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LANDSCAPE ARCHITECTURE MAGAZINE

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TAME THE SUN

HOW TO SPECIFY COMPLEX PAVING PATTERNS TO DEFLECT URBAN HEAT FROM SOLAR EXPOSURE.

BY TRENT OKUMURA, ASLA, AND MICHAEL TODORAN

ABOVE
This complex paving design by SWA Group has light-colored pavers that reflect sufficient amounts of solar heat under L.A. city code and dark-colored ones that don't.

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Designers are challenged by climate change as they attempt to mitigate urban heat, but among the biggest factors are the thermal properties of the very building materials they use in new developments, not least their paving surfaces. The material and color of paving make a critical difference in either contributing to or neutralizing heat gain brought by the sun (as do roofs, which typically involve simpler, monolithic material choices). Darker paving creates a hotter microclimate but lower glare, and lighter paving creates a cooler microclimate and higher glare. The sweet spot in specifying paving lies in brokering a balance between thermal and visual comfort.

The crucial metric is the solar reflectance index, or SRI, which tells the ability of a paving material to reject solar heat. The index, following ASTM standards, assigns a standard black surface a value of zero and a standard white surface a value of 100. The SITES rating system Credit 4.9 requires designers to use paving materials with a solar reflectance (SR) value of 0.33 at installation or a "three-year aged SR value" of 0.28. It also requires maintenance provisions to ensure the surfaces are cleaned every two years to keep their reflectivity. The LEED rating system has similar incentives, as does the California Green Building Standards Code (CALGreen), though its stipulations vary by jurisdiction.

Our office, SWA Group in Los Angeles, recently completed a CALGreen plan-check submission to the City of Los Angeles for a mixed-use project downtown. The city requires that we make sure 25 percent of any sun-exposed paving material meets or exceeds an SRI value greater than 0.29. The total area of exposed paving under consideration is 131,000 square feet; the area needed to qualify for the SRI requirement is about 33,000 square feet.

To design to such a requirement, you must identify the total square footage of paving surface that can be considered subject to SRI review (generally, any exposed surface not under architectural cover). Next, calculate the total paving square footage with a value of 0.29 or greater. Divide that number by total paving square footage for the percentage of the paving that meets or exceeds a value of 0.29.

We began identifying the contributing spaces through the use of diagrams. Hatches on the diagrams identified areas that consisted of

FIGURE 1: HEMISPHERICAL SPECTRAL REFLECTANCE AND TOTAL EMITTANCE TEST REPORT

REFLECTANCE AND SRI

Specimen Code	% Solar Reflectance	SRI
15-154	26.2	27
15-155	30.0	32
15-159	43.1	50
15-160 A	66.9	82
15-160 B	42.9	49

EMITTANCE

Specimen Code	Reflectance (ρ) Measured	Near-Normal Emittance (ε) Calculated
15-154	.09	.91
15-155	.09	.91
15-159	.09	.91
15-160 A	.09	.91
15-160 B	.09	.91

FIGURE 2: TESTING AND EVALUATION RESULTS

RESULTS AND OBSERVATIONS

The average consists of the first three samples of each batch. The results are listed below:

Solar Reflectance

Sample	Solar Reflectance: Average-Batch 1	Solar Reflectance: Average-Batch 2	Solar Reflectance: Average-Batch A & B	Solar Reflectance: Standard Deviation-Batch A & B
Mesabi Black	0.136	0.159	0.15	0.02
Mountain Green	0.174	0.206	0.19	0.02
Carnelian	0.209	0.255	0.23	0.03
Rockville White	0.348	0.405	0.38	0.04
Sierra White	0.477	0.455	0.47	0.02
Academy Black	0.212	0.184	0.20	0.02
Sunset Red	0.386	0.35	0.37	0.03

Emittance

Sample	Emittance: Average-Batch A	Emittance: Average-Batch B	Emittance: Average-Batch A & B	Emittance: Standard Deviation-Batch A & B	SRI (Solar Reflectance Index)
Mesabi Black	0.93	0.91	0.92	0.01	14
Mountain Green	0.96	0.96	0.96	0.00	21
Carnelian	0.93	0.98	0.96	0.04	26
Rockville White	1.01	0.96	0.99	0.04	46
Sierra White	0.93	0.94	0.94	0.01	56
Academy Black	0.93	0.89	0.91	0.03	19
Sunset Red	1.03	0.96	1.00	0.05	45

ABOVE AND BELOW
Materials testing lab report excerpts provide SRI values (Figures 1 and 2); takeoff legend (Figure 3) adds up net square footage needed to meet 25 percent goal. Spreadsheet legend (Figure 4) guided paving composition to meet SRI goal of 0.29 across 25 percent of exposed paving.

exposed paving. Minimum paving square footage required to meet the percentage was then derived from the quantification process. The diagrams included square footage of the qualifying paving material being used and its associated SR value, and were then used to demonstrate how we achieved our 25 percent throughout multiple levels of outdoor space.

The search for documented SR values for various paving materials can be tedious, so it's important to consider lead times for obtaining results. Because paving products are not all similar in content—with, for example, different aggregate colors, concrete pigments, or finishes—paving types will require individual testing. The initial approach is to contact the product supplier to ask what testing or documentation is available. On the whole, there is very little supporting documentation for SR value, but the supplier may have lab results on file or be willing to test the product and issue the results.

The paving schedule for our downtown project consisted largely of varying cool and warm grays. These could not be said to have passing SR values

FIGURE 3

LEVEL	TOTAL PAVING SF
GL	55,280
L3	12,852
L5	6,563
L8	53,287
L18	2,945
TOTAL	130,927
25% OF TOTAL	32,732

FIGURE 4

	KEY	SRI	GL	L3	L5	L8	L18	TOTAL	Material	Color	Finish	LEVEL	TYPICAL LOCATION
P1	P-1A	56	3882					3882	Granite	Sierra White	Diamond 10 Finish	GL	Hotel Entry Paving
	P-1B	<30						0	Granite	Raven Black	Diamond 10 Finish	GL	Hotel Entry Paving
P2	P-2A	49	17363					17363	Lithocrete SS15-160-A	Warm Light Gray	Topcast	GL, L3	Event Space
	P-2B	>30						0	Lithocrete SS15-154	Medium Gray	Topcast	GL, L3	Event Space
	P-2C	<30						0	Lithocrete SS15-153	Dark Gray	Topcast	GL, L3	Event Space
	P-2D	32							Lithocrete SS15-155	Aggregate Gray			
	P-2E	>30							Lithocrete SS15-168	White			
P3	P-3A	56	3150					3150	Granite	Sierra White	Diamond 10 Finish	GL	North Paseo Type
	P-3B	<30						0	Granite	Charcoal Black	Diamond 10 Finish	GL	North Paseo Type
	P-3C	<30						0	Granite	Raven Black	Diamond 10 Finish	GL	North Paseo Type
	P-3D	TBD						0	Granite	Red	Flame Finished	GL	North Paseo Type
P4	P-4A	56						0	Granite	Sierra White	Diamond 10 Finish	GL	
	P-4B	<30						0	Granite	Black Granite	Diamond 10 Finish	GL	
	P-4C	<30						0	Granite	Raven Black	Diamond 10 Finish	GL	
P5	P-5A	<30						0	Raven Black Granite	Raven Black	Diamond 10 Finish	GL	
P6	P-6A	TBD						0	Glass	Translucent with Red Tint	NA	GL	
	P-6B	<30						0	Granite	Raven Black	Diamond 10 Finish	GL	
P7	P-7A	56	2751					2751	Granite	Sierra White	Diamond 10 Finish	GL	South Paseo Paving
	P-7B	TBD						0	Granite	Charcoal Gray	Diamond 10 Finish	GL	South Paseo Paving
P8	P-8A	TBD						0	Gray Crushed Gravel	Pewter	NA	GL	Gravel Paving Under Escalator

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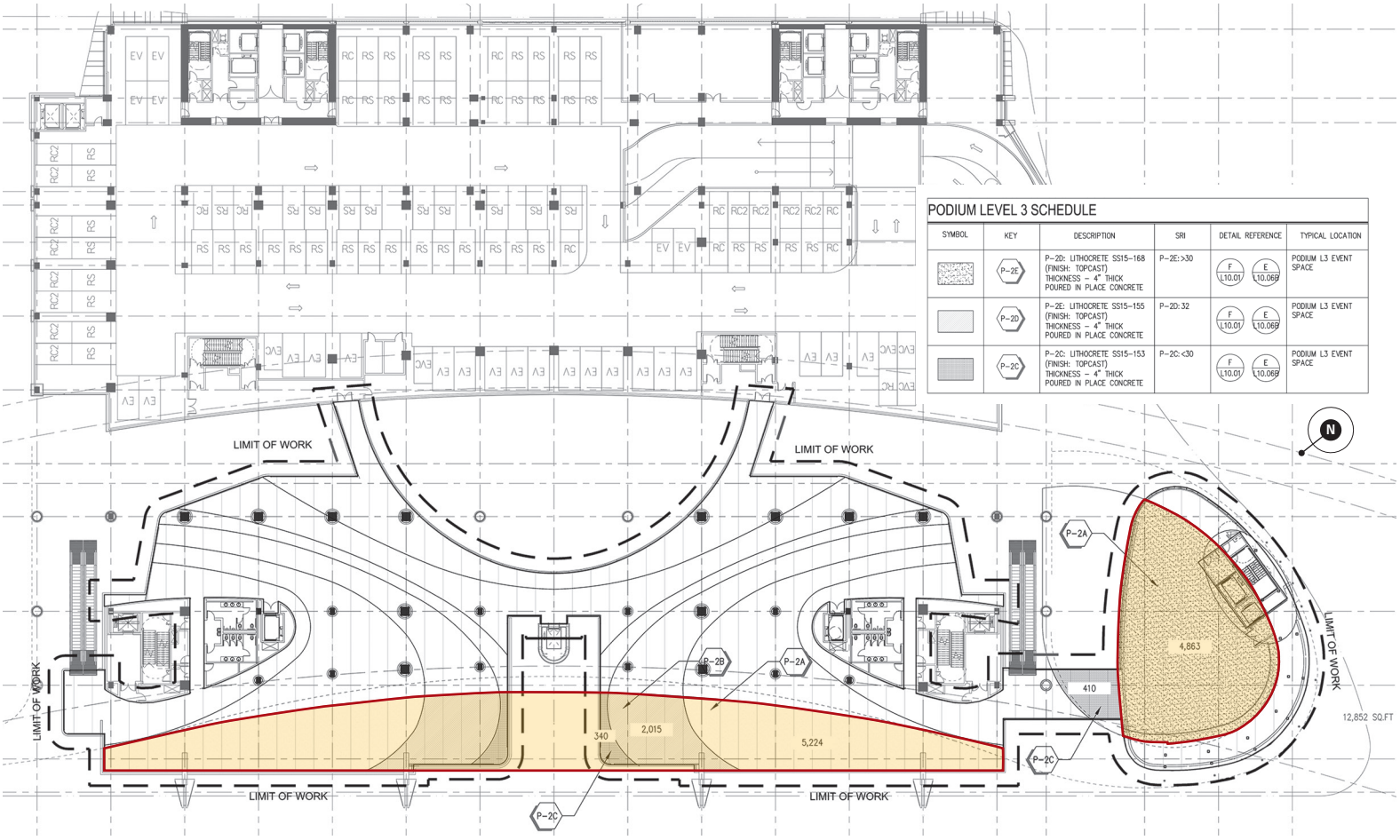
PODIUM L3 SRI & PAVING QUANTIFICATION PLAN



ABOVE
Colored areas indicate sun-exposed areas at the Level 3 podium.

by a simple visual test. This ambiguity was amplified with materials that had different combinations of integral colors and a variety of aggregates. The next task was to determine which paving material within the identified exposed space could potentially meet or exceed the SR value of 0.29. We developed a spreadsheet with all paving types inside the hatched areas. The spreadsheet includes the SR values, square foot quantity, material type, color, finish, applicable level, location within the level, and manufacturer. The spreadsheet helped us visualize the multiple levels as a whole and enabled us to understand the quantities and percentages we were working with.

Without having any test results in hand, we made general assumptions that the medium to dark color paving material would not meet the requirements. We focused our attention on the material most likely to meet SRI requirements. The CALGreen plan-check process requires SRI test result documentation for each material contributing to the 25 percent. Consider having multiple paving types to meet your goal, in case test results are not available, can't be obtained in a timely fashion, or come back with negative results.

Because time was tight for completing our submission, we called each manufacturer to ask which materials on the paving legend they had existing SR values for. We entered the passing values into our master spreadsheet. By talking with the product representatives, we learned that some materials (such as Raven Black granite) would obviously fall below a value of 0.29, so it was of little use to ask and pay for an SRI report for those items. Materials of an obviously passing value (such as Sierra White granite) allowed us to enter into the spreadsheet a passing value greater than or equal to 0.29. But because the manufacturer did not have an existing SRI report and we are unable to prove its value, we assigned those spreadsheet cells' background a pending color of yellow. The materials that were passing with documentation we assigned a color value of green, and of those failing, a value of red.

In general, we have found it easier to locate SRI test results for integral colored concrete pigments than for

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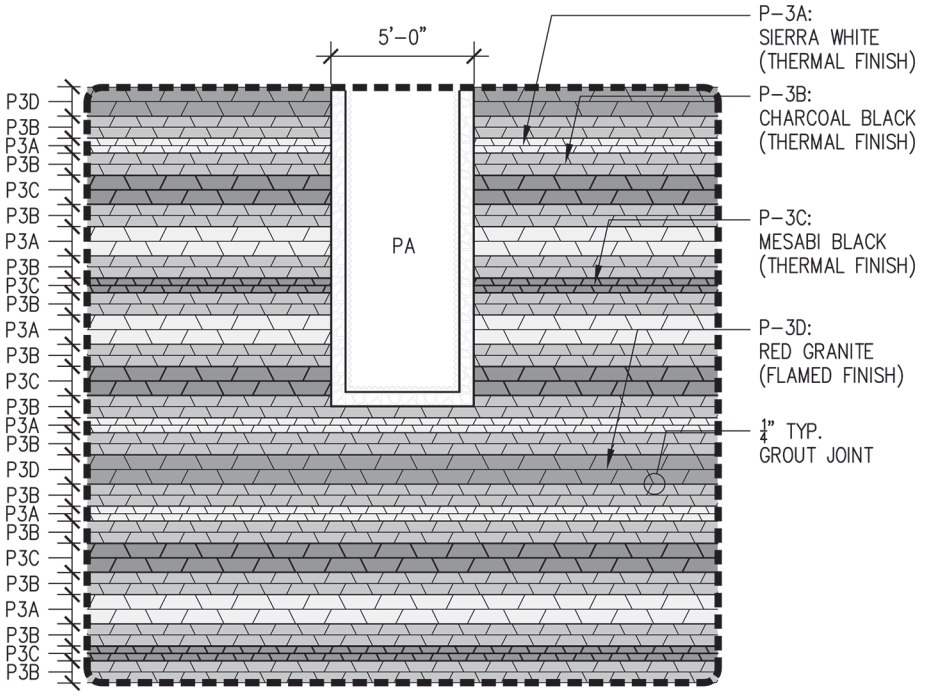
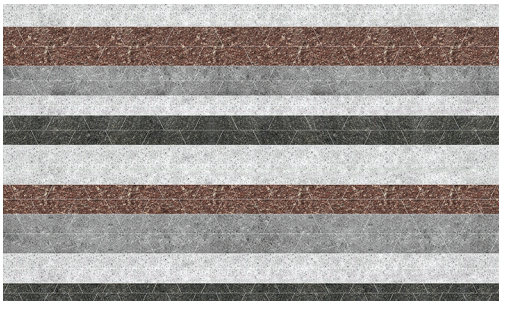
NORTH PASEO PAVING ENLARGEMENT





natural or custom paving materials containing various aggregates. Davis Colors provides an online color chart that provides SRI values for its pigments as well as those of some precast concrete manufacturers.

Having multiple types of Lithocrete blend within the project, we requested a list of potential mixes to be tested. Shaw & Sons Concrete Contractors, in Costa Mesa, California, provided test results, which helped narrow down our approved material list. Because we were unable to obtain some test results owing to various factors, our selection of qualifying material was reduced. This led us to look into isolating paving materials within a multicolor pattern.

In the South Paseo portion of our project, our paving pattern did have varying band sizes and two different materials. However, the materials repeated equally within each band, and the pass or fail values of the contrasting materials were obvious. We calculated the entire square footage of this area and then divided it by two to obtain the passing value.

In the North Paseo portion of our project, our paving pattern also had varying band sizes, but the pattern consisted of four materials. To identify what percentage was passing, we needed to determine when the pattern repeated itself, what percent of each material was within that pattern, and what the SR value of each material was within that pattern. We then determined the entire area of the North Paseo paving pattern but demonstrated only the percentage of the passing Sierra White.

Because only a percentage of the material can be accounted for, we had to determine how much of the isolated paver contributes to its pattern and subtract that amount from the total. The resulting amount was small, but when spread across a large space, it resulted in an amount that contributed to our 25 percent goal.

In the submission were drawings, the spreadsheet showing computation of the 25 percent, and the certified SRI reports. Also included was the diagram with hatches for all of the work within our scope, with the areas that passed highlighted. In the end, we were able to meet the requirements and provide supporting information.

We calculate that the process took three full days to complete. Coordination is complex and requires a lot of calling suppliers. Suppliers are generally amenable to our research requests because they, of course, hope to make the sale. And the final project, particularly one of the scope we worked on, will not only meet the requirement but bring about the benefit of its intent to thwart the buildup of solar heat in the city. ●

TRENT OKUMURA, ASLA, IS AN ASSOCIATE AND FIELD SPECIALIST AT SWA GROUP IN LOS ANGELES. MICHAEL TODORAN IS A LANDSCAPE DESIGNER AT SWA GROUP, LOS ANGELES, AND HOSTS *THE LANDSCAPE ARCHITECTURE PODCAST.*

TOP LEFT
Discrete areas, such as this enlarged section of the North Paseo with a planter, are calculated individually and factored into the total area needed to meet the goal of 25 percent paving with a 0.29 SR value or above.

TOP RIGHT
An illustrative paving plan from the North Paseo.

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