**General Literature Search for ORIL Research Idea Submission (November 2014-2015)**

**Pavement Rehabilitation Strategies for Deep Strength Profile Roadways**

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Ohio Department of Transportation

Pavement Rehabilitation Strategies for Deep Strength Profile Roadways

*Prepared for*

*Ohio’s Research Initiative for Locals (ORIL)*

*November 2014*

*Prepared by*

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*Transportation Literature Searches are prepared for ODOT staff to identify completed research and other authoritative information in an area of interest. The citations below are representative, rather than exhaustive of available English-language studies and other pertinent information on the topic. Primary online resources for the literature search TRID Online, TRB‘s Research in Progress (RiP), and Practice-Ready Papers databases, WorldCat, ASCE, the National Transportation Library (NTL) catalog, and other academic, engineering and scientific databases as available.*

***Keywords (singly/combinations****): deep-strength asphalt, full-depth asphalt, perpetual pavement, preservation, pavement maintenance, pavement preservation, pavement cracking, fatigue cracking, pavement distress, failure, renewal, rehabilitation, costs, maintenance, cost/benefit analysis*

***Citations:*** *Links to online copies of cited literature are provided when available. If you are interested in full reports/articles lacking a web link, please contact me and I will obtain the full report/article if possible.*

***Research idea:*** *Liberty Township, Delaware County, Ohio has two major subdivisions which were permitted to install ‘deep strength profile’ using a construction technique that employed ‘baseless construction’; the pavement is now evidencing significant cracking and wider than normal separation in those cracks. Typical crack sealing efforts have failed, and these areas are susceptible to freeze-thaw cycles leading to further degradation.*

*Liberty Township is seeking ways to preserve existing pavements and bridges while improving on their design. Best case scenarios and best management practices, optimal maintenance plans and rehabilitation strategies are needed with an eye to cost effectiveness.*

***Summary:*** *The transportation literature yields a large number of studies on pavement preservation, pavement maintenance, and rehabilitation strategies with respect to balancing costs versus benefits. The phrase ‘deep strength profile’ construction technique, and ‘baseless construction’ yielded no reports. Using ‘perpetual pavement’ and ‘full-depth asphalt’ was more successful. A selection of the best citations that matched the search parameters follows.*

**Implementation and Thickness Optimization of Perpetual Pavements in 0hio**

[http://www.dot.state.oh.u...esearch/Pages/default.aspx](https://www.dot.state.oh.us/Divisions/Planning/SPR/Research/Pages/default-backup.aspx)

Research in Progress Project 32547

Increases in traffic volume and loads, demands for longer-lasting pavements that reduce user delays due to reconstruction, and rising costs of energy and asphalt materials are some of the major challenges facing the paving industry and state departments of transportation in the United States. The concept of **perpetual pavements** has been identified as an emerging design technique to solve these challenges. Perpetual asphalt pavements are designed and built to last 50 years or more without requiring major structural rehabilitation or reconstruction. In perpetual pavements distresses are confined to the upper layer of the structure, by eliminating or reducing the potential for fatigue cracking through maintaining the strains in the pavement below a critical fatigue endurance limit (FEL).

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Ohio Department of Transportation

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Morse, Aric

Begin date: 2012-1-27

End date: 2015-2-2

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**Next Generation Crack Sealing Planning Tool for Pavement Preservation**

Research in Progress Project 36270

[http://www.nctspm.gatech.edu/pi/next-g...ling-planning-tool-pavement-preservation](http://www.nctspm.gatech.edu/pi/next-generation-crack-sealing-planning-tool-pavement-preservation)

The objective of this research project is to develop a next generation, data-driven crack sealing planning tool for advancing the existing state-of-good-repair practices to achieve the highest return on investment for **pavement preservation** and to better utilize the existing infrastructure by prolonging its life. This tool is especially important because outsourcing has become a trend for crack sealing and transportation agencies' budgets are stringently constrained.

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Start date: 2014- 05-08

End date: 2015-11-15

ALSO

**Study of Georgia's Pavement Deterioration/Life and Potential Risks of Delayed Pavement Resurfacing and Rehabilitation**

Research in Progress Project 36763

The projective objectives are to study (1) the actual pavement life/deterioration based on the confidence level established previously, (2) the current pavement resurfacing delay conditions due to funding shortages; and (3) the impact that delayed pavement resurfacing and rehabilitation have on **pavement life/deterioration**.

Start date: 2014-06-18

Actual completion date: 2015-12-18

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**Maintenance and Preservation 2014**

[http://trb.metapress.com/content/q0083...?p=99ad52d836324bf6bc875a822e4754d9&pi=0](http://trb.metapress.com/content/q0083385k717/?p=99ad52d836324bf6bc875a822e4754d9&pi=0)

This issue contains **12 papers** concerned with maintenance and preservation. Specific topics addressed in this issue include: pavement performance measures; **budget-constrained pavement preservation** strategies; enhanced econometric techniques for verifying the service life of asset interventions; Michigan Department of Transportation’s capital preventive maintenance program; the performance of pavements treated with thin hot-mix asphalt overlays; flushing of chip seal surfaces; asphalt pavement pothole patching methods; laboratory-predicted low-temperature performance of hot-poured crack sealants; anchor rod tightening of high-mast light poles; forecasting the cost of sustaining a set of bridge connections; selection of appropriate material, construction technique, and structural system of bridges by use of a multicriteria decision-making method; and defect-based condition assessment of concrete bridges.

104p

Transportation Research Record: Journal of the Transportation Research Board  
Issue Number: 2431  
Publisher: Transportation Research Board

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**Case Study on Perpetual Flexible Pavement in Connecticut**

Route 82 in Connecticut received a **2007 Perpetual Pavement Award** from the Asphalt Pavement Alliance (APA). This paper presents a comprehensive look at this pavement, including the construction details from 1971, historical and current traffic volumes, up-to-date performance, and **preservation** activities applied since the original construction. Pavement performance is shown in terms of the annual trends for **cracking** collected by the Automatic Road Analyzer (ARAN). The historical trends in pavement deterioration are analyzed and compared with those of similar pavement sections in Connecticut (Route 9) to determine the major factor(s) that contributed the most to the long-lasting service of Route 82. Special emphasis is made on the **pavement preservation** techniques and their timing.

pp 519-532

Yut, Iliya

Nener-Plante, Derek

Zofka, Adam

2010

Compendium of Papers from the First International Conference on Pavement Preservation

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Federal Highway Administration

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Foundation for Pavement Preservation

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**Mechanistic-Empirical and Life-Cycle Cost Analysis for Optimizing Flexible Pavement Maintenance and Rehabilitation**



In this study, an attempt was made to evaluate and select an optimal Maintenance and Rehabilitation (M&R) strategy for a designed flexible pavement by integrating Life-Cycle Cost Analysis (LCCA) and California Mechanistic-Empirical (M-E) design procedures (CalME). A 20-year design life pavement stretching 11.27-km-long section of 4-lane Highway 53, in Lake County, California is considered for this project level study. Three M&R strategies available in the CalME program were evaluated including, **Extended Pavement Preservation (EPP), Preservation-Preservation-Rehabilitation (PPR), and Rehabilitation only (R).** These strategies are applied as certain levels of distresses (rutting and **cracking**) are reached. The California-customized RealCost LCCA program was also employed to compare the various M&R strategies using the Equivalent Uniform Annual Cost (EUAC). LCCA demonstrated that EPP was the best economical alternative to maintain the pavement in a good usable condition for as long as 80 years of service. The methodology employed in this paper also demonstrated that extended life pavement may be achieved from a 20-year design by selecting the optimal **preservation** techniques and optimizing their time of application.

Mandapaka, V., Basheer, I., Sahasi, K., Ullidtz, P., Harvey, J., and Sivaneswaran, N.

2012

*Journal of Transportation Engineering*, 138(5), 625–633.

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**Comparing Performance of Full-depth Asphalt Pavements and Aggregate Base Pavements in NC**

Research in Progress Project 37088

[https://apps.dot.state.nc...h/ProjectInfo.aspx?ID=3621](https://apps.dot.state.nc.us/Projects/Research/ProjectInfo.aspx?ID=3621)

The North Carolina Department of Transportation (NCDOT) has a long history of building aggregate base pavements and, in recent years, has built **full-depth** asphalt pavements more frequently. The NCDOT assumes that the aggregate base pavements and **full-depth** asphalt pavements have the same length of service life and require the same maintenance and rehabilitation (M&R) treatments. However, different distress mechanisms in the aggregate base and full-depth pavements question the validity of these assumptions. If the performance of these two pavement types differs significantly, then the questions to be asked are related to the proper types of M&R treatment that are required, as well as to the appropriate time to apply such treatments. Research is urgently needed to answer these important questions. The answers to these questions are closely related to the NCDOT's ability to predict the performance of these two pavement types using its pavement design software, i.e., AASHTOWare Pavement Mechanistic Empirical (ME) Design (hereinafter called ME Design for brevity). It is expected that new **top-down cracking** and reflective cracking models will be implemented into ME Design in the next few years, and these new models will require the recalibration of ME Design for local conditions and materials. Efforts to address the performance differences between aggregate base and full-depth pavements can be undertaken such that the resulting data can support the future recalibration of ME Design. The objectives of the proposed research are: (1) to provide important performance information regarding asphalt base and aggregate base pavements that can be used to update the NCDOT's life cycle cost analysis (LCCA) procedure, (2) to identify pavement sections that have both base types in order to recalibrate ME Design for North Carolina conditions, and (3) to develop guidelines for the recalibration of ME Design and demonstrate the data collection process using new paving projects. The previous experience of and the databases possessed by the North Carolina State University (NCSU) research team from the NCDOT project Comparative Performance of Pavements and more recent projects on the local calibration of ME Design for hot-mix asphalt and warm-mix asphalt mixtures will be vital to accomplish these objectives successfully and to ensure the consistency within the master database to be developed in the proposed study. One of the products of this research is to determine the typical time at which the appropriate M&R treatment should be applied, referred to as time to treatment, for both base types for various climate and traffic loadings. The two base types also will be compared in terms of performance to test the existing LCCA assumptions. A second product of this study will be to determine candidate test sections for which data are sufficient to allow their use in the recalibration of ME Design. Because recalibration is required whenever models for the software are added or changed, this product will improve the efficiency of the recalibration process. The results of the time to treatment and performance comparisons for the two base types will be used in updating the NCDOT's LCCA procedure and to validate or disprove assumptions that the NCDOT has used up to this time. The test section selection process will allow pavement designers to select sections more easily for future calibration and recalibration. The pavement type selection and bid adjustments are based on LCCA procedures. Therefore, this research will provide data to support and improve the NCDOT's current LCCA procedure.

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Begin date: 2014-08-16

End date: 2016-08-15

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**Cost Effective Means to Managing Pavements in Poor Condition**

[http://www.wistrans.org/c...IRE-05-03-Final-Report.pdf](http://www.wistrans.org/cfire/documents/CFIRE-05-03-Final-Report.pdf)

Tight budgets and dwindling state and federal revenue hinder efforts of transportation agencies to resurrect **pavements in poor condition**. As a “stop-gap” measure, some agencies simply allow roads to deteriorate to gravel. However, this approach can be costly over the long-term and often results in dissatisfied users. This research project will identify construction treatments and/or materials that can be used to extend the service life of pavements in poor condition. These treatments are intended to be economical and practical “stop-gap” measures until permanent and affordable solutions are available. They are not an “alternative” to reconstruction. New emerging pavement rehabilitation strategies are being developed and tested at the Recycled Materials Resource Center (RMRC) at University of Wisconsin-Madison using superior properties of recycled materials (e.g., fly ash stabilized reclaimed asphalt pavement and recycled concrete aggregate) to extend service lives of roadways. Efforts are underway to evaluate their performance by comparative economic and environmental life cycle analyses. These methods show great promise as cost-effective measures to treat poor pavements to achieve stop-gap or longer life cycle results. The research will create tools for selecting and analyzing strategies for pavements in poor condition. The tools, created for Minnesota, will support future decision-making based on cost effectiveness by providing a synthesized method of life cycle cost analysis (LCCA) and life cycle assessment (LCA). This research will illustrate design strategies that offer Minnesota greater economic and environmental sustainability in resurrecting dead roads, resulting in maintaining a healthy road system.

This document was sponsored by the U.S. Department of Transportation, University Transportation Centers Program.

Adams, Teresa

Bloom, Eleanor

Edil, Tuncer

Hanz, Andrew

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74p

2014

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Minnesota Department of Transportation

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Research and Innovative Technology Administration

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Washington, DC 20590 United States

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**Guide to Using the Existing Pavement in Place and Achieving Long Life**

<http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-R23-RW-2.pdf>

On roadways that have acceptable geometric features, **renewal** can be greatly accelerated and costs reduced if the existing pavement can be incorporated into the new pavement structure. Transportation agencies need reliable procedures that allow them to identify when an existing pavement can successfully be used in place and how to incorporate it into the new pavement structure to achieve long life. This guide and the accompanying report and web tool provide guidance for selecting, designing, and constructing long-life pavements using existing pavement structure. The goal of this project was to develop reliable procedures and guidelines for identifying when existing pavements can be used in place and the methods necessary to incorporate the original material into the new pavement structure while achieving long life. “Long life” was defined as 50 years or longer from the time the pavement was renewed or rehabilitated until the next major rehabilitation. The report and guide encourage longer-lasting renewed pavement designs; provide realistic, easy-to-use pavement thickness scoping assessments; and guide users through the data-gathering process needed for input into designing and constructing a long-life pavement using the existing pavement structure. The guide includes the following: project assessment manual; best practices for rehabilitation of flexible pavements and rigid pavements; guide specifications; life-cycle cost analysis; and emerging pavement technology. All the guidance has been incorporated into the web-based pavement design scoping tool, which is meant to complement, not replace, a transportation agency’s normal processes for design and pavement-type selection. As a result of outreach to transportation agencies, a set of enhancements is currently under way and will be included as a future addendum to the report and guide.

374p.

Jackson, Newton

Puccinelli, Jason

Mahoney, Joe

2014

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**Pavement Performance Measures that Consider the Contributions of Preservation Treatments**

Research in Progress Project 37705

<http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3655>

**Pavement preservation** provides a means for maintaining and improving the functional condition of an existing highway system and slowing deterioration. Although pavement preservation is not expected to substantially increase structural capacity, it can lead to improved pavement performance, longer service life, and reduced life-cycle costs. However, currently used measures for quantifying pavement performance do not appropriately account for the potential performance enhancement, life extension, and cost savings resulting from applying preservation treatments at the right time. For example, pavement smoothness (or roughness) which is measured by the International Roughness Index (IRI) and widely used by highway agencies is not a good measure of the effect of many preservation treatments. There is a need to identify or develop pavement performance measures that consider the contributions of preservation to performance, service life, and life-cycle costs. Also, there is a need to prepare a guide document for the American Association of State Highway and Transportation Officials (AASHTO) consideration and adoption to facilitate the implementation of these measures by state highway agencies. This information will ensure that the contributions of preservation to performance and service life are appropriately considered and help highway agencies better assess the benefits of preservation treatments and their role in maintaining the level of service of the highway system.

Begin date: 2014-06-02

End date: 2016-06-01

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National Cooperative Highway Research Program

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**Evaluation of Two Pavement Rehabilitation Techniques for Municipal Roads**



State and local Departments of Transportation, who have primary responsibility for the upkeep of their roadway pavement, must do so under tight budgets. At the expense of lower functioning roads (such as urban and rural collectors), these agencies tend to focus more of their maintenance and operations budget on high-volume roads - such as freeways and multilane highways - due to their importance. However, municipal officials responsible for the maintenance of collector roads are still expected to provide pavements of acceptable quality to the public, but they must do so under even tighter budgets. This paper presents a comparative analysis of the effectiveness of two **pavement maintenance** and rehabilitation techniques for municipal roads. One is the mill-and-overlay method, and the other is a resurfacing technique called NovaLite. The HDM-4 pavement management software was used to perform the analysis on 5th Street in downtown Chattanooga, which is under the jurisdiction of the City of Chattanooga Public Works Department, a municipal agency. The results of the analysis indicate that NovaLite is superior to mill-and-overlay in initial cost, time and ease of construction, and extent of disruption of traffic. Even when life cycle costs are considered, the analysis also shows that NovaLite maintains its advantages in cost and effectiveness, suggesting a way forward for cash-strapped municipalities.

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Pp 273-282

Fomunung, Ignatius

Owino, Joseph

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**Evaluation of Long-Lasting Perpetual Asphalt Pavement with Life-Cycle Cost Analysis**

<http://dx.doi.org/10.3141/2368-01>

In 2006, the Oklahoma Department of Transportation sponsored work at the pavement test track of the National Center for Asphalt Technology to compare the performance of two sections that had been designed to determine the necessary thickness for perpetual pavement. One section (Section N9) was designed to be a **perpetual pavement** at 14 in. thick. The other section (Section N8), at 10 in. thick (according to the AASHTO 1993 design guide), was used to test performance and to identify the thickness needed for perpetual pavement. This paper presents a life-cycle cost analysis for quantifying the benefits of a perpetual pavement section compared with the long-term cost of the thinner section. The life-cycle cost analysis was conducted with RealCost 2.5, which was available through FHWA, and included a determination of quantitative estimates of construction schedule, work zone user costs, and agency costs for initial construction and rehabilitation activities. The perpetual pavement section was found to have had a lower life-cycle cost than the conventional pavement section and to have provided better service to highway users. For better planning of future preservation studies, the estimated present serviceability rating as a function of the international roughness index for two designs (perpetual and nonperpetual) was evaluated. The findings of surface measurements for both sections demonstrate a clear difference between perpetual and conventional pavement serviceability for a given level of roughness and accumulated traffic. These results are also useful for assessing the improvement of conventional pavement after **rehabilitation** treatments.

[Pavement Management 2013, Volume 3](http://trid.trb.org/view/1302179)

Sakhaeifar, Maryam S.

Brown, E. Ray

Tran, Nam

Dean, Jeff

Pp 3-11

2013

[Transportation Research Record: Journal of the Transportation Research Board](http://trid.trb.org/results.aspx?q=&serial=%22Transportation%20Research%20Record%3A%20Journal%20of%20the%20Transportation%20Research%20Board%22)

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**Modeling and Analyzing Budget-Constrained Pavement Preservation Strategies**

<http://dx.doi.org/10.3141/2431-02>

The Washington State pavement management system (WSPMS) has a long and well-known history of describing network condition, predicting necessary rehabilitation, and guiding the Washington State Department of Transportation (DOT) to the best possible value for pavements meeting an acceptable level of service. By definition, lowest life-cycle cost (LLCC) is the most economical way to manage roadways to a required level of service. What does an agency do when it is currently, and projected to be, funded at less than half of what LLCC calculations recommend? This deceptively difficult question reflects the situation that the Washington State DOT currently faces with its preservation budget. To assist the agency in answering this question, the WSPMS developed a tool called the Forecaster, allowing definition of a forecast scenario that enables the user to define a yearly budget with optional allocations, preservation techniques, prioritization of roadways and activities, and more, and analyzes the results of the forecast by using several different performance measures. Presented are an overview of the new WSPMS tool to create forecasts, a general overview of the forecast process, and the performance measures that the WSPMS gives to users to analyze the results of a forecast. Finally, several funding scenarios are compared by the expected performance measure outcomes, and a specific prioritization methodology is recommended for the **severely constrained preservation budget** of the Washington State DOT.

P 6-15

Rydholm, Timothy C.

Luhr, David R.

2014

[Transportation Research Record: Journal of the Transportation Research Board](http://trid.trb.org/results.aspx?q=&serial=%22Transportation%20Research%20Record%3A%20Journal%20of%20the%20Transportation%20Research%20Board%22)

Issue Number: 2431  
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**Best Practices for Crack Treatments for Asphalt Pavements**

[http://onlinepubs.trb.org...bs/nchrp/nchrp\_rpt\_784.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_784.pdf)

**Crack sealing** and **crack filling** are widely used treatments for maintenance of asphalt pavements. However, successful crack sealing and crack filling applications continue to be viewed as an art. When not properly applied, these pavement preservation treatments can result in early failures and costly corrective maintenance for highway agencies. Although much research has been performed in the United States and abroad on the materials, techniques, and designs for crack sealing and crack filling, variability in the current state of the practice regarding construction techniques and the resulting effectiveness of crack sealing and crack filling have not been investigated. This report presents best practices for crack treatments for asphalt pavements developed through a critical review of the current states of the art and practice. The research included a critical review of the worldwide literature on crack sealing and filling, with emphasis on identifying current best practices. A survey of state, local, and provincial highway agencies was then conducted to fill gaps in the results of the literature review. This report fully documents the research and includes chapters on the current states of the art and practice that support the chapter discussing the selected best practices. It will be of interest to engineers in public agencies and industry with responsibility for construction and maintenance of asphalt pavements.

Decker, Dale S.

44p

2014

[NCHRP Report](http://trid.trb.org/results.aspx?q=&serial=%22NCHRP%20Report%22)

Issue Number: 784  
Publisher: Transportation Research Board

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**Pavement Preservation Practices in Cold Regions**



**Pavement preservation** is an emerging approach in road upkeep. The State of Alaska Department of Transportation and Public Facilities (AKDOT&PF) aim to spend wisely the funding for its road upkeep by integrating pavement preservation concept into its Pavement Management System. To do this, a literature review was conducted on the performance and cost effectiveness of pavement preservation treatments in cold regions. This paper presents the results of the literature review. The following include the main findings: **Pavement preservation treatments**, Crack Sealing, Patching, Fog Seals, Chip Seals, Slurry Seals, AST/BST, Microsurfacing, Thin Overlays, Bonded Wearing Courses, Interlayers and In-place Recycling, are all used widely in cold regions. Crack sealing and patching are the most extensively used pavement preservation treatments. Use of chip seals, fog seals, and slurry seals should be considered job specifically. The service life of the treatments varies from about 3 years to 12 years. Microsurfacing and thin overlays have the longest service life. The costs of treatments vary from a region to another as well as from project to another. Other issues despite the cost effectiveness include sustainability and traffic safety.

Zubeck, H.

Mullin, A.

Liu, J.

2012

*Cold Regions Engineering*, pp. 134-143.

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**Strategic Scheduling of Infrastructure Maintenance and Rehabilitation Funding**

Research in Progress Project 36147

It is anticipated that the agency will use results of this study to enhance its decisions with regard to four key elements of asset management: determine the optimal timing of specific treatments for bridge and pavement **preventive maintenance and rehabilitation** (M&R); establish **cost-effective long-term** M&R schedules (treatment types and their respective timings) over asset life cycle; quantify the consequences of delayed M&R; develop network-level performance measures for purposes of benchmarking its overall performance vis-à-vis those of other state agencies.

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Labi, Samuel

Fricker, Jon D.

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Start date: 2014-03-01

End date: 2016-08-30