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Optimizing of near infrared region reflectance of mix-waste tile aggregate as coating material for cool pavement with surface temperature measurement

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ABSTRACT

The heat generated from dark color asphalt, which is low in surface reflectance mainly contributes to the environmental problem called as urban heat island. Low reflectance at high energy wavelength of sunlight, such as visible light and infrared region will cause the pavement to have high surface temperature, due to high energy absorption from solar radiation. This paper presents the optimization result of cool pavement coating material based on selected tiles aggregate to achieve high near infrared region (NIR) reflectance. Three types of waste tiles were used in this study which are Full Body Porcelain (FBP), Monoporosa (MP) and Porcelain Glaze (PG). All the tiles were prepared in the form of aggregates. A linear model was formed as a function of mix tiles fraction and the analysis of ANOVA suggest that the linear term used for this model is significant. Diagnostics of the model was evaluated using box-cox plot, normal plot of residuals and optimized to predict the mix of the different type of tiles to produce the highest surface NIR reflectance value. The first solution suggests that 100% of MP tile can provide NIR reflectance of 0.53, whereas the second solution suggest that the combination of 50% FBP and 50% of MP tile aggregates could give NIR reflectance value of about 0.51. Experimental work on measuring surface temperature found that optimized samples, M1 and M2 with high NIR reflectance could significantly reduce surface temperature of asphalt pavement at range of 4.1 °C–9.6 °C. In conclusion, the results of optimization is reliable and this method able to provide significant information on optimizing mix of tiles material as to achieve high NIR reflectance value for coating materials of cool-pavement.

1. Introduction

Rapid development in modern cities creates significant impact to our environment, directly or indirectly. Modernization involves with the alteration of natural environment, from green natural surface to concrete jungle. Improper planning and design of the cities, e.g. (a) materials selection; and (b) building layout, directly affects the thermal condition in the cities, which is known as urban heat island (UHI) phenomena, a term used to describe the heating phenomenon in the urban areas. UHI is an environmental problem that is identified as a heating process in urban areas, that causing overall temperature at urban area higher compared to its surrounding rural areas [1–3]. A study in countries with four seasons all over the world shows that the daytime average air temperature in urban area is 5.6 °C higher than its surrounding areas [4]. Thermal discomfort, high energy consumption for increasing in cooling demand, and air pollution have been listed as several direct effects of UHI [5–8].

The surface reflectance or albedo of construction material plays important roles that significantly affects the existence of UHI [9]. Usually, the albedo of materials is correlated with the colour of surface materials. Most of the light colour materials have high

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