M E M O R A N D U M

TO: Kevin Beuttell, City of Cambridge

FROM: Ariel Patterson, Kleinfelder

DATE: February 16, 2022

SUBJECT: Solar Reflectivity Index (SRI) Testing of Paving and Surface Materials, Technical Support Services FY 19-22

CC: Kathy Watkins, City of Cambridge

Ben Stoddard, Kleinfelder

INTRODUCTION

The Kleinfelder project team conducted field testing of various surfaces in the City of Cambridge to determine their solar reflectance index (SRI) values. The Solar Reflectance Index (SRI) is a measure of a surface's ability to reject solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. For example, the standard black has a temperature rise of 90°F (50°C) in full sun, and the standard white has a temperature rise of 14.6°F (8.1°C).[1] Once the maximum temperature rise of a particular material is computed, the SRI can be computed by interpolating between the values for white and black. Materials with the highest SRI values are the coolest choices. Due to the way SRI is defined, particularly hot materials can even take slightly negative values, and particularly cool materials can exceed 100. Note that SRI is not a measure of 'mean radiant temperature,' which represents a human's total radiant heat exposure (thermal comfort). Although higher surface reflectivity can cause a reduction in human comfort, it may be a necessary tradeoff to reduce surface temperatures using a reflective surface.[2]

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[1] "Definitions and Terms," Heat Lab, Lawrence Berkeley National Laboratory, 1998, https://heatisland.lbl.gov/resources/definitions-and-terms

[2] "Cool Pavement Pilot Program," Arizona State University, City of Phoenix, AZ, September 2021

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SRI incorporates both solar reflectance and thermal emittance into a single value. Solar reflectance (or albedo) is the percentage of sunlight that is reflected from a surface and thermal emittance (or infrared emittance or emissivity) is the ability of material to release absorbed heat.[3] Both are expressed with a number between 0 and 1 (or 0 percent and 100 percent). High solar reflectance is the most important property of a cool surface.[4] Thermal emittance, however, is a secondary factor since all common paving materials generally have high emittance values: dense-graded concrete and asphalt are similar, ranging from 0.90 to 0.95.[5]

Mitigating heat to address the urban heat island (UHI) effect has been a major initiative for the city in meeting its climate resiliency goals as outlined in the *Resilient Cambridge* Plan and its accompanying reports, the *Climate Change Vulnerability Assessment (CCVA),* among other planning documents. SRI values are key to understanding which materials are most effective in reflecting light from its surface, thus lowering surface temperatures and reducing the amount of heat it absorbs. Researchers at Lawrence Berkeley National Laboratory found that for a 10 percent increase in solar reflectance (albedo), the maximum pavement temperature decreases by about 7°F (4°C).[6] The data gathered from this work provides a basis for decisionmakers to further explore surface materials that provide the most benefits in terms of environment, maintenance, cost, health, energy consumption, stormwater management, livability, and other markers. Results may be used to support efforts to install or retrofit pavements that better mitigate heat and decrease air temperatures.

The project team tested several types of surface materials in ten sites across the city, each site containing multiple points. In total, 26 points were tested for all sites over the course of two days. The sites selected are intended to capture a variety of pavement materials, suppliers, installation dates, geographic areas, and local environmental factors to gain a better understanding of the SRI of standard paved surfaces in Cambridge. Site information and data can be found in Appendix A. Based on an analysis of the testing results, the project team developed a set of conclusions and recommendations for the city.

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[3] Global Cool Cities Alliance (GCCA), *A Practical Guide to Cool Roofs and Cool Pavements*, January 2012.

[4] Global Cool Cities Alliance (GCCA), *A Practical Guide to Cool Roofs and Cool Pavements*

[5] Thomas J. Van Dam, John T. Harvey, Stephen T. Muench, Kurt D. Smith, Mark B. Snyder, Imad L. Al-Qadi, Hasan Ozer, Joep Meijer, Prashant V. Ram, Jeffery R. Roesler, and Alissa Kendall, “Towards Sustainable Pavement Systems: A Reference Document,” FHWA-HIF-15-002, Federal Highway Administration. January 2015.

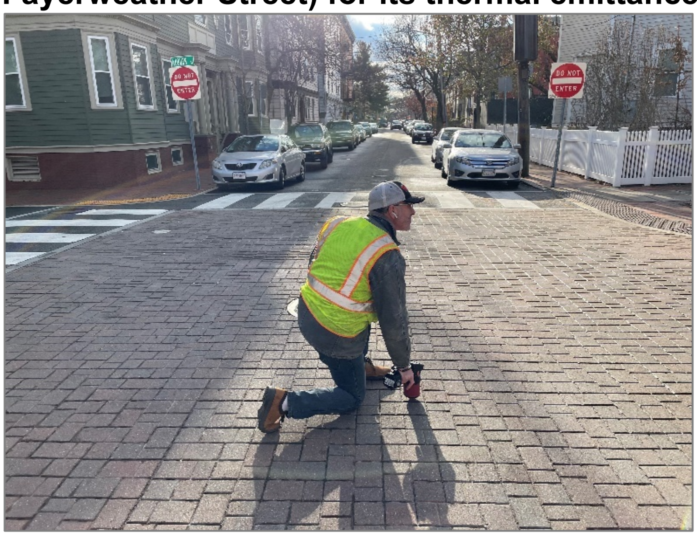
[6] Pomerantz, M., B. Pon, H. Akbari, and S.-C. Chang. The Effect of Pavements’ Temperatures on Air Temperatures in Large Cities. Paper LBNL-43442. 2000. Lawrence Berkeley National Laboratory, Berkeley, CA.

METHODS

Ten locations across Cambridge were identified using a desktop analysis to capture a wide range of traits. Street level pavement materials that were tested include asphalt (parking lanes, bike lane, parking lots), concrete, brick, porous asphalt, raised pavers, and high SRI surface paint coated over asphalt. Figure 3 in the Appendix shows the ten site locations across Cambridge and Table 3 shows the surface materials tested at each location. A representative from the City of Cambridge observed the testing process at the first site.

A Kleinfelder team member accompanied the subconsultant (Briggs Engineering & Testing) to support on-site testing, record data from SRI equipment readings, take photographs, and provide navigation directions to testing sites. The subconsultant was responsible for obtaining equipment, conducting testing, and providing data results. Data collection and testing surfaces was conducted using two pieces of equipment: the ET-100 Thermal Handheld Emissometer that measures the reflectance in the infrared spectral range and calculates directional thermal emissivity, and the 410-Solar Handheld Reflectometer that measures solar reflectance and absorptance.[7,8]

Figure 1 Briggs Engineering & Testing tests a raised paver intersection (Site 4-Fayerweather Street) for its thermal emittance



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[7] "ET-100 Thermal Handheld Emissometer," Surface Optics Corporation, https://surfaceoptics.com/products/reflectometers-emissometers/et100-thermal-hand-held-emissometer/

[8] "410-Solar Visible / NIR Portable Reflectometer," Surface Optics Corporation, https://surfaceoptics.com/products/reflectometers-emissometers/solar-absorptance-measurements-410/

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On-site testing of surface materials took place over two days, December 28-29, 2021. The testing process is summarized in these steps:

- For each surface material, the subconsultant took measurements of the total solar reflectance (TSR) (using the 410-Solar Handheld Reflectometer) and the thermal emittance (using the ET-100 Thermal Handheld Emissometer). To perform measurements, the unit is placed against the surface and the trigger is pressed to record the data. It takes approximately seven seconds to take a measurement.
- Three TSR readings and three thermal emittance readings were taken for each material. The three readings considered the various color shades (i.e., the Pine Hall Pavers (brick) consisted of light, medium and dark brick) and the results reflect a uniform result for that specific material type.
- Wind, weather, and ambient air temperature (°F) were documented at each address.
- The results were recorded into field data sheets from the subconsultant and later transcribed into an Excel worksheet for additional analysis.
- The subconsultant performed the following calculations for each surface type:
    - Average TSR value. This measurement is the average of the three readings taken at the same site.
    - Average thermal (infrared) emittance (ε) value. This measurement is the average of the three readings taken at the same site.
    - Solar Reflectance Index (SRI) values based on averages. SRI is calculated using the test method, ASTM E1980- "Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces."
    - SRI values based on the (ε) reading constant (0.930) as a comparison with the ones obtained in the field. The constant for the (ε) is based on a Federal Highway Administration (FHWA) reference.

RESULTS

Briggs Engineering & Testing provided raw data of testing results and performed all calculations to determine SRI values. The summarized testing results with calculations are in Table 5 and detailed testing results with calculations are in Table 6. Below are the condensed results to depict how the calculated SRI values compare to standard SRI values found in literature.

Table 1

Material	# of areas tested	Measured SRI values	Standard SRI values
Asphalt	8	Range of 1 to 9	New asphalt: 0 Weathered asphalt: 6 Light colored asphalt: 12-18

Asphalt covered by high SRI surface paint	1	23 (SR: 0.255)	Measured by solar reflectance (SR) New paint SR: 0.35
Brick sidewalk	4	Range of 8 to 10	New brick: 3-74 New Red-Brown brick: 10-51 (Hanover Architectural Products brick)
Concrete sidewalk	9	Range of 14 to 41	New gray concrete: 35 Weathered gray concrete: 19 New white concrete: 86 Weathered white concrete: 45
Porous asphalt	2	10 (w/SR: 0.122) and 18 (w/SR: 0.209)	Measured by solar reflectance (SR) 0.074- 0.08
Raised paver intersection	2	1 and 69	32

Figure 2 Springfield Street Parking lot (PL-14) new pavement coating with high SRI surface paint

CONCLUSIONS AND RECOMMENDATIONS

Asphalt surfaces may contribute to the UHI effect in Cambridge

Parking lots, parking lanes, and bike lanes paved with black asphalt had low SRI values, ranging from 1 to 9. Of the ten lowest SRI values for all sites tested, eight are asphalt (the other two are brick and raised paver). Low SRI values indicate that the surface absorbs more heat, which contributes to higher surface temperatures. The testing results were largely consistent with the standard SRI values of 0 to 6. Alternatives to black asphalt may be considered when paving (or re-paving) streets and bike lanes. Using materials with higher SRI values may help reduce the UHI effect, especially when paired with other cooling solutions.

Further study needed to assess performance and reliability of high SRI surface paint

The project team anticipated that the Springfield Street parking lot (site #10) would outperform all other surface materials because it is the only site with high SRI surface paint. The parking lot has an SRI value of 23, which is comparable to the concrete's results. Notably the parking lot surface was weathered, not as bright white as its original condition, which may have affected the results. The paint was installed on June 2021.[9] Effectiveness of high SRI surface paint should be weighed against its maintenance cost, which may be higher than traditional materials, and other factors.

The type of paint used is StreetBond SB150 pavement coating (in Sandstone coloration) which produces cool pavement surfaces for compliance with LEED specifications for urban heat island mitigation and to provide more comfortable environments.[10] The "Heat island reduction" LEED v4 credit that states new construction and existing buildings use paving materials with a three-year aged solar reflectance (SR) value of at least 0.28, or with an initial SR of at least 0.33 at installation.[11,12] The paint used at this site has an SR value of 0.35 for new installation, which meets the credit requirements.[13] However, on-site testing shows its average solar reflectance value of 0.255, falling short of the manufacturer's description.

Concrete has highest SRI values of all materials tested overall

Of the top ten highest SRI values, eight surfaces were concrete sidewalks (the other two are raised paver and high SRI surface paint coated over asphalt). In total, nine concrete

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[9] "City Pilots Pavement Surface Treatment to Reduce Urban Heat Island Effect," City of Cambridge, MA June 21, 2021, https://www.cambridgema.gov/Departments/publicworks/news/2021/06/pavementcoating

[10] StreetBond SB150 Pavement Coating Product Data Sheet, GAF, https://www.gaf.com/en-us/document-library/documents/productdocuments/commercialroofingsystemsdocuments/pavementcoatingsdocuments/streetbondsb150pavementcoatingdocuments/Data_Sheet__StreetBond_SB150_Pavement_Coating.pdf

[11] Heat island reduction, LEED BD+C: New Construction v4 - LEED v4, U.S. Green Building Council, https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-hospitali-1?view=language&return=/credits/New%20Construction/v4/Indoor%20environmental%20quality

[12] Heat island reduction, LEED O+M: Existing Buildings v4 - LEED v4, U.S. Green Building Council, https://www.usgbc.org/credits/existing-buildings-schools-%E2%80%93-existing-buildings-retail-%E2%80%93-existing-buildings-hospitality-%E2%80%93-24?view=language

[13] GAF, *Green Building Playbook for LEED 6 v4*, Updated February 2020

were tested, with a range of SRI values from 14 to 41 and an average of 26.1. Despite the benefits of concrete's high albedo and SRI values, the high-temperature process for making cement is more energy- and carbon-intensive than the production of asphalt from petroleum.[14] Therefore, further analysis of its life cycle may be required.

Adopt design standards for cool pavements

Solar reflectance of a moderate 25 percent or higher can be considered cool for pavements.[15] Of the materials tested, the raised pavers, concrete, and high SRI surface paint coated over asphalt meet this criterion. The data results may be used to support efforts to install or retrofit high SRI surfaces with "cooler" ones that better mitigate heat and decrease temperatures.

Porous asphalt promising, although more to be discovered

Although the SRI values of porous asphalt fell in the middle range, this material is considered a cool pavement type because they can cool a surface through the evaporation of moisture stored in the pavement.[16] Plus permeable pavements are beneficial in stormwater management practices. More exploration into costs, maintenance, environmental benefits, and other markers should be considered.

Brick sidewalks provide few conclusions for gaging the UHI effect

Brick sidewalks were shown to have low SRI values, ranging from 8 to 10 with four samples. These results were consistent across the areas tested but appear to be lower than initially anticipated. One company, Hanover Architectural Products, documents SRI values of brick pavers ranging from 3 to 74, categorized by coloration. Values closer to 3 are dark grays, and values closer to 74 are whites and light buff colors. Red to Brown brick's SRI values fall somewhere in the middle range, between 10-51.[17]

Further testing recommended for raised pavers

The two raised paver intersections tested show a wide range of SRI values (sites #8 and #13). The Fayerweather Street raised paver intersection was 69, the highest value of all materials tested, while the one on Western Avenue was 1, the lowest value of all materials tested. Given this extreme range and small sample size, another evaluation could be

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[14] Chao, Julie, "Not All Cool Pavements Are Created Equal," Berkeley Lab News, May 18, 2017, https://newscenter.lbl.gov/2017/05/18/not-all-cool-pavements-are-created-equal/

[15] Gartland, Lisa. *Heat Islands: Understanding and Mitigating Heat in Urban Areas*. London, UK: Earthscan, 2008.

[16] Global Cool Cities Alliance (GCCA), *A Practical Guide to Cool Roofs and Cool Pavements*

[17] "Reflectance, Emittance & SRI Values," Hanover Architectural Products, November 2021. https://www.hanoverpavers.com/images/PDFs/6203-refl_values.pdf

conducted to gain a more accurate understanding of the material's properties. Especially since raised pavers (or, interlocking concrete pavers), particularly those with lightest coloration, can have cool pavement type properties.[18] The City of Cambridge uses Optiloc pavers which have a SRI value of 32.[19,20]

Potential environmental variables may have impacted the accuracy of readings
Several variables may have potentially affected this experiment including air temperature, weather conditions, and their impact on the testing device. The average air temperature for both testing days was approximately 38°F. Although not indicated in the manufacturer's guide, the testing equipment had a slower responsiveness the longer it was exposed to the air temperature. To mitigate this potential disruptor, the project team restarted the device when it began showing signs of a lagged response to ensure it was fully operational and provided accurate readings. The rainy weather conditions on the morning of the first testing day (December 28, 2021) may have affected the surface readings despite the project team's selection of areas that appeared completely dry.

More investigation of thermal emittance properties may be warranted
The lower SRI values for raised pavers (and brick) may be due to their significantly lower thermal emittance value readings. A better understanding of these discrepancies and the availability and properties of different types of pavers is needed.

Furthermore, the Springfield Street parking lot's (site #25- Asphalt Parking Lot w/high SRI surface paint) thermal emittance was lower than all other asphalt areas tested. It was assumed that high-SRI paint would only impact solar reflectance, but results indicate it may also impact emittance. More investigation may be warranted to understand the impact of high-SRI paint on both reflectance and emittance.

Thermal emittance reading constant may have inflated SRI values
Based on the testing results, the thermal emittance reading constant from FHWA (0.930) turned out not to be a conservative number which may have inflated the calculated SRI values. The constant (0.930) was higher than all test sites' average thermal emittance readings. However, both materials tested at Site #2 (Concord Ave near Huron Ave- concrete sidewalk and asphalt parking lane) were quite close at 0.928 and 0.921 respectively.

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[18] Gartland, *Heat Islands: Understanding and Mitigating Heat in Urban Areas*
[19] Optiloc, Unilock, https://commercial.unilock.com/products/a-z-products/all/optiloc/?region=5
[20] Optiloc Cut Sheet, Unilock, https://contractor.unilock.com/wp-content/uploads/2021/08/2021-Optiloc-Cut-Sheet_Unilock.pdf

APPENDIX A

Pavement Standards – Solar Reflectance Values[21]

Traditional Concrete (gray or light gray)

- New: ranging between 35-40 percent. Note: SR can be as high as 50 percent.[22]
- Aged: 25-35 percent as the concrete ages and picks up dirt. Note: SR can be as low as 20 percent.[23]

Traditional Concrete with lighter-colored binder materials, sands, and aggregates

- New: 40-80 percent

Interlocking concrete pavers

- New or renew: Wide range of reflectance values since they are often tinted with pigment. Choose the lightest colors for the coolest pavements.
- In a study, researchers found it to be 28 percent[24]

Porous or permeable concrete

- New: its slightly rougher surface may lower the solar reflectance by as much as 5 percent. Its ability to hold moisture keeps permeable pavements cooler than impermeable ones.
- Range of 14-26 percent. Note in two separate studies, SR is 14.1 percent [25] and 18-26 percent.[26]

Porous block pavement systems (concrete or other)

- New or renew: If the blocks are filled with aggregate, a lighter-colored option could deliver solar reflectance values of between 30-50 percent.

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21 Gartland, *Heat Islands: Understanding and Mitigating Heat in Urban Areas*
22 Global Cool Cities Alliance (GCCA), *A Practical Guide to Cool Roofs and Cool Pavements*
23 Global Cool Cities Alliance (GCCA), *A Practical Guide to Cool Roofs and Cool Pavements*
24 Li, Hui, John T. Harvey, T. J. Holland, and M. Kayhanian. "The use of reflective and permeable pavements as a potential practice for heat island mitigation and stormwater management." *Environmental Research Letters* 8, no. 1 (2013): 015023.
25 Hideki Takebayashi and Masakazu Moriyama, "Study on Surface Heat Budget of Various Pavements for Urban Heat Island Mitigation", *Advances in Materials Science and Engineering*, vol. 2012, Article ID 523051, 11 pages, 2012. https://doi.org/10.1155/2012/523051
26 Li, Hui, John T. Harvey, T. J. Holland, and M. Kayhanian. "The use of reflective and permeable pavements as a potential practice for heat island mitigation and stormwater management."

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Asphalt (black or dark gray)

- New: 5-10 percent
- Aged: 10-20 percent

Porous Asphalt

- Range of 7.4 to 8 percent[27,28]

Coatings[29]

- New: 35–55 percent

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[27] Hideki Takebayashi and Masakazu Moriyama, "Study on Surface Heat Budget of Various Pavements for Urban Heat Island Mitigation"

[28] Li, Hui, John T. Harvey, T. J. Holland, and M. Kayhanian. "The use of reflective and permeable pavements as a potential practice for heat island mitigation and stormwater management."

[29] Global Cool Cities Alliance (GCCA), *A Practical Guide to Cool Roofs and Cool Pavements*

Table 2 Typical SRI Values from LEED Green Building Rating System[30, 31]

Material	Emissivity	Reflectance	SRI
Typical New Grey Concrete	0.9	0.35	35
Typical Weathered Grey Concrete	0.9	0.20	19
Typical New White Concrete	0.9	0.70	86
Typical Weathered White Concrete	0.9	0.40	45
New Asphalt	0.9	0.05	0
Weathered Asphalt	0.9	0.10	6

Table 3 SRI Values of Different Asphalt Surfaces[32]

Pavement Surface	SRI
Light Coloured Asphalt	12 to 18
Weathered Asphalt	6

[30] Uzarowski, Ludomir, Rabiah Rizvi, and Steve Manolis, "Reducing Urban Heat Island Effect by Using Light Coloured Asphalt Pavement." Paper presented at the Transportation Association of Canada Conference, Saskatoon, SK, 2018.

[31] Medgar L. Marceau and Martha G. VanGeem, "Solar Reflectance Values for Concrete," *Concrete International*, Vol. 30 No. 8, August 2008

[32] Uzarowski, Ludomir, Rabiah Rizvi, and Steve Manolis, "Reducing Urban Heat Island Effect by Using Light Coloured Asphalt Pavement"

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Figure 3 Map of Testing Sites in Cambridge

Cambridge Solar Reflective Index Testing Sites

Table 4 Sites and Addresses of Testing Locations

	Site Location	Material & Number of Points to Test	Site Address
West Cambridge	1: New Street (Danehy Park)	Concrete Sidewalk Asphalt Parking Lane	77 New St Cambridge, MA 02138
	2: Concord Avenue near Huron Avenue (business area)	Concrete Sidewalk Asphalt Parking Lane	208 Concord Ave Cambridge, MA 02138
	3: Fayerweather Street near Huron Avenue	Brick Sidewalk Porous Asphalt Concrete Sidewalk	75 Fayerweather St, Cambridge, MA 02138
	4: Fayerweather Street at Reservoir Street	Raised Paver Intersection	37 Fayerweather St Cambridge, MA 02138
Cambridgeport / Port	5: Western Avenue at Pleasant Street	Porous Asphalt Bike Lane Asphalt Bike Lane Ramp Concrete Sidewalk Brick Sidewalk Raised Paver Intersection	90 Western Ave Cambridge, MA 02139
	6: Parking Lot 8 (Pleasant Street at Green Street)	Asphalt (Aged) Parking Lot Asphalt Parking Lane	375 Green St Cambridge, MA 02139
	7: Lopez Street (between Pearl Street and Brookline Street)	Concrete (New) Sidewalk Asphalt Parking Lane	42 Lopez St Cambridge, MA 02139
	8: Cottage Street (between River Street and Magazine Street)	Brick (New) Sidewalk Concrete Sidewalk	46 Cottage St Cambridge, MA 02139
	9: 425 Massachusetts Avenue	Asphalt Parking Lot Asphalt Parking Lot Concrete Sidewalk Concrete Sidewalk Brick Sidewalk	425 Massachusetts Ave Cambridge, MA 02139
Mid-Cambridge	10: Springfield Street Parking Lot (high-SRI surface paint)	Asphalt Parking Lot w/high SRI surface paint Concrete Sidewalk	15 Springfield St Cambridge, MA 02139
		26 total points to test	

Table 5. Summarized Results of SRI Calculations

Test Date	Site Name	Material Type	Total Solar Reflectance (TSR) Reading Average	Thermal (Infrared) Emittance € Reading Average	Thermal (Infrared) Emittance € Reading Constant	Solar Reflective Index (SRI) Based on Average	Solar Reflective Index (SRI) Based on € Reading Constant	Wind	Weather	Ambient Air Temp (F)
12/29/2021	Parking Lot 8 (Pleasant St at Green St)	Asphalt (Aged) Parking Lot	0.088	0.900	0.930	5	6	0-5'	Cloudy	35
12/28/2021	Western Ave at Pleasant St	Asphalt Bike Lane Ramp	0.116	0.912	0.930	9	10	0-5'	M/Clear	38
12/28/2021	New St (Danehy Park)	Asphalt Parking Lane	0.067	0.895	0.930	2	4	0-5'	M/Cloudy	36
12/28/2021	Concord Ave near Huron Ave (business area.)	Asphalt Parking Lane	0.056	0.921	0.930	2	2	0-5'	M/Cloudy	38
12/29/2021	Parking Lot 8 (Pleasant St at Green St)	Asphalt Parking Lane	0.111	0.864	0.930	6	9	0-5'	Cloudy	35
12/29/2021	Lopez St (between Pearl St and Brookline St)	Asphalt Parking Lane	0.085	0.900	0.930	4	6	0-5'	P/Cloudy	39
12/29/2021	425 Massachusetts Ave	Asphalt Parking Lot	0.059	0.900	0.930	1	3	0-5'	P/Cloudy	39
12/29/2021	425 Massachusetts Ave	Asphalt Parking Lot	0.120	0.900	0.930	9	10	0-5'	P/Cloudy	39
12/29/2021	Springfield Street Parking Lot (high-SRI surface paint)	Asphalt Parking Lot w/high SRI surface paint	0.255	0.828	0.930	23	27	0-5'	P/Cloudy	37
12/29/2021	Cottage St (between River St and Magazine St)	Brick (New) Sidewalk	0.141	0.854	0.930	9	13	0-5'	P/Cloudy	39
12/28/2021	Fayerweather St near Huron Ave	Brick Sidewalk	0.163	0.826	0.930	10	16	0-5'	M/Cloudy	38

12/28/2021	Western Ave at Pleasant St	Brick Sidewalk	0.163	0.826	0.930	10	16	0-5'	M/Clear	38
12/29/2021	425 Massachusetts Ave	Brick Sidewalk	0.115	0.890	0.930	8	10	0-5'	P/Cloudy	39
12/29/2021	Lopez St (between Pearl St and Brookline St)	Concrete (New) Sidewalk	0.293	0.741	0.930	24	32	0-5'	P/Cloudy	35
12/28/2021	New St (Danehy Park)	Concrete Sidewalk	0.384	0.846	0.930	41	44	0-5'	Cloudy	36
12/28/2021	Concord Ave near Huron Ave (business area)	Concrete Sidewalk	0.270	0.928	0.930	29	29	0-5'	M/Cloudy	38
12/28/2021	Fayerweather St near Huron Ave	Concrete Sidewalk	0.218	0.903	0.930	21	23	0-5'	M/Clear	38
12/28/2021	Western Ave at Pleasant St	Concrete Sidewalk	0.224	0.744	0.930	14	23	0-5'	M/Clear	38
12/29/2021	Cottage St (between River St and Magazine St)	Concrete Sidewalk	0.356	0.686	0.930	30	40	0-5'	P/Cloudy	39
12/29/2021	425 Massachusetts Ave	Concrete Sidewalk	0.311	0.799	0.930	29	35	0-5'	P/Cloudy	39
12/29/2021	425 Massachusetts Ave	Concrete Sidewalk	0.234	0.910	0.930	24	25	0-5'	P/Cloudy	39
12/29/2021	Springfield Street Parking Lot (high-SRI surface paint)	Concrete Sidewalk	0.238	0.885	0.930	23	25	0-5'	P/Cloudy	37
12/28/2021	Fayerweather St near Huron Ave	Porous Asphalt	0.209	0.865	0.930	18	22	0-5'	M/Cloudy	38
12/28/2021	Western Ave at Pleasant St	Porous Asphalt Bike Lane	0.122	0.912	0.930	10	11	0-5'	M/Clear	38
12/28/2021	Fayerweather St at Reservoir St	Raised Paver Intersection	0.606	0.752	0.930	69	74	0-5'	M/Clear	38
12/28/2021	Western Ave at Pleasant St	Raised Paver Intersection	0.124	0.752	0.930	1	11	0-5'	M/Clear	38

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Table 6 Full Results of SRI Calculations

Test Date	Site Name	Material Type	Total Solar Reflectance (TSR) Reading 1	Total Solar Reflectance (TSR) Reading 2	Total Solar Reflectance (TSR) Reading 3	Total Solar Reflectance (TSR) Reading Average	Thermal (Infrared) Emittance € Reading 1	Thermal (Infrared) Emittance € Reading 2	Thermal (Infrared) Emittance € Reading 3	Thermal (Infrared) Emittance € Reading Average	Thermal (Infrared) Emittance € Reading Constant	Solar Reflective Index (SRI) Based on Average	Solar Reflective Index (SRI) Based on € Reading Constant	Wind	Weather	Ambient Air Temp (F)
12/29/2021	Parking Lot 8 (Pleasant St at Green St)	Asphalt (Aged) Parking Lot	0.09	0.08	0.094	0.088	0.9	0.9	0.9	0.900	0.930	5	6	0-5'	Cloudy	35
12/28/2021	Western Ave at Pleasant St	Asphalt Bike Lane Ramp	0.145	0.089	0.113	0.116	0.912	0.912	0.912	0.912	0.930	9	10	0-5'	M/Clear	38
12/28/2021	New St (Danehy Park)	Asphalt Parking Lane	0.058	0.075		0.067	0.885	0.905		0.895	0.930	2	4	0-5'	M/Cloudy	36
12/28/2021	Concord Ave near Huron Ave (business area.)	Asphalt Parking Lane	0.057	0.065	0.046	0.056	0.942	0.924	0.897	0.921	0.930	2	2	0-5'	M/Cloudy	38
12/29/2021	Parking Lot 8 (Pleasant St at Green St)	Asphalt Parking Lane	0.138	0.11	0.084	0.111	0.815	0.946	0.83	0.864	0.930	6	9	0-5'	Cloudy	35
12/29/2021	Lopez St (between Pearl St and Brookline St)	Asphalt Parking Lane	0.093	0.089	0.073	0.085	0.9	0.9	0.9	0.900	0.930	4	6	0-5'	P/Cloudy	39
12/29/2021	425 Massachusetts Ave	Asphalt Parking Lot	0.069	0.049	0.06	0.059	0.9	0.9	0.9	0.900	0.930	1	3	0-5'	P/Cloudy	39
12/29/2021	425 Massachusetts Ave	Asphalt Parking Lot	0.136	0.113	0.111	0.120	0.9	0.9	0.9	0.900	0.930	9	10	0-5'	P/Cloudy	39

12/29/2021	Springfield Street Parking Lot (high-SRI surface paint)	Asphalt Parking Lot w/high SRI surface paint	0.329	0.188	0.247	0.255	0.813	0.888	0.783	0.828	0.930	23	27	0-5'	P/Cloudy	37
12/29/2021	Cottage St (between River St and Magazine St)	Brick (New) Sidewalk	0.191	0.159	0.074	0.141	0.861	0.821	0.88	0.854	0.930	9	13	0-5'	P/Cloudy	39
12/28/2021	Fayerweather St near Huron Ave	Brick Sidewalk	0.111	0.222	0.156	0.163	0.823	0.919	0.737	0.826	0.930	10	16	0-5'	M/Cloudy	38
12/28/2021	Western Ave at Pleasant St	Brick Sidewalk	0.222	0.153	0.113	0.163	0.826	0.826	0.826	0.826	0.930	10	16	0-5'	M/Clear	38
12/29/2021	425 Massachusetts Ave	Brick Sidewalk	0.158	0.101	0.085	0.115	0.878	0.887	0.905	0.890	0.930	8	10	0-5'	P/Cloudy	39
12/29/2021	Lopez St (between Pearl St and Brookline St)	Concrete (New) Sidewalk	0.272	0.304	0.303	0.293	0.708	0.772	0.742	0.741	0.930	24	32	0-5'	P/Cloudy	35
12/28/2021	New St (Danehy Park)	Concrete Sidewalk	0.367	0.392	0.393	0.384	0.815	0.821	0.903	0.846	0.930	41	44	0-5'	Cloudy	36
12/28/2021	Concord Ave near Huron Ave (business area)	Concrete Sidewalk	0.236	0.29	0.283	0.270	0.917	0.93	0.936	0.928	0.930	29	29	0-5'	M/Cloudy	38
12/28/2021	Fayerweather St near Huron Ave	Concrete Sidewalk	0.259	0.215	0.179	0.218	0.975	0.865	0.869	0.903	0.930	21	23	0-5'	M/Clear	38
12/28/2021	Western Ave at Pleasant St	Concrete Sidewalk	0.287	0.243	0.141	0.224	0.737	0.757	0.739	0.744	0.930	14	23	0-5'	M/Clear	38
12/29/2021	Cottage St (between River St and Magazine St)	Concrete Sidewalk	0.339	0.351	0.379	0.356	0.708	0.59	0.76	0.686	0.930	30	40	0-5'	P/Cloudy	39

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12/29/2021	425 Massachusetts Ave	Concrete Sidewalk	0.281	0.333	0.318	0.311	0.913	0.677	0.808	0.799	0.930	29	35	0-5'	P/Cloudy	39
12/29/2021	425 Massachusetts Ave	Concrete Sidewalk	0.24	0.211	0.252	0.234	0.915	0.905	0.911	0.910	0.930	24	25	0-5'	P/Cloudy	39
12/29/2021	Springfield Street Parking Lot (high-SRI surface paint)	Concrete Sidewalk	0.237	0.239	0.239	0.238	0.856	0.851	0.949	0.885	0.930	23	25	0-5'	P/Cloudy	37
12/28/2021	Fayerweather St near Huron Ave	Porous Asphalt	0.054	0.053	0.52	0.209	0.834	0.88	0.88	0.865	0.930	18	22	0-5'	M/Cloudy	38
12/28/2021	Western Ave at Pleasant St	Porous Asphalt Bike Lane	0.123	0.086	0.156	0.122	0.912	0.912	0.912	0.912	0.930	10	11	0-5'	M/Clear	38
12/28/2021	Fayerweather St at Reservoir St	Raised Paver Intersection	0.097	0.76	0.96	0.606	0.862	0.742	0.653	0.752	0.930	69	74	0-5'	M/Clear	38
12/28/2021	Western Ave at Pleasant St	Raised Paver Intersection	0.152	0.12	0.099	0.124	0.862	0.742	0.653	0.752	0.930	1	11	0-5'	M/Clear	38