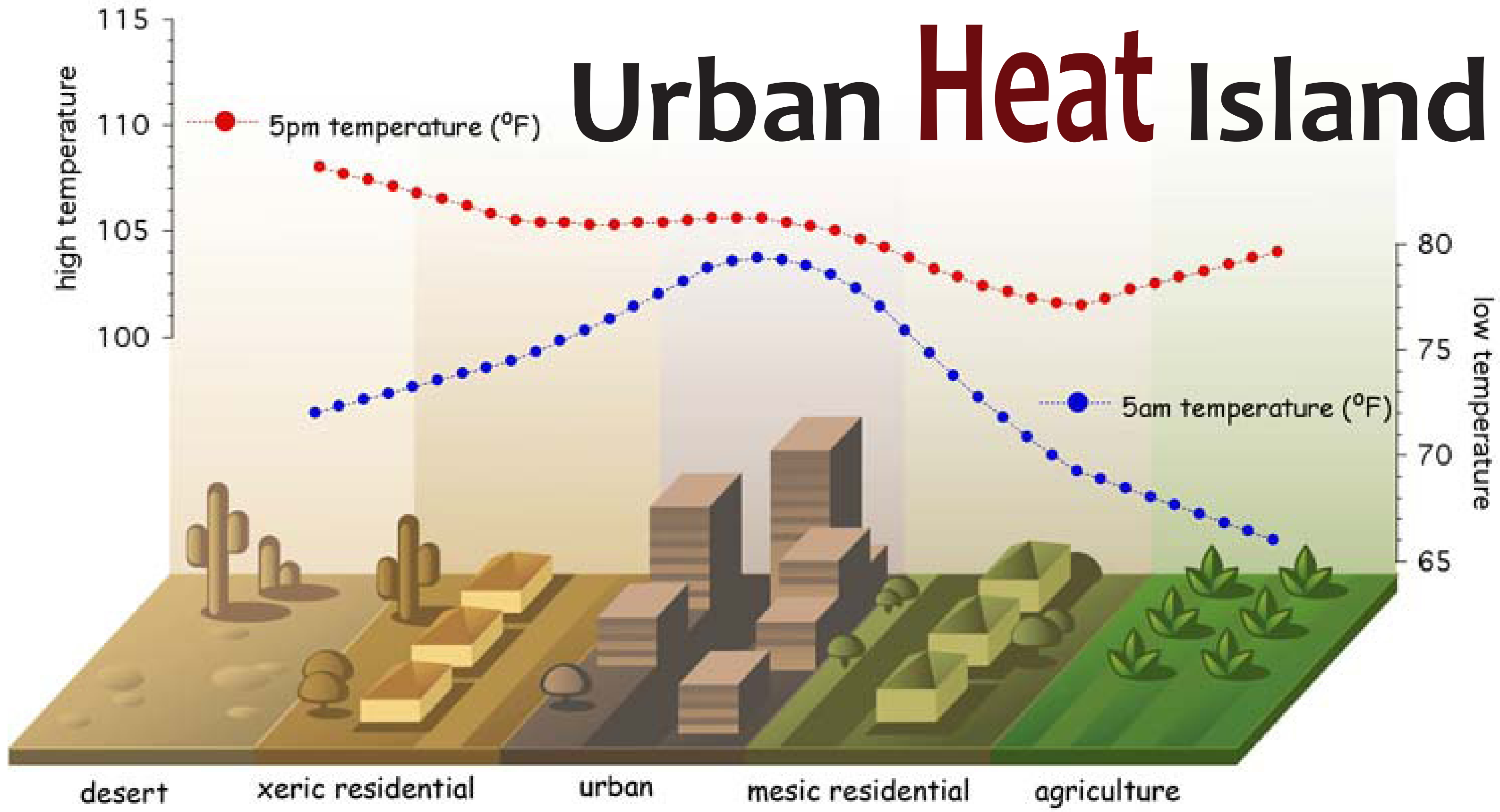
Urban Heat Island



Graph courtesy of the national Center of Excellence SMART Innovations for Urban Climate and Energy at Arizona State University.

Climate Study

Urban regions are among the most rapidly changing environments on earth. As cities grow, they impact local and regional climates, including temperature averages and extremes. Urban areas are known to alter mean annual air temperatures by 2-5°F per 100 years and up to 20°F at night. Temperature changes affect urban dweller in many ways, influencing their health and comfort, energy costs, air quality and visibility levels, water availability and quality, ecological services, recreation, and overall quality of life. The climate section of the UHI initiative is about Analyzing Local and Regional Climate Changes: Past, Present-Day, and Prospects for the Future. In addition to analyzing temperature data - analysis of the circumstances surrounding historical and present day collection sites (location, area characteristics) is key.

What is the Urban Heat Island?

For nearly 100 years, it has been believed that urban areas affect the local climate, mainly in terms of the temperature. The urban effect is due to changes in the thermal properties, moisture and aerodynamic character of the built environment. These changes create a distinct urban boundary layer, or heat dome. This heat dome extends vertically above the city, and in windy conditions can be located downwind as a plume. The temperatures within the heat dome can be 10°F (6°C) higher than the surrounding areas.

At a given time of day, a balance of incoming energy from the sun and outgoing heat from the surface determines the surface temperature. Solar radiation strikes the surface, and reflects a portion back to space and with the remainder both heating the surface and evaporating any water that may be present. The heat is transferred upwards, in part by thermal (infrared) radiation and by turbulence due to the wind flowing over the surface.

In built urban areas, there is generally less water on the surface, as compared to the outlying rural areas. In addition, the walls of buildings radiate horizontally instead of vertically, which traps the heat near the surface. Both of these factors result in the elevation of temperature that is the urban heat island (refer to figure 1).

The low level heating over the cities also has low pressure associated with it. This results in a flow from the rural areas toward the urban center, with the air converging and rising over the city. This rising air can, if conditions are favorable, result in the triggering of thunderstorms over the city.

The higher temperatures within the urban dome can also increase the rate of some chemical reactions, and in particular, the formation of low-level ozone. As a result, the urban heat island can have a profound effect on human comfort and health.

This information is as found at the SMART Innovations website, www.asusmart.com/urbanclimate.php.

Concrete

The Cool Solution to Sustainable Pavements

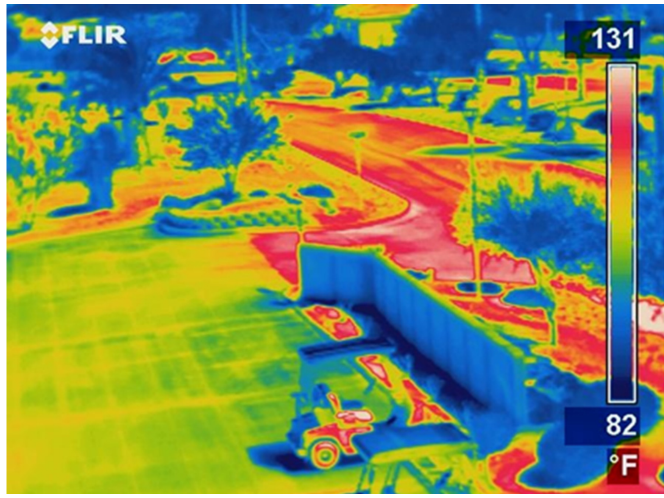
By Randell C. Riley, P.E.

Have you reached a "concrete" solution yet? It's ingrained in our very language as an icon of permanence. Those of us in the concrete industry are well aware of the permanence of long-life concrete pavements, but other aspects of concrete pavements have captured the interest of some in the environmental community that are coming to recognize concrete paving as potentially the most sustainable of pavement types.

For example, every summer we each experience first hand the direct impact of something called albedo. By now most of you in the concrete industry have heard of it. Albedo results in that blast of hot air you feel when you walk across an asphalt parking lot heated by the sun on a summer day. Often you can still feel it late into the night. Most folks do not think about it, but in more ways than one that dark characteristic of asphalt costs each of us money. It creates higher demand for electricity for cooling as a result of daytime heating. It also creates higher demand for electricity at night due to the higher wattages required to light an asphalt pavement for security purposes.

The U.S. Department of Energy on its review of heat island technologies points out specifically that whitetopping with its typically higher albedo of 15 to 30 percent compared to typical asphalt pavement is a partial solution to the heat island effect problem.

In the photos shown at right, are images that clearly demonstrate the affect of albedo on pavement temperatures due to solar heating. These particular pictures show an Ultra-Thin Whitetopping section of a parking lot adjacent to an asphalt road in Rio Verde, Arizona. The photo on the left is generated from an infrared digital imaging camera that provides an indication of the temperatures of the pavement surfaces. What is obvious from the picture is that the UTW section is several degrees cooler than that of the asphalt immediately adjacent to it.



Above are two types of images taken of the same location. In the top photo you see how concrete and asphalt pavements are adjacent. The bottom infrared photo demonstrates the dramatic temperature differences of the two pavements. UTW is much cooler. *Photos courtesy of American Concrete Pavement Association.*

This phenomenon is one of the major contributors to the "Urban Heat Island" effect and is one of the reasons that the City of Chicago and other communities are increasingly looking to lighter colored pavements in combination with landscaping and other techniques to keep their communities cooler. This in turn affects air conditioning demand and hence electrical demand within our communities. Since the major source of electricity today is coal-fired generating stations, asphalt parking lots are indirectly contributing to the CO2 loading in the atmosphere every single summer day – and night!

These higher temperatures which occur in the Urban Heat Island also contribute to increased production of smog and ozone within America's major cities. This, in turn, leads to respiratory distress amongst those susceptible, notably infants and the elderly. Expanded use of UTW in the nation's cities could well aid in eliminating these kinds of problems. In fact, the U.S. Department of Energy in its review of heat island technologies points out specifically that whitetopping with its typically higher albedo of 15 to 30% compared to typical asphalt pavement is a partial solution to the heating problem.

As a starting point for more information on concrete's higher albedo and to better understand how to put this to a marketing advantage, go to *http://eetd.lbl.gov/HeatIsland/*. The information is voluminous, to say the least, as there is a tremendous amount of work going on in this area right now.

Note the photos at the bottom of the page. One store (left) has a concrete lot and the other (right) an asphalt lot. Which of these lots would you prefer on a dark Illinois evening? Which is the most secure and which requires the most energy to light to safe standards? Think about it.

Based on the information in a report published by the Portland Cement Association several years ago, *Road Surface's Reflectance Influences Lighting Design*, it is possible to estimate the additional lighting requirements needed to bring the level of lighting for the asphalt lot up to roughly the equivalent level of the concrete lot. Lighting calculations are particularly complicated, involving considerations of the type and height of fixture, the wattage of the bulb, the spacing, etc. However, in general for highway and pavement applications the report work indicated that it would take about 30% more in equivalent lighting fixtures to achieve the same level of lighting for asphalt as for concrete.

> ***In general for highway and pavement applications the report work indicated that it would take about 30 percent more in equivalent lighting fixtures to achieve the same level of lighting on asphalt as compared to concrete.***

Many of you have seen the below photos before. They were taken in the 90s in Springfield, Illinois, at an upscale services mall about two blocks from my house. Each facility used the same type and number of lighting structures and are virtually identical. The photos were taken minutes apart with the camera on a tripod using its own automatic light exposure settings for the conditions. Do you see a difference? It is hard not to! This results in significant differences, not just in terms of number of required lighting fixtures, but the ongoing energy demands necessary to light those fixtures.

For the astronomers amongst you, the International Dark-Sky Association (IDA), *www.darksky.org*, has made estimates of the costs of lighting, though for a different intended purpose. Their numbers are, however, illustrative for our purposes. According to IDA the average security light switched on by photocell burns about 4100 hours a year or on average about 11.23 hours per night and is irrespective of the latitude the light is placed as hours of usage balance out from winter to summer and northern hemisphere to southern hemisphere. (We are talking about astronomers here.) Using their hour estimate and applying this to calculate the additional cost to provide an additional 250 watt lighting unit to achieve the same luminance level of a concrete lot, we find that nearly 1,025 kilowatt-hours (kWh) would be required. At about $0.085/kWh (the Illinois average cost as of Feb. 2008) that comes to about $87 in additional cost per year just for electricity. Over twenty years for a facility this cost mounts up to $1742, and this does not yet include the cost of the fixture. A quick perusal and ball-park figures from my bidtabs database of Illinois Department of Transportation items indicates that the cost of a fairly typical metal light mast with luminare, foundation, wiring, trenching, etc. probably costs close to $5500. (I'm no expert on this, but it looks reasonable.) The total on that is about $7,250 just do to the difference in lighting.

But what about the impact on the environment? From another source of information I gleaned that the electricity generated per ton of coal is about 2460 kWh/ton at about a 40 percent efficiency rating which apparently is pretty good by utility standards. Therefore, in order to bring the level of lighting for asphalt up to the level of typical concrete pavement, it takes about another 0.42 tons of coal per year converted into electricity with another 0.6 tons of coal lost due to waste in the thermodynamic transfer effects, waste heat, etc. The net result of this would be a contribution of 2,167 lbs., say roughly a ton of CO2 into the atmosphere per year every year of operation. This is just one measly two-acre parking lot!

Think about the parking lot at your nearest major mega-mall and what the implications are for those locations. And this isn't even looking yet at the air conditioning load being generated as a result of the additional heating stemming from the asphalt's lower albedo. But back to the albedo issue for a minute!

Did you know that concrete pavement albedo with some of our newer "green friendly" mixtures containing slag can be quite high? From a Transportation Research Board paper presented at the 86th Annual Meeting, *Mix Design and Benefit Evaluation of High Solar Reflectance Concrete for Pavements*, by Kanok Boriboonsomsin and Farhad Reza, albedo ratings measured on concrete incorporating slag in a range from about 0.34 to 0.58. Observations from space have determined that the Earth's albedo is about 0.39! On average our newer materials are cooler than the Earth.

There are those that think CO2 is the problem contributing to global warming. I think it's asphalt pavement! Concrete pavements alone could turn the planet into a popsicle.

Randell Riley is the Executive Director/Engineer for Illinois Chapter – ACPA, and a consultant to Illinois Ready Mixed Concrete Association. He is actively and enthusiastically involved in the day-to-day building of partnerships and promotion of long-life quality concrete pavements. He can be reached at 217-793-4933 or pccman@ilacpa.com.

HOW does a Project Obtain LEED® Credit for Reducing Temperature in Heat Islands?

Concrete surfaces can earn a LEED for New Construction and Major Renovation (LEED-NC version 2.2) credit through Sustainable Sites Credit 7.1: "Heat Island Effect, Non-Roof". The intent of this credit is to reduce the heat island effect. The intent can be met if materials that stay cool in sunlight are used on at least half of the site's non-roof impervious surfaces, such as roads, sidewalks, courtyards, and parking lots (hardscape). The material's solar reflectance index (SRI) must be at least 29. Where paved surfaces are required, using materials with higher SRI will reduce the heat island effect, consequently saving energy by reducing demand for air conditioning, and improve air quality. Concrete and concrete pavers are ideally suited to meet this requirement. Ordinary portland cement concrete has an SRI in the range of 38 to 52, although it can vary. However, unless it is actually measured, LEED allows an SRI of 35 for ordinary portland cement concrete (see the LEED-NC Reference Guide). New concrete made with white portland cement has an SRI of 86 according to the Reference Guide.

Other options include placing a minimum of 50% of parking spaces undercover (such as underground, under deck, under roof, and under building); using an open-grid pavement system with more than 50% perviousness; or provide shade within 5 years of occupancy.

Information as found at www.concretethinker.com.