# Cool Pavement Application and monitoring

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## A THESIS SUBMITTED FOR THE DEGREE OF BACHELOR OF SCIENCE IN

## CIVIL ENGINEERING (Transportation)

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# APPROVAL

It is hereby certified that the thesis entitled " Cool Pavement Application and monitoring" submitted by Tanvir Hossain has been found as satisfactory and fulfilling the requirements for the Bachelor of Science Degree in Civil & Environmental Engineering.

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# DECLARATION OF CANDIDATE

I hereby declare that the undergraduate research work reported in this thesis has been performed by me under the supervision of Dr. Nazmus Sakib and this work has not been submitted elsewhere for any purpose (except for publication).

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***"In the name of Allah, Most Gracious, Most Merciful"***

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# Abstract

Rapid urbanization and worries about climate change have increased the demand for long-term solutions to mitigate the detrimental effects of urban heat islands. Cool pavement technology has emerged as a potential strategy for lowering surface temperatures and improving urban heat island situation. This research abstract presents a concise and understandable summary of cool pavement application and monitoring, emphasizing its potential to make cities more comfortable and sustainable. Cool pavements are surface materials and coatings that are specially engineered to reflect sunlight and emit less heat than ordinary pavements. Cool pavements help lower local air temperatures, increase outdoor comfort, and minimize energy consumption in nearby buildings by minimizing sun absorption and lowering heat transmission to the environment. The benefits, limitations, and cost-effectiveness of each technique are reviewed. Furthermore, the abstract emphasizes the need to choose cool pavement solutions that are compatible with local climate conditions and urban situations. Another component of this study abstract is about monitoring the performance of cool pavements. Monitoring is critical for determining the long-term efficacy and performance of cool pavement installations. Cool pavements can help cities reduce the heat island effect, improve outdoor conditions, save energy, and encourage sustainable urban growth. However, additional research is required to investigate the scalability and long-term efficacy of cool pavement solutions in a variety of urban contexts.

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# 1. Introduction

## 1.1 Background

The built environment affects our economy, health, and productivity. Designers, builders, operators, and owners are seeking breakthroughs in building science, technology, and operations to create a sustainable built environment and maximize economic and environmental performance.

More individuals are considering municipal infrastructure's lifetime environmental impacts. Roads and pavements contribute to economic and social progress as part of the transportation infrastructure and built environment. Researchers, authorities, corporations, and other highway and pavement stakeholders are working together to reduce environmental impacts and improve economic and social growth. Pavements can reduce heat islands under certain weather and population circumstances.

As the world's population grows, urban and rural regions prosper economically and socially, especially in quickly modernizing nations like China and India. various cities have various paved surfaces, including streets, parking lots, sidewalks, plazas, and playgrounds. The heat island effect, caused by increased energy needed to cool buildings and vehicles, decreased air and water quality, and accelerated pavement deterioration (such as rutting and aging of asphalt pavements and possibly thermal cracking of concrete pavements), can have serious consequences in hot climates during the summer.

Remove heat islands and improve outdoor thermal settings to make a sustainable community walkable and livable. Increasing public transportation and encouraging walking and cycling for short local journeys can reduce VMT, energy consumption, and mobility-related environmental issues. Walking and biking are good methods to exercise and explore. Perceived safety, journey duration, surroundings, and personal choice might influence people's walking and biking habits. Modern infrastructure like smooth sidewalks and bike lanes/paths is needed to improve the street environment and make cycling safer and easier. If the weather is nicer in summer, more people may walk or bike instead of drive. Few studies have examined how pavement design affects site temperature. Thus, especially in hot summer climates, roadway thermal environments must be assessed and improved through pavement design.

However, depending on latitude and season, hotter pavement can either benefit or hurt urban heat islands. Even while heat islands are harmful in hot countries, they can minimize heating energy consumption and thermal discomfort in cold weather and cold locales. These effects must be examined citywide and site-by-site. Localized near-surface impacts are more important for human thermal comfort and pavement life than large-scale urban heat island assessments.

Several research advocates employing high-albedo reflecting surfaces to "cool" the Earth. These include "cool roofs" and "cool pavements.”. In Athens, Greece, it was calculated that extensive deployment of reflecting surfaces might reduce average air temperature by 2°C (Synnefa et al., 2008). It discovered a lesser ambient air temperature reduction of 1°C in a single urban canyon in Athens (Georgakis, n.d.). It observed that Rome's asphalt pavements may lower summer air temperatures by 5.5°C (Carnielo & Zinzi, 2013). An Antwerp metropolitan park's air temperature may be 0.9°C cooler than an adjacent paved region without a park (Toparlar et al., 2018). This study demonstrated that UHI varies greatly within cities based on regional land-use trends. Pavements affect the heat island effect and related environmental issues, including localized near-surface affects (human comfort). To achieve this, it is necessary to understand the thermal interactions between pavement and its surroundings (air, buildings, trees, and vegetation), temperature influencing factors, and their specific effects on pavement and near-surface air where most human activities take place, during hot daytime and cold nighttime, summer and winter, and in different climate regions.

Pavement can contribute to or mitigate the heat island effect, depending on how it is constructed. Pavement thermal performance and behavior can be improved to benefit the environment, energy consumption, and human health and comfort. Cool pavement technologies lessen heat island effect and prolong pavement life.

## 1.2 Objectives

The objective of the present study is:

1. Assessment of various cool pavement options and select viable ones for usage in Bangladesh
2. Calculate temperature variation for every cool pavement method after application in field
3. Do a comparative analysis of different methods of cool pavement
4. Draw a conclusion based on findings

## 1.3 Organizations of the Thesis

The entire research effort is organized into chapters to achieve the stated objectives and to make the evolution of the work more understandable. The rest part of the thesis contents of each chapter are briefly described below.

**Chapter 2:** Literature Review- This chapter covers previous work on similar studies and provides guidance on the scope of work

**Chapter 3:** Methodology- This chapter describes the approach used to conduct the research starting from scratch

**Chapter 4:** Result and discussion- This chapter deals with findings from the experiment and analysis of the collected data

**Chapter 5:** Conclusions and Recommendations- This chapter summarizes the achievement and effectiveness of the study

# 2. Literature Review

There are multiple potential ways for making pavements cooler using various cooling mechanisms, which can be divided into four categories:

(1) Changes in the thermal characteristics of paving materials;

(2) Increased evaporation from pavements;

(3) Convection enhancement; and

(4) Reducing heat energy on and within pavements.

## 2.1 Changes in the thermal characteristics of paving materials

Thermal conductivity, specific heat capacity, density, solar reflectance (albedo), and thermal emissivity affect pavement thermal behavior. Modifying these properties might chill pavements and near-surface air. Thermal conductivity measures a material's heat transfer. It controls heat flow between high- and low-temperature objects/parts. Poor thermal conductivity pavements may heat up near the surface but transport heat slowly. decreasing pavement thermal conductivity might delay heat transport into pavements under solar radiation and high air temperatures, decreasing pavement and near-surface air temperatures.

## 2.2 Increase the heat capacity of the pavement

Heat capacity is the energy (or heat) needed to raise one unit weight of a material by one degree Celsius without phase change. Pavements absorb and store energy depending on temperature. Pavements, for example, store more heat than natural materials. Dry soil and gravel/rock are examples. Built-up regions sometimes catch twice as much solar energy than rural ones during the day. At night, conventional urban materials release the heat they absorbed throughout the day, creating heat islands. However, improving the pavement's effective heat capacity by increasing its specific heat capacity, density, and layer thicknesses might drop daytime high temperatures and raise nighttime low temperatures.

## 2.3 Increase the reflectivity of the pavement surface

A surface's albedo reflects solar radiation. Cool pavement research has focused on solar reflectance, which best predicts a pavement's maximum surface temperature. By reducing heat conduction via pavement layers, high albedo may lower pavement subsurface temperatures. Asphalt and concrete pavement surfaces may easily and unobtrusively enhance this material property. Asphalt binder with dense-graded aggregate make waterproof, impermeable asphalt pavement. Paths, highways, parking lots, freeways, and country roads can utilize it. Tree resin or cool-colored asphalt with pigments or sealant can change the road's hue. After installation, light-colored coatings or chip seals can increase reflectivity, asphalt pavement can be rehabilitated with white topping or ultra-thin white topping (UTW), and micro-surfacing with light-colored aggregate and/or emulsified polymer resin can be used for routine maintenance. These measures may help roadways and parking lots. Hydraulic cement, water, and dense-graded aggregate make typical concrete pavement impermeable. Paths, highways, parking lots, freeways, and country roads can utilize it. Concrete initially reflects more than asphalt. White or light-colored slag-mixed cement increases reflectivity. Early study indicated that asphalt overlays on concrete pavements cooled off faster than normal asphalt pavements and had poorer heat storage capabilities. Concrete block pavement, also called interlocking concrete pavers, is impermeable and comprised of hydraulic cement, water, and dense-graded aggregate. Water can flow between pavers, making the entire paved surface porous. White cement or cement with light-colored slag or pigment can boost block paver reflectivity. There are several techniques to increase road albedo. However, a greater albedo may enhance heat exchanges between pavements and buildings, automobiles, and people. When pavement heat is absorbed by these surfaces, their temperature rises. As they get dirty, asphalt, concrete, and interlocking concrete pavers lose solar reflectivity. Petroleum-based binder with sand or stone aggregate form asphalt pavements. Oxidizing binder and surface wear reveal more aggregate, making them paler. Portland cement, not asphalt, binds interlocking concrete pavers and concrete pavements. Due to pedestrian, bicycle, and motorist filth and grime, cement discolors with time.

## 2.4 Increase the thermal emissivity of the pavement

Thermal emissivity measures how much heat a substance radiates per unit area at a particular temperature. Thermal emissivity affects heat islands. A typical pavement's albedo and emissivity regulate the greatest and lowest surface temperatures, respectively. Albedo-like pavement radiation may help reduce heat islands. If structures or automobiles obstruct or absorb solar radiation, urban canopy heat islands may increase.

## 2.5 Increased evaporation from pavements

Evaporation requires heat. This device harnesses ambient heat to keep the interior warm. Evaporative cooling lowers pavement and air temperatures. When water is in the pavement, soil, or sprayed on it, latent heat is released as water vapor. Water-retentive and permeable pavements—vegetated and non-vegetated—provide this benefit. Non-point sources currently account for most water contaminants. Runoff from impermeable streets, roads, and highways contains significant inorganic and organic contaminants. Regulations that treat runoff or lower pollution levels at the source protect receiving waterways. Most towns use BMPs or SUD to regulate runoff.

Permeable pavement drains water into its layers, unlike impermeable pavement. Porous asphalt, pervious concrete, pervious cast concrete, permeable interlocking concrete, and numerous types of permeable gravel pavements are all permeable pavements. They increase pavement wetness and evaporation, which cools. The dissertation defines "permeable" as permeable, porous, and pervious pavements, which may be utilized in city streets, parking lots, and highway shoulders. Grass pavers and concrete gird pavers use plastic, metal, or concrete lattices to support grass or other plants in the interstices. Vegetated permeable pavements are best for low-traffic areas like alleys, parking lots, and trails in climates with enough moisture or irrigation systems. Evaporation and transpiration cool vegetated permeable pavements. By reducing the likelihood of getting wet and hydroplaning in the rain, permeable pavements can reduce air/pavement noise and tire vibration. Full-depth permeable pavement reduces stormwater runoff and improves water quality. Due to rolling resistance, rough permeable pavements may increase fuel consumption. Due to their coarse texture and raveling, conventional permeable pavements are often unsuitable for high-speed facilities like roads and airports. Wet pavement weakens the subgrade, hence thicker cross-sections are needed.

Permeable pavements may lessen heat island effects. Permeable pavement preserves hydrology. Tokyo and Osaka are testing water-retentive permeable pavements to lessen the heat island effect. These asphalt or concrete pavements contain a water-retentive sublayer that absorbs precipitation and releases it by capillary action when the surface heats. Some shower water from above or below to accelerate road surface water evaporation. Sprinklers may reuse wastewater or rainwater for plant watering in arid climates. Solar/wind hybrid tower generators power sprinklers. The experiment demonstrates that this pavement may decrease the road surface temperature by 25°C in the summer, when it may reach 60°C. Temperatures decreased 2°C-3°C.

## 2.6 Increased convection between the pavement and the air

Convection warms the air above the ground as air travels across hot pavement. Air temperature, speed, surface roughness, and pavement area affect convection. Some permeable pavements, such as asphalt, concrete, cast, and brick or block pavers, have rougher surfaces and more air-voids than conventional pavements to increase air turbulence and circulation. Air movement will cool the pavement and mix the air around it. Careful planning is needed to make the perforations sturdy, water drain effectively, and the surface useable for bicycles, motorbikes, vehicles, and maybe people. Rougher surfaces allow circulation and cooling, but they reflect less sunlight.

## 2.7 Heat energy reduction in pavements

Canopy coverings (e.g., conventional or solar panels) constructed over the pavement are another method for maintaining a more comfortable temperature on the pavement's surface by blocking the sun's rays. Active mechanical cooling is another option for temperature regulation; it entails extracting and reusing the heat energy already present in the asphalt.

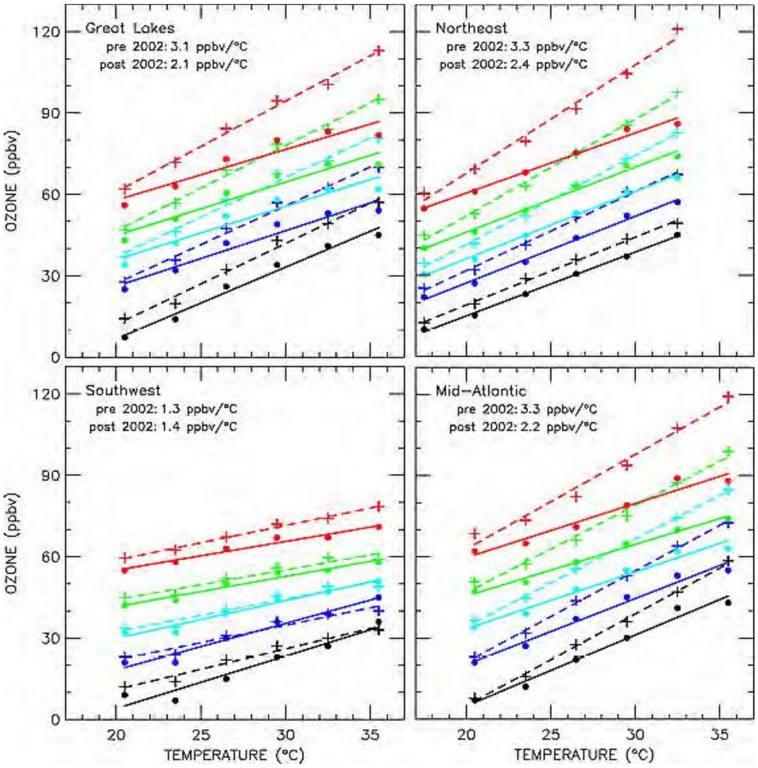

*Figure 1: Temperature effect on ozone*

| **Cooling Technology** | **Cooling Mechanism** | **Eff. (ºC)** | **Co-Benefits** |
|---|---|---|---|
| ***1. Modify material thermal properties*** | | | |
| 1.1 Increase albedo/emissivity | •Increase reflected heat | 4/0.1(s)<br>0.6/0.25(a) | • Enhance illumination<br>• Offset global warming potential |
| 1.2 Increase heat capacity/density | •Increase heat capacity | -- | -- |
| 1.3 Reduce thermal conductivity | •Reduce transfer of heat into material | -- | -- |
| ***2. Evaporation/evapotranspiration*** | | | |
| 2.1 Permeable pavements (+ vegetation) | • Increase latent heat<br>• Increase convection | 10~25 (s)<br>2~8 (a) | • Reduce stormwater runoff<br>• Reduce water pollution<br>• Recharge groundwater<br>• Increase greening (+ vegetation) |
| 2.2 Water-retentive pavements (+ sprinkling) | •Increase latent heat | 10~25 (s)<br>1~5 (a) | • Reuse wastewater/rainwater |
| ***3. Shading*** | | | |
| 3.1 Canopy cover (+ trees) | •Reduce absorbed heat | ~10(s) | • Increase greening (+ tree) |
| 3.2 PV panels | •Reduce absorbed heat | ~25(s) | • Reduce land use dedicated for solar farms |
| ***4. Enhance convection*** | | | |
| 4.1 Ventilation paths | •Increase convection | -- | -- |
| ***4. Harvesting energy*** | | | |
| 5.1 Water pipe | • | | |

*Table 1: Temperature effect on ozone*

# 3. Methodology

## 3.1 Location selection

For my research I selected a pavement inside IUT, Board bazar, Gazipur as my location. As it is inside IUT so there isn’t much fear of safety regarding research work. For the experiment I needed a pavement where I can measure temperature. The location needed to be under bare sky. As a location which is under any type of shed might give us a manipulated data set which may divert our research goals.

## 3.2 Selected cool pavement application methods

### 3.2.1 IR-Reflective coating

Pavements can have their albedo improved by adding color pigments, fillers, and additives. Painting can make aesthetic and glare issues worse because of its reflective nature. Coatings lose reflectivity over time as a result of exposure and weathering (Dornelles et al., 2015). Near-infrared TiO2 reflective coatings' optical and durability performance, such as skid-resistance, anti-abrasion, and film hardness, were investigated. According to the findings, the coating's near-infrared reflectance was as high as 60% when compared to that of a standard coating (Cheela et al., 2021). Asphalt pavement with a reflective coating, which consists of functional coating material, is said to have a reflective coating. Reduce coating surface temperature and pavement temperature by reflecting solar radiation in the visible (0.4-0.7 m) and near infrared band (0.7-2.5 m) and reflecting the absorbed heat energy to the outer space as long wave (2.5-15 m) (Levinson et al., 2007). Using asphalt pavement, A study was done with ten thermally reflective coatings. Coatings were tested for their cooling, anti-skid, and anti-glare abilities. According to the results, the pink coating can bring the temperature of a field road down by as much as 10 degrees Celsius. Extreme glare is caused by light-colored pigments, while black, glare-free pigments are widely used in asphalt. Ceramic particles and mechanical sand are added to increase the material's frictional resistance. on order to mitigate glare and increase traction on the field, the study suggests using reflecting coatings. Sliding resistance is enhanced, meantime, by the incorporation of ceramic particles and mechanical sand. Spreading 1.18 mm machine-made sand with a content of 160 $g/m^2$ is the most effective way to boost the coating's anti-skid performance (Zheng et al., 2015). Fillers made of inorganic metal oxides like $TiO_2$, ZnO, $Al_2O_3$, etc. are commonly employed to boost coatings' reflectivity. In order to examine the parameters that affect the optical properties of reflective cool pavement coverings, many pigments were chosen with varying particle sizes and hues (Xie et al., 2019).

### 3.2.2 Lime

Asphalt pavement concrete has traditionally used mineral filler hydrated lime (HL). Its benefits on the mechanical properties of asphalt concrete mixes and the performance and service life of their constructed pavements under a wide range of traffic loads and environmental conditions have been proven by extensive laboratory and field tests. HL addition reduces bitumen aging and increases resilience to permanent deformation (rutting), moisture damage, heat and fatigue cracking.

Traditional research on HL-modified asphalt concrete has focused on mechanical qualities under varied temperature and environmental exposure settings to determine the best HL addition rate. For instance, HL addition increased moisture damage resistance in a pavement after five years of service, but the differences between 0.5 and 1.5% HL addition were. However, little study has been done on the thermal characteristics of HL-modified asphalt concrete, which needs to be assessed during pavement design. Lime in various forms is utilized in environmental, metallurgical, construction, and chemical/industrial applications, among others. The most common application of lime in construction is soil stabilization for roadways, earthen dams, airfields, and building foundations. Lime can be used with certain chemicals to make other metals, and it is also a crucial constituent in lime slurry mortar and plaster. Lime, when used as an addition in asphalt, enhances cohesiveness, minimizes stripping, and slows the aging process. Other chemical and industrial applications for lime include the manufacture of compounds and the creation of precipitated calcium carbonate. Lime is used in a variety of cool pavement applications to reduce surface temperatures and mitigate the urban heat island effect. It can be used as a coating or sealant to provide a light-colored surface with high solar reflectance, efficiently reflecting sunlight and reducing heat absorption. Lime also acts as a base layer stabilizer, increasing pavement strength and longevity while increasing its reflecting characteristics. Lime can also be used to make porous pavements, which allow for water infiltration and reduce stormwater runoff. In addition, when lime is added to asphalt mixtures, it changes their properties, boosting reflectivity and thermal performance. Lime in cool pavements has several advantages, including reduced urban heat island effect, energy savings, stormwater management, and environmental sustainability, making it a promising alternative for building more comfortable and sustainable urban environments.

### 3.2.3 White-topping

Asphalt pavement rehabilitation Portland cement concrete (PCC) resurfacing technologies such as ultra-thin white topping (UTW), thin white topping (TWT), and conventional white topping (CWT) have gained substantial interest and approval in the last decade.

The installation of a concrete overlay to defective or partially deteriorated asphalt pavements is known as white topping. The thicknesses of ultra-thin, thin, and conventional white topping are widely thought to be between 2 and 4 in., 4 to 8 in., and over 8 in. Unlike the more extensively used conventional white topping approach, the UTW and TWT techniques recognize the existence of a specified bonding strength between the concrete overlay and the existing asphalt layer. As a result, the UTW and TWT pavements exhibit the characteristics of composite pavements. Furthermore, shorter joint spacings, typically ranging from 2 to 12 ft depending on slab thickness, have been employed for UTW and TWT pavements. The use of interface bonding and short joint spacings reduces slab bending, shrinkage cracking, slab curling and warping, and the thickness of the slab overlay required. Thin white topping pavements are commonly utilized on state and secondary highways with moderate truck traffic, while UTW pavements are typically ideal for city streets or intersections with little truck traffic.

Continuous-reinforced concrete and fiber-reinforced concrete were also used on a few projects. In 1994, NCHRP Synthesis 204 published a list of 189 white topping street, highway, and airport pavement projects constructed in the United States since 1918. The increased interest is attributed, in part, to developments in white topping technology and concrete paving technology

The use of Portland cement concrete to white top asphalt pavements can benefit both the traveling public and the highway or airport agency in the long run. A PCC surface's renowned resilience and long-term performance saves pavement maintenance time and life cycle cost. This advantage significantly reduces the time, cost, and user delays associated with the frequent required maintenance of an asphalt surface. Traditional white topping design and construction techniques are well established and detailed in publications by the Portland Cement Association (PCA) and the American Concrete Pavement Association (ACPA). If the pavement is over-designed and there are no design guidelines, the segment works well but at a high initial cost. If the pavement is under-designed, a portion of it will need repair or replacement, reducing users' trust in white topping as a pavement rehabilitation method. As a result, white topping thickness design criteria that are reasonably established are required. The preparation of the existing asphalt pavement is the first step in white topping. The surface is completely cleaned, and any repairs or alterations that are required are carried out. When the surface is complete, a layer of white or light-colored concrete is applied to the asphalt. The concrete mixture has been specially formulated to achieve maximum reflectivity and durability. White topping improves pavement resilience in addition to its cooling characteristics. The concrete layer acts as a protective barrier over the existing asphalt, protecting it from wear and strain and extending its lifespan. This can result in long-term cost savings on pavement maintenance and replacement. White topping is a good solution for cities and metropolitan areas who want to increase their sustainability and reduce the effects of heat. Cities may create more comfortable settings, reduce energy consumption, increase climate resilience, and contribute to a greener and more livable urban landscape by using this technology in cool pavement initiatives.

## 3.3 Data Collection

Data was taken by using K-type thermocouples. The machine has 4 sensors. Each sensor goes in one layer of soil and gives the respective temperature. Each sensor is connected to different depths of soils so temperature variance is noticeable between each sensor. For our experiment we first took one set of data without any sort of alteration and then used the three cool pavement options and calculated temperatures respectively.

# 4. Data Analysis and Results

Here in the plotted graphs each color represents temperature recorded by each sensor. The blue color line represents sensor 1, Orange color represents sensor 2, Grey color represents sensor 3, Yellow color represents sensor 4

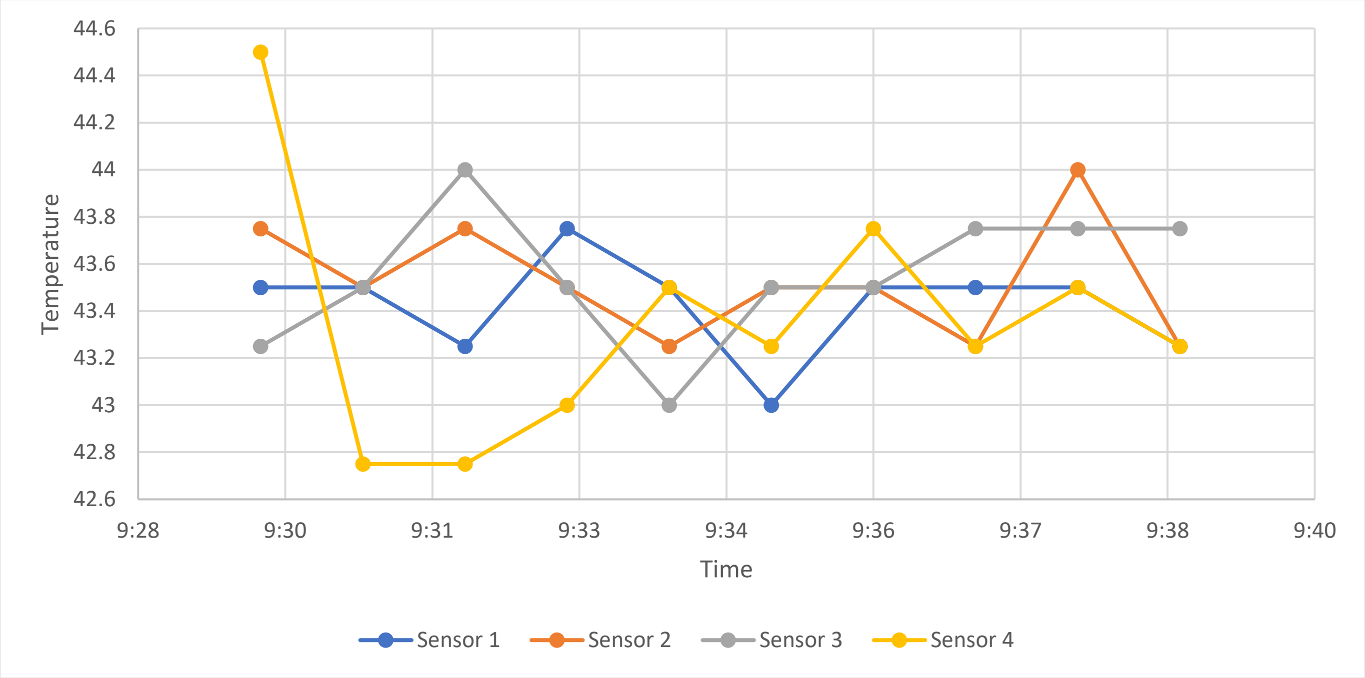

*Figure 2: Temperature of soil layers before any alteration*

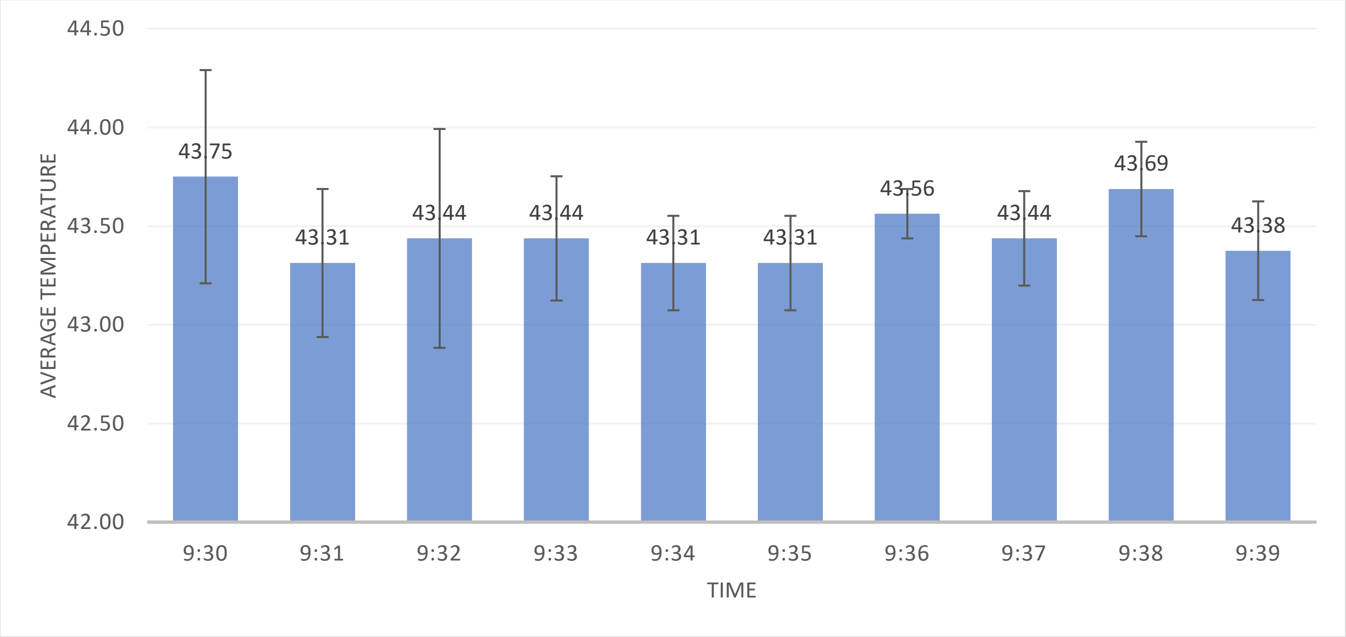

*Figure 3: Average temperature of soil before any alteration*

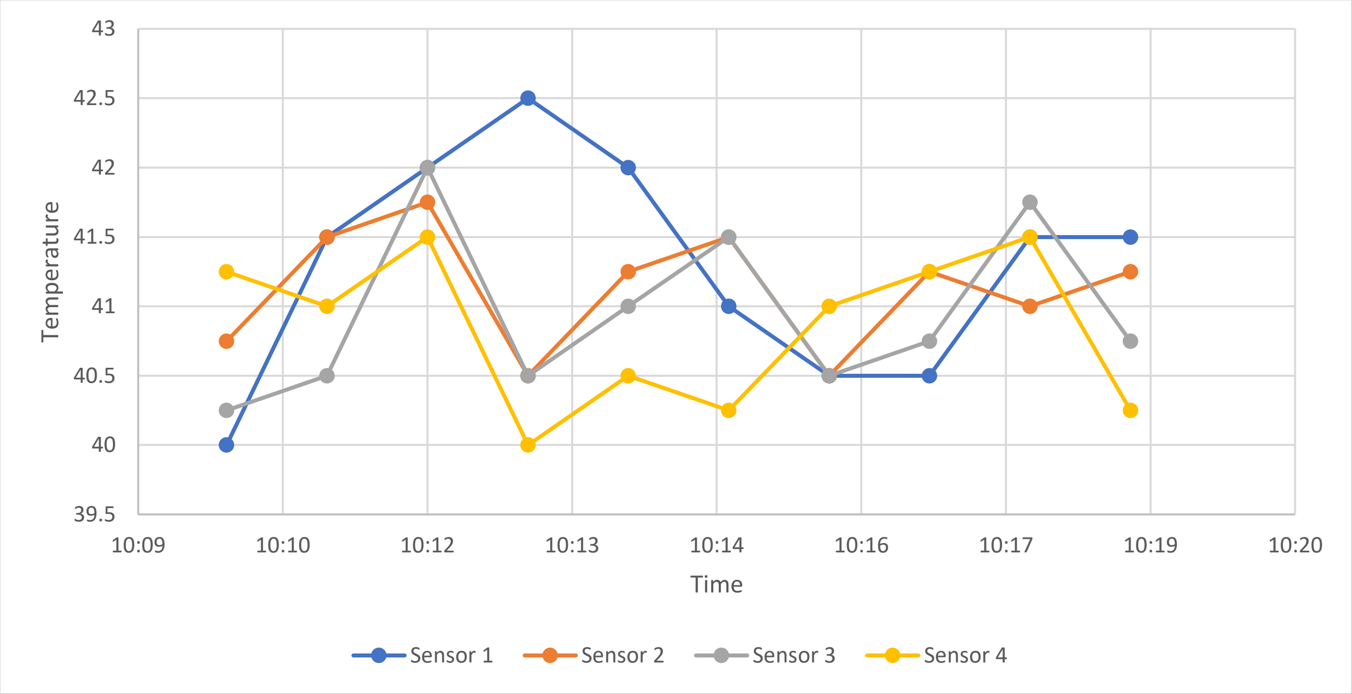

*Figure 4: Temperature of soil layers after white topping*

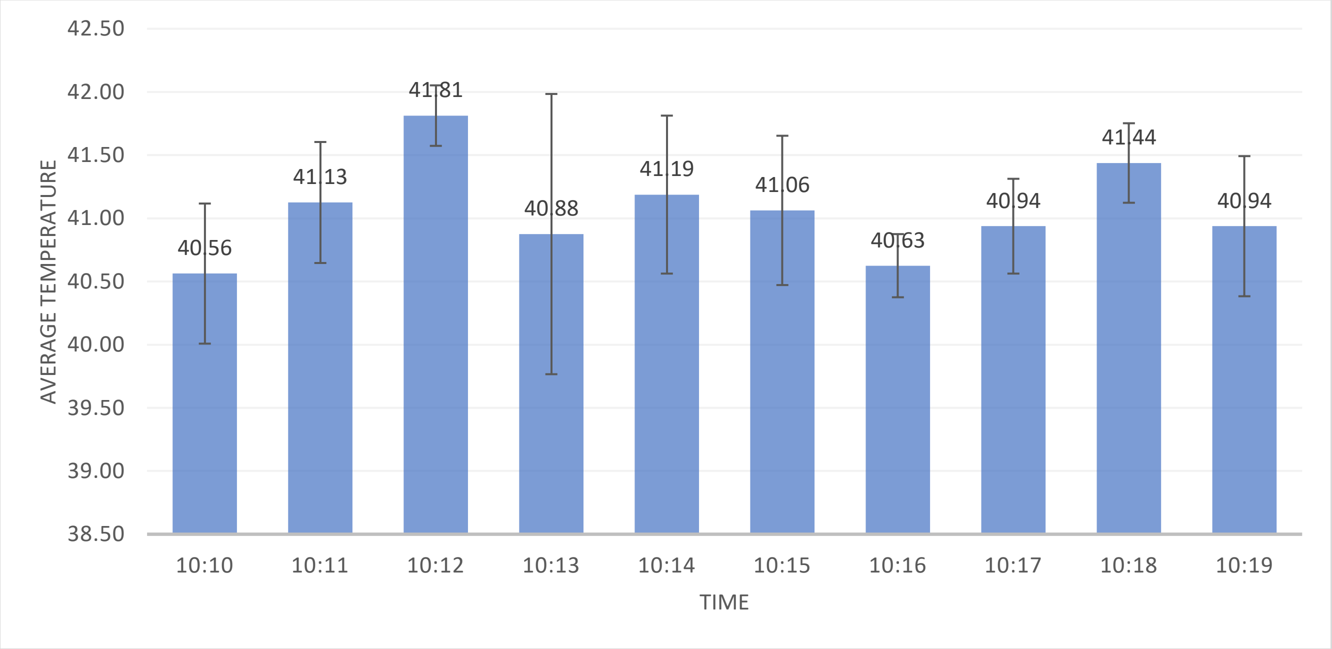

*Figure 5: Average temperature of soil after white topping*

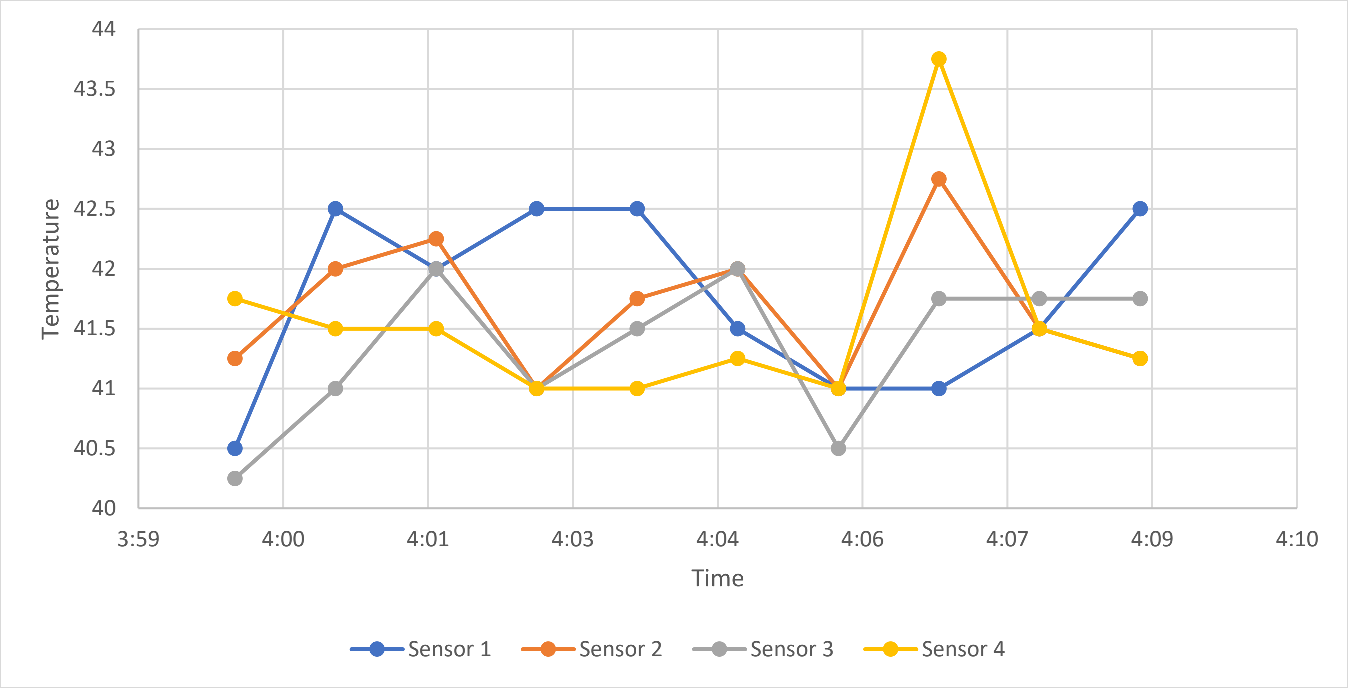

*Figure 6: Temperature of soil layers after using IR-reflective paint*

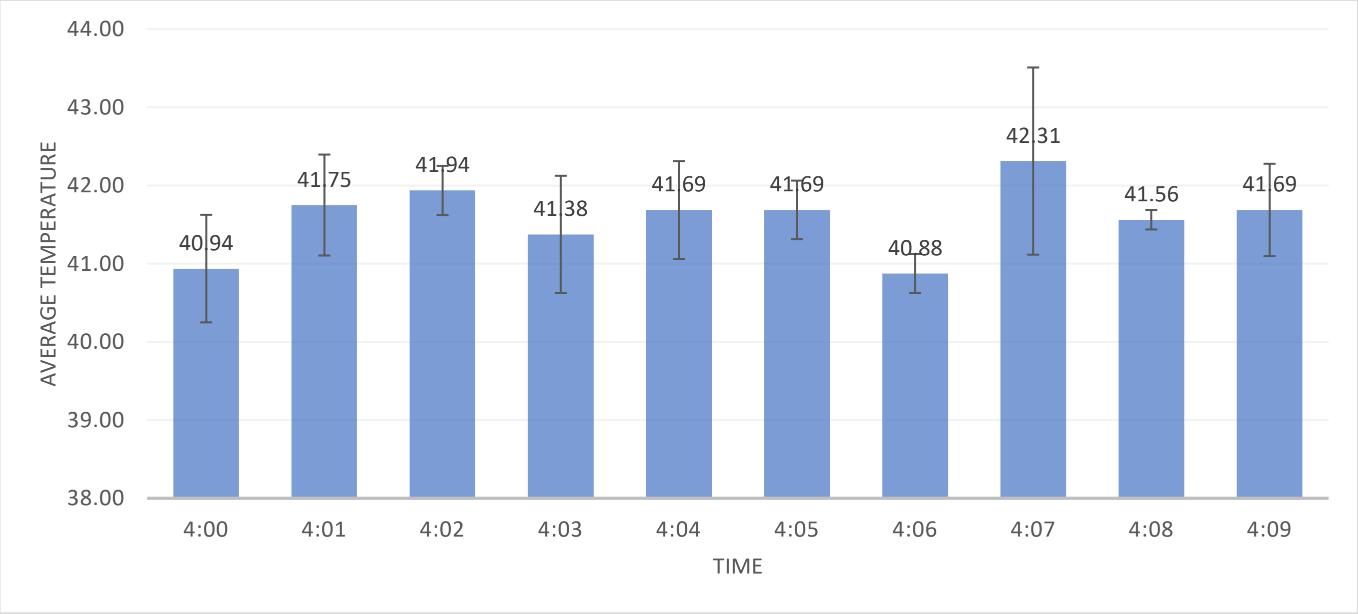

*Figure 7: Average temperature of soil after using IR-reflective paint*

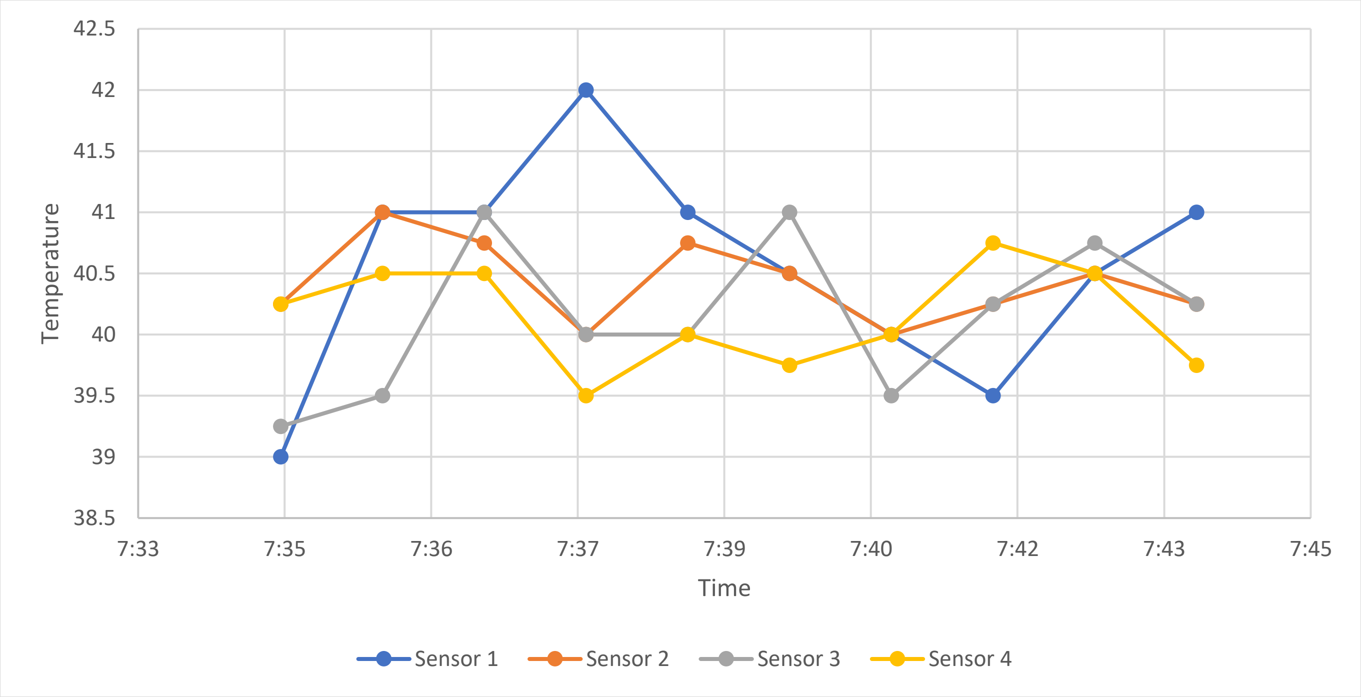

*Figure 8: Temperature of soil layers after using lime*

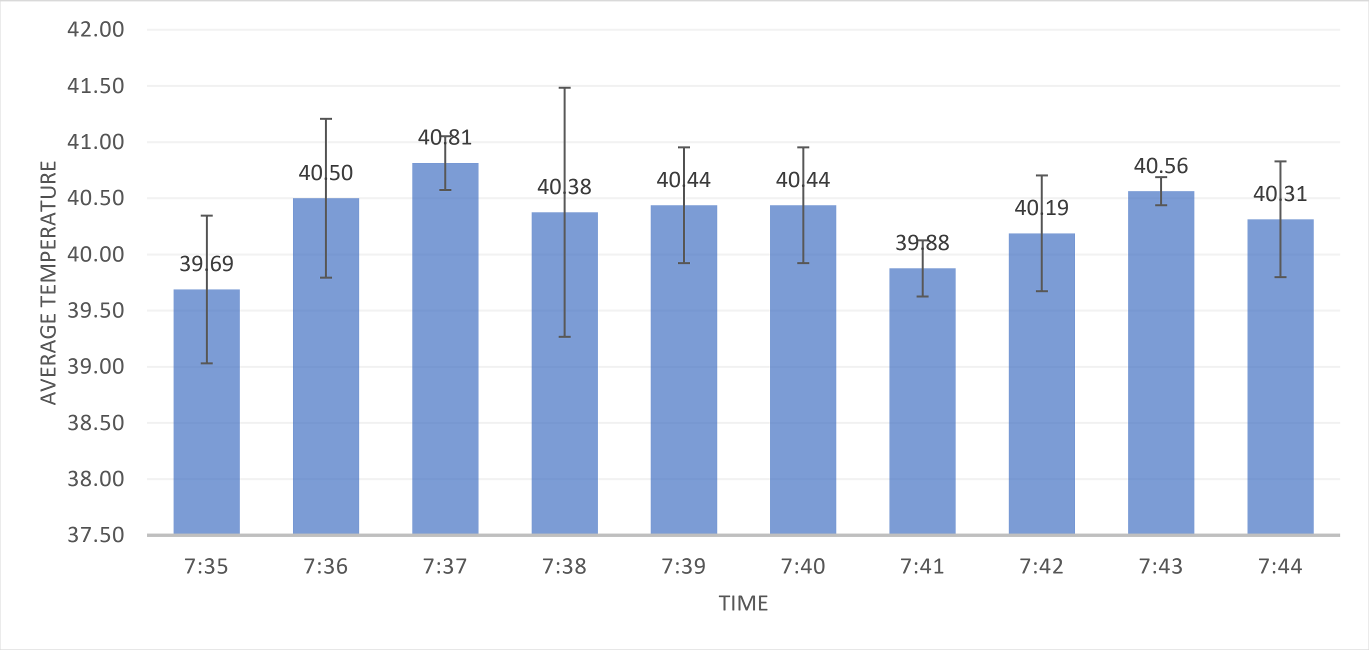

*Figure 9: Average temperature of soil after using lime*

# 5. Conclusion

The research is based on field testing undertaken to evaluate these approaches' ability to reduce temperature. The results showed that the IR reflective coating produced the greatest temperature drop, while lime produced the least. However, in the context of Bangladesh, where the IR reflective coating is expensive and not widely accessible, lime and white topping emerge as more viable possibilities.

1. White topping is the application of a layer of white concrete or cementitious material over the existing pavement surface. It is a low-cost method of reflecting sunlight, lowering solar heat absorption and surface temperatures. Field experiments in Bangladesh revealed a considerable temperature drop when compared to standard asphalt pavement. Furthermore, the white topping’s light-colored surface improves visibility and decreases the urban heat island effect.

White topping has the following advantages: - Low cost: When compared to other cool pavement solutions, white topping is a cost-effective option for low-budget projects.

- Reflectivity: Because the white surface reflects sunlight, heat absorption and surface temperatures are reduced.

- Increased durability: White topping has increased durability and wear resistance, giving it a long-lasting solution.

White topping has the following limitations: - Limited color options: White topping is primarily available in white or light-colored tints, which may not meet all aesthetic tastes or urban design requirements.

- Surface roughness: Depending on the quality of the installation, white topping can result in a harsher surface texture, impacting ride quality and potentially increasing noise levels.

2. Lime: Incorporating lime-based coating on the surface of pavement is how lime is used in cool pavements. In comparison to white topping and IR reflective coating, the field testing demonstrated a substantially lesser temperature reduction. Lime, on the other hand, stands out as a cost-effective option, making it ideal for projects with limited funds.

Lime has the following advantages: - Low cost: Lime is a low-cost additive that can be easily included into asphalt mixes or used as a layer on top of existing pavement, making it a cheap option for cool pavement applications.

- Availability: Lime is readily available and accessible, making it ideal for use in locations where resources are few.

Lime has some temperature reduction benefits, but its effectiveness in considerably lowering surface temperatures may be restricted when compared to other cool pavement approaches.

- Aesthetics: Because lime-based cool pavements retain the dark color of traditional asphalt, they may not contribute to the aesthetic component of urban heat island mitigation efforts.

3. Infrared Reflective Coating: An infrared reflective coating is a specialized pavement treatment that includes infrared reflective pigments or additives. This coating reflects a large part of solar energy, lowering heat absorption and surface temperatures. However, according to my studies conducted in Bangladesh, the IR reflective coating was not accessible in the country, making local application problematic.

Advantages of IR Reflective Coating: - Superior temperature reduction: When compared to other cool pavement systems, IR reflective coatings have exhibited the strongest temperature reduction capabilities. They can achieve significant surface temperature decreases, so contributing significantly to heat island mitigation.

- Improved aesthetics: IR reflective coatings can be custom-colored, enabling for aesthetic integration into urban design schemes.

IR Reflective Coating Limitations: - Cost and Availability: Due to the high cost of IR reflective coatings, it might not be the most optimal cool pavement option.

To summarize, the field experiments show that cool pavement treatments such as white topping and lime can help to reduce temperature by a good margin in metropolitan locations. While the IR reflective coating indicated the greatest potential for temperature reduction, its current scarcity and greater cost make it less practicable for adoption in Bangladesh. As a result, when cost-effectiveness and availability are considered, white topping and lime emerge as viable solutions for cool pavement treatment and can play an important role in decreasing urban heat island effects in the country.

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