# URBAN GEOMETRY AS A DETERMINANT OF OUTDOOR THERMAL COMFORT

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## DECLARATION

I declare that this dissertation represents my own work, except where due acknowledgement is made, and that it has not been previously included in a thesis, dissertation or report submitted to this university or to any other institution for a degree, diploma or other qualification.

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Ranasinghe, D.S.

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## ABSTRACT

Architecture through the time has been an important factor that facilitates life styles and environment. The challenge for architects is to create psychologically and physically comfortable indoor and outdoor spaces. The outdoor public spaces have become the heart of the civic life of the city where people carry out their activities that binds a community.

All the spatial scales in the built environment obeys to rhythms and major forces, which enforce their laws that must be learnt and respect (Bouillot, 2002). The success of these spaces, especially urban public spaces is depending on many factors, of which, the level of thermal comfort is seen as an important aspect. Although the equatorial life is partly outdoor phenomenon, the modern urban design has failed to facilitate such living in a climatically pleasant manner.





Recent studies worldwide have indicated that the influence of densely built urban areas on the formation of urban climatic conditions and particularly on the determination of the microclimate. The evaluation of influence of urban geometry on the microclimate and the human comfort in urban spaces in such areas are among the main aims of the research project. It will also be useful to reveal misreferences, state recommendations and supply tools and tracks for the design.

Nowadays it is more than evident that improving the quality of life in urban centres does not require only successful buildings. It also requires climatically sensitive urban public spaces which could enhance and enrich the urban life.

URBAN GEOMETRY AS A DETERMINANT OF OUTDOOR THERMAL COMFORT

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# INTRODUCTION

## INTRODUCTION

Architecture is the symbol of a civilization. "*...without an architecture of our own, we have no soul of our own civilization*" - Frank Lloyd Wright

Dwellings or houses have been one of an essential need of man since the early civilizations. During that pre-historic stage, the most essential architectural space (Relph, 1976) for them is their houses.

As Moore (1993) states, the primary housing unit is the shelter. The main purpose of the shelter during that time is to reduce the range of local climatic variations. Therefore, the 'house form' was varied with the climatic conditions. The Sri Lankan *village house*, Eskimo *Igloo*, North American Indian *Tipi*, Mongolian *Yurt*, *Matmata* dwellings in Sahara, dome hut of Banbuti Pygmies etc. (Moore, 1993) are fine examples for the climate responsive house forms.

**Fig. 1**- The Mongolian Yurt

**Fig. 2** - Sri Lankan village house

Rapoport (1969) states that, in architecture, climate is only a modifying factor and the determinant factor should be the culture. "*The responses vary from place to place because of changes and differences in the interplay of social, cultural, ritual, economic and physical factors. Also with the passage of time*" (Rapoport, 1969: 46)

However, anywhere in the world, the vernacular architecture was emerged as a response to the climatic conditions in its form and the use of materials. Cultural matters were considered as secondary generators. The cultural and other psychological matters dominated architecture after the man started to control the nature.

> *"Instead of building walls of local bamboo, which is closely spaced to keep out rain while admitting light and air, the white man put up solid walls to keep out light and air and then cut windows in the walls to admit the light and air. Next, he put glass panes in the windows to admit light but keep out the air. Then, he covered the panes with blinds and curtains to keep out the light too"*
>
> (Moore, 1993: 39)

This statement illustrates how the western thinkers have adopted various mechanical means neglecting the passive design methods. Those were the results of the centuries of trial-and-error experiments by the tribes. Those mechanical systems have made us consume more energy as well as many environmental hazards.

The reason for the extensive use of energy is to make the space comfortable physically. People are always in demand for comfort. Thus main purpose of architecture is also to make people comfort physically as well as psychologically. The thermal comfort level of a space facilitates better physical or bodily experience. Thus, it facilitates the expected spatial quality. These are valid for any architectural space (Relph, 1976) regardless of its location - indoor or outdoor.



## OBSERVATION

Contemporary designers are more concerned on the psychological comfort of the space or the beautification of the space. Especially for a tropical country like Sri Lanka, that "beautification" is inadequate to provide a better spatial experience. Therefore, it is a challenge for the architect to create functional, comfortable, lightly ventilated and pleasant interior and exterior spaces creating beautiful objects and places.

Recent studies worldwide have indicated the great influence of densely built urban areas on the formation of urban climatic conditions and

particularly on the determination of the microclimate. This has always been true to the Sri Lankan context as well. Some urban areas in Sri Lanka, especially Colombo Metropolitan area, this phenomenon could be observed clearly.

Due to the thermal discomfort in these urban outdoors people decline to use these urban spaces. Lots of public spaces have become "dead spaces" during the daytime; merely because of they are not habitable. These spaces create "voids" in the middle of urban settings deteriorating the urbanity of the city. It also affects Neighborhood livability, street life, social interactions between neighbors and level of outdoor activities etc. (Hafiz, 2002)

The transformation in "urban physical environment" has made a physical discomfort in the area. This chaotic urban situation is a result of unskilled handling of buildings and open spaces. These haphazard developments have caused many negative effects such as blocking wind flow patterns, retaining heat etc. As a result, the cities have become warmer places than the surrounding rural areas, creating an *Urban Heat Island*. This has affected the urban microclimate and the urban quality of life as well. In addition, the mechanical systems should be utilized to achieve thermal comfort consuming more and more energy.



This is a very crucial subject area, which should be taken in to consideration seriously because in the future, it may be a danger to the humankind as well. The design professionals such as architects and urban designers should intervene in these situations to make cities a healthy place to breathe.

## JUSTIFICATION

> *"Architecture is a physical, emotional and intellectual experience. It facilitates man's bodily comfort, emotionally attaches him in to it, and, as a work of art, through symbolic communication leads to him towards a higher realm of contemplation"*
>
> (Kulatilake, 1994: ii)

It states that the architecture should be experienced in all senses covering both physical and psychological experience. Human mind experiences it psychologically and human body haves it physically. In physical experience, the warmth or the temperature of a space contributes more to the spatial experience. That is called the '*Thermal Comfort*' of a space. An architectural space (Relph, 1976), which has a good thermal comfort level, facilitates desired spatial experiences.

*"All architecture is shelter, all great architecture is the design of space that* ***contains, cuddles, exalts*** *or* ***stimulates*** *the persons in that space"* (Johnson, 1990). According to above words the architecture of a particular space – interior or exterior - should "contain, cuddle, exalt and stimulate" the people in that space. That should be the purpose and the ultimate goal of architecture. Therefore, the architectural space (Relph, 1976) should be a pleasant place, physically and psychologically to accomplish that goal.

The recent trend in the Sri Lankan urban context as cited in the previous chapter is towards a haphazard development. This has caused many chaotic situations, especially in the urban microclimate. High air temperature, excessive relative humidity, zero or low wind speed etc. has deteriorated the urban microclimate.

As Basnayake (2002) explains, a healthy urban environment is vital for genuine urban renaissance and at the same time, it caters as a healing space for the majority of urban dwellers. However, the "**physical discomfort**" is a barrier for the people to experience and make use of the urban space. It may affect the people negatively, since it avoids interaction with other

people, which is essential for human habitation. Converting those spaces to thermally comfortable will fulfil the primary need for usage.

Therefore, it is now the time for design professionals to interfere without hesitation and correct these trends to rejuvenate our outdoor spaces and make a healthy urban physical environment

## INTENTION OF THE STUDY

Intention of this study is to examine the role of urban geometry or urban morphology in the provision of thermally comfortable outdoor spaces. In doing so, it will develop urban shading patterns that facilitate climate conscious urban design in the equatorial tropics, with special reference to Sri Lankan urban contexts.

## OBJECTIVES

- Find out ways to utilize the urban geometry as a shading device or Shadow Umbrella to enhance the urban thermal comfort.
- Discuss the impact of shading on the outdoor thermal comfort.



## HYPOTHESES

- *Shading or shaded spaces have a positive effect on the thermal comfort level of the people using those urban spaces.*
- *The manipulation of urban masses and increased height to width ratio of the built mess increases the level of thermal comfort.*
- *The orientation and the ratio of building height to the width of the streets considered can be consciously modified in order to achieve thermally comfortable urban space.*

## SCOPE & LIMITATIONS

Architecture is for people. Therefore, architect should provide the people with sufficient physical and psychological comfort. Thermal comfort contributes for physical comfort mostly. Therefore, the thermal comfort is essential in indoors as well as outdoors.

This study is mainly focussed on urban outdoor spaces. In a tropical country like Sri Lanka, outdoor spaces are used extensively. In addition, it is more important, because it is not feasible to regulate outdoor climate mechanically.

In the equatorial tropics the best approach to thermal comfort is reducing radiant heating of the environment. This can be achieved by various strategies. However, ***shading*** is the primary and most effective strategy (Emmanuel, 1993b; Givoni, 1998). Other strategies should be implemented in the light of shading.

The primary tool to achieve shading is urban masses. The study will explore the relationship between urban geometry and the outdoor thermal comfort. That means the building morphology (mass, height, orientation etc.), urban density, street lay out, height to width ratio etc. or in other words urban geometry.



In addition, computer software will be used to simulate the shading patterns and thermal comforts in various urban geometries. The thermal comfort will be simulated using "DEROB-LTH" software, which is designed for indoor use. Therefore, the dummy materials should be used for sky and the roads. In addition, ventilation is disregarded.

Urban space consists of streets, squares & blocks. Since the study is on human thermal comfort, it is more appropriate to consider spaces mostly used by people. Therefore, the shading of pedestrian paths are considered.

Though Sri Lanka does not have much variation in climate (Emmanuel, 1993b; Koenigsberger, 1974), it has very slight variations during some periods. The study is carried out for the hottest period of the year, i.e. **April** and **May**. And the thermal comfort levels are simulated for emphasize the hottest times of the day.

## METHOD OF STUDY

The study will be a **research-based simulation study**. The objective is to evaluate the effects of the "building geometry" on the outdoor thermal comfort by **manipulating urban form**. Therefore, after setting the theoretical background and hypothesis for the study, research work is carried for a selected urban setting.

A field survey will be carried out in the selected area to measure the actual temperature data. Those data will be compared with the simulated data to develop an equation in order to calibrate the simulated data in the future.

The main parameters for urban forms are its height to width ratio and the orientation of the building. The shading patterns for the modified urban settings are calculated on computer using AutoCAD with 3 D models. Since this is a simulation study, the required period of the year and time is achievable. The modelled urban masses are simulated to obtain the shading patterns in relation to their geometry.



After that those modified urban settings are simulated further to evaluate their thermal comfort levels. That work is also carried out on computer using parametric building energy simulation programme called DEROB – LTH, which is capable of analysing simulated environments thermally. The temperature levels will calibrate using the previously developed equation.

Finally, urban design implications and conclusions are drawn upon the comparisons of comfort levels for changes in shading patterns and built masses in accordance with the derived hypotheses.