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Laboratory Methods Examining The Effects Of Pavement Runoff

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Abstract

With the growth of our nation's cities, the phenomena of the "Heat Island" effect has impacted the weather of urban areas. One of the main reasons is that our cities have a large percent of pavement that absorbs significant amounts of thermal heat during the day, which in turn is released into the environment during nighttime hours. This paper provides laboratory methods that can be used to test surface heating and cooling cycles for a variety of urban pavements including pervious and impervious concrete samples, concrete pavers, and sod. Thermal experiments using heat lamps and artificial rainfall are used to quantify the effects of insolation on the temperature of different paving materials currently used in residential and commercial development applications. Preliminary observations indicate that pervious concrete samples tend to heat up and transfer heat more rapidly than impervious concrete samples. The observation of different heat storage characteristics in pervious and impervious concrete, while not surprising, can provide insight into design applications that include direct human contact with pavement as well as environmental impacts resulting from pavement choice. Testing in a controlled laboratory environment is necessary to provide reliable thermal properties and response of paving materials as well as runoff and leachate from impervious and pervious surfaces, respectively.

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Keywords: Pavement; Runoff; Thermal; Pollution; Environment

1. Introduction

Pervious concrete also called porous or permeable concrete is a special type of concrete with relatively high porosity (10-20%) that is used for concrete flatwork applications that allow water from rain and other sources to pass through thereby increasing infiltration and reducing runoff. High runoff areas such as roadways, large parking lots and

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cityscapes can benefit from application of pervious concrete (PC). Pervious concrete is not a new technology, but is not widely used in traditional construction projects, but more and more in driveway or parking lot developments. In recent years, there has been more research pertaining to the feasibility of using pervious paving innovatively to mitigate the impacts of urban heat load.

One feasible application of PC is stormwater management by integrating PC into stormwater systems that flow to a central water retention or systems that flow into major waterways such as a river, creek, or embayment. Results presented in this paper include laboratory observations that quantify the potential impact of urban thermal heat loads on waters exiting two types of pavements with potential to degrade receiving waterways with thermal pollution. The thermal impact of elevated temperatures on waterways can be observed in areas such as Mobile Bay, Alabama. This major embayment is the estuary of the Alabama River with a large impact on fishing and seafood industries in the region. The Mobile Bay Watershed drains three quarters of the State of Alabama, much of Georgia and Mississippi, and even portions of Tennessee, making it the sixth largest basin by area with the fourth highest freshwater inflow in all of North America [1]. Habitat loss has been an important environmental issue for the Mobile Bay area and is a concern that needs to be addressed for the sake of the fishing industries of the area and environmental health. Increased water temperatures entering the bay from adjacent urban stormwater systems are at risk of harming wildlife and estuary services near the inflow.

The creation of large concrete infrastructures, roadways and parking lots within urban areas worldwide has left few natural areas for rain to fall and cool the earth. This abundance and concentration of impervious and other paved surfaces results in the phenomena called the urban “heat island” effect or UHI [2]. On average, the temperature of a city is five to ten degrees Fahrenheit higher than the rural areas surrounding it [3]. Pervious concrete is often considered as a means to reduce high ambient temperatures associated with traditional impervious pavements. When stormwater builds up from rainfall on conventional pavements it becomes heated by the sun and the hot pavement surface, often with limited options for outflow or thermal cooling. By implementing PC or permeable paver pavements there is the potential to allow rapid infiltration through the pavement into the ground which alleviates the heated, standing water problem. Thus, PC can reduce “thermal shock” which happens when waterways and natural environments receive heated storm water from communities with an abundance of impervious surface. Thermal shock in a stream is that variation in water temperature, which causes stress in the aquatic environment. Thermal shock can be devastating to heat-sensitive forms of aquatic life. For that reason, this research is needed to observe and document the actual heating and cooling properties of selected paving materials. Information in this report provides preliminary insight into the proper planning and utilization of pervious paving in more applications.

Nomenclature

ACI	American Concrete Institute
DU	Distribution Unity
PC	Pervious Concrete
PR	Precipitation Rate
UHI	Urban Heat Island

2. Literature Review

Concrete, asphalt, and other paving materials are some of the most important components within the construction and building industry. Current research in the area is classified under several main themes: the future of the concrete industry, emerging concrete technologies including additives, and the economic feasibility of the different types of products currently available in the concrete industry. Each of these topics is relevant to research in the area of heat mitigation using pervious concrete.