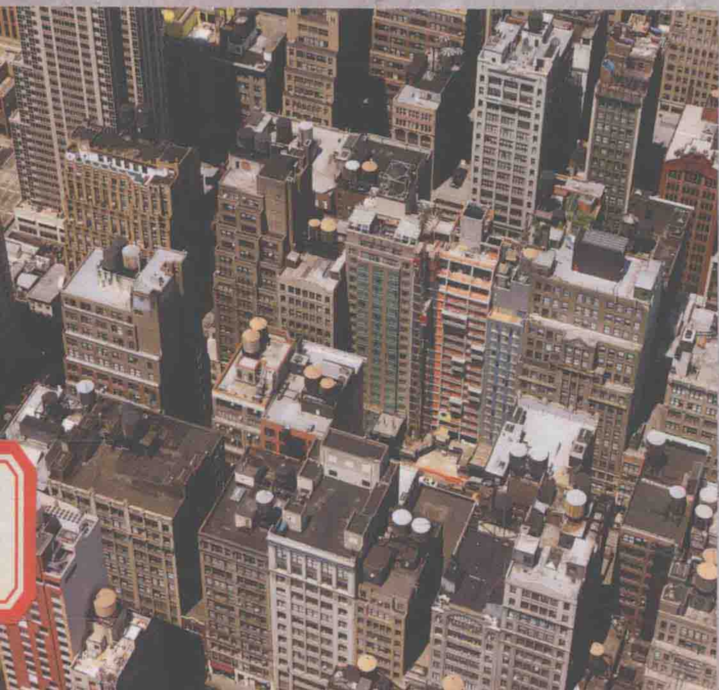
PAVEMENT MATERIALS FOR HEAT ISLAND MITIGATION

DESIGN AND MANAGEMENT STRATEGIES



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PAVEMENT MATERIALS FOR HEAT ISLAND MITIGATION: DESIGN AND MANAGEMENT STRATEGIES

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PREFACE

This dissertation book examines the effects of various cool pavement design and management strategies for improving the thermal environment and mitigating near-surface heat island effects through field measurements, modeling, and simulation. In this research, nine experimental test sections were designed, constructed, and instrumented, and the thermal performance of various types of pavements and management strategies (including high-reflectance pavement, high-thermal-resistance pavement, and permeable pavement with evaporative cooling) was empirically investigated. Different cooling effects were identified for each strategy along with their advantages and associated disadvantages. Relevant properties of pavement materials (e.g., albedo, permeability, thermal conductivity, heat capacity, and evaporation rate) were measured, in many cases using newly developed methods. With these fundamental material properties, a local microclimate model was developed, validated, and applied to conduct sensitivity analysis on some key parameters to evaluate the thermal impacts of various cool pavement strategies in different climate regions. In addition, the impacts of various strategies on outdoor human thermal comfort were evaluated for three different climate regions (Sacramento and Los Angeles in California and Phoenix in Arizona). One type of thermal load associated with building energy use was evaluated for Davis, California.

Findings indicate that using high-reflectance pavement will reduce pavement surface temperature and consequently might help improve the air quality through a reduction in the formation of ground-level ozone. However, increasing the pavement reflectance would affect the human thermal comfort during hot periods owing to an increase in the mean radiant temperature contributed by the increased reflected radiation striking human bodies. Enhancing the evaporation from the pavement through the use of permeable pavement and creating shading on pavement with trees or other devices (e.g., solar panels) are likely to be effective strategies to reduce pavement surface temperature and improve human thermal comfort in hot periods. However, to be effective in arid and semiarid climates such as California, the water level must be kept near the surface of the permeable pavement through infusions of wastewater such as waste landscape irrigation.

Some cool pavement strategies used to improve the summer thermal environment might make the cold winter slightly colder. Therefore strategies such as evaporation and shading only in summer, which can help reduce the summer hot temperatures but will not heavily reduce the winter cold temperatures, are desirable for some regions.

Based on the findings from the studies presented in this dissertation book, some preliminary recommendations on the application of cool pavement strategies for mitigating near-surface heat island effects are:

1. Pave less and plant more. For some areas such as parking lots and alleys, the sites could be partly paved, and more grass and/or trees could be planted on the sites to reduce negative impacts of pavement.
2. Pave smart if it has to be paved. Permeable pavements (integrated with irrigation systems during hot dry seasons), including pervious concrete pavement, porous asphalt pavement, and permeable interlocking concrete pavers and reinforced grass pavers, could be good alternatives for paving if applicable, to both manage storm-water runoff and potentially help mitigate near-surface heat island effects and improve the thermal environment.
3. Care should be taken with the application of high-reflectance pavements. High-reflectance pavements can be used in open areas to help mitigate the heat island effects. However, special attention should be given when applied in high-density areas or areas with frequent walking or cycling human occupancy.
4. Consider evaporation and shading. Evaporation and shading could be very effective strategies to help improve the thermal environment in hot climates.
5. The models developed in the study for local microclimate, thermal comfort, and building energy use can be used, if needed, and improved for evaluating the seasonal impacts of various pavement strategies in different contexts.
6. Life cycle cost analysis and/or cost–benefit analysis, as well as environmental life cycle assessment, should be performed to quantitatively evaluate the life cycle economic and environmental impacts of various cool pavement strategies in different climates.

This book is a compilation of many recent studies and it is recommended as a good read to both academics and policy makers. Read and enjoy.

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