OPTIMISING HEAT GAIN BY BUILDING MATERIALS THROUGH LANDSCAPE ELEMENTS

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Abstract:

Urban areas present distinctive micro climates. In the study of causes of the special climate in cities, it is reported that "The total transformation of natural landscape into houses, streets, squares, big public buildings, skyscrapers, and industrial installations has brought about changes in climate of large cities". Temperature is one of the most important characteristics of urban areas. It is known urban temperatures differ from those of sub-urban and rural areas and the phenomenon commonly known as the" Urban Heat Islands". Mitigation and control of this Urban Heat Island effect is so important for the environmental sustainability of urban areas. The materials used in the urban matrix play key role in causing this distinctive heat gain. The aim of this paper is to relate the thermal conductivity of building materials to the urban heat gain and to find solutions to optimize the heat gain by materials through landscape elements.

Key Words: Urban Heat Island Effect – Building Materials – Optimising – Landscape

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The building material of the construction sector has achieved greater efficiency because of the ever improving fields of science and technology. The environmental cost benefit of the application of materials has to be carried out so that the pro negative impacts of the materials should be optimized with the solutions that are environment friendly. Landscape is one among the tools that can be considered for optimising the negative impact of building materials on environment. The impact of heat is considered for optimising, as in today's context the issue of Global Warming is a very serious issue which is questioning the survival of earth.

Introduction:

Throughout the history of architecture and growth of cities the building materials have always played a key role in shaping them. Though there are many environmental issues in cities the prime of them are the problems and issues related to heat.

Urban climate is characterized by more hot, less humidity, more runoff, noise, pollution etc. particularly its micro temperature commonly known / differentiated as 'urban heat island', i.e. urban areas are separated from its rural surroundings due to its raised air temperature. The factors that contribute to the extreme heat are the increase in carbon di oxide emission, climate change, land degradation, over population, improper waste disposal and the choice of building materials. The impact of building materials to certain extent can be mitigated by the intervention of architects.

Solar Irradiation:

The amount of radiation, both direct and diffuse, that can be received at any given location.

Some of the Sun's radiation passes through the atmosphere and reaches the surface of the Earth. The amount of solar radiation hitting the Earth is called insulation. Energy, from the sunlight that reaches Earth, drives the climate and the ecosystem.

Some sunlight is visible to humans as light, but there are also components of solar radiation that are not visible to the human eye. These are important too. Infrared sunlight is heat and ultraviolet sunlight is damaging to living organisms. However, most of the ultraviolet radiation is blocked by the ozone layer.

Some of the radiation reaching Earth is reflected back into space. This process is called Albedo. Around 30 percent of the sunlight is reflected by Earth's surface and the atmosphere.

The part of the radiation that is not reflected back into space is absorbed and converted into heat. Some of this heat escapes and some of it stays around Earth's surface, because of the greenhouse effect, where greenhouse gases capture the heat and stop it from escaping the Earth.

The Building Materials:

The building materials belong to the following families:

Rock material – found in natural state like stone and clay

Organic material – which is like wood of cellular organization

Metal material – as a refined product of the most compact molecular organization found in the nature

Synthetic material – like glass and plastic found in man's industry

Hybrid material – like concrete or adobe formed by the combination of two or more synthetic material. Cities are formed by many components like the natural elements (biological and non biological) and manmade; of which the man made components play a key role in many environmental issues.

Of the man made components in the city matrix are the infrastructures facilities like the buildings, fly overs, bridges, water canals, roads e.t.c are made of materials which are non natural but manufactured to cater the need .In that process in many cases the environmental sensitivity of the material is not taken into consideration.

Certain materials of that kind contribute to the environmental issues like urban heat island effect, pollution, and glare e.t.c.There has to be technical solutions found to solve the problems caused by some of these materials and the solutions have to be environmental friendly, easy to operate, less cost, less maintenance, long term.

The Issue:

The prime issue which has to be dealt today considering the building materials is the HEAT.

Heat is always not negative. It contributes in maintaining temperature in cool climates, heat is a form of energy were it can be converted to other forms of energy(for example the heat energy could be transformed into mechanical energy there by helps in running some gadget),heat as it is can be stored and can replace the energy form the non renewable energy sources.

Before identifying the uses and finding solutions to enhance or reduce heat it is important to know the heat storing capacity of the various building materials.When we deal with materials and heat, we need to know the following important properties of the materials: Specific heat of material, solar reflectance value or the Albedo, Thermal mass and Thermal Conductivity.

Urban Heat Island Effect:

Heat island is the presence of any area warmer than its surrounding landscape. They can be developed on urban or rural areas.

Urban heat island effect is the phenomenon allusive to the atmospheric temperature rise experienced by any urbanized area. The heat island phenomenon has been commonly associated to cities, because their surfaces are characterized by low albedo, high impermeability and favourable thermal properties for the energy storage and heat release.

The extra sources of urban heat include the following: 1) paved areas (which can account or 1/3 or more of a city's land area) and dark-colored rooftops absorb more sunlight and re-emit more heat than would an area's native soils and vegetation; 2) motor vehicles, buildings and machinery produce waste heat that is not quickly removed from the area; and 3) loss of vegetation eliminates natural cooling from evapotranspiration and shading.

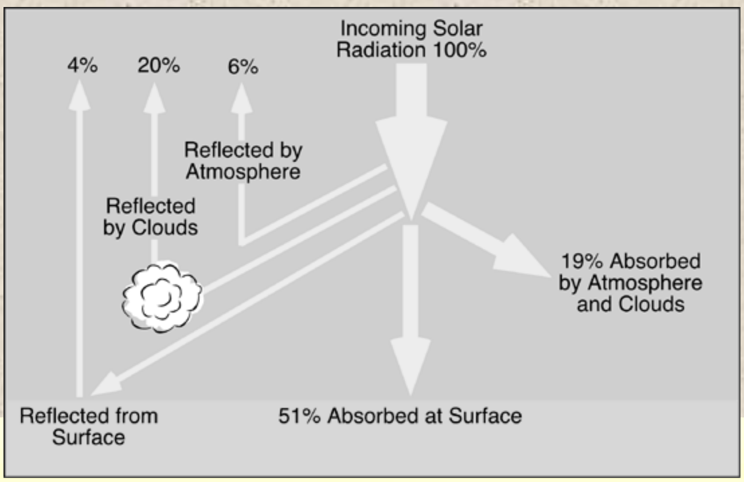


Figure 1: Depicting the possible operations taken up by the incoming solar radiation.

When the radiation reach the buildings in urban area, materials in the base plane (floor), vertical plane (walls), overhead plane (roofs and ceilings) along with the building finishes play key role in adding to the urban heat island effect.

Absorption + Re radiation of heat from surface of built environment +

emission of artificial heat through combustion = URBAN HEAT ISLAND EFFECT

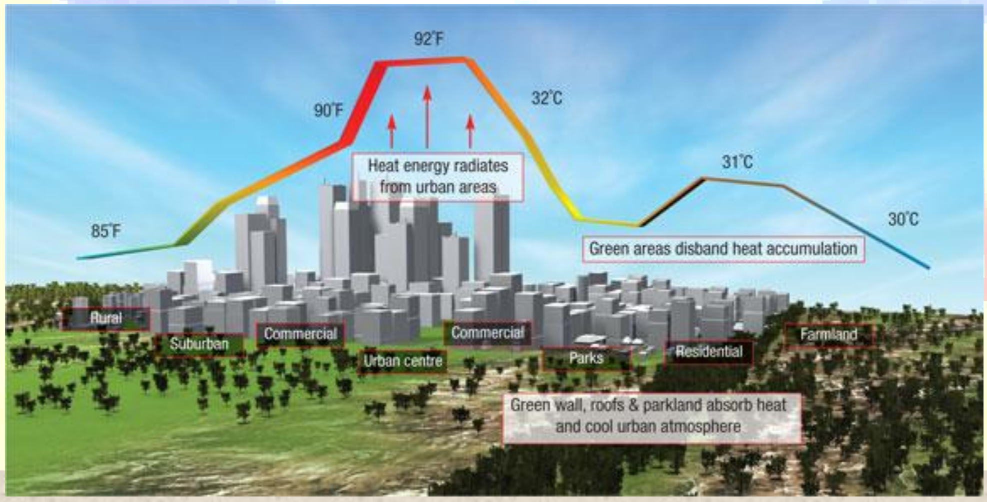


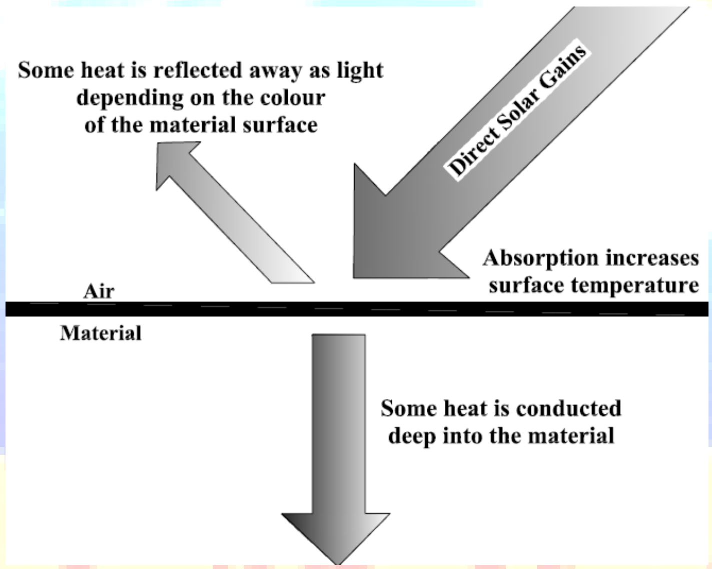
Figure 2: Image depicting Urban Heat Island Effect Source:Ecofinroofgarden.co.uk

Effects of Urban Heat Island Effect (UHIs):

UHIs have the potential to directly influence the health and welfare of urban residents by exacerbating the effects of heat waves.

Causes of Urban Heat Island Effect:

- Increased Temperature caused by:
- Pavement & buildings absorbing heat & emitting at night
- Buildings decrease 'sky view' & block wind
- Less evapo transpiration from reduced vegetation



- Concentrated anthropogenic heat release
- Some Effects of Warmer Urban Climate
- Uncomfortable living environment
- Heat related illness and death
- Increases in Ozone Concentration
- Harms humans and plant-life
- Further increases CO2
- Increase in Energy consumption

Figure 3: Direct solar gains and material response.

- Peak utility loads can increase up to 2% for every 1°F increase

In broad the factors contributing to the UHI effect can be grouped as:

There are two types of factors they are:

1. **Un-controllable Variables**

- Season
- Wind Speed
- Cloud Cover
- Diurnal Conditions
- Anti-Cyclone Conditions

2. **Controllable Variables**

- Urban Design and Structure
- Air Pollutants
- Anthropogenic Heat

The steps to mitigate Urban Heat Island effect include the following:

1. Increase Green Areas in Cities
2. Better Roofing Materials
3. Cool Paving Materials
4. Decreasing Air Pollutants
5. Better Building Materials
6. Better City Planning

Heat Transfer

The prime factor behind the materials in contributing to the urban heat island effect is the process called the Heat Transfer. Heat may transfer across the boundaries of a system, either to or from the system. It occurs only when there is a temperature difference between the system and surroundings. Heat transfer changes the internal energy of the system. Heat is transferred by conduction, convection and radiation, which may occur separately or in combination.

Conduction heat transfer occurs only when there is physical contact between bodies (systems) at different temperatures. Heat transfer through solid bodies is by conduction alone, whereas the heat may transfer from a solid surface to a fluid partly by conduction and partly by convection.

Convection is the heat transfer within a fluid, involving gross motion of the fluid itself. Fluid motion may be caused by differences in density as in free convection. Density differences are a direct result of temperature differences between the fluid and the solid wall surface. In forced convection, the fluid motion is produced by mechanical means, such as a domestic fan-heater in which a fan blows air across an electric element.

Thermal radiation is the energy radiated from hot surfaces as electromagnetic waves. It does not require medium for its propagation. Heat transfer by radiation occur between solid surfaces, although radiation from gases is also possible. Solids radiate over a wide range of wavelengths, while some gases emit and absorb radiation on certain wavelengths only. When thermal radiation strikes a body, it can be absorbed by the body, reflected from the body, or transmitted through the body.

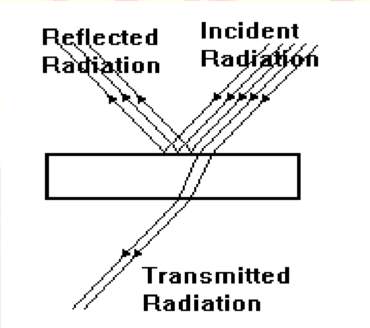


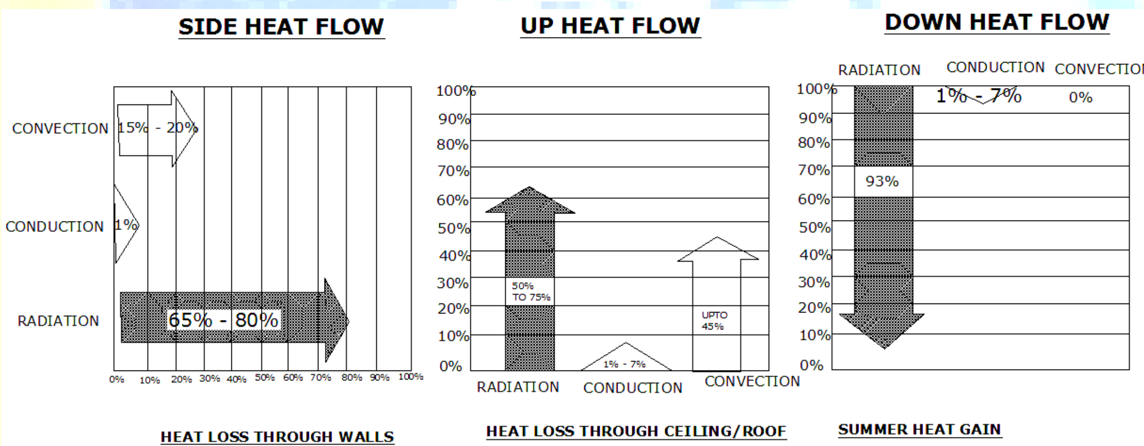
Figure 4: Image showing the path taken by the incident radiation

Conduction – Convection – Radiation and the Built form:

Of the three, radiation is the primary mode of heat transfer; conduction and convection are the secondary and come into play only as matter interrupts or interferes with radiant heat transfer. As the molecules of the built form absorb radiant energy, it is heated, develops a difference in temperature, and results in molecular motion (conduction in solids) or mass motion (convection in liquid and gas).

All substances, including air, building materials, such as wood, glass and plaster and insulation obey the same laws of nature; they do transfer heat. Solid materials differ only in the rate of heat transfer, which is affected by difference in: density, weight, shape, permeability and molecular structure. Materials which transfer heat slowly is said to resist heat flow.

Direct heat transfer is a very important consideration to apply solutions to combat excess heat. Heat is radiated and conducted in all directions, but convected primarily upward. The figures below show modes of heat loss in houses and buildings. In all cases, radiation is the



dominant mode.

Figure 5: The figure shows the nature of heat loss in buildings (source: EPA USA)

Materials and Heat:

The building materials in general react in three different ways to dissipate the heat that they have received either from a natural or artificial heat source. They are:

- The materials which releases heat very fast
- The materials that release heat in a moderate speed
- The materials that take a long time to reradiate the incident heat.

Of the three categories of materials the last type of materials significantly contribute to the Urban Heat Island Effect.

Those kind of building materials have more thermal conductivity and specific heat. This property of the materials to store heat for a long period is really a boon in conditions that require heat to combat climate and weather changes but in conditions that require minimum heat these building materials will prove nuisance. At the same time due to their cost, structural property, ease in construction these materials cannot be compromised, therefore certain solutions have to be made to minimize their heat contribution to the environment.

There are certain properties of materials that play important role in deciding on the surface irradiation, they are:

Specific Heat of material

The amount of heat, measured in calories, required to raise the temperature of one gram of a substance by one Celsius degree. The higher the specific heat, the more resistant the substance is to changes in temperature. Materials like wet mud, clay, granite have more specific heat. Therefore materials with low specific heat will have more influence over the Urban Heat Island Effect (UHI).

Solar reflectance Value or the Albedo Value

Albedo is "the fraction of the total solar radiation incident on a body that is reflected by it." Surfaces that have high Albedo values absorb less incident radiation. Materials with more solar reflectance value contributes less impact on the (UHI).

Thermal Mass

Thermal Mass is the capacity of a material to store heat. The basic characteristic of materials with thermal mass is their ability to absorb heat, store it, and at a later time release it. Building materials that are heavyweight store a lot of heat so are said to have high thermal mass. Materials that are lightweight do not store much heat and have low thermal mass.

Thermal Conductivity

The ability of a material to transfer heat. Lesser the value of thermal conductivity more they contribute to (UHI).

Thermal properties of building materials

Material	Density (kg/m3)	Thermal Conductivity (W/mK)	Specific Heat Capacity (J/kgK)
WALLS			
Asbestos cement sheet	700	0.36	1050
Asbestos cement decking	1500	0.36	1050
Brickwork (outer leaf)	1700	0.84	800
Brickwork (inner leaf)	1700	0.62	800
Cast concrete (dense)	2100	1.40	840
Cast concrete (lightweight)	1200	0.38	1000
Concrete block (heavyweight)	2300	1.63	1000
Fibre board	300	0.06	1000
Plasterboard	950	0.16	840

Stone (Artificial)	1750	1.3	1000
Stone (Limestone)	2180	1.5	910
Tile hanging	1900	0.84	800
SURFACE FINISHES			
External rendering	1300	0.50	1000
Plaster (dense)	1300	0.05	1000
Plaster (lightweight)	600	0.16	1000
ROOFS			
Aerated concrete slab	500	0.16	840
Asphalt	1700	0.50	1000
Felt/Bitumen layers	1700	0.50	1000
Stone chippings	1800	0.96 1000	1000
Tile	1900	0.84	800
Wood wool slab	500	0.10	1000
FLOORS			
Cast concrete	2000	1.13	1000
Metal tray	7800	50.00	480
Timber flooring	650	0.14	1200
Wood blocks	650	0.14	1200
INSULATION			
Expanded polystyrene slab	25	0.035	1400
Glass fibre quilt	12	0.040	840
Glass fibre slab	25	0.035	1000
Mineral fibre slab	30	0.035	1000
Phenolic foam	30	0.040	1400
Polyurethane board	30	0.025	1400
Urea formaldehyde foam	10	0.040	1400

(Table 1: Thermal properties of building materials – source - *The data came from the code of Residential Building Design in Thermal Characteristics GB 50176-93*)

Albedo value of materials

Materials	Solar reflectance
Black Acrylic Paint	0.05
New Asphalt	0.05
Aged Asphalt	0.1
White Asphalt Shingle	0.2
Aged Concrete	0.2 to 0.3
New Concrete(traditional)	0.4 to 0.5
New Concrete (Portland Cement)	0.7 to 0.8
White acrylic paint	0.8
Bare soil	0.17
Green Grass	0.25
Desert Sand	0.4
Deciduous Trees	0.15

(Table 2: Albedo value of building materials – source - *The data came from the code of Residential Building Design in Thermal Characteristics GB 50176-93*)

Quantification of Thermal Performance of Building

The thermal performance of a building refers to the process of modelling the energy transfer between a building and its surroundings.

The thermal performance of a building depends on a large number of factors.

They can be summarised as

1. Design variables (geometrical dimensions of building elements such as walls, roof and windows, orientation, shading devices, etc.)
2. Material properties (density, specific heat, thermal conductivity, transmissivity

3. Weather data (solar radiation, ambient temperature, wind speed, humidity, etc.)
4. A building's usage data (internal gains due to occupants, lighting and equipment, air exchanges, etc.)

Solar Heat Gain Pilot Study

The pilot study was carried out in Tiruchirappalli (Tiruchirappalli, stationed in the center of Tamil Nadu, on the shores of the Cauvery River is 320 km from Chennai) in an area that has a prominent Commercial land use.

The study is along the super Bazaar region of Tiruchurappalli the area that has high density of buildings and population.

Climatic Profile of Tiruchirappalli

The climate of Trichy is Tropical. Temperature Range (deg C): Summer- Max. 37.1°C Min. 26.4°C; Winter- Max. 40.3°C Min. 15.6°C; Rainfall: 835 mm (source – Meteorological Center Chennai).

The study was carried out in the month of September when the sky temperature was around 32degree centigrade.

Aim of the study

Quantification of heat radiated by the building materials.

Need of the study

The study basically helps in identifying the materials that are the key contributors to the urban Heat Island Effect.

Study Area

The super bazaar area in Tiruchirappalli falls under the city core and has more percentage of commercial buildings followed by mixed use buildings(ground floor commercial and first floor residential) then few buildings that fall under the heritage category but now used as Government buildings.

The area which is chosen for study is approximately 24 acres of the flowing percentage of land use:

Commercial – 28862 Square meters

Residential – 1600 Square meter

Government Buildings – 1560 square meter

Limitations:

1. The study does not include the response of vegetation, water, anthropogenic heat, shade and other climate features in calculating heat in the present pilot study but will be a part in my research.
2. This pilot study focuses on to the two dimensional forms of the building and surface of land to have a primary understanding of the material contribution towards Urban Heat Island Effect.
3. The three dimensional aspect of the built form will be a part in my research work which will be carried on in the process.
4. This study limits itself to the building materials and not the heat generation my mechanical instruments or other human related activities.

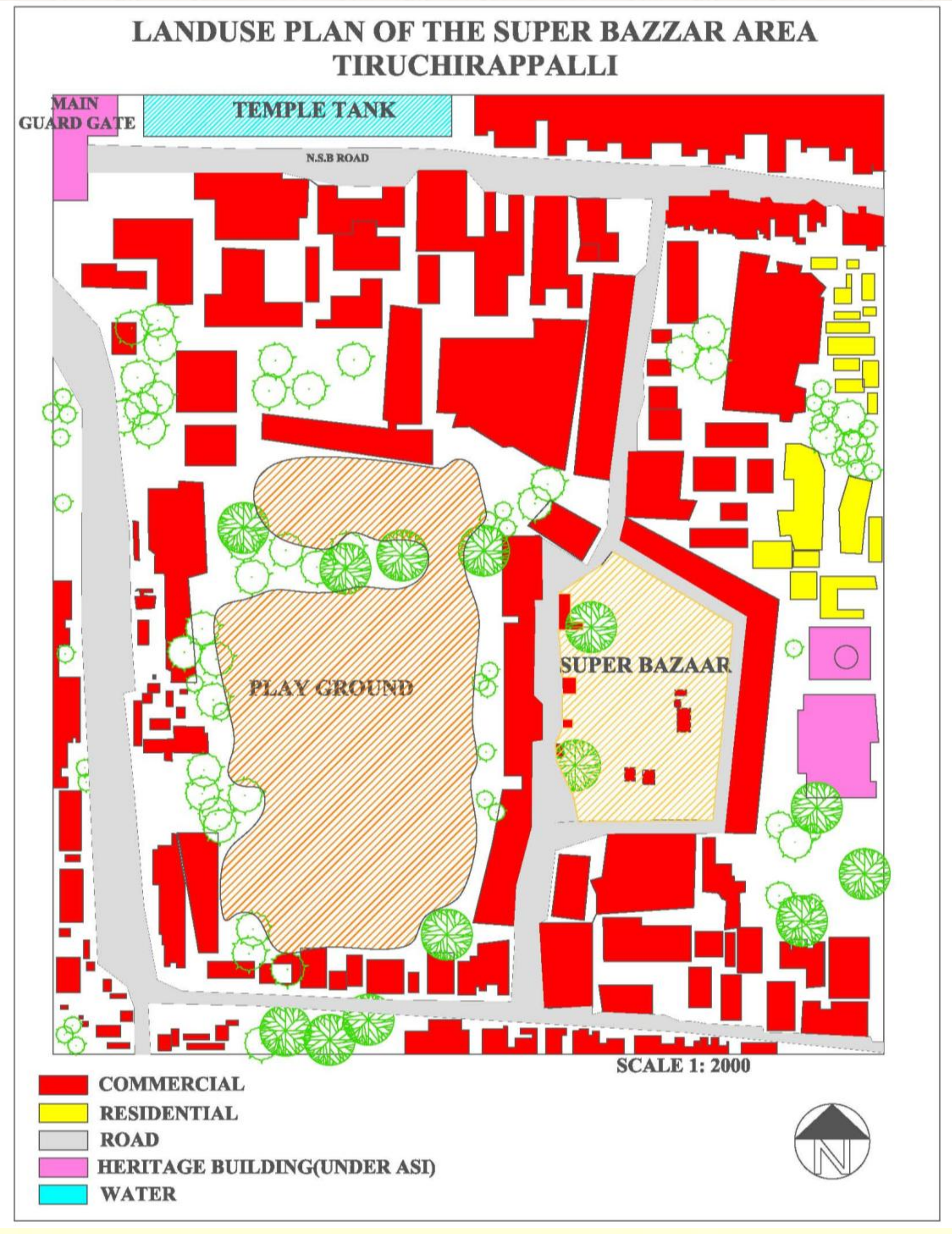


Figure 6: Land Use Plan of study area (Source: Author)

Methodology:

1. Primary survey of the area was carried out to identify the various materials used in the buildings and their area was calculated.

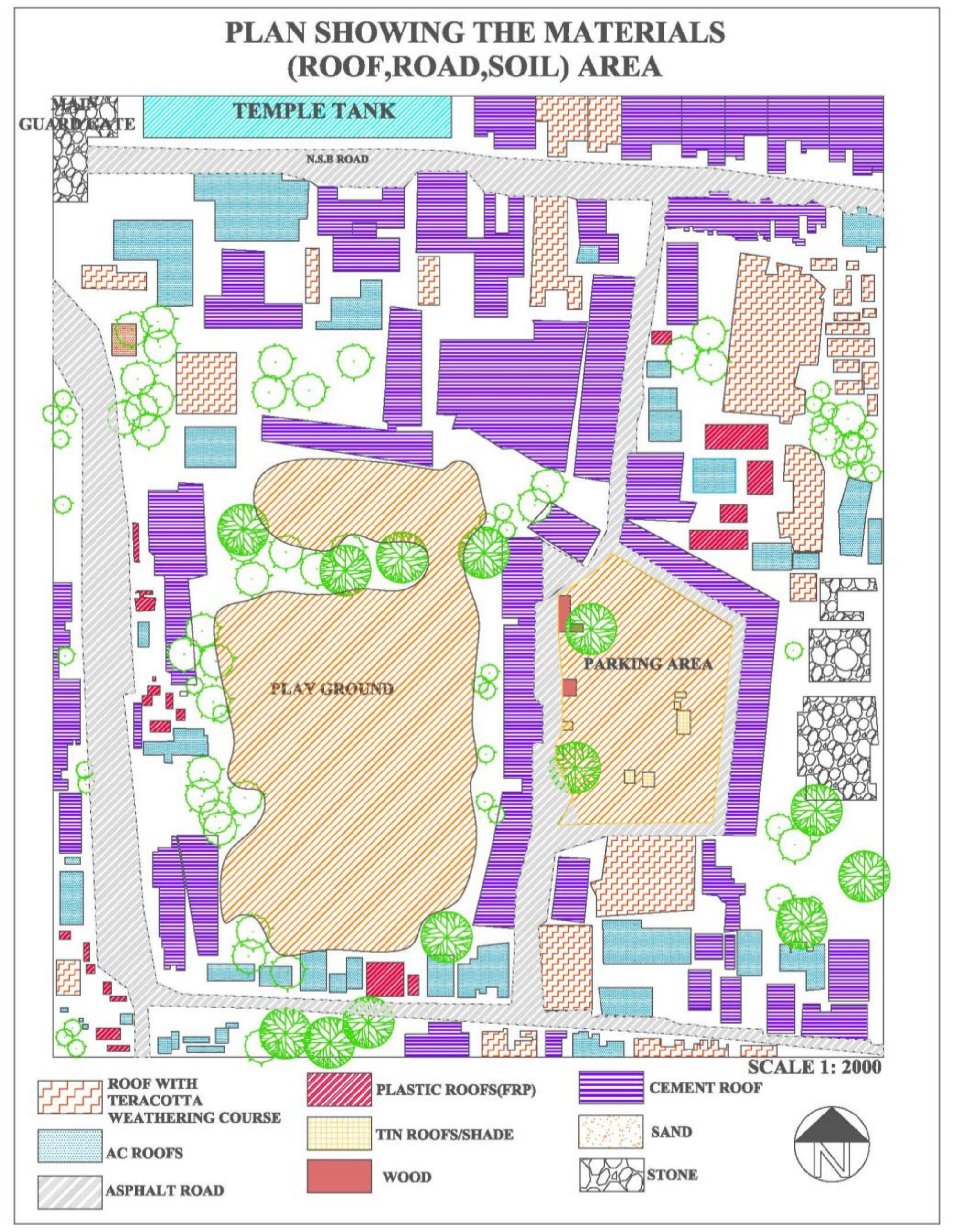


Figure 7: Material Map of study area (Source: Author)

2. From the meteorological department the maximum and minimum temperatures, the sky temperature was known. The study was carried out in the month of September when the temperature of sky was 32 degree centigrade.
3. The radiation emitted by the building materials was quantified using the formula

$$Q_{Radiation} = A\,\epsilon\,\sigma\,(T^4_s - T^4_{Sky})$$

Where A = Area of the building exposed surface (m^2)

ϵ = emissivity of the material of the exposed surface

σ = Stefan-Boltzmann constant (5.67x10-8 W/m2-K4)

T_s = Temperature of the building exposed surface (K)

T_{Sky} = Sky Temperature (K)

4. The results were quantified and tabulated to infer the radiation contribution by the materials.

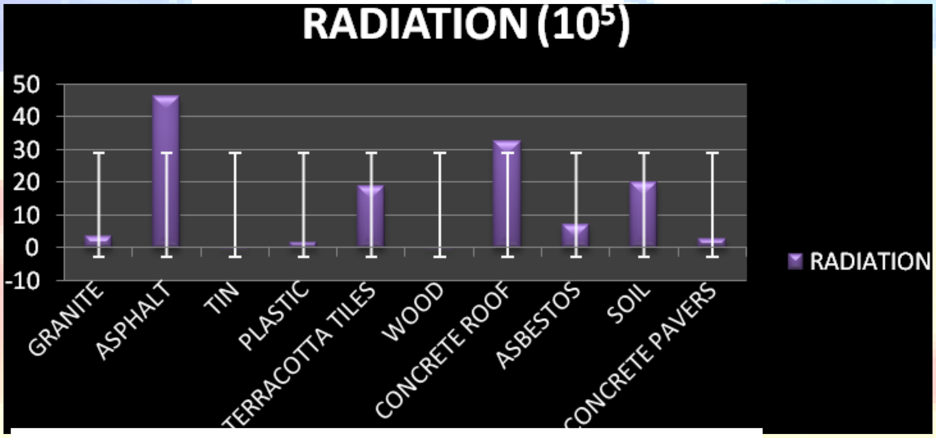


Figure 8: radiation Chart (Source: Author)

5. Result

- It was observed that the material of dark colour which also occupied significant area in the study area contributed to more heat – Asphalt – Black colour.

- Although the concrete roof was light colour and had comparatively lower emissivity value its significant area in the site has listed it second in the table.
- The least contributor of the radiation was the roof structure with tin finish.

6. Conclusion

- It was concluded that the solar emissivity of the material played a key role in the radiation.
- The area of the material distributed in the study region gained importance as in the case of concrete though its emissivity value is less it found to contribute towards radiation.
- The light colour materials contributed less to the Urban Heat Island effect.
- Quantification of materials in contributing towards urban Heat Island Effect was related to their property to radiate heat.

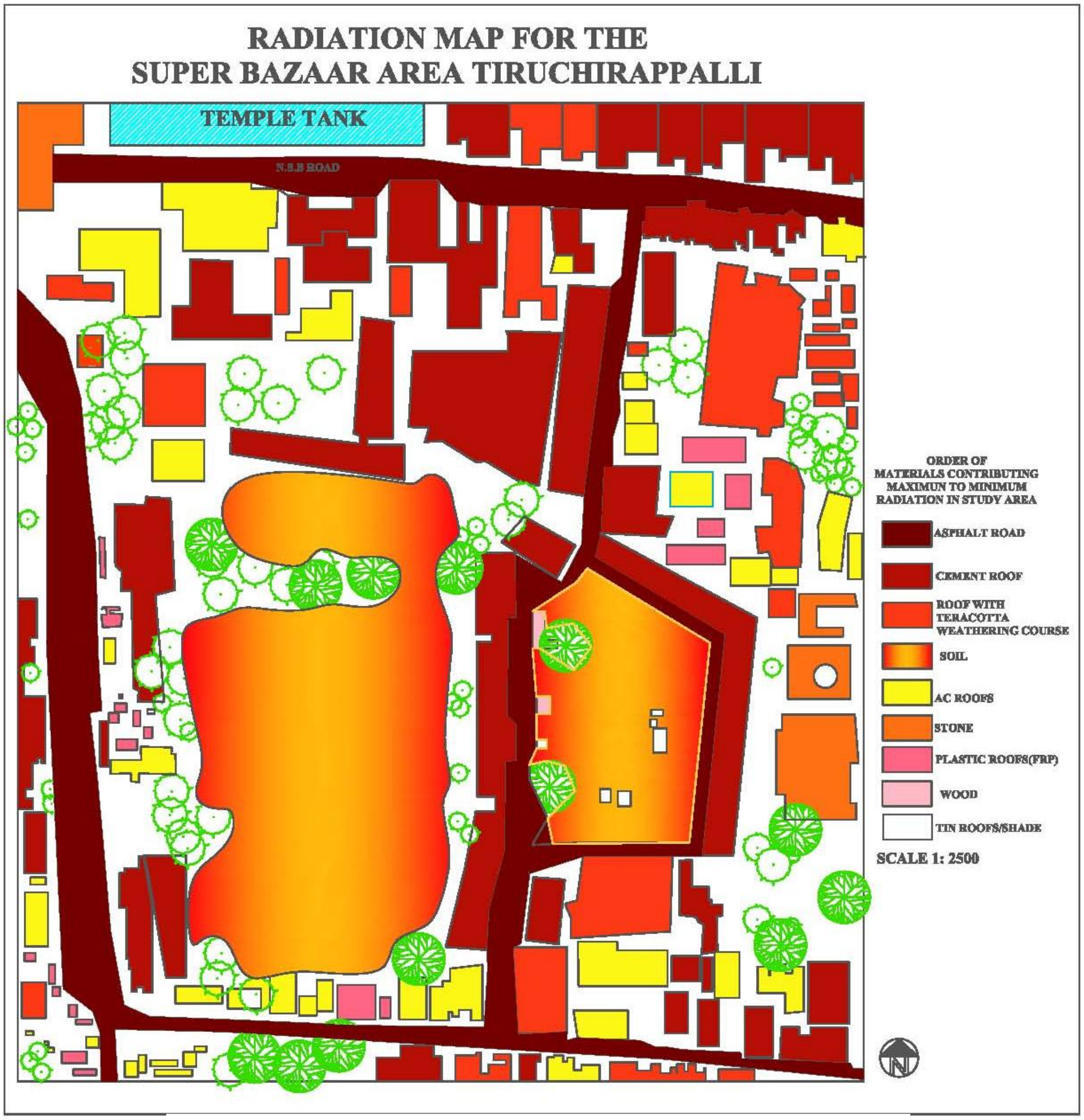


Figure 9: Radiation Map of study area (Source: Author)

Though there are many intervention techniques to optimise the impact of materials on Urban Heat Island effect this paper focuses on the application of landscape. Solutions using landscape are prioritized because they are environment friendly, cost effective, less maintenance and sustainable.

Conventional strategies to reduce heat gain in built environment:

- Proper Design
- Using light colour materials
- Applying reflective coating
- Blocking the heat by insulation and shade
- Channelizing wind to remove heat.
- Water tool to reduce heat gain
- Irrigated landscape
- Climatic factors consideration in building design

The Solution:

The various steps to reduce the heat gain by building materials should include solutions that are cost effective, ease to maintain and long term solutions.

The prime step which would provide a giant leap of urban heat reduction would be to use correct combination of building materials. The combination of materials will include the family of materials along with the landscape elements like vegetation, water e.t.c.

Management of UHI through landscape:

Landscape comprises the visible features of an area of land, including physical elements such as landforms, living elements of flora and fauna, abstract elements like lighting and weather conditions, and human elements like human activity and the built environment.

Landform comprises of refers to seascape and oceanic water body interface features such as bays, peninsulas, seas and so forth, including sub-surface terrain features such as submersed mountain ranges, volcanoes, and the great ocean basins under the thin skin of water, for the whole earth is the province and domain of geology.

UHI mitigation is possible by irrigated landscape treatments—turf grasses and humid-region trees and shrubs. Evaporation from irrigated surfaces cools the scorching daytime desert temperatures and thus prevents the buildup of stored heat, a critical factor in the UHI (Grimmond And Oke, 1999). The challenge, however, in a desert city with limited water supplies lies in the tradeoffs between the temperature-reduction properties of irrigated surfaces and the water required to maintain them. The scientific and planning question is how to achieve the greatest nighttime cooling with the least water used.

The management strategies can be categorized under:

- Management at regional level
- Management at site level

<u>Regional level management of urban heat island is possible through the following methods:</u>

- Increase in open space – regulation. As this would provide the following benefits:
  - To meet positive Human needs – recreation (physically and psychologically)
  - To enhance and protect resource base –air, water, soil, plants and fauna
  - To meet social and cultural needs – social gathering, cultural exchange
- Urban green pockets to be developed & existing greenery to be preserved. Encouraging urban forestry.
- Road landscaping can be encouraged as this would enable the reduction in heat reflectance by the road surface.
- Regulations to Be Framed on Paved Areas at the Regional Level (advising on the nature of material).
- More community parks to be developed.
- Water bodies in the regional scale to be preserved and landscaping can be done to preserve their existence.

- Industrial Zones of a city can be buffered with vegetation as this would reduce the UHI effect
- Possible reduction of concrete usage.
- Encouraging community participation in reduction of UHI effect.

Site level management of urban heat island

- ► Ground level
- ► Vertical Surface
- ► Roof level

Ground level

PAVERS (materials and construction techniques that are used in roads, driveways, parking lots, sidewalks, pedestrian ways and other hard surfaces): COOL PAVEMENTS.

Cool Pavements - which act to reduce the absorption, retention and emittance of solar heat.Landscape shading of paved and hardscape surfaces and use of high reflective and porous materials, can significantly reduce the heat gain. Pervious and open grid materials such as pavers, stone, blocks and interlocking Concrete pavements with high-Albedoreflective materials reduce heat absorption.

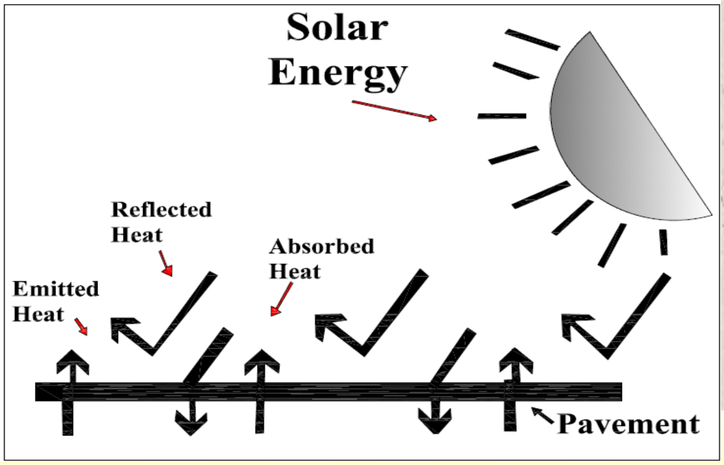


Figure 10: Cool Pavements reflect sunlight and absorb and emit less heat than standard pavements – Source (Brochure on the Use of Cool Pavements to Reduce the Urban Heat Island Effect, prepared by the Town of Gilbert

Vertical Surface – Green Walls

Green wall is wall, either free-standing or part of a building that is partially or completely covered with vegetation and, in some cases, soil or an inorganic growing medium.

There are two main categories of green walls: green façades and living walls. Green façades are made up of climbing plants either growing directly on a wall or, more recently, specially designed supporting structures. The plant shoot system grows up the side of the building while being rooted to the ground. In a living wall the modular panels are often comprised of polypropylene plastic containers, geo textiles, irrigation systems, a growing medium and vegetation.

Living walls can be further broken down into passive and active systems.' Active living walls' are a new, concept in which the living wall is integrated into a building's air circulation system.

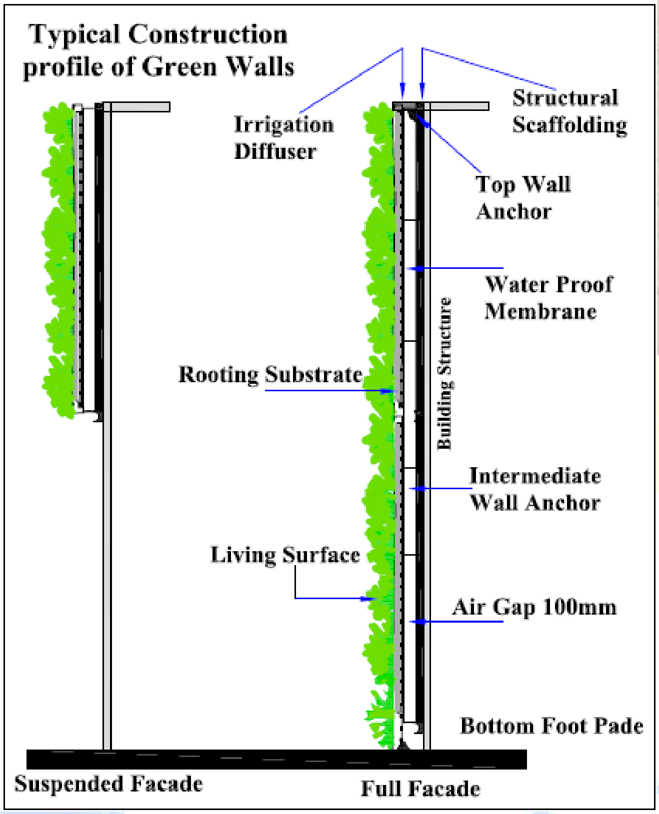


Figure 11: Section showing the details of the Green Walls, source - GSky.com

Passive living walls do not have any means of moving the air into the root system where most of the degradation of pollutants occurs. The impact of passive systems on air quality is scientifically questionable.

Roof Level

The roofs gain direct heat. Surface area and thermal property of the roofing material play key role in heat retention. There are strategies like green roofing help in reducing the heat retention and reduce the contribution of roofs to the urban heat island effect.

Green Roofs

Green roofs have been around for thousands of years. One of the first notable appearances of green roofs occurred in the Hanging Gardens of Babylon around 500 BC. The site is considered one of the Seven Wonders of the World.

There are two types of green roofs: Intensive and extensive. Intensive green roofs can accommodate large trees, shrubs, and well maintained gardens. The extensive green roof accommodates many kinds of vegetative ground cover and grasses.

Benefits of Green Roof

- Reduce sewage system loads by assimilating large amounts of rainwater
- Reduce urban heat island effects
- Absorb air pollution, airborne particulates, and store carbon
- Protect underlying roof material by eliminating exposure to the sun's ultraviolet (UV) radiation and extreme daily temperature fluctuations
- Serve as living environments that provide habitats for birds and other small animals
- Offer an attractive alternative to traditional roofs, addressing growing concerns about urban quality of life
- Reduce noise transfer from the outdoors
- Insulate a building from extreme temperatures

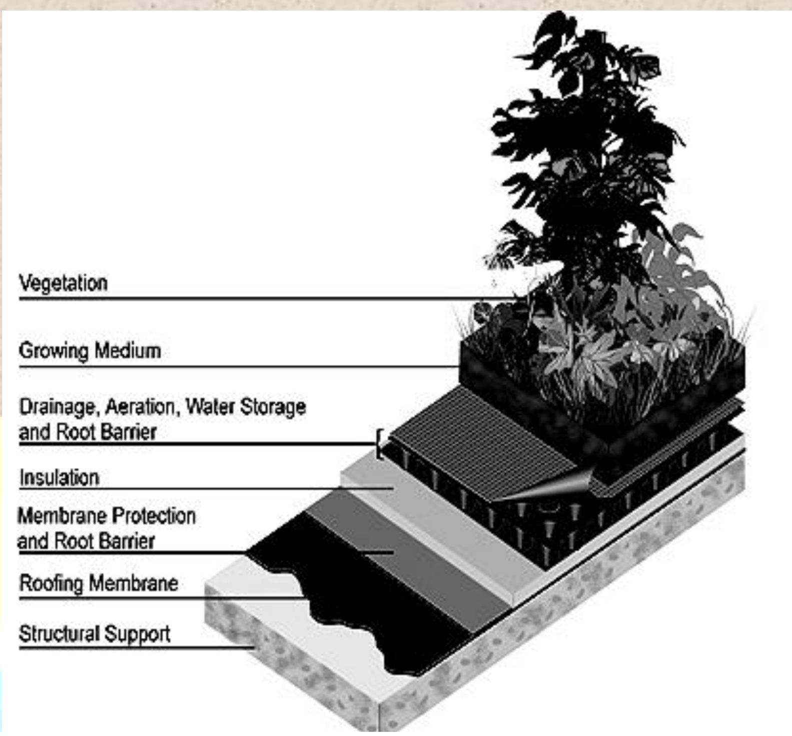
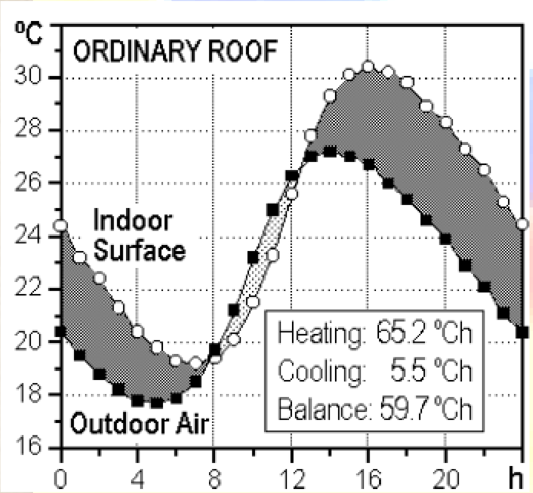


Figure 12: Green roof layers (Source: American Wick Drain Corp.)



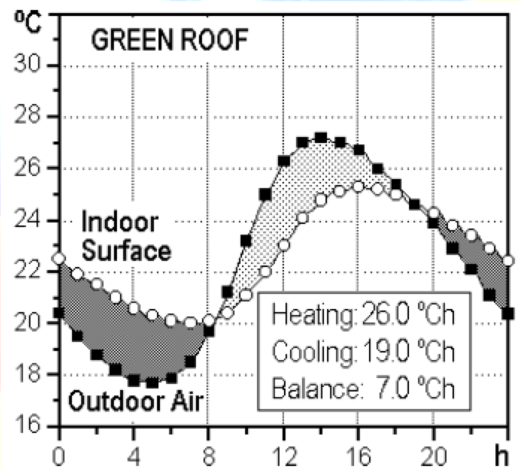


Figure 13

Figure 14

Figure 13 and 14:**(**Source: Study on Thermal Performance of Green Roofs:A Case Study in a Tropical Region by Caroline Santana de Morais1 and Maurício Roriz)

Framework for identifying information needed to assess the benefits of materials used to mitigate urban heat island effect

Variable	Inputs to Calculation	Issues, Concerns, Factors to Consider
External Inputs		
Incoming Sunlight(solar Radiation)	Amount of radiation reaching Earth	
Sunlight reaching the surface	Amount of radiation absorbed by atmosphere, clouds e.t.c.	
Precipitation	Latent heat transfer, soil moisture content	
EFFECT OF URBAN FORM		
Shading	Shading by buildings, trees, and vehicles	These factors will vary by material location and time of day
Sky-view factor	Percent of sky “visible” to the building materials (not blocked by structures, trees, etc.)	Affects ability of materials to cool through long wave radiation by potentially directing heat back at, materials.
Adjacent properties	Percent of reflected light that is absorbed by surrounding structures rather than going out to space	This will vary by materials location and time of day. However, it could have an important impact on the overall effectiveness of a heat island strategy.
EFFECT OF MATERIAL PROPERTIES		
Percent of solar radiation reflected by materials	Actual material Albedo	Albedo of in-use building materials will be affected by aging, dirt, and surface wetness
Effect of permeability on	Porosity of materials	Will need data on how

materials		much permeability reduces material temperature under a variety of moisture and soil conditions.
Effect of rate of heat absorption and radiation on material temperature	Thermal conductivity, heat capacity, emissivity, thickness, and other properties.	Will influence "time lag" in how a material contributes to the heat island in daytime versus nighttime.
IMPACT ON URBAN HEAT ISLAND		
Contribution to local heat island (i.e., change in temperature of air directly above materials)	Amount of heat radiated and convicted to the air above a area of specific materials	Field data collected above a variety of materials that are in use (with vehicles, etc.) will be most useful
Contribution to regional heat island (change in city's temperature)	Percent of regional heat island effect due to materials alone.	Will be difficult to directly measure in the real world due to the scale of the problem.
Diurnal effects (time of day impacts)	Heat storage and release by time over the course of a 24-hour period	Complex issue to address, depending on many competing materials properties.
OTHER ENVIRONMENTAL BENEFITS		
Effect on evaporative emissions by materials in the building surfaces.	Degree to which materials contribute to temperatures result in using materials that generate less urban heat island effect.	As well as incorporating an understanding of local air temperature changes from materials, actual field measurements of evaporative emissions.
Effect on night time illumination	Additional illumination provided at night by materials	Could help reduce energy usage and lighting costs.
COST AND PERFORMANCE IMPLICATIONS		
Life cycle costs of materials that contribute to less urban heat island effect	Initial,maintenance,rehabilitation, and disposal costs	Factors to consider include frequency of maintenance, life expectancy.
Effect on performance	Environmental resistance, noise,	Materials must meet

characteristics	safety, durability, etc.	appropriate standards for their intended uses.
Expected usage	Applicability of materials for different uses	Some materials may only be appropriate for certain uses only so the material and its application should not be compromised

Summary:

The severity of the UHI threat to human health is considerable, and is likely to intensify as the climate continues to change. This issue deserves serious attention. While international cooperation on climate change is stagnating, local levels of government should take the lead in reducing anthropogenic contributions to climate change and take steps to adapt to new climatic conditions. In addition to global warming, physical factors of urban settlements, such as the mineralization of surfaces, low vegetation cover, and the production of waste heat contribute to UHI. It is imperative to address these issues to prepare cities for a warmer climate.

Since anthropometric contribution needs a serious concern, as architects one must employ the correct usage of material in areas so that the material does contribute less to the urban heat gain. Along with the proper usage of building materials the impact of heat generated by them can also be reduced by involving landscape elements like water and vegetation in the design.

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