14 Use Cool Surfaces to Reduce Summer Heat

I. Summary

Issue:
Light-colored roofs and surfaces reflect light and heat back into the atmosphere, cooling buildings and cities. City regulations mandate light-colored roof coatings, but only for flat roofs. These coatings also tend to darken over time, losing their effectiveness. Dark, non-compliant coatings are still sold in NYC, increasing unintentional violation of code.

Recommendations:
Expand existing cool roof requirements to include pitched roofs. Prohibit the sale of dark roofing materials and dark "crumb" rubber in synthetic playing fields. Encourage owners to use self-cleaning cool roof coatings and study the longevity of various cool roof options.

II. Proposed Legislation, Rule or Study

Amendments to the NYC Building Code:

1. Amend Section 1504.8 as follows:

   1504.8 Reflectance. Roof coverings on roofs or setbacks with slope equal to or less than two units vertical in 12 units horizontal (17 percent) shall have:
   1. a minimum initial solar reflectance of 0.7 in accordance with ASTM C1549 or ASTM E1918, and a minimum thermal emittance of 0.75 as determined in accordance with ASTM C1371 or ASTM E408; or
   2. a minimum SRI of 78 as determined in accordance with ASTM E1980.

   Roof coverings on roofs or setbacks with slope greater than two units vertical in 12 units horizontal (17 percent) shall have a minimum SRI of 25 as determined in accordance with ASTM E1980.

2. Amend Section 1507.2 as follows:

   1507.2 Asphalt shingles. The installation of asphalt shingles shall comply with the provisions of this section, [and] Table 1507.2 and section 1504.8.

3. Add a new section 1506.5 as follows:

1506.5 Synthetic turf infill. Any new synthetic turf playing field shall only utilize infill comprised of a material approved by the commissioner of parks and recreation. Dark crumb rubber shall be prohibited.

Amendments to the Administrative Code of the City of New York:

1. Add a new subchapter to Chapter 13 of Title 20 as follows:

Subchapter 13: Roof Coatings

20-699.7 Roof coatings. It shall be unlawful for any person to distribute, sell, offer for sale, or import any roof coating that does not meet the standards of Section 1504.8 of the New York City Building Code.

20-699.8 Civil penalty. Any person who violates any of the provisions of this subchapter shall be liable for a civil penalty in the sum of not more than five hundred dollars for each violation.

Study: Long-Term Cool Roof Performance

The city should research the long-term solar reflectance and thermal emittance of various roof coatings, including bituminous roofs with acrylic and hydrophilic coatings, white rubber, and black rubber with a white coating.

III. Supporting Information

Expanded Issue and Benefits:

The urban heat island effect (UHI) is the increase in ambient air temperature in urban areas that results from the prevalence of materials, like dark pavement and roofing, that absorb solar thermal radiation and reduce the natural cooling that occurs in vegetated areas through evapotranspiration. In the hottest months of the year, the UHI leads to increases in heat-related mortality in the city and exacerbates ground-level ozone, which aggravates asthma and other respiratory conditions. Warmer air temperatures impact NYC's resiliency by increasing cooling demands in buildings and reducing comfort outdoors during hotter months of the year. Research suggests that UHI and waste heat from buildings may also alter the city's microclimate, intensifying summer storms. This Task Force proposal is designed to reduce UHI temperature impacts in order to minimize electricity use during times of peak demand that may cause blackouts, and to minimize health impacts and heat-related mortality during infrastructure outages in the summer.

Roofs with slopes greater than 17% make up a significant percentage of NYC's building stock and currently have no Building Code or regulation to monitor their UHI contribution. Optimally, these surfaces should be of white material or white coating because, as stated in Local Law 21-2011, a white roof reduces the UHI and "increases the durability of the roof membrane because it is subject to reduced thermal cycling amplitude and UV radiation." For situations where darker shingles or tiles are competitively priced, reflective shingle and tile technologies that have a minimum SRI of at least 25 are readily available. Alternatively, newer technologies utilizing a two-layer spray coating process can increase the solar reflectance significantly without sacrificing color options. The LEED® rating system has used an SRI benchmark of 29 for steep-sloped roofs since Version 2.2 was released in 2007.

Thermal maps and on-the-ground data collection have revealed that synthetic playing fields that use "crumb" rubber for infill are some of the hottest places in NYC on summer days, contributing to UHI in some of the city's hottest, poorest neighborhoods, which also tend to have low tree cover. In 2010, Local Law 123 created a Department of Parks Advisory Committee regarding synthetic turf to make recommendations that are non-binding and apply only to Parks Department turf fields. Since that time, data has confirmed that crumb rubber turf has very poor SRI and virtually no evapotranspiration capabilities, resulting in high heat conditions that pose acute risks to public health. Additionally, synthetic turf has little or no stormwater retention (which would help mitigate combined sewage overflow events), an important benefit of natural turf fields. Therefore, it is necessary that the Building Code contain requirements that apply to all synthetic playing fields.

Using alternative organic materials sourced from cork, coconut husks, or other nontoxic, high albedo (reflectiveness coefficient), and water absorptive materials will reduce thermal absorption, thereby reducing surface temperatures by as much as 35ºF on a hot summer day. Initial costs are approximately 10% more than crumb rubber, but relative prices are expected to drop.

Painting dark roofs white significantly reduces their solar thermal retention and therefore leads to reduced ambient indoor and nearby outdoor temperatures (if implemented at scale). However, some studies have shown that roofs painted white with commonly used elastomeric acrylic exterior paints can lose up to 50% of their albedo capabilities in just several years, likely due to unavoidable dirt and particulate buildup. While a white roof performing at 50% of its cooling capability is still 50% better than a black roof, regular washing of white roofs would be beneficial. However, this is an onerous activity that building managers should not be required to conduct, nor could it be easily regulated. As an alternative, new self-cleaning (hydrophilic) paints like StoCoat®, Lotusan®, or HydroPhil™ should be considered.

More research is needed on the degradation of roof coatings. In particular, a study that monitors and compares the long-term solar reflectance and thermal emittance of various roof coatings is needed.

General Background on Urban Heat Island Effect

By increasing the albedo of building surfaces, primarily the roof, walkways, and playing fields, along with increasing the amount of shading provided by trees and other landscaping, the city could reduce the ambient temperature impact of the Urban Heat Island Effect.

Increased temperatures result in higher peak electricity demands (which can lead to blackouts), contribute to heat-related mortality in vulnerable populations, and accelerate the production of

ground-level ozone (which aggravates respiratory symptoms, especially among children and the elderly, and may lead to the development of asthma in children).

The Urban Heat Island Effect exacerbates warming trends resulting from global climate change. Studies have shown that the 31 counties of greater NYC experienced 2ºF warming of average annual temperatures from 1900-1997, and projections for the region in the 2050s range from 2.5º-7.6ºF warmer. There is a 13.05% increase in non-accidental causes of mortality for every 10ºF increase in temperature above the local threshold of 73.54ºF. In the 1990s, weather data showed that the average temperature in Central Park was 4.2ºF warmer than the 23 other weather stations in the region – a figure that is even higher in certain neighborhoods with less vegetation and higher concentrations of dark roofs. In addition, according to multiple research studies, elderly people and people carrying the sickle cell trait (almost exclusively African Americans) have a higher propensity for mortality due to heat-related exertion. According to NASA heat and vegetation maps overlaid with census tract maps, the hottest neighborhoods in the city with the least amount of green area (including Brownsville, the South Bronx, East Harlem, and others) are also predominantly minority neighborhoods.

The table below compares temperatures of different synthetic turf infill types, including “InfillPro Geo” – a coconut, cork, and sand mixture:

Infill System Temperature Testing:

Hydra-Cone Infill Measurement · Infrared Thermometer · ACU-Rite Probe

Time/Day	Air Temp ˚F/ Sky	Humidity %	Wind MPH	Natural Grass ˚F	Raw Soil ˚F	Moisture %	InfillPro Geo ˚F	Rubber Infill ˚F	Sand/Rubber Infill ˚F
11:00/ 1	63/ Sun	44	12	80	89	2.0	84	104	103
2:00/ 1	71/ Sun	32	15	89	110	2.0	107	144	149
Moisture added after 2pm reading:									
3:00/ 1	80/ Sun	19	11	100	126	4.0	113	163	161
4:00/ 1	86/ Sun	15	14	104	131	4.0	116	174	171
Moisture added at 9am: (12 oz. per square foot)									
11:00/ 2	83/ Sun	21	21	88	117	5	109	121	119
2:00/ 2	88/ Sun	33	3	99	124	5	111	126	123
3:00/ 2	93/ Sun	26	10	101	126	4.5	115	164	163
4:00/ 2	97/ Sun	15	16	97	131	4.5	103	171	173
5:00/ 2	98/ Sun	11	20	92	126	4.3	101	147	144
Moisture added at 9am: (12 oz. per square foot)									
1:00/ 3	86/ Sun	31	7	88	117	5.0	99	141	140
2:00/ 3	88/ Sun	33	3	93	119	5.0	104	157	155
3:00/ 3	93/ Sun	21	12	98	126	4.5	115	164	163
4:00/ 3	97/ Sun	15	16	100	131	4.5	117	171	173
5:00/ 3	98/ Sun	11	20	98	126	4.3	114	169	168

Source: Limonta Sports Turf; ISA USA / DMA Sports Design Group (June 30, 2012)

Implementation:

There are no known implementation issues for this proposal.

Asphalt shingles meeting the SRI standards in this proposal are readily available. The top asphalt shingle manufactures, including Owens Corning, PABCO, CertainTeed, and GAF, all

have product lines that meet the proposed SRI standard, and each line comes in an extensive variety of colors.[i] According to the Cool Roof Rating Council, there are at least 51 asphalt shingle product lines available in a variety of colors with an initial SRI of 25 or higher, and at least 14 with an SRI of 29 or higher.

Hydrophilic paints, on the other hand, are less readily available at this time. Once there is more competition in this specialty paint market, it may be plausible to add its use on low-slope roofs to the Building Code.

Numerous materials can substitute for dark crumb rubber in playing fields, including alternative rubber products and organic products such as coconut husks, walnut shells, cork, and sand. Rubber-type infills, such as EcoFill (TPE) by Mondo, have performance characteristics similar to natural turf, and also have significantly less heat absorption than black crumb rubber.[ii] According to Mondo, "On average, EcoFill produces 6% more heat than natural grass compared to 14% more heat for SBR/sand based fields."

The School Construction Authority requires the use of synthetic turf materials that address both the performance of the field for sports and the heat and toxicity issues.

Cost:

Turner Construction Company prepared cost estimates based upon several standardized building typologies. Due to the innate variances in construction costs between projects, the complexity of the Task Force proposals, and the wide range of buildings to which the proposals may apply, these cost estimations should only be used as rough order-of-magnitude guides. The cost analysis is presented at the end of this proposal; more information about the cost methodology is given at the end of the full report.

The following analysis was provided by the authors of this proposal:

According to the Green Affordable Housing Coalition in 2007, asphalt composition shingles that are used on as many as 80% of existing U.S. homes are the least expensive option between the other two common steep-sloped roofing alternatives at approximately $0.50-1.50/ft² (whereas metal = $1.00-6.00/ft² and clay or concrete tiles = $3.00-5.00+/ft²). The Department of Energy states that "[c]ool versions of some roofing materials, including thermoplastic membranes, coated metal products, and clay tiles are available at little or no additional cost. Cool asphalt shingles currently sell for up to $0.50/ft² more than conventional asphalt shingles." High-albedo asphalt shingles (SRI>25) are becoming more competitive in price, although metal and tile roofing is more flexible from a UHI-reducing perspective because metal can easily be painted and tiles come in a variety of colors.

Since properly installed asphalt shingle roofs often have a lifespan of 30 years or more, the energy savings realized from cool roofs can significantly offset or recoup the additional per-square-foot costs associated with improved cool roof products. According to the ENERGY STAR

i. The Timberline® line by GAF, for instance, offers six color options and PABCO's Premier Radiance® line offers grey, off-white, brown, and multicolor options. CertainTeed has asphalt shingles with an initial SRI of 26 in tan, black, brown, grey, orange, yellow, and multicolor.
ii. http://www.piedmont.k12.ca.us/forms/turf/mondoturf/Mondoturf_Temperature_Study.pdf

rating system (which compiles a list of hundreds of qualified cool roof products) the average homeowner spends nearly $1000 per year on heating and air conditioning costs. $40 billion is spent annually on air conditioning alone in America. They state: “ENERGY STAR qualified roof products… can lower roof surface temperatures by up to 100°F, decreasing the amount of heat transferred into a building,” and “can reduce peak cooling demand by 10-15%.”

For low-slope roofs, self-cleaning coatings like StoCoat®, Lotusan®, or HydroPhil™ typically cost approximately $0.50/ft² (including installation) more than the popular elastomeric acrylic exterior paints (e.g., APOC® 247 Sun-Shield), but labor costs remain the same, long-term cleaning costs are mitigated, and the paint lasts longer.

NEW CONSTRUCTION

	Commercial High Rise				Commercial Low Rise				Residential High Rise				Residential Low Rise			
	Quantity	Unit	Unit Cost	Total	Quantity	Unit	Unit Cost	Total	Quantity	Unit	Unit Cost	Total	Quantity	Unit	Unit Cost	Total
14 Use Cool Surfaces to Reduce Summer Heat																
Premium to use roof covering with high solar reflectance index and high thermal emittance in lieu of traditional materials - sloped roofs					2,000	SF	$1.00	$2,000					3,000	SF	$1.00	$3,000
								$0								$0
SUBTOTAL DIRECT WORK								**$2,000**								**$3,000**
Contingency						10%		$200						10%		$300
SUBTOTAL								**$2,200**								**$3,300**
GC Mark-ups						20%		$440						20%		$660
TOTAL				**N/A**	**4,000**	**GSF**	**$0.66**	**$2,640**				**N/A**	**15,000**	**GSF**	**$0.26**	**$3,960**

EXISTING BUILDINGS

	Commercial High Rise				Commercial Low Rise				Residential High Rise				Residential Low Rise			
	Quantity	Unit	Unit Cost	Total	Quantity	Unit	Unit Cost	Total	Quantity	Unit	Unit Cost	Total	Quantity	Unit	Unit Cost	Total
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