Int. J. Highw. Eng. *Vol. 17 No. 2 : 71-78 APRIL 2015*
http://dx.doi.org/10.7855/IJHE.2015.17.2.071

Microsurfacing Successes and Failures

마이크로서페이싱의 성공과 실패 사례

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ABSTRACT

PURPOSES : This study set out to investigate the current state of microsurfacing in Texas and compared the results with the current state of the practice nationwide.

METHODS : For this study, case studies were extracted from the existing literature and compared with the data obtained both from site visits by the research team and data obtained from a survey by Texas Department of Transportation (TxDOT) personnel. The successes and failures of microsurfacing are detailed and explanations of different issues are outlined. Forensic studies from Texas are included in the descriptions of those microsurfacings that failed when configured as part of the cape seals.

RESULTS : Microsurfacing has been shown to be an effective pavement preservation technique when applied to an appropriate road, at an appropriate timing, and as a remedy for certain issues. The failures experienced in Texas can mostly be attributed to cape seals and an inability to recognize structurally faulty pavement.

CONCLUSIONS : When applied to an appropriate road, at an appropriate timing, and as a remedy for certain issues, microsurfacing has been shown to perform well in numerous case studies. The majority of microsurfacing failures are the result of poor project selection, usually involving the treatment being applied to structurally unsound pavement.

Keywords
microsurfacing, case studies, site visits, project selection, construction practices, pavement preservation

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International Journal of Highway Engineering
http://www.ksre.or.kr/
ISSN 1738-7159 (print)
ISSN 2287-3678 (Online)
Received Nov. 27. 2014 Revised Nov. 28. 2014 Accepted Mar. 10. 2015

1. INTRODUCTION

1.1. Background

Preventative maintenance of existing roadways has been found to be the most financially efficient use of available resources by Department of Transportation (DOT). Many studies has been done with the goal of developing a set of criteria which will accurately guide decision-makers in choosing a preventative maintenance strategy producing the most cost-effective improvements in pavement quality and life.

2. OBJECTIVES and SCOPE

This research studied the success and failures of microsurfacing in Texas and compared the findings with the current state of practice in the United States.

States. A survey was conducted to TxDOT engineers who recognized as participants in microsurfacing project in Texas, as well as contractors and emulsion supplied involved in microsurfacing in Texas. Furthermore, an in-depth review of literature, site visits and case study analysis were carried out.

3. CASE STUDIES and SITE VISITS

Case studies and site visits were integral parts of the research project and will be discussed below as the topic of this paper.

3.1. Analysis Method

This paper focuses on the site visits and case studies portion of the microsurfacing synthesis study. Case studies on microsurfacing are available in the literature but comparisons of the results are limited. There is benefit to compiling the results of the case studies and site visits into one paper in order to easily compare the findings and identify patterns.

4. CASE STUDIES

Most reports on microsurfacing in the literature support its use as a pavement preventative maintenance treatment. Almost unanimously the importance of selecting the correct roadway in the correct time of the life of the roadway is mentioned as the most important factor contributing to success in the literature. Case studies of successful microsurfacings from the literature will be examined first followed by case studies of failures and then accounts of the research team's site visits.

NCHRP Synthesis 411 surveyed six case studies on microsurfacing. The summarizing of the conclusions that could be drawn from each study was excellent and will be reported directly here since no improvements could be made on the presentation.

Maine DOT - Snowplowing will abrade microsurfacing and eventually wear it away which is problematic if used for sealing against water intrusion but not if used for rut filling or ride improvement. Microsurfacing corrects loss of friction on pavement in a Northern climate.

York Region - Microsurfacing has shown itself to be particularly effective in reducing accidents in intersections. It can be effectively used to enhance skid resistance in areas where reduced stopping time is important due to highway features.

Oklahoma DOT - This study was very informative and will be dealt with in more detail in the final report. For now, the main conclusions were microsurfacing is a "green" alternative that can use recycled waste products effectively. Aggregate gradation should be altered depending on the main issue the treatment is attempting to address. Microsurfacing is the proper treatment to enhance skid resistance.

Georgia DOT - "Microsurfacing can be used as a cost-effective means to enhance the visual quality of a high-volume road while simultaneously enhancing skid resistance, smoothness, and addressing raveling and cracking issues on a high volume highway."

Kansas DOT - Microsurfacing provides a cost-effective means to improve ride quality on jointed concrete pavements and an expeditious means to improve ride quality while minimizing traffic disruption.

Minnesota DOT - Microsurfacing is a promising means to reduce transverse reflective cracking and the amount of binder can successfully be varied in the field to enhance rut filling ability.

In the course packet for TxDOT MNT 705 class, a microsurfacing in the Tyler district is discussed. $4\frac{1}{2}$ miles of a relatively new hot mix was segregating severely. Average daily traffic was 25,000 vehicles and the median, curb and gutter were flush. A microsurfacing was applied and was still performing well three years later. This project illustrates that when a thin lift treatment is needed to correct surface texture variations, microsurfacing will perform well.

Case studies on microsurfacing failures are less common in the literature. This could be due to multiple factors including significantly lower rates of failure than success, well understood failure processes with further study not needed, the cost and short time windows of performing forensic studies on failed pavements. The biggest factor in most failures is placing microsurfacing on a base pavement that is structurally unsound either due to lack of understanding of appropriate microsurfacing project selection or failure to recognize that the pavement soundness had been compromised. When the research team spoke with microsurfacing contractors in Texas about the lower number of case studies on microsurfacing failures in Texas, the contractors suggested that most failures of microsurfacings had actually been cape seals, for which there is no specification in Texas. A cape seal is the application of a seal coat, on top of which a microsurfacing is applied. So named because it was developed in the Cape Province of South Africa, it will provide 7-10 years of a smooth, dense surface with good skid resistance. The addition of the microsurfacing over the seal coat eliminates the problems experienced with normal seal coats of loose aggregate and traffic noise. Cape seals are performed de facto in Texas with a contract issued for a chip seal and then another for microsurfacing. The result is a cape seal in essence but constructed in a way that does not require a cape seal specification.

The Center for Transportation Research (CTR) performed a study on cape seal performance in Texas which included an infamous failed project in Waco. This notable project failed spectacularly in the early 1990's and still affects the perception of microsurfacing in TxDOT. The CTR study of 20 cape seals found that three of the cape seals performed unacceptably with one rated "poor" one "very poor" and one, the Waco project "failure." Forensic studies were performed on the three failed cape seals and the results are shown below.

4.1. US 281- Fort Worth:

4.1.1. Description:

- Four lane highway between Dallas/Fort Worth and Wichita Falls.
- Existing pavement was old "slick" concrete pavement with some patching. Some portions were milled to "roughen" surface.
- Seal Coat was grade 4, emulsion was CRS-2

4.1.2. Performance:

- Severe bleeding, shoving, movement and sliding of seal coat/micro over concrete. Loss of seal coat and microsurfacing in places (concrete exposed).

4.1.3. Other Observations:

- Time interval between completion of seal coat and start of microsurfacing varied from 1-4 days.
- Considerable aggregate loss of the seal coat under traffic following rain.
- Condition of the seal coat/micro under bridges did not exhibit distress.
- First signs of distress about a week after construction (very hot temperatures).

4.1.4. Conclusions:

- A harder asphalt for the seal coat would have been less susceptible to shoving (i.e., condition under bridges where temperatures were cooler).
- Areas where pavement surface was milled prior to the cape seal performed better; therefore, the slick surface may have contributed to lack of bonding, shoving and bleeding problems.
- Section under bridges also not exposed to water during the rain and would have experienced less aggregate loss in the seal coat.

The cape seal failure on US 281 demonstrates the need for a good mix design.

4.2. Waco SH 6

4.2.1. Description:

- Existing pavement was 1.3 miles of moderately oxidized HMAC with aggregate stripped to a depth of three inches.
- Seal coat was grade 3 aggregate and the emulsion was AC with latex.

4.2.2. Performance:

- Design application rate for seal coat was .42 gsy. Actual application ranged from .40 to .60 gsy. Immediate bleeding and flushing observed. Appeared the seal coat binder had migrated to the surface.

4.2.3. Conclusion:

– Seal coat binder application rate was excessive.

The next case study will be dealt with more extensively because of the almost infamous nature with which it has affected TxDOT personnel's perception of microsurfacing. Throughout the process of this study, the research team was referred to this project as a demonstration of how spectacularly microsurfacing can fail and more specifically, that a new microsurfacing should never be placed on top of an old microsurfacing. To demonstrate the legendary status that this project has achieved, the research team was told that the roadway "looked like the surface of the moon." A summary of the background on this project states that an old microsurfacing (6 years old) on I-35 was beginning to crack and a cape seal was planned for placement on top. The cape seal was finished in September and by December had failed. The failure began on a wet, cold day and in 2-3 days the microsurfacing was completely debonding as well as the seal coat and the old microsurfacing.

The Texas Transportation Institute (TTI) performed a forensic analysis of the project including cores, falling weight deflectometer, ground penetrating radar and seismic testing (16). When the microsurfacing layers, sandwiched seal coat and top layer of HMAC were removed, the underlying pavement showed fatigue cracking in both wheel paths which coring showed to span the full depth of the pavement. As shown by the analysis, the structural soundness of this pavement was significantly reduced. The HMAC around the cracks was damaged and the areas around these cracks expected to continue to deteriorate.

TTI's conclusions are as follows:

It may be difficult to avoid or detect this type of problem. This pavement appears to have reached the end of its service life, but surfacing treatments, properly placed, probably hid the true nature and severity of the problem. Although properly applied maintenance treatments can extend the life of a pavement, they cannot do so indefinitely, especially on such a heavily trafficked highway. In this case, it appears that the approach was to maintain the pavement with a microsurfacing until a major widening and rehabilitation project could be initiated, but the pavement was no longer strong enough. The cold weather accelerated the loss of surfacing but probably did not cause it.

The longitudinal cracking in the wheel paths that probably was reflected through would have given an indication that this pavement was in need of some major work, but since this highway had performed so well for so long, it would have been difficult to justify rebuilding this road.

From TTI's conclusions, it is clear that the microsurfacing held the failing AC together as long as it could but could not sustain the structural integrity of the failed pavement underneath once rain and freezing water entered the equation. Some districts took away the lesson at the time of failure that new microsurfacings cannot be placed on old ones but that is untrue. If a microsurfacing is in adequate shape, a new microsurfacing can, and has been in Texas, placed over it successfully. If an existing microsurfacing is in poor shape, it should be milled off before placing a new microsurfacing, the same as for any pavement treatment.

One notable factor that is present in each of the aforementioned failures is how quickly the distresses showed up after construction. If a microsurfacing or cape seal project is going to fail, it most likely will present within the first few months. A strong case may be made for warranted microsurfacings from this information but it also is important to be aware of early signs of distress.

TxDOT class MNT 706 manual deals extensively with the cause of various microsurfacing distresses present in new microsurfacings. Table 1 summarizes this information but for a more detailed treatment of this material, the class handbook is invaluable.

Table 1. Possible Construction Defects in Microsurfacings and Their Casues

Distress	Cause
Delamination	Inadequate cleaning of original surface.
Drag marks	Emulsion is breaking too fast.
Scratch marks and tears	Poorly maintained equipment, improper application rates.
Poor joints	Contractor inexperience.
Poor edges	Contractor inexperience
Ruts	Filling ruts greater than ½" in single pass, not crowning the ruts.
Early traffic damage	Insufficient cure time, cure conditions or mix design.

Successful microsurfacings will possess few defects post-construction. Defects that are evident post-construction are indicative of the above problems and will be more likely to fail prematurely. Table 2 shows the most common distresses in microsurfacings in Texas as compared to nationwide.

Table 2. Most Common Post-Construction Defects Seen in Microsurfacings Ordered from Most Prevalent to Least Prevalent

NCHRP Synthesis Survey	TxDOT Personnel Survey
Crack reflection	Crack reflection
Streaking	Delamination
Raveling	Raveling
Delamination	Potholes
Transverse joints	Corrugation
Bleeding	Surface texture variations
Longitudinal Joints	Streaking
Corrugation	Transverse joints
	Bleeding
	Longitudinal joints

The fact that crack reflection occurred first in both the NCHRP synthesis and the current project's survey strongly reinforce the fact that microsurfacing cannot correct underlying structural inadequacies. Interesting to note is the higher occurrence of delamination in Texas microsurfacings compared to the rest of the US. This may be due to the lack of a tack coat requirement in Texas or may be due to the heat of Texas causing the emulsion to break too quickly, preventing a good bond to the pavement below. Future analysis is warranted.

4.3. Site Visits

In the survey, the research team asked respondents to identify up to three microsurfacing sites in Texas that they had experience with and to rate their performance. From these responses, the research team selected four sites and performed site visits to them. Table 3 summarizes the sites and detailed discussion may be found below. Also, the information regarding mix design method and material selection can be found in the research report published by TxDOT

Table 3. Summary of Site Visits

District	Road	Date Completed	Measure of Most Prevalent Distresses	Summary
Abilene	US 180	August 2009	Performing well. Little to no visible distress.	Performing well. Little to no visible distress.
Abilene	LP 322	August 2007	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.	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.
Paris	FM 121	November 2010	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.	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.
Dallas	US 287	May 2007	Performing very well after four years. Minor distress at infrequent intervals.	Performing very well after four years. Minor distress at infrequent intervals.

4.4. US 180 in Abilene District

	Bleeding seen where transition occurs from microsurfacing (top) to existing road (bottom). Existing roadway can also be seen to be structurally sound, a major contributor to the success of this project.
	Another view of the bleeding in the microsurfacing. Bleeding was not seen elsewhere on this project, attesting to the difficulties encountered in starting and stopping paving, the reason for continuous travel paving mills. Transverse joint was well constructed as can be seen from lack of cracking or height difference from existing road.
	Project had good joints, no rutting over $\frac{1}{4}$" deep, some minor streaking and good texture.

4.5. LP 322 in Abilene District

	Southbound lanes showing no rutting, good texture, well constructed edges and joints, with crack-sealing.
 	Southbound lanes (right) had some crack sealing but no major distresses. Northbound lanes (left) can be seen under construction. Northbound lanes were reported to be under construction by the area engineer who stated "we are performing in place repairs on areas that cropped up right after the really bad ice and snow spell with 3 consecutive days with temps never getting to 20 degrees (F). I think the weather was the primary problem but it does demonstrate that the condition of the road was probably borderline for consideration of placement of the microsurfacing at the time the decision was made to do so."

4.6. FM 121 in Paris District

	Well constructed edges on pavement with good macro-texture. Microsurfacing had good micro-texture.
	No rutting, good appearance with no streaking or bleeding.
	Delamination seen in intersections. In this case, entrance and exit of landowner immediately prior to paving may have introduced dust onto the surface and prevented adequate bonding.

4.7. US 287 in Dallas District

	No rutting over $\frac{1}{4}$", good surface texture, almost no cracking, no bleeding, good color and ride. This project had a destroy date of 5/2011 and was still performing very well. Example of a well constructed project on an appropriate underlying road.
	Surface texture seen at edge of microsurfacing (top) and existing road (bottom).
	A couple of patched potholes, entire project had approximately 6-8 total potholes.
	One of only two significant distresses in the microsurfacing. Occurred at the beginning of an embankment constructed for a bridge. Settlement of the fill was the obvious cause of failure of the base pavement which reflected through the microsurfacing.
	The second distress was an area of minor raveling and bleeding.
	Cause is unknown but minor variation in the mix may have left a spot of softer binder allowing bleeding and raveling.

4.8. Site Visit Conclusions

The site visits ranged in age from 5 months to 4 years. Each site showed a sample of microsurfacing performance. US 180 indicated how well a microsurfacing can perform, applied to a structurally sound pavement at the right time. Bleeding at the end of the project exhibited the difficulty or starting and stopping paving and strengthened the requirement for a continuous paving machine to minimize this effect. LP 322 in Abilene district showed how poorly even a well-constructed project will perform if there is base failure. The southbound lane performed well while the northbound lane has to be repaired due to base failure. Both lanes 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 fine. FM 121 in Paris district confirmed the importance of a proper mix, not allowing traffic onto the microsurfacing too quickly and ensuring the rear strike off is pulled smoothly. In spite of these minor defects, the microsurfaing obtains good performance ratings overall from TxDOT engineers. Finally, US 287 in Dallas district is an excellent example of a microsurfacing project which has performed well over the course of its life. The only major distress in the microsurfacing came from a base failure stemming from embankment settlement showing yet againg that microsurfacing will not correct structural deficits in pavement.

4.9. TxDOT's Ratings of Microsurfacing

When the experience of TxDOT personnel with microsurfacings was sought in the survey, most respondents answered favorably of microsurfacing. The majority of TxDOT engineers answer that microsurfacing will address the following pavement distresses:

Distress (% of respondents answering this way)

- Friction loss (97%)
- Bleeding (92%)
- Rutting (90%)
- Surface Texture Variations (89%)
- Streaking/Color Variations (80%)
- Raveling (58%)

The majority of TxDOT engineers respond that microsurfacing will NOT address the following pavement distresses:

Distress (% of respondents answering this way)

- 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%)

When asked to identify and describe representative microsurfacing projects in Texas, TxDOT personnel identified projects that they then rated the overall success of in the following way:

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

4.10. Future Research

In order to ensure that microsurfacings are successful in Texas, project selection is the most critical factor. Due to this, criteria for road qualification should be developed that will allow personnel to quantify pavement condition and assess the suitability for microsurfacing. Such criteria could include road profile, crack width and other indicators of structural stability. Research to this end is appropriate. Also, due to the higher rates of delamination in Texas as compared to other states, a tack coat may need to be added to the current specifications.

5. CONCLUSIONS

When applied to the right road, at the right time for the right distresses, microsurfacing has been shown in numerous case studies to perform well. Failures in Texas can mostly be attributed to cape seal sand the inability to recognize structurally faulty pavement. In the future, microsurfacing may benefit from new formulations and additives that increase the treatment's ability to compensate for cracks in the underlying pavement but for now, it is vital to a successful microsurfacing to apply it only to intact road surfaces. The site visits performed in Texas reinforce the beneficial nature of microsurfacing in extending the life of underlying pavement when the road is structurally sound but not when there is failure in the base layer. This is most evident in the well-performing microsurfacing seen on US 287 in Dallas District that showed severe reflective cracking in one isolated area. Lastly, one of the major conclusions of the microsurfacing synthesis study on which this article is based was the importance of project selection and contractor experience in successful microsurfacings. Analysis of the case studies and site visits reinforce this conclusion as improper utilization of the treatment and poor workmanship account for the majority of reported microsurfacing failures.

ACKNOWLEDGEMENTS

This study was conducted under TxDOT and research project (Development of Eco-Friendly Pavements to Minimize Greenhouse Gas Emissions) funded by the Ministry of Land, Infrastructure and Transport (MOLIT) and the Korea Agency for Infrastructure Technology Advancement (KAIA). The authors would like to thank the members of research team, TxDOT, MOLIT and KAIA for their guidances and supports throughout the project.

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