

Rehabilitation Applications for Engineered Emulsions in Olmsted County

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Word Count

2676 words

14 figures = 14 x 250 = 3500

Total = 6176 words

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ABSTRACT

Olmsted County, Minnesota, like many other counties in the U.S., has a limited budget and increasing needs to maintain their current roadway conditions. Many roads are beyond the point where preventive maintenance can provide value to the taxpayer so rehabilitation must be considered. New advancements in pavement rehabilitation practices provide alternatives to conventional design and construction methods. The difficulty arises in defining and applying the proper rehabilitation strategy for roadways that have different characteristics and distress. To address this difficulty, the County Engineer decided to conduct a pavement assessment overview of their roadways in need of rehabilitation. This assessment provided valuable information for selecting the proper design and construction process for each unique section. Engineered Emulsions were incorporated into some of these sections and will be compared to conventional design and construction methods used in other roadway sections within the County.

This paper will discuss rehabilitation selection strategies, the design process that follows and subsequent project construction using rehabilitation applications. These applications and the use of new materials such as Engineered Emulsions will be evaluated for future use. Rehabilitation strategies being evaluated include Cold in Place Recycling (CIR), Full Depth Reclamation (FDR) and CIR with foamed asphalt. Conventional and engineered binders were incorporated and all sections received a bituminous overlay. Structural considerations using these materials are also part of ongoing research that will better define proper rehabilitation design and strategies. Findings from these projects will be considered with the county's past experience for use on additional roadways. The goal of this effort is to better understand proper applications of new materials and rehabilitation practices in order to reduce life cycle costs and provide added value to the taxpayers in Olmsted County.

INTRODUCTION

One of the biggest problems facing most road owners is the lack of sufficient funding to maintain all the roads in their system. Olmsted County, like many other counties in the U.S., has both a limited budget and many miles of roads in need of repair each year. The County, located 70 miles south of St. Paul, must accommodate significant growth while maintaining good roadway conditions within their limited budget. A common rehabilitation fix is applying a hot mix asphalt (HMA) overlay or a mill and fill. These are often short-term fixes because the cracks within the deteriorated pavements below do not allow the overlays to perform satisfactorily. In the case of an HMA overlay, the subsequent thicker pavement compounds the problem with the same distresses returning after a short period of time. Cracks within thicker pavements, often present more difficult rehabilitation options because the distress is often most severe at the bottom of the pavement. With mill and fill, thinner asphalt overlays usually show signs of cracks and potholes within a few years because of insufficient pavement structure and the extreme temperature fluctuations in Minnesota. Alternative rehabilitation techniques such as CIR or FDR better address the problems associated with cracking but in the past had their own limitations primarily related to asphalt binders used within the process.

CIR with slow setting conventional emulsion has been used in Olmsted County with mixed results. Past limitations were primarily related to the cohesivity of the mixture and the cure times required prior to placing the overlay. A moisture content of two percent or less within the CIR section has been required prior to placing the overlay. The time frame to meet this requirement was often several weeks, allowing additional rainfall to complicate the problem. Cohesivity of the mix was not always adequate because traffic would cause raveling at the surface. Raveled sections can hold water compounding the problem and sometimes result in shallow potholes. This condition combined with contractor frustrations in scheduling their crews to place the overlay created an undesirable situation. Once the overlay was placed, any excess moisture in the CIR section could induce stripping which subsequently has a negative affect on the overlay performance. More reliable Engineered Emulsions address these issues, so it was desirable to try them on one of the CIR sections.

CIR with foamed asphalt is another rehabilitation strategy recommended by the contractor for inclusion in this research. This process offers the advantage of utilizing less expensive hot asphalt cement as a binding material. This advantage however can be offset by the reduction in overall coating of the aggregate

potentially leading to performance issues. Both of these CIR strategies were incorporated on different sections of the road and performed very well during construction.

(1) FDR consists of various methods for recycling pavements. These include pulverization, mechanical stabilization, bituminous stabilization and chemical stabilization. Specific information on each of these methods can be obtained from the Basic Asphalt Recycling Manual referenced here. Olmsted County elected to go with bituminous stabilization using an Engineered Emulsion because it provides a good balance between stability and flexibility, which the County wanted for improved performance. This strategy and the CIR strategies will be further discussed later in this paper.

Pavement Assessment Overview

The first step in determining proper rehabilitation strategies is analyzing the needs of Olmsted County's selected road network from the Construction Program. This analysis included a windshield survey, coring the roadway, review of typical sections and roadway history information. The County Construction Program had already prioritized project selection; additional analysis criteria may include prioritizing needs, accounting for population shifts, safety problems, and where routine maintenance costs are the highest. Olmsted County includes the City of Rochester, home to the famous Mayo Clinic, and extensive agricultural areas so traffic loads are variable and diverse. Because of its proximity to the Twin Cities, the County is seeing rapid growth and increasing traffic volumes. Pavement rehabilitation strategies are more desirable if they fit a staged construction philosophy and emphasize a strong base with drainage. CIR and FDR can be a good fit for growing counties like Olmsted because they offer lower life cycle costs, a better pavement network and the flexibility to grow more efficiently.

The roadways included in this pavement assessment overview were County State Aid Highway (CSAH) 21, CSAH 24, and County Road (CR) 124. A windshield survey showed these roads exhibited block cracking with areas of more significant stress such as alligator cracking and localized minor rutting (Fig. 1). They were all excellent candidates for selection of CIR/FDR over a conventional overlay or mill and fill. FDR was selected for CSAH 21 because review of the cores showed distress all the way through the 5 $\frac{3}{4}$ inch pavement. Also, the roadway's typical section (Fig. 2) shows 10 inches of gravel base. CIR is typically limited to about 4 inches of depth and since it was desirable to grind up the entire 5 $\frac{3}{4}$ inch pavement FDR was the most desirable choice. Other advantages of FDR include: conservation of resources, limited equipment required, ability to correct deficiencies during construction, structural improvement with the addition of Engineered Emulsion, and the potential for significant reduction in life cycle costs.

CIR with conventional slow setting emulsion (CSS-1) and foamed asphalt were selected for CSAH 24. This was based on the cores showing most of the distress being located toward the center of the 6-inch in-place pavement (potentially the result of stripping in the intermediate layer). Most of the distress could be removed with a 4-inch depth mill of the existing pavement. This would leave 2 inches of the existing pavement and 8 inches of gravel base to support the recycling train. Support for the heavy recycling train is critical in assuring it will not break through the pavement and get stuck. This is especially true when the underlying base thickness may be less than anticipated or contaminated creating less support than the typical section would lead you to believe. Foamed asphalt was selected for one of the sections based on the contractor recommendation and the County's desire to evaluate this process within this research effort (Fig. 3). The other section of CSAH 24 and most of CR 124 used CIR with a CSS-1 emulsion. The County also elected to use an Engineered Emulsion for a section of CR 124 (Fig. 4). This layout allowed good engineering judgement in selecting the rehabilitation process as well as the ability to evaluate the different processes and materials for constructability and long term performance (Fig. 5). Constructability will be discussed in the construction section of this paper and long term performance will be reported through follow-up research at a future time.

The goal of these evaluations is to better understand proper applications of new materials and rehabilitation practices in order to reduce life cycle costs and provide added value to taxpayers in Olmsted County.

Project, Pavement and Mixture Design

Project Design requires an engineer to identify structural needs (pavement type and thickness) based on traffic and desired level of serviceability; to identify other issues and needs of the project including drainage, profile, and uniformity; and to develop a recommendation based on geotechnical and base/subgrade analysis. For the upgrades to be successful, the roads must have structurally sound bases and good drainage. When existing materials are marginal or questionable, the FDR/CIR alternatives become especially viable because both will enhance the existing structure by incorporating a stronger more uniform base under the subsequent overlay. The project designer must analyze the existing roads and use the data gathered to engineer a solution. The engineered design includes recommendations for corrective steps, reclamation thickness, emulsion formulation, mix design and surfacing requirements. Other standards taken into consideration, include strength, lane width, shoulder slopes, recovery area, signing and vertical / horizontal alignments. Data gathered includes visual inspections, drainage review, cores and interviews of maintenance personnel. More extensive analysis, such as Falling Weight Deflectometer (FWD), Dynamic Cone Penetrometer (DCP) and base/subgrade boring and classifications can be performed if necessary. The pavement designer must weigh the added costs for these assessments against the data gathered through less costly means. When in doubt, it is almost always worthwhile to spend the additional money for more extensive analysis as it can head off a disastrous failure and is typically only a small fraction of the total cost of the project. FWD/DCP data analysis provides a characterization of the subgrade soil strength and an assessment of near surface bearing capacity. Using this data, the pavement design thickness can be optimized for projected loading on the specific roadway. The Local Road Research Board (LRRB) in Minnesota is supported by Olmsted County and is currently conducting more extensive research on pavement design considerations including structural values for optimizing various rehabilitation strategies. This effort should significantly improve the economics for future projects.

Mixture designs were not performed for the CIR foamed asphalt or the CIR CSS-1 emulsion materials used on CSAH 24. Binder application amounts were selected based on past experience.

Mixture designs were performed for FDR and CIR sections utilizing Engineered Emulsions. The emulsion mixture design process was developed to engineer a mixture that would be flexible while providing adequate support for the projected traffic. Koch Pavement Solutions laboratories in St. Paul, Minnesota, Terre Haute, Indiana and Wichita, Kansas did the materials testing and emulsion mix design for the project using the aggregate from the existing roads. Samples were taken by coring various locations on the roadway. These individual samples were used to provide a composite sample. Koch used a new chemistry emulsifier with select base asphalts to formulate an emulsion that would give good dispersion on the project aggregates, meet the engineered mix specifications, withstand the local climate and be compatible with the process. The emulsion was also solventless to provide early mixture strength. More information on these designs is provided in the construction section of this paper.

Construction

MidStates Reclamation, Inc. began the construction on CSAH 21 in early August 2004. The FDR process utilized a CMI RS 650 reclaimer to grind up the entire pavement to a depth just under 6 inches. Engineered Emulsion was then incorporated in a second pass of the reclamation process. The reclaimer is connected by hose to an emulsion tanker (Fig. 6). The reclaimer's cutting drum pulverized the existing pavement 2.4m (8 feet) wide and to a depth of 15.24 cm (6 inches). Three passes were required to cover the full width of the road, which remained open to local traffic during the entire process. The moisture content was adjusted to the level determined by the design and the emulsion was thoroughly mixed at a rate of 2.5 to 3.5% percent by weight of mixture. A nuclear density gauge was used to determine the existing moisture content. A test strip was constructed and evaluated, with nuclear densities taken to determine the optimal rolling pattern (Fig. 7). The use of the emulsion at ambient temperatures means the asphalt is not pre-aged during a hot process. Reduced aging during construction means the asphalt binder will perform longer.

The material was initially compacted with a pad foot roller. A motor grader aerated, spread and shaped the stabilized material (Fig. 8). Breakdown compaction utilized a 25-ton pneumatic roller, then finished with a double drum roller following the patterns established on the test strip (Fig. 9). Variations of this sequence were attempted to assure optimum compaction was obtained. The stabilized material set up quickly with the roadway open to local traffic at all times. The new bound flexible base handled traffic until the overlay was applied.

Rochester Sand and Gravel began construction of CR 124 in early September 2004. They began with the CIR process using CSS-1 emulsion. Their milling train consists of a twelve foot milling machine, a crushing/sizing unit, a pugmill, conveyors and their pickup/laydown paver. The emulsion tanker is also part of the train feeding the emulsion through a line that goes directly to the pugmill. This is the same configuration when using an Engineered Emulsion and allows the train to provide continuous laydown while leaving the opposite lane open for traffic (Fig. 10). Within the same stretch of CR 124, several loads of Engineered Emulsion were also placed (Fig. 11). The main difference in these sections is the properties provided by the different binders. The conventional slow setting CSS-1 binder is typically added at a rate of 2 to 2.5%. Since no mix design is performed for this material, the emulsion content is selected based on observations in the field. These observations typically balance aggregate coating with stability of the mixture. The Engineered Emulsion is based on a design which incorporates "Performance-Related Specifications" (PRS). (2)When the improved technology for emulsion cold in-place recycling was developed, researchers also developed performance-related test methods to improve the reliability of the process and give agencies more confidence in CIR. A laboratory raveling test run on Superpave Gyrotory Compactor prepared samples simulates the raveling that can occur on the newly recycled pavement, and is used as part of an engineered design process as well as specifying raveling resistance and early strength (Fig. 12). The Indirect Tensile Test developed for Superpave design is modified to design and specify CIR resistance to thermal cracking.

Later in September, on a section of CSAH 24, foamed asphalt was incorporated using the same train. Foamed asphalt utilizes hot asphalt cement (AC) that is mixed with water within a foaming chamber (Fig. 13). The violent reaction that occurs with the asphalt and steam helps provide an environment where mixing can occur. Typically the fines within the milled material are coated with AC and provide mastic to hold the larger aggregate particles in place. One of the disadvantages to the foamed asphalt process was that the tanker for transferring AC to the train ran side by side thus shutting down the roadway for extended periods while the hot AC was pumped off (Fig 14). Hot AC also ages more than ambient AC used in emulsions.

It is up to each Agency and engineer to make their own judgement as to which process is most suitable for any given roadway. (3) One thing is certain, by using performance-related specifications, agencies open the door for innovative products, as well as for competition in the marketplace to meet those performance criteria while improving quality and lowering overall system costs. All of the projects and rehabilitation processes outlined in this paper were completed successfully. They all passed the constructability portion of the evaluation. Follow up research will be conducted to better understand the cost benefit of these processes as performance data is acquired. In the mean time the County will continue to follow the process outlined here to make rehabilitation decisions on future roadways.

1. "Basic Asphalt Recycling Manual", Asphalt Recycling and Reclaiming Association (ARRA), Annapolis, Maryland, 2001.
2. Thomas, Todd et al. "Performance - Related Tests and Specifications for Cold In - Place Recycling: Lab and Field Experience", Transportation Research Board, Washington, D.C., 2003.
3. "Performance-related Specifications for Highway Construction and Rehabilitation", *NCHRP Synthesis of Highway Practice 212*, National Cooperative Research Program, Transportation Research Board, Washington, D.C., 1995.