Available online at www.worldnewsnaturalsciences.com

World News of Natural Sciences

An International Scientific Journal

WNOFNS 16 (2018) 125-130 EISSN 2543-5426

Heat Island Mitigation on Imo State University Environment Using Interlocking Pavers

N. B. B. Ewurum

Department of Physics and Industrial Physics, Imo State University,
P.M.B 2000 Owerri, Nigeria

E-mail address: benbickie@yahoo.com

ABSTRACT

Heat Island is the elevation of heat at a particular geographical spot. The unusual occurrence of Heat Island and their derivative problems at Imo State University Owerri required remedy. Herein, the laying of interlocking pavers on the walkways instead of asphalt is intended to help to mitigate heat Island problems by using the method of heat transfer by radiation. In studying the difference this made, we discovered that the ambient mean temperature recorded for both asphalt and interlocking pavers were 32.000 °C ± SDn and 26.744 °C ± SDn where n = 2, respectively. Our result, thus showed that heat Island problems could be holistically mitigated by replacing asphalt surfaces with interlocking pavers.

Keywords**:** Mitigation, Heat Island, Interlocking pavers, radiation, asphalt

1. INTRODUCTION

Heat Island phenomenon has been the subject intense study over past several years. Our initial focus was on the causes of heat Island which has led to a basic understanding of factors affecting heat island development and magnitude. Urban heat island is an environmental problem which is significantly warmer than its surrounding rural areas. This heat island can be felt during summer and winter. Research into the effects of high urban temperature on air quality, energy consumption and human health has led researchers to develop strategies to mitigate heat island effects. These, strategies can be classified into two categories. The first is increasing the evapotranspiration. This can be achieved through a combination of decreasing fraction of impervious surfaces and planting vegetation in urban areas. The second one is

(Received 09 January 2018; Accepted 22 January 2018; Date of Publication 23 January 2018)

increasing albedo (reflectivity of solar radiation). This also can be achieved through high albedo roofing and paving technology. Heat island decreases air quality by increasing the production of pollutants such as Ozone, greenhouse gases etc.

Heat Islands are formed as vegetation is replaced by asphalt roads, concrete pavements, high rise buildings and other structures which absorb rather than reflect the sun's radiation, causing surface temperature and overall ambient temperature to rise (USEPA 2009). The heat from asphalt pavements is a major contributor to rise in temperature in areas with asphalt pavement resulting in what is known as heat island effect (Soder Lund et al 2008). Urban heat island effect is created by high absorptivity of pavement surfaces which subsequently leads to an elevated surface temperature and therefore higher emission from pavement (Belshe et al 2007).

2. IMPACT OF HEAT ISLAND

Among other effects, heat island can produce effects on local meteorology. These include altering wind patterns locally, cloud and fog formation, rates of precipitation and humidity. Urban heat island can affect the health of Urban dwellers causing heat strokes, cramps etc. The night time effect of urban heat island can be harmful during heat waves as it deprives urban residents of cool comfort found in rural areas during the night. Runoff water from rainfall can lead to heating via conduction from surfaces which water is flowing over. Since temperature of rain water was comparatively cool, this could be as a result of hot pavements of city. Another consequence of urban heat island is increasing energy required for air conditioning and refrigeration in cities that are in hot climate as compared to cities in cold climates. Also, studies have shown that air quality deteriorates under increased temperature due to heat island effect (Lawrence Berkeley National Laboratory 2009).

3. ASPHALT PAVEMENT

Asphalt is made using aggregate. Its binder is bitumen. Bitumen is a dark sticky substance derived from crude oil. In building roads, hot asphalt (bitumen mixed with fine aggregate) is poured onto a bed of heavier aggregate and then pressed into it with a steamroller. Once hot asphalt cools to surrounding air temperature, it is strong enough to withstand automobile traffic. Asphalt is extremely hard, it offers' enough flexibility to accommodate imperfection in underlying surfaces. Asphalt surfaces can be formulated and designed to support traffic load and climatic conditions of a specific road. This road is useful in coping with stress of large traffic loads on bridges. After few years of exposure to elements of weather, asphalt may lose some elasticity or resiliency through oxidations. During this process, pavement materials are also subjected to repeated stresses from expansion and contraction due to temperature changes, and cracks begin to appear. Asphalt requires some sort of maintenance every few years because of resistance to cracking and aging exhibited by asphalt roads. Solar radiation absorbed by an asphalt pavement raises its temperature. There are four mechanisms in transfer of heat to a pavement (Bejan, 1993). They are solar radiation in and emitted radiation out of the pavement, conducting transfer of heat through the pavement, and convective transfer of heat above the pavement through wind. The provision of porous mixtures enables capture and storage of water in pavement. The evaporation of water in pavement could be used to keep the pavement cool (Asaeda et al 2000).

4. MAKING OF INTERLOCKING

Pavers are made from a very dry mixture of gravel, sand, cement and colour. There is small water required. A press is inserted into the mold and vibrated at the same time. The high pressure and vibration causes water to set the cement and creates a binding between aggregate. When molds are removed the blocks remain in their finished state.

5. ADVANTAGES OF INTERLOCKING PAVERS OVER ASPHALT PAVERS

Interlocking paver roads have a long service life while asphalt roads last for a short service life and require frequent repairs, services, patches etc. There are less fuel consumption by vehicle running on an interlocking pavement and it means less pollution than the asphalt roads.

Unlike asphalt roads, concrete interlocking pavement roads do not get damaged by the extreme weather conditions like excess rain or extreme heat. Interlocking pavers are better because it prevents skidding, sliding and slipping off the roads during rain and snowing. The traction on types are for better in interlocking pavers than for asphalt roads because rain and snow provides frictionless surfaces in asphalt roads. Interlocking pavers are easier and cheaper to maintain than asphalt roads. Interlocking pavers can provide not only good reflectivity, but also allows water to penetrate the soil and evaporate keeping the pavement cool when moist. High reflectivity and low heat absorption are two more sustainable advantage of interlockers.

6. ENVIRONMENTAL FRIENDLY

Pavers are made of natural aggregates without petroleum - based products therefore it does not produce green house gases that pollute air. Water percolates through the joints preventing runoff water. Between the joints grasses grow (vegetation). These grasses help to reduced surface air temperatures through evapotranspiration. There are pores also on pavers through which the soil breathe. Evapotranspiration described the transfer of latent heat, what we feel as humidity, from the earth's surface to the air via evaporating water. The overall result is that surface temperature of pavers are far less than surface temperature of asphalt pavers. This strategy mitigates heat island effects in our environment. It can be used in all weather. It can be use immediately after laying them by cars and pedestrians. Cracking is not an issue as it is with asphalt pavements due to joints between pavers. They are beautiful pieces of functional art that will add appeal to any styled home. They will also enhance the aesthetics and values of properties. They are highly durable and more environmental friendly as compared to asphalt roads.

7. MATERIALS AND METHOD

The interlocking blocks are made with cement, sand, aggregates, water and colours. Place one digital thermometer on interlocking walkway laid side by side with asphalt. Also place another digital thermometer on the asphalt road. Both thermometers are shielded from direct sun rays. Allow the roads to be warm. Begin to record your readings. Take both readings simultaneously.

8. RESULT

The initial temperature readings of asphalt road and interlocking walkway were 32.4 °C and 26.9 °C respectively. After much heating, the average temperature readings were 32.000 °C and 26.744 °C. The result reveals that the ambient temperature reading of interlocking pavement is much less than the ambient temperature readings of the asphalt road.

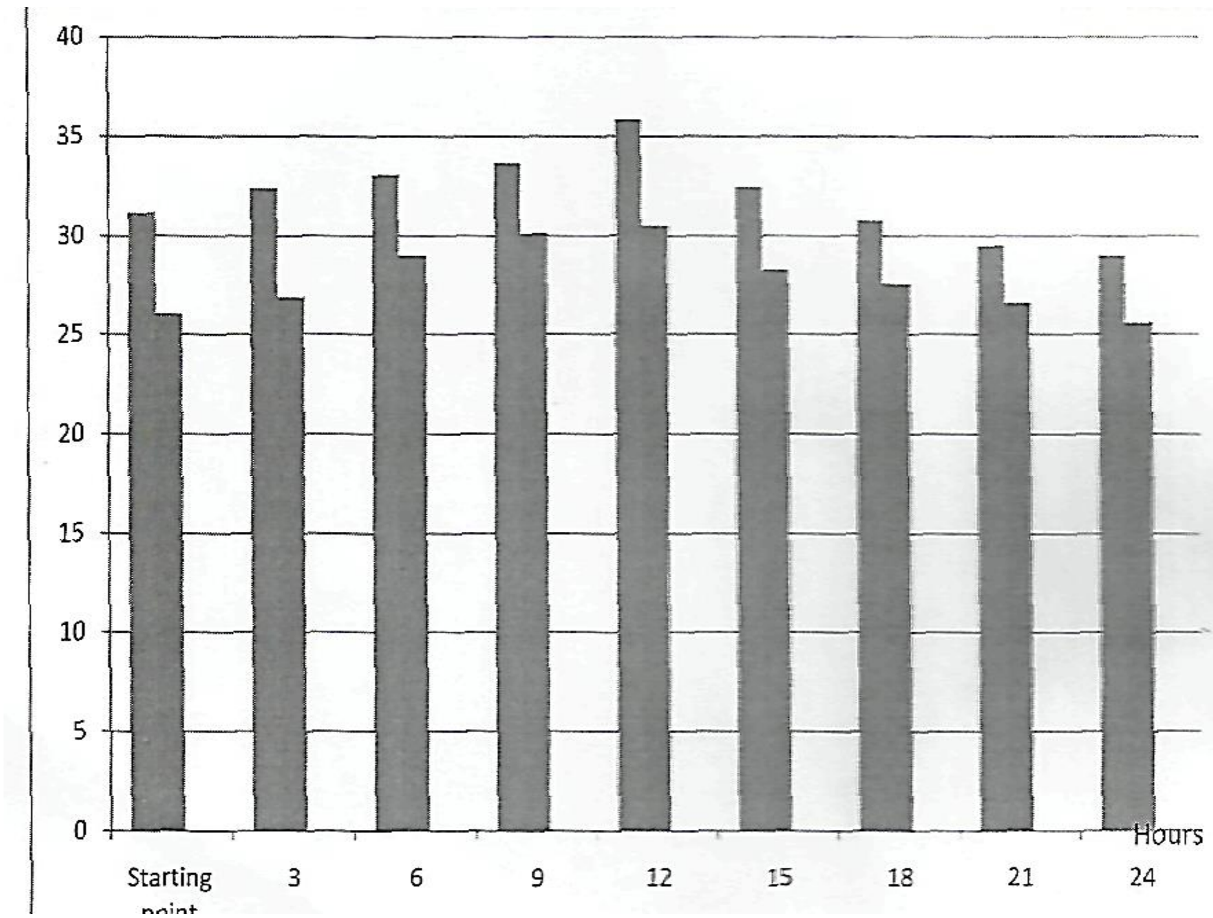
9. DISCUSSION

The use of interlocking pavers in our road will provide better pavements because it has pores where water can be evapotranspirated providing cooling effect on our community. The gap between interlocking blocks will allow grasses to grow thereby reducing excessive carbon dioxide emission in our surroundings. A study conducted by (Kikegawa et al 2006) who have carried out computer simulation to report that the reduction of anthropogenic heat and planting vegetation on the side walls of building could reduce air temperature up to 1.2 °C and reduce space cooling energy demand up to 40%. Also (Ashie et al 1999) used computer modeling and reported air temperature reduction of 0.4 to 1.3 °C with building cooling energy savings of as much as 25% through planting vegetation.

Santamouris et al (2001) also observed in his work that the heat we observed during the day from the roads, buildings and other thermal surfaces in an urban area is sent back after sunset creating high temperature differences between urban and rural areas.

Table 1. Interlocking/Asphalt Pavement

	Time (Hour)	**Tempt. Of the Asphalt Paver**	**TEMPERATURE (°C)**
			Tempt. Of the interlocking paver
	Starting/initial temperature of routes	31.2	26.1
Initial temperature of model before heating	3 6	32.4 33.1	26.9 29.0
Temperature after 9 hours of heating	9 12 15 18 21	33.7 35.9 32.5 30.8 29.5	30.1 30.5 28.3 27.6 26.6
Final cooling temperature after 24 hours of cooling	24	29.0	25.6



10. CONCLUSION

This study has been carried out around Imo State University environment. Within the limits of experimental error, using interlocking pavement to replace the asphalt walkways will provide a better environment to Imo State University Community than using the asphalt pavers. It was concluded that further investigation be carried out to see the possibility of adopting and implementing this model to check the heat island effect in this community.

References

[1] Asaeda T., Thanh V. (2000). Characteristics of Permeable Pavement during Hot Summer Weather and Impact on the Thermal Environment, *Building and Environment Report* No. 35, pp. 363-375.

[2] Ashie Y., Thanh V. C., Asaeda T. (1999). Building Canopy Model for the Analysis of Urban Climate. *Journal of Wind Engineering and Industrial Aerodynamics* 81, 237-248.

[3] Bejan, Adrian, "Heat Transfer". John Wiley and Sons, 1993.

[4] Belshe M. K. E., Kaloush J, S., Golden M. S., Mamlouk P. P. (2007). Asphalt Concrete Friction Course Overlays as Pavement Preservation Strategy for Portland Cement Concrete Pavement. *Transportation Research Board 86th Annual Meeting.*

[5] Kikegawa Y., Gendi Y., Kondo H., Hanaki K. (2006). Impacts of City-Block-Scale Counter Measures against Urban Heat Island Phenomena upon a Buildings Energy Consumption for Air Conditioning. *Applied Energy* 83(6), 649-668.

[6] Santamouris M., Papanikoluou N., Livador I., Koronakis L., Georgakis C, Argiriou A., Assimakopoubs D. N. (2001). On the Impact of Urban Climate on the Energy Consumptions of Buildings. *Energy and Buildings* 70, 201-216.

[7] Soderland M. S. T.., Muench K. A, Willoughby J. S., Uhlmeyer J. W., (2008). Green Roads: A Sustainability Rating System for Roadways. *Transportation Research Board 87th Annual Meeting.*