

REVITALIZING THE ELECTRONIC HUB OF CHENNAI BY IMPROVING THE OUTDOOR THERMAL COMFORT

A Thesis

Submitted in partial fulfillment of the requirements for the award
of
Master of Architecture degree in Sustainable Architecture

by

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**DEPARTMENT OF ARCHITECTURE
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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MAY 2022



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BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **SHWETHA M (40890017)** who carried out the Thesis entitled “**REVITALIZING THE ELECTRONIC COMMERCIAL HUB OF CHENNAI BY IMPROVING THE OUTDOOR THERMAL COMFORT**” under our supervision from January 2022 to May 2022.

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A handwritten signature in black ink, appearing to read 'M. Shwetha', with a stylized flourish at the end.

SIGNATURE OF THE CANDIDATE

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ABSTRACT

Thermal comfort is one of the most important variables that contribute to a better environment and society's well-being, which impacts social, environmental, and economic values. The rapid change in climate and rise in temperature in metropolitan areas has an impact on outdoor spaces. The goal of the study is to revitalise a commercial hub by studying the effects of architectural parameters and climatic elements on the outdoor thermal environment. The study focuses on built geometry elements such as the Sky view Factor and H-W ratio, which influence the outdoor setting.

Outdoor thermal comfort indicators like physiologically equivalent temperature (PET) which can offer detailed information on how this environment performs thermally in outdoor locations, are examined using micro meteorological measurement and outdoor thermal comfort indices. Using a data logger and a hand-held anemometer, micro meteorological measurements such as air temperature, relative humidity, and wind speed were recorded. ENVI-met and RayMan software are used to calculate physiological equivalent temperature and mean radiant temperature. A proposed scenario was developed and analysed by adjusting the sky view factor, plant cover, and aspect ratio. The thermal performance of existing and proposed outdoor spaces was evaluated, and a link between building parameters and outdoor thermal comfort was examined.

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LIST OF SYMBOLS AND ABBREVIATIONS

T_a	-	Air Temperature
T_{mrt}	-	Mean Radiant Temperature
RH	-	Relative humidity
PET	-	Physiological equivalent temperature
SVF	-	Sky view factor
H-W	-	Height to Width ratio

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Micro-climate or climate change is greatly influenced by the urban built environment and anthropogenic heat which results in increased temperature and this results in urban heat island effect. The changes in the micro-climate affects the outdoor spaces where these areas help in social interactions, environment and economic concerns and crucial element for connecting people to their built environment. Discomfort affects the usage and success of urban places. Various studies show the urban morphology such as building geometry, density, greenery affects the outdoor thermal performance. In the urban scenarios, the diversity of shape, size, composition and arrangement of building changes the thermal and wind flow within the canyon. The influence of the urban morphology on the outdoor thermal comfort in the hot-humid climate is reported in several studies, for example, studies by (haninabdel 2020) comfort study on different urban pattern of Al-sharq city, variability on temperature influenced by urban landscape morphology (Sharifah) in hot-humid urban center of Malaysia. The effect of built geometry on micro-climate of Chennai, Impact of building regulations on the perceived outdoor thermal comfort in the mixed-use neighbourhood of Chennai, India. Most of these papers investigate the influence of urban morphology over the outdoor environment of hot-humid climate. In addition, these researches carried out in the urban streets, residential and commercial areas. Therefore, this study attempts to understand the impacts of morphology over the outdoor comfort in an institutional campus where outdoor spaces have a major role.

1.2 AIM

To revitalize the commercial hub by investigating the impacts of built parameters and climatic factors over the outdoor thermal environment.

1.3 RESEARCH QUESTIONS

- What are the impacts of urbanisation over the Outdoor spaces?
- What are the adaptive standards that can be considered to improve the outdoor areas?
- What is the impact on UHI by improving Outdoor thermal environment?
- What is the contribution of built geometry in augmenting outdoor thermal comfort?

1.4 OBJECTIVES

- To understand and investigate the chronological development over the commercial area
- To investigate the building morphology and other parameters affecting thermal performance of the existing area
- To bring up the design measures that could enhance the outdoor thermal performance
- To enhance a place that is easy to get to and move through

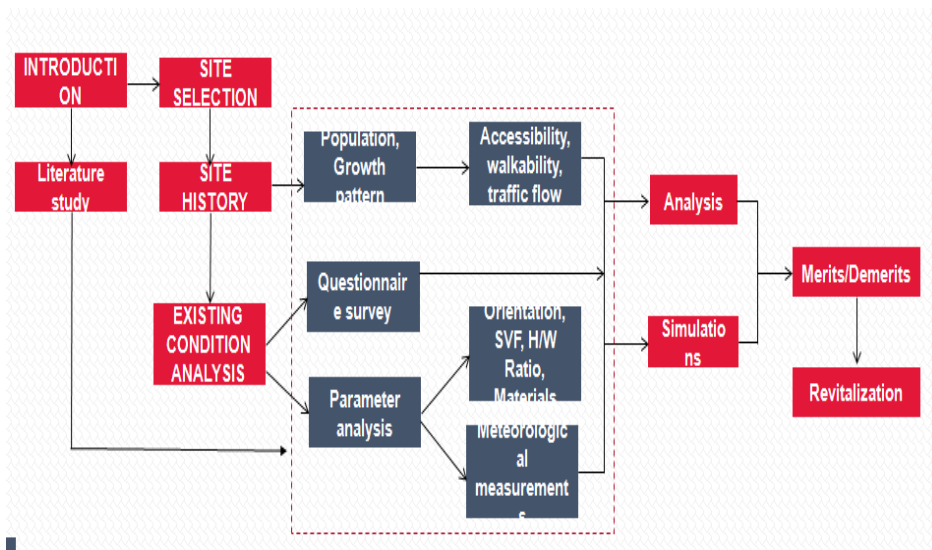
1.5 NEED FOR THE STUDY

Thermal discomfort in market entails strong economic repercussions. Despite being the shopping hub for agricultural products at affordable price, markets usually encounter a drop in sales figures due to discomfort since people generally tend to prefer to shop in an air-conditioned store at a premium. However, a well-designed market layout to mitigate the human perception of heat trap can boost the foot fall and sales. Outdoor thermal comfort plays a vital role in markets given the amount of time spent by the merchant occupants and the high influx of human traffic throughout the day. Hence, a meticulous design of market layout necessitates a strong investigation on the levels of thermal comfort

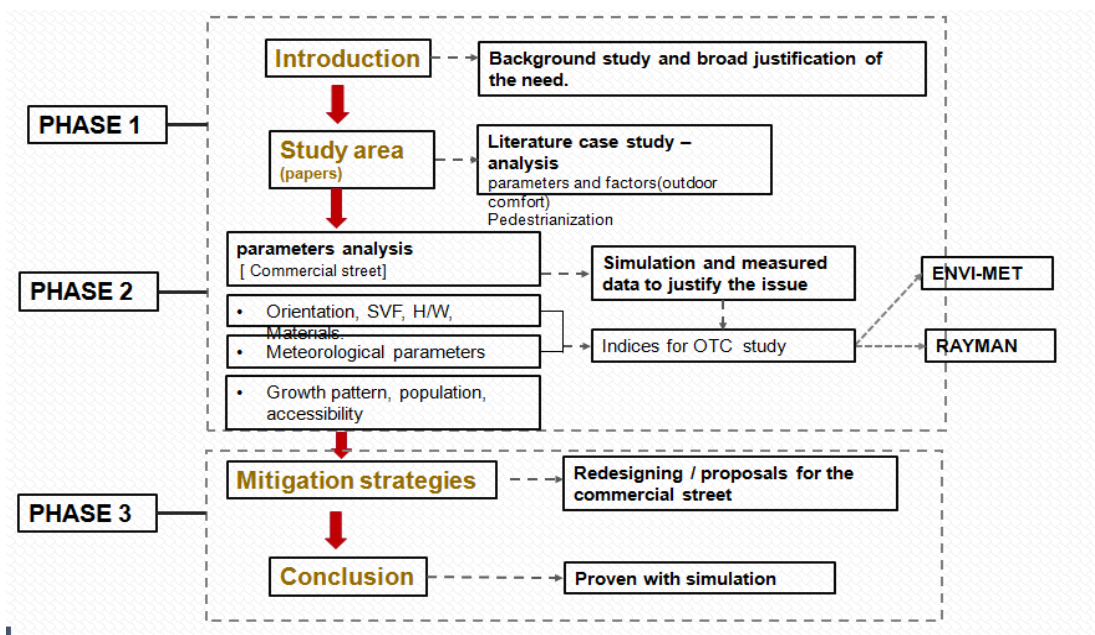
1.6 SCOPE AND LIMITATIONS

- The scope of the thesis is to bring forth the possibility to improve the quality of outside environment and promote character in the commercial street by responding sustainably
- Thermal comfort study is limited to an active commercial area of warm and humid climate and focuses on the outdoor thermal comfort parameters. Design alternatives concentrates on the results of the existing thermal comfort conditions & Social factors and not focuses on the economic factors

1.7 METHODOLOGY



1.8 DETAILED METHODOLOGY



CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND STUDY

Thermal comfort is defined as the ‘condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation’. Human comfort is influenced by all features of urban street canyons, varying from center to edge of the street. Therefore, to control the thermal environment in summer, shading is the key factor to improve the comfort in hot and dry climate. The aspect ratio is a physical factor of urban canyons, which affects the magnitude of UHI and affects microclimatic and outdoor thermal comfort conditions. Air flow and solar access in urban canyons are directly affected by the geometry (H/W ratios and L/W ratios) and orientation of streets, therefore affecting pedestrian temperature comfort. In an urban canyon, wider streets result in better mixing of air, thereby resulting in better airflow. The amount of solar energy absorbed by street surfaces (facades, roofs, and ground) is affected by the H/W ratio and the orientation of the street significantly influences the pattern of diurnal and seasonal irradiation of the street surface, and it is found to be more effective on vertical surfaces. The role of urban street canyons on outdoor thermal environments varies at various times of the year under diverse weather conditions. For instance, urban canyons transform from a nocturnal “heat source” on sunny days to a nocturnal “cold source” on rainy and cloudy days.

The appropriate H/W ratio depends on the type of neighbourhood, such as a higher night time temperature in commercial areas may be more acceptable than in residential ones. In several studies, an increase in aspect ratio has been found to result in a reduction in PET. SVFs represent the ratio between the visible sky and the hemisphere centered over the analysed location at a given point in space. The sky view factors include other objects such as trees, and obstructions in the urban canyon. It was found in a city that higher the SVF the more stressful is the outdoor environment. A low SVF, observed in humid subtropical climates with pronounced summer and winter seasons, resulted in improved summer comfort levels but worsened temperature conditions in winter in humid subtropical climates.

Orientation is another important physical parameter affecting the thermal environment. Few studies proved that North – South oriented street works better than the East-west oriented street. The physiological equivalent temperature is used to analyse the physical and climatic parameters to help improve the thermal comfort. PET is based on the Munich Energy balance Model for Individuals. Analyze the human thermal environment by considering both the meteorological environment and the thermo-physiological parameters, including the individual's energy balance. PET has the advantage of being calculated in degrees Celsius, over the other indices. PET is the equivalent temperature under a virtual indoor condition, which can be applied to a wide range of outdoor conditions. PET is recommended and used to forecast changes in urban or regional climates based on impacts on the thermal component.

2.2 DEPENDENCE OF OUTDOOR THERMAL COMFORT ON STREET DESIGN IN HOT AND DRY CLIMATE

The project aims to connect the theoretical knowledge of urban microclimate with the practical design process. The thermal condition in Canyon is intended to emphasize the variability of the thermal sensation within the street area.

This paper addresses the Aspect ratio, Orientation and Design details are all together used to calculate the comfortable microclimates at the street level during the hot – dry climate.

The major role of the vertical urban geometry and the solar orientation is to create a different microclimate within the canyon at street level. By creating the microclimate we can understand the effect on human thermal sensations outdoors and effect of street design on outdoor comfort. The combined effects of outdoor comfort in the summer and indoor solar access in the winter on the final design of an urban street.

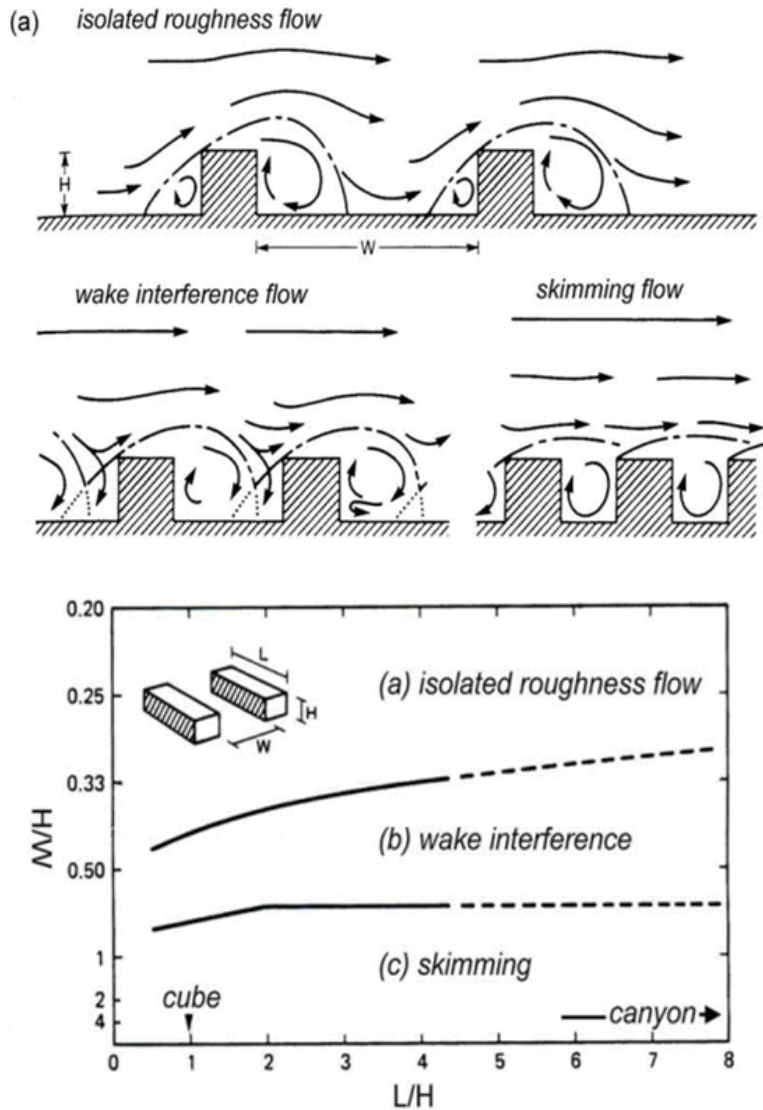
2.2.1 DIFFERENT PARAMETERS ANALYZED:

1. Solar Orientation – E-W, N-S, NE-SW, NW-SE
2. Height to Width Ratio is calculated for:
 - Simple geometry – Symmetrical profile (Shallow to deep canyon)
 - Complex geometry - Asymmetrical profile, galleries, overhangs, vegetation.High spatial and temporal resolution enables a fine understanding of the microclimate at street level
3. The model also requires relatively few input parameters to calculate all required meteorological factors, air and surface temperatures, wind speed and direction, air humidity, short-wave and long-wave radiation fluxes as well as the mean radiant temperature needed for comfort analyses.

2.2.2 WINDFLOW IN AN URBAN CANYON:

Wind is a secondary circulation feature within an urban canyon that is influenced by the above-roof dominant flow, which is largely determined by the street orientation and geometry.

1. **Isolated Roughness Flow:**
It happens between well-spaced buildings, when leeward and windward flows do not interact, similar to how wind moves around an isolated obstruction.
2. **Wake Interference Flow:**
Wakes are disturbed by increasing H/W, resulting in a wake interference regime.
3. **Skimming Flow:**
If the flow intensity is increased further, the street canyon becomes isolated from the above-circulating air, creating a stable circulation vortex in-canyon, resulting in a skimming flow.



2.2.3 SOLAR ACCESS OUTDOORS:

On canyon walls and floors as well as in a pedestrian model, investigated how irradiance varies with aspect ratio and orientation.

The study was conducted for:

- 0.25 to 4 – aspect ratio
- E-W and N-S street orientations for all latitudes and seasons.

Irradiation rates on the whole urban surface were determined by the ratio of H/W .

Surfaces in urban profiles become less exposed to the sun as they become deeper.

2.2.4 EFFECTS OF THE VEGETATION:

Modifying factor of local climate:

- Generally, the climatic advantages of urban vegetation are assessed either according to their effects on the meteorological factors (e.g. T_a , RH or v) or to

the induced energy savings in the buildings as a result of less cooling and/or heating loads

- In an urban structure, the effectiveness of the climate based on the vegetation depends on:
 - i) Green area ratio
 - ii) Built-up area
 - iii) Size
 - iv) Location
 - v) Plants characteristic (species, density, size, volume, age etc.,)

3 Main Properties:

- Shading
- Humidification(Evapotranspiration)
- Wind break

Spacing of vegetation:

- Larger parks with several hundred meters usually can lead to breeze
- Whereas in a small areas, it has been suggested that vegetation in several small areas with regular intervals are more cooling effective than on one large space.

2.2.5 FURTHER ASPECTS:

Nocturnal cooling and canyon surfaces:

Nocturnal cooling is related to the sky view factor and aspect ratio where in the night the long wave radiation from the canyon surface move towards the sky which has lesser temperature when height increases.

Importance of the pavement materials in the resulting heat fluxes and air-ground interface on summer days.

- Asphalt pavement emits an additional 150 Wm⁻² infrared radiation and 200 Wm⁻² sensible transport compared to a bare soil surface.
- The water content in a bare soil and thus the evaporation from it produces much lower surface temperatures. By contrast, waterproof soils such as asphalt, increasing thickness of the covering material increase the temperature and heat stored under the surfaces

2.2.6 RECOMMENDATIONS AND DESIGN EXAMPLES:

From a climatic point of view, shading is the key strategy for promoting comfort in hot-dry climate because it leads to:

- A reduction of the direct solar radiation absorbed by a standing person
- A reduction of the heat released by the surroundings, in particular the ground.
- A decrease of the air temperature as a second effect.

- i) A judicious combination of aspect ratios and orientation
- ii) By arranging galleries, planting trees, greening the facades or by using other shading devices for the irradiated wall and ground surfaces.

2.2.7 Designing a street is primarily conditioned by:

1. Street utility:

- Structural role of the street in the whole urban plan,
- Implying scale (i.e. absolute dimensions: width and height),
- Activity, and
- Usage (pedestrian streets or including motor traffic).

This has a direct impact on the period of time at which comfort is essential (frequentation time by people) and also the area of the street where comfort is at most required (whole area, edges, etc.).

2. Building Usage:

- In non-domestic buildings, comfort is mostly crucial during the daytime where day-lighting is the main concern.
- The potential of natural light is almost equal for all solar orientations and is much more sensitive to sky view, i.e. aspect ratio.

2.3 INDICES FOR THE STUDY:

Physiologically Equivalent Temperature (PET)

- Analyse the human thermal conditions taking into account both the meteorological environment and the thermo-physiological parameters including the human energy balance (Hoppe, 1993)
- The advantage of PET over other indices is that it is calculated in °C. PET is the equivalent temperature under a virtual indoor condition; it is applicable to a wide range of real outdoor conditions. PET is one of the recommended and is used for the prediction of changes in the thermal component of urban or regional climates.
- By using the Software RayMan developed by Matzarakis et al. (2007), PET can be calculated easily. PET results can be presented graphically or as bioclimatic maps.
- PET can be used as a single thermal index for analyzing various microclimates of large built environments like Airports and Railway Terminals.

PET Tropical Region °C	Thermal Perception	Grade of Physiological Stress
42	Very Hot	Extreme Heat Stress
38	Hot	Strong Heat Stress
34	Warm	Moderate Heat Stress
30	Slightly Warm	Slight Heat Stress
26	Comfortable	No Thermal Stress
22	Slightly Cool	Slight Cold Stress
18	Cool	Moderate Cold Stress
14	Cold	Strong Cold Stress
	Very Cold	Extreme Cold Stress

Table2.3.1 PET Scale – Grade of Physiological stress for Tropical Region

Types	Clo Values of various clothes					
Under Garments & Inners	0.05	Briefs				
	0.15	Vest (light)		0.29	Vest (heavy)	
Clothing above waist	0.14	Shirt short sleeve		0.22	Shirt long sleeve	
	0.25	T-Shirt short sleeve		0.29	T-Shirt long sleeve	
Clothing below waist	0.15	Shorts/Half pant				
	0.2	Capris				
	0.3	Jeans				
	0.26	Trouser light material		0.32	Trouser heavy material	
Winter Wears	0.3	Inner above waist		0.3	Inner below waist	
	0.2	Sweater light		0.37	Sweater heavy	
	0.22	Jacket light		0.49	Jacket heavy	
	1.5	Overcoat				
Others	0.5	Hat/Cap				
	0.1	Scarf/shawl				
	0.05	Tie				
	0.1	Socks till knee		0.5	Socks till ankle	
	0.04	Shoes	0.02	Sandal / Slippers	0.08	Boots

Based on ASHRAE Handbook of Fundamentals, 1989 and ANSI/ASHRAE Standard 55-2010

Table2.3.2Clo value for various clothes

External parameters (e.g. activity level, Clo value etc.) required for the thermal comfort conditions calculation can be obtained from this questionnaire survey.

Activity	Metabolic rate (W/ m²)
Sitting	1
Eating	3
Walking	2.6
Playing/exercise	4
Standing	1.2
Studying and sitting	1
Serving	1.6

Source: ASHRAE Handbook of Fundamentals, 1989

Table2.3.3Metabolic rate for various activity

CHAPTER 3 STUDY OVERVIEW

3.1 AREA OF STUDY:

The study was conducted in the electronic commercial hub of Chennai, Ritchie Street which is one of the busiest areas in the Chennai city region, Tamil Nadu. Chennai falls under Hot-Humid climate region and the selected site area lying in the geographical coordinates of 13.07° North and 80.26° East longitude with an elevation of 7m. The temperature ranges between 28°C to 40°C in summer and 24°C to 34°C in winter. The study area lies in the centre of the city and it is 3.4kms away from the central railway station.

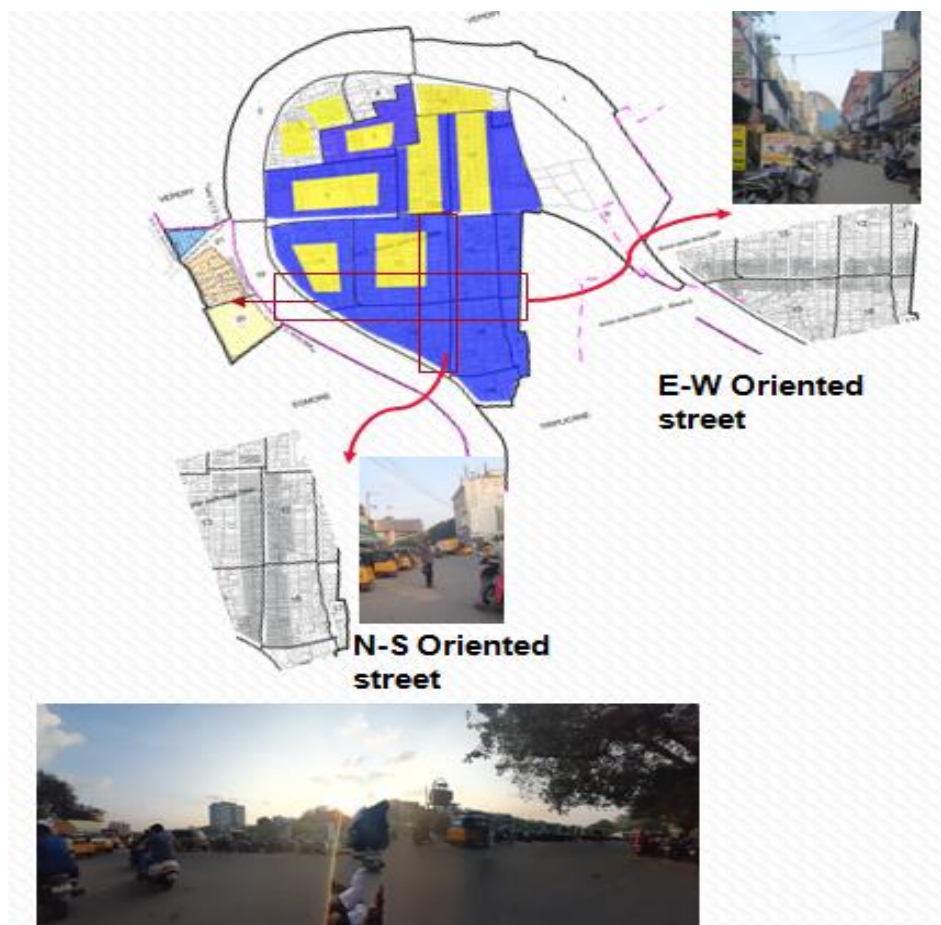


Fig: 3.1.1: Study area

3.1.1 LAND USE MAP OF THE RITCHIE STREET:

Ritchie street – one of the streets in chintadripet which had few radio shops in 1970s, later extended up to 2500 shops and extended to other streets like Waller street, Narasingapuram street etc., which is commonly referred as Ritchie street.

This area comprises of residential and commercial zones. 20% of Residential area and Commercial area is of 80%. Most of the residences had the shops in the front, making this area a mixed zone. The line of influence as the maximum distance a Pedestrian walk to avail any street around the area is approx. 0-100m. The type of vehicle found were 2-Wheeler – workers and buyers, Heavy vehicle – container (only during night times for loading and unloading – 8PM TO 8AM)



Fig: 3.1.2: Entrance from coovam to the Study area

3.1.2 PEDESTRIAN MOVEMENT IN THE WEEKDAYS:

Total Pedestrian flow on a Weekday at (11:00-22:00)

- Location 1: N-S Oriented street – Around 1000 persons
- Location 2- E-W Oriented street – 1000-1200 persons

Total Pedestrian flow on Weekends at (11:00-22:00)

- Location 1: N-S Oriented street – Around 1000-1500 persons
- Location 2- E-W Oriented street – Around 2000 persons

E-W orientated street has few complexes where people find easy to get things in one space. E-W axis has the mount road on the east and coovam road on the west making the street easy to access.

LAND USE MAP:

The street taken for the study is a commercial street and a mixed residential area where there are shops in the front and residence at the back ends.

FIGURE GROUND MAP:

This study reveals that these areas are densely packed and lack open space or parks resulting in a lack of breathing space. There is no void except the streets in this area.

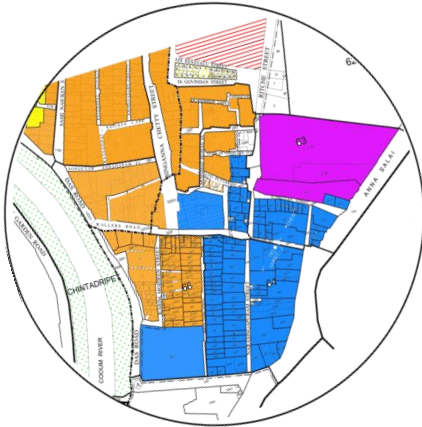


Fig: 3.1.3: Land use map of the region **Fig: 3.1.4: Figure ground map of the region**

UNORGANIZED CLUSTER NETWORK:

The discontinuous pattern of built form creates an irregular and narrow street network that makes vehicular and pedestrian movement difficult

IRREGULAR GRID PATTERN:

Buildings are arranged in an irregular grid pattern. They are divided randomly which creates few junctions in the streets cause traffic congestions.



Fig: 3.1.5: network pattern of the region

Fig: 3.1.6: Pattern of the street region

URBAN GREEN:

Trees are very minimal around this area.
The study area has no vegetation because of the lack of open spaces.

NODES:

3 major nodes in the streets creating a traffic congestion making it difficult for the pedestrian movement



Fig: 3.1.7: Urban green around the site

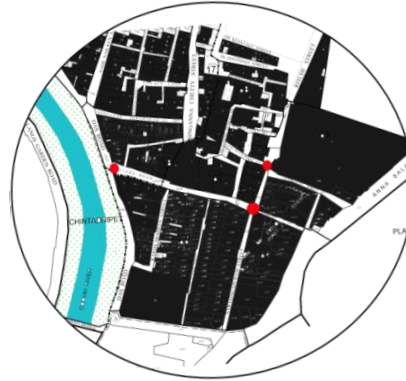


Fig: 3.1.8: Major nodes in the site

MOVEMENT PATTERN VEHICULAR:

The marked streets are heavily used by both vehicles and pedestrians throughout the day.



Fig: 3.1.9: Vehicular movement pattern

CHAPTER 4 RESULTS AND DISCUSSIONS OF ITERATIONS

4.1 COMFORT ANALYSIS FOR THE SELECTED AREAS



Fig:4.1.1: Selected point in the site for the analysis

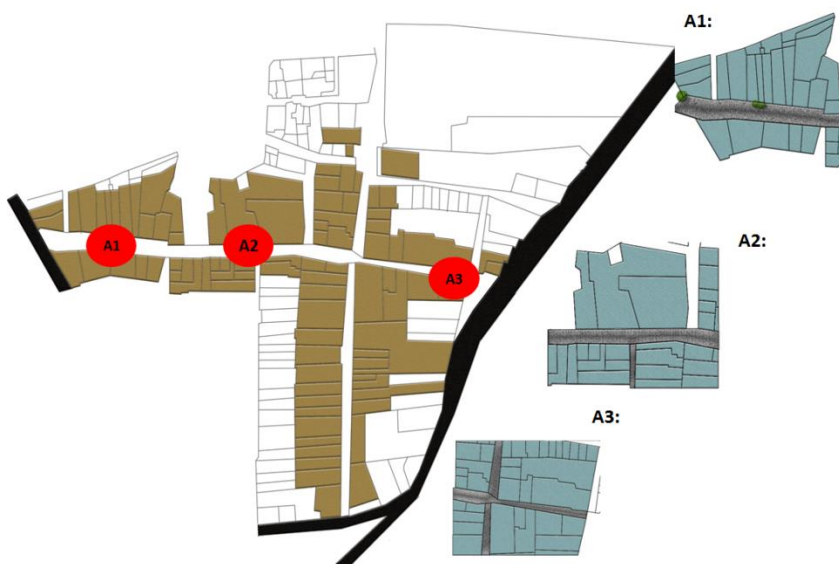


Fig: 4.2.1: Selected point in East – West Orientation

4.2 CHARATERISTICS OF THE SELECTED LOCATIONS:

A1:

- This point has 14m Wide Street in East – west orientation.
- Boundary condition: Koovam River in the east, built structure on the other 3 sides.
- This location has complexes and few small shops and is less crowded.
- Major entry to the site is from the koovam river road.

A2:

- A2 has 10m Wide Street and an intersection area which found to be high occupied area in east west orientation.
- **Boundary condition:**All sides have concrete buildings with no buffer spaces.
- A2 has many small electronic shops, and few complexes.

A3:

- A2 has 7m Wide Street and located in the side of Anna salai road.
- **Boundary condition:**Anna salai in the east – built structure in the other sides.
- Compared to the other 2 points. This location is highly occupied as it has many small shops and easy accessible from the main road.

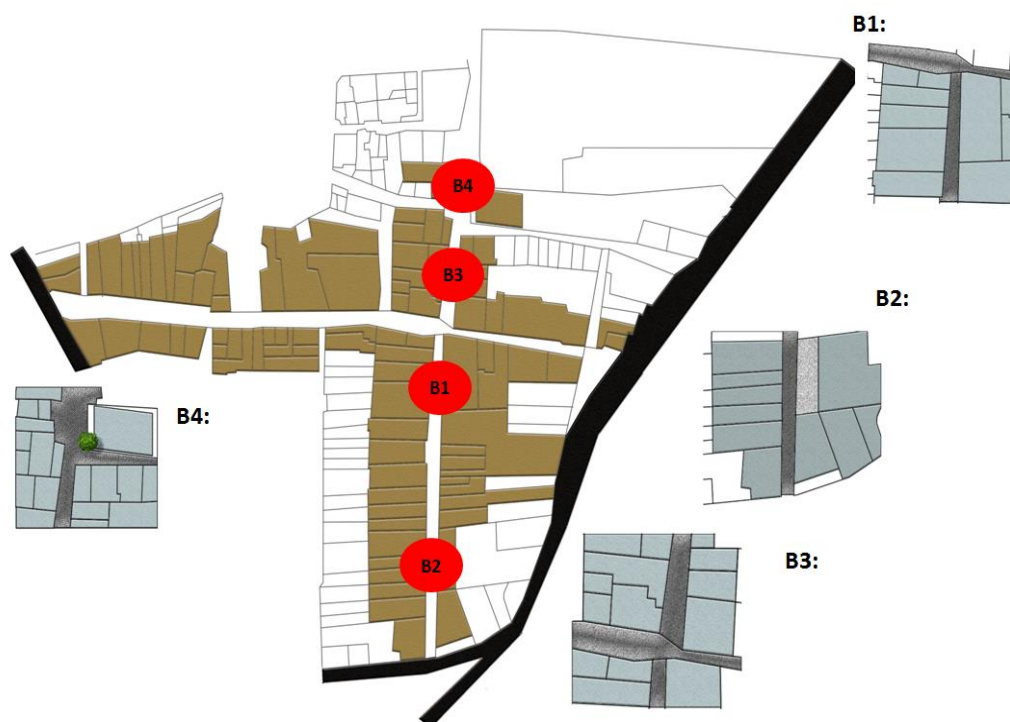


Fig: 4.2.2: Selected point in North - South Orientation

B1:

- B1 is located in the center of the area where many small electronic shops were found.
- **Boundary condition:** All the sides have built structures, having no breathing space. This location also has few derelict buildings which left unoccupied in the 1st and 2nd floors.
- Major entry to the site is from the West – Anna salai.

B2:

- In Point 2 the building setback was found to be 7m and the road width 7m creating a total road width of 14m. Street vendors were found higher in this space as there is more open space.
- **Boundary condition:** Towards south is the Blackers Road.

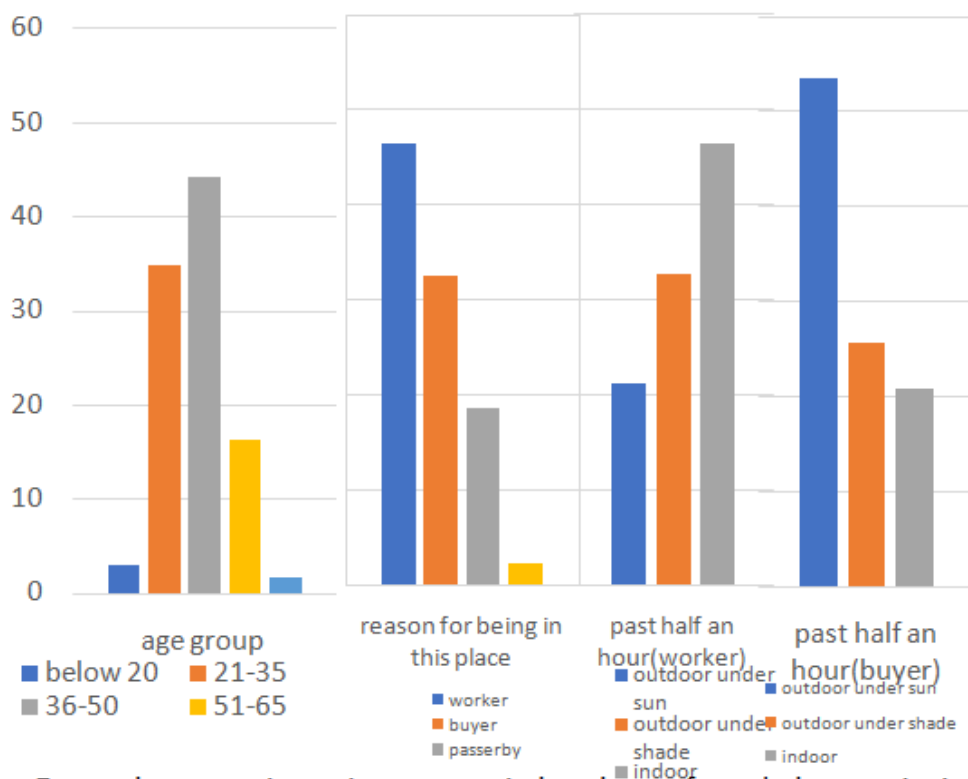
B3:

- Highly occupied area and vehicles parked in the road creating a congestion in the area.
- Electronic shops, automobiles.

B4:

This point has a huge peepal tree which covers the entire street. The building in the east is derelict buildings and west is commercial shops.

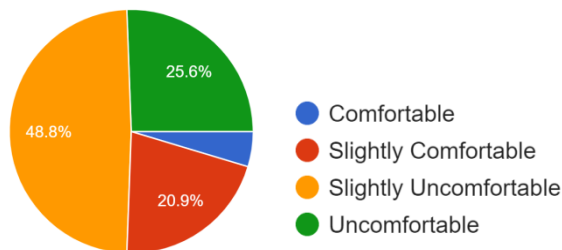
4.3 RESULTS FROM THE QUESTIONNAIRE SURVEY:



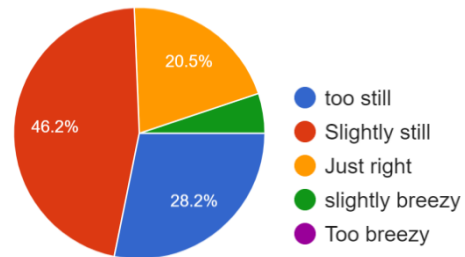
Graph: 4.3.1: Occupancy details

From the questionnaire survey it has been found that majority of the people occupying the space are between 21- 50 age group people.

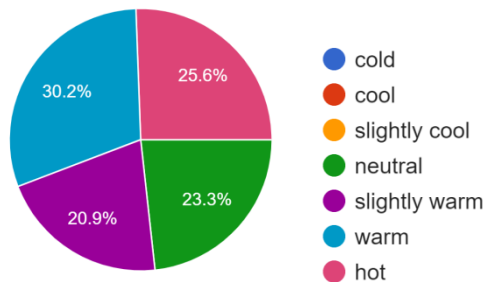
- People falling under 35 – 50years old are majority owners / workers, who works mostly in the indoor spaces
- In 21 – 35 years old age group, some are working in the indoor spaces, and some were working in the outdoor and some were buyers & passer-by of the street.
- As an average people were working/staying in the outdoor areas in most of the times.



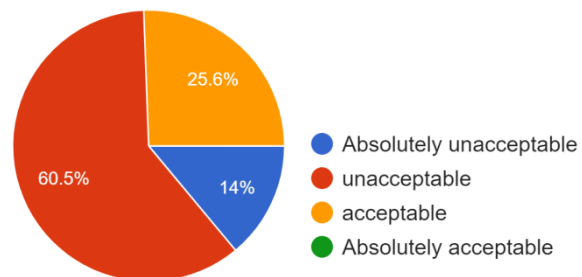
Graph: 4.3.2: Level of comfort



Graph:4.3.3: Level of comfort



Graph:4.3.4: 7-point scale



Graph:4.3.5:Acceptable level of thermal environment

It was found that majority of the people feeling slightly comfortable to uncomfortable for most of the time.

The acceptance level to the thermal environment is found to be unacceptable as they're highly exposed to the direct radiation due to the built parameters.

4.4 PHYSIOLOGICAL EQUIVALENT TEMPERATURE INPUT DATA:

AGE: 35

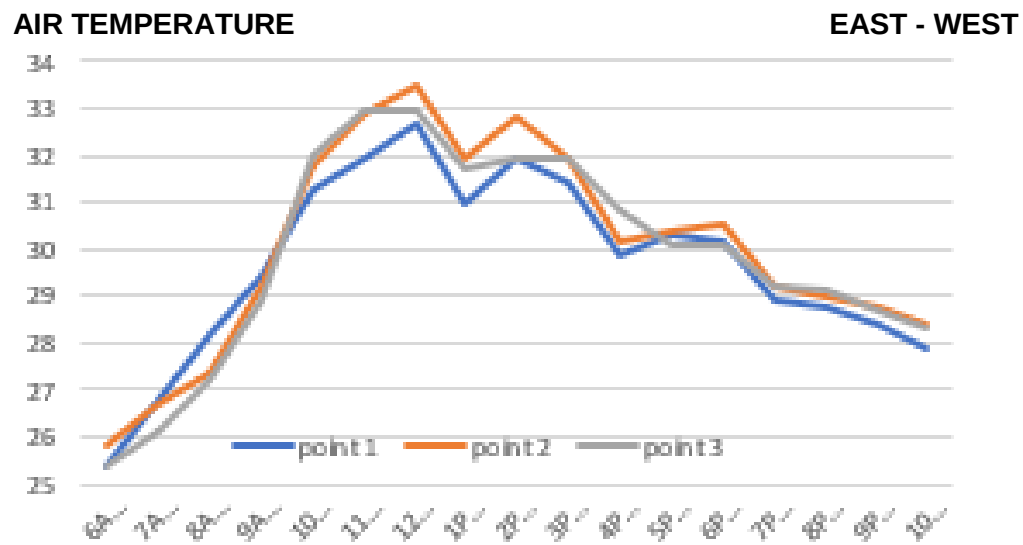
WEIGHT OF THE PERSON – 75KGS

SEX: MALE

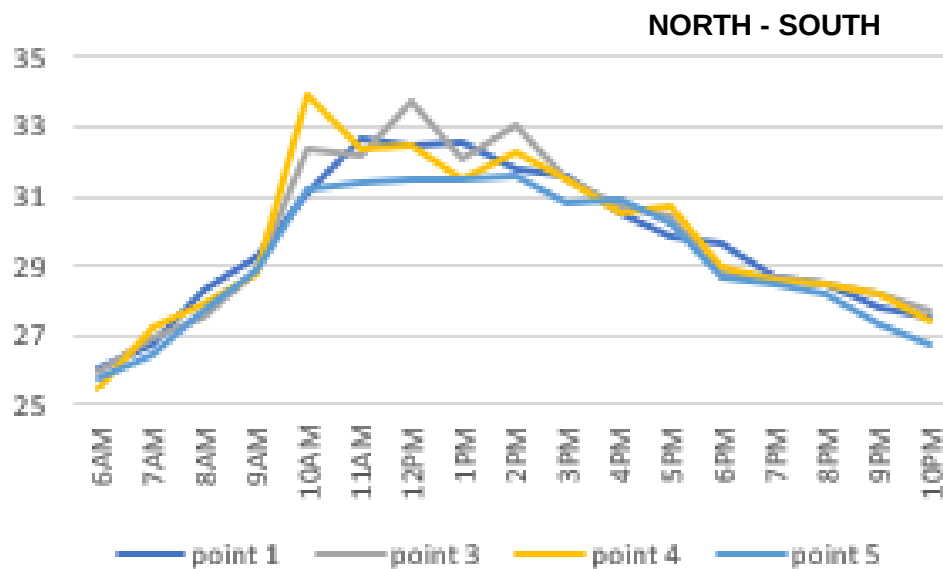
CLOTHING – COTTON, CASUAL

ACTIVITY – WALKING

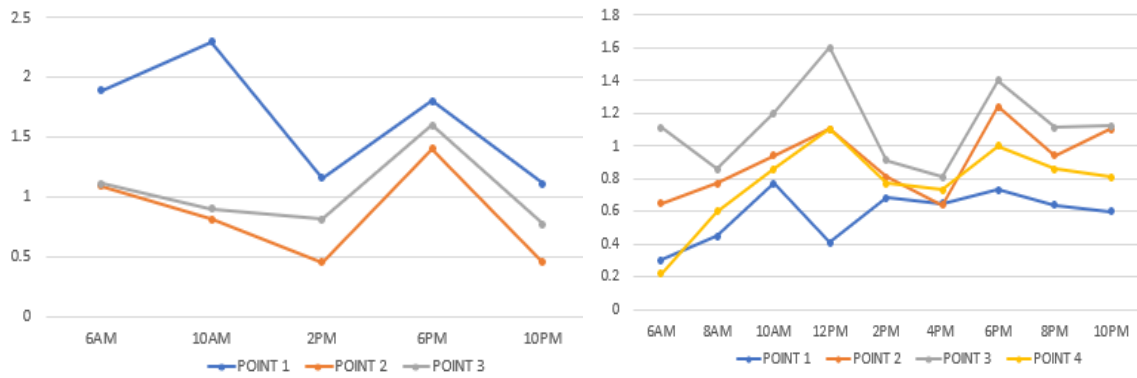
4.5 COMPARISON OF METEOROLOGICAL MEASUREMENTS:



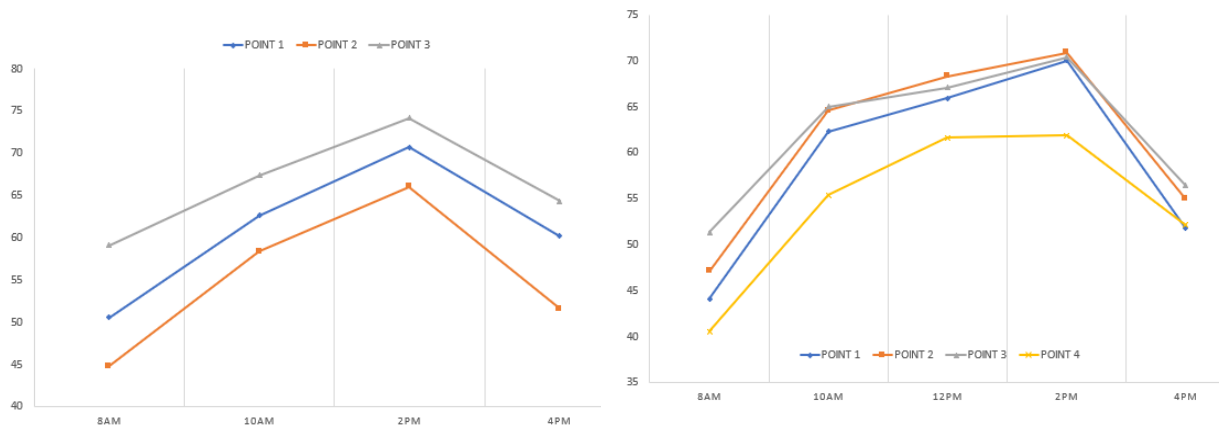
Graph:4.5.1: Air Temperature difference in E-W orientation



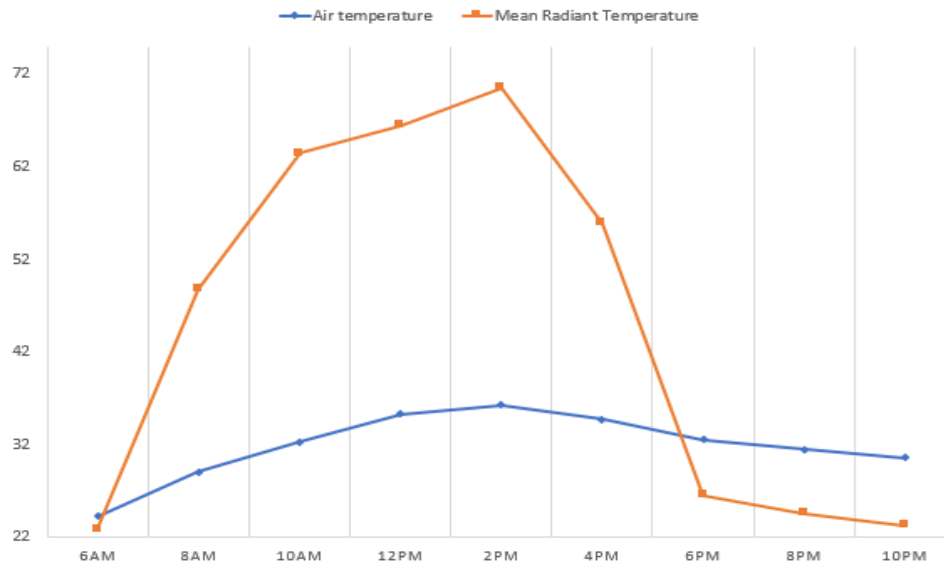
Graph:4.5.2: Air Temperature difference in N-S orientation



Graph:4.5.3: Wind speed comparison along the E-W and N-S orientation

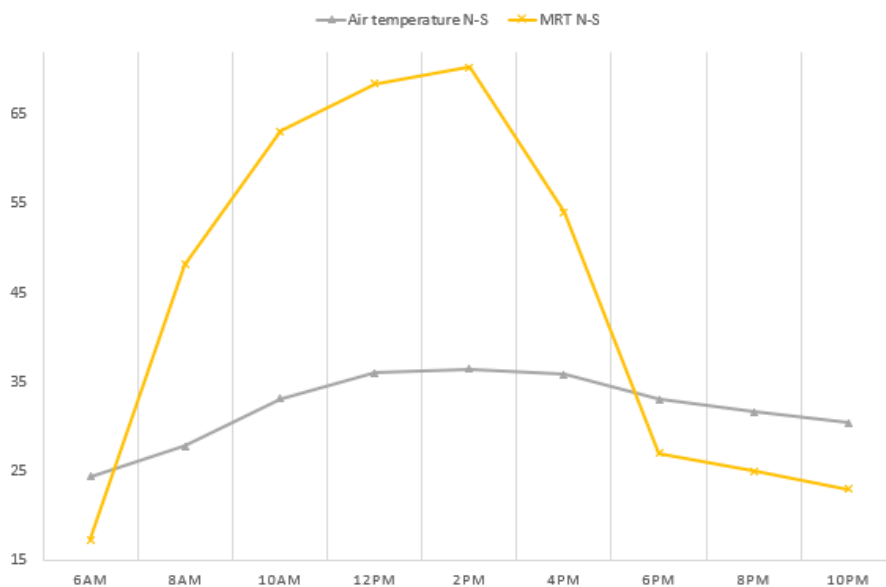


Graph:4.5.4:Mean Radiant Temperature comparison along the E-W and N-S orientation



Graph: 4.5.5: comparison T_a and T_{mrt} of E-W

NORTH - SOUTH



Graph: 4.5.6: comparison T_a and T_{mrt} of N-S

4.5.1 INFERENCE:

- In all the 7 points no major difference in air temperature is found
- The difference based on the parameters was found in the mean radiant temperature.
- In the mean radiant temperature, E-W orientation recorded a highest of 74°C from the orientation it is found that N-S orientation works better

comparing to the E-W orientation. N-S orientation gets mutual shading whereas the shading is less in the E-W orientation.

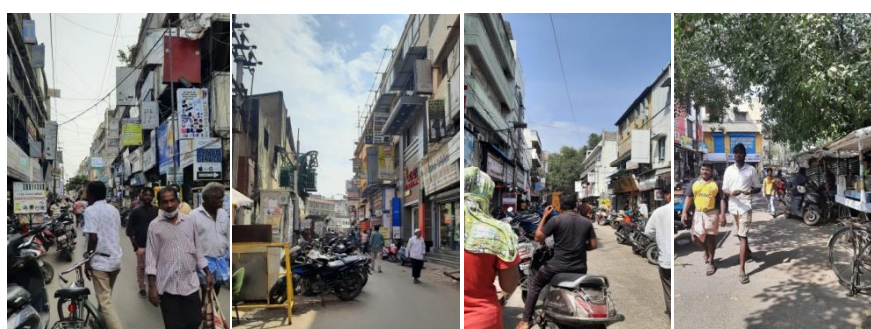


A1

A2

A3

Fig:4.2.3: Image of the selected point of E-W



B1

B2

B3

B4

A1	Wider street	Higher SVF / lesser H-W ratio – lack of pedestrian shading	Increase external shading , vegetation
A3	Wide street	High SVF – lack of pedestrian shading	Increase external shading , vegetation
B1	Narrow street	restricted wind movement	Replace with stilt level to induce wind movement
B2, B3	Wide street	Higher SVF – lack of external shading	Increase external shading , vegetation

Table 4.2.1: Analysed issues in the selected points

4.6 MATERIAL STUDY OF THE LOCATION : PAVEMENT SURFACE

4.6.1 ASPHALT ROAD:

- Asphalt mixture is a composite material consisting of aggregates, bitumen, and air voids.
- In particular, when an asphalt pavement is exposed to solar radiation a part of this radiation is absorbed and the surface temperature increases.



Fig: 4.5.1: Images of the road

4.6.2 SURFACE ALBEDO:

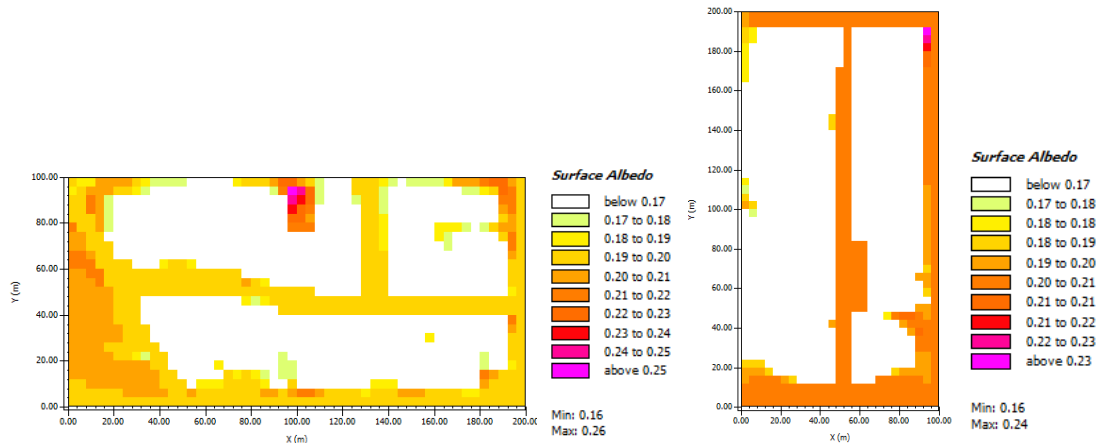


Fig: 4.5.2: Images of the simulation result of surface albedo

Albedo of asphalt was found to be 0.20, where 80% of the heat is trapped and 20% is reflected back to the spaces.

4.7 ITERATIONS WITH DIFFERENT SCENARIOS:

4.7.1 H – W RATIO:

Therefore, Iteration is made by increasing the H-W ratio. By changing H-W, the SVF is reduced which reduces the space exposed to the radiation.

4.7.2 PAVEMENT MATERIAL:

- Asphalt road is replaced by concrete road which has high albedo value. This reduces temperature stored in the surface.
- Cool paving materials are reflective which help to minimize pavement temperatures and heat absorption

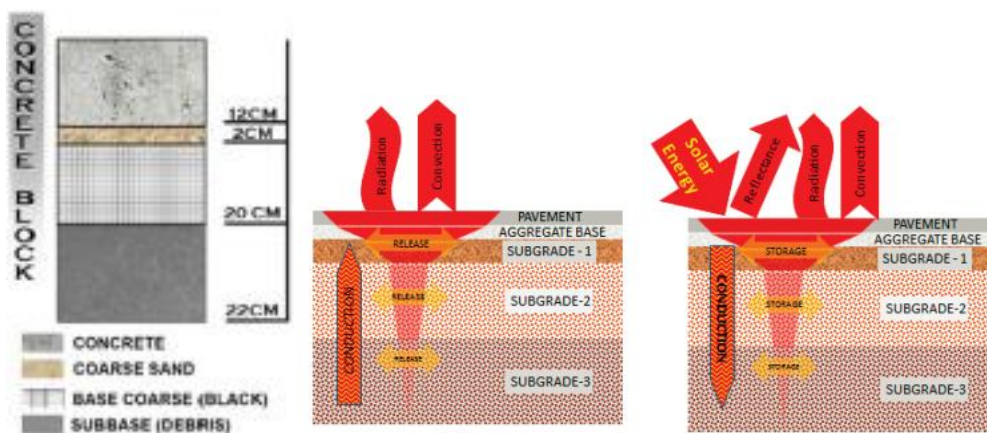


Fig: 4.5.3:Details of the alternative road material

4.7.3 VEGETATION : TREE SPECIES

Indian beech tree: (Millettia pinnata):

- Height: 15 – 25m
- Large canopy – Deciduous tree – flowering plant
- Trunk – 50-80cm
- Withstanding temperature: 0 – 50°C
- Draught tolerant

vaagai : (Albizia lebbeck)

- Height: 18 - 30m
- Large canopy – Deciduous tree – flowering plant
- Trunk – 20 – 50cm
- Withstanding temperature: 0 – 50°C
- Draught tolerant

Indian tulip tree: (Thespesia populnea)

- Height: 6 - 10m
- Large canopy – Deciduous tree – flowering plant

- Trunk – 20 - 30cm
- Withstanding temperature: 0 – 50°C
- Wide range of soil types that may be present in coastal environment draught tolerant

Red cassia: (cassiarox burghii)

- Height: 15 - 20m
- medium canopy – Deciduous tree – flowering plant
- Trunk – 20 - 30cm
- Withstanding temperature: 0 – 50°C
- Draught tolerant

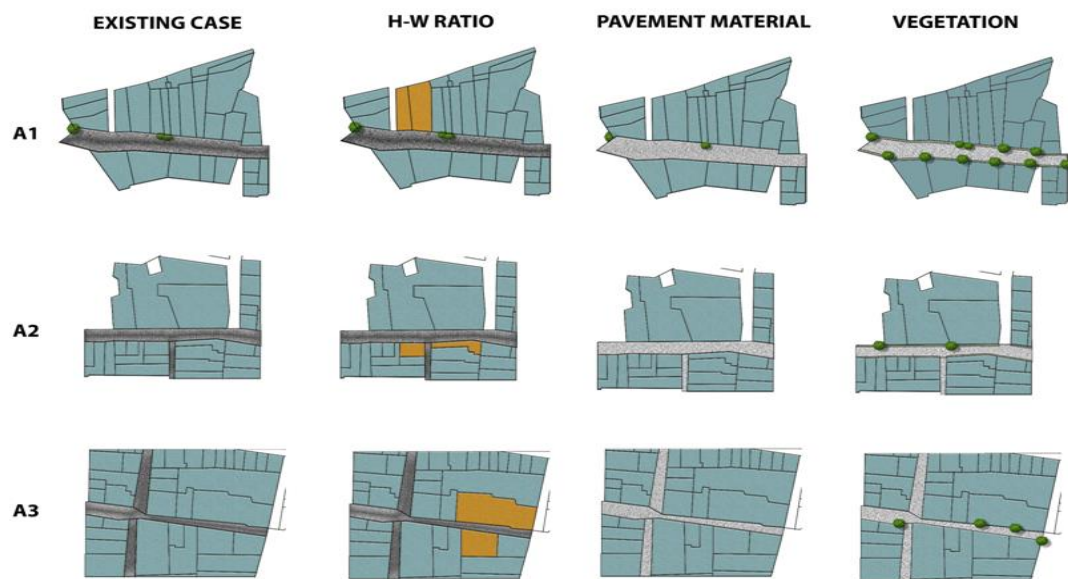


Fig: 4.5.4:Different Iteration scenario of E-W

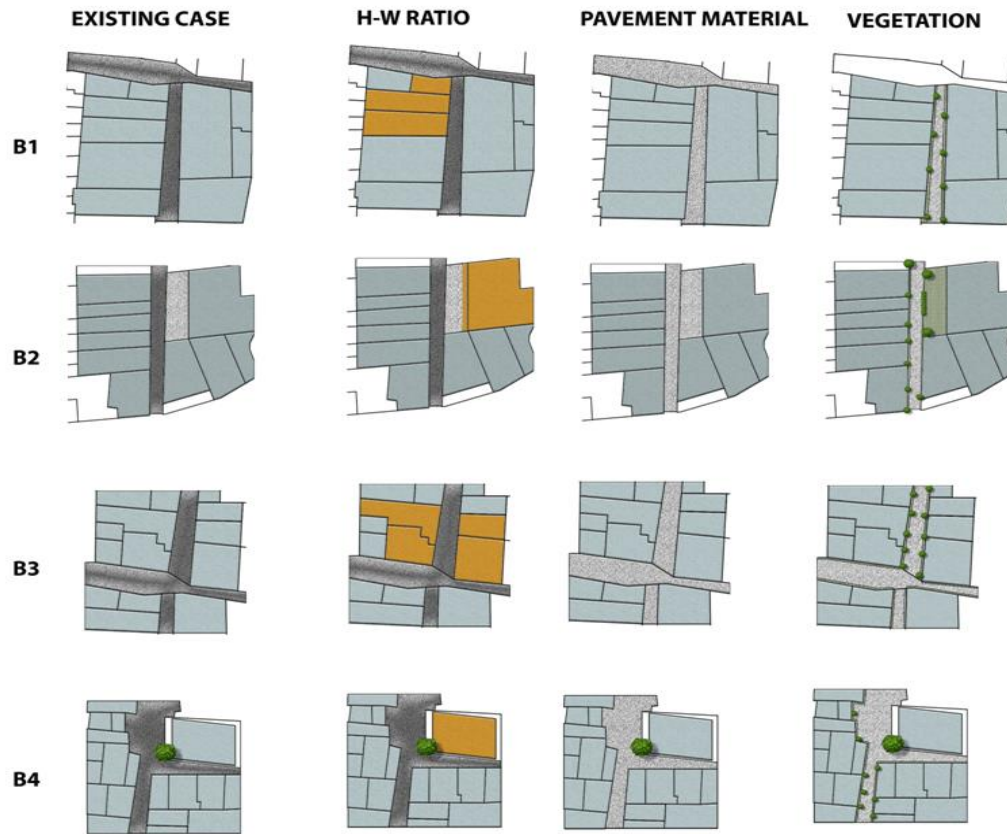
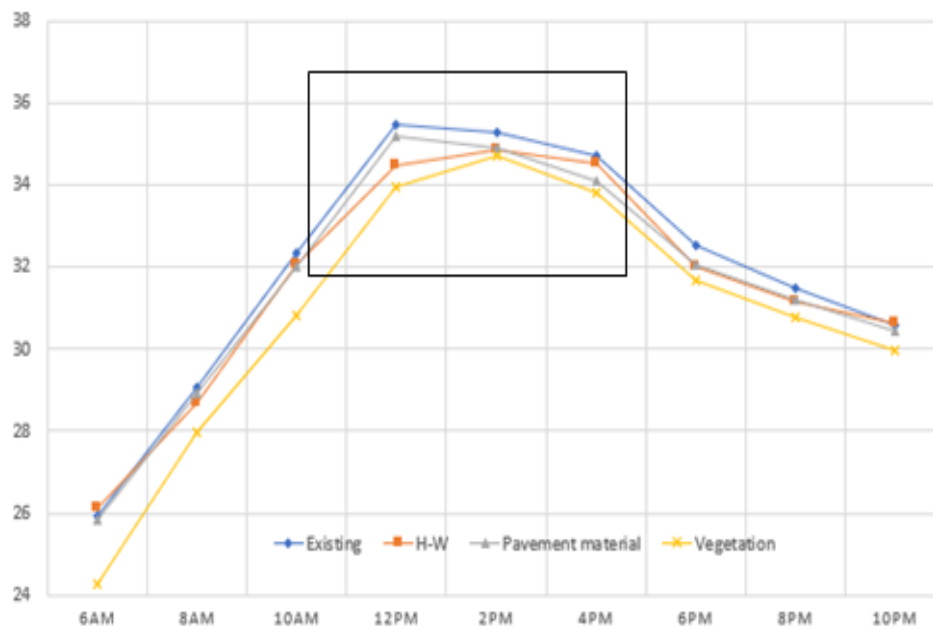


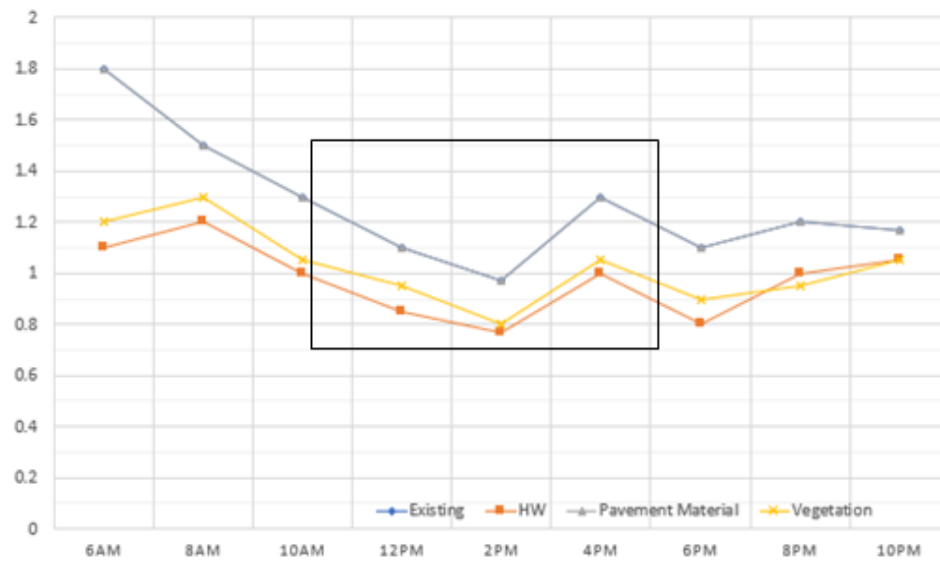
Fig: 4.5.5: Different Iteration scenario of N-S

4.8 RESULTS OF SIMULATION FOR DIFFERENT ITERATION:

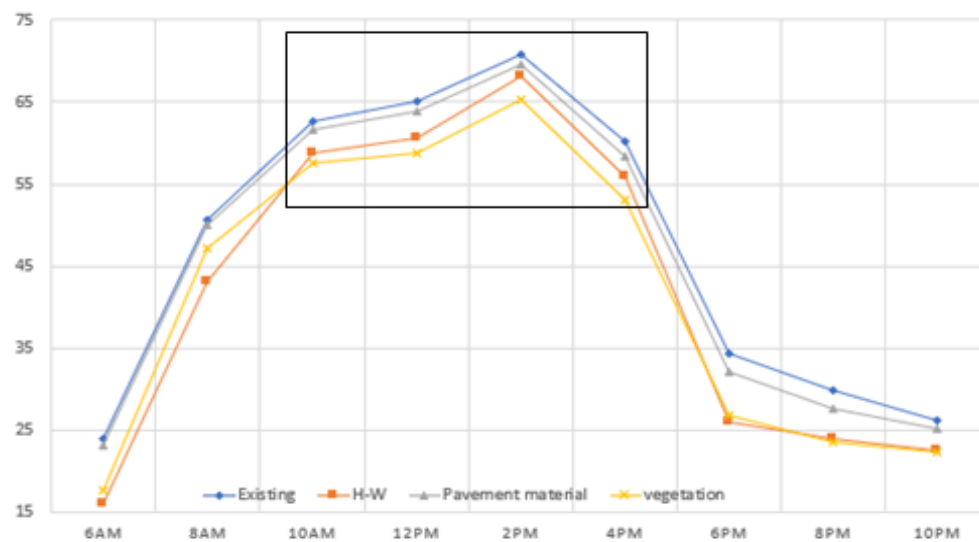
4.8.1 RESULT OF A1:



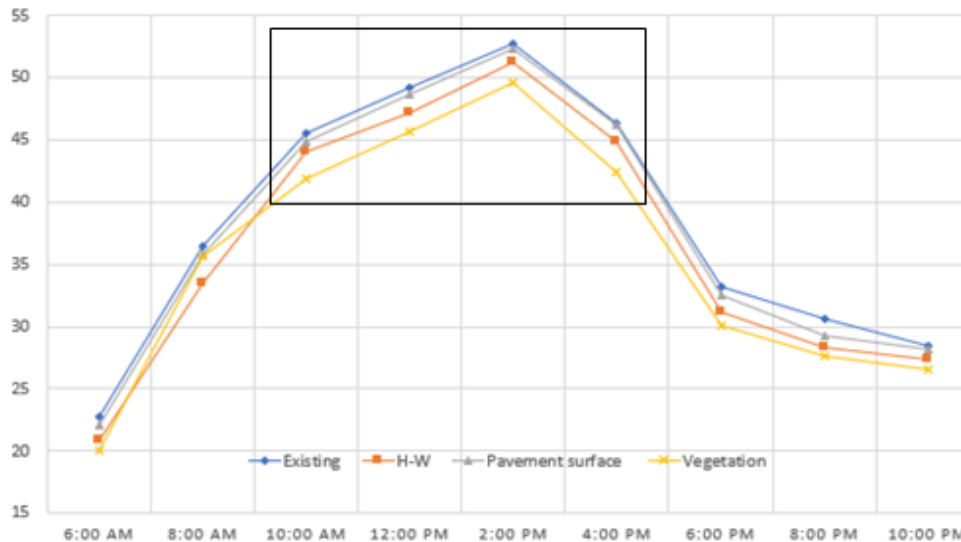
Graph: 4.8.1: Air temperature variation from different iterations of A1



Graph: 4.8.2: Wind speed variation from different iterations of A1



Graph: 4.8.3: Mean radiant variation from different iterations of A1



Graph: 4.8.4: physiological equivalent temperature from different iterations of A1

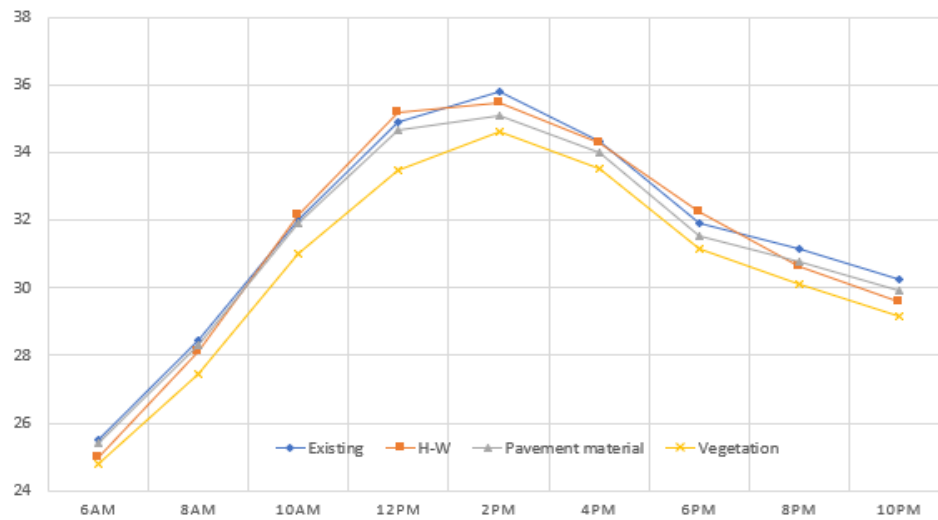
AIR TEMPERATURE A1

- H-w Ratio – reduced SVF. Resulted in 0.5 – 0.7 °c and the increased height has reduced the wind speed to 0.5 - 1m/s.
- Pavement material has reduced the night time temperature as it has high albedo
- Vegetation in the other case has reduced the SVF and reduced 0.7 – 1.2 °c and provides shadow for the pedestrians.

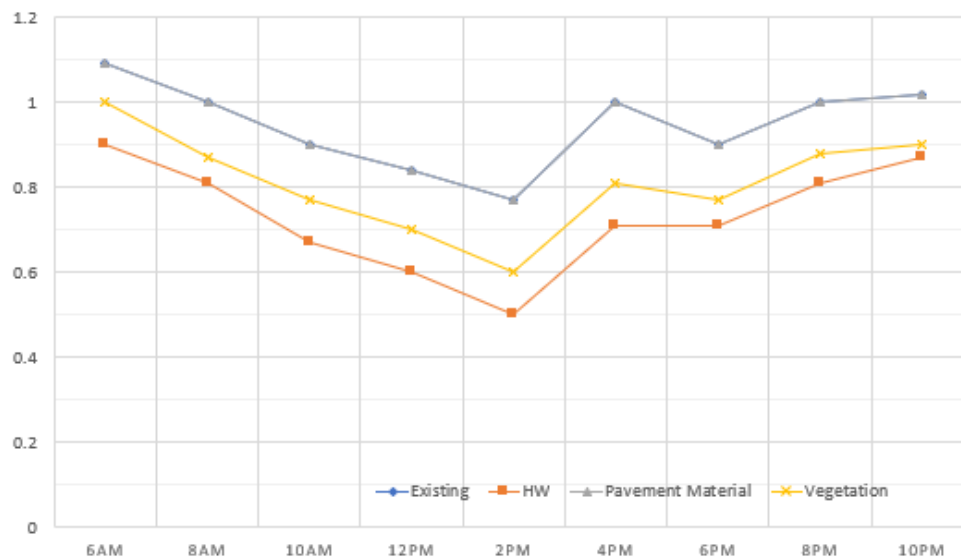
PET

- PET analysis has proved that reducing SVF and increasing pervious area and vegetation can reduce the PET to 5 – 7 °c
- During 2PM – The temperature has reduced from 53 to 48 °c
- From the PET scale existing case extreme heat stress during peak hours with 4 iterations it has been reduced to moderate and strong heat stress.

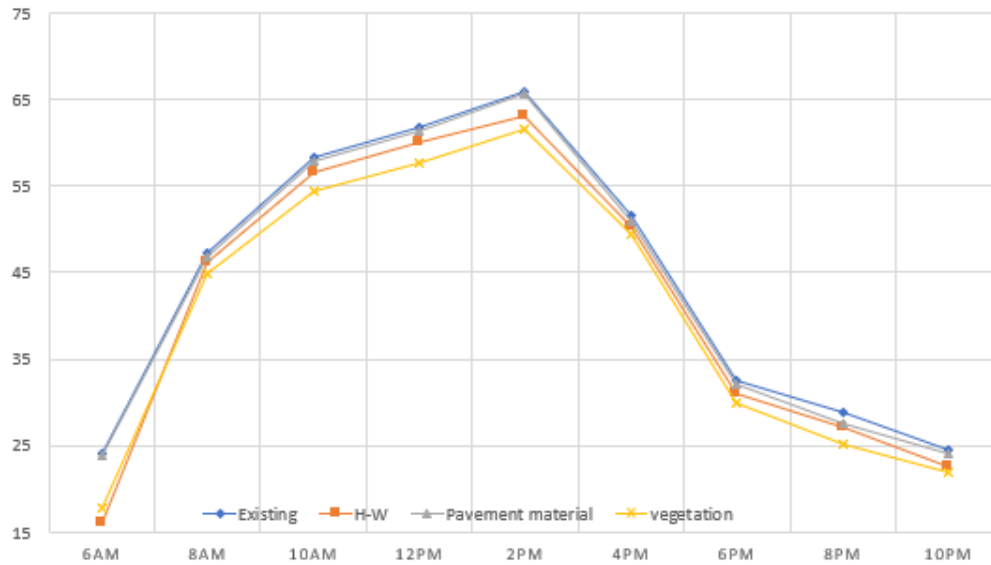
4.8.2 RESULT OF A2:



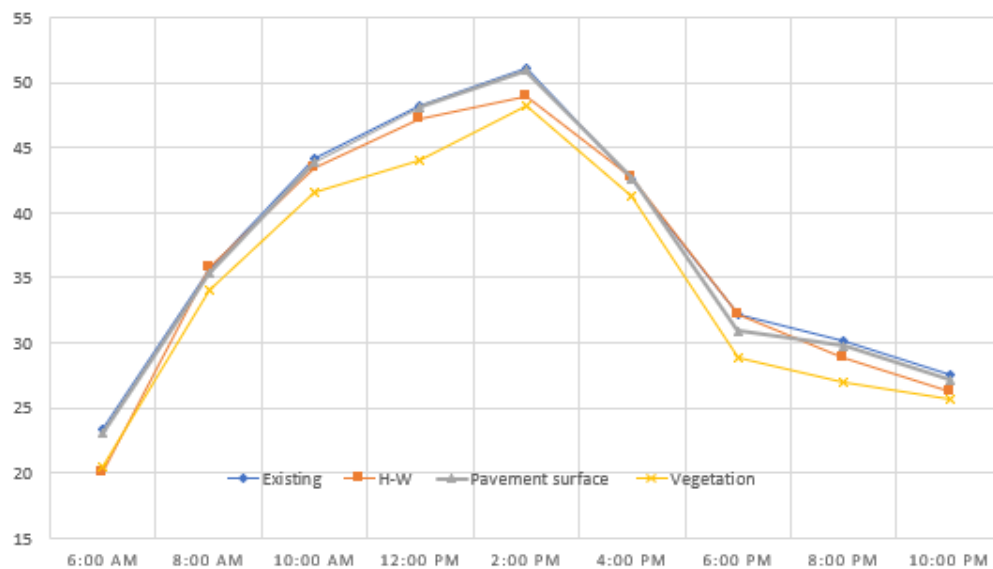
Graph: 4.8.5: Air temperature variation from different iterations of A2



Graph: 4.8.6: Wind speed variation from different iterations of A2



Graph: 4.8.7: Mean radiant variation from different iterations of A2



Graph: 4.8.8: physiological equivalent temperature from different iterations of A2

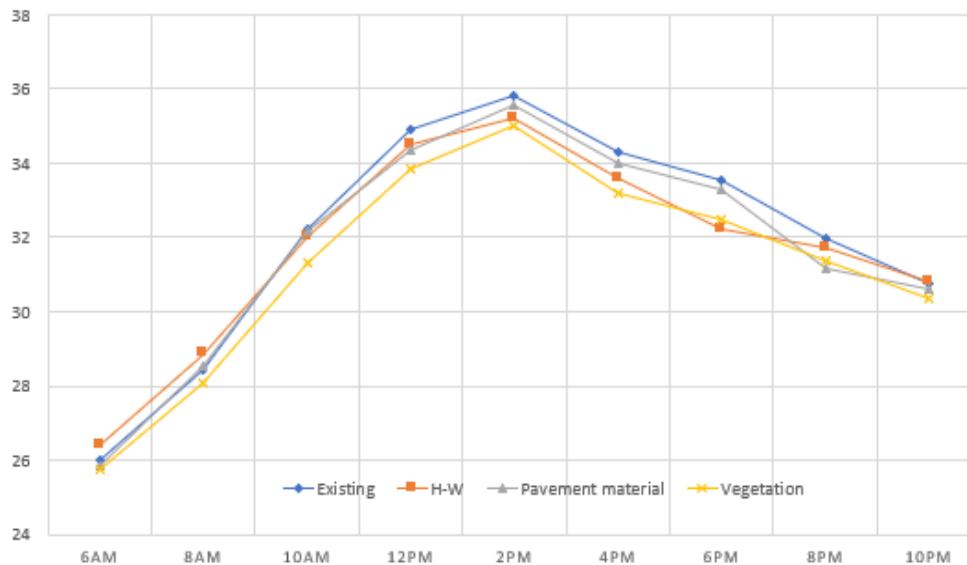
AIR TEMPERATURE A2:

- H-w Ratio – reduced SVF. During the peak hours, the modified scenario has increased the temperature to 0.2 – 0.5 °c as there is a sudden drop in the wind movement.
- Vegetation in the other case has reduced the SVF and reduced 0.6 – 1.4 °c where there is no changes in the H-W ratio and provides shadow for the pedestrians.

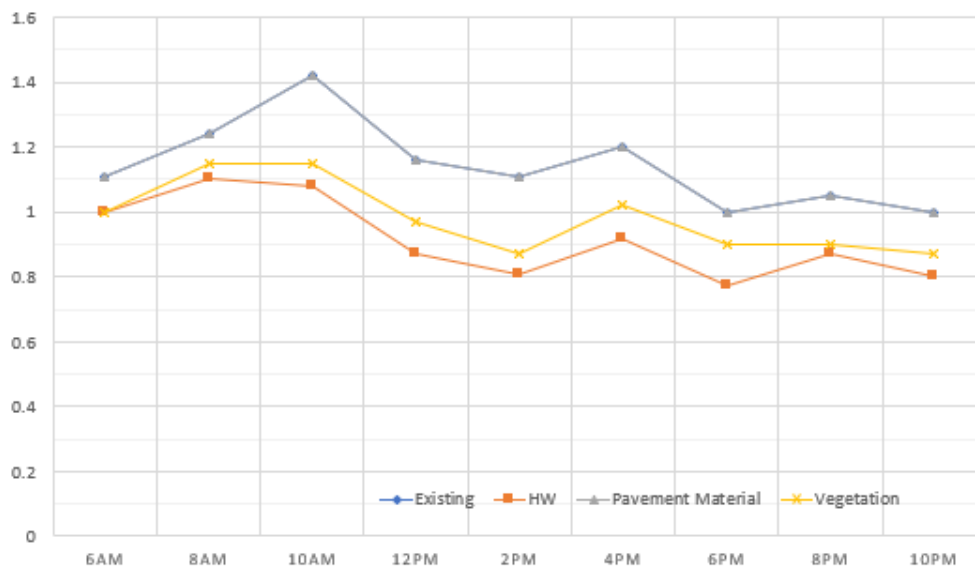
PET:

- PET analysis has proved that reducing direct solar radiation and increasing pervious area and vegetation can reduce the PET to 5 – 7 °c
- During 2PM – The temperature has reduced from 51 to 47 °c
- From the PET scale existing case extreme heat stress during peak hours with 4 iterations it has been reduced to Slight to strong heat stress.

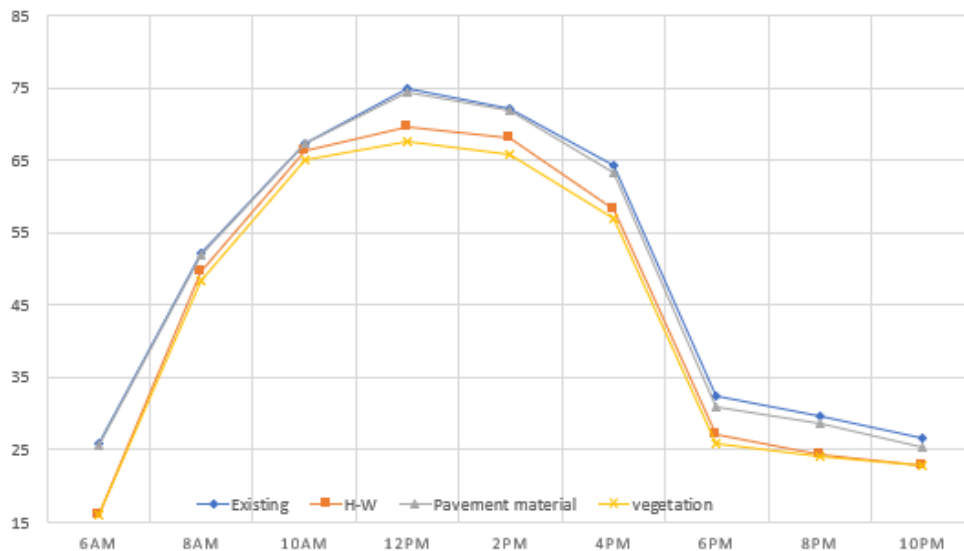
4.8.3 RESULT OF A3:



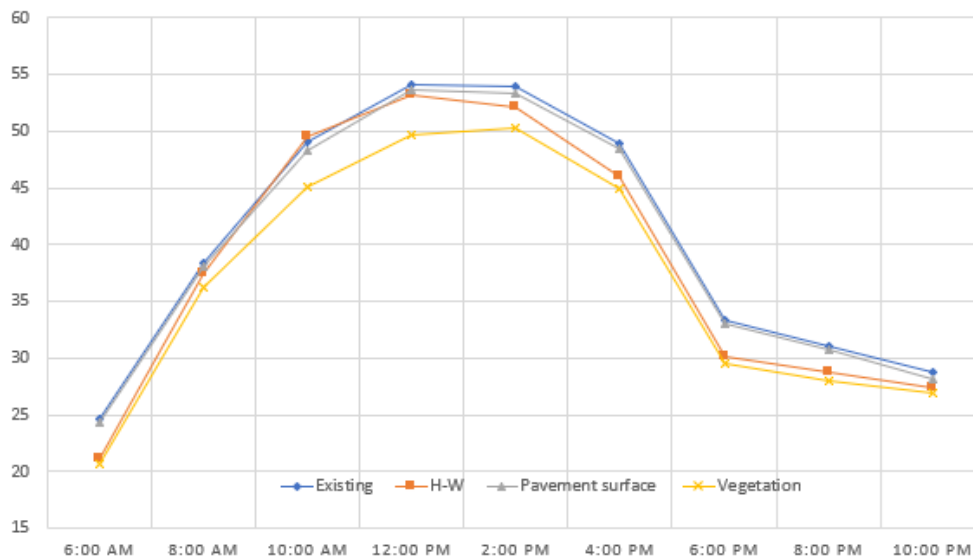
Graph: 4.8.9: Air temperature variation from different iterations of A3



Graph: 4.8.10: Wind speed variation from different iterations of A3



Graph: 4.8.11: Mean radiant variation from different iterations of A3



Graph: 4.8.12: physiological equivalent temperature from different iterations of A3

AIR TEMPERATURE A3:

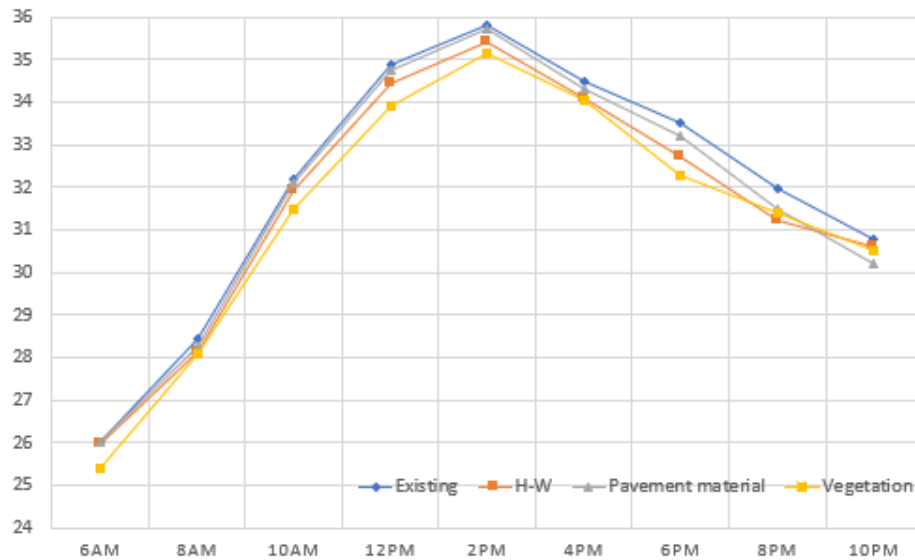
- H-w Ratio – reduced SVF. Reduced temperature to 0.3 – 0.7 °c. The boundary condition in the East is Anna salai – where this point is highly exposed and the changes in the temperature were minimal.
- Vegetation has reduced the temperature to 0.4 – 0.9 °c as the space required for vegetation is minimal.

PET:

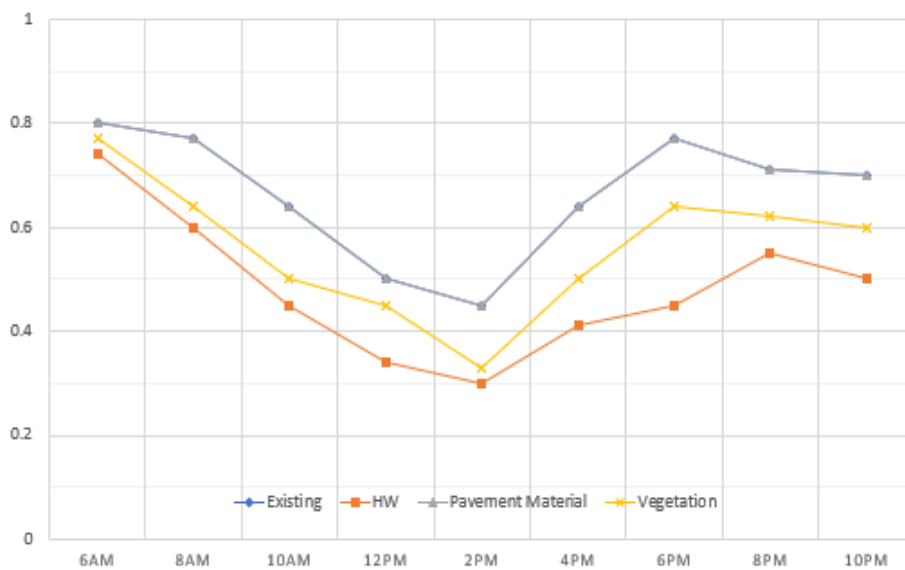
- From the PET it is able to reduce the temperature to 3 – 5 °c as the changes done in this point are minimal.

- During 2PM – The temperature has reduced from 54 to 50 °c
- From the PET scale existing case extreme heat stress during peak hours with 4 iterations it has been reduced to moderate and strong heat stress.

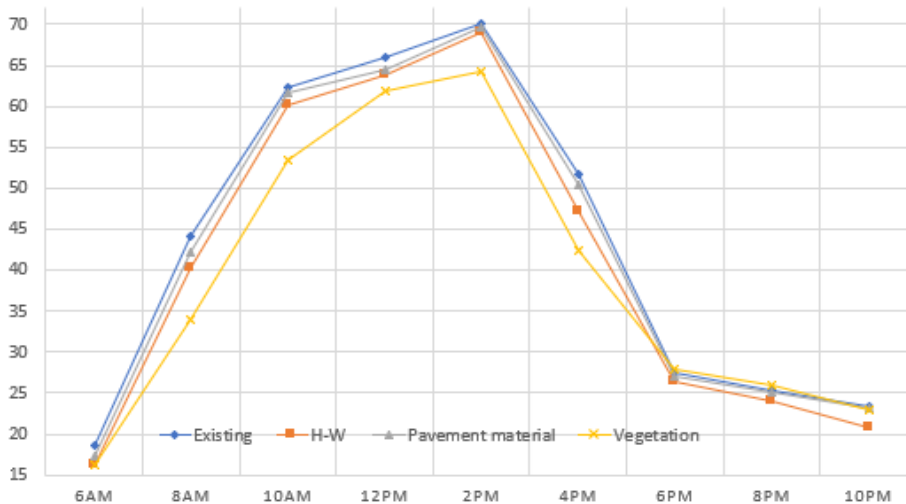
4.8.4 RESULT OF B1:



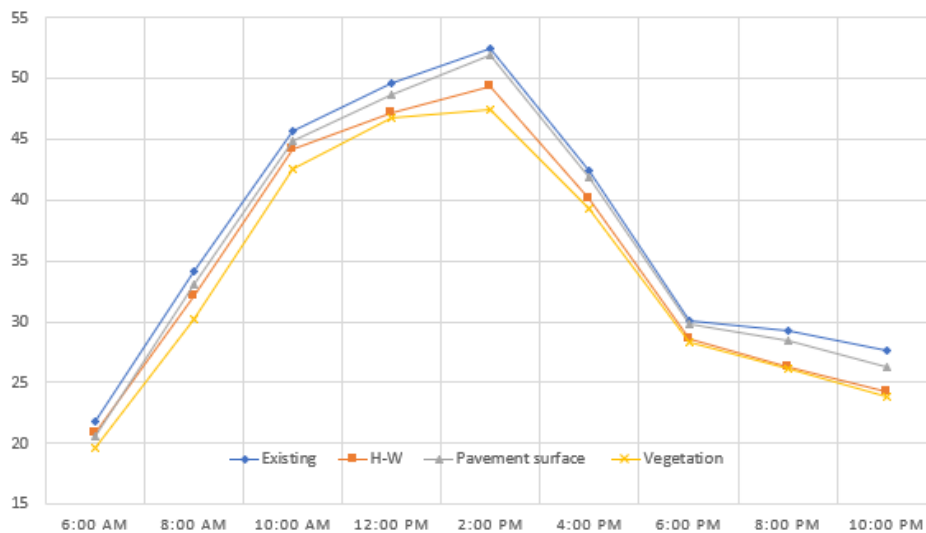
Graph: 4.8.13: Air temperature variation from different iterations of B1



Graph: 4.8.14: Wind speed variation from different iterations of B1



Graph: 4.8.15: Mean radiant variation from different iterations of B1



Graph: 4.8.16: physiological equivalent temperature from different iterations of B1

AIR TEMPERATURE B1:

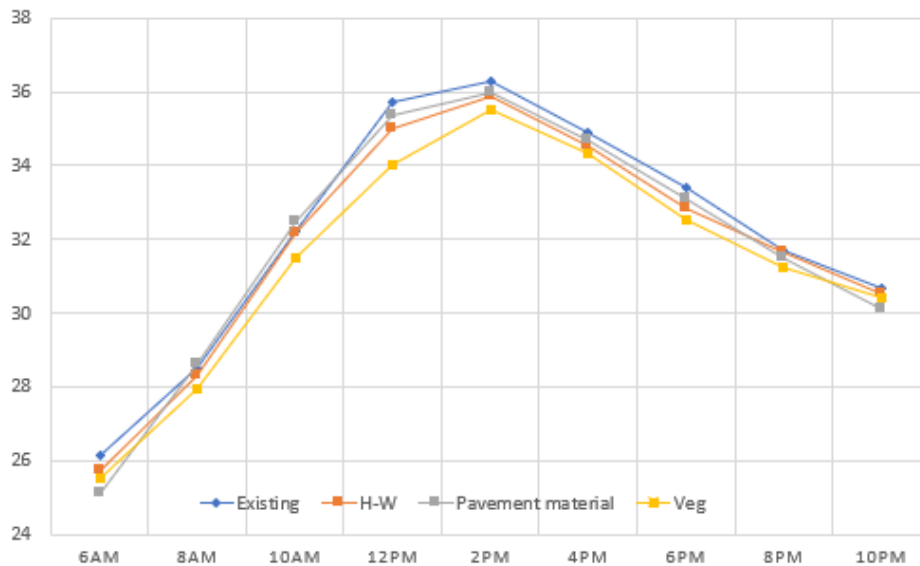
- H-w Ratio - From moderate canyon – deep canyon
- Reduced the temperature to 0.2 – 0.4 °c
- Wind movement is reduced in the H-W case as the height restrict the wind movement.
- Without changing the height the vegetation is added in other iteration has reduced the temperature to 0.5 – 0.7 °c

PET:

- PET analysis has proved that reducing SVF and increasing pervious area and vegetation can reduce the PET to 5 – 7 °c
- During 2PM – The temperature has reduced from 53 to 44 °c

- From the PET scale existing case extreme heat stress during peak hours with 4 iterations it has been reduced to slight heat and strong heat stress.

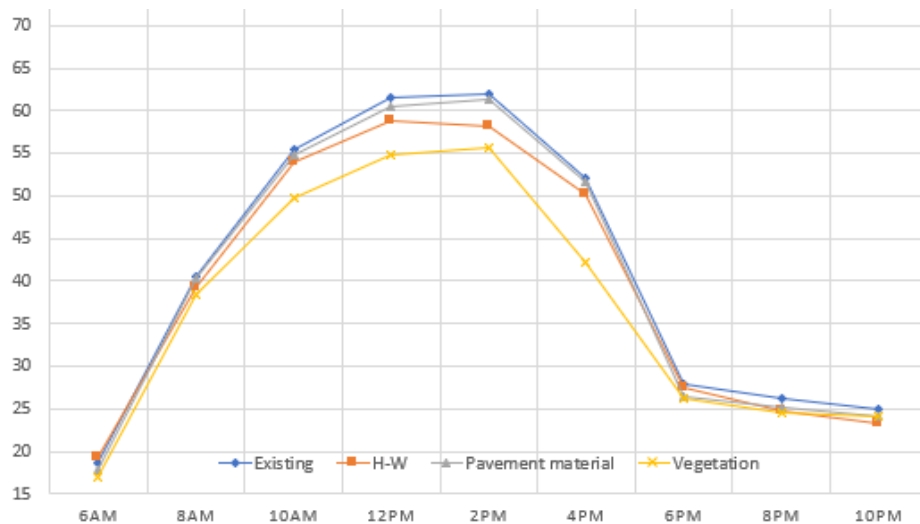
4.8.5 RESULT OF B2:



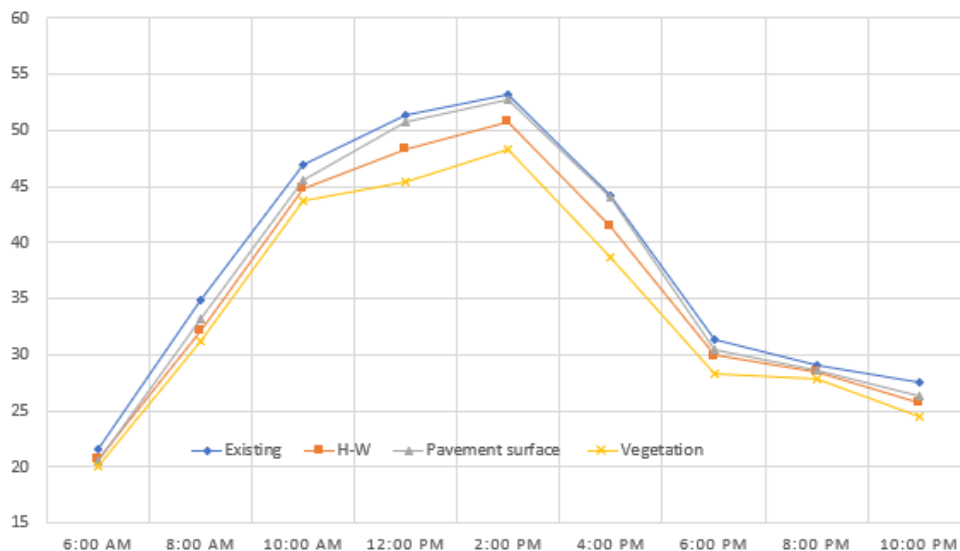
Graph: 4.8.17: Air temperature variation from different iterations of B2



Graph: 4.8.18: Wind speed variation from different iterations of B2



Graph: 4.8.19: Mean radiant variation from different iterations of B2



Graph: 4.8.20: physiological equivalent temperature from different iterations of B2

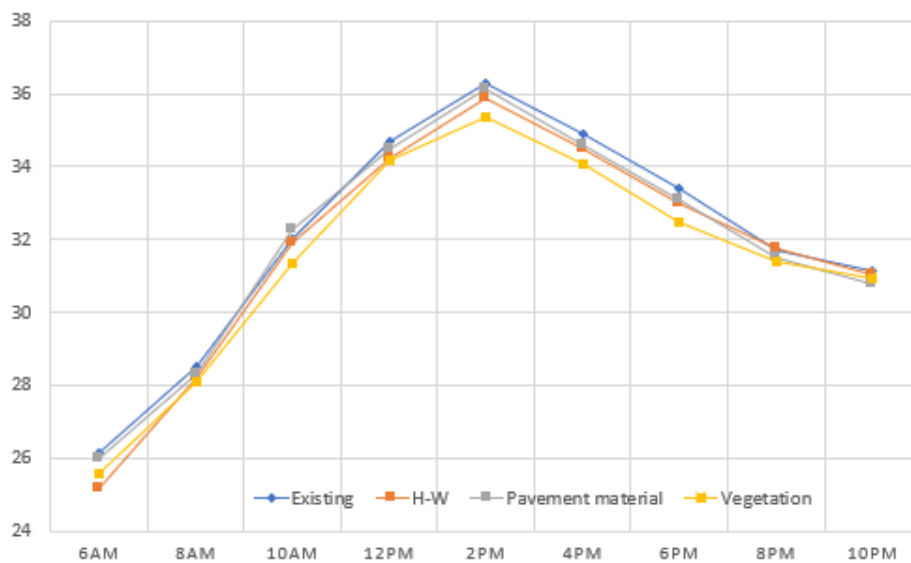
AIR TEMPERATURE B2:

- H-w Ratio – reduced SVF
- Resulted in 0.5 – 1 °c and the increased height has reduced the wind speed to 0.5 - 1m/s.
- Pavement material has reduced the night time temperature as it has high albedo, and the surface has changed from impervious to pervious surfaces
- Vegetation in the other case has reduced the SVF, increased the pervious surface area and reduced 0.7 – 1.4 °c and provides shadow for the pedestrians.

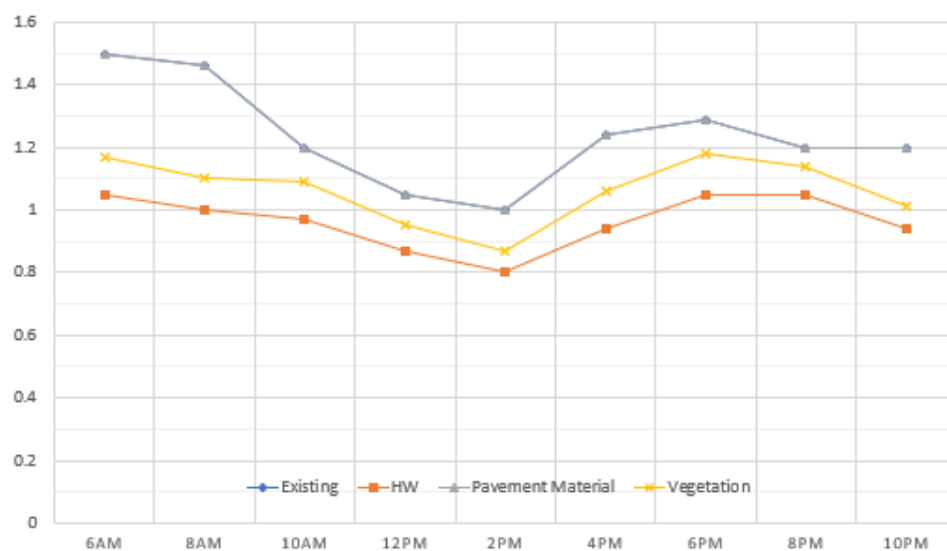
PET:

- PET analysis has proved that reducing SVF and increasing pervious area and vegetation can reduce the PET to 5 – 7 °c
- During 2PM – The temperature has reduced from 53 to 48 °c
- From the PET scale existing case extreme heat stress during peak hours with 4 iterations it has been reduced to moderate and strong heat stress.

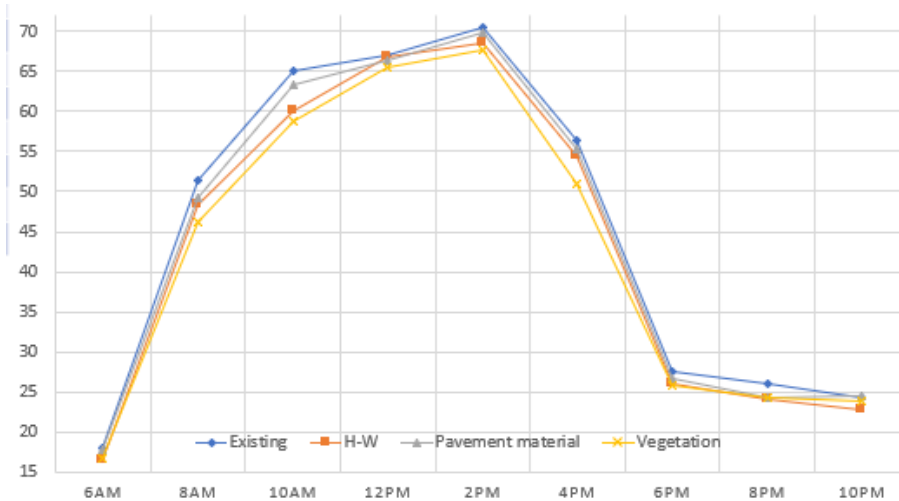
4.8.6 RESULT OF B3:



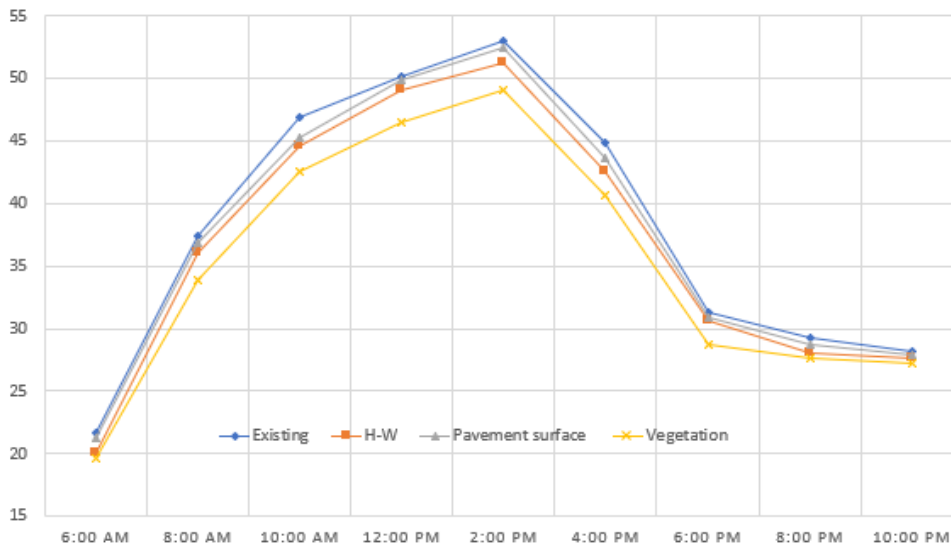
Graph: 4.8.21: Air temperature variation from different iterations of B3



Graph: 4.8.22: Wind speed variation from different iterations of B3



Graph: 4.8.23: Mean radiant variation from different iterations of B3



Graph: 4.8.24: physiological equivalent temperature from different iterations of B3

AIR TEMPERATURE B3:

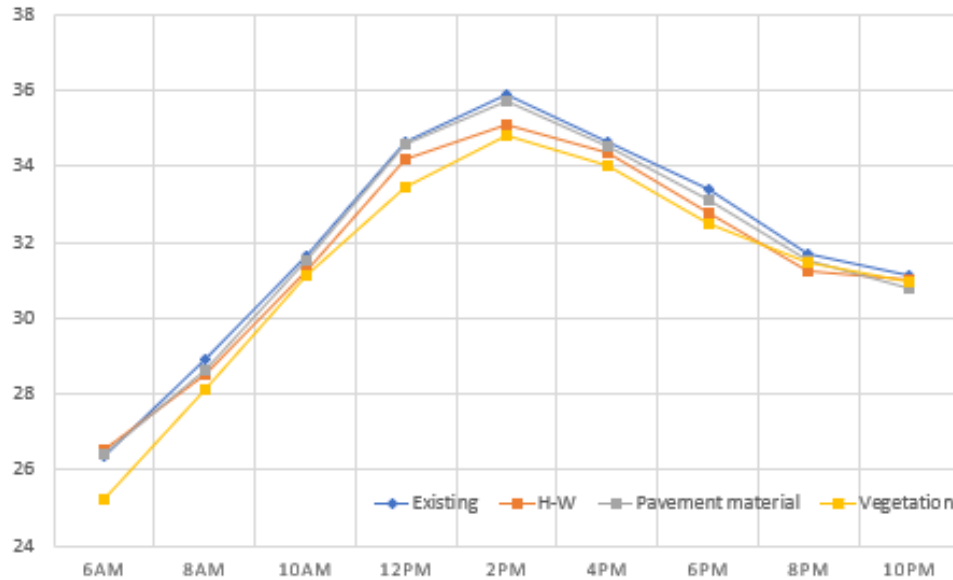
- H-w Ratio – reduced SVF
- Resulted in 0.5 – 0.7 °C and the increased height has reduced the wind speed to 0.2 – 0.7 m/s.
- Pavement material has Replaced to concrete and permeable pavers reduced the surface air temperature.
- Vegetation in added in both the side creates a canyon and reduced the temperature from 36.2 – 35.45 °C

PET:

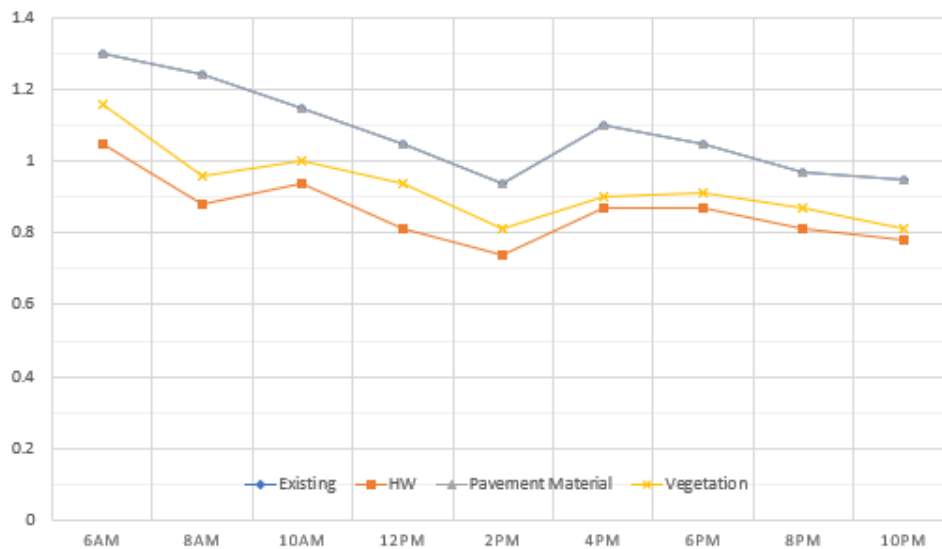
- PET analysis shows that increasing pervious area and vegetation can reduce the PET to 5 – 8 °C
- During 2PM – The temperature has reduced from 54 to 49 °C

- From the PET scale existing case extreme heat stress during peak hours with 4 iterations it has been reduced to moderate and strong heat stress.

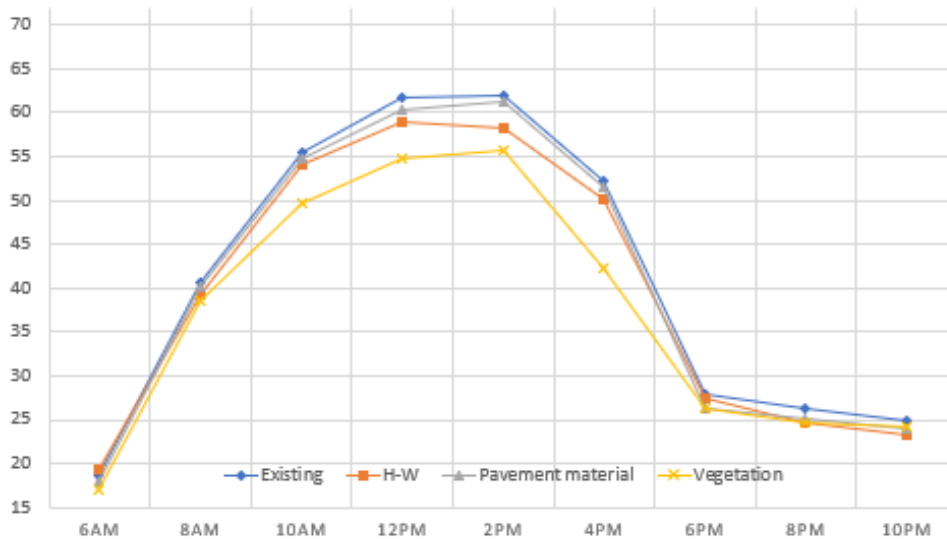
4.8.7 RESULT OF B4:



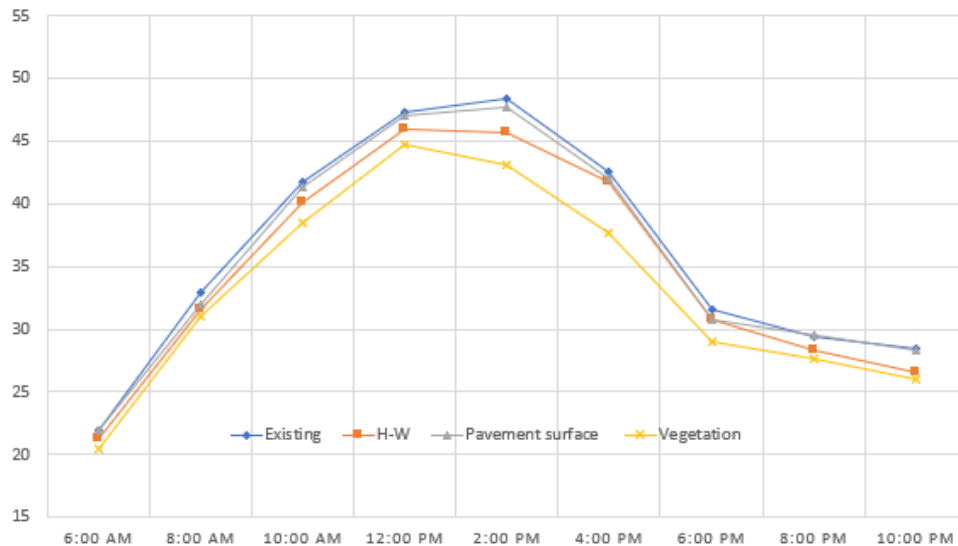
Graph: 4.8.25: Air temperature variation from different iterations of B4



Graph: 4.8.26: Wind speed variation from different iterations of B4



Graph: 4.8.27: Mean radiant variation from different iterations of B4



Graph: 4.8.28: physiological equivalent temperature from different iterations of B4

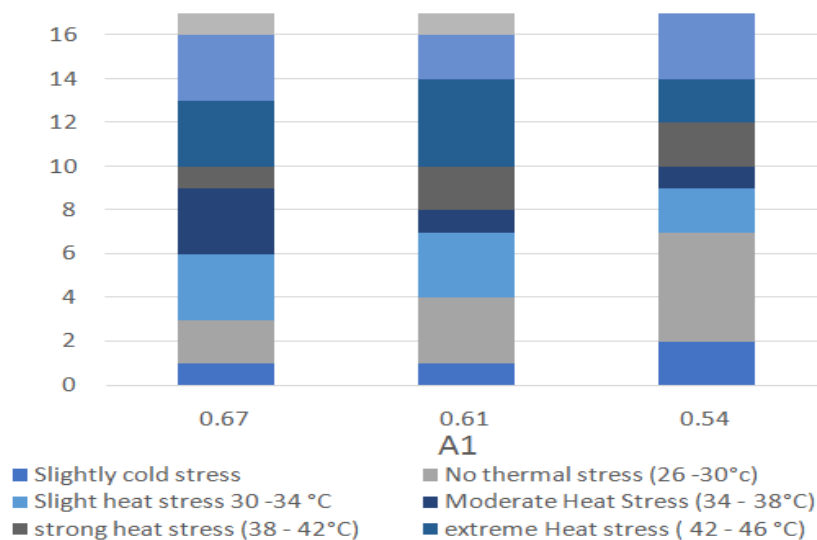
AIR TEMPERATURE B4:

- H-w Ratio – reduced SVF
- Resulted in 0.5 – 0.7 °c and the increased height has reduced the wind speed to 0.5 - 1m/s.
- Vegetation in the other case has reduced the SVF and reduced 0.7 – 1.2 °c and provides shadow for the pedestrians.
- Existing tree has a large canopy which reduces the temperature and improves the comfort when compared to the other points.

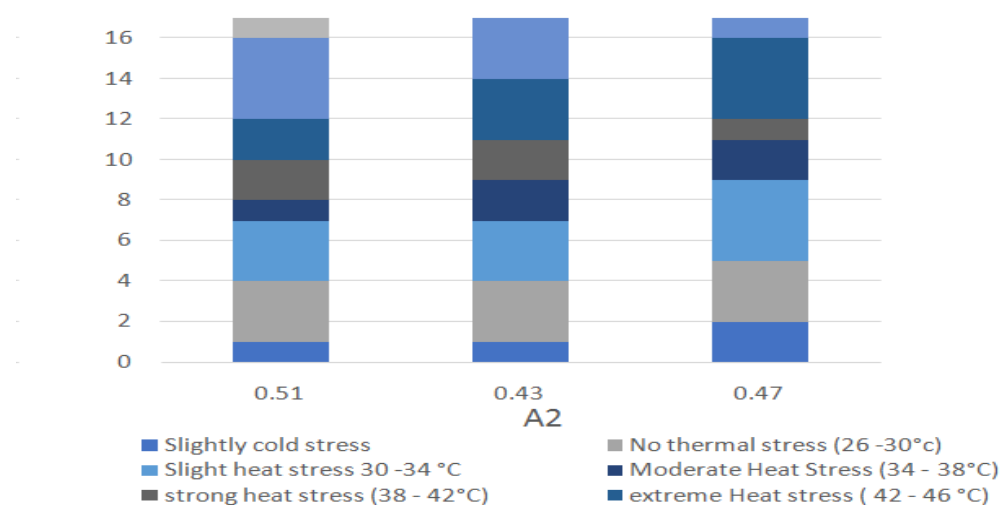
PET:

- PET analysis has proved that reducing SVF and increasing pervious area and vegetation can reduce the PET to 5 – 7 °c
- During 2PM – The temperature has reduced from 48 to 43 °c
- From the PET scale existing case extreme heat stress during peak hours with 4 iterations it has been reduced to moderate and strong heat stress.

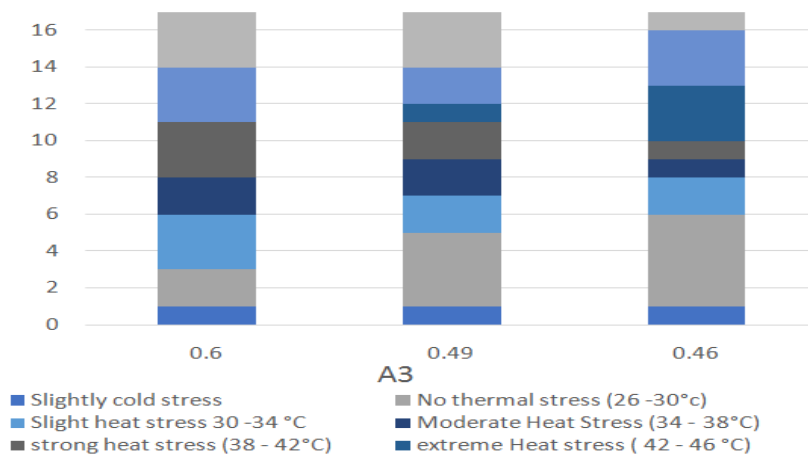
4.9 AVERAGE PET FOR NUMBER OF HOURS FOR THE SELECTED LOCATION



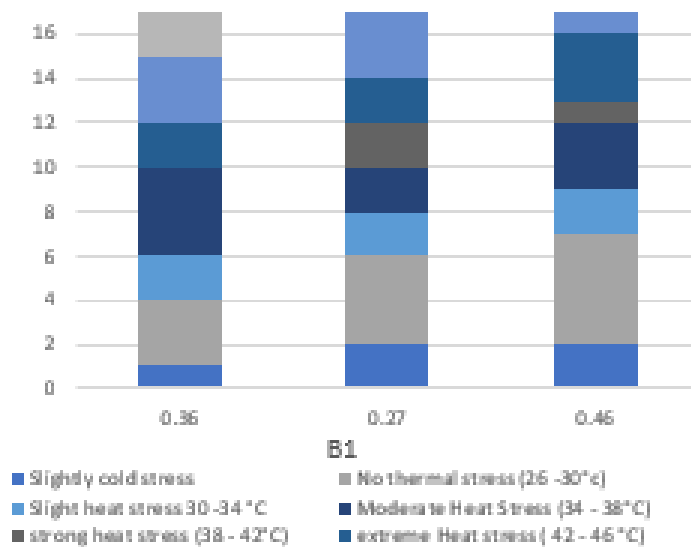
Graph: 4.9.1: Average PET for number of hours for location A1



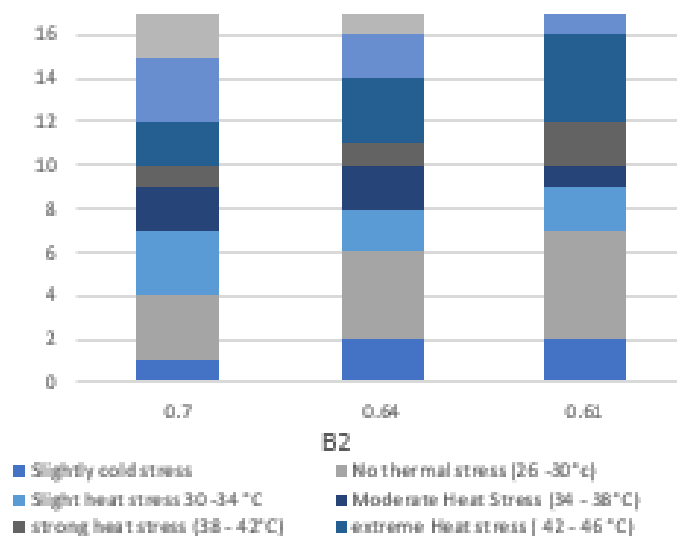
Graph: 4.9.2: Average PET for number of hours for location A2



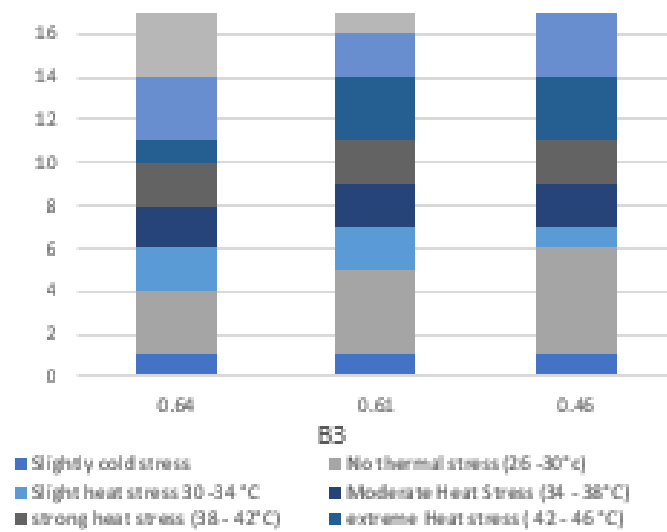
Graph: 4.9.3: Average PET for number of hours for location A3



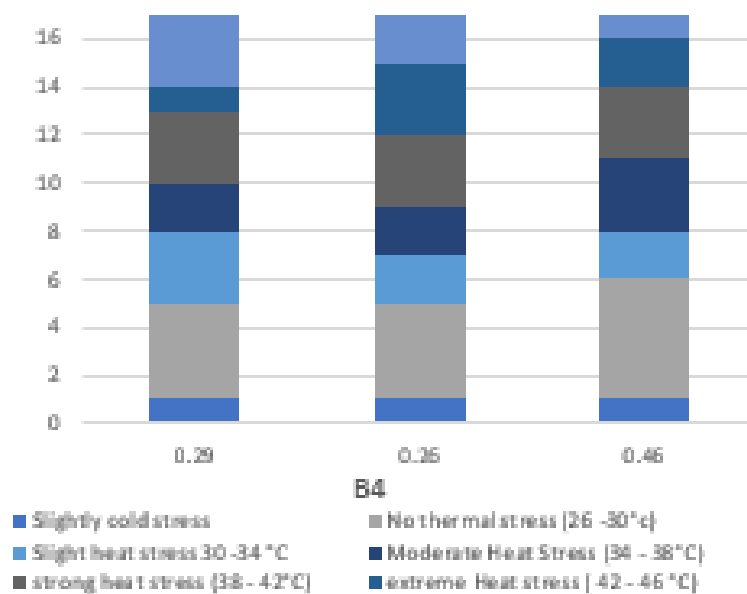
Graph: 4.9.4: Average PET for number of hours for location B1



Graph: 4.9.5: Average PET for number of hours for location B2



Graph: 4.9.4: Average PET for number of hours for location B3



Graph: 4.9.5: Average PET for number of hours for location B4

The study has also revealed that the abovementioned changes could significantly influence the PET distribution. It has been revealed that the thermal stress has been reduced by increasing green cover and reducing the SVF.

CHAPTER 5 PROPOSAL AND SUGGESTIONS

5.1: Redesigning of spaces



Fig: 5.1: Master plan of the proposed design case

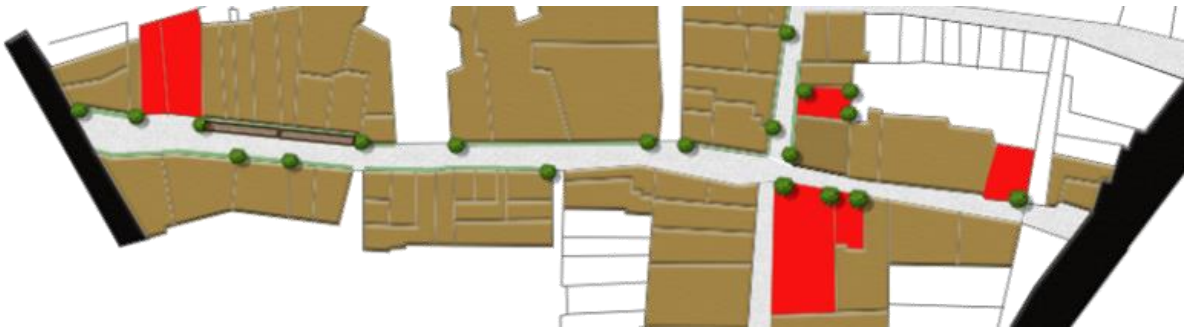


Fig: 5.2 : Proposed design location of east – west orientation

In east west orientation, 3 major spots were selected for the proposal. The proposal made in the 3 points reduce the congestion and scatter the people to the entire east west stretch.

Semi – open space is created which act as breathing space in a cluster of buildings.

5.2 Design Details



Fig: 5.3 : Complex and semi open space design - 1

Complex design of 3 floors and Community space in the first-floor level is designed which act as a decongestion area. This community space has a food court and landscape area. These spaces help in the revenue generation and increase the commercial value and landscape provided improves the comfort of the occupants.



Fig: 5.4 : Complex and semi open space design - 2

It is found to be a congested area where people are highly occupied. Around 300m radius stretch there is no rest space or recreational area is found which creates more discomfort for the occupants. Therefore, in the proposal Stilt parking is provided which reduce the traffic congestion along the road side. Complex design of 3 floors which helps

in revenue generation and Community space in the first-floor level – act as a decongestion area, recreational space. Food Court for the street food shops has been given and seating areas, planters and landscapes is provided to improve the thermal comfort around the place.

Space for the street vendors is given in the East entrance which reduces the crowd and people gathering in the main areas.



Fig: 5.5 : View of the proposals

5.3 Conclusion:

Electronic commercial areas are the busiest areas where there is a high volume of people moving around. Thus, the outdoor spaces become an essential element where these people spend most of their time. As a result of the dense urban fabric, the comfort of the occupants is affected, which reduces the number of people visiting this place. In order to understand the impact of building geometry on outdoor thermal comfort, the proposed scenario was developed and evaluated by altering the Skyview Factor, the green cover, and the Aspect Ratio. Further, the connection between building parameters and outdoor thermal comfort was analysed by presenting a proposal that included recreational spaces, landscape areas, food court areas, as well as parking solutions to reduce the congestion caused by vehicular movements. In turn, this leads to increased social, economic, and environmental sustainability.

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