Case study: Evaluation of cool pavement surface treatments in the City of San Antonio, Texas

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ABSTRACT: Extreme heat is one of the most pressing climate hazards that urban areas face. Elevated temperatures threaten public health, the environment, and urban infrastructure. One mitigation strategy that has gained increasing popularity across cities is the usage of cool pavement. The City of San Antonio, Texas, as part of its broader climate action and adaptation plan, conducted a cool pavement pilot program in 2023. The pilot program evaluated the effectiveness of four cool pavement treatments across San Antonio districts during the summer of 2023. For each product, Skid resistance, friction, bonding strength, and meteorological measurements were collected across the cool pavement sites and representative control sites. The findings indicated that the performance of the cool pavement applications varied across the products tested. In terms of Texture and friction properties, the GuardTop experienced the most reduction while GAF experience the most reduction over the control. In terms of metrological data, the SealMaster displayed the most consistent and statistically significant reductions in surface temperatures with an average reduction of 4°F during the afternoon testing period..

1. INTRODUCTION

The city of San Antonio (COSA) installed cool pavement treatment application on each of its ten districts from April to July of 2023. The map presented in Figure 1 (Dessouky et al. 2024) shows the approximate locations of the treated sections in each District. The selection of cool pavement sites was based on an analytical approach utilizing a series of data sets consisting of; urban heat index, equity score, energy burden, urban tree canopy, pavement condition, and population. The COSA used heat and equity data to identify candidate census tracts with high scores of temperatures, and poverty. COSA selected roads that were in adequate pavement condition and had minimal tree canopy. Finally, each District decided on two locations from the candidate list as shown in Figure 1.

2. COOL PAVEMENT PRODUCTS

Four cool pavement products were evaluated:

Product A *(Seal Master)* is a polymer emulsion coating manufactured with UV resistant, reflective light-colored mineral pigments to provide minimum solar reflectance of 0.33. It is blended with ant-slip aggregate to increase surface texture.

Product B *(GAF)* is a two-component waterborne epoxy-modified acrylic coating blended with silica aggregates. The coating is formulated using ultraviolet reflective technology to provide an initial solar reflectance of 0.33.

Product C *(GuardTop)* is a water-based asphalt emulsion sealcoat. It has fine aggregate and asphalt content of at least 32% and 10% by weight, respectively. It has a Solar Reflectance of 0.33 and a final cured grey color.

Product D *(Pave Tech)* is a TiO_2-based asphalt rejuvenating/sealing agent. It is composed of a petroleum resin oil base uniformly emulsified with water. With its Photo Catalytic Technology, it enables removal of volatile organic compounds, and exhaust pollutants. Aside from the other three products, Product D penetrates into the pavement surface and does not change the surface color and characteristics. All products are applied in one coat with varied application rate depending on existing pavement conditions, age, traffic volume, and expected outcome from the treatment.

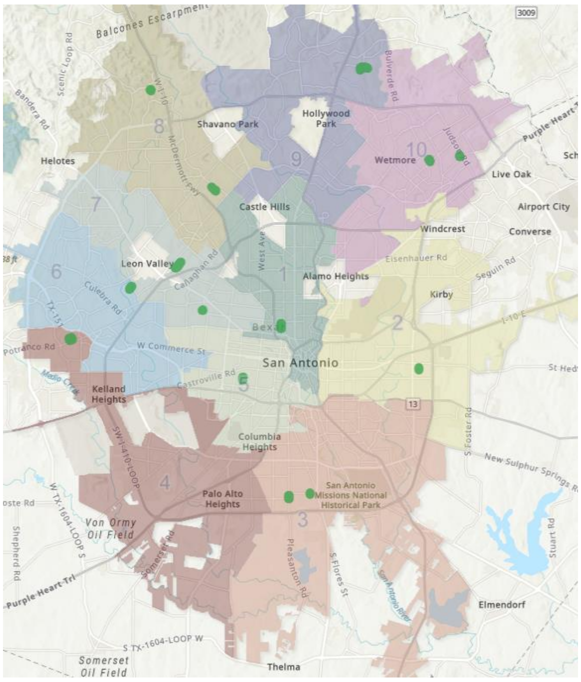

Figure 1. Cool pavement project locations by District.

3. FIELD TESTING

Four field tests were conducted to evaluate pavement texture, friction, bonding strength, and metrological properties. Pavement surface texture was measured with the Nippo Sangyo CT Meter. a laser-based device that reports texture as mean profile depth (MPD) in accordance with ASTM E 1845. Friction was measured with the Nippo Sangyo DF Tester that uses three rubber sliders mounted to a disk that spins parallel to the surface. Friction is measured based on torque as the disk rotational velocity decreases to zero due to friction between the rubber slides and surface (ASTM E1911). The adhesive strength between the applied treatment and existing pavement was measured using the Pull-off tester to assess bond strength (ASTM D 4541). The strength is determined by the maximum tensile pull-off force of coating away from pavement using hydraulic pressure. The metrological data includes; surface temperature, air temperature, and albedo measured with Fluke and NR01 Net Radiometer.

4. MEASUREMENT PLAN

Five measurements were made in the wheelpath, and two measurements were made outside of the wheelpath to capture any potential variations in texture and friction due to traffic wear (Figure 2). Example of cool pavement product is shown in Figure 2.

Figure 2. Typical measurement locations relative to traffic direction and photo cool pavement treatment (Product C).

4.1. *Summary of Texture Measurements*

Figure 3 presents the MPD for control and treated sites at and outside wheelpath. Data suggests that the applications of cool pavement treatment reduced on average the surface texture for products A &C sites at and outside wheelpath to 10 and 20%, respectively. The drop in texture is consistent with other studies which depict the change to the application of surface emulsion layer that reduces the MPD with the treated surface. It is also noticed that the reduction in texture is more pronounced in these two treatments than in products B&D.

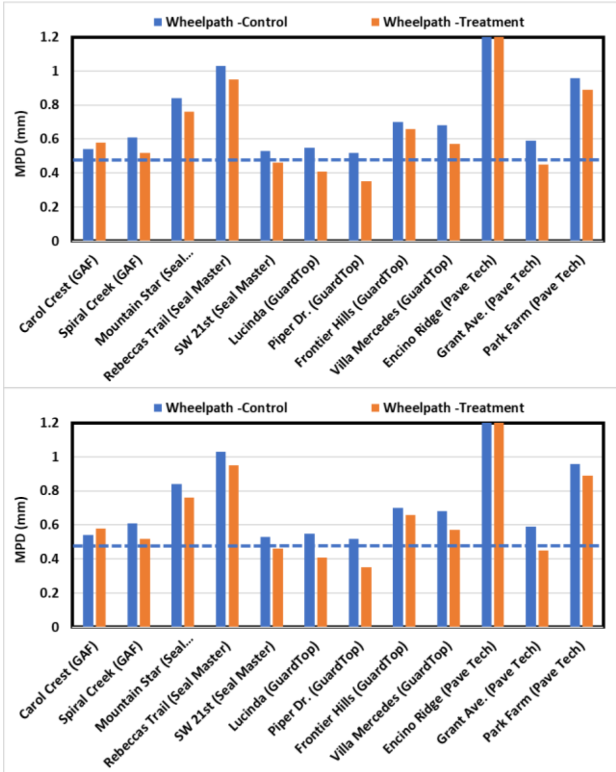

Figure 3. Texture measurements.

4.2. Summary of Friction Measurements

Figure 4 presents the Friction data (DFT_{20}) for control and treated sites at and outside wheelpath. Results suggest that products A & C have significantly reduced surface friction by 52 and 84% at wheelpath and outside wheelpath after less than 90 days of application, respectively. The friction reduction in the treated surface in the wheelpath is lesser degree than in outside wheelpath by 50 and 21% for products A & C, respectively.

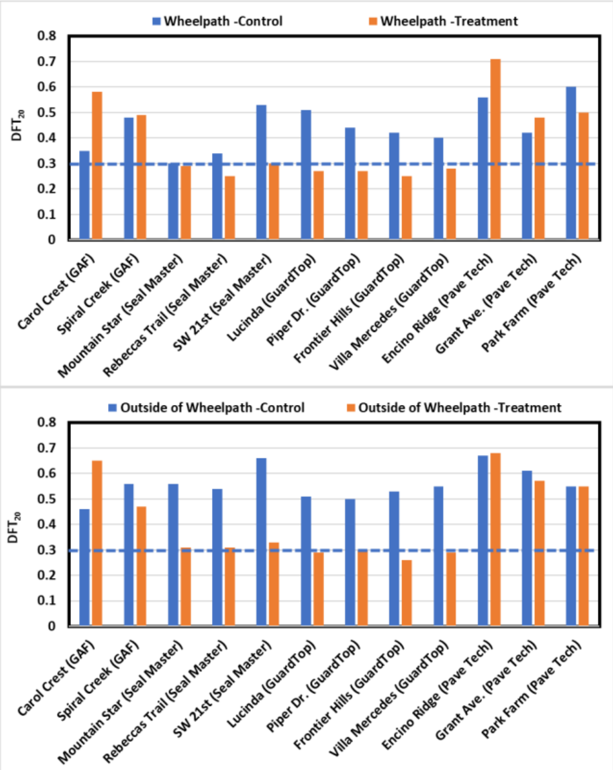

Figure 4. Friction measurements.

4.3. Bonding Strength

It is suggested that traffic will deteriorate the adhesion strength of the treated layer over time. As shown in Figure 5, all sites experienced a reduction in the adhesion. The data suggest that Product A has the least reduction in adhesion while Product C has the highest reduction over the performance period. It was not determined to calculate the adhesion strength of Product D due to the nature of the applied penetrating treatment.

Product	Reduction in adhesion due to traffic	Performance period (days)
GAF	30%	193
Seal Master	22%	173
GuardTop	36%	177
Pave Tech	zero	150

Figure 5. Traffic effect on adhesion of cool pavement.

4.4. Metrological Data

The surface temperature differences between the treated and control sites were modest in the morning and never exceeded +/- 1°F. By noon, differences in the surface temperatures were more pronounced. The largest negative difference occurred with Product D was 4°F cooler than the control site at one site but 12°F warmer than the control in another site. This is attributed to the road surface differences between treated and control site. Example of surface difference is shown in Figure 6.

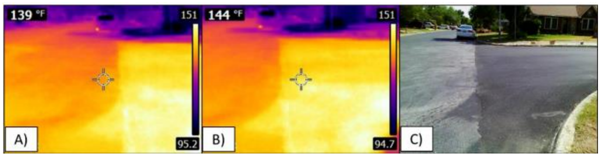

Figure 6. Temperature differences observed at cool and conventional pavement.

The albedo measurements, which evaluated the reflectivity of the surface, revealed several differences between various products (Table 1). Product A material displayed the largest increase (0.06) in albedo relative to the control. The cool pavement at Mountain Star reflected 28% of the shortwave radiation whereas the control street reflected only 22%. Product B increased the albedo by 0.02. The control sites generally exhibited high albedo values. For example, the albedo for fresh asphalt typically ranges between 0.06 and 0.08 This suggests that due to wear and tear as well as exposure to the natural elements, typical streets in San Antonio may often have albedo values that are more analogous to cool pavement surfaces than fresh asphalt.

Table 1. Albedo data for three cool pavement products (Debbage et al. 2024).

	Carol Crest (Durashield)	Grant Ave. (PlusTi)	Mountain Star (SolarPave)
Cool Pavement	0.18	0.14	0.28
Control	0.16	0.21	0.22

5. SUMMARY

Product C experienced a higher reduction (20%) in texture followed by Seal Master (10%). This represents the average reduction among the sites treated with this specific product. Product B showed a decrease in texture by 4% at wheelpath but an increase of 13% outside wheel path. In the case of Product D, an average texture increases of 5% was measured across the surface.

In terms of friction properties and with respect to control sections: Product C experienced higher reduction (66%) in friction followed by Product A (39%) in the wheel path, while Product D and B experienced increase in friction of 5 and 21%, respectively.

In terms of adhesion strength with respect to exposure to traffic (at and outside wheelpath), Product A experienced the least reduction, followed by products B and C after 5-6 months of installation. No difference in adhesion strength was noticed in the case of product D due to the lack of a coating layer.

Overall, the findings highlighted a clear potential for cool pavement to reduce surface temperatures. This was particularly true for product A, which displayed consistent reductions in surface temperatures during the daytime at both sites. The results for the other temperature metrics (i.e., air temperature and WBGT) were more inconclusive in nature due to the small magnitude of the differences between the cool pavement and control sites as well as the accuracy of the instruments used during the fieldwork.

Future work will look into the impact of heat reflection off cool treatment surfaces on human comfort and air temperature.

6. REFERENCES

- Debbage N., Zhai W. Ochoa E.L., Lee R.J., et al. (2024) “Evaluating the Urban Heat Mitigation Potential of the San Antonio Cool Pavement Pilot Program” Report for City of San Antonio
- Dessouky, S. Masad A., Tallon R., and Merritt D. “Evaluation of Cool Pavement Surface Treatments Using Friction, Texture and Adhesion Properties” Report for City of San Antonio

7. ACKNOWLEDGMENTS

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