THERMAL COMFORT MODELING ON URBAN STREETS

Lakmini Mendis[1], Amila Jayasinghe[2], Chethika Abenayake[3]
Department of Town & Country Planning,University of Moratuwa, Sri Lanka.
[1]lakmini.mendis@gmail.com, [2]amilabj@uom.lk,
[3]chethika@uom.lk

ABSTRACT - "Walkability" is a vital constituent on Urban Streets and is a sustainable transportation mode for pedestrians in highly urbanized cities. Psychological comfort of pedestrians is predominantly defined by enhancing walkability on urban streets. Thermal comfort is one of the key attributes for pedestrian comfort and wellbeing. This study considers thermal comfort on urban streets in assessing, walkability by considering the Thermal Heat Indexes (THI) and investigating the Predicted Mean Volt (PMV) values. Empirical data were analyzed and discussed the behavior of measured Air Temperature and Thermal Heat Index (THI) values of selected urban streets. To explore the thermal comfort levels on streets, ENVI-met 4.1 computer simulation and analyzed data on Air temperature, Mean Radiant Temperature (MRT) and Predicted Mean Vote (PMV) values were used. According to the empirical Data, the THI value is higher on Location 01-Main Street than other urban streets. As per the results of the ENVI-met computer simulation, the changing Building Height scenario indicates a significant effect on the thermal comfort as opposed to the tree lines along both sides of the street. Findings from this research express that increasing building height and increasing tree density by proposing a large expanse of vegetation along streets is significantly associated with the thermal comfort conditions on urban streets and enhance the level of walkability as an effective green transport mode.

Keywords: Thermal Comfort Levels; Urban Street; Walkability; THI values; PMV Values

1. INTRODUCTION

In recent decays "walking" had been acknowledged as a vital sustainable transport mode. It provides numerous social and health benefits and assist to mitigate the greenhouse gas emissions by reducing traffic congestion on urbanized cities. One of the main issues is to decline of walking from human being is the psychologically discomfort by walking due to the heat stress. (Kahina Labdaoui, 2021) It is essential for cities to focus more on walking than centering on automobile usage due to the rapid urbanization and the climate change disputes. This "Ecological urban transport" strategy has created an automobile-independent society and makes cities Greener. As an outcome, "walking" has gradually increased as a Green efficacy mode of transport in highly urbanized cities. (Nassima Mouada, 2019)

Therefore, it is crucial to achieve thermal comfort conditions on urban streets to enhance walkability as a new green transportation mode especially in tropical countries. The main aim of the study is investigating thermal comfort conditions on urban streets in assessing walkability by considering the THI and PMV value which is an index to predict the average vote of a vast set of people on the "seven –point thermal sensation /feeling scale" on different urban planning strategies.

ISSN: 2513-2504

2. MATERIALS AND METHODS

2.1. Site Selection

Urban streets (as in Figure 1) were selected from the Pettah, Colombo, Sri Lanka within the same microclimatic condition for the study to explore its thermal comfort levels which requires to enhance walkability.

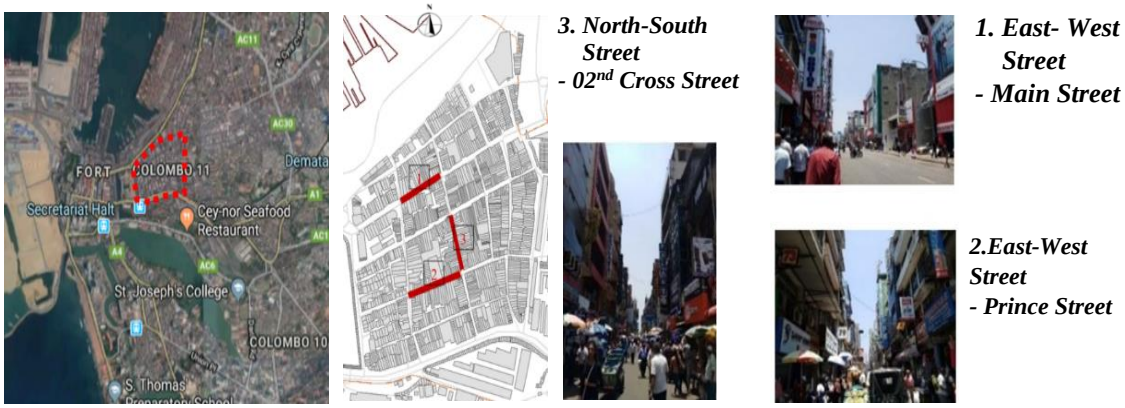

Figure 1. Selected Urban Streets in Pettah

2.2. Methodology

Fore mostly, field measurements were marked on 27th March 2019 using Hobo meters and Wind Anemometer to measure Air Temperature and wind speed on urban streets during 11.00 a.m. to 1.00 p.m. and during 4.00 p.m. to 6.00 p.m.at 1.5m level on selected streets. Measured an air temperature on a reference point for the accuracy of Thermal Heat Index (THI) values. Comfort levels on the urban street was analyzed according to the comfort limits. Secondly, executed the Numerical simulation modeling using ENVI-met 4.1 software. Data on air temperature and Mean Radiant Temperature (MRT) on selected urban streets were obtained from the urban simulation modeling with the respective base line condition. The baseline condition of the street was referred to the simulated values for the daytime (13:00h) and night time (21:00h) based on the empirical data. Then, investigated the thermal stress by interpreting the calculated Predicted Mean Vote (PMV) at the level of 1.5m for the Day time 13:00:00h and the night Time 21:00:00h respectively by preparing relevant graphs by using the Leonardo 2014, of selected urban street (Main Street). The PMV values were obtained using BIOMET V1.01. Use the Thermal Sensation Scale which introduced by the Franger to evaluate the comfort levels. Different scenarios were simulated and investigated thermal comfort levels by assessing PMV values. Scenario 01: Existing Situation: Scenario 02: Alternative Green – Adding Tree Lines for both sides of street; Scenario 03: Changing Building Heights. (Low rise – 03 storied, Intermediate Rise – 08 storied, Medium Rise-12 storied and High Rise-14 storied)

3. RESULTS AND DISCUSSION

3.1. Results on based on Field survey / Empirical Data

According to Figure 2 the THI values were higher than the $26C^0$ during the time of 11:00h to 13:00h. on all streets. All selected urban streets were uncomfortably hot at the time period of 11.00h. to 13.00h as well as the time of 16:00h. to 18:00h. However, the lowest THI value illustrates on the East –West Urban Street – Prince Street among all streets during the measured time on 11:00h to 13:00h. The highest THI value was indicated from the East –West Urban Street- Main Street during the time of

11:00h to 13:00h and also that street indicates the lowest THI value compared to other urban streets during the time of 16:00h to 18:00h.

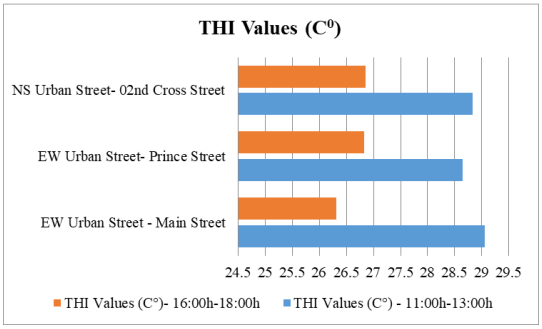

Figure 2. Thermal Heat Index values (THI values) of selected urban streets.

3.2. Results on Thermal comfort Numerical Modeling (ENVI-met Modeling)

3.2.1. Simulated Predicted Mean Vote Values (PMV)

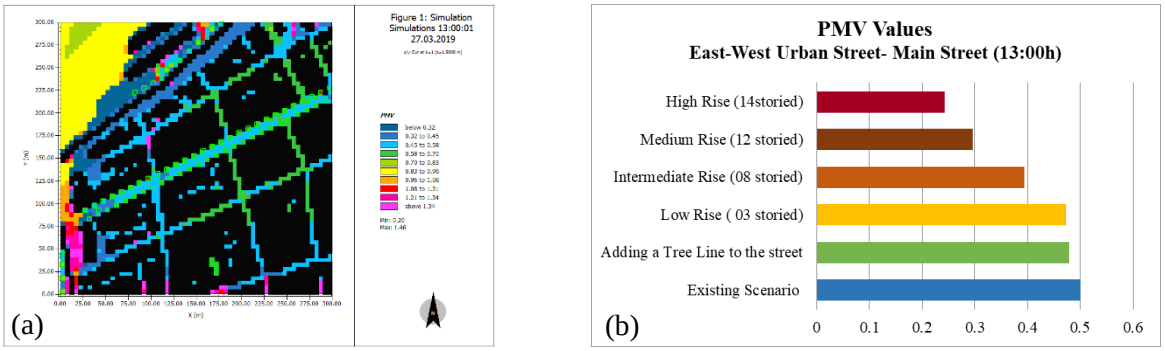

Figure 3. PMV value map for (a) A Tree Line along the Street and (b) PMV values on 13:00h

As shown in Figure 3(b) the Increasing of Building height scenario-High Rise case illustrates the lowest PMV values than other scenarios at the Day time (13:00:00h) as well as to the night time (21:00:00h). According to the "Thermal sensation scale" this PMV value was indicated as much comfortable for pedestrians as opposed to other scenarios.

4. CONCLUSION

In conclusion, there have a massive effect on increasing of building heights on an urban setting by achieving the thermal comfort levels on urban streets. Hence, it is vital to develop shadow massing (Shadow umbrella effect/shading from surrounding buildings) when creating or enhancing urban streets for pedestrians as an effective Transport mode. Moreover, it is essential to have careful attention on vegetation on urban streets when achieving better thermal comfort levels on urban streets.

REFERENCES

1. Kahina Labdaoui, S. M. (2021). The Street Walkability and Thermal Comfort Index (SWTCI): A new assessment tool combining street design measurements and thermal comfort. Science of the Total Environment, 1-54.
2. Nassima Mouada, N. Z. (2019). Urban morphology, outdoor thermal comfort and walkability in hot, dry cities. SPSD, 117-133.
3. R. Emmanuel, H. a. (2007). Urban Shading- a design option for the tropics? A study in Colombo, Sri Lanka. International Journal of Climatology. 1995-2004.