

## Cool Pavements to Fight Urban Heat Islands

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**Abstract:** Urban heat islands are an outcome of the heat absorption and reflection of solar energy with dark surfaces. It causes a significant rise in temperature in the urban areas during summer. Thereby, the energy demand increases with the rising demand for air conditioners. Therefore, the level of greenhouse gas emission gets elevated causing air pollution. Efforts to overcome the adverse effects focus primarily on incoming the reflective property of the environment. The increase in solar reflectance of the urban surface reduces its solar heat gain, lowers the temperature, and decreases the outflow of thermal infrared radiation into the atmosphere. Cool roofs and cool pavements minimize summer heat islands and improve the environment. Few authors have worked on cool pavements and cool roof, but the implementation is minimal. There are little research and policy recommendations for cool pavements in India. This study investigates the actual position on the field of cool pavements and proposes the campaign for the use of cool pavements in India.

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### I. INTRODUCTION

The temperature of the urban area is hotter than the surrounding undeveloped areas by approximately 6-8°F. Urban heat island (UHI) is the phenomenon of this difference in temperature of the environment. This happens because of the prevalence of dark surfaces and lack of vegetation causing infrared energy absorbed and retained from the sun. In order to mitigate the UHI effect, trees and vegetation, cool roof and cool pavement are required to reduce absorption of solar radiation. This reflective property is known as albedo. Albedo measures the percentage of solar energy reflected by a surface. According to the study of concrete pavement research and technology, the albedo of pavement surfaces differs significantly from the materials used in construction<sup>1</sup>.

Most existing flat roofs are dark and reflect only 10 to 20% sunlight. However, in one of the study<sup>2</sup>, authors showed that resurfacing conventional dark roofs with a cool white material has a long-term solar reflectance of 0.60 or more and increases its solar reflectance by at least 0.40. It is well established that cool roofs reduce energy used in air-conditioned buildings and increase comfort in unconditioned buildings. Similarly, the broad application of cool roof and cool pavements helps to mitigate summer urban heat island thereby reducing the overall air-conditioning load and improve outdoor air quality and comfort<sup>3</sup>. Levine has found that cool pavements have a more reflective surface than traditional pavements<sup>4</sup>. They enable evaporative cooling or other methods that allow the paved surface to remain cooler than conventional pavements.

Levine has given the reflectance property of different materials used in the pavement in albedo scale which is being reproduced in table 1. The study suggests that there are little research and policy recommendations for cool pavements in India. This paper explores the actual position on the field of cool pavements in India. In this paper an attempt has been made to highlight on pavement preservation and rehabilitation, construction of new pavements, and plantation. The findings recommend the campaign for the use of cool pavements in India.

Table 1: Reflectance property of different materials

Pavement Type	New Albedo	Weathered Albedo
Asphalt	0.05-0.10	0.10-0.15
Gray Portland cement concrete	0.35-0.40	0.20-0.30
White Portland cement concrete	0.70-0.80	0.40-0.60

## **II. LITERATURE REVIEW**

There has been some research on cool pavements in some of the countries, but this field has not progressed much beyond the laboratory and requires demonstration of projects to provide more concrete data about the real benefit and cost savings of cool pavements. The US Environmental Protection Agency (EPA) outlines few of the factors of lower promotion of cool pavements in India<sup>3,5</sup>. Most of the research points back to the work of the EPA and LBNLs heat island group but both groups have focused more on the benefits and effects of cool roofs, land escaping and other urban design elements rather than pavement. Authors have suggested that pavements are complex with more factors affecting their reflectivity and heat retention<sup>3</sup>. Cool pavements are affected by both radiative and thermal characteristics, unlike cool roofs. Pavements serve a variety of functions with different design specifications and materials. These constraints are evident in the lack of demonstration projects and hard figures on the use of cool pavements in communities. There is interest from some organizations about the implementation of cool pavements, but none has worked beyond the research stage. Outside of a few studies from the USA, Japan and Korea, there has been very little study from the international community including India.

## **III. FINDINGS AND DISCUSSION**

In most of the studies, the temperature of the pavement is reduced by treating the surface of existing pavements or by the designing of construction of new pavements or by providing vegetative cover or shade on it. The study reveals there are three methods of pavement treatment.

### **1. Pavement preservation and rehabilitation**

#### **1.1 Reflective coating and seals**

The traditional (asphalt) pavement is a low albedo and retains the captured heat. In this method, reflectance increases with the application of reflective color paint (light-colored material) on the exposed surface of the pavement. In this process, the albedo increases without reconstructing the whole roadway. A variety of materials are available in the market for the treatment of pavement. Chip seals are the low cost and quick method of surfacing. Using a light-colored aggregate with polymers, emulsion or resin for the binder, these chip seals create a marked improvement of reflectance. Scrub seals also raise the SRI of the surface by using light-colored aggregates. Micro surfacing of the pavement with a thin layer of high albedo material can increase the reflectance of the pavement and extend the life of the pavement. "Emerald cool pavement" is one of the materials available in the market for micro surfacing that raises the albedo.

#### **1.2 White topping**

A concrete overlay known as white topping can dramatically increase the pavement albedo. The benefit of using this technique is that it avoids traditional asphalt overlay and applies on the existing pavement. These toppings are less sensitive to seasonal variations and have the advantage to apply easily and quickly to the surface of the pavements. It helps to reopen the traffic quickly.

### **2. Construction of new pavements**

For the construction of new pavements, use of different materials and technologies than traditional ones, such as using less hazardous binders and waste material from industries as a binder can be used.

#### **2.1 Modified mixes**

##### **2.1.1 Modified asphalt pavements**

Freshly laid, light colored aggregate raise the albedo<sup>6</sup> to 0.15-0.20. Another technique to be considered is the addition of colored pigments to the mix. Non-bituminous binders, such as tree resin, are clear and therefore, depend on the aggregate for an overall reflective property. Resin pavements are suitable for walkways, bike paths, and parking lots. One resin-based product currently on the market is natural pave<sup>7</sup>.

##### **2.1.2 Modified Portland cement concrete pavements**

While unmodified concrete pavements are moderately reflective, steps can be taken to improve their overall reflectivity. The findings of council<sup>8</sup>, U. S. G. B. suggest that using lightly colored aggregates and white cement can increase the albedo to 0.70. Using recycled materials in concrete mixes can also enhance the reflectance. Fly ash, a byproduct of coal-fueled power plants, and slag, a byproduct of blast furnace production of iron ore, can be used as aggregate. The residue is noted for its reduced heat generation, as well as higher strength and improved durability.

## 2.2 Permeable pavement

Permeable pavement is more cooling than traditional roadways due to the increased surface area exposed to air. The porous quality of the pavement allows water to evaporate resulting lowering the temperature. Asphalt and concrete both may be constructed with an open-graded mix of larger aggregate below which a layer of crushed stone is provided enabling drainage of water. Noise reduction is an added benefit of open graded pavements. Permeable concrete is produced using cement and fly ash, ground blast furnace slag, pozzolans or silica fumes, aggregates and water.

## 2.3 Vegetated pavements

Vegetated pavements are the surfaces on which grass can grow. Vegetation has an excellent reflectance which lowers the temperature. Absorptive property helps to runoff water on these pavements. But, vegetated roadways need frequent maintenance.

## 3. Plantation

In the year 2015, the government of India launched a green highway policy, which aims at planting of trees along all the highways in the country. It is a step to provide cool pavement by providing shade. With this policy, every year 1% of the total cost of highway projects will go to the “green highway fund” that works out to around Rs.10,000 million every year. The vision of the policy is to develop eco-friendly highway by the plantation of trees along highways which will reduce the pavement temperature, impact of air pollution and dust, provide shade on glaring hot roads during summer, reduce the effect of noise pollution and soil erosion and prevent glare from the headlights of oncoming vehicles. The authors are of the opinion of extending the policy to the urban streets as well to plant trees or shrubs which will be beneficial for providing a cooling pavement and enhance albedo.

## IV. CONCLUSION

In the area of cool pavements, main research streams have aimed to provide a highly reflective paved surface with the help of white coating and infrared color. It offers permeable pavements making use of cooling through evaporation. Green highway policy of the government of India (2015), suggests the shading devices. It proposes vegetative pavements using plastic or concrete lattice allowing vegetation to grow through interstices which lower the temperature through transpiration. In India, there is an urgent need for large-scale demonstration of projects to assess experimentally all aspects related to cool pavements. At the laboratory level, significant developments have taken place. But, more research on cool pavements has to progress faster which will highly contribute to fighting against urban heat island.

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