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Project Title

Effectiveness of Concrete Bridge Deck Sealants

University

South Dakota State University

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Research Needs

The South Dakota Department of Transportation (SDDOT) questions if the use of the polymer chip seals is efficient and cost-effective in preventing water and chloride infiltration on bridge decks. Polymer chip seals are commonly used to seal the decks, resulting in improved friction (skid resistance). Since the early 1990s, SDDOT has used polymer chip seals on decks to reduce water permeability and chloride penetrability. This prevents deterioration due to corrosion of the steel reinforcement from chloride ingress in the decks. The seals' failure on the deck causes rapid degradation that significantly increases maintenance costs to prolong service life of the decks.

To check the seals' performance and efficiency, SDDOT initially investigated, through inspections, the extent of deterioration on several bridge decks coated with single or double polymer chip seals. They reported visible delamination and peeling of the chip seals over large

areas on the decks and mineral and/or rust staining and spalls with exposed steel near cracks underneath the decks.

With the chip seal failures and resulting deterioration on the decks, SDDOT struggles, to date, to efficiently use the chip seals on the decks. The poor performance may be attributed to parameters related to sealant type and quality, material deterioration, and deck characteristics along with traffic loading conditions and environmental and chemical attacks. Although several studies (Rogers et al. 2011, DeRuyver and Schiefer 2016, Nelsen 2005, Soltesz 2010, Soriano 2002, Tabatabai et al. 2016) have attempted to evaluate the effectiveness of the chip seals on the concrete bridge decks, the specific causes for ineffectiveness of the chip seal applications have not been demonstrated.

To determine the effectiveness of deck sealants and their performance on bridge decks in South Dakota, immediate and rigorous laboratory and field testing-based research considering different types of deck sealants must be done. This work will not only help validate the claim for efficiency and cost-effectiveness of the sealants for South Dakota bridge decks, but also provide technical recommendations regarding their practical use.

Research Objectives

1) Assess the historical performance of polymer chip seals on concrete bridge decks in South Dakota.

2) Evaluate the effectiveness of various concrete bridge deck sealants for preventing water and chloride infiltration and maintaining or improving skid resistance.

3) Recommend best practices of materials, application coatings, application methods, curing, etc. for concrete bridge deck sealant applications.

Research Methods

To complete the objectives, three research methods are presented as indicated below.

Objective 1: The research team will initially identify performance for polymer chip seals on bridge decks through a literature review (e.g., NCHRP reports and various state DOT reports) on concrete bridge deck sealing performance and a relevant survey to be distributed to the surrounding state DOTs (including SDDOT, Minnesota DOT, and Wisconsin DOT). Particularly, the team will investigate the causes of poor performance of our chip seals on bridge decks in South Dakota by reviewing contractor, weather, sealant type, traffic, and other factors. Based on findings from the review and survey, the team will conduct interviews with SDDOT and a detailed review of available data, such as historical inspection reports on South Dakota concrete bridge deck sealants, to assess the sealing performance. Researchers will categorize sealing performance in terms of damage level and type based on all collected data and the project panel feedback.

Objective 2: Based on the findings from Objective 1, the research team will develop an experimental program for both laboratory and field testing to evaluate the effectiveness of different concrete bridge deck sealants. In the laboratory testing, the program will be designed to

determine pull-out and friction performance of concrete deck sealed specimens along with chloride content/penetration of the specimens. The specimens will be tested under various environmental conditions. Sealants used for the lab testing will be applied to a few bridge decks in South Dakota. Note that a baseline chloride content/penetration on the SD bridge decks will be obtained prior to the sealant applications, to determine the amount of chloride that penetrates into each deck annually. The field testing aims to reevaluate the applied sealing and friction performance and to inspect deterioration of decks and measure the chloride contents in coring samples from the decks.

Objective 3: The team will analyze and present findings from Objectives 1 and 2 as recommendations for the practical use of sealants to prevent water and chloride infiltration in concrete bridge decks in South Dakota. Per the SDDOT research guidelines, the team will submit a final report encompassing the research methods, findings, and conclusions along with the recommendations. At the end of this project, an executive presentation summarizing the report will be presented to SDDOT.

Expected Outcomes

1) Detailed survey results used to identify conventionally used concrete bridge deck sealants, sealing practices, evaluation methods, and performance experience from the neighboring state DOTs.
2) Technical summaries for SDDOT's practices and performance experience with concrete deck sealants through the interviews and review of available data.
3) All data from the laboratory tests, including skid resistances (to be used for comparison purposes/recommendations), bond strengths, and chloride contents for the considered slab specimens.
4) All field testing data, encompassing skid resistances, bond strengths, and chloride contents on the selected decks.
5) Three technical memoranda required under the contract.
6) A final report summarizing complete research methods, findings, conclusions, and recommendations of the project.

Relevance to Strategic Goals

The anticipated outcomes from this project will be relevant to two strategic goals, including Economic Competiveness and Safety. The ultimate benefit of this project will be to not only help validate the claims of efficiency and cost-effectiveness of concrete bridge deck sealants in South Dakota but also to develop technical recommendations for sealants efficient use. South Dakota bridge decks are deteriorating due to accelerated failures of currently used chip seals and sequential corrosion from chloride ingress. The recommendations will ultimately assist SDDOT bridge engineers reduce sealing failures and deck deterioration, which will save on long-term maintenance costs and extend the service life of the decks.

Educational Benefits

As a research assistant, one graduate student will work on this project. The student will gain applied research skills and knowledge on laboratory testing and field inspection and testing to quantify skid resistances, bond strengths, and chloride contents. Key findings from this project

will be incorporated into SDSU engineering courses, such as CEE 792: Bridge Engineering, taught by PI Seo.

Tech Transfer

Recommendations for the practical use of bridge deck sealants will be derived based on results and findings obtained through this project. These recommendations can be implemented into South Dakota concrete bridge decks. The team will provide recommended sealing treatments and test methods to local bridge engineers. Sealing performance and deck deterioration will be substantiated through the laboratory and field tests. The recommendations will provide efficient and cost-effective sealants for immediate and long-term implementation. Implementation will help reduce sealants' failures on South Dakota concrete bridge decks, which will improve the decks' maintenance costs and extend the decks' service life. For successful implementation of the proposed work plan, uncertainties related to the application of currently used concrete deck sealants will be addressed. All results from this project will be published in technical journal articles and conferences. Technology transfer activities will also be reported in the Program Progress Performance Reports (PPPR).

Work Plan

Task 1: Meet with the project's technical panel to review the project scope and work plan.
Task 2: Conduct a thorough literature review of concrete bridge deck sealing practice and performance.
Task 3: Develop a survey instrument to distribute to the surrounding state DOTs (e.g., Minnesota and Wisconsin DOTs) on currently used concrete bridge deck sealants, sealing practices, evaluation methods, and performance experience.
Task 4: Submit a technical memorandum and meet with the project's technical panel to present the results of Tasks 2-3.
Task 5: Upon approval by the technical panel, issue the developed survey instrument to the surrounding state DOTs and summarize the results.
Task 6: Through interviews and review of available records, describe SDDOT's practices and performance experience with polymer chip seals on concrete bridge decks.
Task 7: Based on the results of Tasks 2-6, prepare an experimental plan for laboratory testing to evaluate the sealing and friction performance of concrete bridge deck sealants.
Task 8: Based on the results of Tasks 2-6, prepare an experimental plan for field application, testing, and performance monitoring to evaluate the cost, constructability, and sealing and friction performance of bridge deck sealants placed on a few bridge decks.
Task 9: Submit a technical memorandum and meet with the project's technical panel to present the results of Tasks 5-8 and obtain the panel's approval of the testing plans.
Task 10: Upon approval by the technical panel, perform testing defined in the experimental plan for laboratory testing.
Task 11: Upon approval by the technical panel, perform testing defined in the experimental plan for field application, testing, and performance monitoring for two years after application.
Task 12: In the fall of 2019, after deck sealants have been placed, submit a technical memorandum and meet with the project's technical panel to present the results of Tasks 10-11 to date.

Task 13: Upon completion of Tasks 10 and 11, analyze and compare the cost, constructability, and performance of bridge deck sealants.
Task 14: Develop recommendations for concrete bridge deck sealing material specifications, application methods, test methods and best practices, and performance monitoring.
Task 15: In conformance with Guidelines for Performing Research for the South Dakota Department of Transportation, prepare a final report summarizing the research methodology, findings, conclusions, and recommendations.
Task 16: Make an executive presentation to the South Dakota Department of Transportation Research Review Board at the conclusion of the project.

Table 1: Time Schedule for All Tasks.

	FY19		FY20												FY21												FY22									
	2019								2020																2021												2022			
Task	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
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* indicates that the tasks will include feedback from the technical panel.

Project Cost

Total Project Costs: $232,320
MPC Funds Requested: $ 95,221
Matching Funds: $137,099
Source of Matching Funds: South Dakota Department of Transportation

References

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Soltesz, S., (2010). “Evaluation of Thin Overlays for Bridge Decks,” Report FHWA-OR-RD-11-05, Oregon DOT.

Soriano, A. (2002). “Alternative Sealants for Bridge Decks.” Report SD2001-04-D, South Dakota DOT.

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