Some users build a cavity wall as the exterior wall of the house. This cavity wall has a 9” thick brick wall, a 1” air gap and then a 4.5” thick brick wall. This increases the width of the wall to approximately 15” and takes up a lot of space which is why it is not encouraged in smaller houses. Roof and wall insulation materials like polyurethane foam are slowly making their way into the construction industry.

Typological Level

Sense of History, Community and Place

Once the British took over India, they worked toward improving the infrastructure of the city and made way for roads and railways. As the 20th century progressed, the cost of labor and traditional materials increased. Steel girders and cement became the primary building materials. The building industry followed the fashion of western forms which were made possible by the arrival of the electric grid and cooling machines. Traditional architecture was left behind (Cooper & Dawson, 1998). With time, people migrated from the congested urban center and the city started to expand outside the traditional Walled City. Over the years, the new urban development has had little concern for tradition.

At present, though the construction materials, layout and family setup of houses are similar to each other, a variety of front facades are visible throughout the city. As can be seen from the photographs below, there is no distinct regional style present as far as the elevations of the houses are considered. The styles do not relate to the traditional architecture of the region and take inspiration from around the globe. When all these different facades are put together in one housing development, the urban landscape lacks harmony and appears chaotic.



Figure 2.17 Photographs of Famous Housing Developments (Homes Pakistan.2015)

(Top left: Lake City; Top Right: Oasis; Bottom Left: Divine Gardens; Bottom Right: Bahria Town)

Building Type

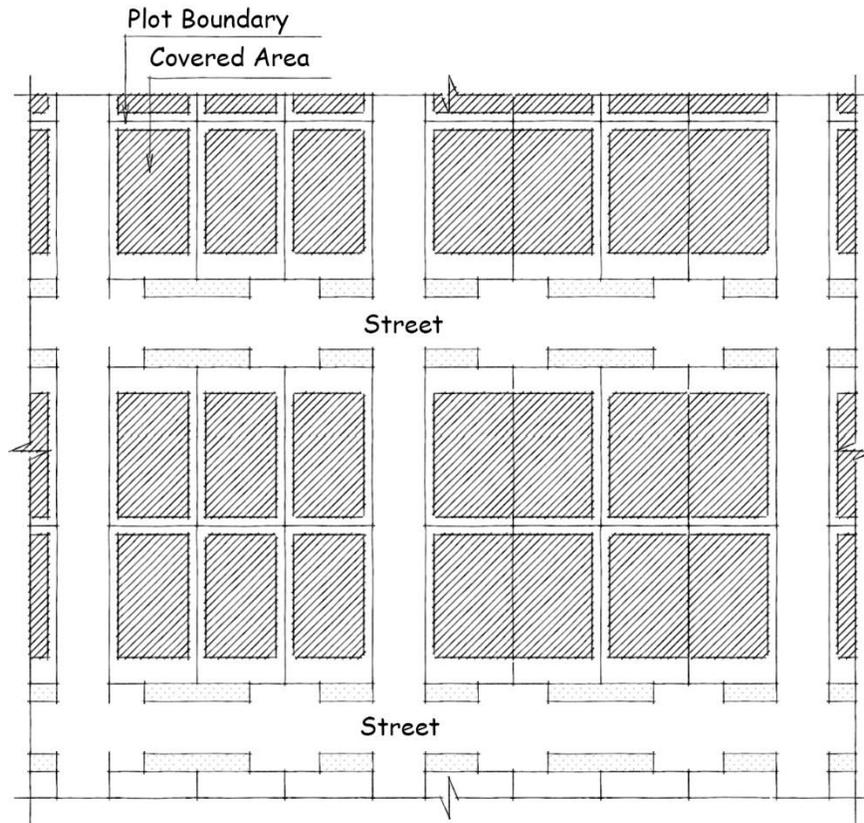


Figure 2.18 Layout of Detached and Semi-Detached, Single Family House

Residences follow two housing typologies: detached, single family house or a semi-detached, single family house (Fig. 2.19). The house is an independent unit that allows its residents complete land ownership. Users have their separate entrance, their own car porch, their independent lawn and so forth. The concept of shared spaces is not entertained. In case of detached houses, the building faces in all direction, allowing the sun to enter from all four sides while in semi-detached houses, three sides are exposed. Since over time land prices have increased along with the population, the covered area of the plot is maximized, which leaves minimum open space between neighboring houses. This results in invasion of privacy when one's window looks into the neighboring house.

Layout

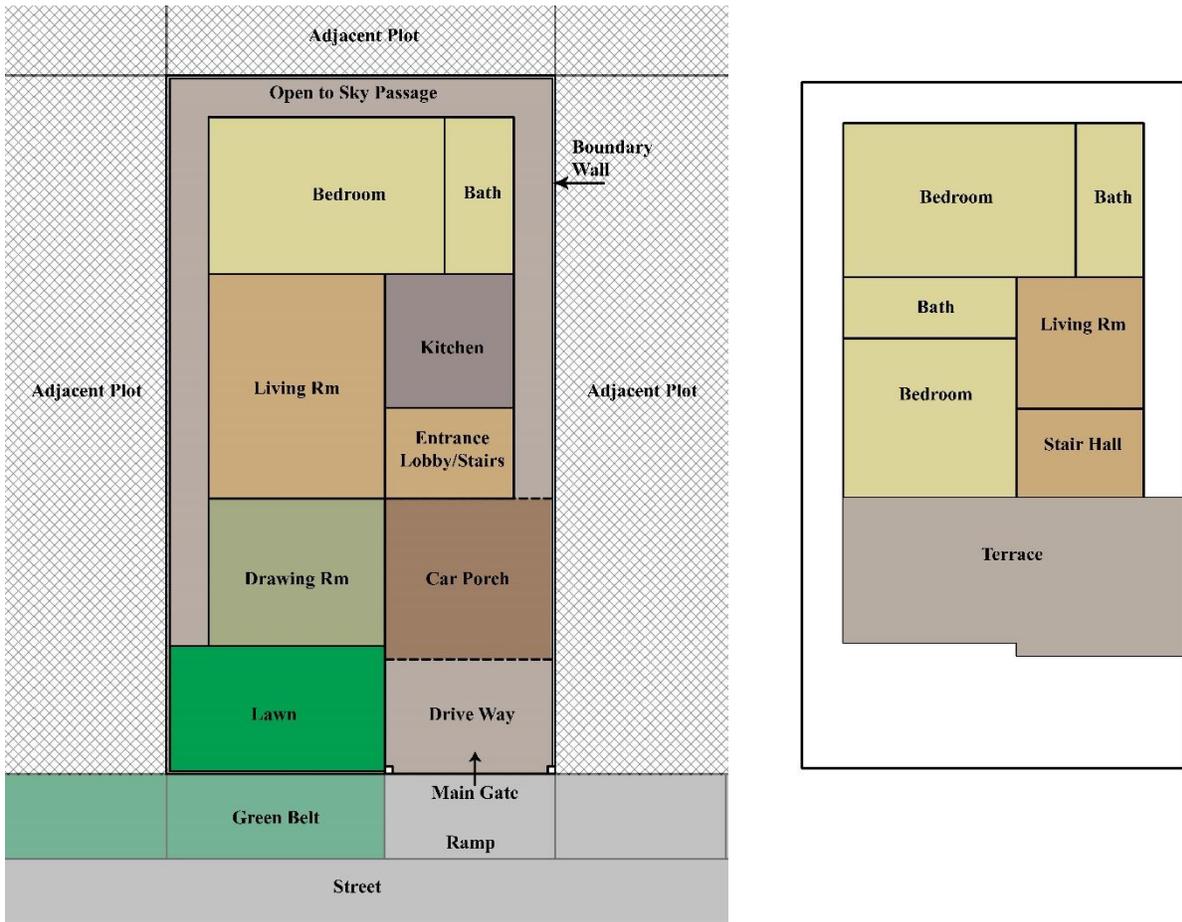


Figure 2.19 Basic Layout of a Modern House (Left: Ground Floor; Right: First Floor)

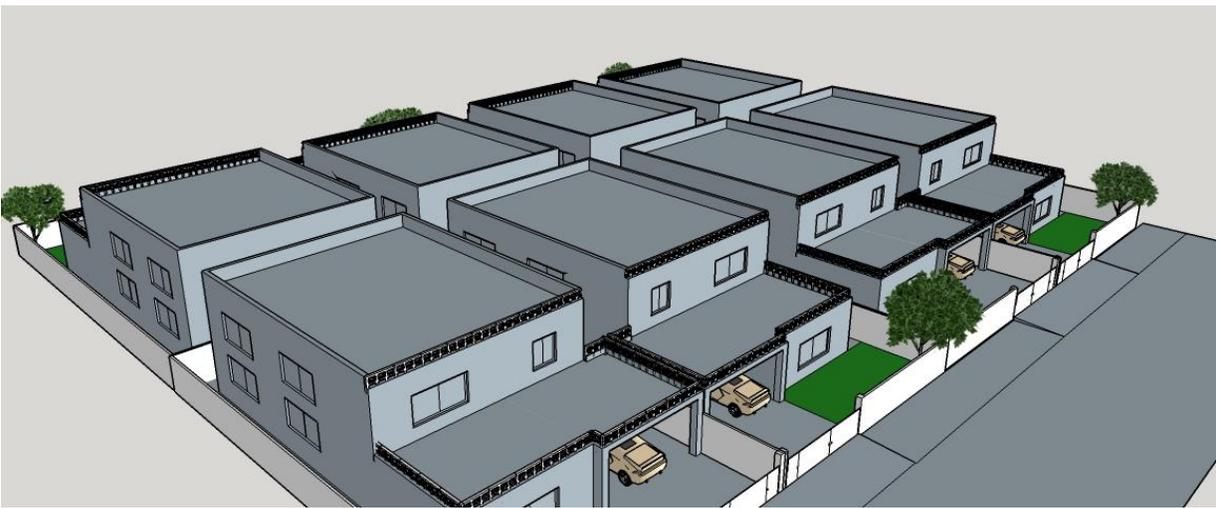


Figure 2.20 3D Image of Typical Modern Houses

The plot is usually surrounded by a 7 foot boundary wall for the purpose of safety and privacy. The front side of the house has a metal gate that leads into a semi-covered car porch. On one side of the car porch is a lawn. Most housing developments require leaving a 5 foot wide open space on all four sides of the building to allow for sunlight and ventilation. The size of the car porch, the lawn and the side passageways can vary according to the size of the plot.

The entrance door typically leads into a lobby that has access to a drawing room, a powder room and the living room. The drawing room is an essential part of the house where guests are entertained. These guests are not intimate enough to be led into the rest of the house and a separate powder room is also provided for them. Over the years the veil system for women has become more flexible but the women still remain inside the privacy of the house and are separated from the male guests.

The living room is the main social center of the house, where all the family members relax, watch TV and discuss family matters. The dining area is sometimes a part of the living room depending on the size of the house. The kitchen is a separate room so that heat, smell and moisture does not penetrate into the rest of dwelling. One or more bedrooms with attached bathrooms are also designed on the ground floor. A staircase from the living room leads upstairs to other bedrooms with attached bathrooms, terrace and the roof top. The terrace and the roof top are sometimes used for activities like laundry.

Electricity load shedding is a common phenomenon these days, which causes people to migrate from one place to another inside the house when the temperature becomes unbearable. The modern houses rely on mechanical systems for interior comfort and so in case of power shutdown, the interior environment can become intolerable. In the summers, people move to the coolest room

of the house or the roof top at night. In the winters, all activities shift to the hottest room of the house or the roof top during the day.

Biophilic Design

As land is expensive in the city and population is high, the residents focus on building on as much land as they can. The idea is to fit as many rooms as possible in the layout of the house with the least amount of area to be left open. The front lawn is the main source of interaction with nature and a smaller patio or backyard is sometimes designed in houses that are 4500sft or larger. The terrace are paved area but can be converted into a roof garden with potted plants.

Swimming pools are not a common phenomenon as the women usually do not swim either because they do not know how to swim or the pool is not in a private enough space. Pools also take up a lot of space and are expensive to build and maintain. Small fountains or waterfalls are designed in the front lawn and/or the interior patios of the house.

Archetypal Level

Orientation in Space

As mentioned earlier, the housing developments do not consider orientation which results in plots that face in all directions. Kabah, the house of God for Muslims, is toward the West from Pakistan. While designing the interior, it is important for people that the bed and the water closet does not face the west direction. It is considered disrespectful to face one's feet or urinate in that direction.

Geometry, Proportion and Numbers

The plot sizes are rectangular in shape with proportions of 25' by 45', 35' by 65', 50' by 90' and so on (Fig. 2.19). The bye laws set by housing developments require certain areas to be left uncovered on the sides. This leaves a rectangle within the plot on which the interior spaces are designed. The proportions of this rectangle can vary according to the requirements of the respective housing development.

The divisions of interior spaces are mostly done based on functionality. Items like doors, windows, tiles, kitchen counter tops and furniture are mostly available in standard sizes in the market. The dimensions of these items dictate the sizes of the rooms.

Spatial Polarities in Natural Settings

The exterior prospect spaces in the house are the front lawn and the front terrace (Fig. 2.22). The rooms that have openings to the front are refuge spaces from where the prospect claiming lawn, terrace and street are visible. Other interior rooms have openings into outdoor spaces on the sides and back that are narrow and do not serve the purpose of a prospect. Variations in ceiling heights are observed in houses. Though the concrete slab is poured at a single height to save cost, false ceiling designs and double height entrance halls create interior prospect and refuge spaces.

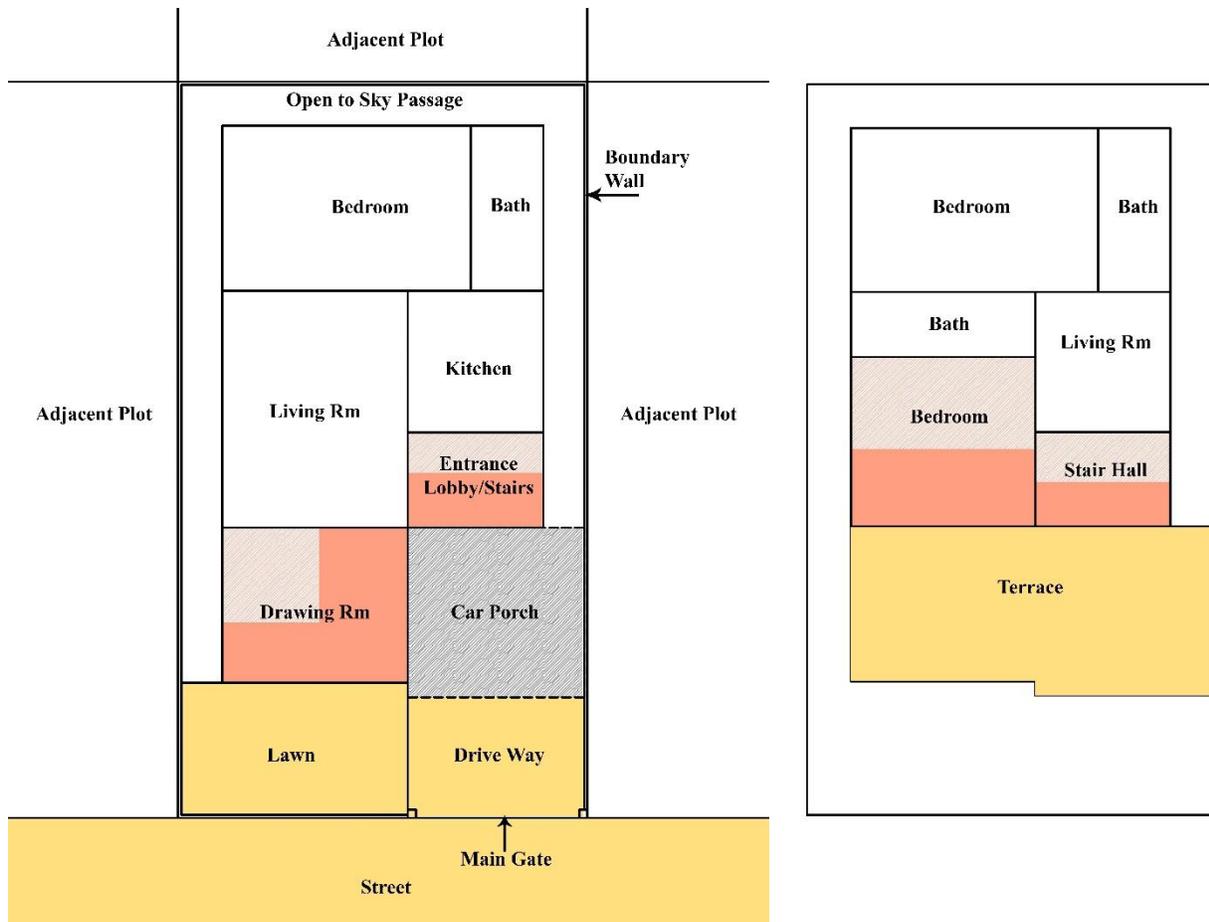


Figure 2.21 Modern House; Prospect and Refuge (Left: Ground Floor; Right: First Floor)

The outdoor spaces are mostly straightforward and do not hold any mystery. The designer has a greater margin to create enticement inside the house by developing paths that turn and disappear. An order is visible in the design as the spaces are arranged in a specific sequence. Strategies that are currently visible in houses to introduce peril are balconies, bridges above double height spaces and glass railings.

Conclusion

The modern house clearly falls short on many aspects of Deep Beauty and sustainability. The house does not take into consideration the orientation of sun and wind. Though the vernacular building material, brick, is mainly used, other imported materials have also invaded the market.

The house depends on machines for thermal comfort and passive design techniques are not applied. Building type is the western detached and semi-detached single family house (Fig. 2.19) and the facades take inspiration from many different architectural styles which results in a lack of sense of history and place. The front lawn is the only source of biophilia for the residents and the open spaces on all the other sides are unused spaces that provide light to the interior rooms. A proportioning system is observed that is based on the availability of interior elements like tile size, door and window size and so on. Geometric shapes and their proportions are not found. Spatial polarities of prospect and refuge can only be experienced in the front of house where the front lawn, the front terrace and the street are prospect spaces (Fig. 2.22).

Traditional Houses of Lahore

The Walled City is one of the oldest parts of Lahore and represents the traditional architecture of the city. This area is also referred to as the “Old City.” Even though much work has not been done to conserve the locality, it remains a tourist attraction.

The Walled City

Origin

Archeologists estimate that this locality was originally founded between the first and seventh century. However, the area was developed during the Mughal Empire (1525-1747). The Mughal Emperor Akbar is responsible for constructing the wall on the periphery of the city. The wall had twelve gates from which only six remain till date (Qureshi, 1979).

Location



Figure 2.22 Location of the Walled City (Google Maps.2015b)

The Walled City is located on the northwest side of Lahore. The river Ravi flows approximately two kilometers west of the area.



Figure 2.23 Map of the Walled City (Google Maps.2015c)

The Walled City is outlined by the Circular Road. Two important historical landmarks of the city, the Badshahi Mosque and the Lahore Fort, are located on the north side. The area is comprised of narrow streets for pedestrians and vehicles, residences, commercial areas, health clinics, schools and colleges.

Layout



Figure 2.24 Walled City Layout Showing the Twelve Gates (Qureshi, 1979)

Ever since the British occupied the area, the Walled City has slowly lost its character. Houses have been demolished and rebuilt over time. Changes have been made to its layout, infrastructural services, building materials and construction techniques. Infrastructural services

have been provided in an unplanned manner which has damaged important architectural characteristics. The unavailability of clean drinking water, an inefficient water drainage system, and a loose and open web of electricity and telecommunications wires has adversely affected the visual and aesthetic value of the facades and the streets (Shahzad, 2011). The layout of the Walled City represents a street system that is haphazard and spontaneous. Due to the increase in population over time, the streets have become congested and lack open spaces. A mixed land use of commercial and residential areas is visible. The first floors of most of the residences have been converted into retail shops. The residents run a variety of businesses from these shops like shoemakers, tailors, jewelers, bakers and so on. Some of the old courtyard houses (*havelis*) now serve the function of schools and colleges.

However, this was not always the case. The Walled City was once a masterpiece of urban design with designated areas for trades and houses of various scales. The *havelis* were among the beautiful residences of the city (Havelis of Lahore.2011) that people still consider as overwhelming and awe-inspiring.

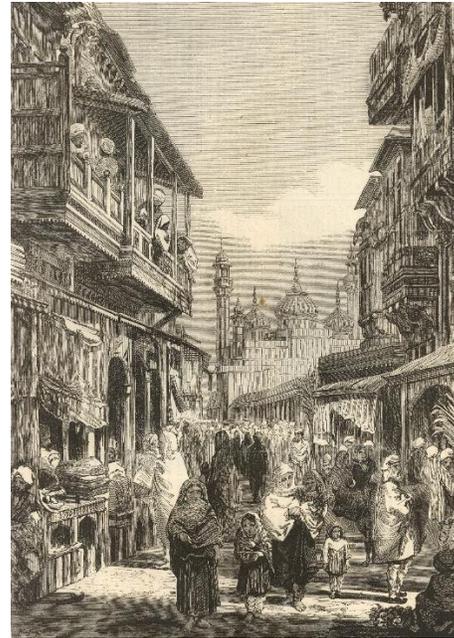
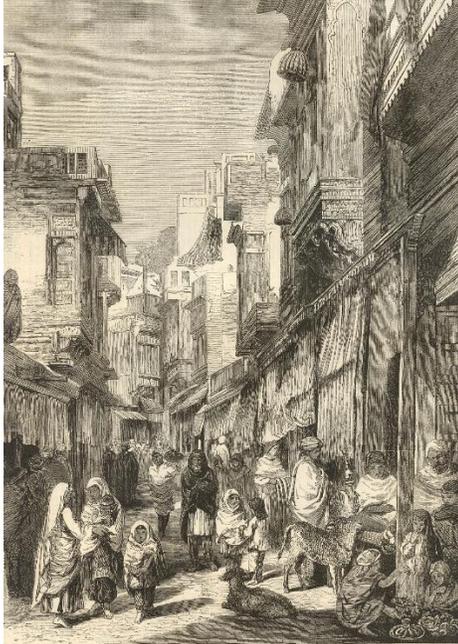


Figure 2.25 Drawings of the Walled City Street in 1858 (W. Carpenter, 1858)



Figure 2.26 Photographs of the Walled City Streets at Present

Left: Mixed Land Use of Commercial and Residential buildings (Iqbal, 2013); Right: Residential Street (Nazir, 2012)

Haveli(s) in the Walled City

Haveli is the regional name for a courtyard house. Though the concept of havelis is credited to the Mughals, it is hard to figure out their true origins as their ancestry is unclear. The Mughal legislation declared that a person's wealth should return to the royal treasury on his death. This discouraged the wealthy from spending their money on building magnificent residences, however, the culture of havelis remained (Cooper & Dawson, 1998). After the nineteenth century, this law was removed and the havelis continued to be glorified. An owner dreamed of an ever-expanding joint family that would carry forward his name. Walls were made thick so that further floors could be added to the haveli as the family size increased (Cooper & Dawson, 1998).



Figure 2.27 Photographs of havelis in the Walled City (Walled City of Lahore Authority, WCLA.2014) (*Left: Nao Nihal Singh Haveli; Right: Lal Haveli*)

Functional Level

Orientation of Buildings

The absence of a grid pattern of streets in the layout of the city has led to a variety of orientations for the houses and the courtyards. Amita Sinha (1989) has observed that the Muslims faced the entrance of their courtyards to the West (towards Mecca) and the Hindus faced it towards the East.

Building Materials and Construction Techniques

Brick was used by the Mughal Emperor Akbar to build the city wall of Lahore, forts, mosques, havelis and the brick-paved streets. The architects and builders faced the brickwork with colorful tiles by taking inspiration from the Persian customs. By the sixteenth century, colored tile was not commonly used for houses, tombs and wells. At times, the brickwork was arranged in a decorative manner to break the plainness of the wall. Laying the bricks diagonally, setting them on an edge or projecting them out from the corners are a few ways in which brickwork was made more interesting. The size of the brick varied over the years. In Lahore, the indigenous ‘Lakhauri’ brick was used but the size of the brick could vary within a single building (Cooper & Dawson, 1998).

Lime plaster was not commonly used before the arrival of Muslims in the sub-continent. The Muslims used it for plaster and stucco as it soon became a vernacular material due to the rich sources of lime present in the country. The havelis were constructed with brick held together with lime plaster. In the ceiling, beams supported the closely spaced joists that were filled with bricks, mortar and rubble. Fine lime would be used to finish the roof that sloped in a way to allow the rainwater to drain properly (Cooper & Dawson, 1998).

Family Structure

The culture of the region favored a joint family system in which three or more generations lived in the same house. After marriage, the son brought his wife home and they both resided with his parents. This led to large domestic formations inclusive of all of the family members and servants that helped with household chores.

Social Setup

Courtyard houses were a part of Islamic Architecture as well as Indian Architecture before the advent of Islam in the sub-continent. When the Muslims arrived, they continued to develop the courtyard type which they found suitable for the climate of this region. The veil system for the women in Islam influenced these houses. The inner court that was separated from the outer court by screens, was used by women. Sometimes the house had separate entrances for the women and men. The fascination of Muslims with light was reflected in the intricate patterns used on windows, screens, doors and shading devices (Das, 2006) that were used for socialization inside and outside the house. The latticework on the exterior windows allowed ventilation and daylight, and provided privacy to the residents. A water feature in the court signified the idea of the courtyard as an oasis (Das, 2006).

The courtyard formed a social center of the house that promoted maximum interaction of people and nature. It provided a natural setting, some furniture to sleep or relax, play areas for the children and sitting for family discussions, all within the privacy and safety of the house. It was also a place where important cultural and religious ceremonies took place.

As the floor levels moved up, the level of privacy increased which allowed the residents on the upper floors to look down from the balconies and the screens. The roof top provided

maximum detachment from the courtyard but granted contact with the neighboring houses and the street from above (Reynolds, 2002).

In the old times, people used animals as a mode of transportation and to earn a living. The courtyard would be the sleeping and eating place for the domestic animals. This way they would remain safe without intruding the interior spaces of the house.

Comfort

Traditional buildings maintained thermal comfort through architectural elements like jalis (screens), verandas, jharokas (balconies), fountains, plants, chajjas (overhangs), courtyards and basements (Batool, 2014). The windows were unglazed but covered with jalis (screens) and opened into jharokas (balconies) that allowed ventilation but prevented direct glare. The chajjas (overhangs) shaded the courtyard and deflected the monsoon rains. At the heart of building was the courtyard that protected the interior spaces from direct sunlight. In some regions of the sub-continent, the courtyards served the purpose of rainwater collectors. Wind scoops for ventilation were also used on the houses. The high ceilings of the rooms facilitated ventilation and kept spaces cool.

Ilay Cooper and Barry Dawson (1998) described three methods that were used to cool a large urban haveli: 'teh khana' (basement), 'khus' (screens made from dried grass roots) and 'punkah' (fan). 'Teh khana' was sunk into the ground and remained indifferent to the fluctuations in the outside temperature. Khus was hung in front of the openings, windows and doors. This screen was wetted which cooled the passing air and scented the air with the smell of grass. Punkah was operated manually by a man who would sit outside the room and pull the ropes to make a to and fro movement of the fan (Cooper & Dawson, 1998).

The functions of the rooms were flexible and their usage was adapted according to the time of the day and the seasons. In summers, people preferred to stay in the basement or in the courtyard where the water features and the plantations provided cool air. At night, they moved to the roof tops to sleep in the cool breeze. However, in the winters, people preferred the roof during the day to gain maximum heat from the sun and moved to the rooms on the upper floor that were warmer than the rest of the house. If the interior spaces became too hot, household activities like cooking would be moved to the courtyard.

Thick walls were built to overcome the structural inadequacies of the building materials but they also provided the advantage of thermal and sound insulation. During summer days, the structure, due to its thermal capacity, absorbed most of the heat and prevented the internal temperature from rising. Shading devices further helped in keeping the wall surfaces cool. At night, the outside temperature dropped and the walls started to quickly lose heat to their surroundings (Ali, 2013). Brick and lime were the main construction material for paving, walls and the roof. Their porous nature has the ability to slowly release moisture back into the environment and create an evaporative cooling effect.

Typological Level

Sense of History, Community and Place

Over the years, India has seen a changing pattern of the predominance of various religions and rulers that have transformed Indian architecture. The history of this region begins from the 3rd millennium BC with the Indus Valley Civilization. The majority of the population at that time lived in courtyard houses made of brick. From the 4th Century B.C. the region was predominantly settled by the Buddhists. The presence of open courts, verandas, lattice screens, balconies is seen in Buddhist monasteries and prayer halls. Hinduism prevailed from the 5th Century A.D until the

arrival of Islam in the 13th Century A.D. The courtyard type continued to exist in religious buildings like mosques and collegiate buildings (*madrasas*) (Tadgell, 1990). A courtyard (an open-to sky and enclosed space) has been a basic element of urban housing in India. Due to the decay of wood and brick, it is difficult to deduce the early evolution of havelis but Cooper and Dawson conclude that they are a contribution of the Mughal tradition (Cooper & Dawson, 1998).

Biophilia was extremely important for the Mughals which was evident from the introduction of the four-square garden (*chahar bagh*). This garden was an image of paradise with flowers and extensive water features. During this time, decorative tile and brick work and calligraphy became an important part of architecture. After the decline of Muslim power in India, the British brought industrial technology and westernization to the region. Gothic architecture became dominant to show Christian power. The Industrial Revolution encouraged many new building types and an eclectic conflict of historical styles was seen in India (Tadgell, 1990).

It can be clearly noted that throughout history of the sub-continent, the courtyard has remained a common architectural element of design until recently. (Randhawa, 1999) highlights the importance of courtyards in India by saying:

“Courtyard house architecture reflected the style and culture of its time. It was indicative of the owner’s self-image and aspirations, with a distillation of the historical influences. It manifested itself in degrees of solidity to extreme ornamentation.” (pg.32)

Features like screens, verandahs, courts, biophilia and geometry are all a part of the region’s architectural history. The havelis of the Walled City Lahore are courtyard houses that possess a sense of history and place. These havelis originated in the region they exist and depict an architectural style that is unique and local.

Building Type

The houses of the Walled City were based on the courtyard housing typology. It mainly involved an open-to-sky court that was surrounded by interior spaces with openings to allow interaction between the outdoor and the indoor.

Layout

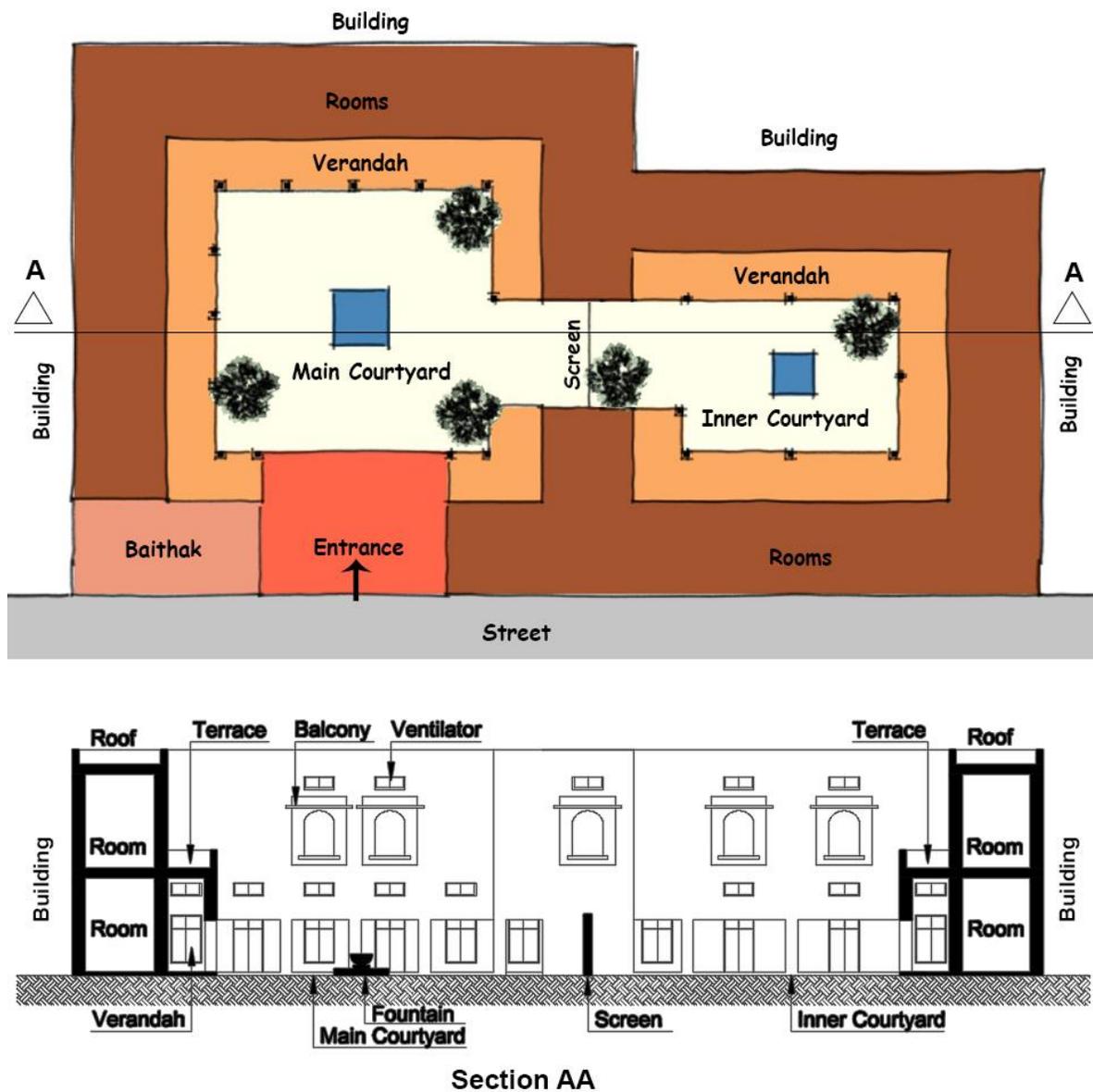


Figure 2.28 Plan and Section of a Typical Haveli in the Walled City

The entrance of a typical haveli was through a huge arched door that would be large enough for an elephant to pass through (Shahzad, 2011). The first room that faced the street is called the 'baithak' (sitting area). 'Baithak' was a male domain and served as a transition between the public space and the private space (Thapar, Bhalla, & Manto, 2004).

A typical haveli had two courtyards, the outer one for the males and the inner one for the women and children of the house. The courtyards were usually decorated with fountains and plants (Shahzad, 2011). A covered corridor with pillars, called the 'beramdah' (veranda), surrounded the courtyard and provided access to the interior rooms. The rooms on the upper floors had shaded 'jharokas' (balconies) from which one could look into the courtyards and the street. These openings were covered with a 'jali' (lattice screen), to provide privacy, prevent glare and decrease the force of hot winds. 'Teh khana' (basement) was used to store valuables and served as a cool refuge in the summers. The staircases were uncomfortable due to their narrow widths and high risers. Ornamentation was an essential part of haveli decoration (Thapar et al., 2004). The flat roof tops were accessible and used at night for sleeping during the summers (Shahzad, 2011).

Biophilic Design

Plants and water features in the courtyards brought nature into the house. It allowed its users an escape from the urban setting to a natural setting. The presence of earth was shown when plants or trees were rooted into the ground. The level of the courtyard was almost always below that of the arcade differentiating the domestic from the more natural. In times of rain, the earth dried slowly, dispersing a strong aroma in the air for the senses. The water on the ground acted as a mirror, reflected its surroundings and dispersed the sunlight to form patterns (Reynolds, 2002).

Seasonal changes affected the aesthetic appeal of the courtyard. In winters, the plants withered out leaving a more barren landscape. When spring arrived, fresh flowers and green leaves

showed up that were enjoyed all through summer until fall, when the plants began to change color and fallen leaves filled up the courtyard floors (Reynolds, 2002).

Plants influence all of our senses. The filtering, reflecting and shading of the sunlight make them a delight for the eye. The rich variety of colors, shapes and textures along with the different smells of the flowers enrich the overall experience of a space. Fruits and vegetables are savored through the sense of taste. Plants provide shade from the scorching sun and cool the air through transpiration which comforts the skin. The ears enjoy the sound of the cool breeze, rustling of leaves and the sounds of insects.

John S. Reynolds (2002) describes the roles of a courtyard. He says:

“The courtyard can represent many things: an oasis in the desert of city streets; a fragment of nature (thus a reminder of natural landscapes beyond the city); a center of interest for the building; a concentration of light, sound, and water; a life-sustaining refuge of safety and privacy.” (pg. 25)

Archetypal Level

Orientation in Space

In a space, direction is important for a person to understand where he or she is. An indefinite space can be given direction with reference to the heavens. The primary system of orientation of north, south, east, west, up and down constitutes the entire world (Ardalan et al., 1973). When Muslims built their courtyards towards the west (Mecca), it allowed them to orient themselves to the Kabah (House of God) which is the center of the world for all Muslims. The presence of monumental buildings like the Lahore Fort, the Badshahi mosque and the Wazir Khan mosque located in the Walled City, allowed the residents to orient themselves. Their tall minarets and the call for prayer that took place five times a day, would give the listener and the viewer a

sense of direction. The close proximity of the Walled City to the river holds importance for the Hindus as sites close to water were considered sacred in India. According to Hinduism, “*Gods reside near forests, rivers, mountains, rivulets and in the cities which are full of gardens.*” (Vasudevan, 2002)(p.1).

Geometry, Proportion and Numbers

Numbers in Islam are qualitative as well as quantitative. So they are not simply identified with the rules of addition, subtraction, multiplication and division but hold a projection of the Unity. For example, in Islam, the number ‘4’ symbolizes the four directions, the four seasons, the four gateways to heaven (Ardalan et al., 1973) and the four rivers that flow in heaven. The number four is prevalent in the design of Mughal gardens known as the ‘char bagh’. The garden is a quadrilateral that is divided into four parts by walkways. Prevalence of number in havelis is unknown but Schoenauer & Seeman (1962) have made an observation about the courtyard houses:

“It is obvious that in a large country like India one must encounter many regional differences in court-house building traditions. However, there is one characteristic which applies to the Indian builder in all regions: he has an excellent sense of proportion and is highly skilled, despite his simple tools, producing buildings with a distinctive dignity and beauty.” (p.43)

Surface adornment is a way in which matter loses its heaviness. This applies to all scales of architecture from monuments to a carpet or a brass tray. Walls of a building are transformed by the patterns of brick, plaster and tiles. Floral patterns and geometric designs are carved on arches to make them appear less heavy (Ardalan et al., 1973). The domes, walls and floors of most Mughal buildings are decorated with geometric patterns, calligraphy and arabesque. Different 6 point, 8

point and 10 point geometric patterns are visible in the interiors of all Mughal buildings situated in Lahore. These patterns are also visible in the jalis, through which sunlight creates numerous configurations of shadows throughout the day.

The mirror-like pool holds symbolic importance in Islam as it reflects the heavens which unites the above with the below (Ardalan et al., 1973). The presence of a fountain or a pool in the center of a courtyard is an essential feature of the havelis and the Mughal gardens.

Spatial Polarities in Natural Settings

A combination of prospect and refuge spaces is an integral part of haveli design which is made possible through various design features. Larger rooms like the dining room and drawing room, usually have high ceilings forming the interior prospect while bedrooms with low ceilings form the interior refuges. Basements of the haveli are dark and cool places to relax and the open courtyards provide a feeling of vastness and openness to the sky. Verandahs surrounding the courtyards, giving the user refuge spaces from where he or she can easily see the prospect-claiming courtyards. Trees in the courtyard develop shaded areas that form exterior prospects and exterior refuges. Courtyards, which expose the residents to the weather, and balconies that look below into the courtyards enrich the experience through their perilous thrill.

The complex street network of the Walled City and the variations in house sizes and shapes leave the visitor with a sense of mystery. The absence of a straight path does not allow the user to identify what will happen once the path turns. Yet, in this complex network, the presence of geometry gives the design the characteristic of complex order that can be recognized by moving through the space.

Chapter 3 - Study Methods

Setting

Barood Khana Haveli

The house selected for this study is known as the ‘Brood Khana Haveli’. It is located in the Walled City of Lahore and is an example of a typical haveli of the region. The architecture of the Walled City has not been conserved by the city management but this house has been well maintained and remains close to its original form due to efforts made by the owner himself. Further details of this house are given in Chapter 4.



Figure 3.1 Photograph of House A (Rehman, 2012)

Rubric for Analysis

Functional Level	Typological Level	Archetypal Level
Orientation of Building	Sense of history, community and place	Orientation in Space
Building Materials and Construction Methods	Building Type	Geometry, Proportion and Numbers
Family Structure	Layout	Spatial polarities found in natural settings
Social Setup	Biophilic Design	Natural Symbols
Comfort		

Table 3.1 Rubrics for Analysis

The performance of this haveli is analyzed at the three levels of Deep Beauty (Functional, Typological and Archetypal). These three levels have their own set of indicators which are examined individually.

The functional analysis seeks to find out how the house fits with its site in terms of climate, orientation, shape and use of local materials. The analysis also judges how well the houses respond to the needs of the social setup of a typical middle class family. Lastly, the strategies used for providing thermal comfort are identified.

The typological analysis is a way to compare the traditional and the modern-day typologies. A building program is the implicit or explicit statement of spatial requirements to be fulfilled within the constraints of available sites, budgets, and technologies; it can be simple or detailed, but it will usually define the building type (such as detached one-family house, or thirty-unit apartment house) and the intended activities such as eating, sleeping, or parking the car. A program will also usually specify what kinds of spaces are to be provided for these activities, such as kitchen, dining room, bedroom, or garage; and how large these spaces must be (Hayden, Dolores,

2002). In this analysis the building layout is studied in detail. The presence of a sense of history, place or community along with biophilia is explored.

The archetypal analysis of the house requires finding the presence of the world's sacred architecture and archetypal elements such as courtyards, towers and basements. The use of mathematics, nature, numbers, geometry, symbolic dimensions and calligraphy is assessed. Occurrence of spatial polarities including complex order, prospect and refuge, enticement, and peril in the overall experience are explored. Natural symbols have not been studied for this house.

Tools for Analysis

The tools for study and analysis include photography and drawings, interview, literature review, computer software program and personal experience.

Photography and Drawings

The owner of the Barood Khana Haveli has provided the drawings of the house including plans and numerous photographs.

Interview

The owner/resident of Barood Khana Haveli, Mr. Yousaf Salahuddin, is interviewed about the house from the time his family moved into the building to date. The questions are based on the rubric mentioned earlier. A sample questionnaire is given in Appendix A.

Computer Software Program

The software program 'Ecotect' is used to extract the climatic data and passive design analysis for the city of Lahore. This software is further used to study the sun path around the Barood Khana Haveli.

Personal Experience

The researcher belongs to a middle class family and has lived in the city of Lahore for twenty four years. She has been a practicing architect for two years and has the opportunity to work on a number of residences in the city. From her personal experience, she is able to provide information regarding the current situation of modern houses.

Chapter 4 - Analysis of the Traditional House

Traditional House (Barood Khana Haveli)

The house is situated in the Barood Khana Bazaar of the Walled City. It is located between Koocha Langay Mandi and Pani Wala Talab (Walled City of Lahore Authority, WCLA.2014).



Figure 4.1 Location and Orientation of Barood Khana Haveli

The haveli is surrounded by streets on the north and the south side (Fig. 4.2). On the west side are residences, shops and a hospital. The haveli faces a cinema and more shops on the north. The shops in this area are on the ground floor with residences on the first floor. Across from the cinema, the private entrance for residents is situated. Further down this street, another entrance is located for the guests that leads into a car parking area. This car parking area was used for communal interactions with the neighbors and public in the old days. From this car parking area, one enters into the main courtyard of the haveli.

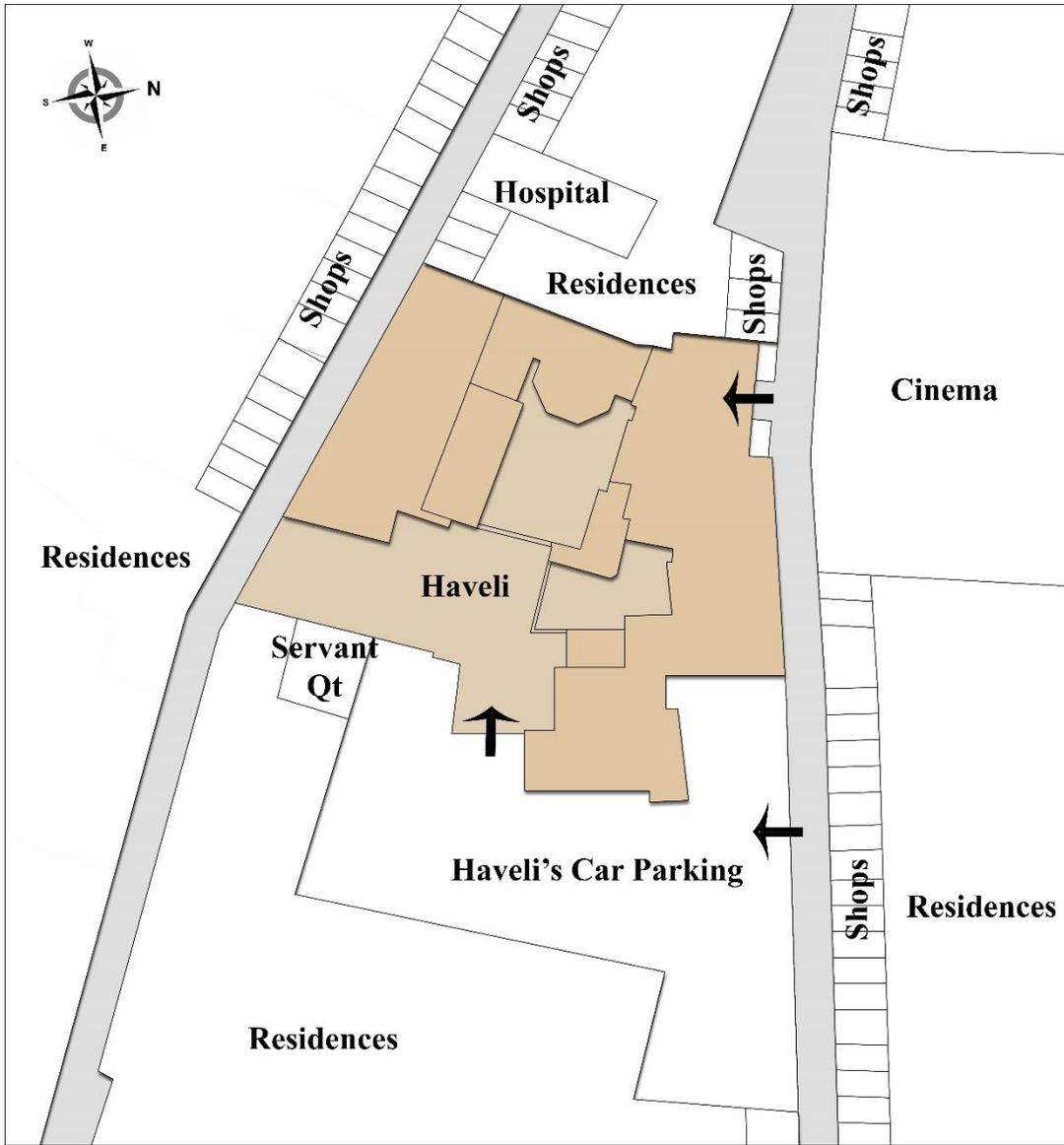


Figure 4.2 Site Plan of Barood Khana Haveli



Figure 4.3 Ground Floor Layout Plan



Figure 4.4 First Floor Layout Plan

Upon entering the main courtyard (Fig. 4.7), toward the right is a bedroom which served the purpose of a public sitting area, known as the ‘baitakh’, in the old days. The main courtyard has a fountain, trees and plants. Two inner courtyards (Fig. 4.8) are separated with screens. The inner courtyard towards the west has a fountain in the center, bedrooms on the south side, a sheesh

mahal on the west and a veranda on the north. The sheesh mahal was built as a religious place for the Sikh. The religious book of the Sikhs called the Guru Granth Sahib, would be set here. Currently, the owner of the house is a Muslim who uses the house as a relic room. On the north side of the sheesh mahal is the basement (Fig. 4.10) which is accessed through a small and steep staircase. This basement is used as a traditional floor or low level seating area. The second inner courtyard is smaller in size with a veranda on the north side that leads to the dining hall and the kitchen. On the north side, the private entrance for the residents arrives into a car porch (Fig. 4.6). A corridor links the car porch to a sitting room, the office of the resident and the second inner courtyard.

Three independent staircases climb up to three different terraces (Fig. 4.9). From the main courtyard, a staircase leads into a terrace that is split into three levels on the south side. The two lower levels look outside into the street and the higher level is more private that looks into the inner courtyard. Underneath the lower level terrace is a bank that opens to the street. The other two terraces are private. They are accessed from the inner courtyards and look below into the courtyards of the haveli. On the first floor, three more bedrooms, a dining room and a TV lounge are located on the north side of the haveli. The roof is easily accessible directly from the courtyards as well as the first floor. The monumental Badshahi Mosque is visible from the roof along with neighboring streets and residences.

The haveli remains in its original form except that some purposes of the areas have changed. The communal space adjacent to the haveli has been converted to a car parking, the baithuk is changed to a bedroom and the sheesh mahal has been converted to a relic room. Other than that, the kitchen has been renovated with modern equipment and air-conditioners and heater

have been installed in the house for extreme weather. The haveli has well-adjusted to the changes in family setup and technology advancement.



Figure 4.5 Exterior Photographs (Left: Street; Right: North Façade of the haveli) (Salahuddin, 2014)



Figure 4.6 Car Porch on the North (Salahuddin, 2014)



Figure 4.7 Main Courtyard (Rehman, 2012)



Figure 4.8 Inner Courtyards (Salahuddin, 2014)





Figure 4.9 Terrace (Salahuddin, 2014)

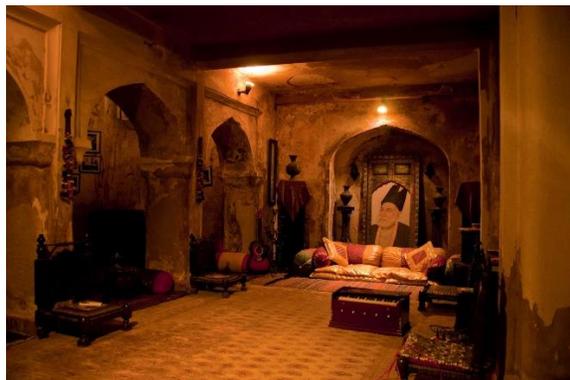


Figure 4.10 Basement (Salahuddin, 2014)



Figure 4.11 Interior Photographs (Salahuddin, 2014) (*Left: Dining Hall; Right: Sheesh Mahal*)

Functional Level

Orientation of Building

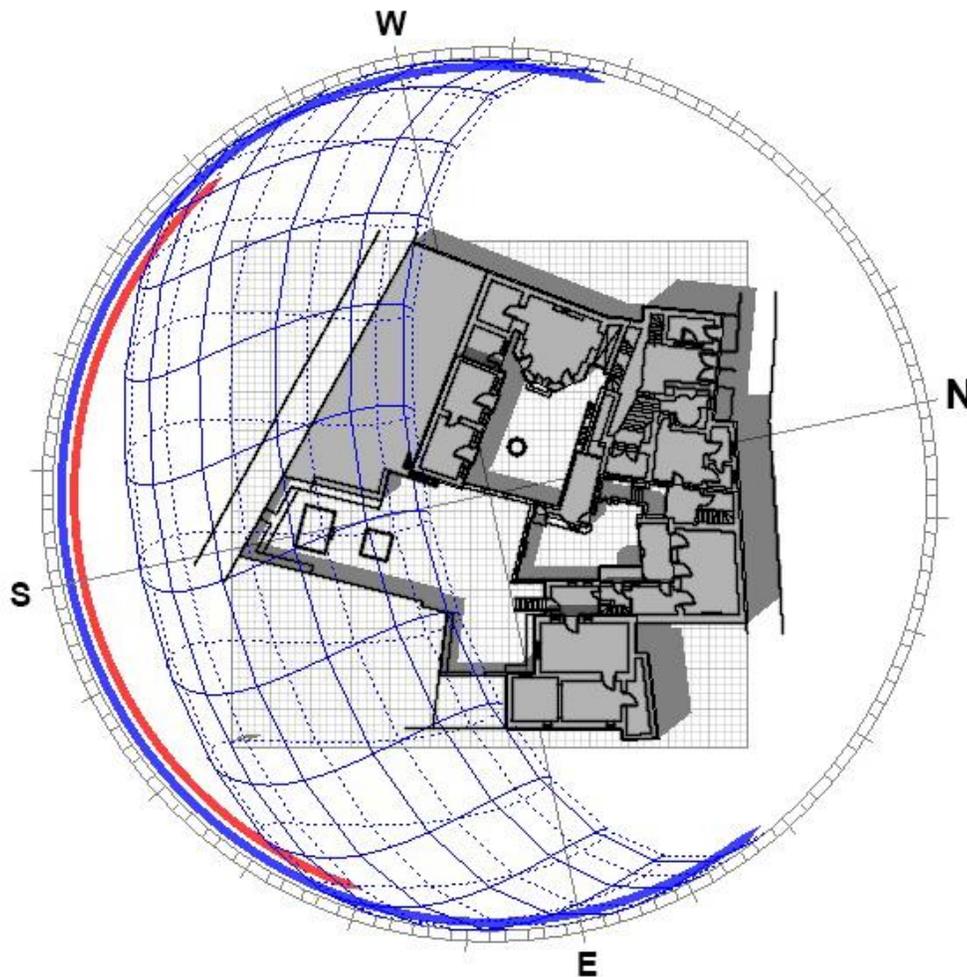


Figure 4.12 South Facing Courtyards and North Facing Windows

Most of the interior rooms are located on the north side of the house. The maximum number of windows open to the northern side where there is least amount of sun throughout the year. The terraces and the courtyards are situated on the south side with maximum sunlight. Christopher Alexander and his colleagues highlight the importance of the south facing outdoors in their book *A Pattern Language*.

“People, use open space if it is sunny, and do not use it if it isn’t, in all but desert climates.” (p.514)

Regardless of how beautiful the outdoor space might be, if it is not placed correctly, it will never become a happy place. The survey conducted by Alexander proved that people with north-facing backyards did not use them at all and preferred the south facing front yards. He also noted that south facing outdoor spaces must have sunny areas and will not work if it is covered with a band of shade (Alexander, Ishikawa, & Silverstein, 1977). In this haveli, two storey structure is constructed on the north side and the rooms on the south-west side are only single storey which allows maximum light to enter the courtyard and provide minimum shade.

Building Materials and Construction

The walls of the haveli are made of the traditional ‘Lakhuri’ bricks held together with lime mortar. Decorative patterns are formed by arranging bricks in a way to break the monotony of the straight wall. Currently, parts of the haveli have been plastered and painted white while some of the brick work is left exposed. The courtyards and terrace floors are paved with brick that are decorated with tile work. Wooden ceilings, doors, blinds for windows and screens are painted dark brown to retain the wooden look. Patterns of colored glass cover the ventilators through which light infiltrates into the interior.

Family Structure

The owner of the house, Mr. Yousaf Salauddin, is 63 years old. This haveli has been his home for his entire life. Currently, the residents of the haveli include himself, his nephew and over ten servants.

Social Setup

Outdoor furniture like benches, swings (Fig. 4.18) and traditional beds (*char pai*) are situated in the courtyard and the terrace for the residents to socialize and relax. During the winter season, a portable fireplace is set in the center of the courtyard around which comfortable seating arrangements are made (Fig. 4.13). The basement functions as a music room. Due to its cool temperature, it is frequently used in the summer to relax and enjoy music. The roof top and terraces are used to get the sunlight.



Figure 4.13 Main Courtyard with Fire Place during the Winter Season (Salahuddin, 2014)

Christopher Alexander and his colleagues in their book *A Pattern Language*, discuss the pattern of ‘Common areas at the heart’. They say “*No social group...can survive without constant informal contact among its members.*” (p.618). To create a space that effectively promotes such contact, it must have three characteristics: it should be located at the center of gravity of the building, the paths in the building should lie tangent to it and it should have an outdoor area and a space for communal activities. ‘Sitting circles’ is another pattern that follows the same characteristics to form an effective sitting arrangement for people to interact. In the pattern

‘Alcoves’, the book says : *“To give a group a chance to be together, as a group, a room must also give them the chance to be alone, in one’s and two’s in the same space.”* (p.829) Family members want to be together but at time they all wish some level of privacy as well. A common area should provide them with a quiet place where one or two people can interact privately without having to leave the entire group (Alexander et al., 1977).

The Barood Khana Haveli has all these three patterns effectively (Fig. 4.14). The courtyards lie at the center of gravity of social life in the haveli. Sitting circles formed inside the main courtyards paths touching them at a tangent so that people passing by keep these spaces but do not cut through the sitting arrangement. In the same courtyards, benches and a swing are placed close to wall, separate from the sitting circle that provides a quiet place for anybody who need privacy from the group.

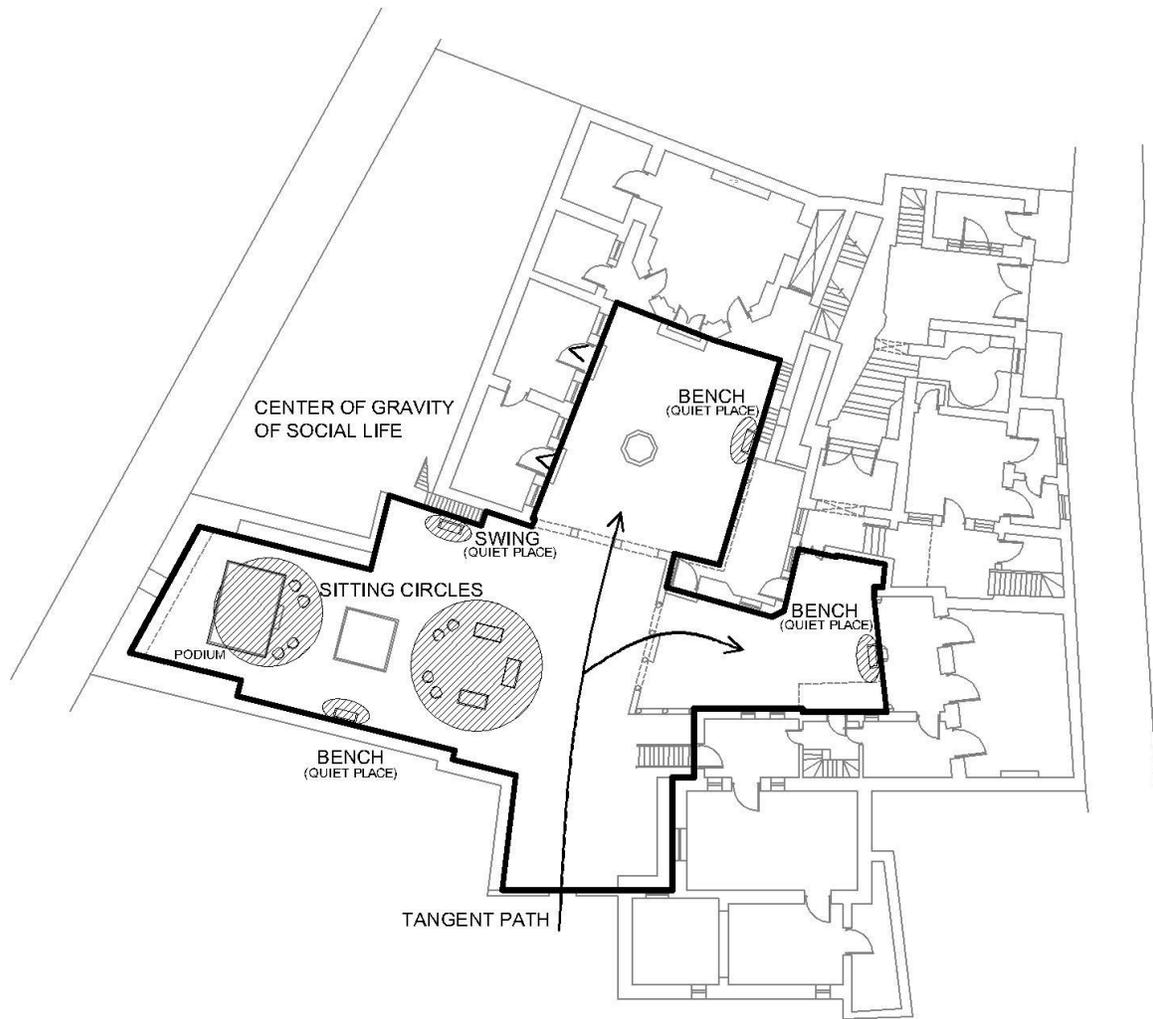


Figure 4.14 Center of Gravity of Social Life, Tangent Paths, Sitting Circles, Quiet Place

The courtyard and the terraces are used for many social events like weddings, musical evenings, dinner parties and shooting of music videos (Fig. 4.15). People, other than the residents of the house, use the house to hold their social gatherings upon permission from the owner. This haveli has also become a heritage site because of how well it depicts the traditional architecture of the city. The owner of the house allows guests to visit the place for the purpose of learning.



Figure 4.15 Courtyards Decoration during Social Events (Salahuddin, 2014)

Comfort

Migration is a strategy in which the residents move from one zone to another in order to achieve thermal comfort (DeKay & Brown, 2013). During the summer season, the basement and the courtyards of the haveli are cool at daytime and at night the terrace and roof tops allow the cool breeze to help remove heat from the building. In the winter season, the roof and the courtyards have maximum exposure to the sun during the day and at night the first floor is occupied because of the warmth it had occupied from the sun.

Currently, migration is not practiced in the courtyards, terraces and the interior rooms. Air-conditioners and heaters have been installed inside which makes migration unnecessary. Other passive techniques maintain thermal comfort in the house which is why the need to run these machines is minimal.

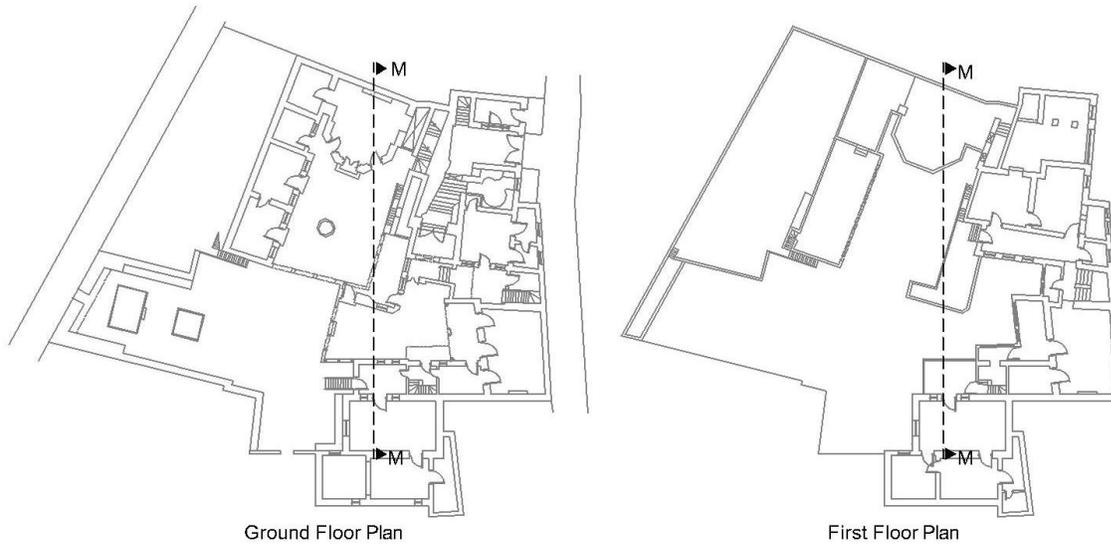
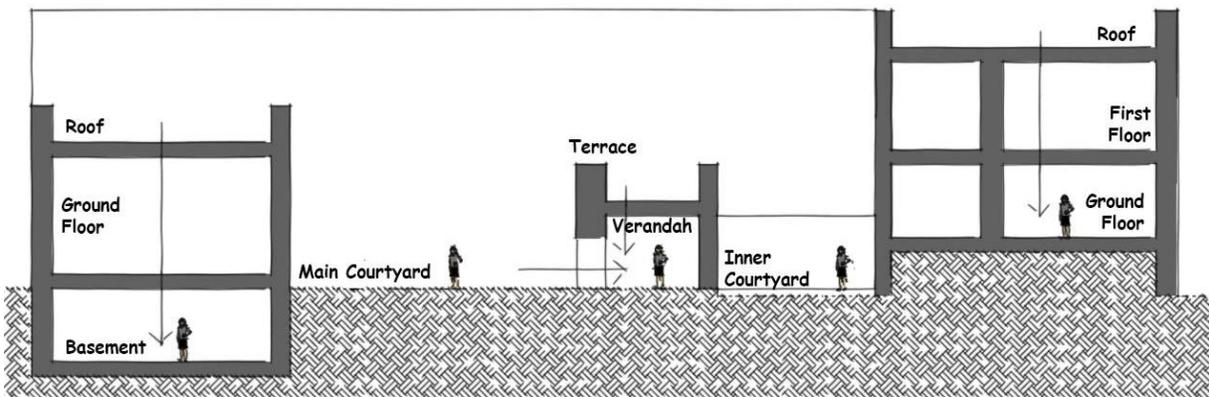
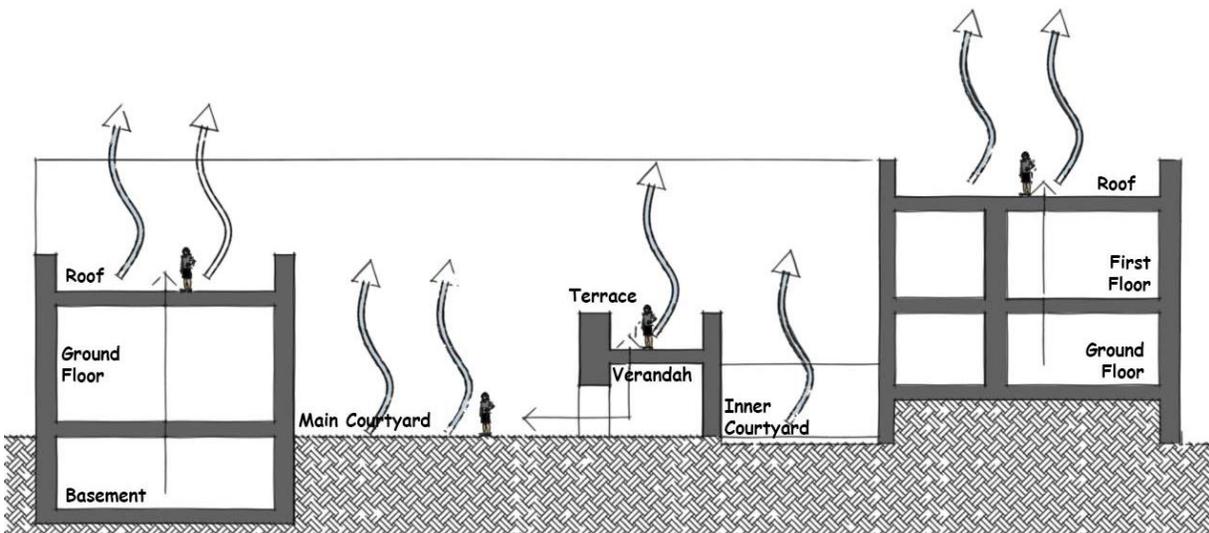


Figure 4.16 Plans Showing Section Line MM for Migration Strategy



Summer Day



Summer Night

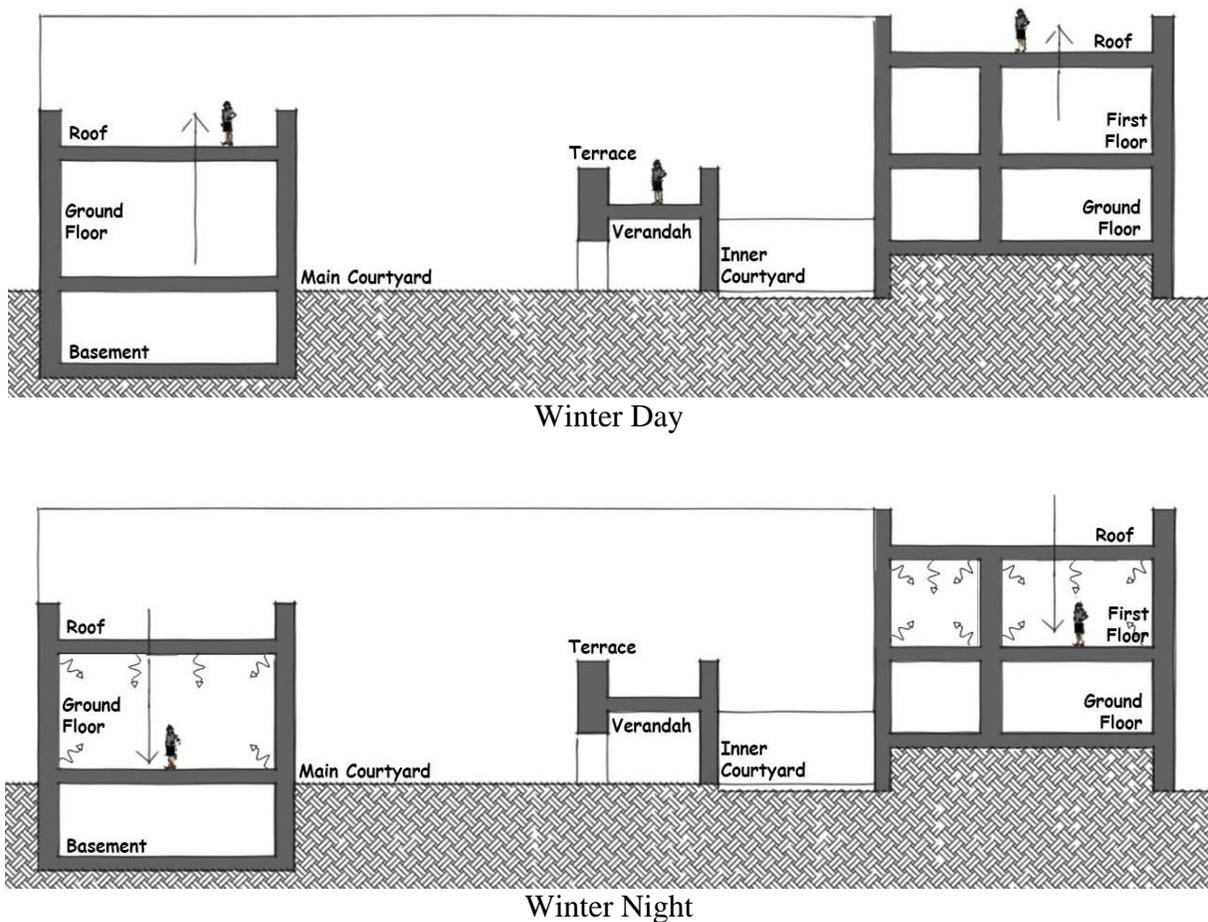


Figure 4.17 Migration Strategy (Section MM)

Jharokas (balconies) are semi-covered spaces, covered with jalis (screens) from where the residents are able to enjoy the breeze without having to face the scorching summer sun. The jalis themselves cannot produce cooling but their intelligent use prevents glare and allows daylight and air to enter. The prevention of direct solar radiation keeps the interior spaces cool. Beramdahs (verandahs) provide shaded spaces that connect a person to the outside with protection from extreme weather conditions. Besides these permanent features, the haveli also has movable shading devices. Screens made from cane serve the purpose of curtains. In winters to avoid heat loss through the openings, windows are closed with solid wooden planks. Vines covering the

jharokas follow the climate, providing full coverage during the summer with their foliage and allowing the winter sun by shedding their leaves.

The fountains and pools in the courtyards cause evaporative cooling. The swing in the main courtyard allows the user to experience a light breeze with its gentle movements during the warm and humid time of the year.



Figure 4.18 Swing in the Main Courtyard(Salahuddin, 2014)

Cross-ventilation is a significant cooling strategy in warm climates because other than removing heat from the environment, it also creates a feeling of cooling by increasing the rate of evaporation of people (DeKay & Brown, 2013). The haveli follows both cross-ventilation and stack effect principles. In a situation where two openings are placed in the same wall, the interior air velocity is 22% higher than the outside air velocity (Fig. 4.19). This results in better rate of cross-ventilation and cooling. (DeKay & Brown, 2013). The majority of the rooms in the house have two or more openings in the same wall (Fig, 4.20).

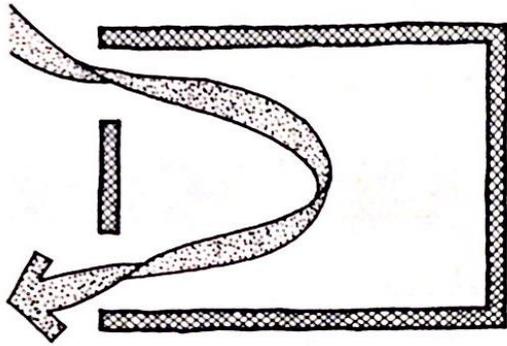


Figure 4.19 Two Openings in the Same Wall (DeKay & Brown, 2013)

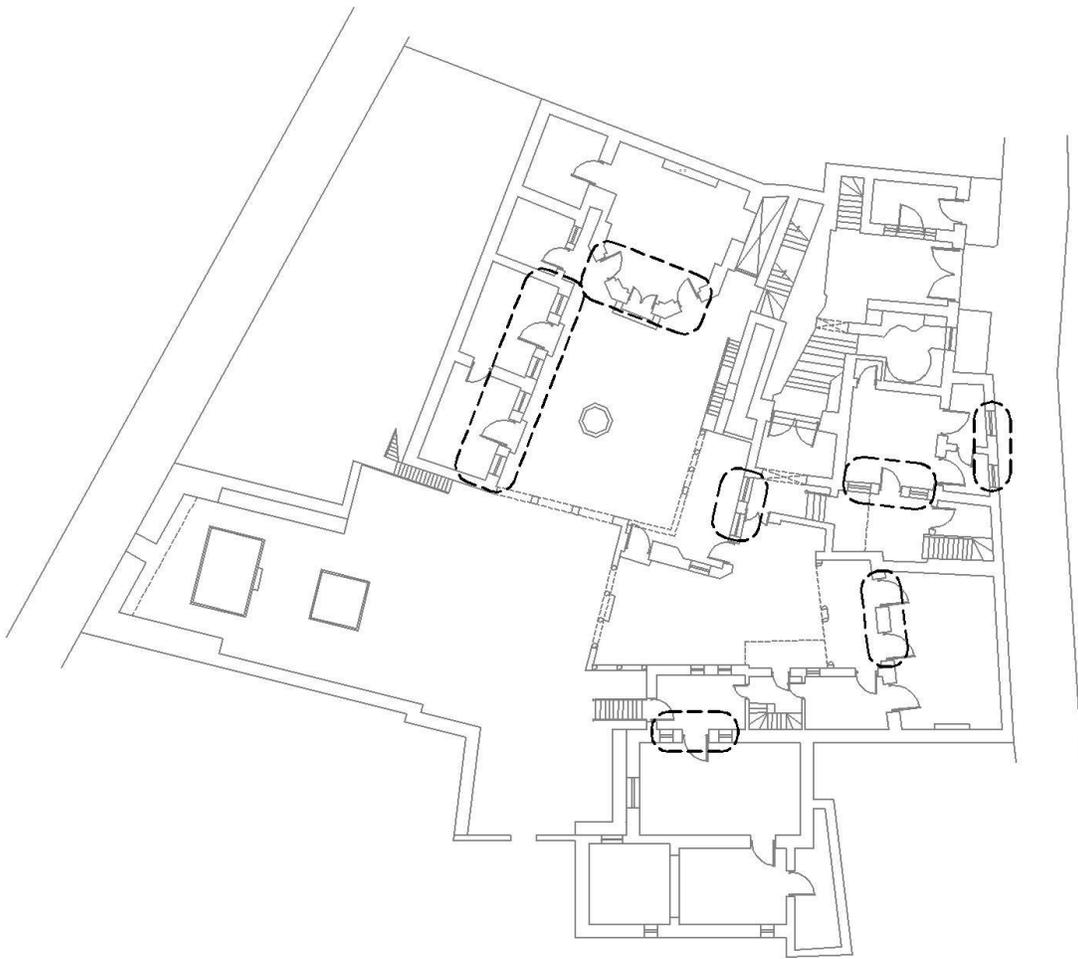


Figure 4.20 Ground Floor Plan Showing Two or More Openings in the Same Wall



Figure 4.21 First Floor Plan Showing Two or More Openings in the Same Wall

Ventilators with high ceilings in the sheesh mahal, kitchen, beramdah and bedrooms create stack ventilation (Fig. 4.22). The warm air rises and escapes through the ventilators and the cool air enters the room through the windows.

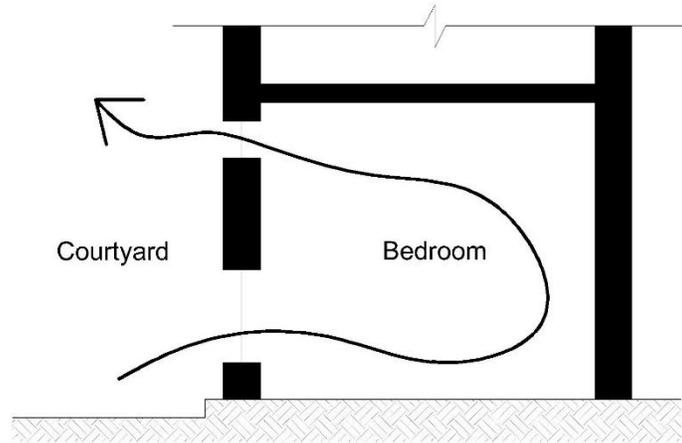


Figure 4.22 Stack Effect in Barood Khana Haveli

Walls of the haveli are three feet thick which provide insulation. The exterior walls are mostly painted white in color and some are beige. The light colors of the walls reflect maximum radiation from the sun.

Typological Level

Sense of History, Community and Place

The house is an example of local authenticity. It depicts the uniqueness of the sub-continent through its use of building materials, passive design techniques, accommodation of social structure and building type. Rejecting the standardization trend and refusing to follow the westernized single family house type, the house is able to well represent the time in which it was created while also being able to fit in with the present. The design of the house respects history by following the time-tested architectural type of a courtyard house. This haveli does not have any changes made to its design that might appear as unfamiliar and has been able to efficiently accommodate developing advancements in lifestyle like the use of car, need of an office space and addition of split air-conditioning units.

Building Type

The Barood Khana Haveli is based on the traditional courtyard housing type of the region. The typical layout plan of a haveli has been transformed to meet the needs of this particular family. Over time, the house has been able to adjust well with the changes that have occurred in family setup, advancement in technology and personal taste of the users.

Layout

Christopher Alexander and his colleagues discuss the pattern ‘Courtyards which live’ in their book *A Pattern Language*. Courtyards in the modern buildings become dead spaces because of no distinction between the inside and the outside, insufficient number of doors open into the courtyard and the courtyards are cordoned off (Alexander et al., 1977). To overcome these problems, they suggest a way to create courtyards which are alive.

“Place every courtyard in such a way that there is a view out of it to some larger open spaces; place it so that at least two or three doors open from the building into it and so that that the natural paths which connect these doors pass across the courtyard. And, at one edge, beside a door, make a roofed veranda or a porch, which is continuous with both the inside and the courtyard.” (p.564)

The layout of the courtyards in the Barood Khana Haveli follow the above mentioned pattern as shown in Fig. 4.23 below.

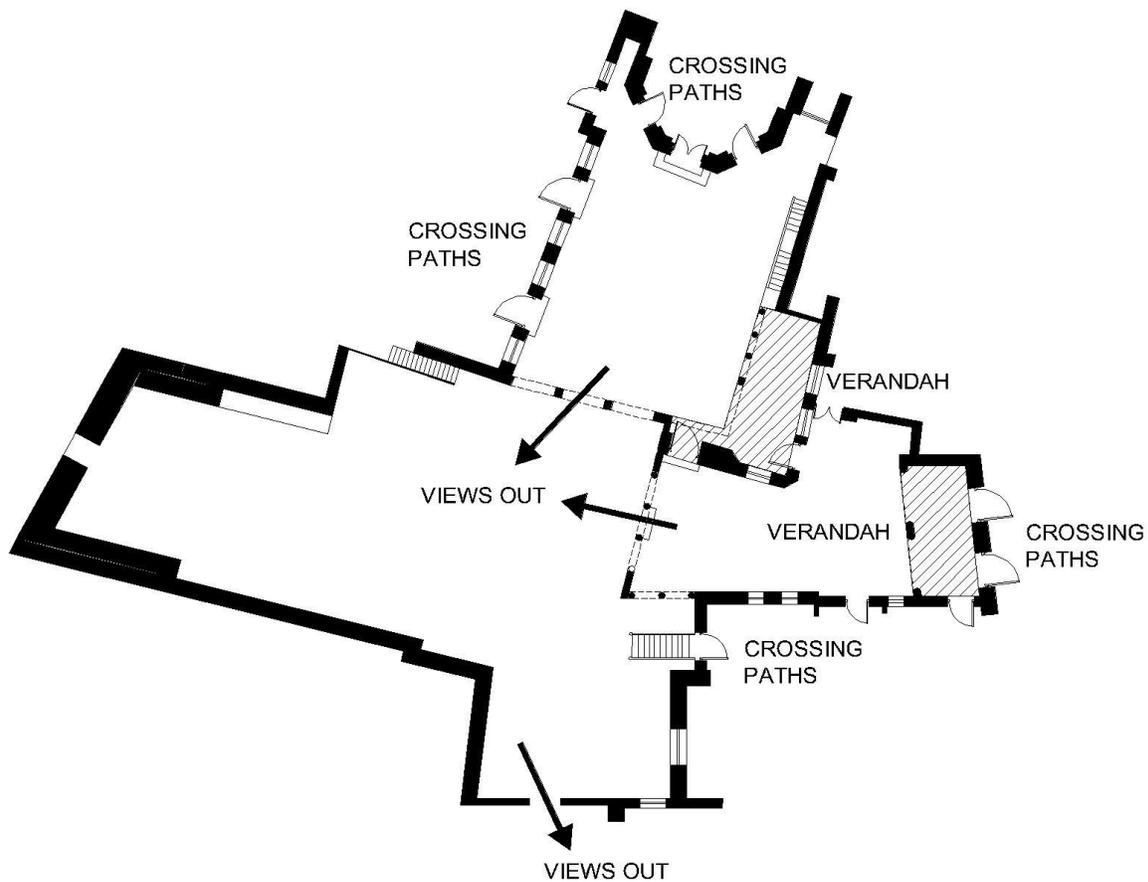


Figure 4.23 Courtyards which Live

Christopher Alexander and his colleagues in the book *A Pattern Language* also discuss the pattern of intimacy gradient. They say,

“Unless the spaces in a building are arranged in a sequence which corresponds to their degrees of privateness, the visits made by strangers, friends, guests, clients, family, will always be a little awkward.” (pg. 610)

In this haveli, a definite gradient from formal spaces to informal spaces can be observed (Fig. 2.24). The entrances lead to the main courtyard and the office space that are more formal areas. Further into the house are the more intimate inner courtyards and then the enclosed rooms.

Moving to the first floor, the level of privacy increases. Slowly over time, the intimacy gradient has diminished. This is because women no more live in the house so no areas are considered private for the women. The guests that are allowed inside the haveli are usually the owner's friends who can access any part of the haveli.

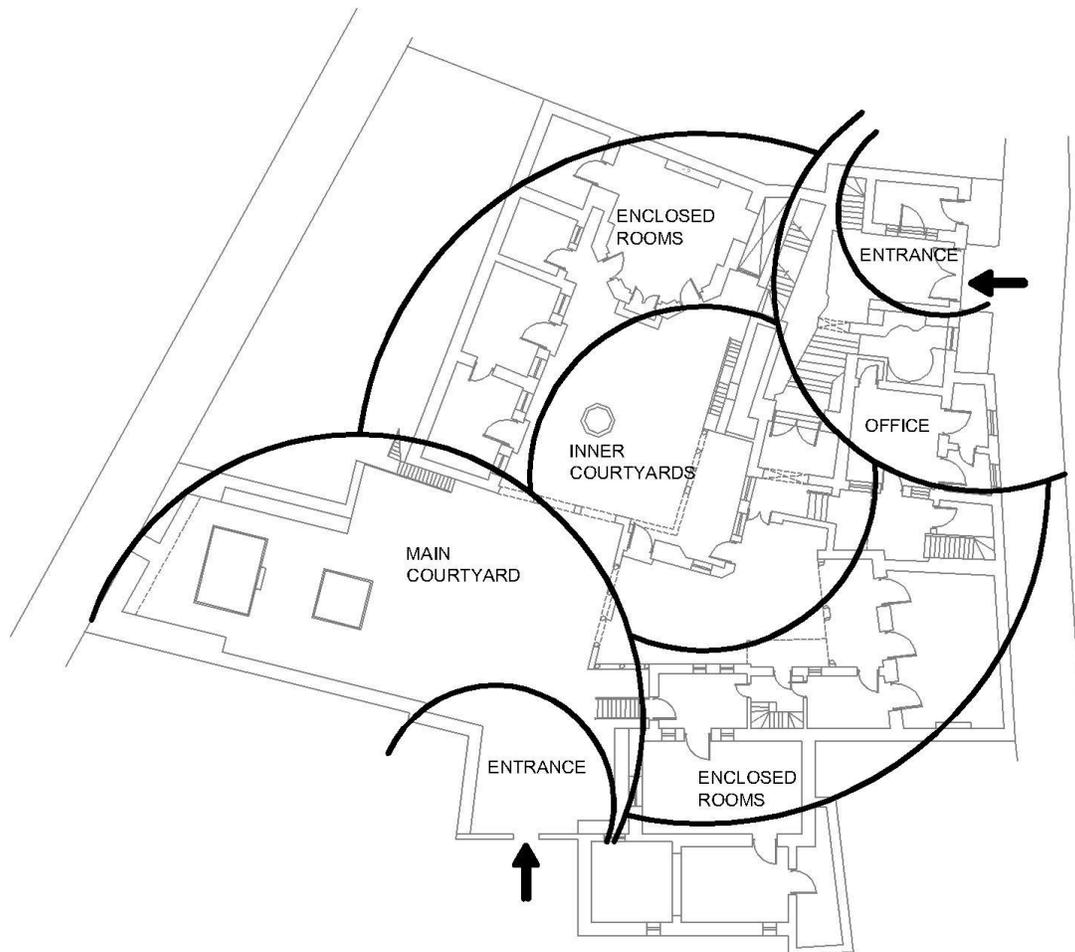


Figure 4.24 Intimacy Gradient

Biophilic Design

Within the privacy of the haveli, the courtyards and the terraces create a calm and beautiful zone that provides relief from the busy urban streets of the Walled City. Plants, water and animals are all part of the haveli design, bringing residents closer to nature. Trees, potted plants, hanging plants, climbers, floating lilies and various other flowers make the outdoors part of the house. The

shade from the trees and the transpiring leaves cool the courtyards while the climbers serve the purpose of a green wall (Fig 4.26). The wind blows through the leaves so that the ear can hear them rustle, the eyes can visualize the coolness and the skin can feel the breeze. Though the courtyards and the terraces are completely paved and very minimal earth and grass is visible, the plants soften the overall look of the outdoor spaces. As the courtyards serve the role of circulation space as well, it is easier to keep the place clean if it is paved. During rain, the wet floor reflects the building around it, the sky and the sunlight (Fig. 4.27). A few rooted plants are found in the haveli compared to the many potted and hanging plants (Fig. 4.25) that sprout colorful flowers during the spring. Reynolds (2002) says,

“Sometimes vines are seen as harbors for mosquitoes or other undesirable insects, unwanted birds, or even for rats. This may explain why so many courtyards contain many potted plants but few rooted ones.” (pg. 74)

One tree in each courtyard and three shrubs in the main courtyard provide partial coverage (Fig. 4.28). The heavy foliage during the summer, cools the benches, swings and other outdoor furniture located below. During the winter, the foliage thins out allowing sunlight to filter through the leaves creating various shadows on the paved floors.

The haveli is home to many animals including birds, fishes and dogs. Bird nests are decorated on the walls from where their chirping can be heard (Fig. 4.29). The rectangular and octagonal pools with circular fountains in the center are geometric forms within which the lilies and the fish create an organic order (4.30). These lilies and fish respond to the sun, the temperature, the time of day and year. Dogs are kept safe from the traffic on the streets (4.31).

Two fountains are evident as water features located in the main courtyard and the inner courtyard (Fig. 4.32). The fountains in their mirror-like pools evoke all the senses. The running

fountain and the ripples bring life into the courtyard, refreshes the mind and cools the body. At night, the building around the courtyards obstructs the lights from the street and the neighboring houses, offering a darkened courtyard that allows the view of the moon and the stars (Fig. 4.33). Fruits like oranges, grapes, jamun and mulberry are grown inside the haveli bringing delight to our sense of taste.

The presence of nature is central to the house thus making it possible for everyone to benefit from it from almost anywhere in the house.



Figure 4.25 Potted and Hanging Plants
(Salahuddin, 2014)



Figure 4.26 Climbers
(Salahuddin, 2014)



Figure 4.27 Courtyards after Rainfall (Salahuddin, 2014) (*Left: Main Courtyard; Right: Inner Courtyard*)



Figure 4.28 Trees in the Main Courtyard
(Salahuddin, 2014)



Figure 4.29 Bird Nests(Salahuddin, 2014)



Figure 4.30 Fish in Pool (Main Courtyard)
(Salahuddin, 2014)



Figure 4.31 Dogs Resting in Courtyard
(Salahuddin, 2014)



Figure 4.32 Fountains and Pools (Salahuddin, 2014) *(Left: Main Courtyard; Right: Inner Courtyard)*



Figure 4.33 Night Sky from Courtyard (Salahuddin, 2014)

Archetypal Level

Orientation in Space

The haveli faces the Lahore Fort. From the roof of the haveli, the grand Badshahi mosque is visible. Both of these monuments facilitate orientation inside the haveli.



Figure 4.34 Orientation in Space of Barood Khana Haveli

Geometry, Proportion and Number

The main courtyard is formed by root 2 rectangles of different sizes (Fig. 4.35 & Fig. 4.37). The square in the smaller rectangle defines one side of the courtyard. The middle axis of this square is also the middle axis for the podium and the pool. The podium has the proportions of a root 2 rectangle and the pool is a square. The opposite corner of the larger root 2 rectangle in the courtyard meets a root 3 rectangle on one side which forms the entrance area. The inner courtyard has an octagonal pool which is in line with the octagonal shape that becomes the sheesh mahal. The sheesh mahal is a half octagon that is attached to a root 3 rectangle (Fig. 4.38). The second inner courtyard has rooms with proportions of a square, root 2 rectangle, root 3 rectangle and the golden rectangle. It is difficult to assess the proportions of the courtyard itself due to the angled lines (Fig. 4.36).

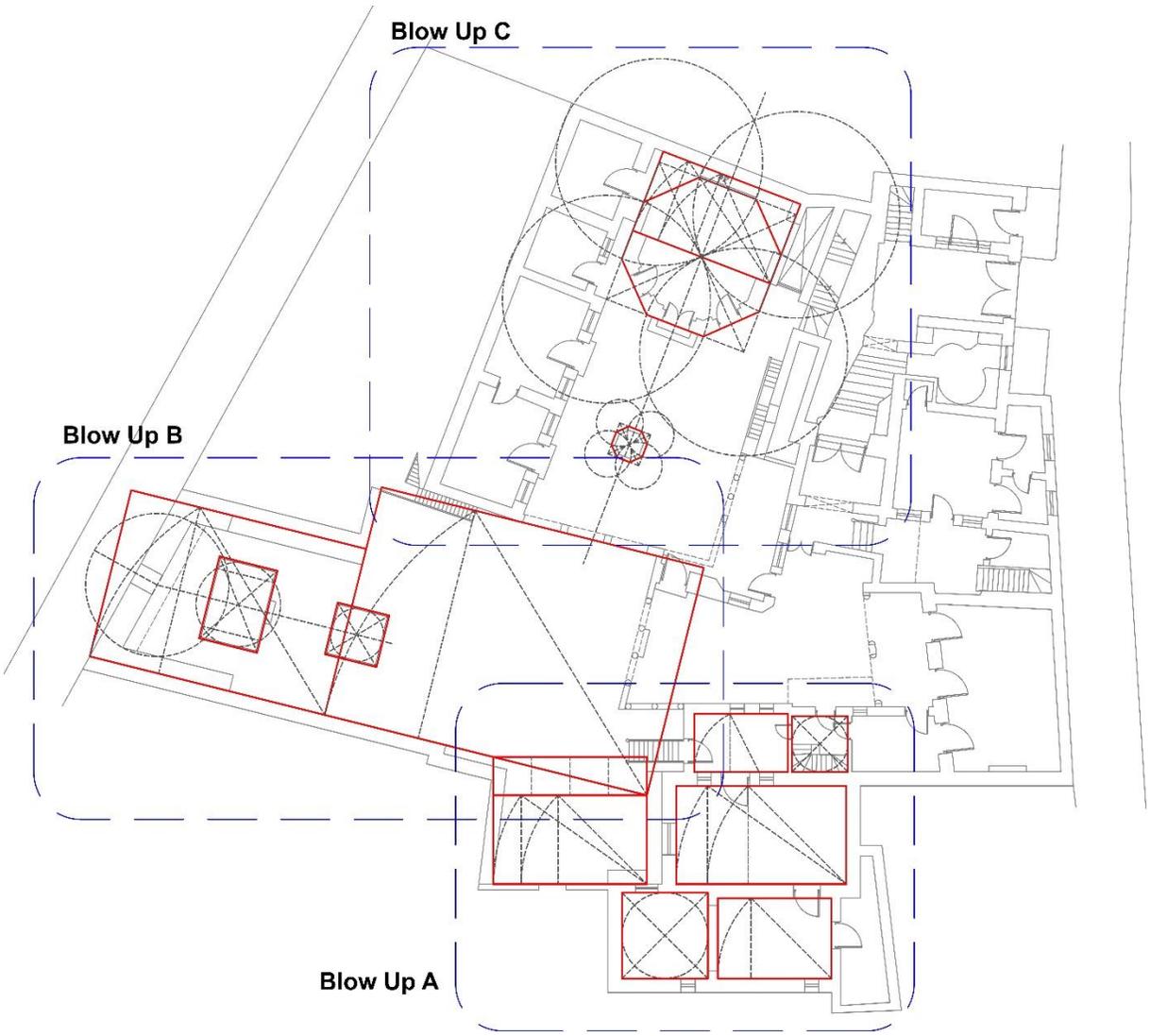


Figure 4.35 Geometric Analysis of the Ground Floor Plan

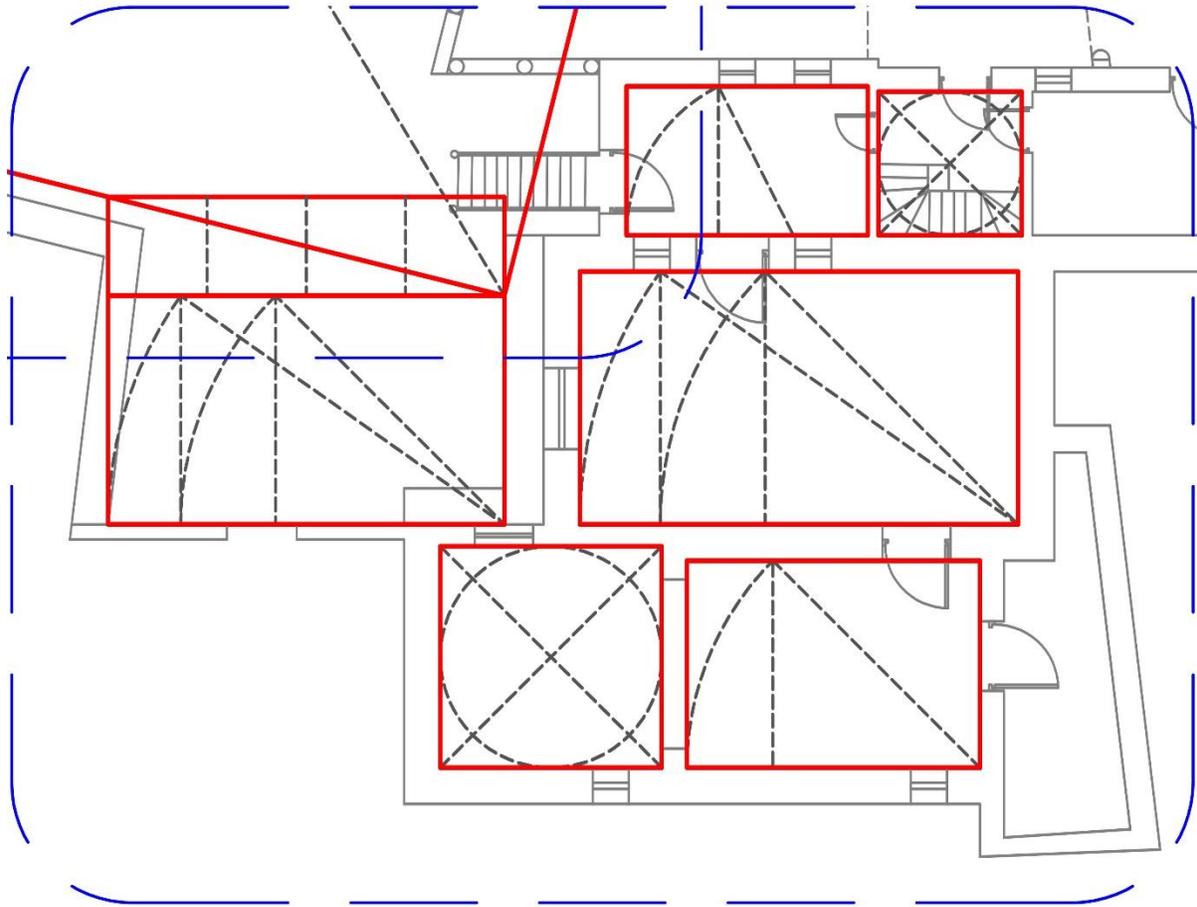


Figure 4.36 Blow Up A of Geometric Analysis

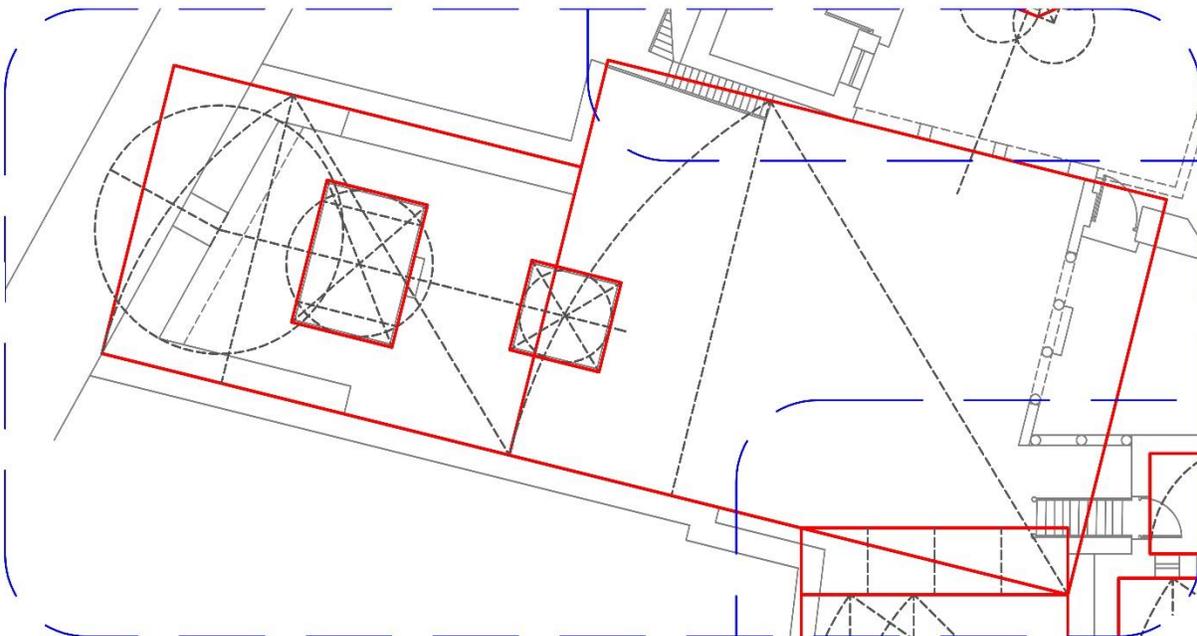


Figure 4.37 Blow Up B of Geometric Analysis

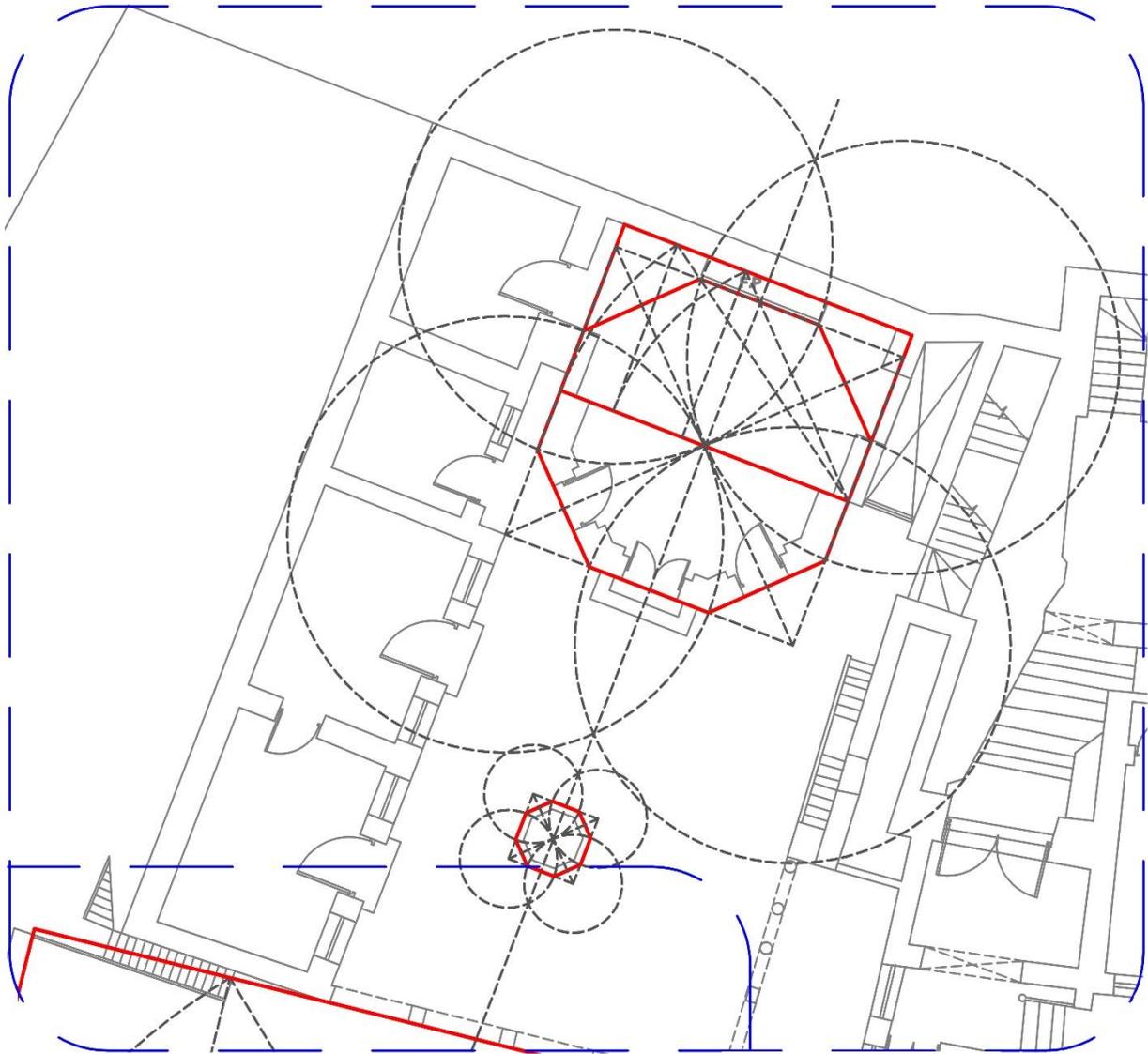


Figure 4.38 Blow Up C of Geometric Analysis

Geometric patterns and arabesque designs are part of Islamic art that decorates the haveli. Intricate designs combining the circle, square, hexagon and curve cover the floors, screens, balconies, doors and windows in different colors and materials including wood, stone and glass. The hexagonal grid has been used multiple times in the screens, terrace railing and the bench in the courtyard (Fig. 4.39). A combination of the 6 point star with the hexagon forms the top of the doorways (Fig. 4.40). The floor pattern in the main courtyard is comprised of designs constructed

with circles, curves and octagons (Fig. 4.41). The terrace floor has the 8 point star as the main geometric element (Fig. 4.42) and the terrace screen is the standard diamond grid (Fig. 4.43).

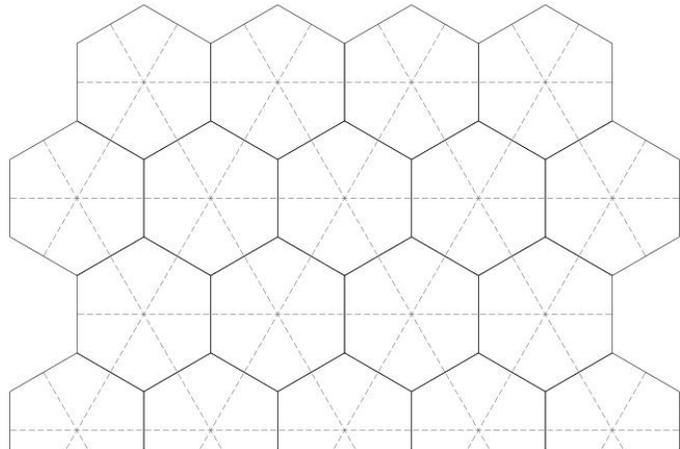


Figure 4.39 Geometric Pattern on Terrace Railing, Bench and Window Screen (Hexagonal Grid)

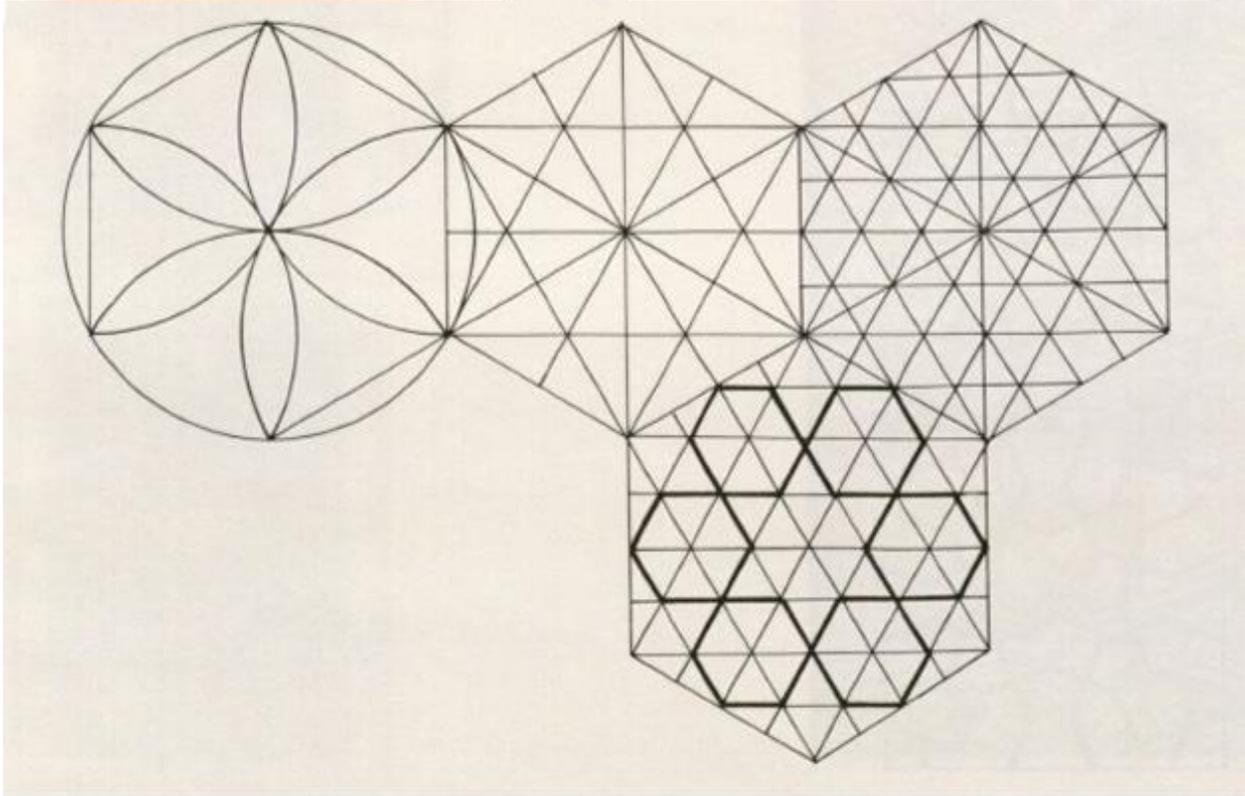


Figure 4.40 Geometric Pattern on Dining Room Doorways and Ventilators

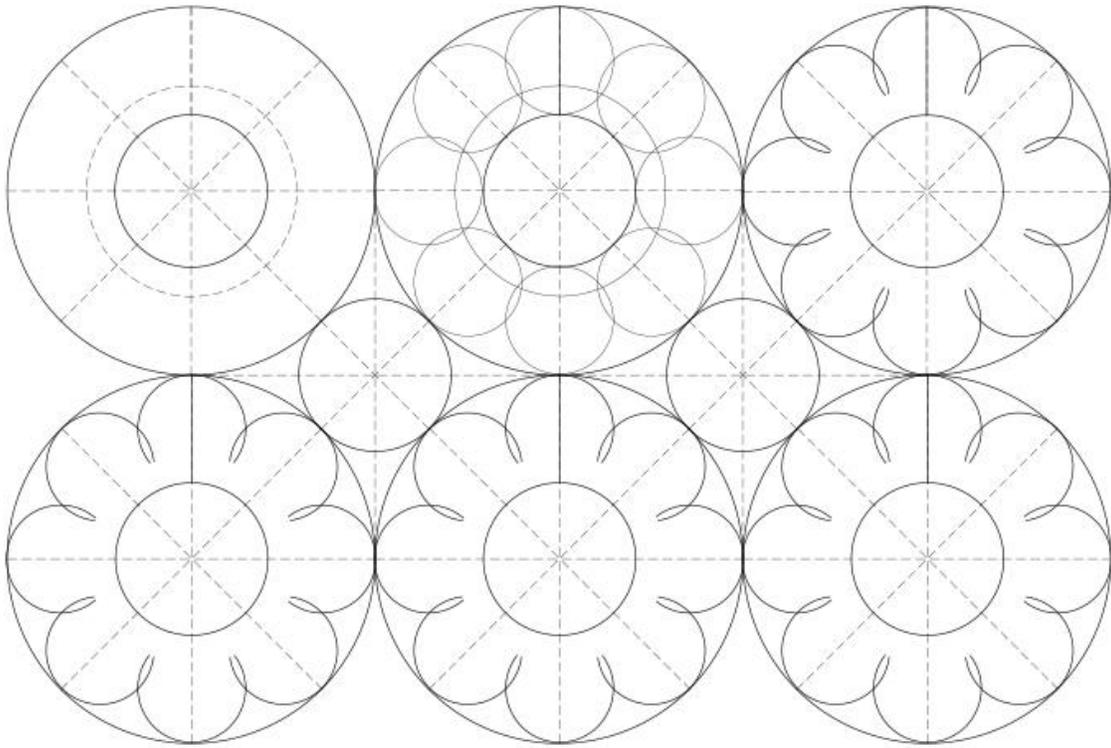


Figure 4.41 Geometric Pattern on Main Courtyard Floor

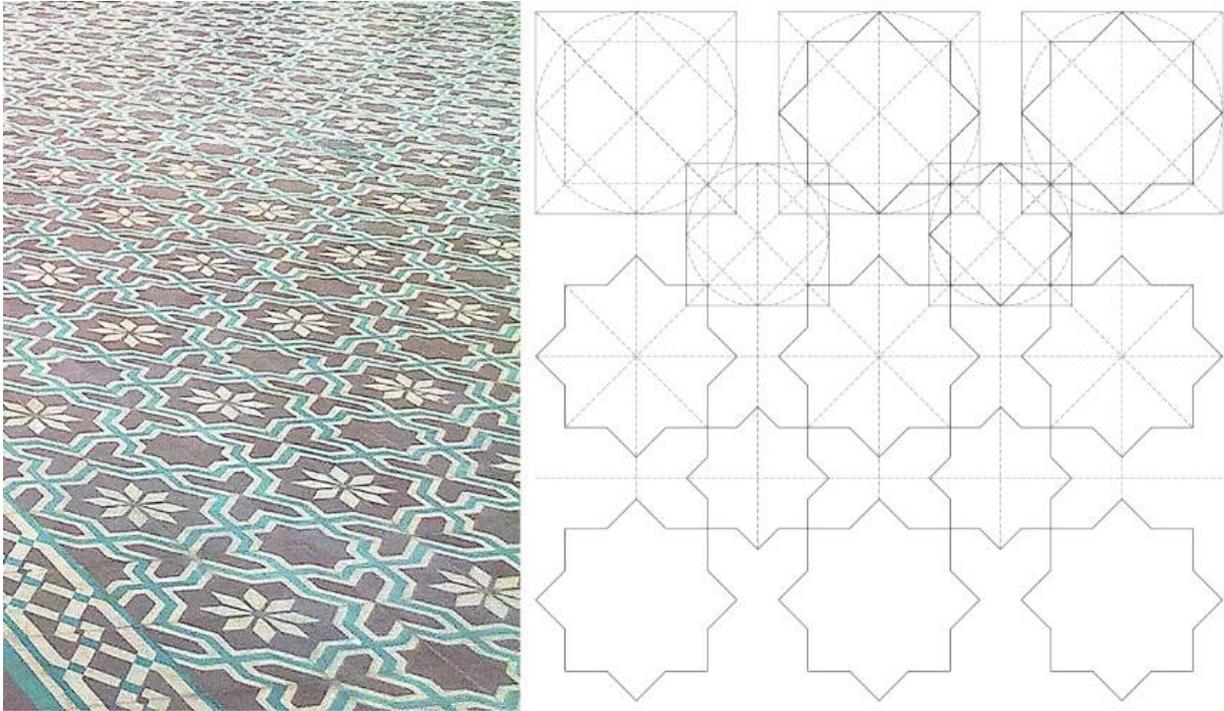


Figure 4.42 Geometric Pattern on Terrace Floor

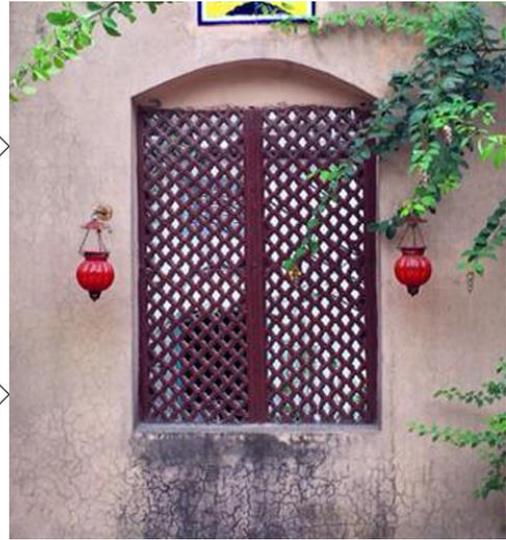
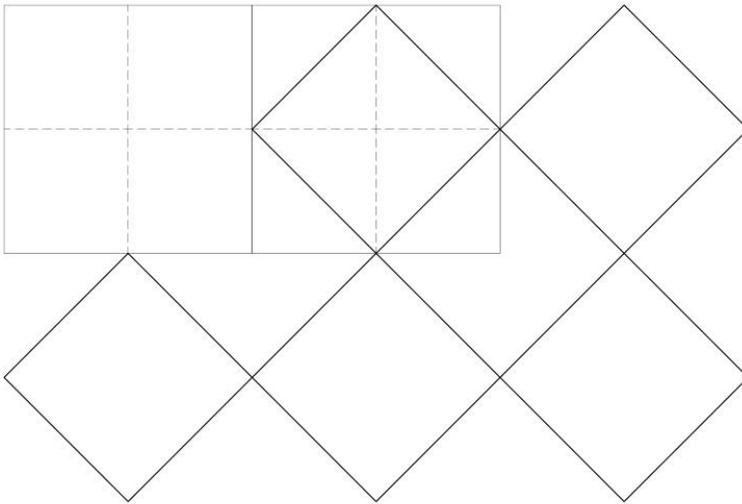


Figure 4.43 Geometric Pattern on Terrace Screen (Diamond Grid)

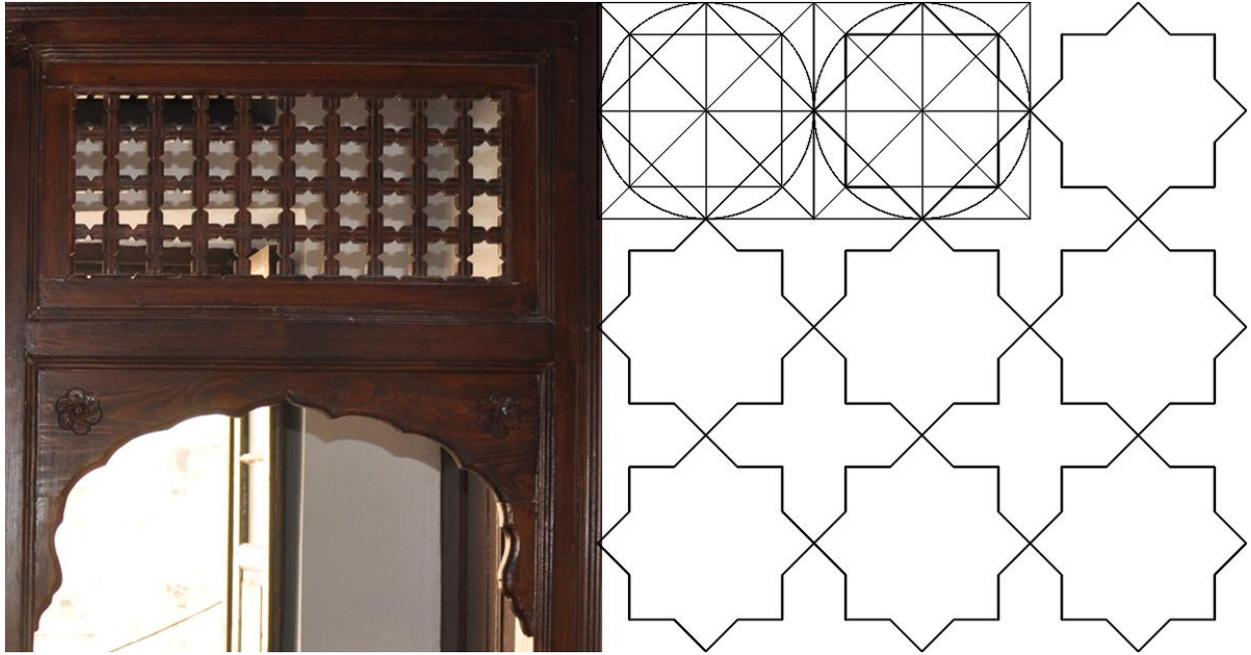


Figure 4.44 Geometric Pattern on Bedroom Doorways



Figure 4.45 Geometric Pattern on Terrace Screen (Salahuddin, 2014)



Figure 4.46 Geometric Pattern on Wooden Screen (Salahuddin, 2014)



Figure 4.47 Arabesque Pattern on Wooden Screen (Salahuddin, 2014)

Spatial Polarities in Natural Settings

The house is comprised of both outdoor and indoor spaces. For the purpose of this study, the spaces have been divided into two groups. The first is the exterior prospect and exterior refuge and the second is the interior prospect and interior refuge (Fig 4.48 & Fig. 4.49).

The courtyards of the house have trees and balconies under whose shadows exterior refuge spaces are created. Other exterior refuges are the verandahs that provide dark sheltered spaces. All these exterior refuges open into the uncovered, brightly lit courtyard floor which is the exterior prospect space (Fig 4.50).

Most rooms contain a refuge and prospect within themselves (Fig 4.51). The windows create dark and light zones inside the rooms. The octagonal part of the sheesh mahal is lit while the other half is dark and cozy. This distinction is also defined from the arch in the ceiling. From the interior refuge one looks into the interior prospect that further looks into the courtyard which is the exterior prospect. The passage connecting the rooms on the north side of the building does not have direct light. It is an interior refuge that opens directly into an exterior prospect.

The balconies and some parts of the terraces are covered by screens (Fig 4.52). These refuge spaces are private and dark zones from where a person is able to view the open courtyard and the open terrace. The trees on the terraces create refuge spaces with their foliage.

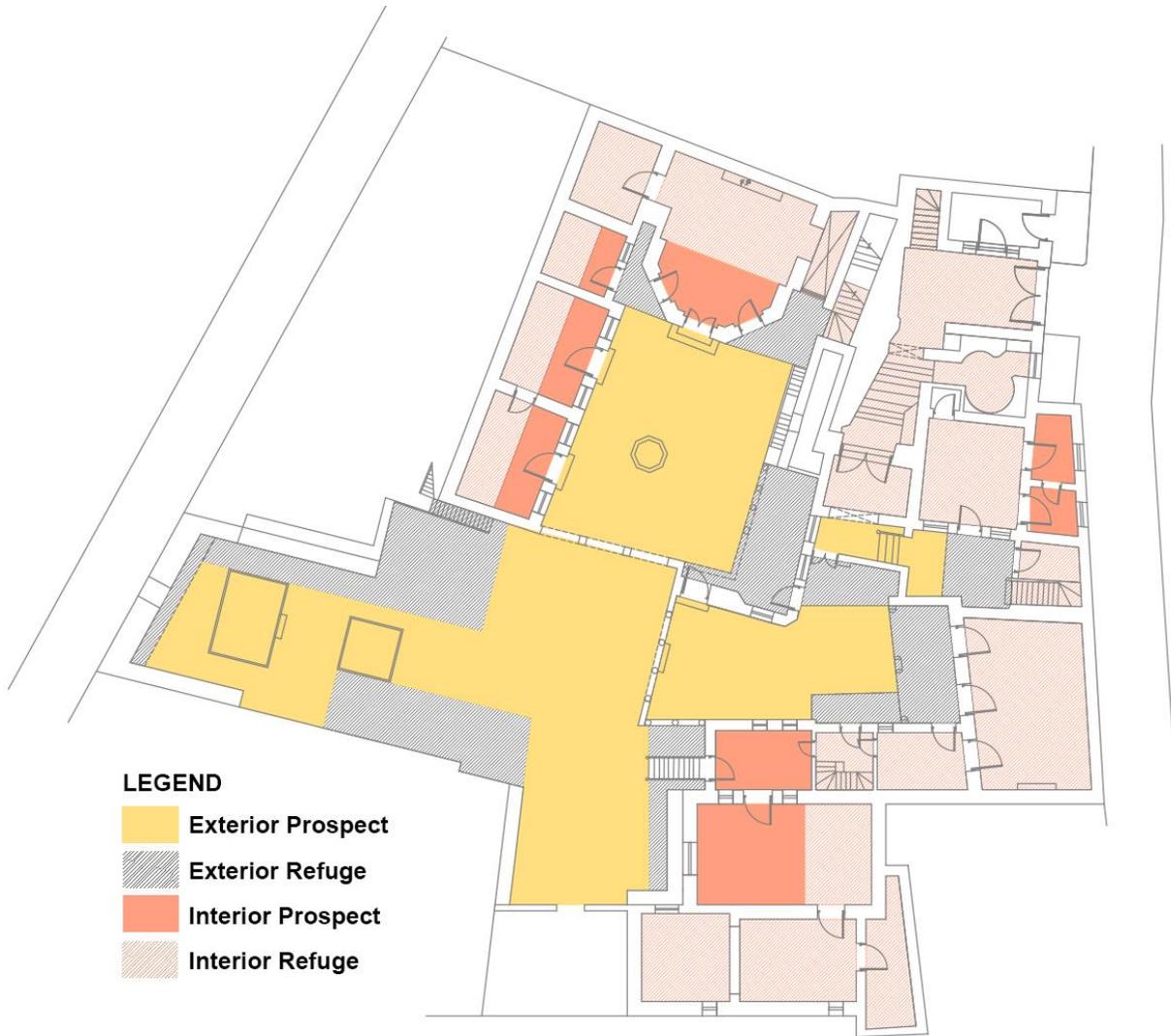


Figure 4.48 Ground Floor Plan; Prospect and Refuge

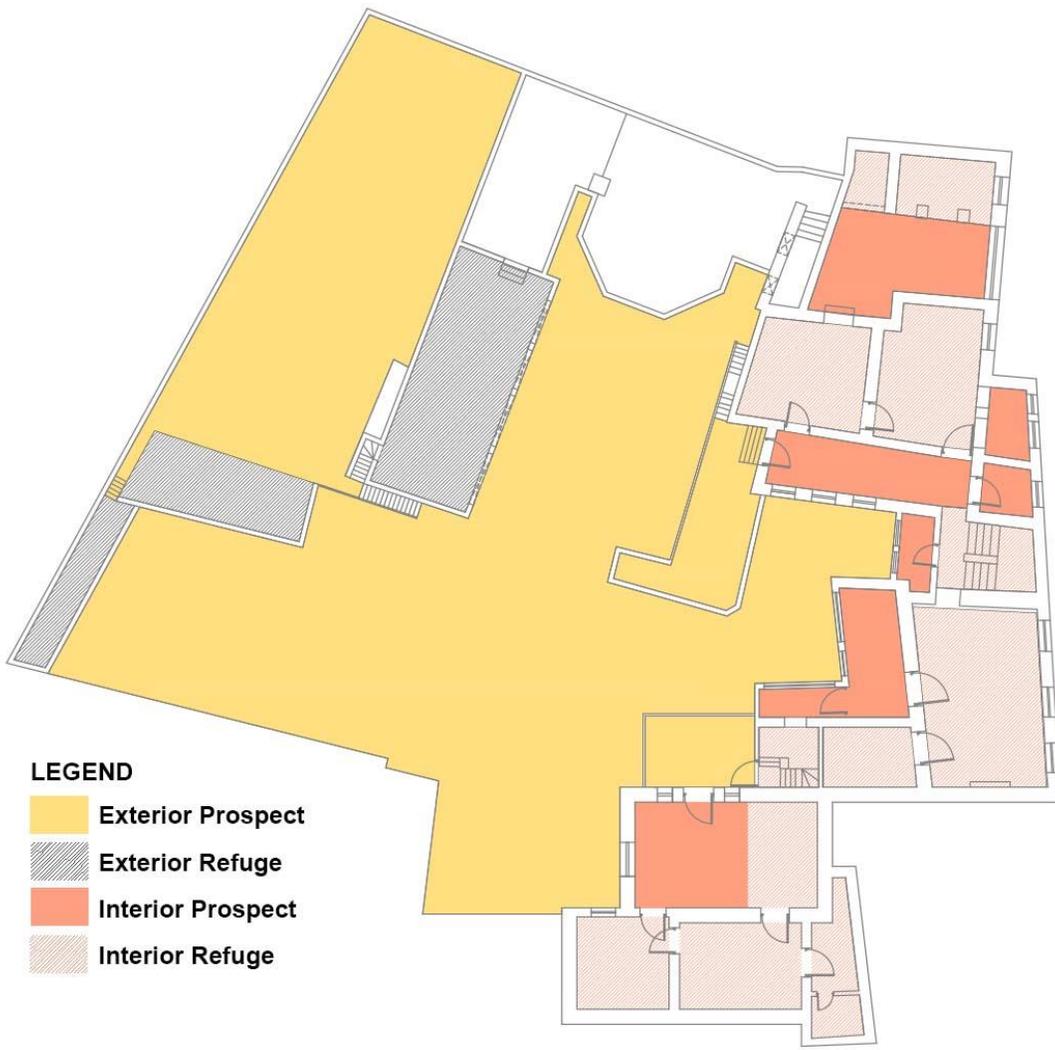


Figure 4.49 First Floor Plan; Prospect and Refuge

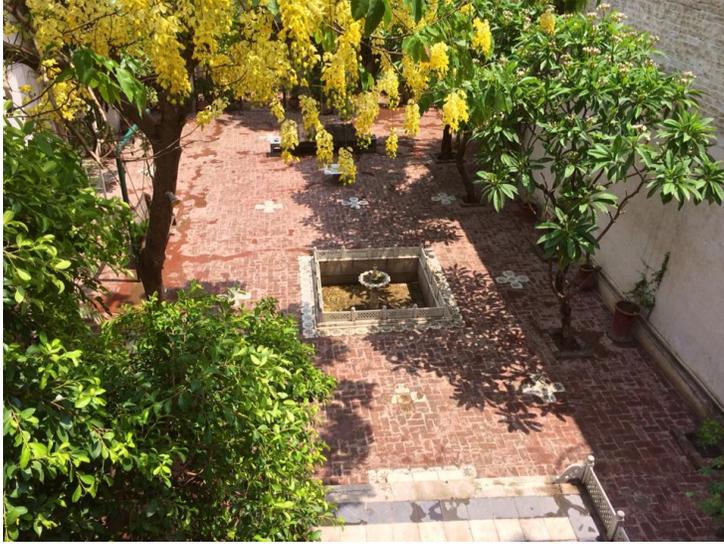


Figure 4.50 Main Courtyard and Verandah; Exterior Refuge and Exterior Prospect (Salahuddin, 2014)



Figure 4.51 Sheesh Mahal and the North Side Passage; Interior Refuges (Salahuddin, 2014)



Figure 4.52 Terrace; Exterior Refuges (Salahuddin, 2014)

The ground floor plan has a number of enticing trails that disappear around bends creating the characteristic of enticement possible. In the diagrams (Fig. 4.53 & Fig. 4.54) below, the black arrows represent these enticing bends in pathways inside the haveli. Upon entering into the main courtyard, screens and the location of other courtyards allow the user to partially view the inner courtyards while creating a sense of mystery. The linkages of the rooms, the passageways and the combinations of prospects and refuges throughout the plan entice the observer into exploring further. The dark and narrow staircases turn and disappear mysteriously (Fig 4.55).

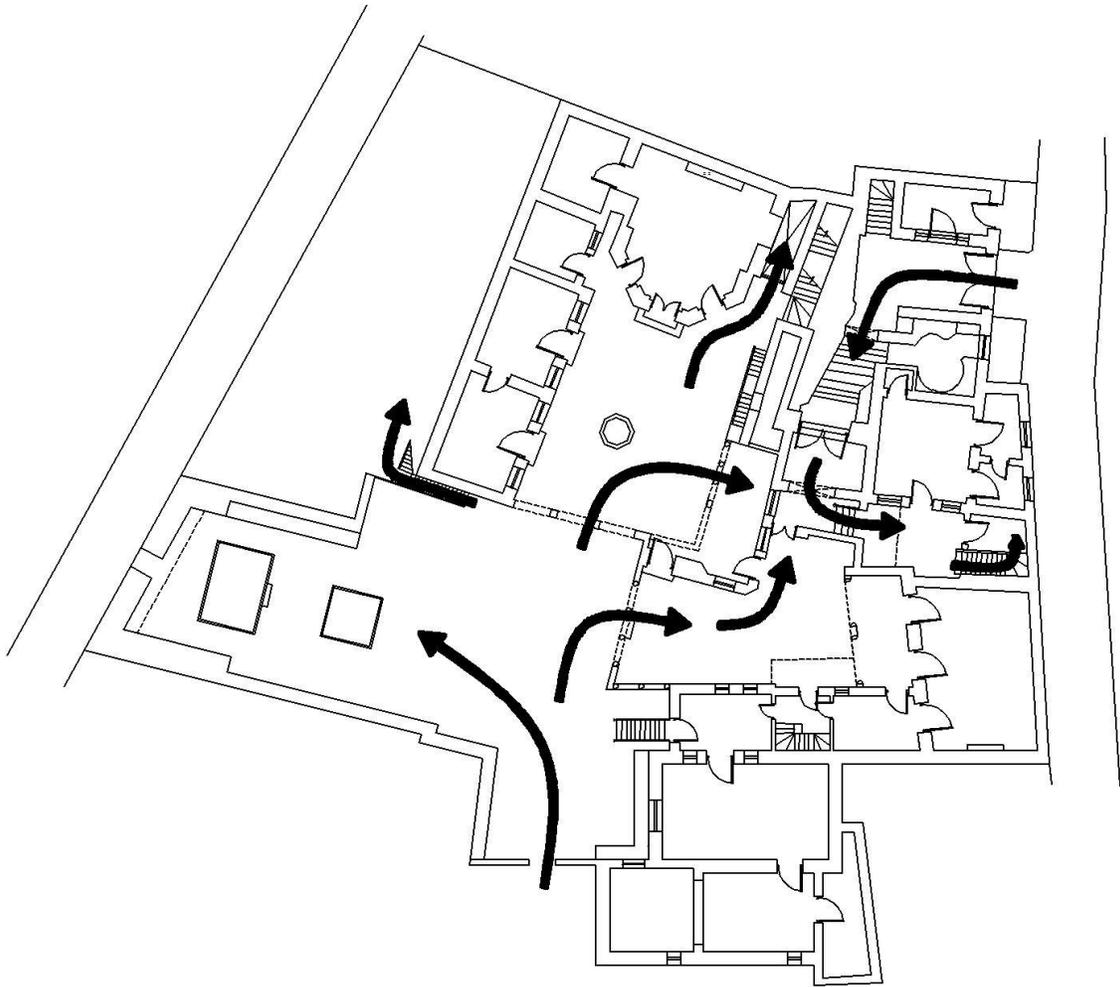


Figure 4.53 Ground Floor Plan; Enticement (Paths that Turn and Disappear)

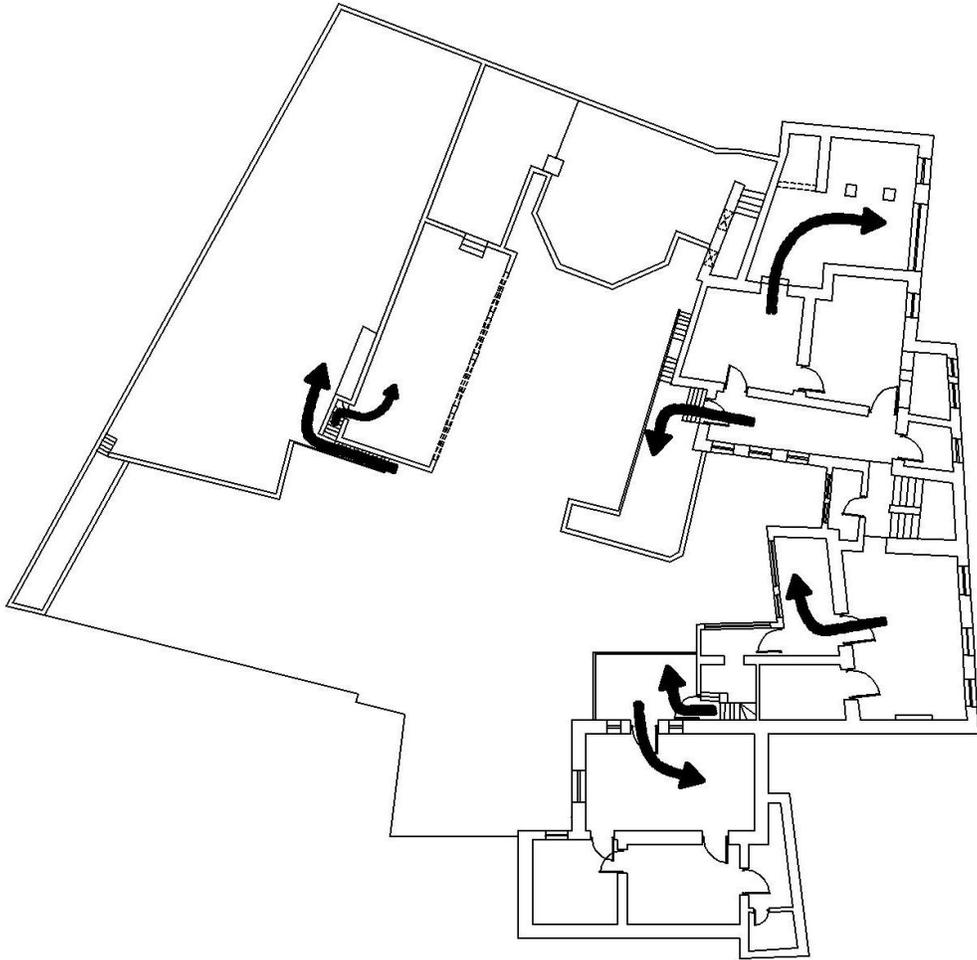


Figure 4.54 First Floor Plan; Enticement (Paths that Turn and Disappear)

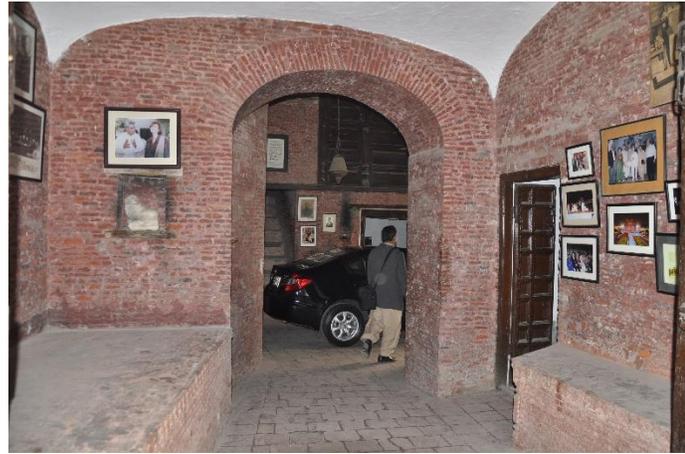


Figure 4.55 Staircase and Car Porch; Paths that Turn and Disappear (Salahuddin, 2014)

The geometric analysis in the earlier pages explain the presence of order and complexities in the plan of the house. The plot is not a distinct uniform shape but the spaces created inside are based on certain geometric rules. These spaces have complex relationships that cannot be easily understood while visiting the place. It takes time for the user to discover how the areas are connected.

The open courtyards and the roof top offer a perilous thrill to the users (Fig. 4.56). The open to sky court generates a feeling of danger by how it is affected by the weather, the intrusion of birds and the darkness at night. The roof top gives the view of all the terraces, courtyards and the street from a height offering the thrill of elevation.



Figure 4.56 Views from Roof Top; Peril (Salahuddin, 2014)

Chapter 5 - Summary and Conclusions

Increased environmental degradation across the globe is bringing the world's attention toward sustaining human existence (Das, 2006). To achieve such sustainability, creating livable spaces is essential. Pakistan is a developing country struggling to achieve the same goal. Residential architecture of Lahore, Pakistan relies on machines to maintain a comfortable thermal interior. This increased energy demand exceeds the supply which results in frequent power shutdowns and an intense energy crisis throughout the city. Air-conditioners and heaters provide a consistent interior environment that disconnects inhabitants from the outside world and brings an end to our cultural rituals and habits (Hosey, 2012). It reduces the tolerance of people to a narrow range of temperature (O'Neill, 2003). Increased globalization detaches us from our traditions. The standardization of the built environment results in a lack of our cultural habits and a regional identity.

To resolve these problems and create sustainable living spaces in the city, designers seek help from science and technology but in fact, the answer to a better future lies in our past. The difficulties that we see today were not a part of history. Sometimes, it is best to look back and learn from the wisdom of tradition to create solutions for the future. The traditional residential architecture of Lahore can provide solutions to the problems of present day housing.

In general, sustainability is associated with carbon emissions, energy efficiency, cost and environmental performance. Usually, the criteria used for evaluating green buildings does not include aesthetics. However, appearance affects survival as proven in nature through the colors of birds, tastes of fruits and scents of plants. Our emotional attachment to something is also another reason for its endurance (Hosey, 2012). Therefore, it can be said that anything is more likely to sustain if it is functional as well as beautiful rather than being one or the other. The 'Deep Beauty'

framework is a holistic approach which looks at both the aspects of functionality and aesthetics. Gary J. Coates (2014) says, “*To create Deep Beauty in whatever we make and do is an act of love, because only that which is loved is beautiful.*” The way to create sustainable built environments is to use all three levels of this framework i.e. functional level, typological level and archetypal level.

Functional Level

This level deals with all the practical requirements of the building’s users (Coates, 2014). Besides providing shelter, a house serves the purpose of a social unit of space (Rapoport, 1969). Being appropriate for the family structure and the social setup of its users is an important function. Functional buildings merge well with their sites, respond to sun, wind and light, are an optimum size, are energy efficient and make use of local building materials (Coates, 2014). Biomimicry is an approach that can provide functional solutions by taking inspiration from nature (Benyus, 2008).

Typological Level

At this level, buildings possess a sense of history, community, nature and place. By taking inspiration from the bioregional traditions and historical building types, architecture is created that is both new and familiar (Coates, 2014). Typology is regenerative so buildings can be of the same building type yet appear so different from each other (Polyzoides et al., 1992). Time-tested architectural types provide important lessons to reach high standards of excellence. Nature also provides lessons of sustainability and life-enriching design. Biophilic design in a built environment connects the users to nature through plants, animals and water.

Archetypal Level

The Archetypal level reaches the deepest layer of meaning (Coates, 2014) to attain a beauty that is universal. Buildings use archetypal elements from the world's sacred architecture. They speak the language of space (Coates, 2014) consisting of natural symbols of up and down, horizontal and vertical, inside and outside, light and dark and center and periphery (Harries, 1993). Such buildings possess greater levels of higher order by using sacred geometry and the qualitative number. The presence of biologically rooted polarities of prospect and refuge, complex order, enticement and peril respond to our psychophysical opposites (Coates, 2014).

Lahore

Lahore is the second largest city of Pakistan located on the north east side of the country (Walled City of Lahore Authority, WCLA.2014). Its history begins from the Indus Valley Civilization, includes the prevalence of Buddhists, Hindus, Muslims, Sikhs and British and culminates with the independence of Pakistan (Tadgell, 1990). The climate of the city is hot semi-arid with long and hot summers, dry and warm winters and a monsoon season (Walled City of Lahore Authority, WCLA.2014). Joint family system prevails and the average household size is 6.9 persons per house (Pakistan demographic and health survey 2006-2007.2008).

To be able to provide design solutions, it is important to first discuss the current and traditional residential architecture of the city in general.

Present Day Housing of Lahore

All the housing developments for middle class families in the city sell plots with areas of 1125sft, 2275sft, 2700sft, 3150sft, 4500sft, 6750sft and 9000sft. These rectangular plots have proportions of 25' by 45', 35' by 65', 50' by 90' and so on. Various examples of housing

developments can be found which have plots orientated in all directions without any consideration of sun, wind and light. The locally available brick and cement mortar is used for the construction of walls and ceilings are made of concrete. For the interior of the house, both local and imported tiles, wood, stone and aluminum is available in the market. The close placement of buildings enables them to shade each other from three sides while the front is left exposed to the sun. Insulation techniques like building cavity walls and using polyurethane foam is starting to gain popularity. The house relies on air conditioners and heaters for thermal comfort. So during regular instances of power shutdown, the interior can become unbearable and people are forced to migrate inside the house for comfort.

Due to globalization, a variety of architectural styles paint the urban landscape of the city. Two housing typologies that are found in the city are the detached, single family house and the semi-detached single family house. Each house is an independent unit, surrounded by a boundary wall, giving complete ownership to its residents. A predetermined amount of open space is mandatory on all or at least three sides of the house. The formal areas of the house are at the front that include a lawn, a car porch, an entrance lobby and a drawing room. Further inside the house, is a living room, a kitchen and bedrooms with their attached bathrooms. On the first floor, is another living area that leads to more bedrooms and the terrace. The front lawn is mostly the only way to connect with nature.

The front location of the exterior prospect claiming lawn and the terraces allow the prospect to be visible only from a limited number of rooms that are placed at the front side of the plot. Other outdoor spaces cannot be experienced as prospects due to their narrow widths.

The above description of the modern house shows that it lacks many attributes of Deep Beauty and fulfills only a few. Though houses are mostly constructed from locally available

materials, the single family housing type is not local. This western housing type was introduced in this region with the arrival of electricity as only machines could make this building type livable in this climate. Having no regard for sun, wind and light, the house falls short on the functional level. In the current energy crisis, this energy centric house is unfit. Due to lack of regional identity this dwelling fails to evoke any connection with history and place. The intimacy gradient present in the layout of the house functions well with the social setup of families but limiting biophilia to only the front lawn of the house, deprives the residents of any connection with the outside world. Geometry is absent in the design and the proportionating system of the house is based on regular plot sizes and pre-fabricated materials available in the market. Enticement and peril are two spatial polarities that can be sometimes found in the interior layout of the house. However, prospect and refuge can only be experienced from a limited number of spaces that are placed in the front of the building.

Traditional Housing of Lahore

Traditional residential architecture of the city can be found in the Walled City of Lahore. An important highlight of this area was the courtyard house regionally known as a 'haveli'. The brick courtyard house has been a part of this region since the 3rd millennium BC with the Indus Valley Civilization (Tadgell, 1990). A typical haveli was built from two vernacular materials i.e. brick and lime mortar. (Cooper & Dawson, 1998). Thermal comfort was achieved by elements like high ceilings, ventilators, thick walls, jalis (screens), beramdahs (verandahs), jharokas (balconies), fountains, plants, chajjas (overhangs), courtyards and basements (Batool, 2014). Other strategies included migration within the house and evaporative cooling from brick and lime.

A typical haveli in the Walled City had two courtyards, the main courtyard and the inner courtyard, that were separated by a screen (Das, 2006). The main courtyard was mostly a male

domain and the inner one was for women and children. A verandah around the court led to the interior rooms. The upper levels were more private from where one could look below into the courtyard. A fountain was situated in the center of the court and plants and trees softened the look of the paved floor.

Number and proportions held importance in the Indian Architecture. Geometric patterns adorned surfaces. Spatial polarities were experienced in the haveli because of the connection between the inside and the outside, varying ceiling heights, presence of basement(s) and light and darkness provided by shades of trees, overhangs, and balconies.

From the above description of the traditional house, it is clear that it succeeds in meeting the Deep Beauty criteria. The house presents itself as a zero energy model that is able to achieve a comfortable environment through passive design strategies alone. The use of locally available building materials and provision of spaces for social interaction and different levels of privacy, make the design functionally successful. Following the historical courtyard housing typology, the house possess a sense of history and place. Water, plants and animals bring nature into the house and connect with all the human senses. An order is visible in design through the use of geometry, proportions and number. Presence of all the spatial polarities enrich the lived experience.

Barood Khana Haveli

The Barood Khana Haveli is selected as an example of a typical haveli. The in depth analysis of this single traditional house gives a more detailed picture of how a traditional house follows the Deep Beauty framework. The important questions here are: What can we learn from the traditional house? Can the design of the traditional house be adapted in the modern house? How can we improve the design of the modern day house in the light of this analysis?

To answer the first question, it is important to identify the design strategies that the traditional house follows to meet the criteria of the three levels of Deep Beauty.

Design Strategies Used by the Barood Khana Haveli

Functional Level

- 1) ***South Facing Courtyard and Terraces (Fig. 4.12)***. Maximum sunlight reaches the courtyards of the haveli because they are oriented toward the south. Since most of the interior spaces acquire daylight through the courtyard, it is important that it is well-lit. Christopher Alexander and his colleagues conclude in their book, *A Pattern Language*, that people only use open spaces if they are sunny except in desert climates (Alexander et al., 1977). Human beings are acclimatized psychologically and biologically to the changing daylight patterns throughout the day. Along with psychological needs, sunlight also fulfills our physiological necessities like regulating our body clock rhythms, metabolism of Vitamin D and levels of hormone melatonin (Ulrich, 2008). Roger S. Ulrich summarizes the importance of sunlight by saying, *“In sum, an evolutionary conceptual perspective predicts that well-lighted or sunny nature settings should be more effective than dark and overcast nature scenes in eliciting positive responses, improving emotional well-being, fostering restoration, and promoting health.”* (pg. 91)
- 2) ***Interior Windows Open on the North Side (Fig. 4.12)***. The windows of the interior enclosed rooms mostly face north and the ones facing south are protected by a verandah. In this way, solar heat gain is reduced inside the building and spaces remain cool throughout the summer.
- 3) ***Brick Construction and Lime Construction***. Brick and lime mortar are vernacular building materials that are inexpensive, easily available, energy efficient and durable. Both these materials have the ability to retain moisture and slowly release it back into the environment causing a cooling effect. Floors, walls and ceilings can all be built using brick and lime mortar.

- 4) ***Centrally Located Courtyards (Fig. 4.14).*** The courtyards lie at the center of gravity of the haveli making them easily accessible to everyone in the house. They are positioned in a manner that residents must go through the courtyards to access other areas of the house thus making them usable by everyone, throughout the day, informally and naturally. The outdoor furniture, plants and fountains attract people to spend time in this common area. Positive social interaction takes place between the household members themselves and their guests as well.
- 5) ***Outdoor Furniture (Fig. 4.14).*** A podium located in the main courtyard is used for floor sitting. Chairs on one side of the podium and loose furniture including chairs and traditional beds set besides it, form two sitting circles. In winters, a portable fireplace anchors one of these circles. The passage into the haveli to the other courtyards lies tangent to this sitting. This way people continuously pass through the space keeping it alive but do not intrude directly into the furniture arrangement. The circular shape allows people to sit at an angle to one another which is a human preference (Alexander et al., 1977). On the sides of all three courtyards, underneath the shadows of the trees, benches and a swing provide quiet enclosures for one or two persons to experience some solitude. Every family experiences the two opposite needs for some privacy and some community in the same space at the same time (Alexander et al., 1977). These quiet places in the courtyards, give people some privacy without having to give up the entire gathering.
- 6) ***Passive Design Techniques.***
 - a) ***Cross-Ventilation (Fig. 4.19).*** Two or more openings in the same wall enhances cross ventilation by increasing the interior air velocity by 22% more than that of the outside air velocity. It is so because one opening behaves as an inlet and the other as an outlet (DeKay

- & Brown, 2013). In the haveli, windows and doors of most room follow this strategy which increases the air movement and the rate of cooling inside the house (Fig. 4.20 & Fig. 4.21).
- b) Stack Effect (Fig. 4.22). Most rooms including sheesh mahal, dining room, bedrooms and kitchen have high ceilings and windows and ventilators on same wall. Warm air escapes through the ventilators and cool air enters through the windows.
 - c) Migration (Fig. 4.17). In the traditional times, residents inside the house moved across spaces according to the time of the day and year. In the summer season, at daytime people occupied the basements and the courtyards and at nighttime they moved to the terraces and roof tops for the cool breeze. In the winter season, at daytime the roof tops, terraces and courtyards were occupied for maximum heat gain and at night, residents slept on the first floor that was still warm from the day sun. This strategy is no more implemented because in times of extreme weather, air conditioners and heaters restore thermal comfort.
 - d) Shading Devices. Jharokas (balconies) covered with jalis (screens) and beramdahs (verandahs) connect the users with the outside but protect them from weather extremes like the scorching sun and rain. Screens made of cane form a curtain in front of windows. The heavy foliage of the vines cover windows in the summer but in the winter they shed their leaves and permit maximum sunlight.
 - e) Evaporative Cooling. Two water fountains and pools in the courtyards cool the air through evaporation. Vegetation inside the house including plants, trees and vines, have leaves that transpire and follow the same cooling strategy.
 - f) Insulation. The three feet thick walls insulate the interior spaces and maintain a comfortable environment.

- g) Reflect Solar Radiation. White exterior walls of the haveli reflect solar radiation during summer and winter. Since summers are hot and long in the climate of Lahore, the benefits of reflecting solar radiation outweighs its shortcomings (DeKay & Brown, 2013).

Typological Level

- 1) ***Courtyard Housing Type***. The courtyard house is a time tested architectural type of this region which is present from as early as the Indus Valley Civilization in the 3rd millennium BC (Tadgell, 1990). Though the courtyard house has been present throughout the Indian history during prevalence of Buddhism, Hinduism and Islam (Tadgell, 1990), the evolution of havelis is credited to the Mughal tradition (Cooper & Dawson, 1998).
- 2) ***Courtyard which Live (Fig. 4.23)***. Christopher Alexander and his colleagues write in their book *A Pattern Language* about how to make a courtyard alive. They say, “*Place every courtyard in such a way that there is a view out of it to some larger open spaces; place it so that at least two or three doors open from the building into it and so that the natural paths which connect these doors pass across the courtyard. And, at one edge, beside a door, make a roofed veranda or a porch, which is continuous with both the inside and the courtyard.*” (pg. 564) The verandas in the haveli provide a transition through which people can naturally flow between the outside and the inside. A number of doors open into the courtyard from multiple directions so that residents continuously pass through the court and enliven it throughout the day. Our need for enclosure can be traced back to our primitive instincts. The courtyards are partly enclosed but they also provide views into larger open spaces.
- 3) ***Intimacy Gradient (Fig. 4.24)***. In a building, the spaces should be arranged in a sequence according to the degree of privateness, so that positive social interaction can be made possible (Alexander et al., 1977). The Barood Khana Haveli has a gradient of settings and the sequence

is: entrances - main courtyard, main terrace and office - inner courtyards and inner terraces - enclosed rooms.

- 4) ***Presence of Biophilia.*** A combination of trees, potted plants, hanging plants, climbers, floating lilies and various other flowers and fruits enrich the outdoor experience. They soften the look of the paved courtyards and terraces. All of the human senses are influenced through the rustling of leaves, smell of the flowers, stroking of the breeze, tastes of the fruits and visualization of the nature scene. Two fountains in their mirror-like pools located in two of the courtyards bring life into the haveli, refreshes the mind and cools the body. Decorated nests for birds, pools for the fish and courtyards for dogs provide home for animals inside the haveli.

Archetypal Level

- 1) ***Geometry in Plan (Fig 4.35- Fig. 4.37).*** Proportions of root 2 rectangle, root 3 rectangle, the golden rectangle, square and octagon are found in the division of spaces inside the haveli.
- 2) ***Geometric Patterns and Arabesque Designs (Fig. 4.39-Fig. 4.47).*** Patterns found in the haveli are inspired from Islamic art. The floors, screens, balconies, doors and windows are decorated with geometric patterns made from circles, squares, hexagons, curves, the 6 point star and the 8 point star. The wooden jali (screen) dividing two of the courtyards has carvings depicting arabesque design.
- 3) ***Exterior Prospects and Refuges (Fig. 4.48- Fig. 4.52).*** Due to our primitive instincts, humans need shelter spaces, referred as ‘refuge’, to feel safe but we also have a fondness for vast open spaces, referred as ‘prospect’, where we can easily see resources and threats. Refuge is dark and narrow while prospect is well-lit and spread out. A meaningful space is created when prospect and refuge are both present and one can be seen from the other (Hildebrand, 2008). In this haveli, prospect and refuge spaces can be found in the outdoor. The prospect claiming

courtyards can be seen from refuge spaces such as the verandahs and the shades of trees and balconies.

- 4) ***Interior Prospects and Refuges (Fig. 4.48- Fig. 4.52).*** Spaces close to the windows are well-lit and high ceilings give a feeling of vastness. Both of these strategies create prospects within the interior. Refuges are dark and cozy areas that are found away from the window and have low ceilings.
- 5) ***Enticement (Fig. 4.53-Fig 4.55).*** Spaces inside the haveli are linked in such a way that one space is only partially visible from the other creating a sense of mystery for the observer. The courtyards are separated by perforated screens. Staircases are L-shaped, dark and narrow. This characteristic of design that presents a mystery and fulfills our primitive need of discovering is called 'enticement' (Hildebrand, 2008).
- 6) ***Peril (Fig. 4.56).*** Humans experience pleasure in thrilling situations where they face dangers that they can overcome. This characteristic is referred to as 'peril' (Hildebrand, 2008). In the Barood Khana Haveli, roof tops create a sense of danger due to their height and views down below. The courtyards offer a perilous thrill because of their openness and vulnerability to the weather, insects, birds, and darkness at nighttime.

Problems with Courtyard Housing

After identifying all the design strategies and concluding that the traditional house is more sustainable than the modern one, it is important to understand why the architects of the modern day have not adopted the courtyard house.

The housing developments and urban policies of today are different from that of the Walled City. The plot sizes are uniform, forming a rectangular shape with fixed proportions. The arrival of mechanical means to regulate temperature ended the need for the courtyard house that operated

on passive design techniques. The typical family size continues to reduce and the joint family system is endangered. This has given rise to the detached or semi-detached single family house. The covered area is dictated by the by-laws set by the housing authorities. This leaves little margin for the architect to deviate from the prevalent housing type.

The plot area of the haveli is five times more than a typical 4,500sft modern house for a middle class family. The rise in land prices has resulted in this reduction of plot size. To accommodate the family size of 7 persons, the present day designers focus on covering the maximum plot area, which leaves less space for a spacious courtyard. The client also wants maximum land area to be covered because it is a general opinion that this way he/she will be able to get greater land value. Leaving large amounts of space for a courtyard will usually be seen as a waste of expensive land.

The ornamentation in the traditional haveli is expensive and requires skilled labor. The tile and work that form geometric patterns on floors and lattice screens are difficult to build as compared to a modern house that has less ornamentation.

Lastly, clients and designers both are inspired from the West. Exposure to magazines, internet and television generates a desire to mimic other architecture styles from around the globe. Being a developing country, Pakistan takes inspiration from the developed western world. It can be said that the traditional courtyard house is now considered as out-of-fashion among the general public of the country.

Design Solutions

Keeping in mind all the above mentioned problems associated with a courtyard house and the design strategies summed up from the analysis in this report, design solutions are proposed below (Fig. 5.2 & Fig. 5.3) to cater for the modern day housing problem. In Lahore, the

infrastructure for many new housing developments is under construction presently. These developments have been designed according to the standard plot sizes and proportions that already exist (Fig. 5.1). Therefore, to make the design solutions more applicable, typical modern day plot size and proportions are considered. Since privacy of women is an important part of the social structure and security problems in the city are common, the plots are kept independent of each other and secured by a boundary wall.

The two design options proposed Option A and Option B are shown in Fig. 5.2 and Fig. 5.3. In option A, the courtyards of four adjacent plots are placed together to allow maximum sunlight. To avoid invasion of privacy that might occur by penetration of sound from one courtyard to another, option B looks at a design in which only two courtyards are next to each other. This way the building acts as a buffer zone between two courtyards.

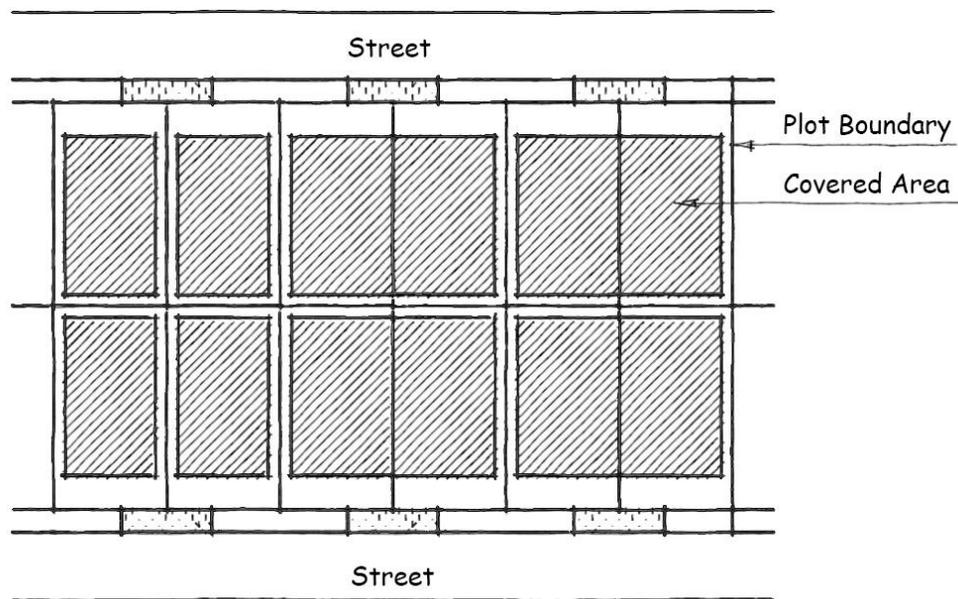


Figure 5.1 Existing Housing Typology

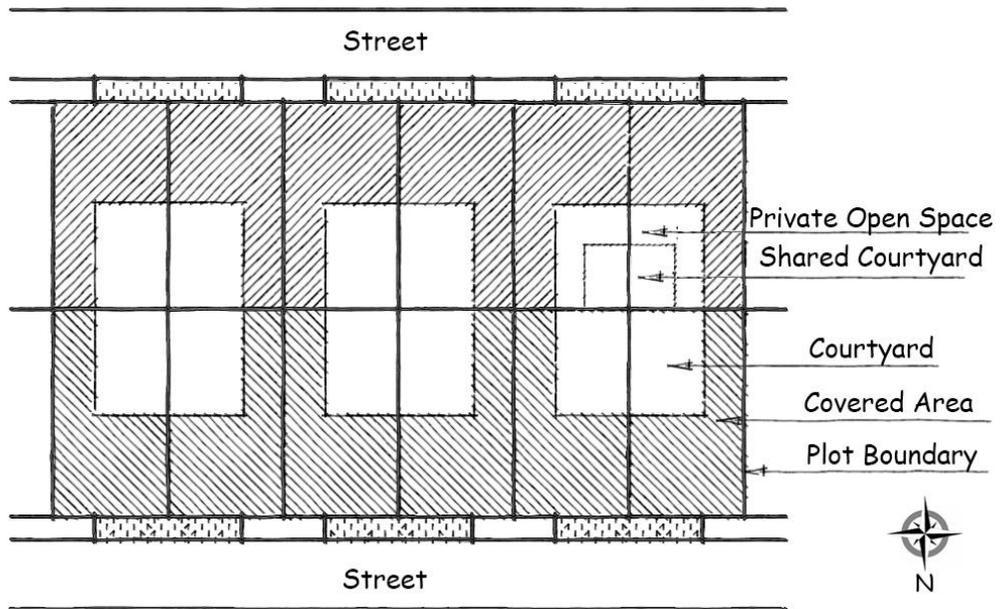


Figure 5.2 Proposed Courtyard Housing in Existing Plots (Option A)

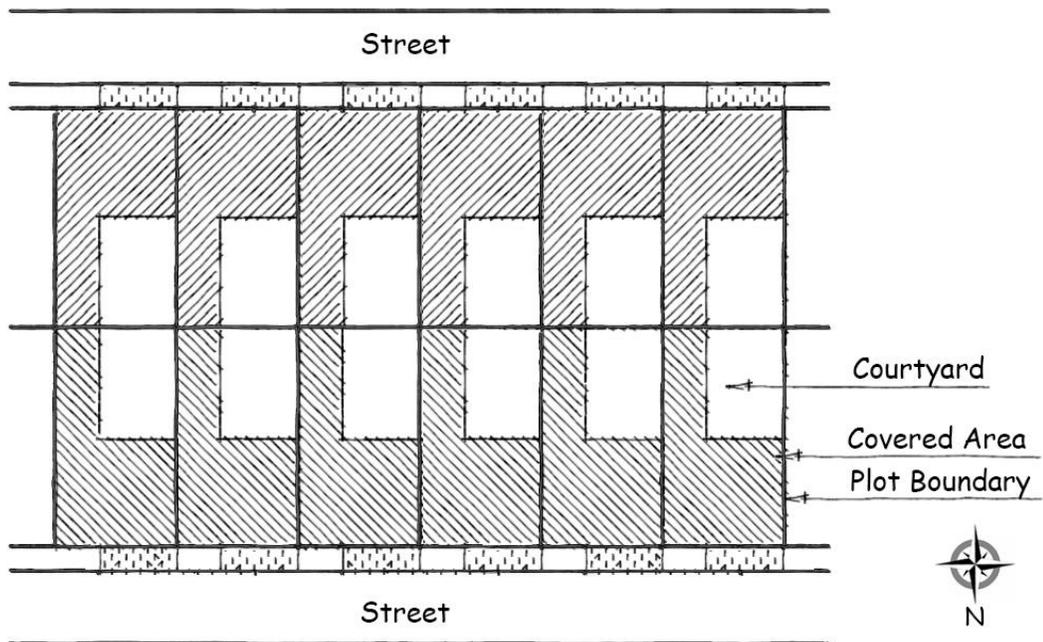


Figure 5.3 Proposed Courtyard Housing in Existing Plots (Option B)

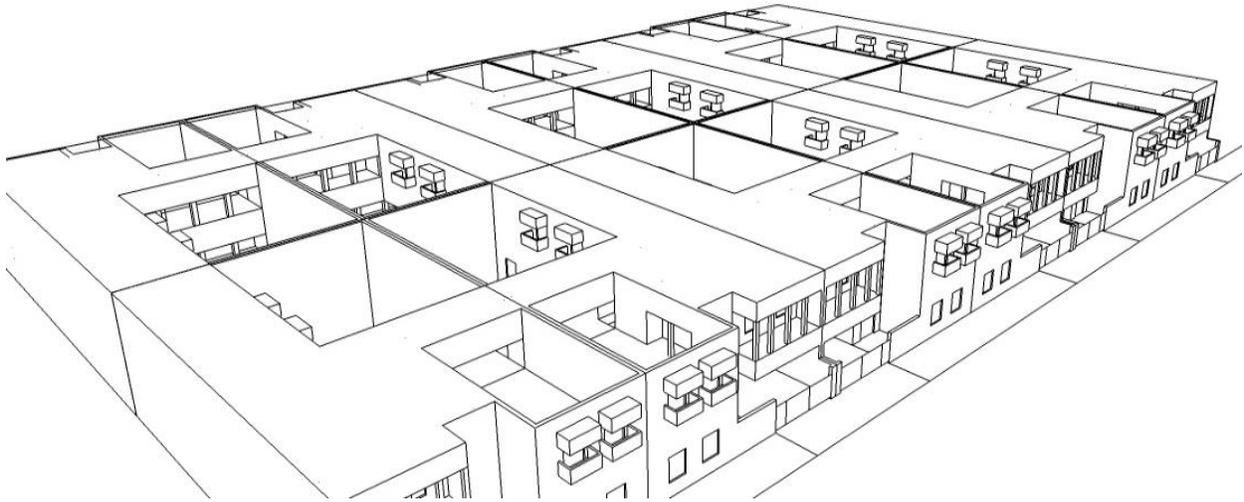


Figure 5.4 Isometric View of Proposed Courtyard House (Option A)



Figure 5.5 Top View of Proposed Courtyard House (Option A)

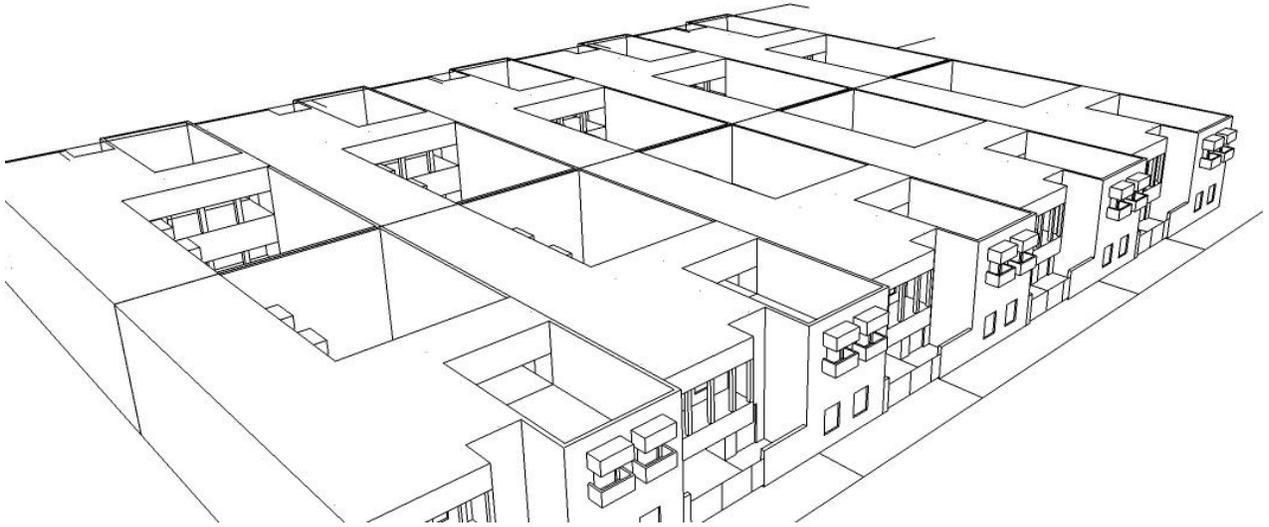


Figure 5.6 Isometric View of Proposed Courtyard House (Option B)



Figure 5.7 Top View of Proposed Courtyard House (Option B)

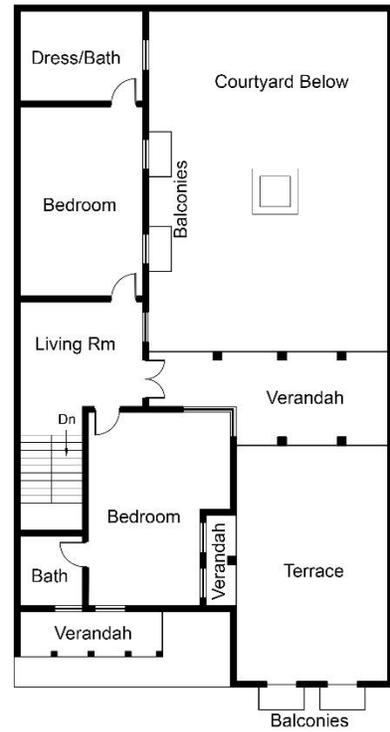
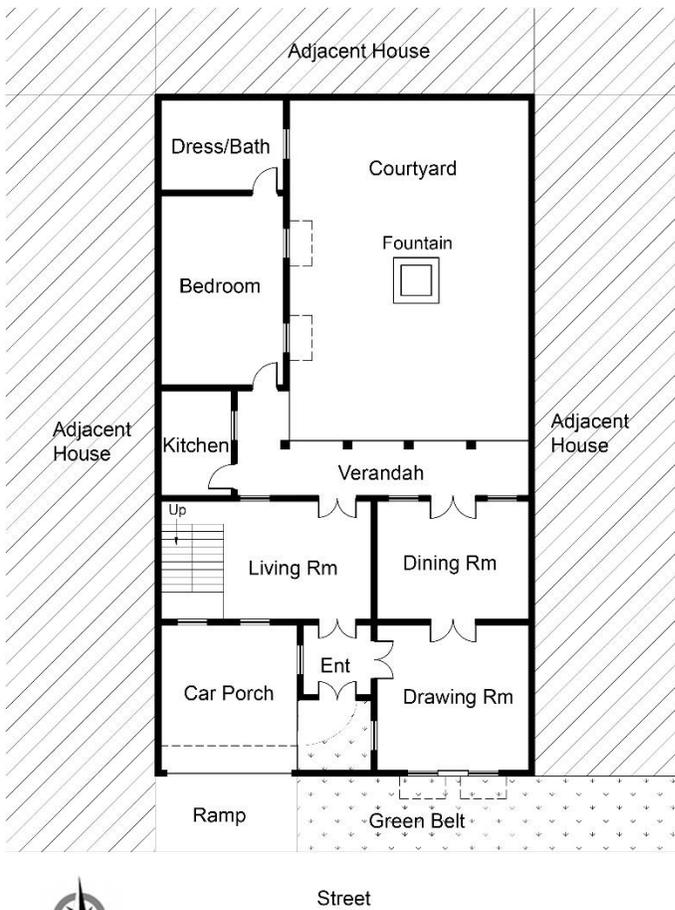


Figure 5.8 Plans of Proposed Courtyard House (Option A)
(Left: Ground Floor Plan; Right: First Floor Plan)

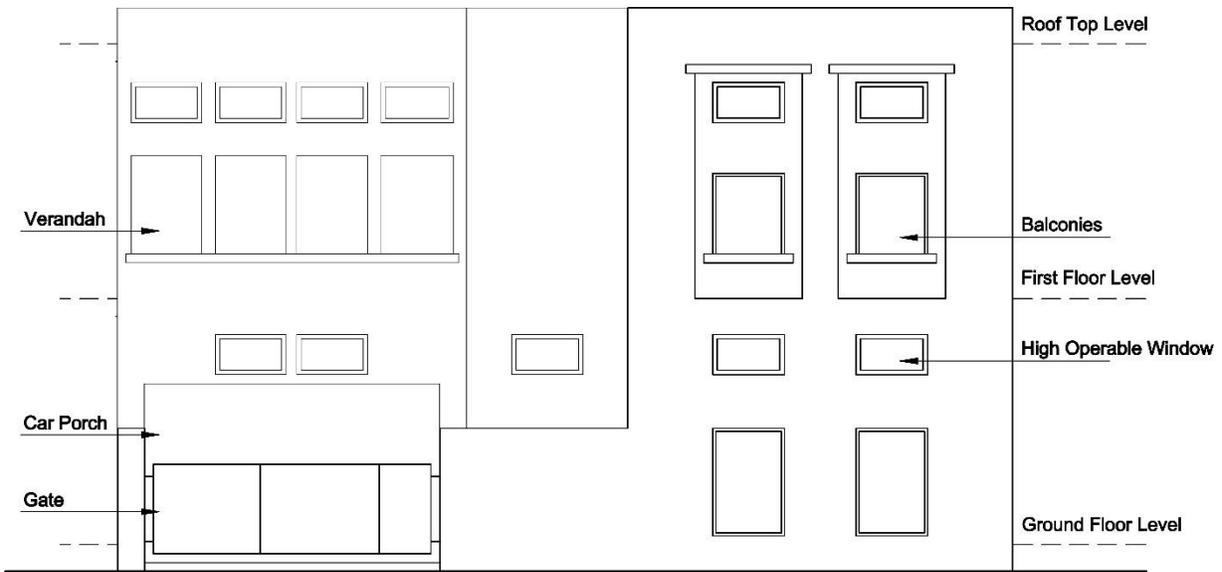


Figure 5.9 North Elevation of Proposed Courtyard House (Option A)

The house is designed to meet the present day needs of socializing, living style and technology. Following the typical design of a modern housing development of Lahore, the entrance into the plot is through a gradual ramp. This slope enables cars to enter into a semi covered car porch. One enters the interior of the house through an entrance lobby from where, the guests are taken to a formal space, the drawing room, and the family members enter into the living room which is an informal space. The dining room is accessible for both guests and family members. The drawing room, the dining room and the courtyard lead one into another so that in case of a larger social gathering they can be opened up to form one large space. A verandah runs around the courtyard which has a fountain in the center. From this verandah, the kitchen and the bedroom can be entered. A staircase from the living room climbs to a living area on the first floor. This living room connects the two bedrooms and a verandah. Balconies and verandahs on the south look below into the courtyard and the ones on the north look out on the streets.

Comparison of Square footage

L-shaped house with a south facing courtyard and terrace can well adapt to the shape of the plot. To address the issue of vast open land in a courtyard house, the amount of open and covered areas have been kept the same in the proposed design as that of typical modern house. The diagram (Fig. 5.10) below illustrates how the open spaces on the sides of the house that have no utility due their narrow widths, can be more efficiently used. Bringing all that open area into one central location can form a positive courtyard.

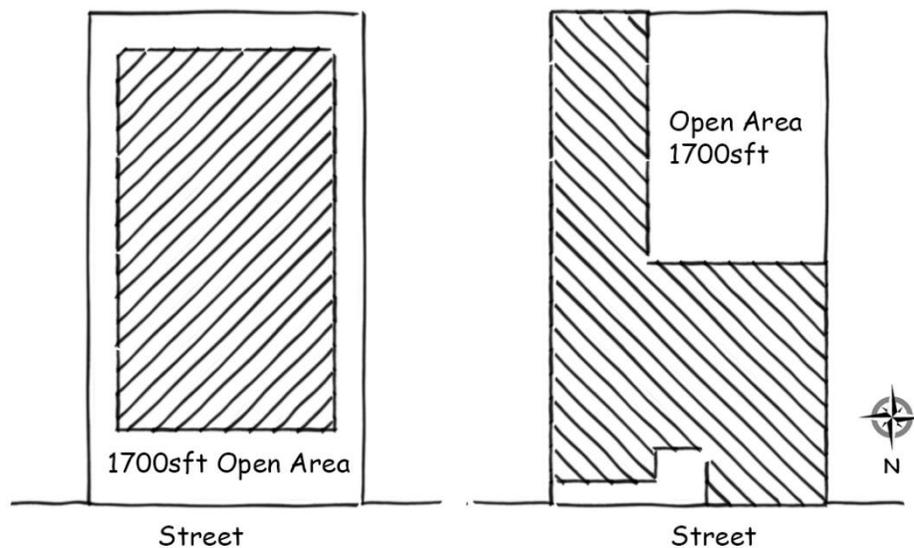


Figure 5.10 Same Open Area in Existing and Proposed Modern House
(Left: Existing Modern House; Right: Proposed Modern House)

Analysis of Proposed Design According to the Deep Beauty Framework

Functional Level

The courtyard is visible and directly accessible from all of the informal spaces. This preliminary design has the potential to allow features like outdoor furniture and plants along with the central fountain to create a social space with a sitting circle and quiet places. This house can

easily be constructed with brick. Cross ventilation has been enhanced by placing two or more openings adjacent to each other in one room. Stack ventilation is created by high ceilings and high operable windows (Fig. 5.9). The fountain in the center of the courtyard and plants can create evaporative cooling.

Typological Level

The design follows the courtyard housing typology that is native to this region. The intimacy gradient of a typical modern house is followed in the proposal where the car porch and drawing room are formal spaces located at the front for the guests. Further into the house, are the living room, the dining room and the courtyard. The most intimate space is the bedroom which is located furthest into the house.

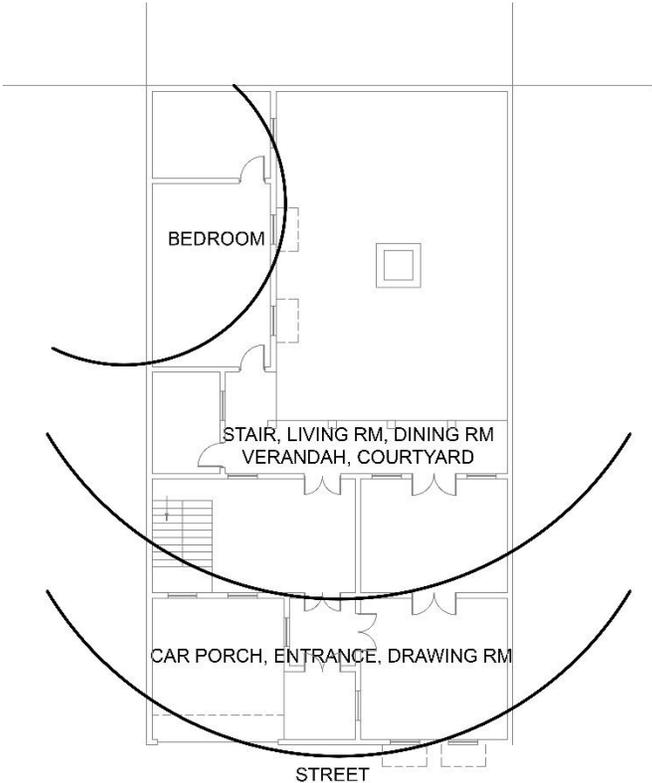


Figure 5.11 Intimacy Gradient of Proposed Design

The central location of the courtyard is the key to bringing nature into the house. Potted plants, trees, water fountain, water pools, climbers are all features that can be easily incorporated into the courtyard and terrace.

Archetypal Level

Courtyard of the house has the proportions of a root 2 rectangle. When combined with the adjacent courtyard, it becomes a larger root 2 rectangle. Geometric and arabesque patterns can be designed on the doors, screen, windows, floors and ceilings for decoration purposes.

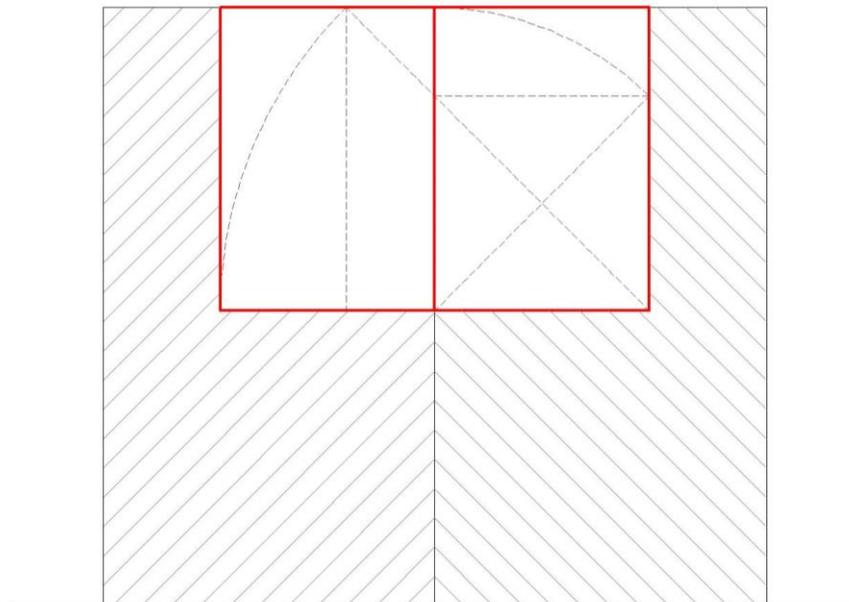


Figure 5.12 Geometric Analysis of Proposed Design

The spatial polarities of prospect and refuge can be fully experienced in the house (Fig. 5.13). The prospect claiming spaces are the courtyard, street and the terrace. The shaded verandas and balconies provide outdoor refuge spaces from where the outdoor prospect spaces can be seen. Inside the house, the areas close to the windows have more light and provide outdoor views while the ones away from these openings are dark refuge spaces.



Figure 5.13 Prospect and Refuge in Proposed Design

Paths that bend and disappear around corners create mystery for the user. These bends shown in the diagram (Fig. 5.14) below with arrows. A sense of mystery is alive that can be experienced as a person moves inside the house. These bends allow a partial view of the next space making its presence felt but not completely disclosing what lies ahead.

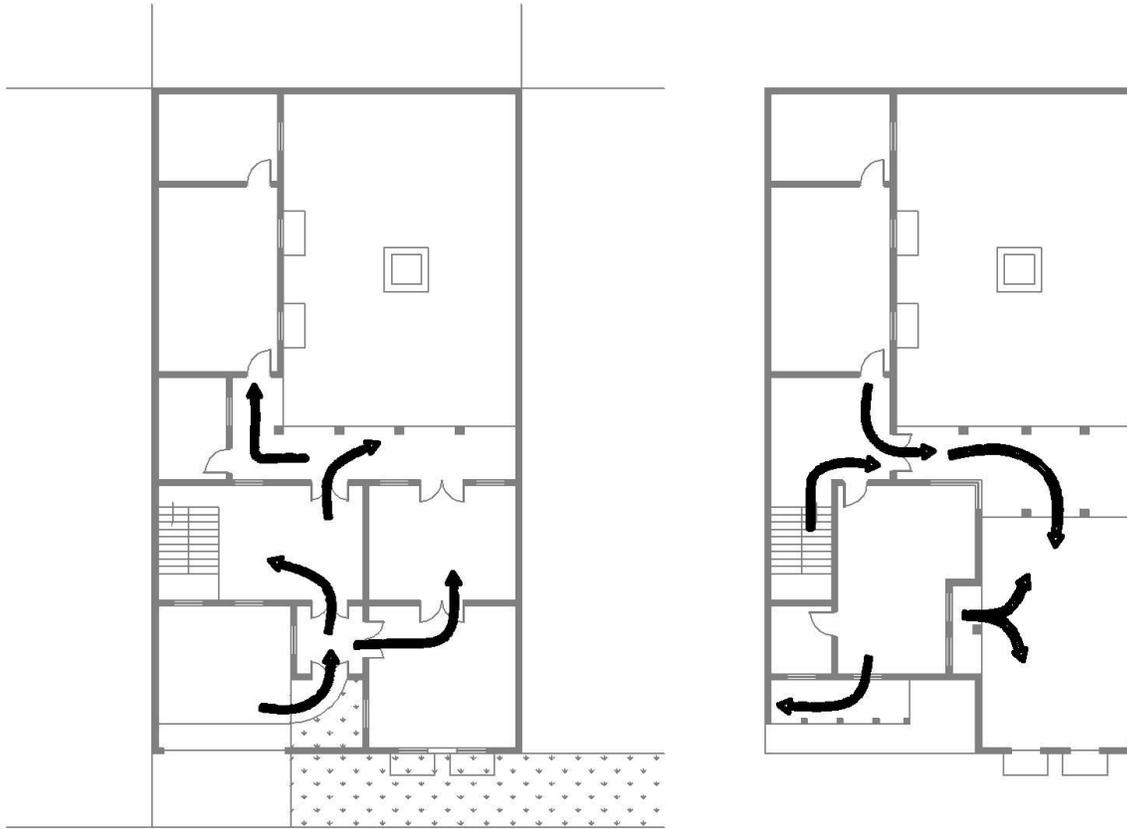


Figure 5.14 Enticement in Proposed Design

This new proposed design shows that the more sustainable courtyard house can be brought back and incorporated into the modern urban fabric. The design can be adopted by any typical housing development in Lahore with certain changes in the by-laws. Most of the design strategies mentioned earlier in this chapter can be applied today to bring Deep Beauty and sustainability into the residential architecture of the city.

Future Directions

The rubric developed in this report establishes a criteria that can be used in the future to assess sustainability of any architectural work. The analysis performed in this research sets an

example to show how the Deep Beauty framework can be operationalized and explains the process of assessment. The rubric can also be further detailed out to allow a more in-depth study. For example, tools like computer software and on-site measurements of temperature, wind velocity and so on, can be used to perform a more thorough analysis at the functional level. Assessment of natural symbols can be added to the rubric for a complete evaluation of the archetypal level.

The proposed plans for the future house are preliminary sketches that can be further developed by designing more details like placement of furniture. To assess the practicality of this new design, a market survey can be conducted to learn about peoples' reactions to it. The design can be presented to carefully selected focus groups that represent the general middle class families of Lahore. The results of this research can be used to find out the feasibility of this proposal and how it can be further improved.

For this research, the design solutions are proposed for the immediate future so they can be applied to existing and upcoming housing developments. Starting from this point, further options can be explored for a farther time ahead where new urban policies and improved urban design can be proposed. Adopting the research method of this report, traditional urban housing can be studied and learnt from. Following the design strategies from the past, it is possible to rethink more sustainable housing developments for the future.

This research must be seen as a beginning for further exploring and reinventing architecture for the future. It provides a base from where more investigations can be initiated.

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Appendix A - Questionnaire

Purpose of Questionnaire

This questionnaire is used to hold a telephonic interview with Mr. Yousaf Salauddin who is the resident/owner of the Barood Khana Haveli. These questions are based on the rubric developed for the analysis of this haveli. The aim is to better understand the sustainability level of the house.

Questionnaire

Demographics and General Questions

1. Age
2. Sex
3. How long have you lived in this courtyard house?

Family Structure

1. How many people are currently living in this haveli?
2. What other members of the family reside here? Do servants also live in the house?
3. Besides residential, are there any other purposes this haveli has been used for?

Social Setup

1. What is the importance of the haveli's courtyards in your everyday activities? When is it usually used?
2. What is the importance of the basement and roof top in your everyday activities? When is it usually used?

3. Are there security issues related to the courtyard houses? If yes, how do you address them?
4. Are the women of the house kept in private or has that changed over time?
5. I have been told that the haveli is sometimes rented out by people to hold wedding events. Is that true? How often would you say you rent it out?

Comfort

1. What is the role of machines (AC and Heaters) in cooling and heating of this house?
2. Do you think that the design features of the house (like the courtyard, jalis, jharokas thick walls, etc.) play a role in cooling and heating of the house?
3. Would you say that this haveli has less heating and cooling loads as compared to a modern house?
4. Are the functions of the rooms fixed or flexible? For example, in the old days, during the hot summer season people moved to the basement to escape the hot sun and moved to the terrace at night for sleeping. Is that still the case?
5. What are the building materials used in this haveli? Has the new construction been made from new materials like cement and concrete or traditional materials like lime mortar is used?

Layout

1. What different purposes do the two separate entrances serve? Is there a car parking area in both the entrances?
2. Which entrance is used by the guests?
3. Where do guests park their cars?

4. What is the purpose of the podium in the courtyard?
5. Where are the bathrooms in the house?
6. What is the purpose of the Sheesh Mahal? Is it a drawing room?
7. Why did you switch the baithuk to a bedroom? Has the purpose of other rooms also been converted?
8. Which areas of the house would you consider as intimate? Please identify the areas where guests are allowed and where they are not?
9. Do all three courtyards have the same level of privacy? Or some are more private than others?
10. What purpose did the office area serve originally?
11. What are the functional purposes of three different terraces?
12. Are there any servant quarters in the house?
13. I have read that this haveli was built for the Sikh army's commanding general and served as an arsenal as well as his residence. Which areas of the house served as the arsenal?
14. What changes have been made to the plan over the years and why were they made?
15. Which parts of this haveli are newly added and which were originally there?
16. Do you plan to make further changes to the haveli design?
17. What is the plan of the basement?
18. What is the depth of the terrace besides the main courtyard? What is located underneath this terrace? What is located underneath Yousaf Sahab's bedroom?
19. Please identify the unknown rooms in the plan.
20. Can you provide photographs of the kitchen and the exterior photographs from all three sides?

Biophilic Design

1. Are you growing any fruits in the haveli?

Evaluative Questions

1. If you could, what would you change about the haveli and why?
2. How would you compare this haveli with modern day houses?
3. Would you want to move out of this haveli into a modern day house of the haveli? Please explain your choice.