

Microsurfacing as a Preventative Maintenance Program in Texas

Benjamin Broughton¹ and Soon-Jae Lee¹⁺

Abstract: Microsurfacing has been shown as an effective pavement preservation tool when applied to the right road, at the right time, for the right distress. This study looks at the current state of practice of microsurfacing in Texas and compares it to best practices extracted from existing literature. A survey of DOT personnel, contractors, and emulsion suppliers in Texas provides insight into the most crucial factors contributing to the success or failure of microsurfacing. From the results of the survey, literature reviews, case studies, and site visits, the research team analyzed material selection and mix design methods, construction practices, equipment practices, and performance measures for microsurfacing. It was concluded that project selection is the most important contributor to a successful microsurfacing; this factor falls under DOT control. However, reliance on contractors for input into proper project selection places the agency in a vulnerable position. A certification course to educate personnel is recommended.

Key words: Construction practices; Microsurfacing; Pavement preservation; Project selection.

Introduction

A study by Queiroz et al. (1994) demonstrated the relationship between a country's economic development and well-being and the quality and quantity of its road infrastructure. For the task of creating and maintaining a country's infrastructure, especially in today's age of tight budgets and ecological sensitivity, it is crucial that existing roads last as long as possible to utilize resources as efficiently as possible. Preventative maintenance of existing roadways has been shown to be the most financially efficient use of available resources by Departments of Transportation (DOT) [1].

Many studies have tried to develop a set of criteria that will accurately guide decision-makers in choosing a preventative maintenance strategy that produces the most cost-effective improvements in pavement quality and life [2-10]. Depending on which model or analytical tool is used, answers vary on which treatment is best under a certain set of conditions. The life-cycle cost analysis (LCCA) has been used widely over the last decade by agencies to evaluate road infrastructure projects [9]. Chan et al. (2008) reports that "the literature is limited in examining the effectiveness of state department of transportation (DOT) Life-Cycle Cost Analysis in projecting and picking the pavement alternative with the lowest life-cycle costs." Whether or not effective strategies are in place for choosing the best treatment, the importance of using preventative maintenance treatments is agreed upon as a crucial component of providing an affordable and usable road system [6, 8].

As stated by the Transportation Research Board, "Pavement preservation strategies are cost-effective approaches to keeping pavement levels of service at desired levels, and they should be employed even more during periods of constrained budgets." Every one dollar spent on preventative maintenance now results in \$6-10 in future savings [11]. Among different preventative maintenance treatments, microsurfacing is known to have economical and

ecological advantages when used correctly [12].

Microsurfacing is a road maintenance tool that involves laying a mixture of dense-graded aggregate and polymer modified asphalt emulsion (3% polymer by weight of asphalt cement, and about 7% residual asphalt cement by weight of dry aggregate) to correct or prevent certain deficiencies in pavement conditions. In the same category of pavement treatments as seal coating and thin hot mix asphalt (HMA) overlays, microsurfacing treatments cover the entire width of the roadway to which they are applied [8].

The treatment may be as thin as 3/8 inch (9.5 mm), or it can fill wheel ruts up to 2 inches (50.8 mm) deep using multiple passes. Because of the similar ingredients used in slurry seals, microsurfacing is sometimes referred to as a "polymer-modified slurry seal." The primary difference between the two treatments is that slurry seals cure through a thermal process while microsurfacing utilizes a chemically controlled curing process. One of the main benefits achieved from microsurfacing over alternative pavement treatments results from the polymer-modified asphalt emulsion that chemically speeds evaporation of moisture. Rapid breaking of the mixture enables it to set in less than one hour in most instances, requires no rolling, and allows traffic to return to the roadway quickly.

Objectives and Scope

This study investigated the current state of practice of microsurfacing in Texas and compared the results to the current state of practice nationwide. A survey was created and administered to TxDOT personnel identified as stakeholders in microsurfacing projects in Texas, along with contractors and emulsion suppliers. Additionally, a thorough review of literature, site visits, and case study analyses were conducted.

Study Approach

Literature Review

The study began with a comprehensive review of literature on the topic of microsurfacing. Survey questions were extracted from the

¹ Department of Engineering Technology, Texas State University.

⁺ Corresponding Author: E-mail soonjae93@gmail.com

Note: Submitted January 23, 2012; Revised April 18 2012; Accepted May 1, 2012.

Table 1. Summary of Site Visits.

District	Road	Date Completed	Measure of Most Prevalent Distresses	Summary
Abilene	US 180	August 2009	7 mile Project. 20 ft ² of Bleeding in one Area. One 100' Section had Minor Raveling in Wheel Path, Less than 40 ft ² Total.	Performing Well. Little to no Visible Distress.
Abilene	LP 322	August 2007	3.5 mile Project. Average of 40 Linear Feet of Crack Sealing Per 100 Foot Section in South Bound Lanes.	Southbound Lanes Performing Well after Almost 4 Years. Little to no Distress Beyond Crack Sealing. Northbound Lanes Receiving In-place Base Repairs at Time of Site Visit. Performing Well after 5 Months. Some Tears in Intersections which Appeared to be Early Traffic Damage. Microsurfacing was Slightly Soft, Possibly due to Lack of Compaction on Low Average Daily Traffic (ADT) Road.
Paris	FM 121	November 2010	11 Mile Project. Tearing and Delamination in Two Intersections Totaling 50 ft ² . 1000 ft ² of Corrugation in One Area.	
Dallas	US 287	May 2007	9 mile Project. 50 ft ² of Raveling and Bleeding in one Intersection. One Large Transverse Crack at Bridge Embankment. 6-8 Potholes in Entire Project.	Performing very Well after Four Years. Minor Distress at Infrequent Intervals.

data gathered and deemed relevant to current best practices. At the midpoint of the study, *National Cooperative Highway Research Program (NCHRP) Synthesis 411: Microsurfacing* (NCHRP 411) was published. The study relied heavily on this seminal work from that point forward, and the focus of the study analyzed practices in Texas in light of national practices reported in NCHRP 411 [13].

Survey

The survey utilized in this study was developed by the research team and based on a survey by NCHRP created to study chip seals [14]. The survey was sent to 138 personnel within Texas' Department of Transportation (TxDOT). Responses were received from 39, for a response rate of 28%. One person from each of the four contractors currently performing microsurfacing in Texas responded to the survey, as well as one of the two major emulsion suppliers. Questions on the survey fell into one of four categories: Mix Design and Material Selection, Equipment Practices, Construction Practices, and Performance Measures. Respondents were also asked to identify up to three microsurfacing sites in Texas and rate the performance of the projects.

Site Visits

From the representative microsurfacing projects that were identified by survey respondents, four sites were selected for visits. The purpose of the site visits was to observe firsthand performance of microsurfacing in Texas, and to calibrate the team to the ratings reported to the research team by survey respondents. TxDOT personnel responded to the request to rate the overall success of microsurfacing projects in Texas in the following way:

Excellent	15.5%
Good	45.3%
Fair	24.7%
Poor	11.4%
Unsatisfactory	3.1%

The site visits enabled the research team to obtain a reference

point for what defects and the rate of defects would present in microsurfacing projects that were rated "Excellent" and "Good." Table 1 provides a summary of the site visits.

Case Studies

Case studies were gathered from existing literature, the synthesis report from NCHRP, and from microsurfacing participants within Texas. Of special importance was the inclusion of forensic analysis done by Texas Transportation Institute (TTI) on three notable failures of cape seals in Texas. No specifications for cape seals exist in Texas and, therefore, cape seals at times have been confused with microsurfacing. One spectacular failure of a cape seal in Waco, TX, in the late 1990s resulted in negative bias toward microsurfacing that was still encountered by the research team during this study. The case study on the aforementioned cape seal concluded that failure of the existing roadway, not the treatment, created the catastrophic delamination [15, 16].

Analysis Method

Throughout the study, the research team sought to link responses from the survey regarding key practices for microsurfacing success to actual, measureable projects. The nature of a synthesis study lends itself to gathering and reporting large amounts of information. However, the researchers exerted efforts to apply critical analysis to the synthesized data to create worthwhile recommendations for changes to microsurfacing practices that were deemed beneficial.

Results and Discussions

Mix Design Method and Material Selection

It is difficult to identify specific inadequacies in mix design or material specifications as major contributors to the success or failure of microsurfacing. The current mix-design methods for microsurfacing in Texas are found in Texas Transportation Institute

Report 1289-F (TTI 1289). Texas specifications could be altered to include higher performance mix design testing or gradation requirements, depending on the harshness of the aggregate. Or, a completely new set of specifications with some improvement in microsurfacing performance could be a possible result. However, since no one response to mix design inquiries stands out as crucial, greater gains in performance would be seen by addressing project selection and contractor experience. This stems from the fact that five times more respondents to the survey cited project selection as the most critical factor in successful microsurfacing projects as opposed to material selection or mix design. Three and one half the number of respondents reported contractor experience as the most critical factor when compared with material selection or mix design.

NCHRP 411 (2010) concluded that "Microsurfacing design can be successfully assigned to the microsurfacing contractor with the agency reviewing and/or approving the final job mix formula." This research team agrees with this conclusion. While the performance ratings of microsurfacing in Texas from the NCHRP survey suggested that a change in formal mix design might be warranted, the higher levels of performance ratings and the reported adequacy of TTI 1289 from this study's survey suggest that no such change is needed.

Equipment Practices

In general, Texas appears to have adequate specifications in the category of equipment practices. Therefore, those practices should become a non-issue in light of the powerful contributors to project success found in project selection and construction practices. An improperly maintained microsurfacing machine may introduce problems into a project, such as leaving more drag marks at the rear squeegee, but adequate construction practices dictate correcting such issues by hand. Additionally, specifications on the finished product should force the contractor to rectify such problems. As long as a contractor has the proper equipment called for in the specifications, and keeps such equipment calibrated, sufficient practices should result. Until computerized machines can actually adjust the mixing ratios automatically, the final product is much more affected by the experience and skill of the crew using that machine.

Performance Measures

Contractor experience is vital to determining microsurfacing success—38.5% of TxDOT personnel claim that a certification program should be required of contractors in Texas, while 33.3% say there should not be such a certification, and 28.2% are uncertain. A construction certification program for contractors would still leave a knowledge deficit in TxDOT, but would assist in strengthening the crucial factors of contractor skill in a pool of microsurfacing candidates. With the importance of contractor experience and the discomfort felt by TxDOT personnel relying on the contractors so heavily, a construction certification could be a viable solution. It is notable, however, that when asked what action would result in a respondent's district utilizing more microsurfacing, having more contractors bidding the projects tied for the most frequent answer. Any barriers to entry, such as certification

requirements, need to be evaluated to determine if they would reduce the number of contractors or discourage new contractors. The benefit from certifying contractors would be greatest if it allowed TxDOT to switch from the current method-related specifications to performance-related specifications. Once a contractor was certified and an appropriate expectation could be placed on that firm, performance specifications would allow the experience and innovation of those who perform this work daily the leeway to accomplish quality however they saw best. Of course, the desire for more qualified contractors at the disposal of DOTs is ubiquitous across the country.

In the study, TxDOT personnel reported changes that would result in their district utilizing more microsurfacing. Two changes were reported with the most frequency, and they were "We (TxDOT) had additional training to better understand the process" and "There were more contractors bidding on the projects." These results provide another reason to implement a training class for TxDOT personnel. Additionally, strategies to encourage more contractors to enter the microsurfacing industry in Texas should be sought. NCHRP Synthesis 411 reports that the uncertainty in amount of microsurfacing that will be let every year discourages contractors from investing in the resources needed to develop the microsurfacing capability. With that conclusion in mind, this study found 30% of TxDOT respondents uncertain as to whether they would utilize more microsurfacing in the future. A more stable market for microsurfacing should give more contractors the confidence to enter the industry.

Project selection is the most important contributor to microsurfacing project success, yet TxDOT personnel do not have formal training in selecting appropriate microsurfacing projects. Therefore, they report that assistance from contractors in project selection is sought. This creates a strong case for implementing a training class for TxDOT personnel that would help overcome this imbalance in knowledge.

Microsurfacing Successes and Failures

Site Visits

The sites visited ranged in age from 5 months to 4 years. Each site offered an example of microsurfacing performance. US 180 showed how well microsurfacing can perform when applied to a structurally sound pavement at the right time. Bleeding at the end of the project illustrated the difficulty of starting and stopping paving, and reinforced the need for a continuous paving machine to minimize this effect. LP 322 in Abilene demonstrated how poorly even a well-constructed project will perform when there is base failure. The southbound lane performed well, while the northbound lane had to be repaired due to base failure. Both were constructed at the same time by the same contractor, but the side with base failure performed poorly, while the side with a structurally sound base performed well. FM 121 in the Paris District demonstrated the importance of a proper mix, not allowing traffic onto the microsurfacing too quickly, and ensuring the rear strike-off is pulled smoothly. Despite these minor defects, the microsurfacing received good overall performance ratings from TxDOT personnel. Lastly, US 287 in the Dallas District is an excellent example of a

Table 2. Distresses that Microsurfacing Corrects.

Distress	Yes (%)	No (%)
Loss of Friction	97	
Bleeding	92	
Rutting	90	
Surface Texture Variations	89	
Streaking/ Color Variations	80	
Raveling	58	
Fatigue Cracking		100
Reflection Cracking		97
Potholes		97
Delamination		94
Permeability		79
Poor Transverse Joints		76
Poor Longitudinal Joints		73
Corrugation/Poor Ride Quality		60

microsurfacing project that has performed well over the course of its life. The only major distress in the microsurfacing came from a base failure resulting from embankment settlement showing, yet again, that microsurfacing will not correct structural deficits in a pavement.

Microsurfacing as a Pavement Preservation Treatment

Most DOT personnel respondents to the survey answered favorably toward microsurfacing as a preventative maintenance treatment. The majority of TxDOT personnel report that microsurfacing will address the following pavement distresses: Loss of Friction, Bleeding, Rutting, Surface Texture Variations, Streaking/Color Variations, and Raveling (Table 2).

The important question to ask of all pavement preservation treatments is, “When said treatment is applied to the right project at the right time with good construction practices, is it a beneficial treatment?” Defining exactly what entails a beneficial treatment may vary slightly from agency to agency and application to application. In general, a beneficial pavement preservation treatment should extend the life of the underlying pavement beyond what would be expected without application of the given treatment and more efficiently or effectively than alternative treatments. If the answer to this question is “no,” utilization of the treatment should stop. The responses gathered during this study answer this question affirmatively for microsurfacing. In the literature review for this paper, an average service life of six years was found [6, 17-23]. In NCHRP 411 the average service life from that study’s survey was seven years. Texas reported design life’s between five and seven years. When TxDOT personnel reported on representative microsurfacing projects in Texas in this study’s survey, 67% reported that the projects did “Good” or better at meeting expected service life. The next logical step must then determine the right project, the right time, and good construction practices for microsurfacing. Determining these answers directed the study and uncovered an interesting relationship between contractors and the DOT involved in microsurfacing.

Unique Departmental Position

Construction practices are the most powerful contributors to the

success of microsurfacing. Project selection, contractor experience, and workmanship are consistently the frontrunners in literature, survey data, and discussions of crucial components for a microsurfacing project to perform well. Since construction practices fall into the purview of the microsurfacing contractor, emphasis was placed on analyzing what a “good” microsurfacing contractor does differently than a “poor” microsurfacing contractor.

From the survey, the reported factor that most often correlates to a good microsurfacing contractor is a contractor that knows which projects are suitable for microsurfacing and communicates that knowledge to TxDOT personnel. This answer is somewhat surprising because of the three crucial components of successful microsurfacing listed above, project selection is the one area that a DOT might easily control. Why, then, are agency personnel reporting it as the most important attribute of a good contractor?

The results of this study show that microsurfacing is a complex product that requires extensive experience in construction practice and project selection in order to ensure success. Many, if not most, TxDOT personnel logically conclude that microsurfacing contractors have more experience and, therefore, more knowledge of these factors. Since the two biggest factors contributing to the success or failure of microsurfacing are construction practices and project selection (with the highest level of knowledge of both of these factors currently belonging to the contractors), TxDOT is in a precarious position. Relying on contractors to inform TxDOT if the state has selected a project unsuitable for microsurfacing requires a level of trust that may not be established with all microsurfacing contractors. TxDOT could approach this knowledge deficit in one of three ways.

Option one would have TxDOT require certification for contractors in order to encourage a contractor to identify and communicate poor project selection. Nationally, only one state currently requires certification of microsurfacing contractors [5]. In option two, TxDOT would implement a warranty or pay factor system on all microsurfacing projects to encourage contractors to communicate when a proposed project will not respond well to microsurfacing, as their profits are based on project performance. Texas has a specification for warranted microsurfacings; however, increased use of the warranted microsurfacing was not one of the main changes that TxDOT personnel said would result in more microsurfacing use. Additionally, warranties are difficult to administer and enforce on a treatment that is extremely susceptible to underlying pavement structure, which is the most common cause of failure. Option three would have TxDOT develop much clearer guidelines on project selection criteria for microsurfacing and/or provide a course for TxDOT personnel to make them more knowledgeable on project selection. In fact, when asked what action would result in TxDOT using more microsurfacing, the answer that tied for the highest number of responses was, “We (TxDOT) had additional training to better understand the process (of microsurfacing).” The first option puts the responsibility in the hands of the contractors where it already lies. The second option has proven difficult to develop and implement, and may incent contractors to be overly conservative in their recommendations since microsurfacings are not always designed for maximum possible life due to budgetary restrictions. The third option places the power back into TxDOT’s hands. While this study concludes, as

does NCHRP Synthesis 411, that microsurfacing design be effectively assigned to microsurfacing contractors, project selection should not be. Any DOT will certainly want to work from an informed position in order to offer a strong partnership with a contractor.

Summary and Conclusions

To investigate the best practices of microsurfacing, the research team observed the current state of microsurfacing in Texas, compared it to best practices nationwide, and solicited input from those directly involved with microsurfacing on a regular basis within Texas. From the results of these efforts, the following conclusions were drawn:

- 1) The most important factor in constructing a successful microsurfacing is project selection. Microsurfacing will address rutting, bleeding, loss of surface friction, oxidation and raveling, but will not perform well when applied to structurally deficient pavements.
- 2) When applied to “the right road, at the right time, for the right distress,” microsurfacing can be expected to provide an average service life of five to seven years.
- 3) Microsurfacing is an effective preventative maintenance tool, as well as pavement preservation tool. Microsurfacing is an excellent tool for extending the life of existing pavement, and should be utilized as such.
- 4) Contractor experience is the second most important factor contributing to a successful microsurfacing project. Texas, like most DOTs, would like to see more contractors bidding on and performing microsurfacing in their state. This may improve if the amount of microsurfacing was consistent from year to year.
- 5) TxDOT resides in a position of vulnerability due to the disparity of knowledge of microsurfacing between agency personnel and contractors. Contractors provide the mix design, the product, and some of the roles in QC/QA, which results in dependence on the contractor for many levels of microsurfacing knowledge.
- 6) Most practices that have the potential to result in the application of successful microsurfacing lie in the hands of contractors due to the importance of construction practices. Project selection is the most important factor in contributing to success for microsurfacing. Fortunately, any DOT can have complete control over this factor. However, increased understanding of project selection for microsurfacing needs to be disseminated among the personnel involved in this treatment. Relying on contractors to alert a DOT to a poor project selection involves considerable risks. Such a conclusion is not unique to Texas, as the NCHRP Synthesis 411 concludes, “that a microsurfacing training and/or certification program is needed.”

Acknowledgements

The authors greatly appreciate TxDOT for supporting this research, and also thank Dr. German Claros and Mr. Dale Rand for their assistance with this research. The results and discussions expressed in the paper are solely those of the authors and do not reflect the

views of TxDOT.

References

1. Syed, I.M., Freeman, T.J., and Smith, R.E. (1999). Effectiveness of highway maintenance treatments used in Texas, Symposium on Flexible Pavement Rehabilitation and Maintenance, *ASTM STP 1349*, pp. 136-150.
2. Chan, A, Keoleian, G., and Gabler, E. (2008). Evaluation of life-cycle cost analysis practices used by the michigan department of transportation. *Journal of Transportation Engineering*, 134(6), pp. 236-245.
3. Chassiakos, A., Panagolia, C., and Theodorakopoulos, D. (2005). Development of decision-support system for managing highway safety. *Journal of Transportation Engineering*, 131(5), pp. 364-373.
4. Chu, C.Y. and Durango-Cohen, P. (2008). Incorporating maintenance effectiveness in the estimation of dynamic infrastructure performance models. *Computer-Aided Civil and Infrastructure Engineering*, 23, pp. 174-188.
5. Hesp, S., Soleimani, A., Subrmani, S., Phillips, T., and Smith, D. (2008). Asphalt pavement cracking: analysis of extraordinary life cycle variability in eastern and northeastern Ontario. *International Journal of Pavement Engineering*, 10(3), pp. 209-227.
6. Hicks, R.G., Dunn, K., and Moulthrop, J. (1997). Framework for selecting effective preventative maintenance treatments for flexible pavements. *Transportation Research Record*, No. 1597, pp. 1-10.
7. Labi, S. and Sinha, K. (2003). Measures of short-term effectiveness of highway pavement maintenance. *Journal of Transportation Engineering*, 129(6), pp. 673-683.
8. Labi, S. and Sinha, K. (2005). Life-cycle evaluation of highway preventative maintenance. *Journal of Transportation Engineering*, 131(10), pp. 744-751.
9. Li, Z. and Madanu, S. (2009). Highway project level life-cycle benefit/cost analysis under certainty, risk, and uncertainty: methodology with case study. *Journal of Transportation Engineering*, 135(8), pp. 516-526.
10. Pasupathy, R., Labi, S., and Sinha, K. (2007). Optimal reconstruction periods for stochastically deteriorating infrastructures. *Computer-Aided Civil and Infrastructure Engineering*, 22, pp. 389-399.
11. Galehouse, L, Moulthrop, J.S., and Hicks, R.G. (2003). Principles of pavement preservation. *TR News*, September-October 2003, pp. 4-15.
12. Takamura, K., Loka, K.P., and Wittlinger, R. (2001). Microsurfacing for Preventive Maintenance: Eco-Efficient Strategy. *Proc., International Slurry Seal Association Annual Meeting*, Maui, Hawaii, USA.
13. Gransberg, D.D. (2010). *NCHRP Synthesis 411: Microsurfacing; a synthesis of highway practices*, Transportation Research Board of the National Academies, Washington, DC., USA, 115 pp.
14. Gransberg, D.D. and James, D.M.B. (2005). *NCHRP Synthesis 342: Chip Seal Best Practices*, Transportation Research Board of the National Academies, Washington, DC., USA, 124 pp.

15. Yildirim, Y., Estakhri, C., Montgomery, P., and Dunn, B. (2011). Maintenance 705: guidelines on the use of micro-surfacing. Austin, Tx: Texas Pavement Preservation Center.
16. Yildirim, Y., Estakhri, C., & Dunn, B. (2011). Maintenance 706: best practices of microsurfacing application. Austin, Tx: Texas Pavement Preservation Center.
17. Bausano, J.P., Chatti, K., and Williams, R.C. (2004). Determining Life Expectancy of Preventive Maintenance Fixes for Asphalt-Surfaced Pavements, *Transportation Research Record*, No. 1866, pp. 1-8.
18. Chehovits, J. and Galehouse, L. (2010). Energy Usage and Greenhouse Gas Emissions of Pavement Preservation Processes for Asphalt Concrete Pavements, *Proceedings of the 1st International Conference on Pavement Preservation*, Newport Beach, Calif., USA, pp. 27-42.
19. Labi, S., Lamprey, G., and Kong, S.H. (2007). Effectiveness of microsurfacing treatments. *Journal of Transportation Engineering*, 133(5), pp. 298-307.
20. Lyon, C. and Persaud, B. (2008). Safety Effects of Targeted Program to Improve Skid Resistance, *Transportation Research Record*, No. 2068, pp. 135-140.
21. Smith, R.E. and Beatty, C.K. (1999). Microsurfacing usage guidelines. *Transportation Research Record*, No. 1680, pp. 13-17.
22. Temple, W., Shah, S., Paul, H., and Abadie, C. (2002). Performance of Louisiana's chip seal and microsurfacing program, *Transportation Research Record*, No. 1795, pp. 3-16.
23. Watson, D. and Jared, D. (1998). Georgia department of transportation's experience with microsurfacing. *Transportation Research Record*, No. 1616, pp. 42-46.