ORIENTATION AND HOUSE PLAN CONFIGURATION FOR ENERGY CONSERVATION IN LAHORE

S. Arif[1], A. Khan[2], M. Mushtaq [3] and K. Alamgir [4]

[1, 2] Deptt. of Architectural Engg. & Design, University of Engg. & Technology, Lahore
[3] Deptt. of Mathematics, University of Engg. & Tech., Lahore, Pakistan
[4] National Institute of Vacuum Science & Technology, Islamabad, Pakistan
Corresponding author Email:sabahatarif@hotmail.com

ABSTRACT: This research focuses on energy conservation giving emphasis on Passive design application in residential buildings of government and private sectors with respect to solar orientation. The environmental data are calculated and presented for the solar passive application in architectural and urban designing for thermal control. The study is based on the experimental findings of test rooms at main orientations and the results are applied on a standard house plan configuration for the validity. The results showed the SW an optimum orientation for heating and cooling requirements for energy conservation.

Key words: Simulation, Building Orientation, plan configuration, altitudes, temperatures.

INTRODUCTION

On a certain geographical location, solar radiations is the key factor affecting the buildings as it varies seasonally hence there is a need to heat or cool the building accordingly (Brophy *et al*., 2000). For urban design of housing developments, it is justified to divide innumerate climates into a limited number of zones, where the temperature is an important aspect and has been used to grade climatic zones on a scale of climatic archetypes. The rate of heating and cooling of the surface of earth is the main factor determining the temperature of the air above it and the solar radiations have an indirect effect on the air temperature (Das, 2006), (Tzonis *et al*., 2001). Temperature difference on the earth's surface causes significant variations locally. The diurnal and seasonal temperature variations are affected by the sky conditions (Olgay, 1963). The building envelope gets hotter when they are exposed to solar radiations, and the temperatures inside the buildings vary as a response of the outside air temperature (Fry and Drew, 1964). Temperature is affected by the altitude and orientation of a location. Pakistan has a variety of climates and climatic zones like very cold, humid, arid range in addition to hot and very hot. The city of Lahore has the variety of seasons which set a difficult task for the building designers.

The Earth's orientation affects the amount of solar radiation received at different latitudes on earth. Different positions of earth in the orbit which varies from declination angle of $+23.5^{o}$ on 22^{nd} June (summer solstice position) to -23.5^{o} on 22nd December (winter solstice). The zero declination angle on both, 21st March and September 22nd (Equinox positions), is important to understand the building design problems. The climate of earth is determined by the energy input from the sun. The solar geometry and the energy flows from the sun are important at a location on earth with regard to passive design technique. The latitude of Lahore varies from 31^{o} $15^{'}$ to 3 $b1^{0}$ $45^{'}$ and Longitude from 74^{o} to 74^{o} $39^{'}$. Lahore is situated at an elevation of 213 meters (712 feet) above the mean sea level.

The buildings can be oriented according to the sun path sun in the respective month for the desired amount of sunshine for energy conservation and sustainability.

METHODOLOGY

a. **Identification of features in House Plan Configuration:** For the sustainability, the form of residential plans in Lahore is investigated with respect to architectural planning and designing in different developments within and suburbs of Lahore. The essential elements of planning are identified after wide survey of the new and older developments and the essential components are listed in the following Table 1.0.

Unlike other buildings, the residential buildings are occupied for the twenty four hours and there can be a number of orientations in any hosing development. The components/zones in a house can face any orientation. Windows being the main recipient of solar load are more important with respect to sun orientation. In general practice, windows are provided for the view and aesthetic consideration of the facades by the professionals as well as the users. Day lighting, ventilation and solar loads are not being given the priority in architectural design.

Table 1.0 Essential architectural design components of the house plan.

Essential Features/zones	Optional components
Car –Porch	Terrace
T.V Lounge/Living- room	Verandah/s
Drawing- room	Powder- room
Dining- room	Study- room
Bed- room/s	Store- room
Bath room (attached)	Dressing- room
Kitchen, (dry and wet)	Pantry
Stair- case	Laundry
Servant- quarter	Guest- bed

The orientation can be related to the sustained house plan configuration in Lahore, as follows:

i. Almost all the residences are comprised of a number of zones and orientations resulting different temperature profiles.
ii. The different temperature profiles result in different solar- loading conditions imposed by outside environmental conditions through the building envelope. The Residential buildings are single or double story houses in practice in Lahore. Multi-family houses are similar to the single- family detached house which has exposed walls in all the four directions. As the architectural design is dictated by aesthetical consideration which may impede the integration of passive features when they are without quantification. It is essential that each zone in a plan configuration should have proper load calculation (ASHRAE, 2002). The flow diagram shows essential and optional features of a typical house form in Figure 1.
iii. . The main entrance is essentially attached with the car porch. The drawing room and the guest rooms are approached either through a lobby or passage directly linked with the television lounge/ living room. The living room and the dining room are connected with the kitchen so that guests from the drawing room can reach the dining room with maintaining the house privacy requirements. The bed rooms including master and the children bed are designed together and have a direct social link with each other.
iv. Each zone in a house plan configuration is independent of orientation because of the typical house form and space organization.

The flow activity chart as shown above attained its form due to the social, cultural and functional needs of the society. The location of the guest room is essentially placed near the entrance zoning. The living room has acquired a central location as it is assumed to be the center of activities and the bath rooms are attached to the bed rooms mostly through a dressing room; each component or zone having a special character attached with its space and function and solar exposure for the indoor thermal comfort.

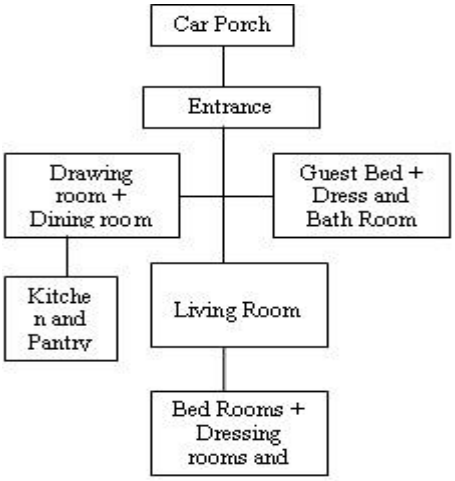

Figure 1: Identified essential features of a typical house plan configuration.

b. **Sun Path Chart for Lahore and Plan Configuration:** The solar radiations greatly vary with the weather, latitudes and altitude according to the Sun Path Diagram (SPD) as shown in Figure 2. Pakistan is located between the 25° N and 35° N latitudes where the % age of direct solar radiations is very high (ENERCON, 1990). The direct radiations affect the buildings greatly by entering through the windows. The SPD can be used for any latitude to determine the position of sun at any hour of the 21 day of each month.

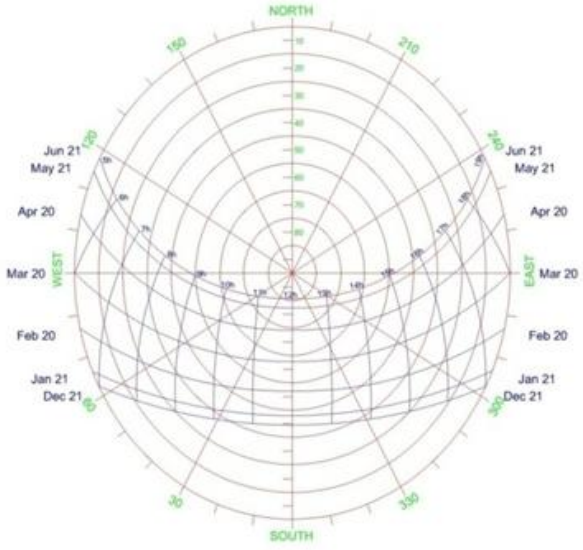

Figure 2: SPD for Lahore, Pakistan.

Source: ENERCON Design Manual, 1992.

The sun's rays have an altitude of 0° at 5:00 a.m., on 21st June as shown in the SPD for the latitude of Lahore. The sun's azimuth angle at 6.00 am is 62° E/W and 118° E/W

on 21st June and 21 December respectively. It has an altitude of 12° according to SPD at 6.00 a.m, on the summer solstice day; whereas, the altitude angle reaches 81.5 at 12 noon on the same day. The Altitude angles for summer and winter solstice positions in Lahore. The azimuth angles for the summer and winter solstice positions are S62° E/W and S118° E/W. The azimuth angles east ward in the morning and westward in the afternoon. The SPD is the appropriate way for determining the position of sun at any hour or any day of the year. The SPD is composed of two paths of summer and winter solstice positions of sun. Therefore, each line of sun path is marked with two Roman numbers on the SPD.

It is evident that the solar radiations are greater in winter on south orientation and lesser on east and west orientation whereas in summer, the impact is reverse. Similarly, in winter season the impact of solar radiations increases from 8.00 am to the maximum at 12 noon and then deceases at 4.00 p.m. However, the west exposure is more troublesome for buildings in summer due to higher afternoon temperatures combined with the effect of radiations.

c. **Identified Solar Altitude Angles (SAA) for Lahore:** The SAA for 32°N latitude, are calculated and the value for important dates are reproduced in Table 2.0.

Table 2.0. Solar Altitude Angles (SAA) at noon for the solstice and equinox.

Month and Date	Ka(SA coefficient) Butler, 2002.	SAA
21st January	69.5	37. 5°
21st Mar.& Sept.	90.0	58°
21st April	101.5	69. 5°
21st June	113.5	81. 5°
21st September	90.0	58°
21st October	78.5	46. 5°
21st December	66.5	34. 5°

The above information can be helpful in designing shading device with south orientation.

Analytical Results and Discussion: The above calculated solar altitude angles with the help of SPD for Lahore can be integrated in house plan configuration (ENERCON, 1990 and 1992) for energy conservation in any housing developments in Lahore. Each zone in the plan form identified can be designed with the SAA for optimized conditions in summer and winter seasons (Sodha *et al*., 1986).

The analysis through simulation while incorporating the sun path chart and the weather data for Lahore, were also conducted to verify the experimental data and results. The house plan configuration simulated is shown in Figure 3.

The results of this research study showed that significant part of energy can be conserved by appropriate control of heating and or air conditioning for cooling. The results of experimental study and simulations showed the SW an optimum orientation for heating and cooling requirements.

Figure 3: Simulated house plan configuration.

Conclusion: It is evident from the above study for a passively designed energy efficient house design in Pakistan, it is very important for the design professionals to incorporate the solar data provided in this study for the buildings' sustainable design. Many research studies demonstrated that the sun affects the temperatures of the buildings indoor depending upon their orientations. The results of simulations of house plan orientations showed the SW an optimum orientation for heating and cooling requirements for energy conservation.

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