ISSN No:-2456-2165

Effect of Vertical Urban Surfaces on Human Thermal Comfort in Outdoor Environment

Ar. Jayesh Khaire
Assistant Professor, KMEA College of Architecture, Kerala, India.
Ar. Buddhista Morey
Practicing Architect, Design Horizons, Saket, New Delhi, India.

Abstract:- Thermal comfort for outdoor space is important because it accommodate important outdoor activities. Immediate open spaces to buildings in urban areas where these activities take place are often affected by vertical surfaces of buildings. These surfaces may provide shade for outdoor open space, it may reduce or increase wind speed, which ultimately affects thermal comfort of that space. It is quite evident that Indian cities are facing thermal discomfort in outdoor areas. If we can make indoor spaces comfortable why not outdoor spaces also equally comfortable? This paper discusses possible reasons for the effect of vertical urban surfaces on outdoor thermal comfort. The role of vertical surfaces in thermal discomfort remained unresolved, unobserved, unexplored and unapplied at the neighborhood scale. Vertical surfaces are unobserved by conventional remote sensing technologies and usually only top of the structure is considered when it comes to the study of urban heat islands studies. The research will contribute to understanding the causes and potential countermeasures to mitigate the urban heat island effect, increased temperature in neighborhood open spaces and facilitate integration of architectural, and neighborhood scale climatology to enhance climate sensitive urban and architectural design.

Keywords:- *Urban heat island effect, thermal comfort, thermal discomfort, sun path, outdoor environment.*

I. INTRODUCTION

"Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation" [1].Vertical surfaces will keep increasing day by day since people are migrating to cities. These surfaces gives out substantial amount of heat transferred, reflected or radiated through the windows, ventilators, exhausts, walls etc. It makes outdoor environment warmer or colder than required. These vertical surfaces also contributes to urban heat island effect. It affects environmental quality of outdoor spaces, leading to human heat stress, particularly in summer conditions. The consequence of the urban heat island effect also includes the reduction of the efficiency of human being in outdoor environment. Architecture plays an important role in human thermal comfort levels. It is important role for an architect to create habitable outdoor spaces so that they improve the outdoor activities. User experience of space is greatly affected by the thermal comfort level of that space. Metropolitan cities and city squares are facing challenges of increased heat at microclimatic scale. Cities are facing challenges to mitigate the environmental impact due increased surface area of buildings [2].Due to thermal discomfort people have declined the use of public open spaces. Lots of public spaces became *dead spaces* during the daytime. Merely because there are not habitable. Which creates cultural gap due to lack of interaction between people in outdoor areas which also affect the neighborhood livability, street life, outdoor activities etc. The professionals such as Architects, landscape architects, urban designers should intervene in these situations to make cities habitable to live. Innovative approaches to urban open spaces will become more important as the Indian population is becoming more urban. Research and solutions are focused mainly on the pollution, greenhouse gases, burning of fossil fuels for urban climate change, whereas the whole surface area of a building contributes to the heat emission in higher quantity. Design of vertical surfaces will show designers how to work to create climatically habitable spaces for human activities. With remarkable clarity, it covers both the scientific background and the design techniques needed for shaping spaces that increase comfort and reduce energy consumption.

This paper aims to study the effect of vertical urban surfaces on human thermal comfort in outdoor environment in case of Delhi.

To achieve the above aim, following objectives and methodological steps were undertaken.

In the first stage, survey is conducted to understand the possible reasons of thermal discomfort in various parts of the city, it is then compared with comfort level of the city achieved through *psychrometric chart* from the software 'climate consultant'. Comfort level of people and their experience were studied through interviews and structures questionnaire. In the second stage, neighborhood scale study is done by analyzing sun path to understand surface height to the width ratio and surface orientation. This research is limited to urban open spaces adjacent to buildings in case of the composite climate of Delhi. Study is not oriented towards the surface material characteristics like thermal transmittance i.e.

U value, conductance i.e. K value, reflectance etc. Aspects like design and orientation of surface are focused.

II. AREA OF THE STUDY

New Delhi the capital city of India located between the latitudinal extent of 28°23'17"–28°53'00" N and longitudinal extent of 76°50'24"–77°20'37" E and covers area of 1484 sq.km. With an average altitude of 213-305m above mean sea level [3].Location and area is important for sun path study. Maximum temperature in summers goes above 43°C and minimum temperature goes below 3 °C. The temperature difference of close to 40°C, makes it difficult for user make themselves comfortable in outdoor environment.

III. BACKGROUND LITERATURE

Thermal comfort can be broadly divided into two main categories, physical comfort and psychological comfort. Physical comfort deals with the body and psychological comfort deals with the mind and thinking of the user. Physical and psychological discomfort thus affects the spatial experience of the user. In different weather conditions, people's response to microclimate will vary, even if only subconsciously, leading to a different uses of these open spaces. Thermal comfort of outdoor spaces was always been a challenging aspect for composite climate of Delhi. From historic times we have seen various methods to counter the thermal discomfort in neighborhood areas. These methods includes the provision of water bodies, green areas, vegetated areas etc. Due to urbanization these natural areas are reduced in size. Provision of water bodies and vegetated areas is now difficult to accommodate in the neighborhoods. This resulted into higher temperature in neighborhoods. Cities gives out substantial amount of heat back to the nature which resulted into urban heat island effect, if we see it on a broader scale.

Impact of urbanization: Cities were initially consisting of buildings and open spaces. Open spaces are keep reducing as time is progressing. Past few years' urbanization has progressed rapidly. "Cities act as sources of heat and the effect of pollution is seen in the thermal structure of the atmosphere above them" [4].

Fig 1:- NASA MODIS satellite image from January 4

Field survey: Survey was conducted in different parts of the city. Opinion was taken from different levels of the society with various occupations. The survey was done in the areas where building heights are less than 12 metres. It is useful for the study to understand the amount of vertical urban surfaces contributed by these structures.

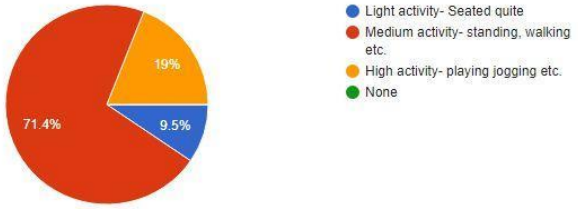

Fig 2:- current outdoor activity level

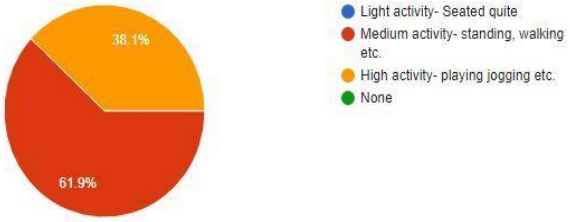

Fig 3:- Activity level user wish to do

Figure 2 and figure 3 compare the activity levels citizens currently and wish to do. As per current scenario it is difficult for user to perform high level activities such as playing, jogging etc. in the outdoor environment.

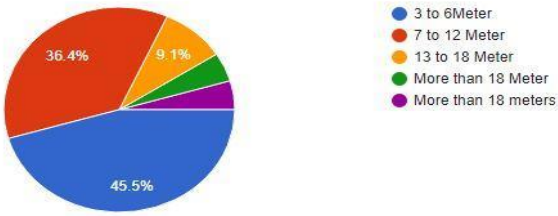

Fig 4:- Height of surveyed buildings

Fig 5:- probable reasons for thermal discomfort

According to the residents of various parts of Delhi neighbourhoods, 45% people say that the reason for thermal discomfort is the incoming sunlight heats up the outdoor

ISSN No:-2456-2165

space. The reason can be *the urban heat island*. 20% people says that building surfaces gives out heat in the form of reflection, transmission and radiation from the building surfaces. Building wall thicknesses, materials, material properties, building orientation can be the probable reason. 20% people says that too much or too less air movement around the buildings. Remaining 15% people have various other reasons.

To analyse the user survey the facts are studied in the form of psychrometric chart to understand actual thermal comfort level in the city.

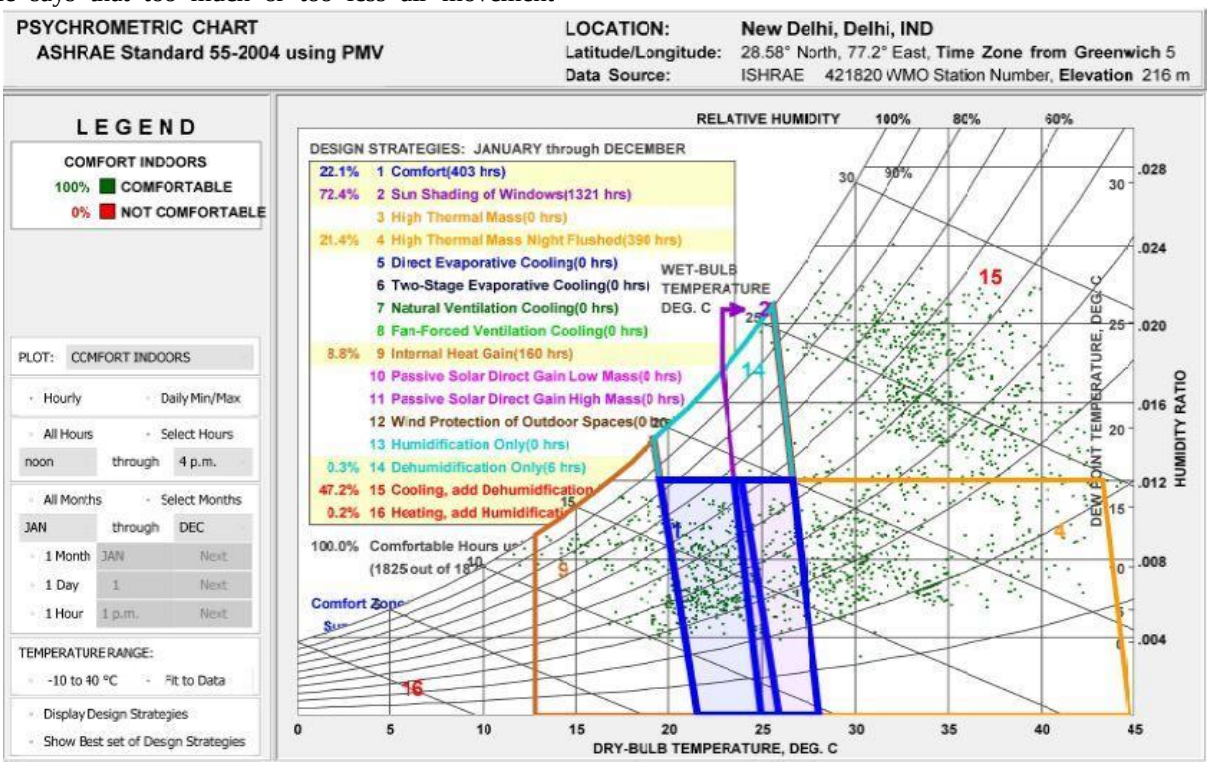

Fig 6:- Psychrometric chart for New Delhi

From the psychrometric chart it is evident that the city has comfort level of only 22.1%. With most of the green dots in the zone of higher humidity and temperature levels. Heat gain or loss in buildings is through walls, roof, ceiling, floor, and glass etc. i.e. the building fabric of envelope. The load due to such heat transfer is often referred to as heat gain or heat loss. It is possible through outer walls of the structures. In case of sunlit wall, the heat gain of the room will be more in comparison to a shaded one. The heat load in buildings are due to the direct sunlight through south-west direction. Maximum the surface area perpendicular to the solar radiation, more the heat gain through the surface. Maximum heat may occur on the surface during noon and due to the time lag it will reflect back to adjacent areas after few hours.

Heat transfer: Majority of heat transfer takes place in buildings through building envelope. Envelope consists of walls, roof, fenestrations etc. Heat transfer through materials takes place by conduction from warm to cold side. This process takes place inside as well as outside the buildings. The heat gained through building surfaces is transferred to adjacent spaces through conduction. When the heat is transferred by air or water, this is called convection [6].The convection depends on the speed of the passing air.

Sun path analysis: The longest day of the year, highest sun altitude is at 84.92 (on 21st june) and on the smallest day of the year, highest sun altitude is 38.11

ISSN No:-2456-2165

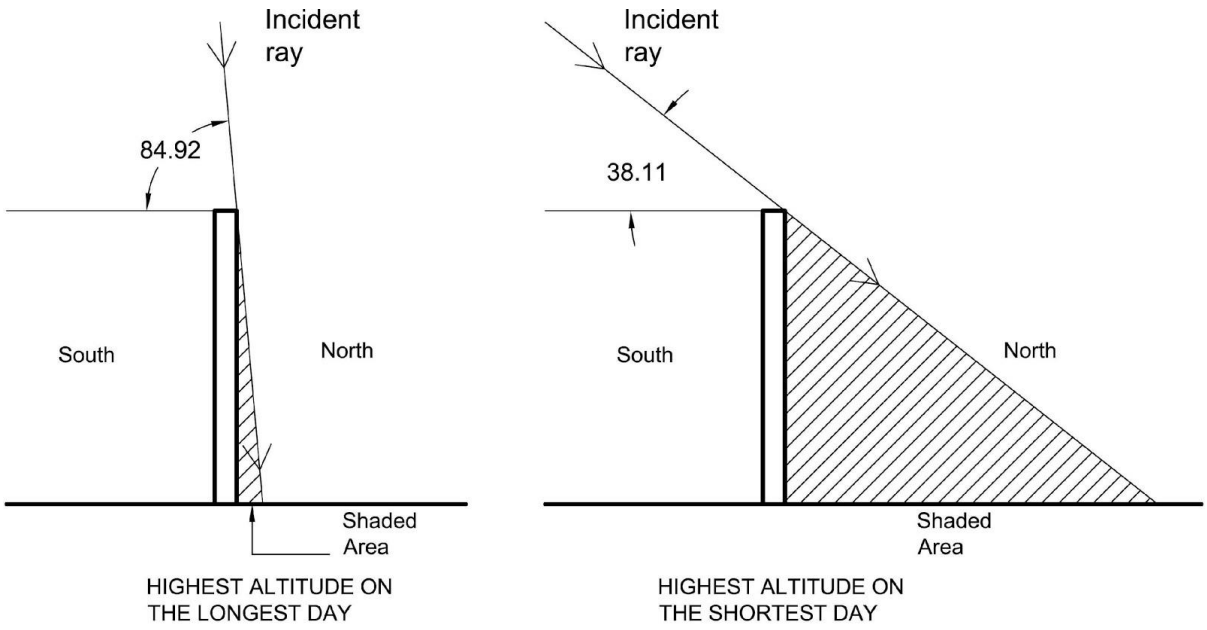

Fig 7:- Comparative sections of summer and winter sections showing shaded are at highest altitude of sun.

Results: Ratio of height to depth of shade is minimum 1 : 0.090 in summers and 1 : 1.275 in winters. To achieve the openness of the space, horizontal projection or shading device on the top of the space can be avoided. It is not always necessary to cover a space on top to protect it from direct sunlight. Height to width ratio also determines the shaded portion of the open space. As we go towards winter season the altitude of the sun goes down in the direction of horizon. As a result the depth of shade increases during winters. The depth of shade decreases during summers. But it can be observed that for the latitude of the city sun altitude is never on the top of head i.e. 90 °. Which is a positive point when it comes to shading the space only with vertical surfaces.

Surface orientation of building: Exposure of walls to the sunlight affect the heat gain. The amount of heat gain will result into heat transfer to the adjacent open spaces. From the sun path analysis it is evident that the maximum heat gain is between 12 pm to 3pm. When sun position is in south-west direction of the structure. By standard it is not preferred to have building surfaces perpendicular to the direction of sunlight. That is the reason orientation of building surface towards south-west should not be preferred. North facing surface will never receive direct incident sunrays keeping it cooler than other surfaces which will radiate very less amount of heat to adjacent open spaces. Whereas, the surfaces which are facing south-west and south direction will consume the heat throughout the day and radiate back to adjacent spaces even after the sunset which makes these spaces difficult for user.

Results: South- west facing direction of vertical surfaces should be avoided or reduced. It not only opens up the space to harsh direct sunlight during afternoon hours but also allows the surfaces to gain heat which will ultimately reflect and radiate back to the open space after few hours. On the other hand, if space is open to north, east or north-east direction, then the space is shaded from the vertical surfaces located on south, west or south-west direction. Also, the space will not receive any radiation from vertical surfaces since there won't be a heat gain through these surfaces.

Wind movement and humidity: Average annual humidity is 54.3%, and average monthly humidity ranges from 33% in May to 73% in August [7]. Wind movement study of neighbourhood areas is important to analyse the wind circulation. Over the last 18 years, the average relative humidity has increased from nearly 56% to over 61%. Increase in moisture content in air traps particulate matter. The wind speed over the last 18 years has increased from 2.1 m/s to 2.8 m/s. but in the last five years it has declined, making it difficult for particulate matter to disperse [8].

IV. RESULT

To maintain the thermal comfort of outdoor areas, building surfaces can be oriented and placed in such a way that it allows sufficient wind movement which will not allow the amount of moisture to build up.It will reduce level of thermal discomfort. Emphasis can be given on the spacing, orientation, height and profile of vertical urban surfaces.

V. CONCLUSION

The study clearly establishes the impact of vertical urban surfaces on amount of shade, exposure to sunlight and ultimately the thermal comfort. This study mainly focused on shading, in order to make the urban outdoor spaces thermally

comfortable. The height to width ratio of the built environment and surface orientation affects the thermal comfort level. The research found that the height to open space ratio can be handled positively to achieve required thermal comfort. The study can help designers in formulating the parameters that help in creating thermally comfortable outdoor spaces.

REFERENCES

[1]. Thermal environmental conditions of human occupancy, ANSI/ASHRAE Standard 55-2013:3-4.

[2]. Riffat S., Powell, R. Aydin, D., Future cities and environmental sustainability, Future cities and environment (2016): 1.

[3]. Maps of India, The states reorganisation Act-1956, ministry of Law and Justice (India).

[4]. Oke T.R., street design and urban canopy layer climate, Energy and Buildings, 1988, volume 11, issues 1-3: 32.

[5]. Oke T.R., The energetic basis of the urban heat island, Q.J.R. Meteorological society 1982, 108, 1-24.

[6]. Incropera, Frank P., DeWitt, David P., Fundamentals of heat and mass transfer (3rd edition), John Wiley and Sons. ISBN 0-471-51729-1. (1990): 28

[7]. Forecast of Delhi (Safdarjung station), meteorological department of India.

[8]. More humidity, low wind speed wrecked Delhi air', The Times of India (Delhi), 8th July 2018.