Portland Cement Association

Research & Development Information

PCA SP393

A Sustainable Approach to Outdoor Lighting Utilizing Concrete Pavement

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A Sustainable Approach to Outdoor Lighting Utilizing Concrete Pavement

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Due to the differences in the light reflectance of paving materials, asphalt pavement requires 57% more energy to light than portland cement concrete pavement (refer to reference in the 2nd paragraph). On average, for a typical 54,000 sq-ft, 146 cars, parking lot, installed lighting for asphalt pavements costs $28/year per each parking space more than when concrete pavement is used for the same application.

An investigation on lighting of surface parking lots was completed by engineer and University of Waterloo professor emeritus Werner Adrian and has been published by Portland Cement Association as *Influence of Pavement Reflectance on Lighting for Parking Lots,* SN2458.

Sustainability

Sustainable development considerations broaden the perspective of impacts caused by our built environment and attempt to strike a balance between economic, environmental and social effects of a project.

Utilizing concrete pavement instead of asphalt for a parking lot leads to a sustainable solution. The higher reflectance of the concrete pavement results in less electricity required and in a reduced number of installed lamp poles and luminaries to provide the same level of illumination. The net cost savings of the long-term electrical and maintenance costs is a direct economic benefit. The social implications of sustainable development are addressed by the concrete pavement surface providing improved luminance uniformity, avoiding drastic variation in light and dark spots; hence, providing for the public safety. The resulting reduced energy consumption and the reduced demand on virgin material for the aluminium poles is the environmentally responsible solution. The overall longer performance life of concrete means the parking lot will last the life of the building structure without any major rehabilitation work.

Implementing a sustainable design utilizing concrete is enhanced with early in-depth interdisciplinary interaction of all stakeholders in the design and construction process, including the architect, engineer, contractor, and owner.

Reflection Characteristics of Pavement

The investigation compared the lighting performance of concrete and asphalt surfaces. The total light reflected from pavement surfaces was determined by analyzing a large number of samples taken from road pavements across North America. The reflection characteristics of the samples were measured in a laboratory, and the results indicated that concrete pavements reflect considerably more light than asphalt pavements.

The essential quantity that appears as the brightness of a lit object is called luminance. Luminance refers to the intensity of brightness and is measured in candela per unit area of a surface; higher luminance values are associated with brighter surfaces. The investigation determined that the average luminance of concrete pavement was almost twice that of asphalt pavement. Figure 1 indicates the light reflected from tests on pavement samples.

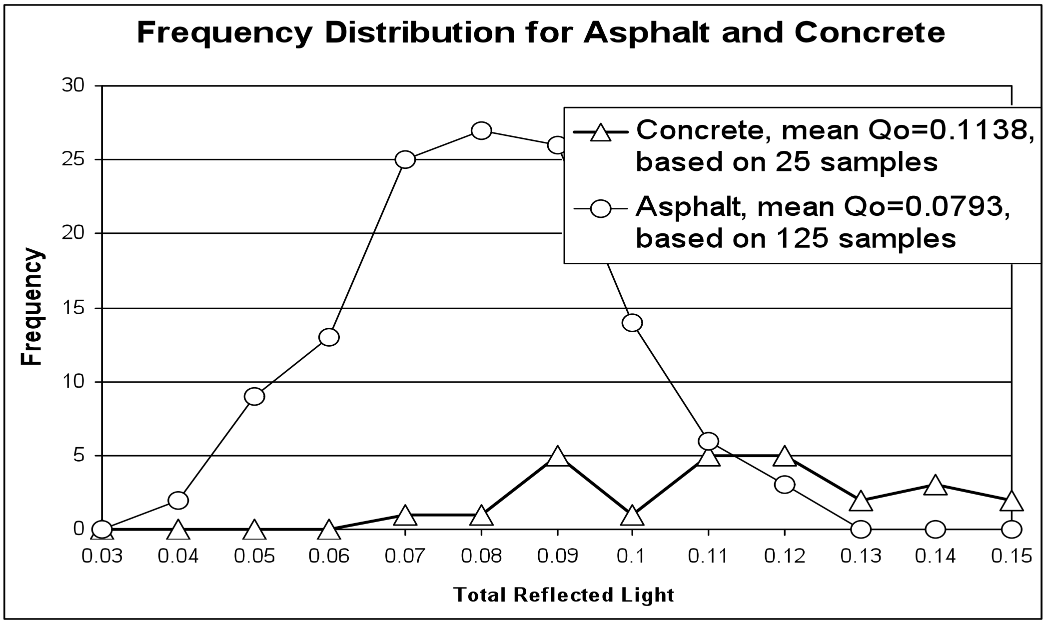

Figure 1. Frequency Distribution for Total Reflected Light, Qo, from Test Samples

Parking Lot Lighting

The investigation evaluated lighting installations for parking lots, using typical light fixture layout patterns to compare the average luminance level and visibility levels for concrete and asphalt pavements, as well as the amount of energy used for the lighting systems. The tests compared the lighting of concrete and asphalt surfaces (1) by modifying the lamp power and (2) by reducing the number of light poles to achieve comparable luminance levels. It was determined that comparable luminance levels could be obtained with less energy when concrete pavement is used versus asphalt pavement, since asphalt parking lots required 57% more energy than concrete parking lots. It also became evident that concrete surfaces improved luminance uniformity, to avoid light and dark spots. A similar conclusion can be drawn for lighting roadway pavements.

Spectral Reflection Characteristics

Next, the selective reflection properties of concrete and asphalt surfaces were measured to determine the spectral (range of light wavelength) influence of the surface reflections. Observations showed that the amount of light reflectance decreased for shorter wavelengths and increased for longer wavelengths for both concrete and asphalt surfaces. Interestingly, concrete's reflectance was greater than that of asphalt over the entire light spectrum, as shown in Figure 2.

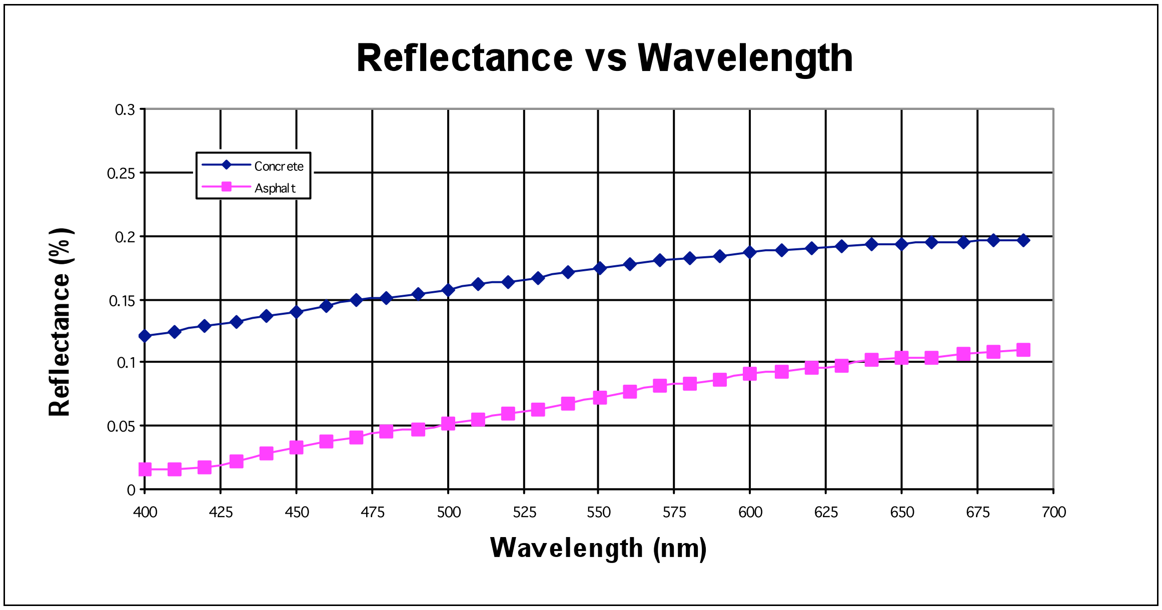

Figure 2. Effect of Pavement Material Selection on Light Spectral Reflectance

Typical Parking Lot Lighting System

To test specific lighting installations for parking lots, a typical configuration of luminaries was used to compare the average luminance level for concrete and asphalt pavements. In the calculations, Lumen Micro 7.5™ software was used to model the parking lot lighting system and to calculate luminance. There are many variables that can contribute to final values, so to ensure consistency of the calculations, variables such as pole height, luminary tilt, and geometry of lighting installation were held constant. The McGraw-Edison HPS 400 WATT luminary was used in the calculations.

The investigation attempted to create equal luminance by reducing the number of luminaries in the parking lot lighting system. The asphalt scenario was kept unchanged with an average luminance of 3.40 cd/m^2 (candela per square meter), while the number of luminaries in the concrete scenario was reduced until an average luminance of about 3.40 cd/m^2 was achieved. It was found that a configuration with 14 luminaries for the concrete parking lot provided the same amount of luminance as did 22 luminaries for an asphalt parking lot. Also, only 11 light poles were required for the concrete paving as opposed to 16 light poles for the asphalt.

Cost Comparison

In order to do a fair cost comparison between lighting systems for concrete and asphalt parking lots, the comparison must consider initial lighting installation cost as well as ongoing maintenance and energy costs. Because more luminaries must be used in the asphalt parking lot to achieve equivalent reflectance, asphalt requires 57% more electrical energy than does the concrete parking lot. In addition, the larger number of poles in asphalt lot impacts the initial installation cost. Table 1 shows the cost comparison based input from RS Means construction cost data (Means CostWorks Valuator Data Release: 2009, Qtr 1).

Item	Concrete Parking Lot	Asphalt Parking Lot
Initial Installation	$52,261	$77,025
20yr Annualized initial cost	$4,194	$6,181
Annual Electricity	$1,074	$1,687
Annual Maintenance	$2,520	$3,960
Total Annualized Cost	**$7,787**	**$11,828**

Table 1. Annualized Cost Comparison for Parking Lot Lighting Systems

Summary

For parking lots and roadways, the selection of paving materials is an important consideration for sustainable developments. It is critical to consider all aspects of the project, including the long-term energy costs associated with outdoor lighting systems. The total annualized cost and energy demand of lighting an asphalt pavement is significantly more than for a concrete pavement.