Evaluation of RePLAY for Mainline, Shoulders, and Rumbles: Pilot Study in Clinton County

tech transfer summary

This project conducted comprehensive field and laboratory investigations into the use of RePLAY as a fog seal material, and, based on the assumptions utilized in this study, the results of the life-cycle cost analysis indicate that the RePLAY treatment can reduce equivalent uniform annual costs by extending the service life of pavements.

January 2022

RESEARCH PROJECT TITLE
Evaluation of RePLAY for Mainline, Shoulders, and Rumbles: Pilot Study in Clinton County

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The Program for Sustainable Pavement Engineering and Research (PROSPER) is part of the Institute for Transportation (InTrans) at Iowa State University. The overall goal of PROSPER is to advance research, education, and technology transfer in the area of sustainable highway and airport pavement infrastructure systems.

Background

Asphalt pavements steadily deteriorate over time due to traffic, weather, and aging. Pavement preservation, among other things, involves applying proper treatments on deteriorated roads to maintain good conditions and extend their service lives. Typical asphalt pavement preservation treatments include fog seals, slurry seals, chip seals, and overlays, each of which are used for various purposes on preventive maintenance projects.

Fog sealing is a low-cost application of liquid asphalt or emulsion to improve skid resistance, prevent oxidation, and seal against water infiltration. Bio-based fog sealers for asphalt pavement preservation can be sustainable alternatives for extending pavement service life.

In recent years, many bio-based fog sealers have been developed as sustainable alternatives to traditional petroleum-based sealers. For example, the manufacturers of the RePLAY agricultural oil seal and preservation agent claim that it protects asphalt from potholing, edge rutting, and cracking and can extend the life of paved asphalt surfaces when applied every three to five years.

Some states in Iowa's vicinity have reported success in using bio-based fog sealers for county road preventive maintenance. The observations reported include quick shedding of water off roadways treated with RePLAY while retaining the skid resistance of a typical section of pavement.

Problem Statement

Encouraged by anecdotal evidence, the Iowa Department of Transportation (DOT) was interested in evaluating RePLAY as a fog seal material for Iowa main lanes, shoulders, and rumble strips.

Objective

This project aimed to evaluate RePLAY as a fog seal material for asphalt pavements via a five-year pilot project that included a cost analysis.

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Research Description

In coordination with a vendor in Clinton County, Iowa, an asphalt pavement preservation project was selected for investigation. The proposed work included field, laboratory, and economic evaluation of the RePLAY application at the project site.

The commercial bio-based fog sealing material, RePLAY, was applied on a low-volume asphalt road. Its five-year performance was evaluated, and a life-cycle cost analysis was conducted.

RePLAY Application in Clinton County

The selected sites for RePLAY application in 2016 were a 3.3-mile road on County Road (CR) E-63/Y-32 with a 3-in. hot-mixed asphalt (HMA) overlay and another 0.3-mile road through the City of Toronto with a 2-in. HMA overlay.

The test sections at the installation site were divided into five sub-sections as follows: 100 ft of control section (CS with 0 gal/yd^2), 1,000 ft of treated section No. 1 (TS 1 with 0.030 gal/yd^2), 1,000 ft of treated section No. 2 (TS 2 with 0.025 gal/yd^2), 1,000 ft of treated section No. 3 (TS 3 with 3, 0.020 gal/yd^2), and the remaining roads used as other treated sections (RS with 0.020 gal/yd^2). The items involved with field and laboratory investigations are summarized as follows.

Summary of field investigations for 2016 installation site:

- Documentation of the RePLAY installation procedure
- Pavement appearance and distresses
- Retroreflectivity
- Skid resistance
- British pendulum test
- Specimen coring for laboratory tests

Summary of laboratory investigations for 2016 installation site:

- Water absorption
- Air permeability
- Depth of penetration

The installation site in Clinton County had RePLAY applied on June 29, 2016. The spraying work was completed by a vehicle equipped with an automatic spray machine. During spraying, county engineers controlled traffic on the two-lane roadway by allowing only one lane to be open for vehicle traffic. After RePLAY application to the first lane, it was opened to traffic, with the second lane remaining closed for subsequent spraying work.

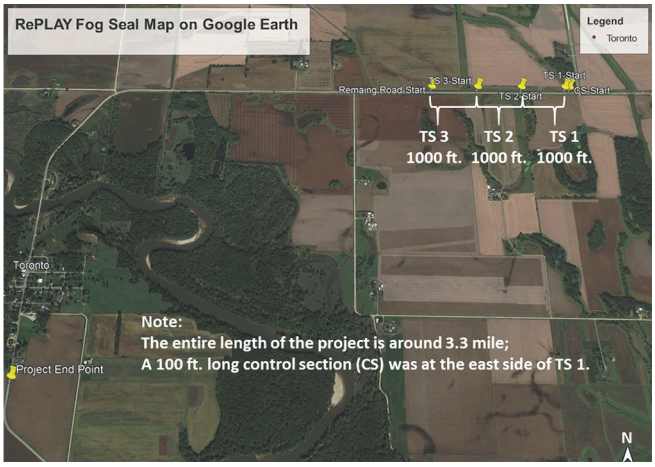

Image © Google Earth

Clinton County RePLAY installation and test sections

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Untreated lane (left) vs. treated lane (right) in section No.3

Field Investigation

The RePLAY installation procedures in Clinton County were documented, and the resulting pavement performance was evaluated annually until the summer of 2021.

Retroreflectivity was documented until the summer of 2018. Due to an accidental repainting that occurred at the end of 2017, the retroreflectivity of the pavement markings measured in 2018 showed this, and there was no need to continue the retroreflectivity measurements after 2018.

The skid number (SN) and British pendulum number (BPN) were measured for the installation sections in this study.

Pavement appearance and distress were also documented for these test sections. On June 29, 2016, the researchers performed the first survey before the RePLAY application, and follow-up surveys were conducted every year until August 24, 2021, about five years after the first application.

Laboratory Investigation

Water absorption tests were conducted in the laboratory for this study. The specimens were immersed into a water tube; then, dry weights, water weights, and saturated surface-dry weights were measured for calculation of water absorption.

A specifically designed air-permeability testing device was used to measure the real-time air pressure graph of specimens over time.

Examination of the penetration depth of RePLAY with in situ specimens was also attempted.

Life-Cycle Cost Analysis

To evaluate the economic benefit of using RePLAY, life-cycle cost analysis (LCCA) was performed. This study adopted the equivalent uniform annual cost (EUAC) model rather than the standardized net present value (NPV) model.

The cost of RePLAY was $2.12/yd^2 based on the contract for RePLAY application in Clinton County in 2016, for a 20-year expected service life of the untreated pavement, after which a reconstruction cost of $40/yd^2 or a rehabilitation cost of $25/yd^2 would be needed. The crack sealing was also assumed to be repeated every year at a cost of $1/ft. All cases used 5% as the discount rate.

This study created four different scenarios by considering the causes of cracking and options at the end of the pavement service life, as follows:

- Scenario A is the one that reconstructs a new surface after the service life and counts all cracking, including the coring-related cracking
- Scenario B is a rehabilitation scenario instead of reconstruction that also counts all cracking, including the coring-related cracking
- Scenario C is a reconstruction scenario, but the coring-related cracking is eliminated for estimating the crack growth rate
- Scenario D is a rehabilitation scenario, but the coring-related cracking is eliminated for estimating the crack growth rate

As shown in the tables, seven cases for each scenario were evaluated in the cost analysis, including one untreated case, three one-time treatment cases, and three re-treatment cases.

The different cases of RePLAY treatments were assumed to begin their first treatment from the fifth year to simulate the treatment schedule of the project site.

Various cases utilized in Scenario A and B for LCCA in this study

Cases	Treatment Times	Total Effective Period (year)	Service Life (year)	Extended Service Life (year)	Total EUAC ($/yd^2)	
					Scenario A	Scenario B
Untreated Case	0	0	20	0	1.30	0.85
Case 1-a	1	3	21.4	1.4	1.28	0.89
Case 1-b	5	15	26.9	6.9	1.18	0.95
Case 2-a	1	4	22.4	2.4	1.20	0.84
Case 2-b	4	16	29.5	9.5	0.97	0.78
Case 3-a	1	5	23.4	3.4	1.13	0.79
Case 3-b	3	15	30.1	10.1	0.89	0.69

Various cases utilized in Scenario C and D for LCCA in this study

Cases	Treatment Times	Total Effective Period (year)	Service Life (year)	Extended Service Life (year)	Total EUAC ($/yd^2)	
					Scenario C	Scenario D
Untreated Case	0	0	20.0	0.0	1.26	0.81
Case 1-a	1	3	21.1	1.1	1.29	0.88
Case 1-b	5	15	25.4	5.4	1.31	1.00
Case 2-a	1	4	22.1	2.1	1.21	0.82
Case 2-b	4	16	28.3	8.3	1.05	0.80
Case 3-a	1	5	23.1	3.1	1.13	0.77
Case 3-b	3	15	29.2	9.2	0.93	0.70

Field Test Key Findings

The pavement-marking retroreflectivity results showed that retroreflectivity was restored to the level before application within two weeks after RePLAY application. A surface treatment like a fog seal could reduce the retroreflectivity of the glass beads due to the covered and blocked retroreflective illuminance.

However, since the documented retroreflectivity of the treated sections before and two weeks after installation of the bio-based fog seal did not exhibit a significant difference, it indicated that the pavement surface had absorbed the RePLAY. Traffic wear, rain washing, and wind blowing can also contribute to the abrasion of the remaining oil retained on the pavement surface. Therefore, the potential reduction in retroreflectivity in the short-term due to the application of RePLAY could be fully recovered within two weeks.

The results of the SN and BPN tests indicated that RePLAY can influence surface friction. About one week after RePLAY installation, the SN had distinctly decreased, while, after several months, skid resistance was restored to its original condition. BPN results showed that the RePLAY-treated sections had higher BPN values than the control section one year after application. In summary, while pavements treated with RePLAY displayed short-term decreases in surface friction, they resumed their previous condition after several months and were able to maintain the earlier friction condition.

Pavement appearance and distress results indicated that the RePLAY treatment could effectively control cracking five years after treatment, with an application rate of 0.02 gal/yd^2 achieving the best performance in terms of lowest crack growth rate.

Laboratory Test Key Findings

The laboratory water absorption test results indicated lower absorption achieved by all RePLAY treated specimens due to these specimens having less pore space than control specimens, with RePLAY filling the voids in the asphalt mixture.

The results of the laboratory air permeability tests indicated that an increase in the application rate reduced air permeability in the specimens, with filled voids in the treated asphalt mixtures being the probable reason for the lower permeability. From the perspective of pavement preservation, lower permeability is desired since it can prevent water infiltration into the pavement structure.

Blue light-emitting diode (LED) and ultraviolet (UV) lights could not detect the penetration depth of RePLAY in the in situ specimens by observing different colors in the samples. The presence of RePLAY could not be visualized, probably due to the absorption from aggregate or evaporation to the environment.

Life-Cycle Cost Analysis Key Findings

The EUCA evaluations shown in the tables indicated that replication cases with three RePLAY applications (Case 3-b) in Scenario D exhibited the lowest EUCA, indicating that this scenario is the most cost-effective option for road preservation.

Key Findings Summary

- Field distress investigations indicated that the RePLAY-treated sections exhibited lower crack growth rates than the untreated sections.
- While the skid resistance of the investigated site decreased immediately after the application of the bio-based fog seal, the original friction value was restored within 11 months after spraying.
- While the RePLAY application could cause the temporary retroreflectivity reduction of pavement strip marking, the original retroreflectivity was restored within two weeks after RePLAY application.
- Laboratory investigations indicated that an increase in the application rates of RePLAY resulted in reduced water absorption and air permeability in tested specimens.
- It was difficult to determine the depth of penetration of the RePLAY material under either LED or UV lighting
- Based on the assumptions utilized in this study, the results of the life-cycle cost indicated that the RePLAY treatment can reduce EUACs by extending the service lives of pavements.

Implementation Readiness and Benefits

In summary, the application of RePLAY appears to extend the service life of asphalt pavement and reduce the life-cycle cost by maintaining surface friction, controlling crack growth, and reducing moisture penetration into the pavement structure. Based on the assumptions utilized in this study, RePLAY re-application is recommended every three to five years.

The performance of the treated site will be monitored for up to five additional years. The results of this study are beneficial to both the Iowa DOT and local agencies in developing another effective alternative for the purpose of pavement preservation.

Future Research

To evaluate additional benefits and limitations for the RePLAY treatment, the researchers recommend a follow-up study focusing on re-applying RePLAY or other proprietary fog sealers or rejuvenators. Additional field testing, such as short-term friction, international roughness index (IRI), pavement condition index (PCI), and surface texture measurements, is also advised. For comparison purposes, traditional fog sealer-treated sections could be included in the testing.

Reference

Yang, B., Y. Zhang, H. Ceylan, and S. Kim. 2020. Evaluation of Bio-Based Fog Seal for Low-Volume Road Preservation. *International Journal of Pavement Research and Technology*, Vol. 13, pp. 303–312.