NOVEMBER 1983

ON BUILDINGS AND THERMAL COMFORT

Vinod Gupta

School of Planning and Architecture
G-4 Masjid Moth
New Deihi 110048
India

INTRODUCTION

A new consciousness evident In modern architecture Is the need to design buildings so that they stay cool In the summer and warm In the winter without consuming a great deal of energy In the process. "Passive solar architecture", as It Is called, is the architect's response to the global energy crisis. The availability of cheap fossil fuels in the decades past was responsible for distorting people's expectations from buildings. Glass, concrete and steel boxes were built by the thousands and each of these had to have air conditioning plants to control the Internal temperature within the narrow range defined as "comfortable". While It Is likely that the working efficiency In such buildings Is high, It Is equally likely that continuous exposure to the controlled environment makes people lose, at least partially, their natural ability to adapt to different thermal conditions.

A much better situation Is one In which buildings are designed to ameliorate the worst of the weather, and man can then Interact positively with the environment to find comfortable working and living conditions. In the cities of northern India this has been achieved by appropriate organization of social and economic activities, In addition to good town planning and building design. Even though there Is a superficial similarity between them, the northern Indian cities of Jalsalmer and Deihi have been built and function differently. It Is Interesting to see how the builders of these cities overcame the problems of building in the harsh climate.

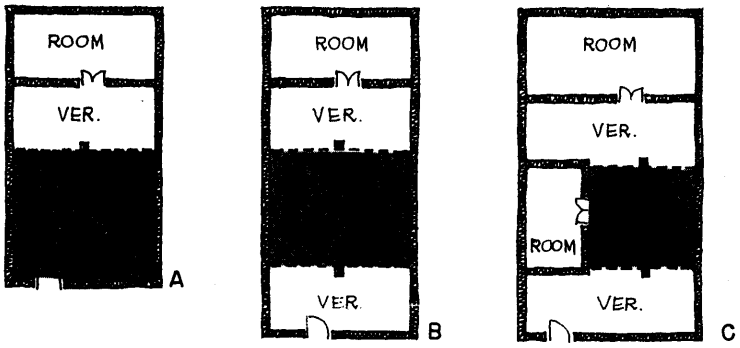
JAISALMER

This Is a medieval town situated in the heart of the Great Indian Desert. The daytime temperatures in the shade In June reach 50 degrees Centigrade, while the nighttime temperatures In January are just above the freezing point. There is very little rainfall (120-150 mm. in the whole year) and during the summer months of May and June the town is subject to severe dust storms. The climate demands protection from the scorching summer sun and sand storms, on the one hand, and cold winter nights on the other. As the summers are dry It would be possible to provide thermal comfort easily by evaporative cooling. But this cannot be done because water is a very scarce commodity In the summer. The main source, a tank outside the city, dries up in summer.

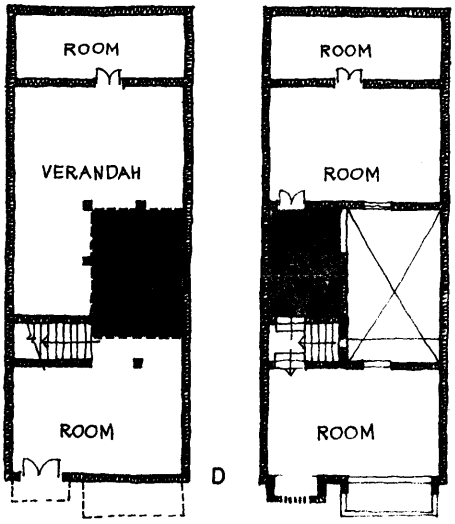
The layout of the town is the first defense against the harsh climate. The streets are narrow and partly shaded from the sun. For protection from the dusty winds, the main street orientation is at right angles to the prevailing winds. At many places buildings overhang the streets on both sides, providing a cool shaded area for most of the day. The continuous construction ensures mutual shading of the buildings. Even though by these arrangements the town is much cooler than some other newly constructed areas nearby. The day can be very hot, therefore life begins in the town before sunrise, the dally chores being completed by late morning. The hottest part of the day, from noon until about five or six in the evening, is a period of rest when people stay indoors. Many shops in the bazaar are closed during these hours. As the sun moves lower down in the sky and the air cools down, the town comes back to life. Children come out into the streets to play, housewives go about to fetch water, cattle that live in the streets move about in search of food and the bazaar begins to fill up with people. Most shops are open until late in the evening so people can purchase their requirements in comfort.

The second defense against the heat is the massive construction of buildings. Built mainly from the locally available yellow colored sandstone, these buildings have thick walls and even thicker roofs of mud supported on timber beams. There are few windows toward the street but all houses are arranged, around small courtyards and there are large openings toward the courtyard. According to the economic and social status of the house owner there are three types of buildings. The poorest live in very small single story houses (Figs. A, B & C) built of mud. There is usually a courtyard enclosed by high walls, on one side of which is a verandah and a small room beyond it. Such major living activities as cooking, bathing, sleeping, etc. take place either in the verandah or in the courtyard. The room is merely a storage area wherein the family's few possessions are displayed proudly. Under the room there is usually a small basement approachable only through a heavy trap door. This is where such valuables as jewelry and even food-grains are stored safely. The thick roof and walls allow little heat to penetrate into the room and it thus can be used during the daytime. The courtyard, together with the verandah, is used at all other times. In winter the situation is reversed, the room being used at night, and the sunlit courtyard and verandah being used in the daytime.

The middle-income house (Fig. D) is a two-or-three-- storied structure with a completely enclosed courtyard. The deep and narrow building is surrounded by similar houses on three sides which protect it from the sun. On the fourth side is the street and the entrance to the building. The size of the courtyard is such that direct sunlight can penetrate down to the lowest



SINGLE - STOREY HOUSES



DEVELOPMENT OF TYPICAL HOUSE PLAN

TWO- STOREY HOUSE

floor only for a short period during the day. Protected from all sides the ground floor rooms stay comfortably cool during the day. The verandah is used for cooking and washing etc. Such activities as cleaning grain and stitching clothes, which need better light, are carried out In the courtyard. The front room is where visitors are entertained and where women spend the afternoon. This is the room where there is maximum air movement due to the courtyard effect. Just as in the smaller houses the rear room is used only as a storeroom.

The rooms on the upper floors are better lit. In the larger families, these rooms are used by different family members. However, there are no "bedrooms" as sleeping is an activity in which the whole family Is together. Most often women sleep on the terraces, whereas men sleep on the raised platform at the entrance to the house. The rooftop and street are the two cool areas at night in the summer.

Jaisalmer is famous for the richly carved stone facades of its buildings. While every building in Jaisalmer has some of this carving, it is the rich men's houses that are Intricately carved from top to bottom. These buildings, called "Haveli", are the third type of Jalsalmer houses, much larger and more interesting than the other two house types. These are three-or four-storied structures with additional wind pavilions on the top floor. Each building Is built around one or two courtyards with additional ventilation shafts provided at appropriate locations. The most interesting of all the havelis is Nath Mal's Haveli in which are embodied most of the special design features found in other havells.

This building (Fig. E) is planned around two courts, the one in the front being much smaller than the one In the rear. The front part of the building is three stories high and serves as the main living quarters of the family. The rear portion, a story lower, contains the servants' quarters. The front court was used by family members, the rear court for keeping animals. On either side of the front courtyard there is a small apartment built around a narrow vertical shaft. Thus there is a variety of vertical ducts of different sizes In the building. Because of their difference in size and orientation the sun penetrates these courts unequally. The differential heating of these courts causes air movement from one to the other ensuring ventilation in the rooms that are in between. Similarly, air movement from the street to the courtyards occurs.

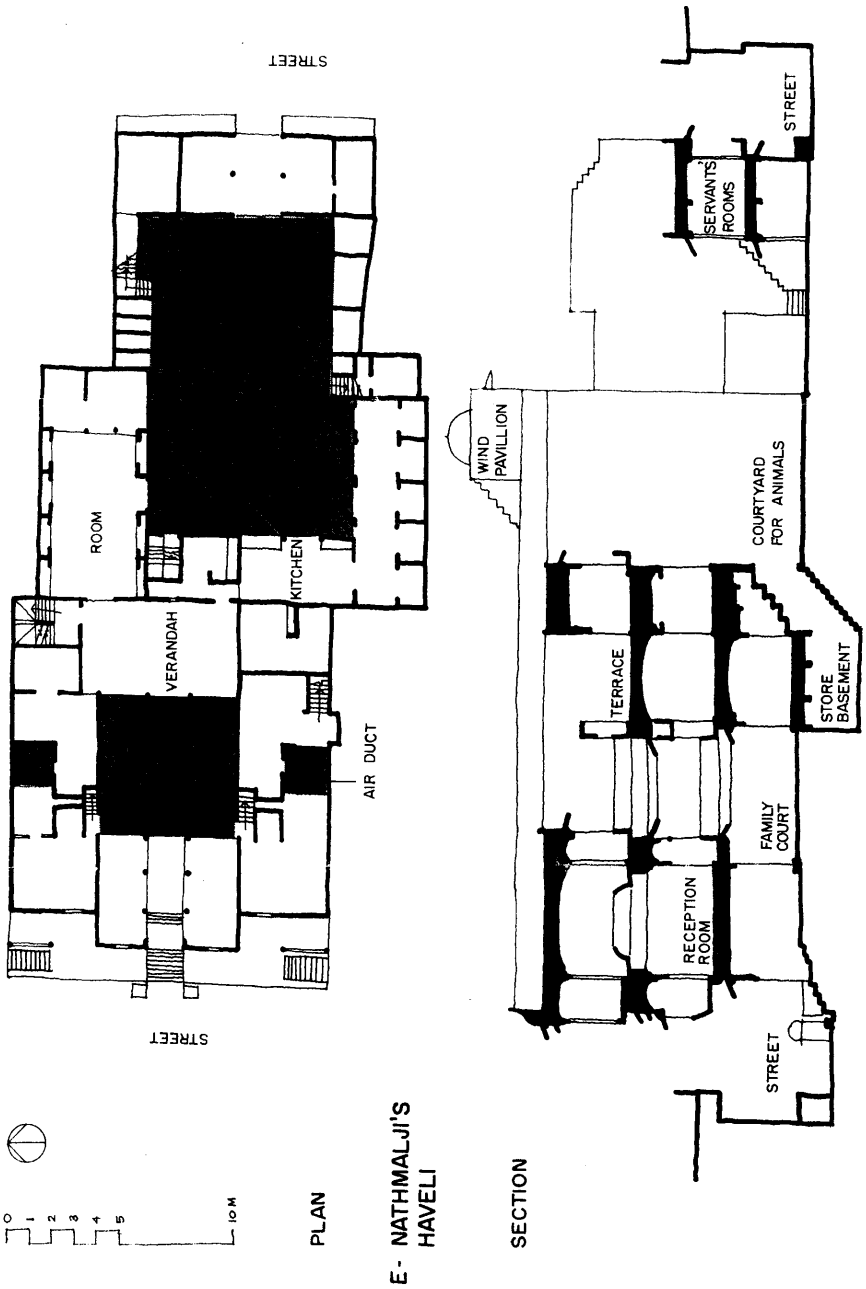
The reception room of the family is located on the first floor above the entrance way. This richly decorated room is two stories high internally. There are timber shuttered windows opening toward the street and a large number of small ventilation holes in the upper part of the room. Together these openings ensure heat removal by ventilation.
As this building is taller than the others around It part of the external walls are exposed to solar radiation. To avoid undue heating up of the walls they are shaded with projections and carvings. The Internal walls of the courtyard are also treated in a similar manner. The total effect of the massive structure, the sun shades and the ventilation system is such that the family has not felt it necessary to install ceiling fans In the rooms, even though they now have an electrical connection in the house.

OLD DELHI (SHAHJAHANABAD)

Old Delhi was established by the Mogul emperor Shahjehan in the 17th century A.D. when he shifted the capital from Agra to Delhi. Essentially a trading city, it has developed into an important commercial center for northern India. The climate is characterized by a long dry summer followed by a warm humid monsoon and a short dry winter with clear skies. The diurnal temperature variation is large except during the monsoon. In summer the daytime temperature exceeds 40 degrees Centigrade while the winter night temperature may fall below 5 degrees Centigrade.
This composite climate is, perhaps, more difficult to design for than that of Jaisalmer, but the builders of Shahjahanabad have done an equally good job. Located on the banks of the river Yamuna the city was not short of water even in the summer and, therefore, people used evaporative cooling in many different ways.

As in Jaisalmer, the streets of the old city are narrow and the buildings are tightly packed together. The few major streets, however, are wider and these were originally lined with trees on either side. These bazaars had continuous colonnades in front of the shops, where people could walk in the shade. The narrower streets were further protected from the summer sun by canvas awnings set up by the shopkeepers. To provide cool drinking water to the passersby the pious set up water stalls called "piau" along the streets.

A number of building materials were available to the builders of Shahjahanabad. These included bricks, sandstone, lime and timber. Accordingly they built the houses with thick walls in brick and roofed them with stone slabs supported on timber beams on top of which they placed a thick layer of earth and, finally, finished it with lime concrete. All walls were given coats of heat-reflecting lime wash each year.


STREET
ROOM
KITCHEN
VERANDAH
AIR DUCT
STREET
0 1 2 3 4 5 10M
PLAN
E- NATHMALJI'S HAVELI
SECTION
STREET
SERVANTS' ROOMS
WIND PAVILLION
COURTYARD FOR ANIMALS
TERRACE
STORE BASEMENT
FAMILY COURT
RECEPTION ROOM
STREET

The smaller houses (Fig. F) were built around a single courtyard and were generally two stories high. The larger havelis were sometimes three or four floors high and would have two or more courtyards. For reasons of privacy very small windows were provided toward the street but the" walls facing the courtyard were mainly a number of timber shutters which, when folded back, changed the room into a verandah. The best rooms were those that had courtyards on two sides for the reason that this would result in continuous air movement in the room. Whenever windows were constructed they were located both near the floor and near the ceiling to provide continuous ventilation. The idea of windows for viewing was unknown.

An interesting feature of the Shahjahanabad houses is a room built on the terrace. Called "Saiwaan", this room was invariably constructed of timber with large windows and doors and a light roof, in contrast with the massive construction of the lower floors. The latter would stay cool during the daytime but would tend to warm up in the evenings. The airy Saiwaan, on the other hand, would be warm during the daytime but would cool down quickly at night, when it could be used for sleeping.

By themselves, these buildings perhaps would not be very comfortable. They became quite comfortable, however, with appropriate organization of activities and by use of simple cooling devices. Not all areas of the house were comfortable at any given time of the day either in summer or winter. But at all times there was at least one area in the house which was quite comfortable and that is where the family moved. In summer the days were spent on the lower floor and the night on the terrace. In winter, when the sun is welcome, the day was spent on the terrace and nights inside the house.

Evaporative cooling was used in summer in different ways. People hung mats of a special grass called "khas" in front of the windows and doors and sprinkled water on them. These mats absorbed water and allowed it to evaporate slowly, cooling the air entering the house. Floor washing was another important cooling method. The stone floors inside the rooms were washed in the morning and because of water absorption and evaporation they stayed cold throughout the day. Before moving to the terrace in the evening the family washed the terrace floor also. This released the heat absorbed in the roof during the day, causing it to cool down quickly. Earthen jars were used for storing drinking water- and kept the water cool by evaporation.

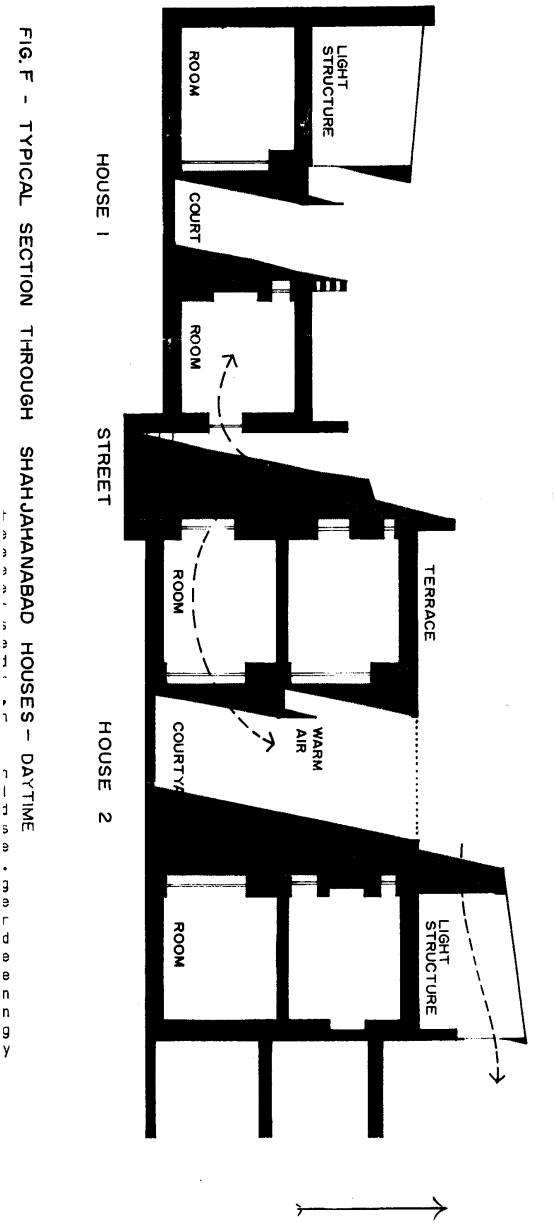


FIG. F - TYPICAL SECTION THROUGH SHAHJAHANABAD HOUSES - DAYTIME

CONCLUSION

It is perhaps unreasonable to expect that by using passive solar techniques indoor temperatures could be confined to the narrow range defined as "comfortable" by air-conditioning engineers. But it is highly possible to ensure a reasonable degree of comfort by proper building design. The success of such techniques, however, will depend upon the willingness of the occupants to put up with minor inconveniences, improving and reviving their adaptive capabilities. Unlike machines, human beings can adapt to changes in the thermal environment by moving from a less comfortable place to one more comfortable, by putting on or taking off clothes, and by organizing their activities according to the time of day. The purpose of environmental control in buildings is not to control temperature but to provide relative comfort for human beings. The igloo of the Eskimos and the tent of the Bedouins of the Sahara are buildings of unsurpassed efficiency and economy. But if the arbitrary "comfort scale" of engineers were to be used to measure the performance of these buildings they would be declared as not worth consideration as buildings of value.